Sarcouncil Journal of Internal Medicine and Public Health

ISSN(Online): 2945-3674

Volume- 04| Issue- 05| 2025

Research Article **Received:** 20-07-2025| **Accepted:** 10-08-2025 | **Published:** 09-09-2025

Antibiotic Resistance of Selected Bacterial Pathogens Causing Respiratory Infections at Tay Nguyen University Hospital in 2025

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Abstract: Objective: To evaluate the antimicrobial susceptibility of bacterial pathogens isolated from respiratory tract infections at Tay Nguyen University Hospital. Methods: Bacterial isolates were tested using the Kirby–Bauer disk diffusion method on Mueller–Hinton agar, interpreted according to CLSI 2023 guidelines. Results: *Streptococci:* High resistance to Erythromycin (80.5%), Vancomycin (70.7%), Ampicillin (68.3%), and Tetracycline (65.9%); susceptible to Levofloxacin (70.7%) and Ofloxacin (65.9%). *Pseudomonas aeruginosa:* Resistant to Amikacin (67.9%), Levofloxacin (57.1%), and Ofloxacin (53.6%); Piperacillin/Tazobactam showed highest susceptibility (75%). *Staphylococcus aureus:* Strong resistance to Erythromycin (87.0%) and Tetracycline (71.4%); Amikacin remained effective (97.8%). Conclusion: Respiratory pathogens exhibited high resistance to common antibiotics, notably Macrolides and Tetracyclines. Continuous surveillance and antibiotic stewardship are necessary for effective treatment.

Keywords: Respiratory tract infection, antimicrobial resistance, antibiotic susceptibility, Vietnam.

INTRODUCTION

Antimicrobial resistance has become a major challenge for modern medicine, leading to increased mortality, prolonged hospitalization, and higher treatment costs. According to the World Health Organization (WHO), Vietnam is among the countries with the highest rates of antimicrobial resistance worldwide. While many developed nations can still effectively use first-generation antibiotics, in Vietnam, third- and fourth-generation antibiotics are already required (CDC, A. 2019; Ministry of Health, 2025)

Respiratory pathogens, particularly *Streptococci*, *Staphylococcus aureus*, and *Pseudomonas aeruginosa*, have been reported to exhibit high resistance rates to commonly used antibiotics such as Penicillin, Erythromycin, Ampicillin, and Tetracycline (Ministry of Health, 2023). The national antimicrobial resistance surveillance report in Vietnam (2020) indicated that *S. aureus* showed resistance to Penicillin, Oxacillin, Erythromycin, and Clindamycin ranging from 75% to 100% (Ministry of Health, 2023).

In the context of increasing antimicrobial resistance, regular monitoring of bacterial susceptibility at each hospital is essential to establish appropriate treatment regimens and to limit the ineffective use of antibiotics. Therefore, this study was conducted to assess the antimicrobial resistance patterns of bacterial strains isolated from patients with respiratory infections at Tay Nguyen University Hospital in 2025.

SUBJECTS AND METHODS

Study subjects:

Bacterial strains isolated from throat swab specimens of patients with respiratory infections at Tay Nguyen University Hospital (March 2025 – May 2025).

Study site and period:

The study was conducted at the Microbiology Laboratory – Department of Laboratory Medicine, Faculty of Medicine and Pharmacy, Tay Nguyen University, from March 2025 to May 2025.

Study design: A descriptive cross-sectional study.

Sample size

The required sample size n was estimated using the single-proportion formula:

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

where $Z^{2}_{(1-\alpha/2)}$=1.96 for a 95% confidence level, the allowable margin of error d=0.05, and the expected prevalence p=0.231 based on Pham Ngoc Toan (2019) (Toan, P. N.& Hong, L. T. B. 2021). The minimum required sample size was calculated to be 272. In practice, the study successfully collected 278 clinical samples.

Laboratory techniques:

Antimicrobial susceptibility testing was performed using the Kirby–Bauer disk diffusion method on Mueller–Hinton agar. Bacterial suspensions were standardized to a density equivalent to 0.5 McFarland standard (≈10^8 CFU/ml). Results were interpreted after 18–24 hours of incubation at 37°C by measuring inhibition zone diameters and classifying isolates as susceptible (S), intermediate

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DOI- https://doi.org/10.5281/zenodo.17083617

(I), or resistant (R) according to the Clinical and Laboratory Standards Institute (CLSI, 2023) guidelines. Reference strains *E. coli* ATCC 25922 and *S. aureus* ATCC 29213 were used for quality control.

Tested antibiotics:
Ten antibiotics were included: Amikacin (30 µg), Ampicillin (10 µg), Colistin (10 µg), Erythromycin (15 µg), Gentamicin (10 µg), Levofloxacin (5 µg), Ofloxacin (5 µg), Piperacillin/Tazobactam (100/10 µg), Tetracycline (30 µg), and Vancomycin (30 µg).

Data Processing and Analysis
Data were entered and processed using SPSS version 22.0.
Qualitative variables were presented as frequencies and percentages.
Comparison of resistance rates between bacterial strains was performed using the Chi-square test, with statistical significance set at $p < 0.05$.

RESULTS

Table 1. Distribution of bacterial isolates in clinical specimens

Bacteria	Number (n)	Percentage (%)
Streptococci	41	24.1
Staphylococcus aureus	21	12.4
Pseudomonas aeruginosa	28	16.5
Escherichia coli	31	18.2
Streptococcus pneumoniae	17	10.0
Fungi	12	7.1
Other bacteria	20	11.8
Total	170	100

Bacterial Identification In Respiratory Tract Infections
Out of 278 throat swab specimens, 170 (61.2%) showed positive cultures, while 108 (38.8%) were negative. Among the positive samples, the predominant bacterial isolates were as follows: *Streptococci* – 41 strains (24.1%), *Escherichia coli* – 31 strains (18.2%), *Pseudomonas aeruginosa* – 28 strains (16.5%), and *Staphylococcus aureus* – 21 strains (12.4%).

Table 2: Antibiotic susceptibility of Streptococci

Antibiotic	Susceptible (n, %)	Intermediate (n, %)	Resistant (n, %)
Amikacin	21 (51.2%)	6 (14.6%)	14 (34.1%)
Ampicillin	7 (17.1%)	6 (14.6%)	28 (68.3%)
Erythromycin	8 (19.5%)	0 (0.0%)	33 (80.5%)
Levofloxacin	29 (70.7%)	6 (14.6%)	6 (14.6%)
Ofloxacin	27 (65.9%)	6 (14.6%)	8 (19.5%)
Tetracycline	7 (17.1%)	7 (17.1%)	27 (65.9%)
Vancomycin	12 (29.3%)	0 (0.0%)	29 (70.7%)

Antibiotic susceptibility of Streptococci
Antibiotic susceptibility testing of 41 *Streptococci* isolates showed a high resistance rate to commonly used antibiotics: Erythromycin (80.5%), Vancomycin (70.7%), Ampicillin (68.3%), and Tetracycline (65.9%); The isolates were relatively susceptible to Levofloxacin (70.7%) and Ofloxacin (65.9%).

Table 3: Antibiotic susceptibility of P. aeruginosa

Antibiotic	Susceptible (n, %)	Intermediate (n, %)	Resistant (n, %)
Amikacin	7 (25.0%)	2 (7.1%)	19 (67.9%)
Colistin	5 (17.9%)	18 (64.3%)	5 (17.9%)
Gentamicin	13 (46.4%)	4 (14.3%)	11 (39.3%)
Levofloxacin	8 (28.6%)	4 (14.3%)	16 (57.1%)
Ofloxacin	11 (39.3%)	2 (7.1%)	15 (53.6%)

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Piperacillin/Tazobactam	21 (75.0%)	1 (3.6%)	6 (21.4%)
Tetracycline	15 (53.6%)	1 (3.6%)	12 (42.9%)

Antibiotic Susceptibility of Pseudomonas Aeruginosa

Antibiotic susceptibility testing of 28 *P. aeruginosa* isolates revealed relatively high resistance to several commonly used antibiotics: Amikacin: 67.9% resistant; Levofloxacin: 57.1% resistant; Ofloxacin: 53.6% resistant; Tetracycline: 42.9% resistant; Other antibiotics showed lower resistance rates. Notably, *P. aeruginosa* exhibited a high susceptibility rate to Piperacillin/Tazobactam at 75%.

Table 4: Antibiotic susceptibility of S. aureus

Antibiotic	Susceptible (n, %)	Intermediate (n, %)	Resistant (n, %)
Amikacin	7 (33.3%)	5 (23.8%)	9 (42.9%)
Erythromycin	3 (14.3%)	0 (0.0%)	18 (85.7%)
Gentamicin	12 (57.1%)	1 (4.8%)	8 (38.1%)
Levofloxacin	11 (52.4%)	1 (4.8%)	9 (42.9%)
Ofloxacin	11 (52.4%)	2 (9.5%)	8 (38.1%)
Tetracycline	9 (42.9%)	1 (4.8%)	11 (52.4%)
Vancomycin	14 (66.7%)	0 (0.0%)	7 (33.3%)

Antibiotic Susceptibility of Staphylococcus Aureus

Antibiotic susceptibility testing of 21 *Staphylococcus aureus* isolates revealed a relatively high resistance rate to most commonly used antibiotics. The resistance rate to Erythromycin was 85.7%, and to Tetracycline was 52.4%; Other antibiotics showed lower resistance rates; Notably, Vancomycin maintained a relatively high susceptibility rate of 66.7%.

DISCUSSION

Prevalence of bacterial isolates commonly associated with respiratory tract infections

In this study, we recorded 170 positive culture samples, accounting for 61.2%. The most frequently isolated bacteria were *Streptococci* (24.1%), *Pseudomonas aeruginosa* (16.5%), and *Staphylococcus aureus* (12.4%). Comparison with previous studies revealed marked variations in bacterial isolation rates.

Specifically, the study by Nguyen Ngoc Lan (2016–2017) reported a higher rate of positive cultures (69.8%), with *Streptococci* (16.62%), *P. aeruginosa* (11.57%), and *S. aureus* (12.02%) (Lan, N. N. *et al.*, 2018). In contrast, Nguyen Van An (2022) observed a lower positivity rate (32.7%), in which *P. aeruginosa* (1.3%) and *S. aureus* (9.8%) were both lower than those in our study (An, N. V. Binh, 2024). Conversely, the research conducted by reported a positivity rate of only 38.5%, but the proportion of *P. aeruginosa* was higher (25.54%) (Quynh, L. T. *et al.*, 2022).

Besides the predominant bacterial pathogens, we also isolated several other organisms; however, these were not within the scope of the study objectives. Overall, differences in bacterial isolation rates across studies may be attributed to geographic factors, study period, patient population characteristics, and laboratory methods. These factors likely explain the observed variability in the etiological agents of respiratory infections.

Antibiotic Resistance Rate of Streptococci

In recent years, the development of numerous novel antibiotics has provided opportunities to improve the effectiveness of infectious disease treatment. However, alongside these advances, antibiotic resistance has been rising steadily, particularly among drug classes commonly used in clinical practice. This situation not only diminishes therapeutic efficacy but also complicates infection control measures within hospitals. Therefore, the selection and use of antibiotics must be carefully considered, especially in cases of severe or life-threatening infections, in order to optimize treatment outcomes and limit the spread of resistant bacteria. Furthermore, it is necessary to establish strategies to preserve new generations of antibiotics, regarding them as valuable resources to combat complex infectious challenges in the future.

Our findings showed that *Streptococci* were the most frequently identified pathogens in respiratory infections, accounting for 24.1%. Notably, *Streptococci* strains exhibited high resistance rates

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to Erythromycin (80.9%), Vancomycin (70.7%), Ampicillin (68.3%), and Tetracycline (65.9%). In contrast, lower resistance rates were observed with Amikacin (34.1%), Levofloxacin (14.6%), and Ofloxacin (19.5%). Compared with previous studies,(Lan, N. N. *et al.,* 2018) reported that *Streptococci* strains were resistant to Erythromycin but remained 100% susceptible to Vancomycin, a finding consistent with (Dang Dieu Linh 2022). However, our data indicate that the resistance rate to Vancomycin has increased substantially, reflecting a concerning new epidemiological trend.

This observation has critical clinical implications: Vancomycin, once considered a cornerstone therapy against resistant *Streptococci* infections, is gradually losing its effectiveness. Consequently, antibiotic administration should be not only judicious but also guided by antimicrobial susceptibility testing to ensure appropriate therapeutic regimens. In addition, hospital infection control must be reinforced, including antibiotic stewardship, surveillance of resistant pathogens, and strict implementation of patient isolation measures, in order to curb the spread of antibiotic-resistant *Streptococci* strains.

Antibiotic resistance rate of Pseudomonas aeruginosa

Our findings revealed that *P. aeruginosa* exhibited variable levels of antibiotic resistance: the highest resistance was observed against Amikacin (67.9%), followed by Levofloxacin (57.1%), Ofloxacin (53.6%), Tetracycline (42.9%), and Gentamicin (39.3%). In contrast, lower resistance rates were recorded for Colistin (17.9%) and Piperacillin/Tazobactam (21.4%).

These results are consistent with the study by, in which *P. aeruginosa* showed the lowest resistance rates to Colistin (16.3%) and Piperacillin/Tazobactam (11.6%) (Trinh, N. T. D. *et al.,* 2023). Similarly, (Hoang Thi Minh Hoa, 2020) reported no resistance to Colistin (0%) and only 14% resistance to Piperacillin/Tazobactam . However, compared to previous publications, the resistance rates to Colistin and Piperacillin/Tazobactam in our study were higher, suggesting an emerging trend of resistance to Colistin - an antibiotic traditionally regarded as the "last-resort option" in treatment.

The observed increase in resistance may be attributed to several factors, including antibiotic overuse, the emergence of acquired resistance mechanisms in the community, insufficient infection control practices in healthcare facilities, and the spread of multidrug-resistant strains within the population.

In this context, the treatment of *P. aeruginosa* infections should not rely on monotherapy. Instead, combination antibiotic therapy is recommended to enhance bactericidal activity, limit the emergence of resistance, and reduce toxicity - particularly when using Carbapenems, Aminoglycosides, and Colistin. This finding also serves as a cautionary note for clinicians to carefully evaluate the use of Colistin and Piperacillin/Tazobactam, ensuring both therapeutic effectiveness and mitigation of resistant strain dissemination.

Antibiotic resistance rates of Staphylococcus aureus

According to the World Health Organization (WHO, 2018), the pathogenicity and antibiotic resistance of *Staphylococcus aureus* (S. aureus) pose a serious threat to global public health. Previous studies conducted in several provincial hospitals in northern Vietnam demonstrated that *S. aureus* exhibited resistance to many commonly used antibiotics such as Ampicillin, Tetracycline, and Sulfamethoxazole, with rates ranging from 70–90% (Anh, L. K. *et al.,* 2002). The national antimicrobial resistance surveillance report of the Ministry of Health in 2020 also recorded very high resistance levels to Penicillin, Oxacillin, Erythromycin, and Clindamycin, ranging from 75–95% (Ministry of Health, 2023).

A recent study by (Vo Pham Minh Thu , 2023) reported a resistance rate of 29.2% to Tetracycline and found no resistance to Vancomycin . However, our findings revealed considerably higher resistance rates to both Tetracycline and Vancomycin, indicating an increasing trend in *S. aureus* resistance to these antibiotics over time. Notably, our study also demonstrated an improvement in the susceptibility of *S. aureus* to Levofloxacin, with a sensitivity rate of 52.4%. This figure is higher than that reported by at 32.6% (Lan, N. N. *et al.,* 2018) and by (Vo Pham Minh Thu, 2023) at 34.8%.

In the current context, rational and controlled use of antibiotics is an urgent necessity. This requires healthcare workers, physicians, and the community to adopt appropriate awareness regarding antibiotic selection, dosage, and adherence to antimicrobial susceptibility testing in treatment. Antibiotic misuse remains prevalent, particularly in remote

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and economically disadvantaged areas, where self-medication practices are common and contribute significantly to the escalation of antimicrobial resistance.

CONCLUSION

In this study, three main pathogens causing respiratory tract infections were isolated at different rates. *Streptococci* accounted for the highest proportion (24.1%), followed by *Pseudomonas aeruginosa* (16.5%) and *Staphylococcus aureus* (12.4%). This finding reflects the diverse nature of respiratory pathogens, in which both Gram-positive and Gram-negative bacteria play significant roles.

Notably, the isolated bacterial strains exhibited high rates of antibiotic resistance, particularly to the Macrolide group (Erythromycin), Tetracycline, and Ampicillin. These antibiotics have been widely and long used in treatment, resulting in selective pressure and increased resistance.

However, some antibiotics still maintain therapeutic effectiveness. Specifically, Amikacin demonstrated good activity against *S. aureus*, Quinolones (Levofloxacin, Ofloxacin) remained effective against *Streptococci*, while Piperacillin/Tazobactam proved to be a valuable option for *P. aeruginosa*. This highlights the necessity of selecting antibiotics based on the resistance profile of each pathogen rather than relying on broad empirical therapy.

RECOMMENDATIONS

Antibiotic susceptibility testing should be performed before prescribing treatment for patients with respiratory infections in order to improve therapeutic effectiveness and reduce the risk of antimicrobial resistance. Healthcare facilities should develop and regularly update treatment guidelines based on local antimicrobial surveillance data. Strengthen antibiotic stewardship and promote the rational use of antibiotics, limiting inappropriate overuse.Encourage periodic large-scale surveillance studies on antimicrobial resistance to monitor evolving trends and propose effective control strategies.

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Source of support: Nil; **Conflict of interest:** Nil.

Cite this article as:
Nien, L. V., Thao Vy, T. N., and Thuy, L. H. "Antibiotic Resistance of Selected Bacterial Pathogens Causing Respiratory Infections at Tay Nguyen University Hospital in 2025." *Sarcouncil Journal of Internal Medicine and Public Health* 4.5 (2025): pp 8-13.

Publisher: SARC Publisher