Doi: https://doi.org/10.3329/ewmcj.v14i2.86253

Original Article

PREVALENCE AND ANTIBIOTIC RESISTANCE PATTERN OF ESBL-PRODUCING *ESCHERICHIA COLI* AMONG URINARY TRACT INFECTION PATIENTS IN A TERTIARY CARE HOSPITAL, DHAKA

Munny NN[1], Chowdhury MZU[2], Johora FT[3], Khatun S[4]

Article History:
Received: 11th December 2025
Accepted: 1st January 2026

Abstract:

Background: *Extended-spectrum β-lactamases producing Escherichia coli (ESBL-EC) lend resistance to most β-lactam antibiotics. Because of limited treatment options, ESBL-EC infection generally more difficult to treat, leading to higher hospital costs, reduced rates of microbiological and clinical responses. This study aimed to determine the prevalence and antibiotic resistance pattern of ESBL-EC isolated from patients with urinary tract infection in a tertiary care hospital, Dhaka.*

Materials and methods: *This retrospective laboratory-based cross-sectional study was conducted at East West Medical College and Hospital, Turag, Dhaka from January 2024 to December 2024. A total of 1902 urine samples were collected from urinary tract infection patients and processed by standard microbiological methods. According to the CLSI guidelines In vitro susceptibility testing to different antibiotics of all identified isolates of E. coli was performed following Kirby–Bauer's disc diffusion method on Mueller–Hinton Agar.*

Results: *Among 1902 urine samples 535 (28.12%) were culture positive. Among culture positive isolates around 369 (68.97%) Gram negative isolates and 166 (31.03%) Gram positive isolates were found. E. coli and Staphylococcus aureus were the most isolated organism among Gram-negative and Gram-positive isolates respectively. Out of 227 isolates 64 (28.19%) were ESBL producers, of which 40 (62.5%) isolated from adult patients (over the age of fifty), Most of the ESBL producers was isolated from indoor patients 36 (56.25%). Among ESBL-producing E. coli, the highest antibiotic resistance was observed with ceftazidime (100%), ampicillin (98.43%), cefepime (100%), ceftrioxone (100%), aztreonam (98.43%) and ciprofloxacin (78.12%) and the highest antibiotic sensitivity was observed with carbapenem (100%), fosfomycin (98.43%), nitrofurantoin (93.75%) and gentamicin (55.56%).*

Conclusion: *The development of antibiotic resistance by ESBL-E. coli, the most frequent pathogen linked to urinary tract infections plays a crucial role in determining which antibiotic therapy is appropriate. This study highlights the importance of ongoing surveillance to guide empiric therapy and promote appropriate antibiotic use.*

Keywords:
Uropathogenes, Extended-spectrum beta-lactamase, Antibiotic resistance, Urinary tract infection, Escherichia coli, Prevalence

EWMCJ Vol. 14, No. 2, July 2026: 170-178

Introduction

Antimicrobial resistance is a serious public concern, especially in developing countries, where easy access and inappropriate usage of antibiotics have increased the prevalence of resistance levels. According to the World Health Organization (WHO), antimicrobial resistance (AMR) stands out as a paramount global health and development challenge. Of the 4.95 million infection-related deaths worldwide, approximately 1.27 million have resulted directly from the predominance

1. Dr. Nazmun Nahar Munny, Assoc. Professor, Depart. of Microbiology, East West Medical College, Turag, Dhaka.
2. Prof. Md. Zaforullah Chowdhury, Principal and Head, Depart. of Microbiology, East West Medical College, Turag, Dhaka.
3. Dr. Fatima Tuj Johora, Assoc. Professor, Depart. of Microbiology, East West Medical College, Turag, Dhaka.
4. Dr. Sumaiya Khatun, Assoc. Professor, Depart. of Microbiology, East West Medical College, Turag, Dhaka.

Address of Correspondence: Dr. Nazmun Nahar Munny, Assoc. Professor, Depart. Of Microbiology, East West Medical College, Turag, Dhaka. E-mail: nazmunmunny. 13@gmail.com, Orchid ID:0000-0001-6595-7872

of bacterial AMR. [1] Urinary tract infection (UTI) is one of the most prevalent infectious diseases in humans and the second most common cause, following respiratory tract infections. The Enterobacterales group was a commonly isolated species in urine (85%), with *E. coli* as the predominant organism (72%).[2,3] As a member of the Enterobacteriaceae family, *Escherichia coli* is the most frequent bacterial cause of urinary tract infections, accounting for up to 80% of cases. [4,5] The extensive occurrence of *E. coli* and its persistent development of antibiotic resistance put humans and animals at significant risk of infection, with projections indicating a 67% increase in antibiotic usage by 2030, thereby imposing a financial strain on healthcare systems.[6]

βlactam antibiotics are the most commonly prescribed and safest antimicrobial agents for urinary tract infections (UTIs).[7] They are a class of broad-spectrum antibiotics that contain a beta-lactam ring in their molecular structure.[8,9] But several studies prove the increased resistance of *E. coli* in UTIs to beta-lactam antibiotics.[10,11] The emergence of extended-spectrum beta-lactamase (ESBL) produces bacteria that hydrolyze the beta-lactam ring, inactivate the antibiotic, and reduce, consequently, the number of treatment options, which becomes another worry. [9,12] Extended-Spectrum Beta-Lactamase (ESBL) *E. coli,* a significant multidrug-resistant bacterium, is responsible for severe infections in both hospital and community environments, particularly in lower-middle-income countries where hygiene and sanitation are lacking. As a result, hospital admissions, fatalities, illness prevalence, and healthcare costs increase.[13] The beta-lactam antibiotics, in particular carbapenems, have been widely regarded as the treatment of choice for ESBL-EC infections.[14] However, the worldwide emergence of beta-lactam antibiotic-resistant strains of Enterobacteriaceae poses a threat to the effectiveness of this class of antibiotics.[15,16] In addition, co-resistance to sulfonamides and fluoroquinolones occurs frequently, restricting the options for alternative treatments.[17,18]

Bangladesh experienced an increasing prevalence of UTIs. However, the magnitude of the UTI associated with ESBL-producing uropathogens, with particular concern to *E. coli,* needed more attention. Recognizing current regional data on the antimicrobial susceptibility patterns of common uropathogens is essential for guiding effective treatment decisions. Therefore, this study has been conducted to investigate the prevalence of ESBL-producing *E. coli* in patients with urinary tract-associated infections. Additionally, examine the magnitude of antimicrobial-resistant ESBL-producing *E. coli* from UTI patients. The findings of this study will be useful in the management of ESBL-producing *E. coli* associated with UTI and also improvement of treatment outcomes for patients with UTI in Bangladesh.

Materials and Methods

This is a retrospective cross-sectional laboratory-based study from January 2024 to December 2024. Data were collected during routine bacteriological culture at the East west Medical College Microbiological Laboratory. Here consecutive sampling method were used.

A total of 1902 urine samples were included in this study. Patients with clinically suspected UTI were included in the study. We included all individuals whose urine cultures were positive in this study. The exclusion criteria were negative microbiological cultures, a lack of culture requests, cases with other microbes identified, and urine specimens obtained after the initiation of empiric antibiotic therapy. Each isolate was categorized as either community-acquired or hospital-acquired. Community samples included those originating from outpatient rooms of the hospital or of external general practitioners in the surrounding area.

Sample collection and processing

Clean catch midstream urine was collected in a sterile urine container by the patient or by the caregiver of the patient (in case of children). Urine culture was done in the clinical microbiology lab of East-west Medical College Hospital following standard procedure[19]. Briefly, a loopful (~10μl) of urine samples were streaked on MacConkey agar (Oxoid Ltd., UK) and blood agar (Oxoid Ltd., UK) by a semi-quantitative method using a calibrated loop. Plates were incubated at 35°C aerobically and examined at 18–24 hours and they were further incubated for another 24 hours before a negative report was issued. Cultures were quantitated, and 'significant' bacteriuria was defined as a case of UTI in specimen containing bacterial species 1.0×10^5 CFU/ml of urine according to the standard guidelines.[20] Patients with non-significant bacteriuria (<1.0x105 CFU/ml) were excluded from further analysis.

Identification of bacterial species

Isolates were identified based on Gram's stain reaction, culture characteristics and biochemical properties.

Antimicrobial Susceptibility Testing

In vitro susceptibility testing to different antibiotics of all identified isolates of *E. coli* was performed following Kirby–Bauer's disc diffusion method on Mueller–Hinton Agar (Hi-Media, India) according to the Clinical Laboratory Standards Institute (CLSI) guidelines (CLSI 2020)[21]. Antibiotics tested in our study include the following: Ampicillin (10 µg), amoxicillin clavulanate (AMC; 20/10µg), cefoxitin (FOX; 30µg), piperacillin/tazobactam(TZP; 100/ 10µg), fosfomycin (FOS; 200 µg), gentamycin (CN; 10 µg), tobramycin (TOB; 10 µg), amikacin (AK; 30 µg), ciprofloxacin (5µg), levofloxacin (5µg), ceftriaxone (CRO; 30 µg), ceftazidime (CAZ; 30 µg), cefixime (CFM; 10 mg), cefuroxime (CXM; 30 µg), imipenem (IPM; 10 µg), meropenem (MEM; 10µg), co-trimoxazole (SXT; 1.25/23.75 µg), nitrofurantoin (F; 300µg), mecelinum (MEL;25µg), and colistin (CT; 10 µg) (Oxoid™, UK).

Screening and Confirmation of ESBL Producers

Conventional microbiological method was used to identified the ESBL-producing *E. coli* isolate. Moreover, screening of ESBL-producing *E. coli* was carried out through a zone of inhibition of ≤25mm for ceftriaxone and/or ≤22 mm for ceftazidime and or ≤17 mm cefuroxime and or 27mm for cefotaxime considered as positive ESBL producer[20]. ESBL-producing *E. coli* was confirmed phenotypically using the combined disc method. Discs containing ceftazidime (30µg) and a combination of discs containing clavulanic acid (30µg + 10µg) were placed at 25mm apart. The isolate was considered an ESBL producer when an increase in zone of the diameter of ≥5mm in the zone of inhibitor for ceftazidime+ clavulanic acid compared to ceftazidime alone was confirmed as ESBL-producing *E. coli* according to CLSI guideline[21]. For quality assurance, the reference strains of *E. coli* (ATCC 26122) were used in quality control for culture and susceptibility tests as well as for the detection of ESBL detection.

Statistical Analysis

Data were seized and analyzed by using IBM SPSS Statistics for Macintosh, Version 23.0 (IBM Corp, Armonk, NY, USA) and presented in percentage base distribution. The statistical analysis of ESBL and Non-ESBL variables (age, sex and origin) was analyzed by Chi-square Test. $P<0.05$ was considered statistically significant.

Results:

During the study period, among 1902 urine samples 535 (28.12%) were culture positive (Figure 1). Among the culture positive uropathogens, 369 (68.97%) were Gram negative isolates and 166 (31.04%) were Gram positive isolates. Among Gram negative isolates, *E. coli* was most common organism 227 (61.52%) followed by *Enterobacter* 82 (22.22%) (Figure 3). On the other hand, *Staph. aureus* was the most prevalent organism among Gram positive isolates 92 (55.42%) followed by *Enterococci* 78 (46.99%) (Figure 4). Out of 227 *E. coli* isolates, 64 (28.19%) were ESBL producer (Figure 2) of which most 40 (62.50%) isolates were isolated from adult patients (fifty or more than fifty). Most ESBL producers were isolated from indoor patients 36 (56.25%). For gender, females have higher prevalence of UTI caused by ESBL producing *E. coli* compared to men (table I). Out of 64 sample of ESBL producing *E. coli*, 38 (59.37%) sample were isolated from female patients. The calculated p-value for sex ($p = 0.412$), for age ($p=0.614$) and for origin ($p= 0.873$) as displayed in Table 1 shows that the risk of contracting ESBL-EC is similar between the two groups studied.

The resistance observed in ESBL-EC sample detailed in Table 2. Analysis of â-lactam and cephalosporin family shows that all strains of *E. coli* producing ESBL were resistant to ceftazidime, cefepime, ceftriaxone, 98.44% resistant to ampicillin, cefuroxime, aztreonam, and 82.81% were resistant to ciprofloxacin, 68.75% were resistant to levofloxacin, 48.44% and 46.88% were resistant to tetracycline and co-trimoxazole respectively.

However, the analysis shows that the carbapenems are very effective against ESBL-EC with a sensitivity (100%) followed by Fosfomycin (98.44%) and nitrofurantoin (93.75%).

Table-I

Some key risk variables in urine E. coli isolates from January, 2024 to December, 2024

Factor	Non-ESBL *E. coli* isolates (N =163)	ESBL-*E.coli* isolates (N =64)	Total (N=227)	P*
Sex				
Male	55 (33.74%)	26 (40.63%)	81 (35.68%)	0.412
Female	108(66.26%)	38 (59.37%)	146 (64.32%)	
Age				
0-5	12(7.36%)	03(4.69%)	15 (6.61%)	
6-18	06 (3.68%)	01(1.56%)	07 (3.08%)	0.614
19-49	56 (34.35%)	20 (31.25%)	76 (33.48%)	
≥ 50	89 (54.60%)	40 (62.50%)	129(56.83%)	
Origin				
Inpatients	88 (53.99%)	36 (56.25%)	36 (56.25%)	0.873
Outpatients	75 (46.01%)	28 (43.75%	28.43.75%)	

"p value" obtained by the chi-square test provides to determine the existence of link between ESBL-EC and various risk factors.

Table-II

Antimicrobial susceptibility pattern of ESBL-producing E. coli from the urine samples of patients suffering from urinary tract infections (N=64).

Antibiotic susceptibility	Sensitive	Resistance
Ceftriaxone (CRO)	*00*	*64 (100%)*
Ceftazidime (CAZ)	*00*	*64 (100%)*
Cefuroxime (CXM)	*01(1.56%)*	*63 (98.44%)*
Cefepime (FEP)	*00*	*64 (100%)*
Cefoxitin (FOX)	*64 (100%)*	*00*
Ampicillin (AMP)	*01 (1.56%)*	*63 (98.44%)*
Amoxyclav (AMC)	*55 (85.94%)*	*09 (14.03%)*
Piperacillin-tazobactam (TZP)	*51 (76.69%)*	*13 (20.31%)*
Trimethoprim/sulfamethoxazole(SXT)	*34 (53.12%)*	*30 (46.88%)*
Tetracycline (TE)	*33(51.56%)*	*31 (48.44%)*
Ciprofloxacin (CIP)	*11 (17.19%)*	*53 (82.81%)*
Tobramycin (TOB)	*50 (78.13%)*	*14(21.87%)*
Mecelinum (MEL)	*57 (89.06%)*	*07(12.28%)*
Gentamycin (CN)	*57 (89.06%)*	*07(12.28%)*
Nitrofurantoin (F)	*60 (93.75%)*	*04 (6.25%)*
Levofloxacin (LEV)	*20 (31.25%)*	*44(68.75%)*
Amikacin (AK)	*44 (68.75%)*	*20 (31.25%)*
Imipenem (IPM)	*64(100%)*	*00*
Meropenem (MEM)	*64 (100%)*	*00*
Aztreonam (ATM)	*01 (1.56%)*	*63 (98.44%)*
Fosfomycin (FOS)	*63(98.44%)*	*01 (1.56%)*

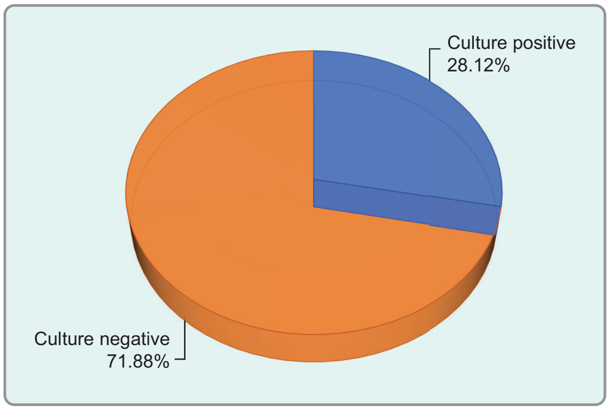

Figure 1: *Proportion of culture-positive urine samples identified during the study period (28.12%).*

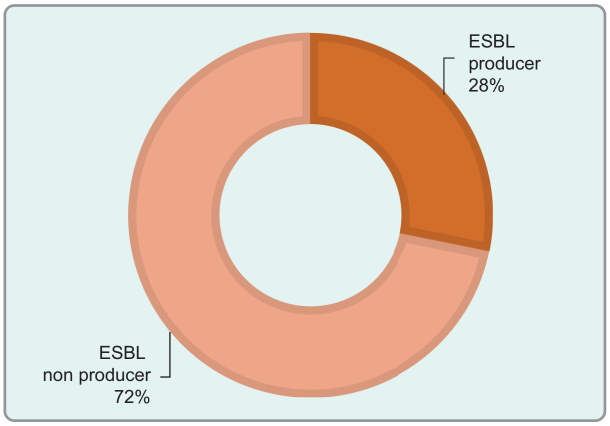

Figure 2: *Percentage of ESBL-producing Escherichia coli isolates among the total samples analyzed (n = 227).*

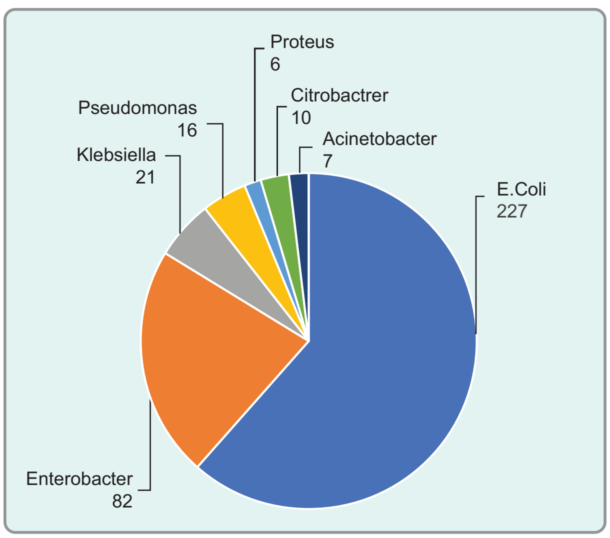

Figure 3: *Distribution of Gram negative uropathogens isolated from urine culture (n = 369).*

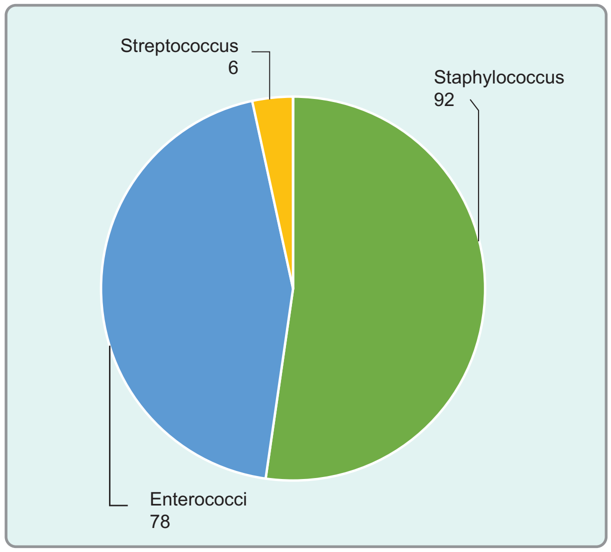

Figure 4: *Distribution of Gram positive uropathogens isolated from urine culture (n = 166).*

Discussion

The emergence and rapid dissemination of drug-resistant strains of Enterobactericeae particularly *E. coli* causing urinary tract infection leads to frequent treatment failure and complications. Since the 2000s, ESBL-EC have been considered as serious pathogens both in nosocomial and community infections around the world, and their virulence varies by region. [5] Drug-resistant urinary tract infection becomes a concerning health issue, especially in developing country like Bangladesh. However, there is continuous changes in etiology, burden of infection and antibiotic susceptibility pattern in different regions. Understanding the local epidemiology and its changes over time is essential for selecting an effective first-line antibiotic treatment that is appropriate for each region. We are aware of the significant burden we carry in our community due to various factors intertwined with the characteristics of medical practice, legislation, and the health care system. [22,23]

The overall isolation rate of uropathogens in our study was found to be 28.12% which is comparable with previous research of Ethiopia. [24,25] This study showed gram-negative bacteria were more frequent (68.97%) than gram-positive bacteria (31.03%). Similar finding had seen reported by several studies. [24, 26-27]

Current study shows that *E. coli* was the most predominant bacterium (61.52%) followed by *Enterobacter spp* and *Klebsiella spp* among gram-negative bacteria and *Staphylococcus aureus* was the leading cause of UTI among gram-positive isolates. The isolation rates of *E. coli*, which is the most common isolate, and other pathogens in this study were comparable to the rates documented previously and also strongly agreed with similar research [28-30]. However, two studies carried out with patients attending tertiary level hospitals outside of Dhaka, Bangladesh (in Rajshahi and Mymensingh), reported that *Staphylococcus saprophyticus* was the second leading cause of UTI after *E. coli* . [31,32] Out of 227 *E. coli* strains recovered from urine samples, 64 (28.19%) produced ESBLs, whereas 71.80% did not. Parallel results were previously reported regarding the occurrance of ESBL-*E. coli* isolates recovered from patients with UTIs, such as 37.11% [9] and 46.87%.[33] Adil Abalkhail et al. found 33.49% uropathogenic ESBL producing *E. coli*. [34] In the present study, among the positive *E. coli* cases, the prevalence rate of UTIs was found more in females, 108 (66.26%) than males, 55 (33.74%) for non-ESBL-EC. As for positive ESBL-EC cases, the prevalence rate was 38 (59.37%) in females and 26 (40.63%) in males. This finding is inconsistent with result reported by Sauda Arabia and Morocco. [34,35] Because of the architecture of their sexual organs, women are more commonly affected by UTIs, that is, the compact size and proximity of the urethra to the rectum encourage the spread of ESBL-*E. coli*. [35] Furthermore, most of ESBL-E. coli was detected in people 50 years old or above (62.5%) which is in parallel with the finding in Morocco. [35] Many studies confirm that advanced age (usually over 65 years) is a UTI risk factor for ESBL-EC (16,36-38]. This could be linked to the fact that women in these groups may experience vaginal prolapse after menopause, which can heighten the risk of bacteriuria. This is due to an increase in vaginal pH resulting from a reduction in lactobacillus in the birth canal, creating an opportunity for other uropathogens to establish themselves and making these patients' immune systems more susceptible to infections.

Our findings regarding the prevalence of ESBL-EC in the community (43.75%) and hospital (56.25%) settings are likely underestimated, which leads us to recommend systemic surveillance.

Precious study showed that ESBL-*E. coli* is more prevalent among women than men, and in hospitalizations, it accounts for a large proportion of all hospital-acquired infections and thus seems to be very dangerous. [39]

According to the result of the antibiogram, the highest antibiotic resistance among ESBL-EC was observed with ampicillin (98.43%), cefixime (100%), ceftrioxone (100%), Cefuroxime (98.43%), ceftazidime (100%), aztreonam (98.43%) and ciprofloxacin (82.81%). The highest antibiotic sensitivity was observed with carbapenems (100%), cefoxitin (100%), fosfomycin (98.43%) and nitrofurantoin (93.75%). Our findings are parallel with those of certain former investigations. [35,38,40] In our country, beta-lactamase and third generation cephalosporin groups of antibiotics used as an empirical antibiotic that can be easily purchased from a retail pharmacy. Moreover, the incomplete duration of drug treatments, the easy availability of drugs, self-medication practices, lack of strict laws of on drugs that punishes for drug misuses hence all this contributed to high emerging rate of drug resistance. [41] The development of resistance to beta-lactamase and cephalosporin groups that we detected in the current study indicated that these drugs may no longer be appropriate for symptomatic treatment. The standard recommendations state that an antibiotic must have been tested >90% sensitive on the community's pathogenic *E. coli* in order to be used as an empirical antibiotic. [42]

Conclusion

The current study demonstrates that the therapeutic prospects of beta-lactam antibiotics pose a significant issue and a major obstacle for physicians, as in recent years, ESBL-*E. coli*-induced UTIs have increased in frequency. Therefore, in both community and hospital settings, early diagnosis of infections caused by this organism is essential for timely treatment. Additionally, it is important to routinely measure and analyze antibiotic resistance, especially that caused by ESBL-*E. coli*, at different intervals. These results further imply that earlier and accurate approaches for detecting ESBL-producing bacteria should be employed to prescribe relevant antibiotics. Future studies should focus on improving the accuracy of empirical antibiotic prescriptions, optimizing sensitivity testing protocols, and addressing gender-based disparities in resistance patterns to reduce treatment failure and complications of antimicrobial resistance

Limitations of the study

Several limitations should be considered. First, as a retrospective analysis based on electronic medical records, some data were missing, and certain variables might have led to the outcomes not being consistently documented. Notably, data on the timing of infection onset were not available, limiting our ability to distinguish between hospital acquired and pre-existing infections. Second, the study was conducted within a single institution, meaning the findings may not fully reflect practices or outcomes at other hospitals, potentially limiting their generalizability to different settings or regions.

Funding

This research received no external funding.

Institutional Review Board Statement Ethical approval granted from corresponding authorities.

Informed Consent Statement

Patient consent was waived because this was a retrospective laboratory data-based study, as approved by the ethical committee.

Conflict of interest:

The authors declare no competing interests.

Acknowledgements

We acknowledge our respected patients and want to express our gratitude to all hospital and laboratory staff who contributed to data availability. This includes physicians, microbiology laboratory assistant who facilitated data collection and analysis.

Abbreviations

The following abbreviations are used in this manuscript:
UTI Urinary Tract Infection
E. coli Escherichia coli
ESBLs Extended-Spectrum Beta-Lactamases

References:

1. Murray CJ, Ikuta KS, Sharara F, Swetschinski L, Aguilar GR, Gray A, Han C, Bisignano C, Rao P, Wool E, Johnson SC. Global burden of bacterial antimicrobial resistance in 2019: a systematic analysis. The lancet. 2022 Feb 12;399(10325):629-55. DOI: 10.1016/S0140-6736(21)02724-0 .
2. Bullens M, de Cerqueira Melo A, Raziq S, Lee J, Khalid GG, Khan SN, Zada A, Wailly Y, Zeshan SM, Saad NJ, Gil-Cuesta J. Antibiotic resistance in patients with urinary tract infections in Pakistan. Public Health Action. 2022 Mar 21;12(1):48-52. DOI: 10.5588/pha.21.0071
3. Mohapatra S, Panigrahy R, Tak V, JV S, KC S, Chaudhuri S, Pundir S, Kocher D, Gautam H, Sood S, Das BK. Prevalence and resistance pattern of uropathogens from community settings of different regions: an experience from India. Access Microbiology. 2022 Feb 9;4(2):000321. DOI: 10.1099/acmi.0.000321
4. Farzana R, Shamsuzzaman SM, Mamun KZ, Shears P. ANTIMICROBIAL SUSCEPTIBILITY PATTERN OF EXTENDED SPECTRUM(beta-LACTAMASE PRODUCING GRAM-NEGATIVE BACTERIA ISOLATED FROM WOUND AND URINE IN A TERTIARY CARE HOSPITAL, DHAKA CITY, BANGLADESH. Southeast Asian Journal of Tropical Medicine & Public Health. 2013 Jan 1;44(1):96-103. doi: 10.4103/ijabmr.IJABMR_28_16
5. Shakya P, Shrestha D, Maharjan E, Sharma VK, Paudyal R. ESBL production among E. coli and Klebsiella spp. causing urinary tract infection: a hospital based study. The open microbiology journal. 2017 Apr 28;11:23. DOI: 10.2174/1874285801711010023
6. Arbab S, Ullah H, Wang W, Zhang J. Antimicrobial drug resistance against Escherichia coli and its harmful effect on animal health. Veterinary Medicine and Science. 2022 Jul;8(4):1780-6. DOI: 10.1002/vms3.825
7. Magale HI, Kassim IA, Odera SA, Omolo MJ, Jaoko WG, Jolly PE. Antibiotic susceptibility of organisms causing urinary tract infection in patients presenting at Kenyatta National Hospital, Nairobi. East African medical journal. 2015 Oct 14;92(7):333-7. PMID: 27867208; PMCID: PMC5111625.
8. Ahmed I, Sajed M, Sultan A, Murtaza I, Yousaf S, Maqsood B, Vanhara P, Anees M. The erratic antibiotic susceptibility patterns of bacterial pathogens causing urinary tract infections. EXCLI journal. 2015 Aug 4;14:916. DOI: 10.17179/excli2015-207
9. Rajabnia, M., Forghani, M.S., Hasani, S., Bahadoram, M., Mohammadi, M. and Barahman, M., 2018. Prevalence and antibiotic resistance pattern of extended spectrum beta lactamase producing Escherichia coli isolated from urinary tract infection. *Journal of Renal Injury Prevention*, *8*(2), pp.78-81.doi: 10.15171/jrip.2019.15
10. Glasner C, Albiger B, Buist G, Andraseviæ AT, Canton R, Carmeli Y, Friedrich AW, Giske CG, Glupczynski Y, Gniadkowski M, Livermore DM. Carbapenemase-producing Enterobacteriaceae in Europe: a survey among national experts from 39 countries, February 2013. Eurosurveillance. 2013 Jul 11;18(28):9-15. DOI: 10.2807/1560-7917.es2013.18.28.20525
11. Tacconelli, Evelina et al. “Surveillance for control of antimicrobial resistance.” *The Lancet. Infectious diseases* vol. 18,3 (2018): e99-e106. doi:10.1016/S1473-3099(17)30485-1.DOI: 10.1016/S1473-3099(17)30485-1
12. Heras IP, Sanchez-Gomez JC, Beneyto-Martin P, Ruano-de-Pablo L, Losada-Pinedo B. Community-onset extended-spectrum â-lactamase producing Escherichia coli in urinary tract infections in children from 2015 to 2016: Prevalence, risk factors, and resistances. Medicine. 2017 Dec 1;96(50):e8571. doi: 10.1097/MD.0000000000008571
13. Bazaid AS, Saeed A, Alrashidi A, Alrashidi A, Alshaghdali K, A Hammam S, Alreshidi T, Alshammary M, Alarfaj A, Thallab R, Aldarhami A. Antimicrobial surveillance for bacterial uropathogens in Ha’il, Saudi Arabia: A Five-year multicenter retrospective study. Infection and Drug Resistance. 2021

Apr 16:1455-65. DOI: 10.2147/IDR.S299846

14. Nepal K, Pant ND, Neupane B, Belbase A, Baidhya R, Shrestha RK, Lekhak B, Bhatta DR, Jha B. Extended spectrum beta-lactamase and metallo beta-lactamase production among Escherichia coli and Klebsiella pneumoniae isolated from different clinical samples in a tertiary care hospital in Kathmandu, Nepal. Annals of clinical microbiology and antimicrobials. 2017 Sep 19;16(1):62. DOI: 10.1186/s12941-017-0236-7

15. Stapleton PJ, Lundon DJ, McWade R, Scanlon N, Hannan MM, O'Kelly F, Lynch M. Antibiotic resistance patterns of Escherichia coli urinary isolates and comparison with antibiotic consumption data over 10 years, 2005–2014. Irish Journal of Medical Science (1971-). 2017 Aug;186(3):733-41. DOI: 10.1007/s11845-016-1538-z

16. van Driel AA, Notermans DW, Meima A, Mulder M, Donker GA, Stobberingh EE, Verbon A. Antibiotic resistance of Escherichia coli isolated from uncomplicated UTI in general practice patients over a 10-year period. European Journal of Clinical Microbiology & Infectious Diseases. 2019 Nov;38(11):2151-8. DOI: 10.1007/s10096-019-03655-3

17. Cheng MF, Chen WL, Huang IF, Chen JR, Chiou YH, Chen YS, Lee SS, Hung WY, Hung CH, Wang JL. Urinary tract infection in infants caused by extended-spectrum beta-lactamase-producing Escherichia coli: comparison between urban and rural hospitals. Pediatric Nephrology. 2016 Aug;31(8):1305-12. DOI:10.1007/s00467-016-3338-0

18. Senard O, Lafaurie M, Lesprit P, Nguyen Y, Lescure X, Therby A, Fihman V, Oubaya N, Lepeule R. Efficacy of cefoxitin versus carbapenem in febrile male urinary tract infections caused by extended spectrum beta-lactamase–producing Escherichia coli: A multicenter retrospective cohort study with propensity score analysis. European Journal of Clinical Microbiology & Infectious Diseases. 2020 Jan;39(1):121-9. DOI: 10.1007/s10096-019-03701-0

19. Murray PR, Barron EJ, Jorgensen JH, Pfaller MA, Yolken RH. Manual of Clinical Microbiology. 8th ed. Washington DC: ASM Press; 2003. doi: 10.1016/S0732-8893(03)00160-3

20. Nicolle LE, Bradley S, Colgan R, Rice JC, Schaeffer A, Hooton TM. Infectious Diseases Society of America guidelines for the diagnosis and treatment of asymptomatic bacteriuria in adults. Clinical infectious diseases. 2005 Mar 1:643-54. DOI: 10.1086/427507

21. CLSI. Performance Standards for Antimicrobial Susceptibility Testing—30th Edition: M100.

22. Kettani Halabi M, Lahlou FA, Diawara I, El Adouzi Y, Marnaoui R, Benmessaoud R, Smyej I. Antibiotic resistance pattern of extended spectrum beta lactamase producing Escherichia coli isolated from patients with urinary tract infection in Morocco. Frontiers in Cellular and Infection Microbiology. 2021 Aug 18;11:720701. DOI: 10.3389/fcimb.2021.720701

23. Pokharel S, Raut S, Adhikari B. Tackling antimicrobial resistance in low-income and middle-income countries. BMJ global health. 2019 Nov 1;4(6):e002104. DOI: 10.1136/bmjgh-2019-002104

24. Firissa YB, Shelton D, Azazh A, Engida H, Kifle F, Debebe F. Prevalence and antimicrobial sensitivity patterns of uropathogens, in tikur anbessa specialized hospital emergency medicine department Addis Ababa, Ethiopia. Infection and Drug Resistance. 2023 Dec 31:1649-56. DOI: 10.2147/IDR.S402472

25. Adugna B, Sharew B, Jemal M. Bacterial Profile, Antimicrobial Susceptibility Pattern, and Associated Factors of Community and Hospital Acquired Urinary Tract Infection at Dessie Referral Hospital, Dessie, Northeast Ethiopia. International journal of microbiology. 2021;2021(1):5553356. DOI: 10.1155/2021/5553356

26. Alhumaid S, Al Mutair A, Al Alawi Z, Alzahrani AJ, Tobaiqy M, Alresasi AM, Bu-Shehab I, Al-Hadary I, Alhmeed N, Alismail M, Aldera AH. Antimicrobial susceptibility of gram-positive and gram-negative bacteria: a 5-year retrospective analysis at a multi-hospital healthcare system in Saudi Arabia. Annals of clinical microbiology and antimicrobials. 2021 Jun 12;20(1):43.DOI: 10.1186/s12941-021-00450-x

27. Kasew D, Desalegn B, Aynalem M, Tila S, Diriba D, Afework B, Getie M, Biset S, Baynes HW. Antimicrobial resistance trend of bacterial uropathogens at the university of Gondar comprehensive specialized hospital, northwest Ethiopia: A 10 years retrospective study. PloS one. 2022 Apr 11;17(4):e0266878. DOI: 10.1371/journal.pone.0266878

28. Schito GC, Naber KG, Botto H, Palou J, Mazzei T, Gualco L, Marchese A. The ARESC study: an international survey on the antimicrobial resistance of pathogens involved in uncomplicated urinary tract infections. International journal of antimicrobial agents. 2009 Nov 1;34(5):407-13. DOI: 10.1016/j.ijantimicag.2009.04.012

29. Tiruneh M, Yifru S, Gizachew M, Molla K, Belyhun Y, Moges F, Endris M. Changing trends in prevalence and antibiotics resistance of uropathogens in patients attending the Gondar University Hospital, Northwest Ethiopia. International journal of bacteriology. 2014;2014(1):629424. DOI: 10.1155/2014/629424

30. Beyene G, Tsegaye W. Bacterial uropathogens in urinary tract infection and antibiotic susceptibility pattern in jimma university specialized hospital, southwest ethiopia. Ethiopian journal of health sciences. 2011;21(2):141-6. DOI: 10.4314/ejhs.v21i2.69055

31. Haque R, Akter ML, Salam MA. Prevalence and susceptibility of uropathogens: a recent report from a teaching hospital in Bangladesh. BMC research notes. 2015 Sep 5;8(1):416. DOI:10.1186/s13104-015-1408-1

32. Parvin US, Hossain MA, Musa AK, Mahamud C, Islam MT, Haque N, Muhammad N, Khan SI, Mahmud NU. Pattern of aerobic bacteria with antimicrobial susceptibility causing community acquired urinary tract infection. Mymensingh Medical Journal: MMJ. 2009 Jul 1;18(2):148-53. DOI: 10.1002/14651858.CD001363

33. Martin D, Fougnot S, Grobost F, Thibaut-Jovelin S, Ballereau F, Gueudet T, De Mouy D, Robert J, Alexandre F, Andorin P,

Artur F. Prevalence of extended-spectrum beta-lactamase producing Escherichia coli in community-onset urinary tract infections in France in 2013. Journal of Infection. 2016 Feb 1;72(2):201-6. DOI: 10.1016/j.jinf.2015.11.009

34. Abalkhail A, AlYami AS, Alrashedi SF, Almushayqih KM, Alslamah T, Alsalamah YA, Elbehiry A. The prevalence of multidrug-resistant Escherichia coli producing ESBL among male and female patients with urinary tract infections in Riyadh Region, Saudi Arabia. InHealthcare 2022 Sep 15 (Vol. 10, No. 9, p. 1778). MDPI. DOI: 10.3390/healthcare10091778

35. Kettani Halabi M, Lahlou FA, Diawara I, El Adouzi Y, Marnaoui R, Benmessaoud R, Smyej I. Antibiotic resistance pattern of extended spectrum beta lactamase producing Escherichia coli isolated from patients with urinary tract infection in Morocco. Frontiers in Cellular and Infection Microbiology. 2021 Aug 18;11:720701. DOI: 10.3389/fcimb.2021.720701

36. Seifu WD, Gebissa AD. Prevalence and antibiotic susceptibility of Uropathogens from cases of urinary tract infections (UTI) in Shashemene referral hospital, Ethiopia. BMC infectious diseases. 2018 Jan 10;18(1):30. DOI: 10.1186/s12879-017-2911-x

37. Heytens S, Boelens J, Claeys G, DeSutter A, Christiaens T. Uropathogen distribution and antimicrobial susceptibility in uncomplicated cystitis in Belgium, a high antibiotics prescribing country: 20-year surveillance. European Journal of Clinical Microbiology & Infectious Diseases. 2017 Jan;36(1):105-13. DOI: 10.1007/s10096-016-2776-8

38. Sbiti M. Profil épidémiologique des entérobactéries uropathogènes productrices de bêta-lactamases à spectre élargi. Pan African Medical Journal. 2017;28(1). DOI: 10.11604/pamj.2017.28.29.11402

39. Iqbal R. Determination of epidemiology and antimicrobial susceptibility of extended spectrum beta lactamase producing uropathogens. JPMA. The Journal of the Pakistan Medical Association. 2019 May 1;69(5):690-4. Available at: PubMed (PMID: 31105289).

40. Tan K, Nguyen J, Nguyen K, Huse HK, Nieberg PH, Wong-Beringer A. Prevalence of the carbapenem-heteroresistant phenotype among ESBL-producing Escherichia coli and Klebsiella pneumoniae clinical isolates. Journal of Antimicrobial Chemotherapy. 2020 Jun 1;75(6):1506-12. DOI: 10.1093/jac/dkaa048

41. Kolawole AS, Kolawole OM, Kandaki-Olukemi YT, Babatunde SK, Durowade KA, Kolawole CF. Prevalence of urinary tract infections (UTI) among patients attending Dalhatu Araf Specialist Hospital, Lafia, Nasarawa state, Nigeria. International journal of medicine and medical sciences. 2009 May;1(5):163-7. DOI: 10.5897/IJMMS

42. Kettani Halabi M, Lahlou FA, Diawara I, El Adouzi Y, Marnaoui R, Benmessaoud R, Smyej I. Antibiotic resistance pattern of extended spectrum beta lactamase producing Escherichia coli isolated from patients with urinary tract infection in Morocco. Frontiers in Cellular and Infection Microbiology. 2021 Aug 18;11:720701. DOI: 10.3389/fcimb.2021.720701

Peer-Review History:
The peer review history for this paper can be accessed here: https://ewmch.com/review/