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Antimicrobial Resistance Patterns of Uropathogenic *Escherichia Coli* in Women: A Cross-Sectional Study Kirkuk

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Abstract: Urinary tract infections (UTIs) are among the most common bacterial infections in women, primarily caused by Uropathogenic *Escherichia coli* (UPEC). The increasing emergence of Antimicrobial Resistance (AMR) globally limits the effectiveness of commonly used antibiotics and complicates empirical therapy. This cross-sectional study included 100 urine samples collected from female patients with suspected UTIs in Kirkuk, Iraq. All samples were cultured and identified using the VITEK 2 Compact system (bioMérieux) according to CLSI guidelines. Fifteen samples (15% of total samples) yielded significant bacteriuria and were confirmed as *E. coli*, while the remaining samples showed either no bacterial growth or growth of non-target organisms. Antimicrobial susceptibility testing revealed high resistance rates (over 50%) to commonly prescribed oral antibiotics, including Amoxicillin (53.3\%) and Cefalexin (53.3\%). Moderate resistance was observed for Ampicillin/Sulbactam (40.0\%), Ciprofloxacin (33.3\%), and Trimethoprim-Sulfamethoxazole (33.3\%). Lower resistance levels were recorded for most cephalosporins and \beta-lactam/\beta-lactamase inhibitor combinations. Crucially, all isolates (15/15) remained 100\% susceptible to Amikacin, Tigecycline, Imipenem, and Meropenem. These findings highlight a significant and concerning shift in the resistance pattern among UPEC isolates in Kirkuk women. While common first-line oral treatments show limited effectiveness, Carbapenems, Amikacin, and Tigecycline remain reliable options for complicated cases. Continuous local surveillance is essential to guide updated empirical treatment protocols and mitigate the spread of multi-drug resistant strains.

Keywords: *Escherichia Coli*, UTI, Antimicrobial Resistance, MDR, Women, Kirkuk, Iraq

1. Introduction

Urinary tract infections (UTIs) impose a substantial burden on public health, especially among females, due to anatomical and physiological predisposing factors (shorter urethra, proximity to perineal flora). In healthy individuals, urine is generally sterile; infection occurs when uropathogens, often from intestinal flora, ascend the urethra to colonize the bladder or higher urinary tract (Mancuso et al., 2023). Globally, UTIs account for millions of outpatient visits annually, significant morbidity, and considerable healthcare costs.

1.1 Significance of *E. coli* in UTIs & global resistance trends

Among causative agents of UTIs, *Escherichia coli* is predominant, accounting for the majority of both uncomplicated and complicated UTIs (Flores-Mireles, Walker, Caparon, & Hultgren, 2015). The pathogenic variants—termed uropathogenic *E. coli* (UPEC)—possess virulence factors that aid adherence, invasion, biofilm formation, and evasion of host defenses (Mancuso, Midiri, Gerace, & Biondo, 2023).

A mounting global challenge is the rapid rise in antimicrobial resistance (AMR) among UPEC isolates. Resistance to first-line oral antimicrobials such as amoxicillin (or amoxicillin-clavulanate), trimethoprim-sulfamethoxazole, and fluoroquinolones is increasingly reported (Gupta et al., 2011). In some regions, ampicillin resistance among urinary *Escherichia coli* exceeds 80% (Kot, 2019). The proliferation of multidrug-resistant (MDR) strains and extended-spectrum β -lactamase (ESBL)-producing *E. coli* further complicates empirical therapy (Fasugba, Gardner, Mitchell, & Mnatzaganian, 2015).

1.2 Clinical and Economic Impact of Resistance

The rise in antimicrobial resistance among UPEC isolates has profound clinical consequences. Patients with resistant infections experience prolonged illness, higher rates of recurrence, and greater risk of progression to severe conditions such as pyelonephritis and urosepsis (Kahlmeter, 2019; Gupta et al., 2011). These outcomes not only increase morbidity but also mortality in vulnerable populations. Economically, resistant infections lead to extended hospital stays, repeated medical consultations, higher diagnostic testing, and the need for more costly second-line or last-resort antibiotics (Fasugba, Gardner, Mitchell, & Mnatzaganian, 2015; Dadgostar, 2019). Together, these factors create a significant financial burden on healthcare systems and on patients, particularly in low- and middle-income countries where resources are already limited (World Health Organization [WHO], 2017).

1.3 Challenges in Empirical Therapy

One of the key challenges in managing UTIs is the reliance on empirical treatment—prescribing antibiotics based on common resistance patterns rather than culture results (Gupta et al., 2011). While this approach is often necessary to provide timely relief, it becomes problematic when local resistance rates are high. The loss of efficacy of first-line antibiotics such as trimethoprim-sulfamethoxazole or fluoroquinolones has been widely documented, leaving clinicians with limited oral options (Lee, Lee, & Choe, 2018). This situation pushes reliance on injectable or broader-spectrum agents, a practice that accelerates resistance development and undermines antimicrobial stewardship goals (World Health Organization [WHO], 2017; Kahlmeter, 2019).

1.4 Rationale for a Local (Kirkuk, Iraq) Study

While global and regional data provide a general picture of resistance trends, the applicability to local contexts can be limited by geographic variation in antibiotic use, municipal practices, and bacterial ecology (Collignon & McEwen, 2019). In Iraq and its provinces, data on UPEC resistance are still sparse or outdated, with few systematic surveillance reports available (Al-Khikani, 2020). Without up-to-date local surveillance, clinicians rely on empirical regimens that may no longer be effective, risking treatment failure and further resistance development (Ayobami et al., 2022). By conducting a cross-sectional study in Kirkuk, this research intends to fill the gap in local knowledge and provide up-to-date antimicrobial susceptibility profiles of UPEC in women. Such data are essential to support better empirical therapy choices, promote antibiotic stewardship, and help curtail the further emergence of resistant strains in the region (WHO, 2017).

2. Materials and Methods

2.1 Patients

The study was conducted at the Ashti Central Laboratory in Kirkuk, Iraq, with ethical approval obtained from the relevant institutional committee prior to initiation. Written informed consent was obtained from all 100 female participants. Urine samples were collected from these patients who presented with clinically suspected urinary tract infections (UTIs). Only samples demonstrating significant bacteriuria and yielding pure *Escherichia coli* growth were included, resulting in a total of 15 *E. coli* isolates (15% of the total samples) for further analysis.

2.2 Bacterial Isolation

Urine samples were cultured on routine bacteriological media, including MacConkey Agar and Blood Agar, following standard microbiological procedures. Isolated microorganisms were identified using the VITEK-2 Compact automated system (bioMérieux, France). All fifteen isolates included in the study were confirmed as *Escherichia coli* with an identification probability ranging from 89% to 99%, according to the VITEK-2 instrument reports.

2.3 VITEK-2 Compact System

All isolates were confirmed using the automated VITEK-2 Compact system, which provides rapid and accurate bacterial identification as well as antimicrobial susceptibility testing (Nakasone et al., 2007).

Principle of VITEK-2:

The system uses reagent cards containing 64 wells, each impregnated with specific substrates for biochemical reactions (acidification, alkalization, enzyme activity, growth inhibition, etc).

After inoculation, bacterial metabolism produces measurable colorimetric or turbidimetric changes.

Results are interpreted automatically by the VITEK-2 software

Preparation of Inoculum for VITEK-2:

1. A sufficient number of colonies from a pure culture on Blood Agar were suspended in 3.0 mL of sterile saline (0.45–0.50% NaCl, pH 4.5–7.0) in a 12 × 75 mm polystyrene test tube.
2. The suspension's turbidity was adjusted to 0.5–0.63 McFarland using the DensiChek™ turbidity meter.
3. The prepared suspension was loaded into the VITEK-2 cassette, where the reagent card was automatically filled, sealed, and incubated.
4. Final results for bacterial identification and antimicrobial susceptibility testing were obtained within 4–6 hours.



Figure 1. VITEK 2 Compact System and Preparation of Reagent Cards for Antimicrobial Susceptibility Testing.

2.4 Antimicrobial Susceptibility Testing (AST)

Antimicrobial susceptibility testing was performed on all *E. coli* isolates using the VITEK-2 Compact system. The Minimum Inhibitory Concentration (MIC) for each antibiotic was determined, and results were interpreted as Susceptible (S), Resistant (R), or Susceptible Dose-Dependent/Intermediate (SDD/I) according to the Clinical and Laboratory Standards Institute (CLSI) guidelines.

The panel of antibiotics tested included:

Penicillins/Beta-Lactamase Inhibitors: Amoxicillin/Clavulanic Acid, Ampicillin/Sulbactam, Piperacillin/Tazobactam, Ticarcillin.

Cephalosporins: Cefalexin, Cefoxitin, Cefotaxime, Ceftazidime, Ceftazidime/Avibactam, Cefepime, Ceftolozane/Tazobactam.

Carbapenems: Imipenem, Meropenem

Aminoglycosides: Gentamicin, Amikacin.

Fluoroquinolones: Ciprofloxacin.

Other agents: Colistin, Tigecycline, Trimethoprim/Sulfamethoxazole.

2.5 Statistical Analysis

Data were entered and analyzed using SPSS software (version 26.0; IBM Corp., Armonk, NY, USA). Descriptive statistics were applied to summarize the data. The frequency and percentage of resistant, intermediate, and susceptible isolates were calculated for each antibiotic tested. Results were presented as proportions (%) of the total number of *E. coli* isolates (n = 15).

Due to the relatively small sample size, no inferential statistical tests (e.g., chi-square or t-tests) were applied; instead, the analysis focused on identifying resistance trends and distribution patterns across antimicrobial classes. The findings were interpreted in the context of existing literature to highlight clinically relevant resistance patterns among uropathogenic *E. coli* isolates.

3. Results

To A total of 15 pure *Escherichia coli* isolates were recovered from 100 urine samples collected from female patients during the study period. The organism identification probability ranged from 89% to 99% using the VITEK 2 instrument.

3.1 Antimicrobial Resistance Patterns

The table below summarizes the resistance rate (R) shown by the fifteen isolates for each tested antibiotic (percentage calculated based on 15 isolates):

Table 1. Antimicrobial Susceptibility and Resistance Patterns of Uropathogenic *E. coli* Isolates (N=15) from Women in Kirkuk.

Antibiotic	R	R %	I\SDD	S	S %
Amoxicillin	8	%53.3	0	7	46.7%
Amoxicillin\Clavulanic Acid	4	%26.7	1	10	66.7%
Ampicillin\Sulbactam	6	%40.0	1	8	53.3%
Ticarcillin	4	%26.7	1	10	66.7%
Piperacillin\Tazobactam	2	%13.3	0	13	86.7%
Cefalexin	8	%53.3	0	7	46.7%
Cefoxitin	3	%20.0	0	12	80.0%
Cefotaxime	5	3%33.	1	9	60.0%
Ceftazidime	4	%26.7	1	10	66.7%
Cefepime	4	%26.7	2	9	60.0%
Ceftazidime\Avibactam	2	%13.3	1	12	80.0%
Ceftolozane\Tazobactam	2	%13.3	0	13	86.7%
Imipenem	0	%.00	0	15	100.0%
Meropenem	0	%.00	0	15	100.0%
Gentamicin	4	%26.7	0	11	73.3%
Amikacin	0	%.00	0	15	100.0%
Ciprofloxacin	5	%33.3	1	9	60.0%
Tigecycline	0	%.00	0	15	100.0%

Colistin	1	%6.7	1	13	86.7%
Trimethoprim\Sulfamethoxazole	5	%33.3	0	10	66.7%

3.2 Summary of Resistance Patterns

Highest resistance: (>50%)13.2.

- Amoxicillin: 8/15 (53.3%)
- Cephalexin (Cephalexin): 8/15 (53.3%)

Moderate resistance (25% - 40%)23.2.

Ampicillin/Sulbactam: 6\15 (40.0)

- Cefotaxime: 5/15(33.3%) – 1 intermediate (I) reported
- Ciprofloxacin: 5\15 (33.3%) – 1 intermediate (I) reported
- Trimethoprim–Sulfamethoxazole: 5\15 (33.3%).
- Ceftazidime: 4/15 (26.7%)— 1 intermediate (I) reported
- Cefepime: 4/15 (26.7%) – 2 intermediate (I\SDD) reported
- Gentamicin: 4/15 (26.7%)
- Amoxicillin/Clavulanic acid: 4\15 (26.7%)— 1 intermediate (I\SDD) reported
- Ticarcillin: 4\15 (26.7%)— 1 intermediate (I) reported-

3.2.3 Low resistance (<20%)

Cefoxitin: 3\15 (20.0%).

- Piperacillin/Tazobactam: 2/15 (13.3%)
- Ceftazidime/Avibactam: 2/15 (13.3%) – 1 intermediate (I\SDD) reported-
- Ceftolozane/Tazobactam: 2/15 (13.3%)
- Colistin: 1\15 (6.7%) – 1 intermediate (I) reported

3.2.4 Lowest resistance / High susceptibility (0% resistant)

- Imipenem: 0/15 (0%)
- Meropenem: 0/15 (0%)
- Amikacin: 0/15 (0%)
- Tigecycline: 0/15 (0%)

3.3 Multidrug resistance (MDR) and extensive drug resistance (XDR) – interpretation caution

The table provides aggregate resistance frequencies per antibiotic but does not include isolate-level antibiograms required to classify individual isolates as MDR (resistance to ≥ 3 antimicrobial classes) or XDR. Therefore, definitive statements about the number of MDR/XDR isolates cannot be made from these aggregated data alone. Notably, no carbapenem resistance was observed (Imipenem and Meropenem 0%), which argues against carbapenem-resistant XDR isolates in this cohort. Nevertheless, resistance across multiple classes (penicillins, cephalosporins, fluoroquinolones, and TMP–SMX) indicates the potential circulation of MDR strains and underlines the need for isolate-level reporting and ongoing surveillance.

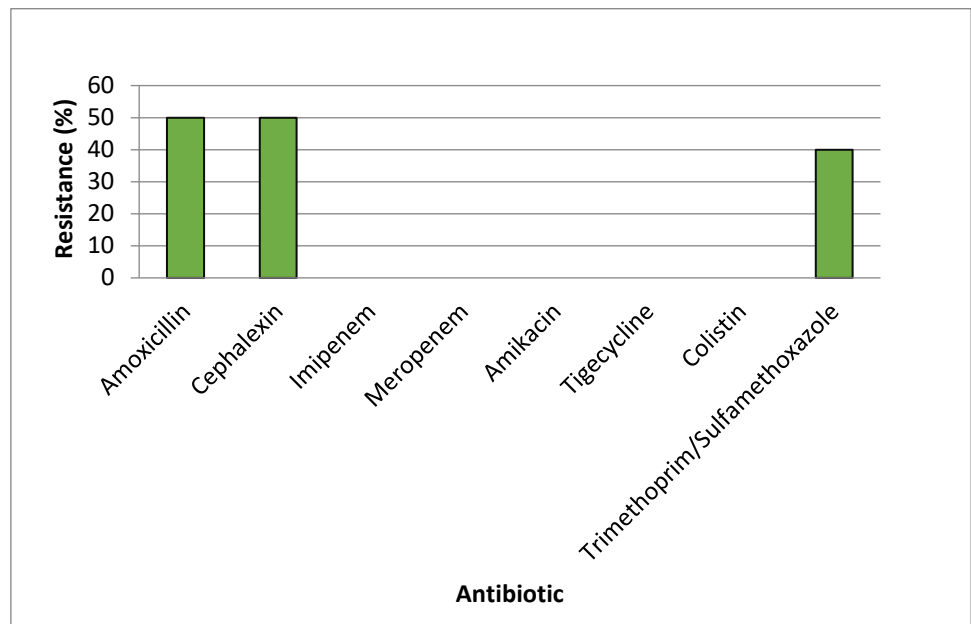


Figure 2. Antimicrobial Resistance Patterns of Uropathogenic *E.coli* (Kirkuk).

4. Discussion

The present study demonstrated notable antimicrobial resistance among *Escherichia coli* isolates recovered from female patients with suspected urinary tract infections in Kirkuk. The highest resistance rates were observed for Amoxicillin and Cephalexin (53.3%), similar to reports from other regions indicating widespread β -lactam resistance among uropathogenic *E. coli* (Kot, 2019; Al-Khikani, 2020). Moderate resistance to Ampicillin/Sulbactam, Ciprofloxacin, and Trimethoprim–Sulfamethoxazole aligns with findings from previous studies conducted in Iraq and neighboring countries (Lee, Lee, & Choe, 2018; Ayobami et al., 2022).

Encouragingly, all isolates were fully susceptible to Carbapenems (Imipenem, Meropenem), Amikacin, and Tigecycline, reflecting global trends that these antibiotics remain highly effective against multidrug-resistant *E. coli* strains (Fasugba, Gardner, Mitchell, & Mnatzaganian, 2015; Kahlmeter, 2019). The absence of carbapenem resistance suggests that local MDR or XDR strains have not yet acquired carbapenemase mechanisms, although continuous monitoring is warranted.

The 33–40% resistance observed for Trimethoprim–Sulfamethoxazole indicates decreasing effectiveness of this commonly used empirical therapy for uncomplicated UTIs, consistent with WHO reports on global resistance escalation (WHO, 2017). Overall, these findings emphasize the need for regular antimicrobial surveillance in Kirkuk to inform empirical therapy and support antibiotic stewardship program.

5. Conclusion

This study confirms a significant increase in the resistance of *E. coli* to first-line antibiotics like Amoxicillin, Cephalexin, and Trimethoprim/Sulfamethoxazole, which is consistent with global and regional trends. The high susceptibility results for Carbapenems (Imipenem, Meropenem), Amikacin, and Tigecycline indicate that these drugs may be the effective treatment options available for severe or resistant cases. These findings are crucial for updating the empirical treatment protocols for UTIs in women in the region.

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