International Journal of Academic Health and Medical Research (IJAHMR)
ISSN: 2643-9824
Vol. 9 Issue 7 July 2025, Pages: 95-102

Survey on antibiotic resistance of Escherichia Coli isolated from patients at Thanh Hoa Provincial Hospital, Vietnam in 2024

[1]Bach Tuong Vi, [2]Tran Tinh Yen, [3]Nguyen Hoai Nam

1.Vinschool Smart City, Hanoi, Vietnam. Email: vibach2101@gmail.com
2. Vinschool Harmony Campus, Hanoi, Vietnam. Email: liam3012208@gmail.com
3. Thanh Hoa Provincial Hospital, Vietnam. Email: hoainamnguyen1909@gmail.com

Abstract: *This study evaluates the antibiotic resistance of clinical isolates of E. coli gathered from Thanh Hoa Provincial Hospital during the year 2024. All 886 E. coli strains collected were evaluated for their susceptibilities to 24 antibiotics of different classes using the disc diffusion method, which is in accordance with CLSI 2023 guidelines. The results showed 51.9% of the strains were E. coli, producers of Extended-spectrum beta-lactamase (ESBL). E. coli strains exhibited high resistance to Ciprofloxacin (83.3%), Levofloxacin (75.2%), Ampicillin (98.3%), and Co-trimoxazole (68.5%), while showing high susceptibility to the carbapenem antibiotics Imipenem (97.9%), Meropenem (97.6%), and Amikacin (95.7%). A more detailed analysis by patient characteristics (gender, age, department) and specimen type was performed to provide additional epidemiological context, which complemented the resistance profile mapping. This study emphasizes the need to gather and analyze relevant clinical information to empirically prescribe appropriate antibiotics and formulate strategic treatment plans to mitigate the dissemination of resistant strains.*

Keywords: *Antibiotic resistance, Escherichia coli, ESBL, Thanh Hoa Provincial Hospital*.

1. INTRODUCTION

Escherichia coli (E. coli) is an enteric bacterium associated with serious human infections, including urinary tract infections, bloodstream infections, peritonitis, and neonatal meningitis. E. coli is a microorganism of concern within public health because of its increasing prevalence as a hospital and community-associated pathogen, its diverse pathogenic potential, and its considerable contribution to morbidity and mortality. The growing antibiotic resistance rate of E. coli has emerged as a critical public health issue in recent decades. The growing and disseminating of MDR (multidrug-resistant) strains, which synthesize ESBL (extended-spectrum beta-lactamases) and carbapenemases, is endangering the effectiveness of conventional antibiotics. The infections associated with these strains are now increasingly associated with longer hospital stays, higher medical costs, and increased mortality. ESBLs are enzymes that hydrolyze a wide variety of beta-lactam antibiotics, especially third-generation cephalosporins and aztreonam, which makes treatment very challenging.

As with several bacteria, Escherichia coli's (E. coli) antibiotic resistance is becoming more commonplace throughout the world. Variability in the rate of antibiotic resistance geographically persists, and for China and India, the situation is particularly severe, notably high. As noted by the WHO and CDC, the rates of fluoroquinolone and third-generation cephalosporin resistance in E. coli are increasing in these countries at an alarming rate. Some regions of Asia report the prevalence of E. coli producing ESBL exceeding 60%.

The fight against antibiotic misuse is equally intensive in Vietnam. Many national surveillance programs and cross-sectional studies conducted in Vietnamese hospitals documented the dissemination of E. coli with resistance to several important classes of antibiotics. There are reports of the prevalence of ESBL E. coli in Vietnam ranging from 30-70, and lower in some populations. This phenomenon undermines the clinical treatment. There are geomaps of Vietnam indicating the prevalence of antimicrobial resistance in E. coli, and understanding these maps is important in developing treatment protocols and designing intelligent policies of antibiotic therapy and resistance.

The objectives of this study were:

To describe the epidemiological features of E. coli strains extracted from clinical specimens at Thanh Hoa Provincial Hospital in the year 2024, marking their distribution by sex, age, type of specimen, and department within the hospital.

To evaluate the antibiotic resistance rates of E. coli strains to the commonly prescribed and last-line antibiotics.

To identify the proportion of ESBL-producing E. coli strains.

To evaluate the factors relating to antibiotic resistance in E. coli and to analyze the comparison with other published studies.

The study results are expected to serve as a critical scientific foundation for revision of the guidelines for antibiotic prescription and for improvement of treatment outcome and prevention of infection in Thanh Hoa Provincial Hospital and in the Vietnamese healthcare system as a whole.

2. MATERIALS AND METHODS

2.1. Study Subjects

Study subjects were the 886 Escherichia coli isolates obtained from clinical specimens collected from patients at Thanh Hoa Provincial Hospital.

Inclusion criteria: Patients diagnosed with hospital-acquired *E. coli* infection who had not received antibiotic treatment for the current infection prior to specimen collection; no repeat isolates from the same patient; and accurate clinical diagnosis.

Duration of the study: January 2024 to December 2024.

2.2. Study Location

The Thanh Hoa provincial hospital Microbiology Department was the study site. Blood culture and other examinations for the isolation and identification of the bacteria and their antibiotic determination were carried out in the hospital laboratory.

2.3. Methods of Bacterial Isolation and Identification

• Urine, blood, and pus clinical samples were inoculated on MacConkey and Blood Agar Plates.

• E. coli was subcultured from the selective MacConkey agar into selective and biochemical media, SIM, Citrate, Urea, and Triple Sugar Iron agar for preliminary identification.

• Confirmatory identification was done, when necessary, by molecular techniques such as PCR or VITEK 2 Compact (bioMérieux, France) as per the manufacturer's protocol.

2.4. Procedures for Testing Antibiotic Susceptibility

• Optimization of Disk Diffusion Method: Antibiotic susceptibility testing was conducted using the Kirby-Bauer disk diffusion method on Mueller-Hinton agar according to CLSI regulations from the year 2023.

• Antibiotics tested: Included in the study were 24 antibiotics belonging to 11 different groups, such as:

1. Penicillin group: Ampicillin, Amoxicillin/Clavulanic acid, Piperacillin/Tazobactam.
2. Cephalosporin group: Cephalexin, Cefazolin, Ceftazidime, Cefotaxime, Ceftriaxone, and Cefepime.
3. Carbapenem group: Imipenem, Meropenem.
4. Aminoglycoside group: Gentamicin, Amikacin.
5. Quinolone/Fluoroquinolone group: Ciprofloxacin, Levofloxacin, and Norfloxacin.
6. Folate pathway inhibitors group: Trimethoprim/Sulfamethoxazole.
7. Monobactam group: Aztreonam.
8. Tetracycline group: Tetracycline.
9. Nitrofurantoin group: Nitrofurantoin.
10. Fosfomycin group: Fosfomycin.
11. Lipopeptides group: Polymyxin B.

Measurement and Interpretation of Results: The diameters of the inhibition zones were measured the rims of growth, zones were measured and interpreted as susceptible (S), intermediate (I), and resistant (R) based on CLSI 2023.

2.5. Technique for identifying ESBL-producing E coli strains

Isolates resistant to third-generation cephalosporins, for example, Cefotaxime, Ceftazidime, and Ceftriaxone, or those showing a reduced susceptibility ZOI, were screened for ESBL production using the Combination Disk Test with Ceftazidime and Cefotaxime, both with and without Clavulanic acid. The increase of inhibition zone diameter, ranging 5 mm or more, with the addition of Clavulanic acid, confirmed the production of ESBL.

2.6. Data processing and statistical analysis

All information was organized and managed within a single database that was created using the Microsoft Excel application. The analysis was carried out using the SPSS version 20.0 software. The qualitative variables are displayed with their absolute and relative frequencies (%). The comparison of proportions between groups was done with the Chi-square ($\chi 2$) test with a significance level set at p-value <0.05.

3. RESULTS

A total of 886 E. coli strains were isolated and included in the study.

3.1 Distribution by Gender

The analyzed data confirmed that the prevalence of E. Coli strains obtained from females exceeded that of males. Females represented 461 strains (52.0%) and males represented 425 (48.0%). The differences observed were also noted to be statistically not statistically significant (p>0.05). As noted in the literature on the epidemiology of E. coli infections, and specifically urinary tract infections, it is well-recognized that women are infected in far greater numbers than men, and this is due to having a short urethra, which is near the anus.

3.2. Distribution by Age Group

Age Group	Number of Strains	Percentage (%)
< 16	18	2,0
16 - 29	59	6,7
30 - 39	78	8,8

40 - 49	93	10,5
50 - 59	142	16,0
60 - 69	219	24,7
70 - 79	190	21,4
≥ 80	87	9,8
Total	886	100,0

Table 1

Patients with Escherichia coli infection were primarily from the 60 to 69 years age bracket (24.7%), with 70 to 79 and 50 to 59 year age groups following at 21.4% and 16.0% respectively. The pediatric population (under 16 years) had the lowest diagnosed proportion of 2.0%. This suggests that older adults sustain a greater risk of E. coli infection, possibly due to comorbid conditions such as diabetes and chronic kidney disease, age-linked immunity, or health care-associated exposures.

3.3. Distribution by Specimen Type

Specimen Type	Number of Strains	Percentage (%)
Urine	671	75,7
Other Fluid	79	8,9
Blood	74	8,4
Sputum	38	4,3
Pus	24	2,7
Total	886	100,0

Table 2

Given the predominance of UTI infections, the collection of specimens through urination was the most common form of specimen collection at 75.7%. This supports the identification of Escherichia coli as the most common causative pathogen of urinary tract infections at Thanh Hoa Provincial Hospital, supporting both international and domestic findings. In addition, E. coli was also cultured from blood and other normally sterile fluids, illustrating the ability of E. coli to cause both systemic and localized infections.

3.4. Distribution by Department

Department	Number of Strains	Percentage (%)
Internal Medicine	319	36,0
Intensive Care Unit	253	28,6
Surgery	137	15,5
Infectious Diseases	61	6,9
Pediatrics	35	4,0
Other	81	9,0
Total	886	100,0

Table 3

The Internal Medicine Department and the Intensive Care Unit (ICU) reported the highest isolation rates of Escherichia coli at 36.0% and 28.6% respectively. These figures reveal the vulnerability of critically ill patients, particularly those with multiple chronic diseases, prolonged lengths of stay, and are prone to health systems-related infections. The considerable percentage of infected patients in the ICU is concerning due to the common convergence of these units with infections due to multidrug-resistant organisms and a high risk of nosocomial infections.

3.5. Antibiotic Resistance Rates of *Escherichia coli*

The results of susceptibility testing of 886 E. coli strains to 24 antibiotics are presented in detail below. The Susceptibility (S), Intermediate (I), and Resistance (R) rates were calculated and analyzed for each antibiotic group.

3.5.1. Penicillin and Beta-lactamase Inhibitor Combinations

Antibiotic	S (%)	I (%)	R (%)
Ampicillin (AMP)	1,7	0,0	98,3
Amoxicillin/Clavulanic acid (AMC)	49,6	23,3	27,1
Piperacillin/Tazobactam (TZP)	88,4	7,6	4,0

Table 4

E. coli demonstrated remarkably high resistance rates to ampicillin (98.3%). This is parallel to the well-known capability of this microorganism to produce either chromosomal or plasmid-mediated beta-lactamases, which hydrolyze beta-lactam antibiotics. This strongly indicates that ampicillin is no longer an effective empirical treatment of choice for E. coli infections in Thanh Hoa Provincial Hospital.

For amoxicillin/clavulanic acid (AMC) – a beta-lactam/beta-lactamase inhibitor – the proportion of resistant isolates increased to 27.1%, with an additional 23.3% showing intermediate susceptibility. It is concerning that more than half of the tested isolates were non-susceptible, indicating the rising prevalence of ESBL-producing strains or other resistance mechanisms that are not countered by clavulanic acid. This further is an increase in the 20–25% resistance rate reported by Nguyen Thi Thu (2018) in Hanoi.

Conversely, the activity of piperacillin/tazobactam (TZP) was strongly retained in vitro. Of the tested isolates, 88.4% were susceptible and only 4.0% resistant. These findings further underscore the criticality of piperacillin/tazobactam for the treatment of severe infections, particularly when there is a need for broad-spectrum coverage and beta-lactamase inhibition.

3.5.2. Cephalosporin Group

Antibiotic	S (%)	I (%)	R (%)
Cefazolin (CFZ)	24,8	47,8	27,4
Cephalexin (CL)	23,2	45,9	30,9
Ceftazidime (CAZ)	23,3	21,9	54,8
Cefotaxime (CTX)	24,7	22,1	53,2
Ceftriaxone (CRO)	25,2	21,7	53,1
Cefepime (FEP)	44,3	23,3	32,4
ESBL	-	-	51,9

Table 5

The proportion of resistance for both first generation (cefazolin and cephalexin) and third generation cephalosporins (ceftazidime, cefotaxime, and ceftriaxone) was markedly high within the range of 27.4% - 54.8%. Furthermore, the resistance rates of all third-generation cephalosporins were greater than 53%, which supports the hypothesis of the circulation of strains of ESBL-producing E. coli.

The overall ESBL-producing E. coli prevalence was exceptionally high, at 51.9%. This raises concerns as it implies that over half of the isolates were resistant to cephalosporins. This was corroborated with data retrieved from Vietnam, such as Le Minh Quynh (2017), who reported an ESBL prevalence of 45%, as well as Vu Thi Thoa (2020), who stated that the rates were up to 60% in some major tertiary care hospitals. The finding of 51.9% prevalence was, in the authors' view, a cause for significant concern; it highlights the intensifying and increasingly urgent challenge posed by ESBL-producing organisms.

Nevertheless, one fourth-generation cephalosporin, cefepime, demonstrated a higher susceptibility rate of 44.3% than the third-generation resistance rate of 32.4%. In either case, this observation points to the disturbing reality that even fourth-generation cephalosporins are being compromised by existing resistance mechanisms, which diminishes the possibility of their use as monotherapy for severe infections.

3.5.3. Carbapenem Group

Antibiotic	S (%)	I (%)	R (%)
Imipenem (IPM)	97,9	1,6	0,5
Meropenem (MEM)	97,6	1,2	1,2

Table 6

Imipenem and meropenem carbapenem drugs have maintained high antibiotic activity in vitro, with susceptibility rates of over 97% and resistance of 1.5%

or lower. For this reason, carbapenem drugs will continue to be the first-line treatment of severe infections of E. coli, especially those infections produced by ESBL strains.

Nevertheless, the presence of minimal levels of resistance for both drugs, 0.5% for Imipenem and 1.2% for Meropenem, necessitates continuous surveillance and stewardship for antimicrobial resistance and infections, as any increase in the numbers could indicate the rise of carbapenemase-producing E. coli, which have scant treatment options and high rates of spread.

Similar to our findings, recent studies from Vietnam have reported low rates of carbapenem resistance in E. coli, although some tertiary care centers appear to be experiencing an increase.

3.5.4. Aminoglycoside Group

Antibiotic	S (%)	I (%)	R (%)
Gentamicin (GEN)	65,3	15,2	19,5
Amikacin (AMK)	95,7	0,0	4,3

Table 7

Amikacin showed notable bacteriologic effectiveness against E. coli with a susceptibility and resistance rate of 95.7% and 4.3% respectively. These results further support the position arguing the role of amikacin in the management of complicated and severe infections, as well as urinary and bacteremia infections involving multidrug-resistant organisms.

In comparison, the resistance rate for gentamicin was notably higher at 19.5%. This fits, and perhaps exceeds, what has been documented in other Vietnamese studies, which recorded resistance rates in the range of 15% to 20%.

3.5.5. Quinolone/Fluoroquinolone Group

Antibiotic	S (%)	I (%)	R (%)
Ciprofloxacin (CIP)	16,7	0,0	83,3
Levofloxacin (LEV)	23,3	1,6	75,2
Norfloxacin (NOR)	15,2	0,0	84,8

Table 8

The resistance to specific quinolones and fluoroquinolones is particularly concerning. Ciprofloxacin, norfloxacin, and levofloxacin have resistance rates of 83.3%, 84.8%, and 75.2%. Their frequent prescription for urinary and gastrointestinal infections renders these high resistance rates particularly troubling. This is further concerning when contrasted with reported resistance rates of 40–60% five to ten years ago. This growing shift, likely related to prescription volume, remains troubling. For this reason, ciprofloxacin and levofloxacin are no longer appropriate for E. coli infections in patients at Thanh Hoa Provincial Hospital.

3.5.6. Other Antibiotics

Antibiotic	S (%)	I (%)	R (%)
Trimethoprim/ Sulfamethoxazole (SXT)	26,0	5,5	68,5
Nitrofurantoin (F)	83,7	2,4	13,9
Fosfomycin (FOS)	95,2	0,0	4,8
Aztreonam (ATM)	24,5	0,0	75,5
Tetracycline (TE)	0,0	0,0	100,0
Polymyxin B (PB)	0,0	25,0	75,0

Table 9

Trimethoprim/Sulfamethoxazole (SXT): The high resistance rate (68.5%) indicates that SXT is no longer an appropriate choice for empirical treatment of E. coli infections.

Nitrofurantoin (F): With a susceptibility rate of 83.7%, nitrofurantoin remains effective, particularly for uncomplicated urinary tract infections, due to its low resistance profile and limited impact on gut microbiota.

Fosfomycin (FOS): Fosfomycin showed excellent activity, with 95.2% of isolates susceptible and only 4.8% resistant. Like nitrofurantoin, it is a suitable agent for treating lower urinary tract infections.

Aztreonam (ATM): The resistance rate to aztreonam was high (75.5%), comparable to third-generation cephalosporins. This is expected, as ESBL-producing E. coli strains often exhibit cross-resistance to aztreonam.

Tetracycline (TE): All isolates were resistant to tetracycline, confirming its ineffectiveness against E. coli in this setting.

Polymyxin B (PB): Although only four isolates were tested, 75% showed resistance. Given Polymyxin B's role as a last-line agent against multidrug-resistant Gram-negative bacteria, this finding is concerning. However, further investigation with a larger sample size is necessary to validate this observation.

4. DISCUSSION

Findings from 2024 highlight the concerning rate of antibiotic resistance of E. coli at Thanh Hoa Provincial Hospital.

Prevalence of ESBL: The ESBL rate reaching 51.9% poses significant difficulties for treatment. The emergence of ESBL-E. coli obligates the use of stronger antibiotics such as Carbapenems, thereby heightening the risk of developing Carbapenem-resistant strains.

High resistance to commonly prescribed antibiotics: High resistance rates to commonly prescribed agents, such as ampicillin, quinolones (e.g., ciprofloxacin, levofloxacin), and co-trimoxazole, render them ineffective for empirical therapy. This is likely driven by their extensive use.

Carbapenems and Amikacin antibiotics: Amikacin and Carbapenems are two antibiotics that still retain their potency. They are crucial antibiotics that must be preserved and must not be abused in therapy, as they should be reserved for when all other alternatives have failed.

Treatment of urinary tract infections: As such, fosfomycin and nitrofurantoin are the preferred treatment for lower urinary tract infections, as these medications are not broad-spectrum and minimize the use of broad-spectrum antibiotics.

Increasing trends of resistance– The resistance profile of E. coli captured from Thanh Hoa Provincial Hospital, with comparison to other studies done in Vietnam as well as other countries, shows increasing trends for several important classes of antibiotics, particularly third-generation Cephalosporines and Quinolones. This suggests that more efforts need to be made in regard to the use of antibiotics.

Risk factors– Among the distribution of E. coli bacteria with respect to the age groups and the departments, there exist important high-risk areas such as geriatrics, Internal Medicine, and the Intensive Care Unit (ICU). These areas need to be closely managed with regard to special control measures and individualized management, such as concentrated surveillance for a high-level resistance profile.

Study limitations: While depicting a single-site hospital's environment in detail, this study is a cross-sectional survey. Multi-center studies with larger cohorts and longitudinal follow-up would offer a more holistic understanding of the resistance trends over time. Furthermore, the determination of concrete resistance genes would enhance the understanding of the resistance mechanisms.

5. CONCLUSION

E. coli was most commonly isolated from urine specimens, with high rates in the elderly and in Internal Medicine and Intensive Care Unit departments.

The proportion of ESBL-producing E. coli reached 51.9%, a concerning figure illustrating the extensive circulation of multidrug-resistant strains within the hospital.

E. coli isolates demonstrated almost complete resistance towards Penicillin class antibiotics (Ampicillin), Quinolones (Ciprofloxacin, Levofloxacin, and Norfloxacin), and Trimethoprim/Sulfamethoxazole, limiting the clinical utility of these antibiotics for empirical therapy.

Carbapenem group antibiotics (Imipenem, Meropenem) and Amikacin still maintain high susceptibility rates, confirming their crucial role in treating severe E. coli infections.

Nitrofurantoin and Fosfomycin remain effective options for uncomplicated urinary tract infections.

These results emphasize the necessity of continuous surveillance of antibiotic resistance, developing and strictly adhering to antibiotic use guidelines at Thanh Hoa Provincial Hospital, and implementing effective infection control measures to limit the spread of multidrug-resistant bacterial strains.

REFERENCES

[1] Dellinger, R. P., Levy, M. M., Rhodes, A., Annane, D., Gerlach, H., Opal, S. M., et al. (2013). Surviving Sepsis Campaign: International guidelines for management of severe sepsis and septic shock, 2012. Intensive Care Medicine, 39(2), 165–228. https://doi.org/10.1007/s00134-012-2769-8

[2] Medical Service Administration, Ministry of Health. (2015). National guidelines for antibiotic use: Issued with Decision No. 708/QD-BYT on March 2, 2015. Hanoi.

[3] Ministry of Health. (2011). Circular No. 43/2011/TT-BYT: Regulations on the management of infectious disease specimens.

[4] Ministry of Health. (2013). Medical Microbiology. Hanoi: Medical Publishing House.

[5] Ministry of Health (Ed.). (2015). Guidelines for antibiotic use. Hanoi: Medical Publishing House.

[6] Nguyen, K. V., Nguyen, T. V., Nguyen, P. D., Nguyen, C. T., Nguyen, T. T., & Hoang, B. V. (2019). Antibiotic use and resistance in emerging economies: a situation analysis for Viet Nam. BMC Public Health, 19, 1–11. https://doi.org/10.1186/s12889-019-6764-5

[7] Quynh, L. M. (2017). The antibiogram rate of ESBL-producing Escherichia coli at Bach Mai Hospital. Vietnam Journal of Preventive Medicine, 27(6), 123–128.

[8] Tängdén, T., & Giske, C. G. (2015). Global dissemination of extensively drug-resistant carbapenemase-producing Enterobacteriaceae: Clinical perspectives on detection, treatment and infection control. Journal of Internal Medicine, 277(5), 501–512. https://doi.org/10.1111/joim.12342

[9] Thoa, V. T. (2020). A review of the antibiotic resistance of ESBL-producing Escherichia coli in Vietnam. Journal of Medical Research, 131(4), 56–62.

[10] Thu, N. T. (2018). Antibiotic resistance of Escherichia coli causing urinary tract infections at Hanoi Medical University Hospital in 2018 [Master's thesis, Hanoi Medical University].

[11] World Health Organization. (2017). Global priority list of antibiotic-resistant bacteria to guide research, discovery, and development of new antibiotics. https://www.who.int/publications/i/item/WHO-EMP-IAU-2017.12