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Detection of blaCYM-2 from Third generation Cephalosporin's Resistance Amp-c E.coli Among Urinary Tract Infection Patients in Najaf Province

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Abstract		**Original Research Article**

Third-generation cephalosporin (3GC)-resistant Enterobacteriaceae infections were substantially linked to higher mortality risk, longer hospital stays, and higher expenses. Antimicrobial resistance (AMR) is thought to have caused 4.95 million deaths worldwide in 2019. Third generation cephalosporin-resistant *Escherichia coli* (3GCR E. coli), one of the most common bacterial infections, was a major contributor to these deaths [1]. Antimicrobial resistance is a natural phenomenon, but every use of antimicrobials, including overuse and misuse in both human and veterinary medicine, contributes to the emergence and spread of antimicrobial-resistant bacteria that can be passed from humans to animals directly or indirectly [2]. Extended-Spectrum Beta-Lactamase (ESBL)-encoding genes can spread quickly across the bacterial population by horizontal gene transfer when they are transferred on mobile genetic elements like plasmids [3]. The ampC gene (often written AmpC or ampC) is a bacterial gene that encodes AmpC β-lactamase, an enzyme responsible for antibiotic resistance, particularly against β-lactam antibiotics. blaCMY-2 is the most prevalent plasmid-mediated AmpC β-lactamase gene worldwide. Frequently found in: *E.coli, Klebsiella pneumoniae* and *Salmonella* spp that Confers resistance to cephamycins (e.g., cefoxitin) and many cephalosporin's especially third generation and forth generation cephalosporin's. ***Methodology***: 66 urine samples were taken from female and male patients who came to Najaf Teaching Hospital and were suffering from urinary tract infections. The samples were taken and cultured on special culture dishes (blood agar) to isolate and diagnose Escherichia coli bacteria. The drug susceptibility test of the bacteria was tested for three types of third-generation cephalosporin's. **Results**: Molecular detection of *blaCYM-2* show that most isolates were positive (35/66) (53%) while 31/66 of isolates were negative. Data analysis of bacterial antibiotic resistance show different patterns of resistance of *E.coli* to third generation cephalosporin where the rate of resistance Ceftazidime was 64% and Ceftriaxone was 57% while cefotaxime was 38%. ***Aim of Study***: Detection of *blaCYM-2* gene of *E.coli* from patients with UTI and its resistance to third generation cephalosporin antibiotics.
Keywords: *Cephalosporin's, E.Coli, Antibiotic Resistance, UTI, Hospitalized*.

1. INTRODUCTION

One of the most prevalent bacterial diseases in people is a urinary tract infection (UTI) [4]. A minimum of one symptomatic UTI episode is thought to occur in the lives of 40% of women and 12% of men, with recurrent UTIs affecting 27–48% of affected women [5]. About 40% of all hospital-acquired infections and 50% of bacterial infections that lead to higher morbidity and longer hospital stays are UTIs [6]. UTIs are a financial issue as well. Approximately 11 million Americans receive treatment for UTIs each year, at a cost of roughly $6 billion [7]. Patients with renal failure, structural urinary tract anomalies including urine blockage and retention, or those who utilize medical devices like catheters are at risk for complicated UTIs, which necessitate long-term treatment. Immunosuppression and prior antibiotic exposure are also linked to complicated UTIs. The risk of repeated and/or chronic infections is increased by this type of UTI. Considerable antibiotic use is linked to UTIs, which has consequences for bacterial ecology and the emergence of antibiotic resistance, particularly when it results from the empirical antimicrobial treatment of recurrent UTIs. A clinical issue is the rise of MDR UPEC in recent decades and antimicrobial resistance in UPEC, especially in women with recurrent UTIs. MDR UPEC is becoming more common, particularly in poor nations, which leads to overuse of broad-spectrum antibiotics such

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aminoglycosides, cephalosporin's, and fluoroquinolones, which increases hospitalization and treatment costs [8]. It was discovered that 13.8–21.3% of *E. Coli* isolates from urine samples from hospitalized patients in England were resistant to third-generation cephalosporin's (cefotaxime/Ceftazidime) [9]. In Romania, 87% of UPEC were sensitive to third-generation cephalosporin's [10]. The World Health Organization has designated third-generation cephalosporin's (3GC) as "critically important antimicrobials" in human medicine. In Iraqi hospitals, third-generation cephalosporin's are most frequently used in post-operative care, burn patients, and patients with urinary tract infections. High rates of resistance to certain antibiotics have been noted recently.

In *Escherichia coli*, resistance to β-lactam antibiotics is primarily mediated by the production of β-lactamase enzymes [21, 22]. Among the various β-lactamase types, AmpC β-lactamases have emerged as a clinically significant group [23]. AmpC enzymes are chromosomally encoded in certain members of the *Enterobacterales;* however, they can also be mobilized onto plasmids, facilitating horizontal transfer among different bacterial species. These enzymes confer resistance to oxyimino-cephalosporins (e.g., Ceftazidime and cefotaxime), cephamycins (e.g., cefoxitin), and monobactams (e.g., aztreonam). Moreover, their hydrolytic spectrum may extend to include fourth-generation cephalosporin's, such as cefepime [24]. Based on amino acid sequence variations, plasmid-mediated AmpC β-lactamases are classified into eight families: CMY (cephamycin), FOX (cefoxitin), ACC (Ambler class C), LAT (latamoxef), MIR (Miriam Hospital, Providence), ACT (AmpC type), MOX (moxalactam), and DHA (Dhahran Hospital, Saudi Arabia) [23-25]. Among these families, CMY-2 is the most prevalent AmpC variant in E. coli and has been widely reported across Asia, Europe, and North America [26–29].

2. METHODOLOGY
2.1 Sample Collection
(66) urine samples were collected from patients suffering from urinary tract infections, from female (56) specimen and male (10) specimen, who attended Najaf Teaching Hospital for the period from (October 2025 to December 2025), and the samples were transferred to the laboratory for the purpose of isolating and diagnosing the samples.

2.2 Bacterial Culture and Antibiotic Sensitivity
These isolates were cultured on culture media such as blood agar (figure 1), and bioMérieux VITEK 2 compact was used by using the ID CARD for confirming the diagnosis of *E.coli* and the AST CARD to detection antibiotics resistance for three types of third generation cephalosporin antibiotics (ceftriaxone, ceftazidime, cefotaxime).

Figure 1: *E.coli* growing on blood agar

2.3 VITEK® 2 System Protocol for Bacterial Identification and Antimicrobial Susceptibility Testing
A. Preparation of Bacterial Suspension
Pure bacterial colonies (18–24 h old) grown on appropriate non-selective agar (e.g., blood agar) were used. Several morphologically similar colonies were selected and suspended in 0.45% sterile saline. The turbidity of the suspension was adjusted to 0.50–0.63 McFarland using a densitometer (bioMérieux).

B. Inoculation of VITEK® 2 Cards

1. Identification (ID): Depending on the organism, appropriate ID cards (e.g., GN, GP, or YST) were used. The standardized bacterial suspension was transferred into the ID card using the VITEK® 2 cassette and filling device.
2. Antimicrobial Susceptibility Testing (AST), For AST, the same bacterial suspension was used to inoculate the corresponding AST card (e.g., AST-GN or AST-GP), following the manufacturer's instructions.

2.4 DNA Extraction PCR Amplification

Genomic DNA was extracted using the alkaline lysis method, and DNA concentration was quantified using a NanoDrop spectrophotometer. Conventional PCR reactions were performed in a total volume of 20 µL, consisting of 1 µL of each primer, 10 µL of master mix, 1.5 µL of $MgCl_2$, 2 µL of template DNA, and 3.5 µL of deionized water. The PCR cycling conditions included an initial denaturation at 94 °C for 1 minute, followed by 30 cycles of denaturation at 94 °C for 30 seconds, annealing at 52 °C for 35 seconds, and extension at 72 °C for 4 minutes, with a final extension step at 72 °C for 5 minutes. The amplified PCR products were separated by electrophoresis on a 1.5% agarose gel (Merck) at 80 V for 180 minutes and visualized under ultraviolet light using a gel documentation system table (1),(2) [20].

Table 1: Primers used in PCR amplification

Gene Name	Primer sequence	Reference
BlaCMY-2 (F)	5- CACTAAGGGGTCCTCGAATGTA-3	Mandakini R,2020 [20]
BlaCMY-2 (R)	5-AAGTTAGTGACTGGGGTGAGCG-3	Mandakini R,2020 [20]

Table 2: component of PCR cycle for detection *blaMCY-2* gene

NO	COMPEMENT	Volume (µl)
1	PCR Master mix	10.0
2	Distilled water DNA-free	3.5
3	Forward primer (10 pmol/µl)	1.0
4	Reverse primer (10pmol/µl)	1.0
5	DNA template	2.0
6	MgCl2	1.5

3. RESULTS

3.1 Distribution According to Gender

The current study showed that the majority of resistant isolates were from women suffering from urinary tract infections, at a rate of (85%) compared to isolates from men, which was (15%), figure (2):
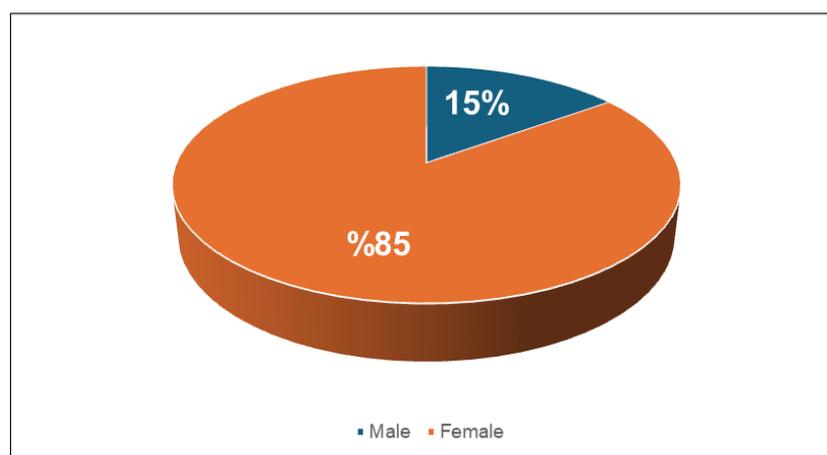

Figure 2: Distribution of antibiotic resistance *E.coli* according to gender

3.2 Distribution According to Age

The results for age groups from (9 to 70) years showed that the middle age group (31-50 years) had the highest incidence of urinary tract infections at 55%, followed by the age group (21-30 years) at 25%, then the group from (51-70 years) at 20%, in addition to showing a high rate of antibiotic resistance, figure (3):
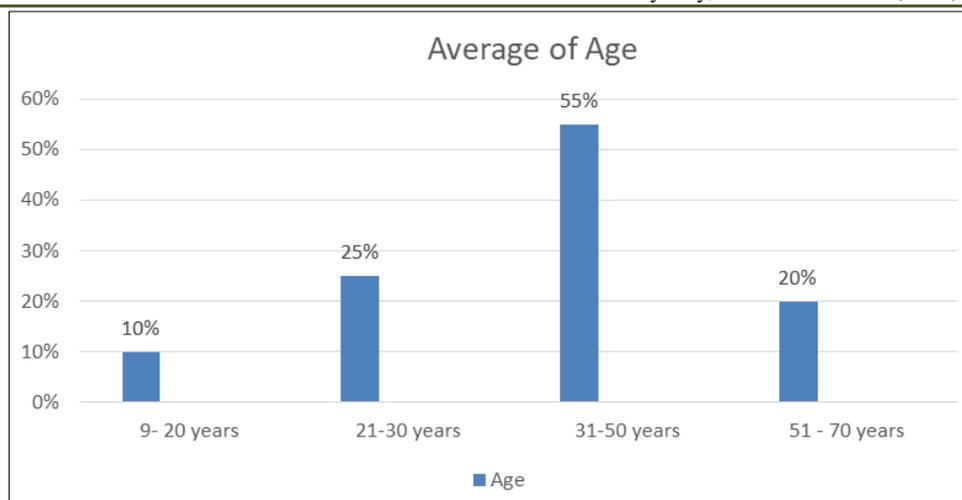
Figure 3: Distribution of antibiotics resistance *E.coli* according to age

3.3 Antibiotics Resistance to Cephalosporins

The results recorded varying rates of resistance of *Escherichia coli* to the third generation of cephalosporins, where three different antibiotics were tested that be given parentally for urinary tract infection patients in hospitals. The data showed a high resistance rate of 64% to ceftazidime (42/66), while the resistance rate to ceftriaxone was 57% (38/66), while the resistance rate to cefotaxime was 38% (25/66), table (1):

Table 3: *E.coli* resistance to third generation cephalosporin from patients with UTI

Antibiotics	Number of isolates resistance	Percent %
Ceftazidime	42 / 66	64%
Ceftriaxone	38 / 66	57%
Cefotaxime	25 / 66	38%

3.4 Molecular Detection of *Blacmy-2*

In the current study, the results showed that 35 out of a total of 66 isolates gave a positive result (53%) at (650bp), while 31 out of 66 isolates showed a negative result in gel electrophoresis, Figure (4), table (4):
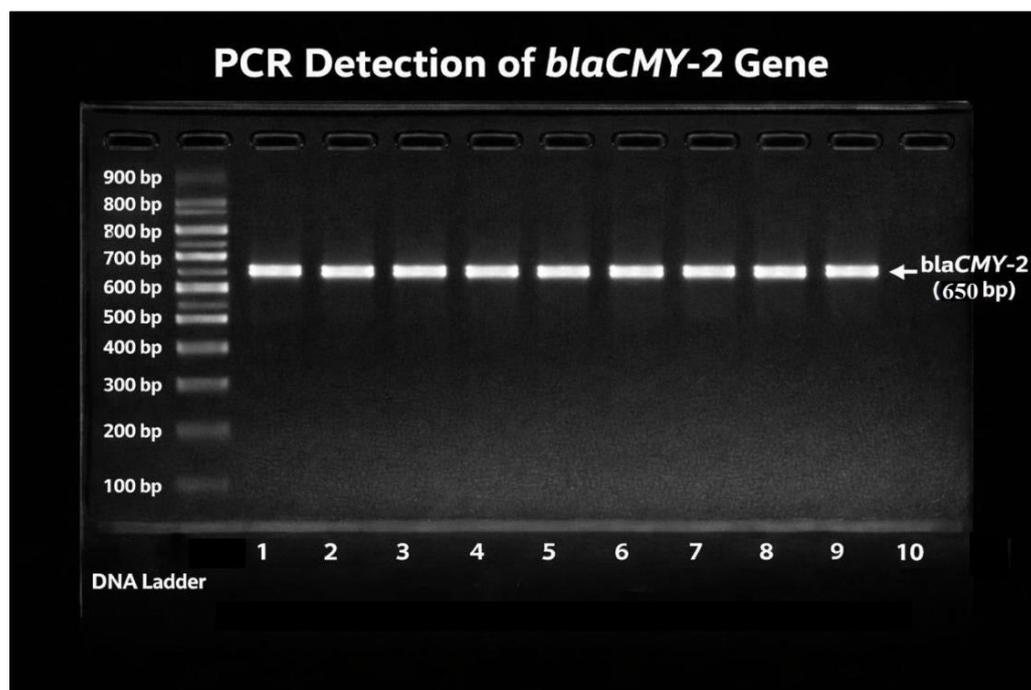

Figure 4: Gel electrophoresis of amplification product PCR for rmpA gene at 650 bp, M (marker or ladder), line (1-9) were positive. The electrophoresis was at 70 volt for 80 min.

Table 4: percent of *BlaMCY-2* distribution among E.coli isolates

No of Specimen	BlaMCY-2 (+/-)	Percent (%)
E.1,E2,E3,E4,E5,E6,E7,E8,E9,E19 E.22,E23,E24,E25,E27,E29,E31,E32,E33,E35 E37,E38,E40,E41,E47,E48,E50,E52,E53,E55, E61,E62,E63,E65,E66	Positive	53%
E10,E11,E12,E13,E14,E15,E16,E17,E18,E20,E21,E26,E28,E30,E34,E36,E39,E42,E43,E44, E45,E46,E49,E51,E54,E56,E57,E58,E59,E60.E64	Negative	47%

4. DISCUSSION

One of the primary human pathogens that causes illnesses in both hospitals and the community is *Escherichia coli*. The majority of urinary tract infections (UTIs) caused by *E. coli* are simple, but some develop into more complex infections such meningitis, sepsis, or upper UTIs [11]. A significant global public health concern is *E. Coli* that is resistant to -lactams, especially to third generation cephalosporin's (TGCs). TGCs are used to treat intra-abdominal infections, bloodstream infections, and UTIs caused by *E. coli.* Treatment options are limited since resistance to TGCs frequently coexists with resistance to other antimicrobials used in therapy. Many mechanisms, such as chromosomally encoded AmpC-lactamase hyper-production, increased efflux, or decreased outer membrane permeability, can mediate resistance to TGCs in *E. coli*; however, the two most important mechanisms are plasmid-mediated extended-spectrum-lactamases (ESBLs) or plasmid-mediated AmpCs enzymes [12]. Currently, many ESBLs have been identified in *E. coli isolates*, with CTX-M being the most often found family. Despite the fact that over 230 CTX-M variations have been identified, the most commonly documented enzymes among Enterobacteriales are CTX-M-2, CTX-M-9, CTX-M-14, and CTX-M-15 [15].

The ampC gene produces AmpC β-lactamase, which hydrolyzes β-lactam antibiotics, rendering them ineffective. AmpC enzymes are not inhibited by common β-lactamase inhibitors such as clavulanic acid, sulbactam, or tazobactam. Chromosomal ampC: Naturally present in some bacteria and may be inducible (expression increases after exposure to antibiotics, While Plasmid-mediated ampC: Can spread between bacteria, contributing to multidrug resistance.

In comparison to another Iraqi study conducted in Baghdad in 2022, which revealed high resistance of *E. coli* to third-generation cephalosporin's (ceftriaxone 82%, cefotaxime 78%, and Ceftazidime 74%), this study revealed high resistance to third-generation cephalosporin's (64% for Ceftazidime and 57% for ceftriaxone) [18]. Another Iraqi study conducted in Karbala [19] revealed that patients with UTIs had high levels of *E. coli* resistance to cefotaxime (77%) and ceftriaxone (79%). In contrast to the results in Jordan (18%) [16], and Lebanon (22%) [14], our study differs from another Iraqi study in Wasit [13], that found 32% resistance to ceftriaxone. This could be due to the increased use of cephalosporin's in Iraqi outpatient practice (due to their perceived effect of strength or marketing), which is also observed in LMICs [17]. According to a 2023 WHO surveillance report, more than 40% of *E. Coli* isolates worldwide are resistant to third-generation bacteria, including those that cause UTIS.

CMY-2 was found in 74 isolates (2.6%) of the 2,813 *E. Coli* isolates that were gathered in 69 healthcare facilities across the United States in 2014 as part of the International Network for Optimal Resistance Monitoring (INFORM) program [30]. CMY-2 was found in 1739 E. coli isolates at a frequency of 10.2% (n = 178) in the Study for Monitoring Antimicrobial Resistance Trends (SMART), which was conducted in 12 Asia-Pacific countries between 2008 and 2014 [31].

CMY-2 has been reported in three Latin American countries: Brazil (0.5%), Colombia (3.5%), and Argentina (0.9%) [32, 33]. Only one investigation from Mexico found that an adult patient had a urinary tract infection due to E. coli generating CMY [34]. These enzymes have been found in isolates from animals, including dogs (11.3%), sheep (0.64%), and turtles (9.8%), according to other research [35–37]. The molecular and epidemiological traits of *E. Coli* isolates that produce CMY-type beta-lactamases in the Mexican pediatric population, however, are unknown.

In Table (5), there are some results of many studies locally and globally for *E.coli* resistance for third generation cephalosporin's from UTI patients:

Table 5: Resistance Rates of *E. coli* to Third-Generation Cephalosporin's (UTI Isolates)

Region / Source	Cefotaxime (%)	Ceftriaxone (%)	Ceftazidime (%)
Baghdad, Iraq	78%	82%	74%
Karbala, Iraq	77%	78%	Not Reported
Basrah, Iraq	79%	89%	68%
Global Meta-analysis	91%	89%	87%
WHO Global Estimate	>40% (overall resistance)	—	—

5. CONCLUSION

There are multifactor outcomes commonly reported in Iraqi and global studies showing high resistance of *E. coli* (from UTI patients) to third-generation cephalosporin's (such as cefotaxime, ceftriaxone, and Ceftazidime):

1. High Prevalence of Amp-c and ESBL-Producing *E. Coli*

Many studies report a high percentage of isolates producing Amp-c and Extended-Spectrum Beta-Lactamases (ESBLs). ESBL enzymes break down third-generation cephalosporin's, leading to treatment failure.

2. Reduced Effectiveness of Empirical Therapy

Third-generation cephalosporin's are often used as first-line empirical treatment.

High resistance rates result in:
- Delayed clinical improvement
- Need to change antibiotics
- Increased treatment cost.

3. Increased Multidrug Resistance (MDR)

Cephalosporin-resistant strains are frequently resistant to:
- Fluoroquinolones
- Trimethoprim-sulfamethoxazole
- Aminoglycosides

This limits oral treatment options for UTI.

4. Higher Hospitalization and Complication Rates

Patients infected with resistant strains may experience:
- Longer hospital stays
- Higher risk of pyelonephritis or bacteremia
- Increased healthcare burden

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