



ORIGINAL RESEARCH ARTICLE

Antimicrobial Susceptibility Pattern and Prevalence of Extended-Spectrum Beta-Lactamase Production Among Escherichia coli Isolates from Urinary Tract Infections at a Tertiary Care Hospital: A Cross-Sectional Study

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Abstract

Background: Escherichia coli remains the most common uropathogen isolated from urinary tract infections (UTI), and rising antimicrobial resistance, particularly extended-spectrum beta-lactamase (ESBL) production, poses a significant challenge to empirical antibiotic selection. **Objectives:** To determine the antimicrobial susceptibility pattern and prevalence of ESBL production among E. coli isolates from patients with UTI, and to identify risk factors associated with ESBL production. **Methods:** A cross-sectional study was conducted on 200 non-repetitive E. coli isolates from urine culture. Antimicrobial susceptibility testing was performed by the Kirby-Bauer disc diffusion method per CLSI guidelines, and ESBL production was confirmed by the combined disc test.

Results: Imipenem (96.5%) and nitrofurantoin (88.5%) showed the highest susceptibility, while ampicillin (22.0%) showed the lowest. ESBL production was detected in 38.0% of isolates. ESBL-producing isolates showed markedly reduced susceptibility to ciprofloxacin (21.1% vs 54.0%) and cotrimoxazole (15.8% vs 45.2%) compared with non-ESBL producers. Prior antibiotic use and hospital-acquired UTI were the strongest independent risk factors for ESBL production.

Conclusion: A substantial proportion of E. coli urinary isolates in this population are ESBL producers with markedly reduced susceptibility to commonly prescribed oral antibiotics, underscoring the importance of local antibiogram-guided empirical therapy and antimicrobial stewardship.

Keywords: Escherichia coli, urinary tract infection, antimicrobial susceptibility, extended-spectrum beta-lactamase, microbiology.

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1 | INTRODUCTION

Escherichia coli remains the single most common causative organism of urinary tract infections (UTI) across both community and hospital settings, accounting for the majority of cases in most published series. (1, 2) Empirical antibiotic selection for UTI has traditionally relied on locally generated antibiogram data, given the well-recognised geographic and temporal variability in uropathogen susceptibility patterns. (3, 4)

The emergence and global spread of extended-spectrum beta-lactamase (ESBL) producing Enterobacteriaceae has substantially complicated the management of E. coli UTI, conferring resistance not only to extended-spectrum cephalosporins but frequently also to fluoroquinolones and cotrimoxazole through co-resistance mechanisms, as extensively reviewed by Bradford and by Paterson and Bonomo. (5, 6) Indian hospital-based surveillance studies, including the work of Mathur and colleagues at a major tertiary referral centre, have documented a substantial and rising burden of ESBL-producing gram-negative bacteria, with important implications for empirical antibiotic policy. (7)

The Kirby-Bauer disc diffusion method, standardised over half a century ago, remains the most widely used method for antimicrobial susceptibility testing in routine clinical microbiology laboratories, owing to its simplicity, low cost, and established correlation with clinical outcome when interpreted according to current CLSI breakpoints. (8, 9) Given the well-documented variability in resistance patterns across different institutions and geographic regions, as illustrated in comparative Indian studies by Chitnis and colleagues and by Tambekar and colleagues, periodic local surveillance of antimicrobial susceptibility and ESBL prevalence remains essential for guiding rational empirical therapy. (10, 11)

This study was undertaken to determine the antimicrobial susceptibility pattern and prevalence of ESBL production among E. coli isolates from patients with UTI attending a tertiary care hospital, and to identify clinical risk factors associated with ESBL production.

2 | MATERIALS AND METHODS

2.1 | Study Design and Setting

This was a laboratory-based, cross-sectional, analytical study conducted in the Department of Microbiology of a tertiary care teaching hospital over a defined study period.

2.2 | Study Population

Non-repetitive E. coli isolates recovered from urine samples of patients with clinically suspected UTI and significant bacteriuria ($\geq 10^5$ CFU/mL) were included.

2.3 | Inclusion and Exclusion Criteria

The first E. coli isolate from each patient with significant bacteriuria during the study period was included. Repeat isolates from the same patient, mixed growth cultures, and isolates with insufficient clinical data were excluded.

2.4 | Sample Processing and Identification

Urine samples were cultured on cystine-lactose-electrolyte-deficient (CLED) agar and incubated at 37°C for 18-24 hours. Isolates were identified as E. coli based on colony morphology, Gram staining, and standard biochemical tests.

2.5 | Antimicrobial Susceptibility Testing

Antimicrobial susceptibility testing was performed by the Kirby-Bauer disc diffusion method on Mueller-Hinton agar, with results interpreted according to current CLSI guidelines. (1, 11) The antibiotic panel tested included ampicillin, cotri-

Supplementary information The online version of this article ([10.15520/ijmhs/8-8-76](https://doi.org/10.15520/ijmhs/8-8-76)) contains supplementary material, which is available to authorized users.

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moxazole, norfloxacin, ciprofloxacin, ceftazidime, cefotaxime, gentamicin, amikacin, nitrofurantoin, and imipenem. ESBL production was screened using indicator cephalosporins (ceftazidime, cefotaxime) and confirmed by the combined disc test with clavulanic acid, with an increase in zone diameter of 5 mm or more in the combination disc considered confirmatory of ESBL production.

2.6 | Statistical Analysis

Data were entered into a spreadsheet and analysed using descriptive statistics. Categorical variables were expressed as frequencies and percentages. Odds ratios with 95% confidence intervals were calculated for clinical risk factors associated with ESBL production using univariate logistic regression. A p -value <0.05 was considered statistically significant. Results were tabulated and represented graphically using multiple chart formats, including a schematic illustration of representative antibiogram patterns.

3 | RESULTS

A total of 200 non-repetitive *E. coli* isolates from patients with UTI were included. Female patients accounted for 62.0% of cases, and the 20-59 year age range accounted for the majority of isolates. The age and gender-wise distribution is summarised in Table 1 and illustrated in Figure 1.

Imipenem (96.5%) and nitrofurantoin (88.5%) showed the highest susceptibility rates, while ampicillin (22.0%) and cotrimoxazole (35.5%) showed the lowest (Table 2, Figure 2).

ESBL production was confirmed in 76 of 200 isolates (38.0%; 95% CI 31.4-45.0) (Table 3, Figure 3). ESBL-producing isolates showed markedly reduced susceptibility across most tested antibiotics compared with non-ESBL producers, most notably for ciprofloxacin (21.1% vs 54.0%) and cotrimoxazole (15.8% vs 45.2%) (Table 4, Figure 4).

On univariate analysis, prior antibiotic use within 3 months (OR 3.42, 95% CI 1.86-6.29, $p<0.001$), hospital-acquired UTI (OR 2.94, 95% CI 1.58-5.47, $p=0.001$), indwelling urinary catheter (OR 2.76, 95%

CI 1.42-5.37, $p=0.003$), diabetes mellitus (OR 2.18, 95% CI 1.19-3.99, $p=0.012$), and recurrent UTI (OR 1.87, 95% CI 1.02-3.43, $p=0.043$) were each significantly associated with ESBL production (Table 5).

4 | DISCUSSION

The antimicrobial susceptibility pattern observed in this study, with high susceptibility to imipenem and nitrofurantoin but low susceptibility to ampicillin and cotrimoxazole, closely mirrors the pattern described in comparable Indian hospital-based studies, including the work of Chitnis and colleagues and Tambekar and colleagues, both of which similarly documented preserved susceptibility to carbapenems and nitrofurantoin alongside substantial resistance to older, more widely prescribed oral agents. (3, 7) The relatively low fluoroquinolone susceptibility observed in this study (42.5% for ciprofloxacin) reflects the well-documented consequence of widespread, often unrestricted fluoroquinolone use in many healthcare settings, consistent with the broader resistance trends described by Akram and colleagues in a comparable North Indian tertiary care population. (10)

The ESBL prevalence observed in this study (38.0%) is broadly consistent with, though somewhat higher than, the prevalence reported by Mathur and colleagues in their tertiary care hospital surveillance, reflecting the continued rise in ESBL prevalence over time documented across successive Indian surveillance studies, consistent with the global epidemiological trends reviewed by Bradford and by Paterson and Bonomo (4-6) The markedly reduced co-resistance to fluoroquinolones and cotrimoxazole observed among ESBL-producing isolates in this study is a well-recognised phenomenon, reflecting the frequent co-location of ESBL genes with other resistance determinants on shared mobile genetic elements, substantially narrowing empirical oral treatment options for infections caused by these organisms.

The independent association observed between prior antibiotic use and ESBL production in this study is consistent with the well-established selective pressure exerted by antibiotic exposure in promoting the

TABLE 1: Age and Gender-wise Distribution of Study Subjects (n = 200)

Age Group (years)	Male (n)	Female (n)	Total (n)	Percentage (%)
<20	8	22	30	15.0
20–39	18	46	64	32.0
40–59	26	38	64	32.0
60 and above	24	18	42	21.0
Total	76	124	200	100.0

Figure 1: Age and Gender-wise Distribution of E. coli UTI Cases (n=200)

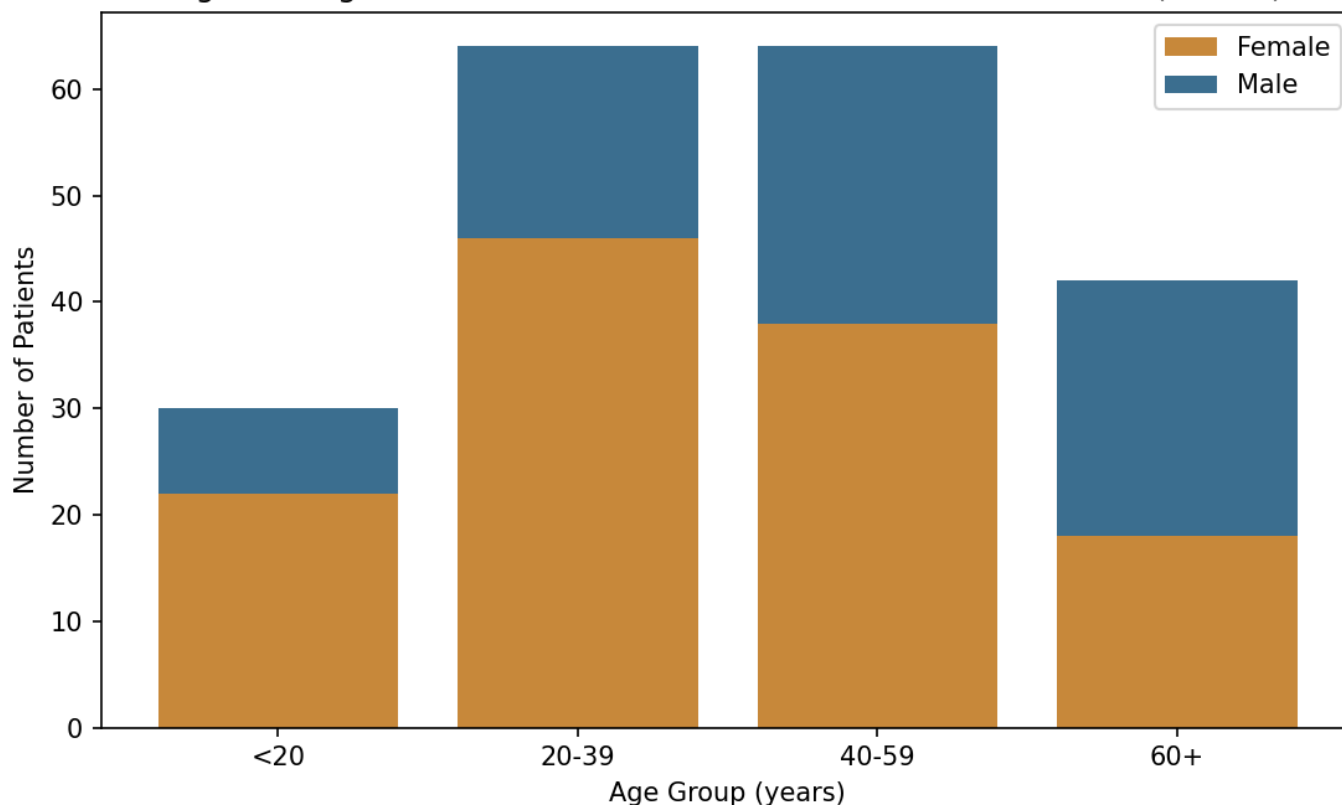


FIGURE 1:

TABLE 2: Antimicrobial Susceptibility Pattern of E. coli Isolates (n = 200)

Antibiotic	Susceptible, n (%)	Resistant, n (%)
Imipenem	193 (96.5)	7 (3.5)
Nitrofurantoin	177 (88.5)	23 (11.5)
Amikacin	172 (86.0)	28 (14.0)
Gentamicin	148 (74.0)	52 (26.0)
Cefotaxime	92 (46.0)	108 (54.0)
Ceftazidime	89 (44.5)	111 (55.5)
Ciprofloxacin	85 (42.5)	115 (57.5)
Norfloxacin	78 (39.0)	122 (61.0)
Cotrimoxazole	71 (35.5)	129 (64.5)
Ampicillin	44 (22.0)	156 (78.0)

Figure 2: Antibiotic Susceptibility Pattern of E. coli Isolates (n=200)

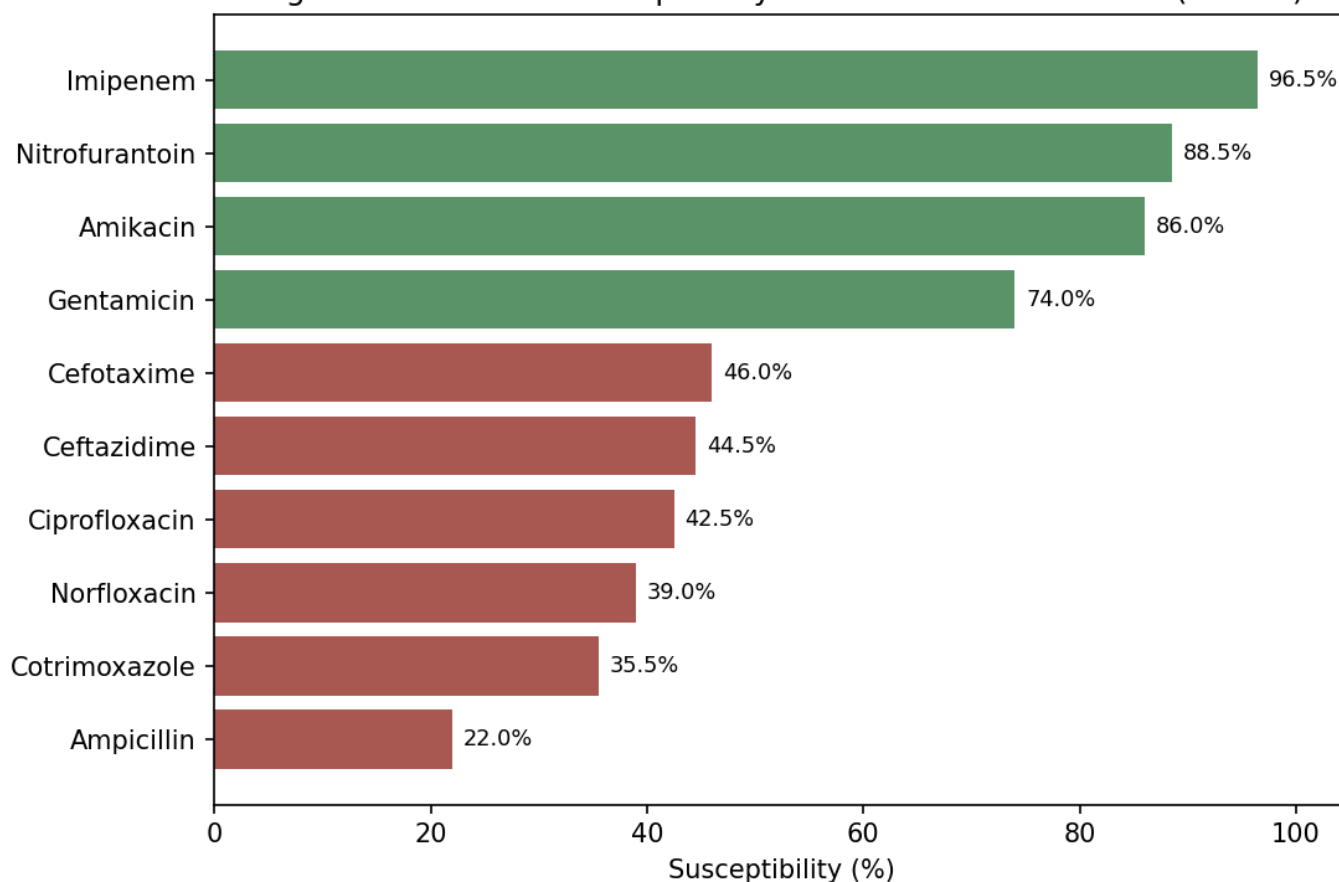


FIGURE 2:

TABLE 3: Prevalence of ESBL Production Among E. coli Isolates

ESBL Status	n	Percentage	95% CI
ESBL producer	76	38.0%	31.4 – 45.0
Non-ESBL producer	124	62.0%	55.0 – 68.6
Total	200	100.0%	—

TABLE 4: Antibiotic Susceptibility Comparison Between ESBL and Non-ESBL Producing Isolates

Antibiotic	ESBL Producers Susceptible (%)	Non-ESBL Producers Susceptible (%)
Ciprofloxacin	21.1	54.0
Cotrimoxazole	15.8	45.2
Gentamicin	51.3	85.5
Nitrofurantoin	72.4	96.0
Imipenem	92.1	99.2

Figure 3: Prevalence of ESBL Production Among E. coli Isolates (n=200)

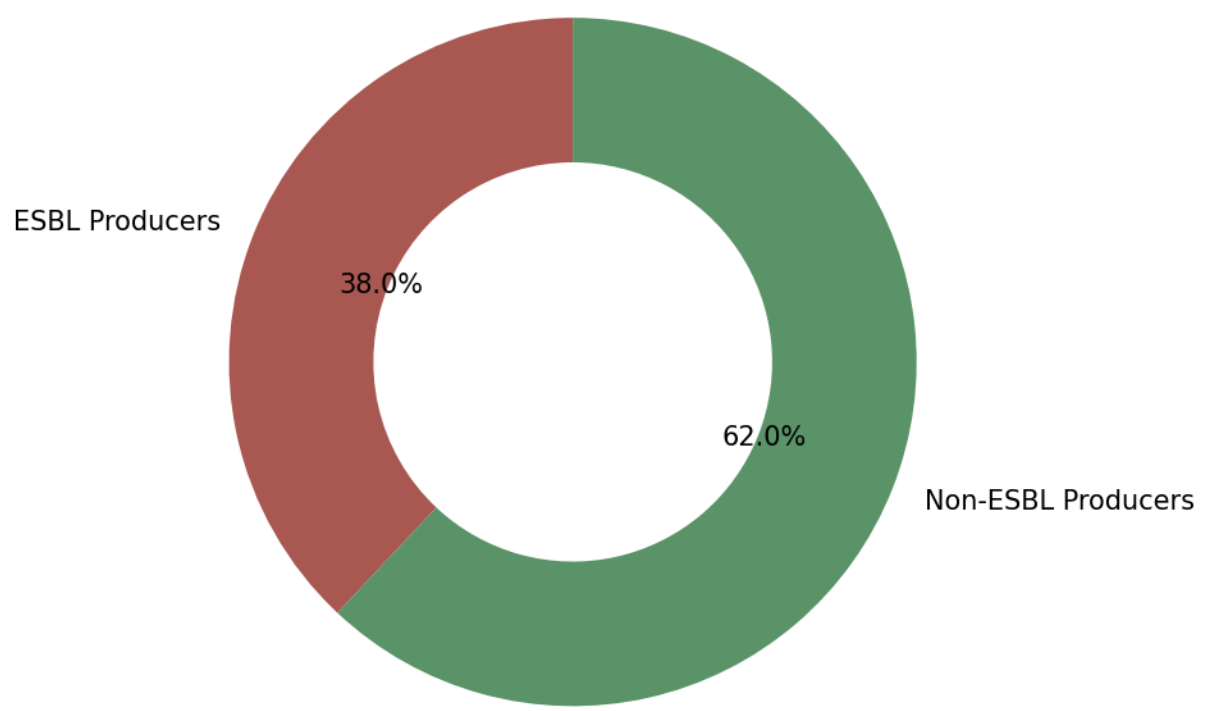


FIGURE 3:

TABLE 5: Risk Factors Associated with ESBL Production

Risk Factor	Category	OR	95% CI	P-value
Prior antibiotic use (within 3 months)	Present vs absent	3.42	1.86 – 6.29	<0.001
Hospital-acquired UTI	Present vs absent	2.94	1.58 – 5.47	0.001
Indwelling urinary catheter	Present vs absent	2.76	1.42 – 5.37	0.003
Diabetes mellitus	Present vs absent	2.18	1.19 – 3.99	0.012
Recurrent UTI (≥2 episodes/year)	Present vs absent	1.87	1.02 – 3.43	0.043

emergence and persistence of resistant organisms, a relationship extensively documented across the antimicrobial resistance literature. (6) Similarly, the association observed between hospital-acquired UTI, catheterisation, and ESBL production reflects the well-recognised role of the healthcare environment in the acquisition and transmission of resistant organisms, reinforcing international guidance, including that of the Infectious Diseases Society of America, emphasising judicious antibiotic use and infection

control practices in reducing this burden. (9) These findings collectively underscore the critical importance of local antibiogram-guided empirical antibiotic selection for UTI, given the substantial and clinically important divergence between susceptibility patterns of ESBL and non-ESBL producing isolates, and support continued institutional antimicrobial stewardship efforts, including restriction of empirical fluoroquinolone and cotrimoxazole use

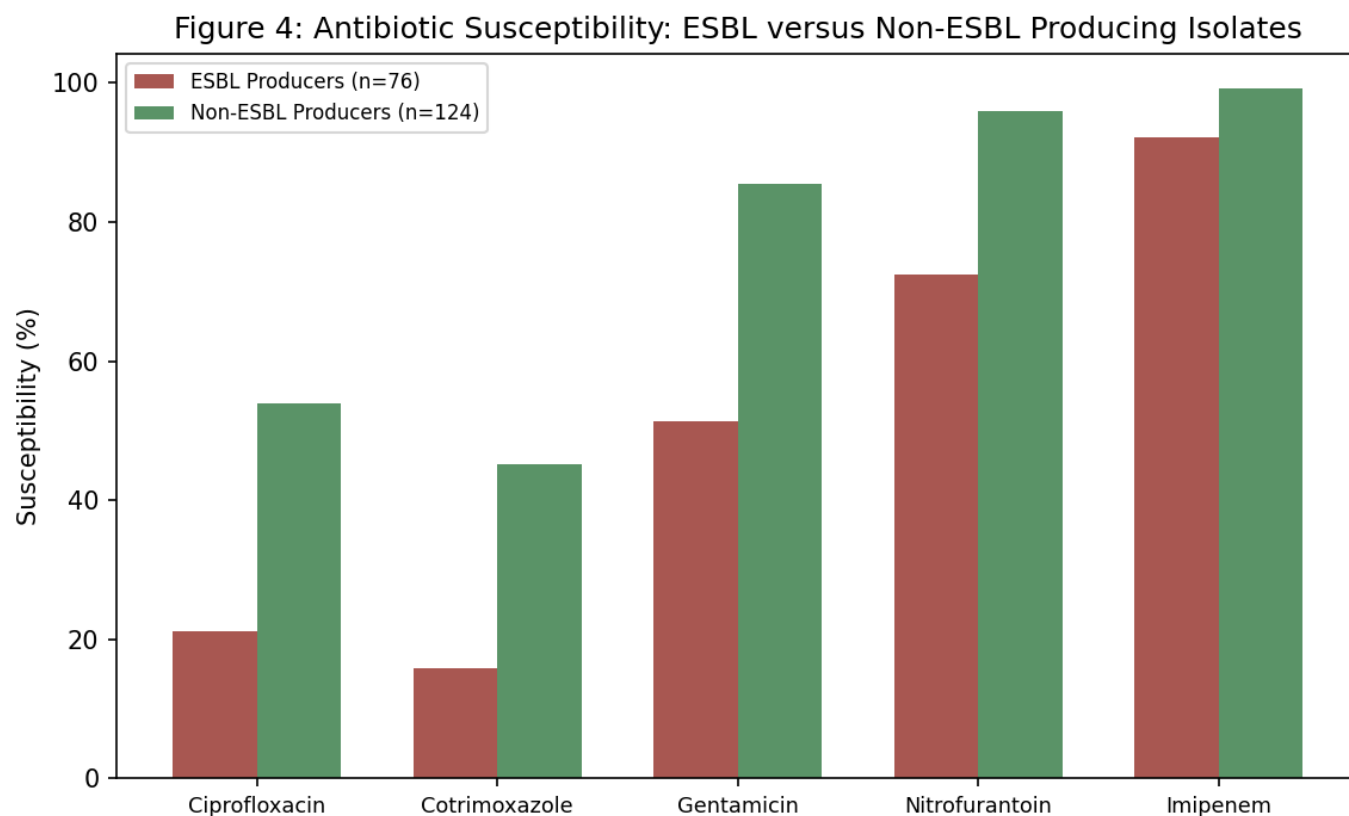


FIGURE 4:

Figure 5: Schematic Illustration of Disc Diffusion Antibiogram Patterns (Illustrative diagram, not an actual laboratory photograph)

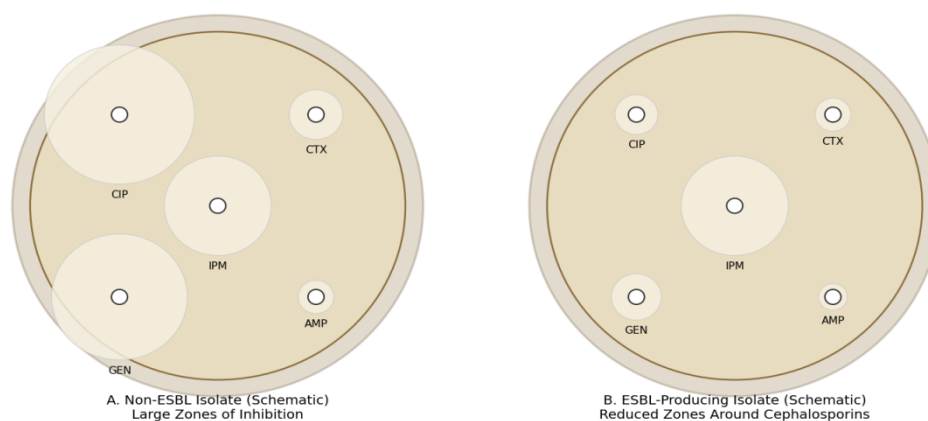


FIGURE 5: Schematic illustration of disc diffusionantibiogram patterns for a non-ESBL and an ESBL-producing isolate.

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in patients with identified risk factors for ESBL-producing infection. (8, 9)

5 | STRENGTHS AND LIMITATIONS

This study's strengths include comprehensive antimicrobial susceptibility testing across a broad antibiotic panel and phenotypic confirmation of ESBL production using a standardised method. Limitations include the single-centre, cross-sectional design, which limits generalisability to other healthcare settings with differing local resistance patterns; the absence of molecular characterisation of specific ESBL genes, which would have provided additional epidemiological insight; and reliance on phenotypic rather than genotypic methods for ESBL confirmation, which, while widely used and clinically validated, may have marginally lower sensitivity than molecular methods in detecting certain ESBL variants.

6 | CONCLUSION

A substantial proportion of *E. coli* urinary isolates in this population are ESBL producers with markedly reduced susceptibility to commonly prescribed oral antibiotics, particularly fluoroquinolones and cotrimoxazole. Prior antibiotic use and hospital-acquired infection were the strongest identified risk factors for ESBL production. These findings underscore the importance of local antibiogram-guided empirical therapy and continued antimicrobial stewardship to preserve the effectiveness of available antibiotic agents.

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How to cite this article: Kawase P.U. **Antimicrobial Susceptibility Pattern and Prevalence of Extended-Spectrum Beta-Lactamase Production Among Escherichia coli Isolates from Urinary Tract Infections at a Tertiary Care Hospital: A Cross-Sectional Study.** Innovative Journal of Medical and Health Science. 2018;896–903. <https://doi.org/10.15520/ijmhs/8-8-76>
