# Comparative Antibiogram of *Escherichia coli* Isolated from the Urinary Tract Infection in Patients of Different Age and Sex Groups in Chittagong, Bangladesh

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## Abstract

Background: Urinary tract infections (UTIs) are prevalent worldwide, with *Escherichia coli* (E. coli) responsible for over 85% of cases. Rising antibiotic resistance among UTI pathogens, largely due to antibiotic misuse, complicates treatment and demonstrates the need for regular resistance monitoring. Methods: This study investigated antibiotic resistance in *E. coli* isolates from 256 UTI patients, analyzing resistance to ten commonly prescribed antibiotics and assessing multidrug resistance (MDR) patterns across demographic groups. Results: *E. coli* was isolated in 15.63% of samples, showing high resistance to Cefuroxime (92%) and low resistance to Imipenem (5%), indicating Imipenem's potential as an effective treatment. Overall, 72.5% of *E. coli* isolates were classified as MDR, with resistance to five or more antibiotics. Notably, young females and elder males exhibited the highest MDR rates (81.81%), suggesting demographic-specific resistance trends. Conclusion: This study showed the critical need for routine antibiograms to guide empirical therapy, as well as for improved antibiotic stewardship to limit resistance spread. Cefuroxime's high resistance rate suggests it may be ineffective in this patient group, whereas Imipenem and Nitrofurantoin may serve as better options. These findings emphasize the importance of targeted antimicrobial strategies and continuous surveillance to manage UTIs effectively in the face of growing antibiotic resistance. Future research should focus on understanding MDR drivers and developing novel treatments to improve UTI outcomes and mitigate the public health impact of resistant infections.

**Keywords:** Urinary tract infection (UTI), *Escherichia coli* (*E. coli*), Antibiotic resistance, Multidrug resistance (MDR), Empirical therapy

***Significance*** | This study showed the critical need for regular antibiotic resistance monitoring and targeted therapies to manage multidrug-resistant E. coli in UTIs effectively.

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## Introduction

Urinary tract infections (UTIs) are a prevalent global health issue, affecting millions of individuals annually and resulting in significant morbidity and healthcare costs. Defined as infections that occur when bacteria enter the urinary tract, UTIs can impact various anatomical structures, including the kidneys, bladder, ureters, and urethra. Although UTIs can affect individuals across all demographics, women are particularly vulnerable due to specific anatomical and physiological characteristics. Research indicates that more than half of women will experience at least one UTI in

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their lifetime, with many suffering from recurrent infections, further complicating management strategies (Foxman, 2000; Salvatore et al., 2011).

*Escherichia coli* (E. coli), a bacterium normally found in the intestines, is the primary culprit behind UTIs, accounting for over 85% of cases (Schaeffer et al., 2001; Zhanel et al., 2006). Other notable pathogens implicated in UTIs include Klebsiella, Enterobacter, and Streptococcus species, each contributing to the overall burden of these infections (Naber et al., 2008; Nicolle, 2008). The predominance of *E. coli* in urinary tract infections underscores the importance of understanding its pathogenicity and the factors that influence its ability to cause disease.

A growing concern in the management of UTIs is the rise of antibiotic-resistant strains of bacteria. The emergence of these resistant strains complicates treatment options and increases the risk of serious health complications. In particular, the overuse and misuse of antibiotics, especially in developing countries where self-medication practices are widespread, have accelerated the development of antibiotic resistance (Baddour et al., 2017; Kahlmeter & ECO.SENS, 2003). This trend poses a significant challenge to healthcare providers, as infections that were once easily treated with standard antibiotic regimens have become increasingly difficult to manage (Akram et al., 2007; Ehinmidu, 2003). Continuous monitoring of resistance patterns is therefore crucial to maintaining effective empirical antibiotic therapies and ensuring favorable patient outcomes.

This study aims to evaluate the antibiotic resistance profile of *E. coli* isolated from urine samples of patients diagnosed with UTIs. A comprehensive analysis of 256 urine samples revealed that *E. coli* was the most commonly isolated pathogen, identified in 15.63% of cases. The investigation assessed resistance to various antibiotics, finding that Cefuroxime had the highest resistance rate at 92%, while Imipenem exhibited the lowest resistance at 5% (Amdekar et al., 2011; Manikandan et al., 2011). These findings suggest that Imipenem may be a viable treatment option in cases of resistant infections. The study further explored multidrug resistance (MDR) among different age and gender demographics, revealing distinct resistance patterns. Notably, young and elderly patients of both genders exhibited varying rates of MDR, with young females and elderly males demonstrating the highest resistance rates at 81.81% (Mathai et al., 2001; Ronald, 1999).

The results indicated that 72.5% of *E. coli* isolates were classified as multidrug-resistant, demonstrating resistance to five or more tested antibiotics. This alarming statistic highlights the urgent need for ongoing surveillance of antibiotic resistance patterns. As resistance profiles can vary significantly across geographical regions, regular antibiogram assessments are essential for guiding clinicians in prescribing effective treatments for UTIs (Griebling, 2001; Schappert & Rechtsteiner, 2008). Furthermore, this study emphasizes the critical importance of responsible antibiotic use to combat the escalating threat of antibiotic-resistant infections (Lane & Takhar, 2011; Stapleton, 2003).

## Materials and Methods

This study assessed antibiotic resistance patterns in *Escherichia coli* strains isolated from urine samples of patients diagnosed with urinary tract infections (UTIs). The study included 256 patients with clinical symptoms of UTI, representing various age and gender groups. Samples were collected, transported, and processed according to standardized procedures to ensure consistent and accurate results.

### *Sample Collection and Transport*

Urine samples were collected using the clean-catch midstream method to minimize contamination. Each patient was instructed in proper sample collection techniques to ensure accuracy. Approximately 4–5 mL of urine was collected in sterile tubes and promptly transported to the laboratory for analysis. This immediate transport helped to preserve sample integrity and avoid overgrowth of contaminants.

### *Bacterial Culture and Identification*

Urine samples were cultured on both MacConkey Agar and Blood Agar plates to promote growth and isolation of Gram-negative and Gram-positive bacteria. MacConkey Agar was used to differentiate lactose-fermenting bacteria, while Blood Agar supported a broader range of bacterial growth and allowed for hemolysis observation. Plates were incubated at 37°C for 24 hours, after which colony morphology, lactose fermentation, and hemolysis were assessed to identify potential pathogens.

### *Biochemical tests were conducted to confirm E. coli identity among the isolates.*

These tests included:

Indole Production Test – Determining tryptophan metabolism

Methyl Red (MR) Test – Confirming stable acid production from glucose fermentation

Voges-Proskauer (VP) Test – Testing for acetoin production

Citrate Utilization Test – Assessing the ability to use citrate as a carbon source

Only isolates confirmed as *E. coli* through these conventional biochemical methods were included in the resistance analysis.

### *Antibiotic Susceptibility Testing*

Antimicrobial susceptibility testing was performed using the Kirby-Bauer disk diffusion method on Mueller-Hinton Agar, following guidelines provided by the Clinical and Laboratory Standards Institute (CLSI). A standardized bacterial suspension, equivalent to a 0.5 McFarland turbidity standard, was prepared for each *E. coli* isolate and swabbed evenly across the agar surface. Antibiotic-impregnated disks (Oxoid Ltd, UK) were placed on the inoculated agar plates, which were then incubated at 37°C for 16–18 hours. The diameters of inhibition zones around each disk were measured in millimeters and interpreted according to CLSI breakpoints to classify the isolates as susceptible, intermediate, or resistant.

***The antibiotics tested included:***

Cefuroxime (20 µg), Azithromycin (15 µg), Amikacin (20 mg), Cefepime (20 µg), Amoxicillin (20 µg), Nitrofurantoin (300 µg), Ciprofloxacin (5 µg), Nalidixic Acid (30 µg), Imipenem (10 µg), Gentamicin (10 µg)

***Multidrug Resistance Analysis***

To analyze multidrug resistance (MDR) patterns, isolates were classified as MDR if they showed resistance to five or more of the tested antibiotics. The study stratified MDR findings by patient age and gender, with patients categorized into four demographic groups: young male (25–35 years), older male (above 35 years), young female (25–35 years), and older female (above 35 years). This categorization enabled a more nuanced understanding of resistance trends among different patient demographics.

***Statistical Analysis***

Data were analyzed using descriptive statistics to calculate resistance frequencies for each antibiotic, as well as the prevalence of MDR strains across the four patient groups. Comparative analysis of resistance rates between these groups was also performed to detect any significant age- or gender-related variations in resistance patterns.

## Results

This study analyzed the antibiotic resistance patterns of *Escherichia coli* isolated from urine samples of 256 patients diagnosed with urinary tract infections (UTIs). Out of the total samples, 40 (15.63%) were confirmed to contain E. coli, making it the most prevalent pathogen in the study. The *E. coli* isolates exhibited varying levels of resistance to the panel of antibiotics tested, and multidrug resistance (MDR) patterns were further analyzed across different age and sex groups.

***Antibiotic Resistance Patterns***

All *E. coli* isolates demonstrated some level of resistance to at least one antibiotic, underscoring a widespread resistance profile among the isolates. The highest resistance rate was observed for Cefuroxime, with 92% of the isolates being resistant. In contrast, Imipenem exhibited the lowest resistance rate, with only 5% of isolates showing resistance. These findings suggest that Cefuroxime may be largely ineffective in treating E. coli-related UTIs in this population, whereas Imipenem remains a highly effective therapeutic option (figure 1).

***A breakdown of the resistance rates to each antibiotic is as follows:***

Cefuroxime: 92% resistance, Amoxicillin: 85% resistance, Azithromycin: 70% resistance, Cefepime: 68% resistance, Nalidixic Acid: 60% resistance, Ciprofloxacin: 58% resistance, Gentamicin: 52% resistance, Nitrofurantoin: 27% resistance, Amikacin: 25% resistance, Imipenem: 5% resistance

These results highlight that the majority of *E. coli* isolates are resistant to commonly prescribed antibiotics, particularly second-generation cephalosporins like Cefuroxime. Nitrofurantoin and Imipenem remain more effective choices for treating uncomplicated UTIs, as they showed relatively high levels of susceptibility (73% and 95%, respectively).

***Multidrug Resistance (MDR) Patterns***

Multidrug resistance was defined as resistance to five or more antibiotics. Overall, 72.5% of *E. coli* isolates (29 out of 40) met this criterion (figure 2), confirming the high prevalence of MDR strains within the UTI patient population studied.

***MDR Distribution by Age and Sex***

The MDR patterns were further categorized by patient demographics, revealing notable differences in resistance based on age and sex:

Elder Male Patients: 81.81% (9 out of 11) of *E. coli* isolates from elder male patients (above 35 years) exhibited MDR.Young Male Patients: 63.63% (7 out of 11) of *E. coli* isolates from young male patients (25–35 years) showed MDR. Young Female Patients: 81.81% (9 out of 11) of *E. coli* isolates from young female patients (25–35 years) demonstrated MDR. Elder Female Patients: 36.36% (4 out of 11) of *E. coli* isolates from elder female patients (above 35 years) were classified as MDR (figure 3).

These findings indicate that MDR prevalence is particularly high among elder males and young females, with both groups showing a similar MDR rate of 81.81%. In comparison, elder female patients exhibited a lower MDR rate of 36.36%, suggesting potential age- and sex-related variations in resistance patterns.

***Comparative Analysis and Clinical Implications***

The data suggest a concerning level of resistance among *E. coli* isolates, with many showing MDR and some displaying resistance to nearly all tested antibiotics. This pattern aligns with global trends showing an increase in resistance, which is further complicated by the emergence of MDR strains. The pronounced effectiveness of Imipenem, followed by Nitrofurantoin, suggests that these antibiotics could be prioritized for empirical treatment of UTIs

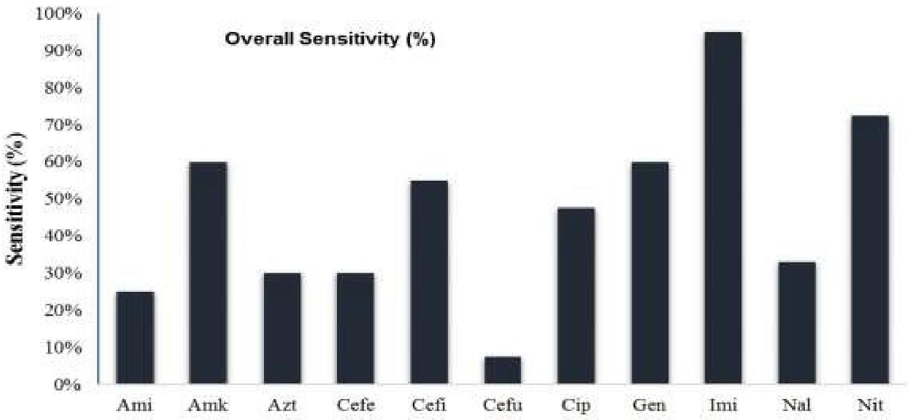


**Figure 1.** Antibiotic sensitivity (%) pattern of E. coli isolates in UTI patients.

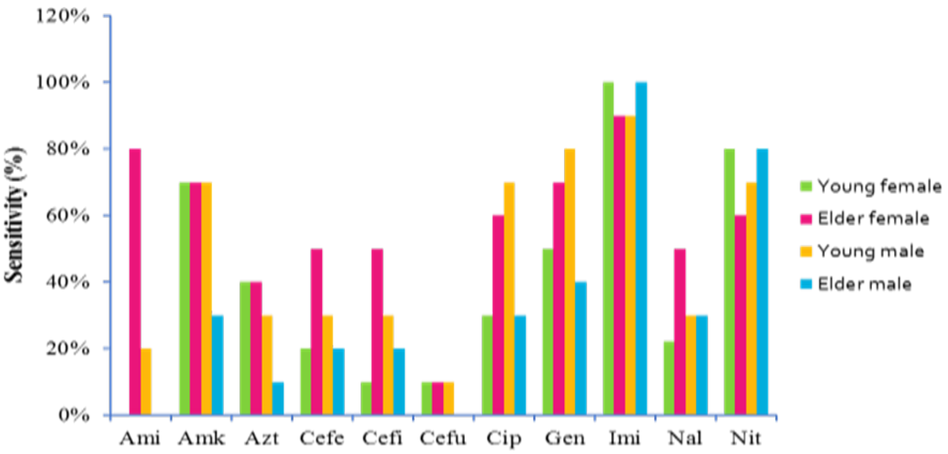


**Figure 2.** Comparative analysis of sensitivity (%) of E. coli to antibiotics in different age and sex distribution.

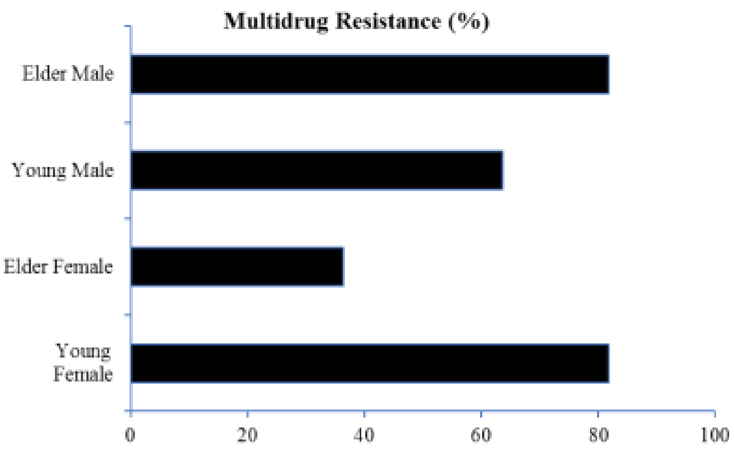


**Figure 3.** The multidrug-resistant pattern of E. coli in different age groups

where *E. coli* is suspected as the causative agent. However, due to the continuous evolution of antibiotic resistance, routine antibiograms are recommended for local and individualized treatment planning.

**Discussion**

The findings of this study underscore the critical issue of antibiotic resistance in *Escherichia coli* isolates from urinary tract infection (UTI) patients. The widespread resistance, particularly the high rate of multidrug resistance (MDR) observed in E. coli, mirrors global trends and emphasizes the urgency of addressing antimicrobial resistance on a local and national scale.

***Prevalence and Resistance Patterns of E. coli***

The identification of *E. coli* in 15.63% of the samples aligns with its well-established role as the primary pathogen in UTIs. The highest resistance observed was against Cefuroxime (92%), and the lowest was against Imipenem (5%), findings consistent with prior research that highlights Cefuroxime as increasingly ineffective against *E. coli* due to its frequent use and subsequent resistance buildup. Imipenem's effectiveness as the most sensitive drug tested positions it as a potentially ideal option for UTI treatment, particularly in severe cases or for patients with recurrent infections. Additionally, Nitrofurantoin, which showed 73% sensitivity, remains a viable choice for uncomplicated UTIs, which aligns with prior studies that recommend it due to its efficacy and narrower spectrum, making it less prone to resistance development.

***Gender and Age-Related Variations in Resistance***

Interestingly, the analysis revealed significant age and sex variations in MDR patterns. Younger females (25-35 years) and elder males (above 35 years) showed the highest rates of MDR (81.81%), suggesting that physiological, social, and possibly behavioral factors may play roles in these differences. Young women, who commonly experience recurrent UTIs, are often exposed to repeated antibiotic courses, which may contribute to higher MDR rates. Similarly, elder males may experience chronic or recurrent UTIs, possibly linked to age-related changes in the urinary tract, increased antibiotic exposure, or comorbidities that may predispose them to infections. The lower MDR rates in elder females (36.36%) could point to different antibiotic exposure levels or lower overall UTI prevalence in this group. Additionally, as men under 50 generally have low UTI rates due to antibacterial factors in the prostate, the moderate MDR rates in young males (63.63%) may reflect a demographic less frequently treated with antibiotics for UTIs.

***Implications of Multidrug Resistance***

The high MDR prevalence (72.5%) among the isolates poses a substantial challenge for empirical UTI treatment. MDR in *E. coli* complicates the selection of effective antibiotics, often leading to treatment failures, prolonged illness, and increased healthcare costs. Such resistance patterns in UTI-causing pathogens not only restrict therapeutic options but also demand the use of higher-tier antibiotics, such as Imipenem, which should ideally be reserved for more severe infections to prevent the acceleration of resistance.

***Antimicrobial Stewardship and the Need for Surveillance***

The high resistance rates to commonly prescribed antibiotics such as Cefuroxime, Amoxicillin, and Azithromycin emphasize the necessity of responsible antibiotic prescribing practices. Overuse and misuse of these antibiotics in UTI treatment likely contribute to the escalating resistance levels. This study reinforces the critical need for antimicrobial stewardship programs that advocate for targeted therapy, informed by regular antibiogram assessments, to track local resistance patterns and guide more effective treatments. The varied resistance profiles across different localities, regions, and countries necessitate ongoing surveillance to capture emerging resistance trends. Regular antibiograms are essential to adapt empirical treatment protocols based on current resistance data, ultimately improving patient outcomes. The findings here strongly advocate for a structured, location-specific approach to managing UTIs and suggest integrating routine antibiotic resistance monitoring into clinical practice to guide empirical therapy.

**Conclusion**

This study showed the urgent need to address multidrug resistance (MDR) in *E. coli* isolates from urinary tract infection (UTI) patients. High resistance rates, particularly to Cefuroxime, reveal the limited effectiveness of commonly prescribed antibiotics, while Imipenem and Nitrofurantoin emerge as promising options for treatment. The study also uncovers age- and gender-specific resistance trends, with young females and older males displaying the highest MDR rates, underscoring the complexity of resistance dynamics. These findings reinforce the importance of routine antibiograms to guide empirical treatment and call for robust antimicrobial stewardship to mitigate resistance. Future research on the drivers of MDR and the development of new treatments remains essential to combat rising resistance, enhance UTI management, and improve patient outcomes.

**Author contributions**

S.D. conceptualized the project and developed the methodology. M.F.A., H.A., and D.A. conducted formal analysis and drafted the original writing. M.A. contributed to the methodology. M.S.S.S. conducted investigations, provided resources, and visualized the data. D.A. contributed to the reviewing and editing of the writing.

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## Competing financial interests

The authors have no conflict of interest.

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