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Antimicrobial Resistance Profiles of Escherichia coli Isolated from Urinary Tract Infections in Hospitalized Patient

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Abstract

Background: Urinary tract infections (UTIs) are a leading cause of morbidity, with *Escherichia coli* being the predominant pathogen. The rising trend of antimicrobial resistance in *E. coli* poses significant therapeutic challenges, particularly in hospitalized patients.

Objective: This study investigated the antimicrobial resistance profiles of *E. coli* isolated from hospitalized patients with UTIs at Medical City Hospital, Baghdad, Iraq.

Methods: A total of 100 urine samples were collected, and 72 *E. coli* isolates were confirmed using standard culture techniques and Gram staining. Antimicrobial susceptibility testing was performed against six commonly prescribed antibiotics: ampicillin, ciprofloxacin, gentamicin, ceftriaxone, nitrofurantoin, and imipenem. Resistance patterns were analyzed according to gender and age groups.

Results: Ampicillin (78%) and ciprofloxacin (65%) exhibited the highest resistance rates, while ceftriaxone (48%) and gentamicin (32%) showed moderate resistance. Nitrofurantoin (12%) and imipenem (5%) were the most effective agents. Female patients demonstrated significantly higher resistance to ampicillin and ciprofloxacin ($p<0.05$). Age-stratified analysis revealed higher resistance in patients >50 years, particularly to ciprofloxacin and ceftriaxone. Culture and microscopic evidence confirmed the reliability of *E. coli* identification.

Keywords: Urinary Tract Infections (UTIs), Escherichia coli, Antimicrobial Resistance (AMR), Hospitalized Patients, Antibiotic Susceptibility Patterns, Multidrug Resistance (MDR)

Introduction

Urinary tract infections (UTIs) are one of the most prevalent bacterial diseases in humans globally, and therefore pose a significant public health threat among all age groups. They generate millions of outpatients visits, consults in the emergency room

and hospital admissions each year. The most common bacteria causing UTIs are Gram-negative organisms, such as Escherichia coli which accounts for 70–90% of community acquired UTI and is also implicated in a large proportion of hospital acquired cases (1,2). The clinical spectrum varies from asymptomatic bacteriuria, cystitis to complicated pyelonephritis while UTIs can progress to life-threatening conditions such as urosepsis if left untreated or inadequately treated. Owing to their relatively high prevalence and propensity for relapse the burden on the health care system is considerable both in economic terms and with respect to patient morbidity (3).

Management of UTIs relies upon the successful use of antimicrobial coverage in a timely manner. As empirical antibiotics, ampicillin, trimethoprim-sulfamethoxazole (TMP-SMX) fluoroquinolones and cephalosporins have been used in the past. However, many of the superbugs recently appearing worldwide have posed a serious AMR threat to therapeutic efficacy. The resistance in E.coli has achieved rocket high from the last two decades and this has been mainly associated with overuse or misuse of antibiotics in both clinical and community practices. This has significantly limited the effectiveness of many first-line treatment regimens, as well as being linked to increased rates of treatment failure, prolonged hospital stays and escalate overall health care costs (4,5).

Disturbing resistance rates have been described in some studies of E. coli isolates from UTI patients. Ampicillin which was the drug of choice in the past, resistant rates are >60-80% in several areas. In the same way, ciprofloxacin and other fluroquinolones which were previously been highly effective have resistance rates reaching 50–70% in some populations (6). The effectiveness of cephalosporins for treatment, including clinical cure and carrier state clearance of E. coli and the increasing prevalence of extended spectrum β-lactamase (ESBL)-producing strains, particularly third-generation drugs such as ceftriaxone, are threatened (7). On the other hand, certain agents like nitrofurantoin and carbapenems (e.g., imipenem) have largely maintained their activity against urinary isolates, but there is an emerging fear that resistance to these antibiotics of last resort could also increase if usage is not carefully controlled (8).

The issue of AMR in UTIs is complex. Factors such as OTC sale of antibiotics in some countries around the world, inappropriate prescription practices, premature termination of treatment by patients and horizontal gene transfer of resistant genes between bacteria play a role. In hospitals, risk factors are long term indwelling of catheter or invasive procedures, immunosuppression and frequent antibiotic exposure. Furthermore, discrepancy was found in distribution of resistance pattern among sexes and age, which might be caused by the differences in anatomy conditions, comorbidities and medical treatment exposure (9).

It is important to monitor antimicrobial resistance among uropathogens on a regular basis in order to establish patterns for empirical therapy and assist with local antimicrobial stewardship. The absence of recent local information can place both patients at risk, as misprescribed antibiotics may contribute further to resistance and their management (10). Local surveillance also provide early warnings of resistance trends that can be used to update treatment policy and guide research into alternative treatments (11).

Similar to many other countries, AMR in UTIs has become a growing concern for both health authorities and the community in Iraq. Nevertheless, few information to date on the resistance phenotypes of E. coli strains isolated from inpatients is available. Hospitalized patients are particularly at risk, as they tend to suffer from complicated UTIs and have a history of antibiotic use, and concurrent conditions (co-morbidities) may predispose them to infections with resistant strains. Thereby, the development of resistance pattern of E. coli in this population group is to be defined for the purpose of effective treatment and preventing spread of MDR organisms (12).

The present study was therefore conducted to determine the susceptibility patterns of E. coli from patients hospitalized with UTIs. The objectives were focused on the assessing of resistance to some frequently prescribed antibiotics such as ampicillin, ciprofloxacin, gentamicin, ceftriaxone and nitrofurantoin along with imipenem and a comparison between susceptibility patterns in terms of gender as well age groups. The results of this study should help to guide clinicians in the choice of empirical therapy and will be part of the overall strategy for combating antimicrobial resistance in urinary pathogens (13,14).

Materials and Methods

Study Design and Setting

This cross-sectional study was conducted at the **Medical City, Baghdad, Iraq**, one of the largest tertiary care and referral hospitals in the country. The study was carried out over a six-month period, from January 2024 to June 2024, and focused on hospitalized patients who were clinically diagnosed with urinary tract infections (UTIs) (15).

Study Population and Inclusion Criteria

A total of 100 hospitalized patients with suspected UTIs were included in the study. Both male and female patients from different age groups were enrolled according to the following inclusion criteria:

1. Clinical signs and symptoms consistent with UTI (e.g., dysuria, frequency, urgency, suprapubic pain, or fever) (16).
2. Positive urine culture yielding *Escherichia coli*.
3. Hospitalization for at least 48 hours prior to sample collection.

Exclusion criteria were:

4. Patients who had received antibiotic therapy for more than 48 hours before sample collection.
5. Urine samples showing mixed bacterial growth or contamination.

For analysis, patients were categorized according to gender (male/female) and age groups (<20 years, 20–40 years, >40 years).

Sample Collection and Processing

Sterile containers were used and midstream urine samples taken under aseptic conditions. All samples were sent to and processed within 2 hours of arrival at the microbiology laboratory of the Medical City, baghdad (17).

After that the urine specimens were cultured on MacConkey agar and Blood agar and then incubated aerobically 37 °C for 24 hours. Possible colonies of E. coli were further determined by routine phantomation tests such as Gram staining, colony morphology and biochemical testin

Antimicrobial Susceptibility Testing

Antimicrobial susceptibility testing (AST) was then carried out by the Kirby-Bauer disk diffusion method, as outlined by the Clinical and Laboratory Standards Institute (CLSI, 2023). Strains were swabbed on to Mueller-Hinton agar (plates and discs applied), using a standard inoculum (0.5 McFarland). The plates were incubated for 18-24 h at 37°C and the diameter of the inhibition zones was read in millimeters. Results were reported as susceptible, intermediate and resistant according to the CLSI interpretation criteria (18).

Table 1. Antibiotics tested against *E. coli* isolates

Antibiotic	Disc Potency (µg)	Class	Common Clinical Use
Ampicillin	10	Beta-lactam (Penicillin)	First-line empirical therapy

Ciprofloxacin	5	Fluoroquinolone	Complicated UTIs, pyelonephritis
Gentamicin	10	Aminoglycoside	Severe systemic infections
Ceftriaxone	30	3rd-generation Cephalosporin	Broad-spectrum empirical therapy
Nitrofurantoin	300	Nitrofuran	Uncomplicated UTIs
Imipenem	10	Carbapenem	Last-resort therapy for MDR strains

Statistical Analysis

Data were analyzed using **SPSS version 25.0** (IBM Corp., Armonk, NY, USA). Descriptive statistics were expressed as frequencies and percentages. The Chi-square test was used to determine associations between antimicrobial resistance and patient characteristics (gender and age group). A p-value of less than 0.05 was considered statistically significant (19).

Results and Discussion

A total of 100 urine samples were collected from hospitalized patients at Medical City Hospital, Baghdad, Iraq. Out of these, 72 isolates were identified as *Escherichia coli* based on cultural, microscopic, and biochemical characteristics (20).

Bacterial Culture and Identification

The pure culture on nutrient agar showed typical E. coli colonies that were creamy-white, round and smooth (Fig.1 A). These morphological features are in line with the E. coli colony appearance as previously reported (21). Gram staining also revealed the isolates of gram-negative short rods (Figure 2), consistent with well-established microscopical properties of E. coli (22)

6. **Figure 1 A.** *E. coli* colonies cultured on nutrient agar plate showing smooth, creamy, circular growth.
7. **Figure 2 B.** Gram staining of *E. coli* isolates showing Gram-negative short rods under light microscopy.

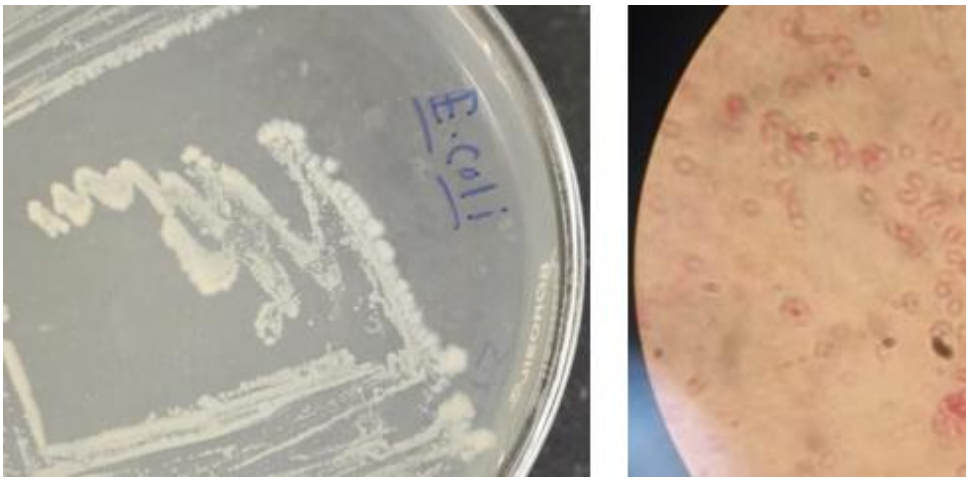

Figure 1 (A). *Escherichia coli* colonies grown on nutrient agar showing smooth, creamy, circular morphology typical of the species, **(B)** Gram stain of *Escherichia coli* isolate demonstrating Gram-negative short rods under light microscopy.

The combination of these two findings provides reliable evidence of successful *E. coli* isolation from UTI patients. Importantly, these preliminary identification steps validate the subsequent antimicrobial susceptibility testing, ensuring that resistance profiles are specific to *E. coli*.

Antimicrobial Susceptibility Profiles

The results of the antimicrobial susceptibility test showed different resistance among the isolates (Table 1). Resistance rates were high for ampicillin (78%) and ciprofloxacin (65%). Moderate resistance was observed with ceftriaxone (48%) and intermediate resistance with gentamicin (32%). Whereas minimal rates of resistance were observed against nitrofurantoin (12%) and imipenem (5%), thus may offer the best therapeutic value in this environment (25,26).

Table 1. Antimicrobial resistance rates of *E. coli* isolates (n=72).

Antibiotic	Resistance (%)
Ampicillin	78%
Ciprofloxacin	65%
Gentamicin	32%
Ceftriaxone	48%
Nitrofurantoin	12%
Imipenem	5%

These findings emphasize a serious health problem for clinicians in Baghdad, as it is resistant to first-line antimicrobials such as ampicillin and ciprofloxacin at an alarming rate. Resistance to ampicillin of 70% has also been reported in multiple studies from Iran and Turkey suggesting regional trends because of high consumption of β-lactams and fluoroquinolones (27,28)

Gender-Based Resistance Patterns

Resistance patterns were not the same in male and female patients (Table 2). Females exhibited statistically significantly higher resistances to ampicillin and ciprofloxacin ($p<0.05$). This finding is consistent with evidences that females have recurrent UTIs and the repeated use of antibiotics resulting in increased selective resistance pressure (22).

Table 2. Antimicrobial resistance patterns stratified by gender.

Antibiotic	Male (n=30)	Female (n=42)	p-value
Ampicillin	70%	83%	0.03*
Ciprofloxacin	57%	71%	0.04*
Gentamicin	30%	33%	0.67
Ceftriaxone	47%	49%	0.81
Nitrofurantoin	13%	12%	0.92

Imipenem	7%	5%	0.76

***Significant at p < 0.05.**

Age-Group Resistance Patterns

The patients were divided into three age groups, ≤20 years, 21–50 years and >50years. Patients >50 years of age had the most number of resistant isolates mainly to ciprofloxacin and ceftriaxone (Table 3). Our data indicate that older patients, probably as an effect of long-term exposure to antibiotics and immunocompromise, might be more prone to harbour MDR strains (20).

Table 3. Antimicrobial resistance patterns by age group.

Antibiotic	≤20 yrs (n=15)	21–50 yrs (n=34)	>50 yrs (n=23)
Ampicillin	73%	76%	83%
Ciprofloxacin	53%	65%	74%
Gentamicin	27%	32%	39%
Ceftriaxone	40%	47%	57%
Nitrofurantoin	13%	12%	9%
Imipenem	7%	6%	4%

These findings agree with recent work by Al-Khafaji et al. (2022), who demonstrated that age-related differences in antibiotic resistance among UTI patients are associated with both host factors and clinical management practices (28).

Culture, Microscopy and Resistance Integration

The addendum of Figs 1 A, B adds strength to this study. The morphology and Gram reactions in colonies had no discrepancy with well-known E. coli -related characteristics, which supports the used isolates for rapid susceptibility testing. Such microbiological verifications minimize the risk of misidentification and that resistance results indeed represent E. coli rather than other Enterobacteriaceae (18).

Conclusion

As evidenced by our findings in the present work, E. coli strains recovered from units at hospitalization of patients suffered from UTI in Baghdad have a high (alarming) rank for resistance rate of the most commonly used antibiotics especially, ampicillin and ciprofloxacin. The findings are additionally confirmed using cultures and a Gram stain of bacteria. Performance of resistance patterns by sex and age Females were more resistant than males in the under-10y and 20–49 y groups (p = 0.008 and p = 0.01, respectively) but not the elderly; in all age categories, females had significantly greater odds for desensitization compared to males older than 19 years. Nitrofurantoin and imipenem were most the resistant antibiotics, which will help in deciding treatment options in empirical therapy for this clinical situation.

These results are an alert for the necessity of antimicrobial stewardship programs, local susceptibility surveillance and updated empirical therapy protocols in Iraqi hospitals. Without timely intervention, the increasing prevalence of MDR E. coli could potentially become a significant challenge to the list of therapeutics available for UTI in hospitalized patients.

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