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EVALUATION OF DIAGNOSTIC FRAMEWORK OF UTI INFECTION CAUSED BY ESBL PRODUCING BACTERIA IN PREGNANT WOMEN

Nisha tamboli[1], Dr. Navneet kumar[2]

[1]Research scholar Teerthanker Mahaveer University College of Allied and Healthcare Sciences, Moradabad (UP) Orcid id - 0009 0002 2830 3700. Email: nishatamboli.scholar@tmu.ac.in
[2]Professor Teerthanker Mahaveer University College of Allied and Healthcare Sciences Moradabad (UP) Orcid id - 0000 0001 9573 0732, Email: principal.paramedical@tmu.ac.in

ABSTRACT:
Background: Pregnancy-related urinary tract infections can vary from asymptomatic bacteriuria to acute cystitis and pyelonephritis. If left untreated, these infections can cause maternal sepsis, premature labor, and low birth weight. ESBL-producing Gram-negative bacteria like Escherichia coli and Klebsiella pneumoniae reduce the efficacy of widely used antibiotics, making identification and treatment more difficult, while hormonal changes and ureteral dilatation during pregnancy enhance susceptibility to infection.
Objectives: Determine the frequency and pattern of ESBL-producing uropathogens, investigate their relationship to gestational age, and study antibiotic susceptibility and dosing practices in order to evaluate the diagnostic framework for UTIs in pregnancy.
Methods: From June 2025 to March 2026, 1,190 pregnant women with and without UTI symptoms participated in a hospital-based observational study. Antimicrobial susceptibility and ESBL generation were assessed in accordance with CLSI standards after midstream urine samples were cultured and organisms were identified using standard procedures and VITEK® 2 Compact.
Results: 208 women (17.5%) had culture-confirmed UTIs, mostly caused by K. pneumoniae and E. coli. 50.8% of significant Gram-negative pathogens were ESBL-producing isolates, with the third trimester having the highest prevalence (24.9%; $p < 0.001$). Fosfomycin and nitrofurantoin were good choices for simple lower UTIs, while carbapenems, particularly meropenem, had the highest susceptibility and were more frequently used for severe infections.
Conclusion: Pregnancy-related UTIs are frequently caused by ESBL-producing E. coli and K. pneumoniae, which have significant multidrug resistance and an increased risk in the later trimesters. To enhance maternal-fetal outcomes and promote antibiotic stewardship, routine urine culture, early ESBL detection, and susceptibility-guided therapy—using carbapenems for severe infections and fosfomycin or nitrofurantoin for susceptible lower UTIs—are essential.

KEYWORDS: CRISPR-Cas systems; Antimicrobial resistance; multidrug-resistant pathogens; precision antimicrobial therapy; genome editing.

INTRODUCTION

Urinary tract infection (UTI) is a spectrum of disease caused by microbial invasion of the genitourinary tract that extends from the renal cortex of the kidney to the urethral meatus. (Shakya, Pooja, et al.) This study was performed with the objective to examine the diagnostic framework of urinary tract infection in pregnancy and physician response to the clinical diagnosis, and to correlate response to the result of urine culture and sensitivity. (Jido, T. A. 2014).
Urinary tract infections are a common consequence of pregnancy. Examples of UTIs include pyelonephritis, acute cystitis, and asymptomatic bacteriuria (a positive urine culture in an asymptomatic woman).
Acute cystitis affects 1-4% of pregnant women, and asymptomatic bacteriuria is common throughout pregnancy. Pregnancy-related UTIs can arise for a variety of reasons. Ureteral dilatation, which is believed to be caused by hormonal influences and mechanical compression from the expanding uterus, is one significant reason. Pyelonephritis risk is increased by ureteral dilatation, which can allow germs to go from the bladder to the kidney.
A higher risk of preterm delivery and low birth weight has been linked to asymptomatic bacteriuria during pregnancy. Pyelonephritis may develop later in pregnancy in 20–40% of pregnant women with asymptomatic bacteriuria if treatment is not received. Therefore, in order to lower the incidence of pyelonephritis in pregnant women with asymptomatic bacteriuria, antibiotic treatment is recommended.
Pregnancy-related pyelonephritis needs to be treated quickly and aggressively because it might have major repercussions such maternal sepsis, preterm labor, and early delivery.
Antibiotics administered intravenously and hospitalization are typically necessary. Typically, intravenous antibiotics are administered until the patient has been afebrile for 48 hours. For ten to fourteen days, oral antibiotics are administered.In

order to make an accurate diagnosis, it is essential for practitioners to understand the value and limitations of urinalysis and urine cultures. Use of these tests in conjunction with an assessment of urinary symptoms will yield a diagnosis of either asymptomatic bacteriuria or symptomatic UTI. (Bates, B. 2013).

One of the leading antimicrobial resistance mechanisms for many UTI-causing Gram-negative bacteria is extended-spectrum beta-lactamase (ESBL) enzyme production, which hydrolyzes the beta-lactam ring of antimicrobials. This confers bacterial resistance to commonly prescribed antibiotics, including: penicillin, carbapenem , nitrofurantoin. (Belete, M.A. 2020).

Patients and methods: Study design, region, and time frame: Sarvodaya Hospital and Research Center hosted an observational research from June 2025 to March 2026. Using a convenient sample technique, 1190 pregnant women with and without UTI symptoms were included.

Data and specimen collection: A standardized data collection form was used to gather clinical and demographic information, such as age, gestational age, obstetric history, and clinical symptoms. Every pregnant lady had a clean-catch midstream urine specimen taken under aseptic circumstances. The samples were quickly sent to the microbiology lab so that uropathogens could be cultured and identified using standard microbiological techniques. Significant bacterial isolates underwent ESBL detection and antibiotic susceptibility testing in accordance with CLSI standards.

Cultivation and isolate identification: Urine samples were cultivated on Cysteine Lactose Electrolyte Deficient (CLED) agar using a calibrated loop and aerobically incubated for 18–24 hours at 35–37°C.Gram staining, colony morphology, routine biochemical tests, or an automated identification system called VITEK 2 Compact were used to identify significant bacterial growth ($\geq 10^1$ CFU/mL). Standard microbiological techniques were used to identify significant uropathogens.

Antimicrobial susceptibility testing: The VITEK® 2 Compact automated system was used to conduct antimicrobial susceptibility testing (AST) on all relevant bacterial isolates. The Clinical and Laboratory Standards Institute (CLSI) criteria were followed in the interpretation of the results. Based on the system-generated minimum inhibitory concentration (MIC) values, isolates were classified as susceptible, intermediate, or resistant.

As appropriate for each organism, the antibiotic panel comprised ertapenem, imipenem, meropenem, nitrofurantoin, fosfomycin (only for E. coli), piperacillin-tazobactam, gentamicin, and trimethoprim-sulfamethoxazole.

Extended-spectrum beta-lactamase detection: The VITEK® 2 Compact automated system (bioMérieux, France) was used to identify ESBL synthesis, which was then interpreted in accordance with CLSI recommendations. Isolates of K. pneumoniae and E. coli that were found to produce ESBL were added for additional examination.

Conflict of interest and ethical approval: The authors declared that they had no conflicts of interest and received ethical approval from the Teerthankar Mahaveer University Institutional Review Board.

Results: The study included 1,190 pregnant women in total. Of these, 982 (82.5%) had no discernible bacterial growth, while 208 (17.5%) had urinary tract infections (UTIs) confirmed by culture.

Table 1: Distribution of Antibiotic Therapy Used for ESBL-Producing UTIs in Pregnant Women.

Total pregnant women enrolled = 1,190

Pregnant women with ESBL-producing UTI = 208

Antibiotic Used	Number of ESBL UTI Patients (n = 208)	Percentage (%)
Meropenem	62	29.8
Ertapenem	34	16.3
Fosfomycin	48	23.1
Nitrofurantoin	39	18.8
Piperacillin–Tazobactam	15	7.2
Imipenem–Cilastatin	6	2.9
Amikacin	4	1.9
Total	208	100.0

Among the 208 pregnant women diagnosed with ESBL-producing UTIs, Meropenem was the most frequently prescribed antibiotic, administered to 62 (29.8%) patients. This was followed by Fosfomycin (48; 23.1%), Nitrofurantoin (39; 18.8%), and Ertapenem (34; 16.3%). Piperacillin–Tazobactam was prescribed in 15 (7.2%) cases, while Imipenem–Cilastatin (6; 2.9%) and Amikacin (4; 1.9%) were used less frequently. Carbapenems were predominantly reserved for severe or complicated infections, whereas Fosfomycin and Nitrofurantoin were commonly prescribed for uncomplicated lower UTIs when the isolates were susceptible.

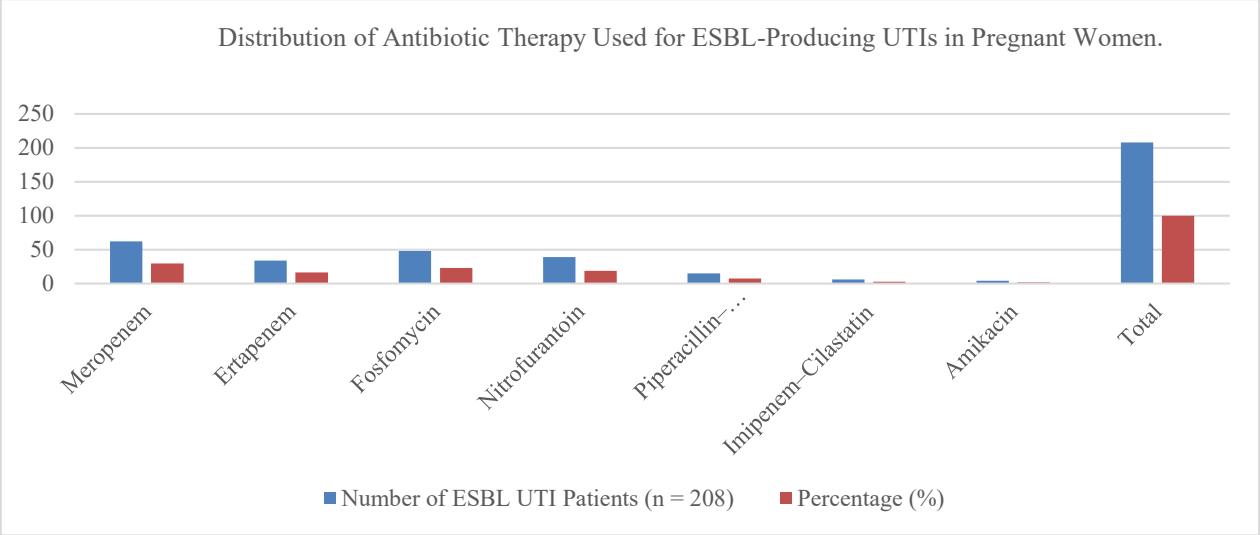

Table 2. Prevalence of Isolation of Various Significant Uropathogens in Urine of Pregnant Women (n = 1,190)

Isolated Uropathogen	Number of Isolates (n)	Prevalence (%)
Escherichia coli	128	10.8
Klebsiella pneumoniae	46	3.9
Enterococcus faecalis	18	1.5
Proteus mirabilis	8	0.7
Pseudomonas aeruginosa	4	0.3
Staphylococcus saprophyticus	3	0.3
Citrobacter freundii	1	0.1
Total Culture-Positive UTI Cases	208	17.5
Culture-Negative Samples	982	82.5
Total Samples	1,190	100.0

Escherichia coli accounted for 128 (10.8%) of the culture-positive isolates, making it the most common uropathogen. Klebsiella pneumoniae came in second with 46 (3.9%). Enterococcus faecalis (18; 1.5%), Proteus mirabilis (8; 0.7%), Pseudomonas aeruginosa (4; 0.3%), Staphylococcus saprophyticus (3; 0.3%), and Citrobacter freundii (1; 0.1%) were among the other bacterial isolates.

Gestational age had an impact on the prevalence of ESBL-producing UTIs. The first trimester had the lowest prevalence (11.2%), while the third trimester had the highest frequency (24.9%), followed by the second trimester (14.7%). ESBL-producing UTI was shown to be significantly correlated with gestational age ($\chi^2 = 15.84$, df = 2, $p < 0.001$), suggesting that the risk of ESBL-producing UTI rose as pregnancy progressed.

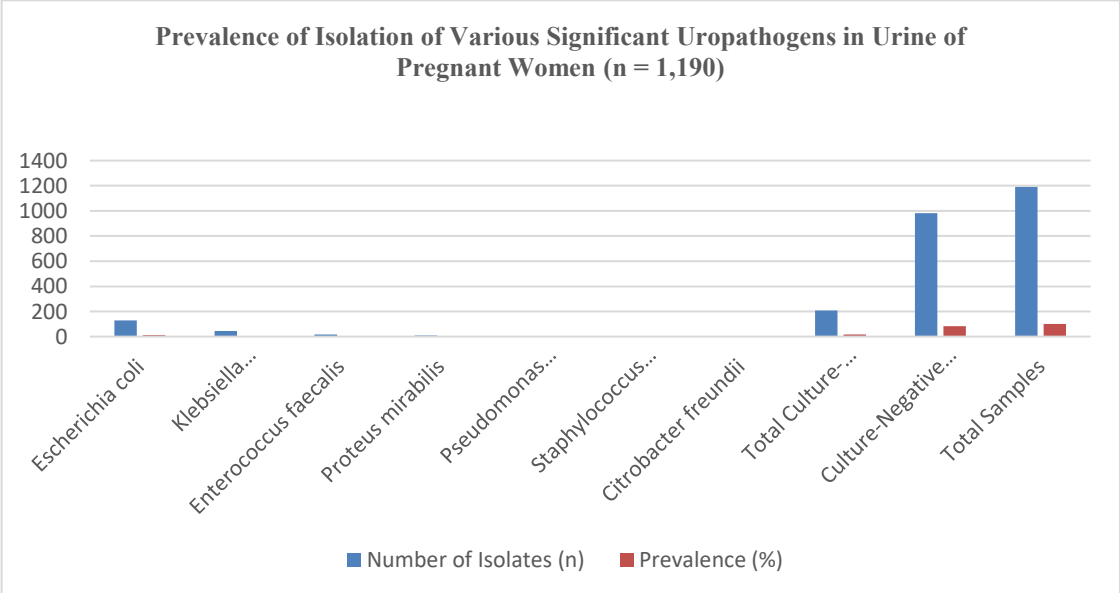

Table3: Prevalence of ESBL-Producing UTIs in Pregnant Women According to Gestational Age.

Gestational Age (Trimester)	Total Pregnant Women (n)	ESBL UTI Positive (n)	ESBL UTI Negative (n)	Prevalence (%)
First Trimester (1–12 weeks)	250	28	222	11.2
Second Trimester (13–27 weeks)	530	78	452	14.7
Third Trimester (28–40 weeks)	410	102	308	24.9
Total	1,190	208	982	17.5

• There were 1,190 pregnant women in the research.
• 208 (17.5%) pregnant women had ESBL-producing UTIs that were verified by culture.
• As gestational age grew, so did the prevalence of UTIs that produced ESBL.
• The first trimester (11.2%) had the lowest prevalence, whereas the third trimester (24.9%) and second trimester (14.7%) had the highest prevalence.

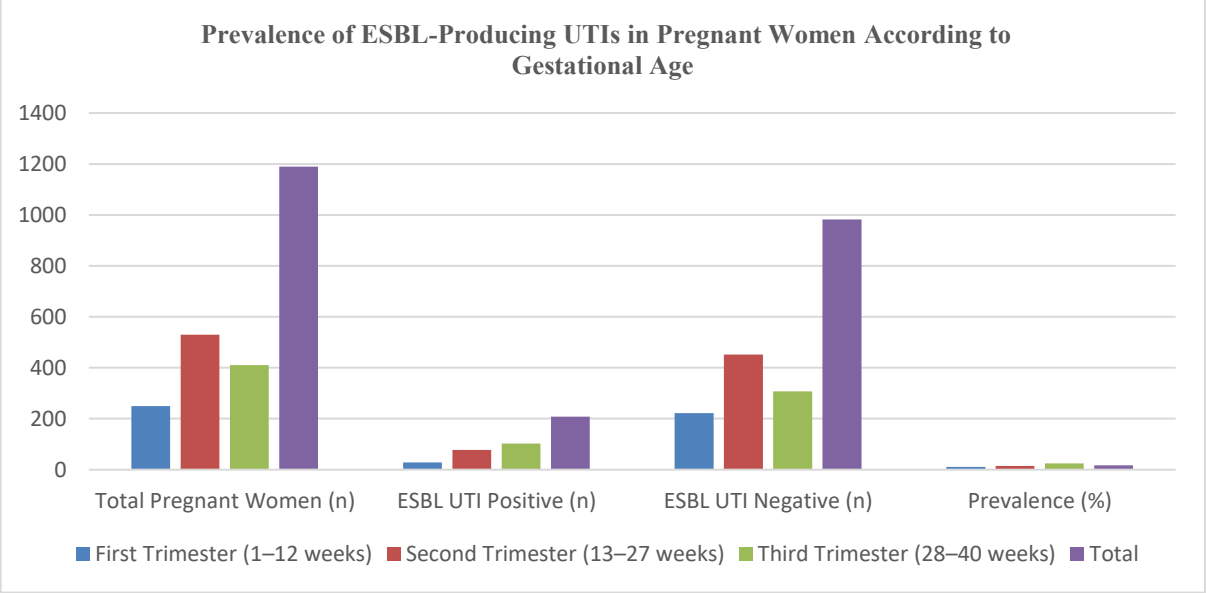

Table 4. Distribution of ESBL-Producing Uropathogens Isolated from Pregnant Women

Organism	Total Isolates (n)	ESBL Positive (n)	ESBL Rate (%)
Escherichia coli	128	74	57.8
Klebsiella pneumoniae	46	21	45.7
Proteus mirabilis	12	3	25.0
Enterobacter cloacae	8	2	25.0
Citrobacter freundii	5	1	20.0
Total	199	101	50.8

Escherichia coli was the most prevalent uropathogen that produced ESBL, accounting for 74 (57.8%) of the isolates. With 21 (45.7%) ESBL-positive isolates, Klebsiella pneumoniae finished second.

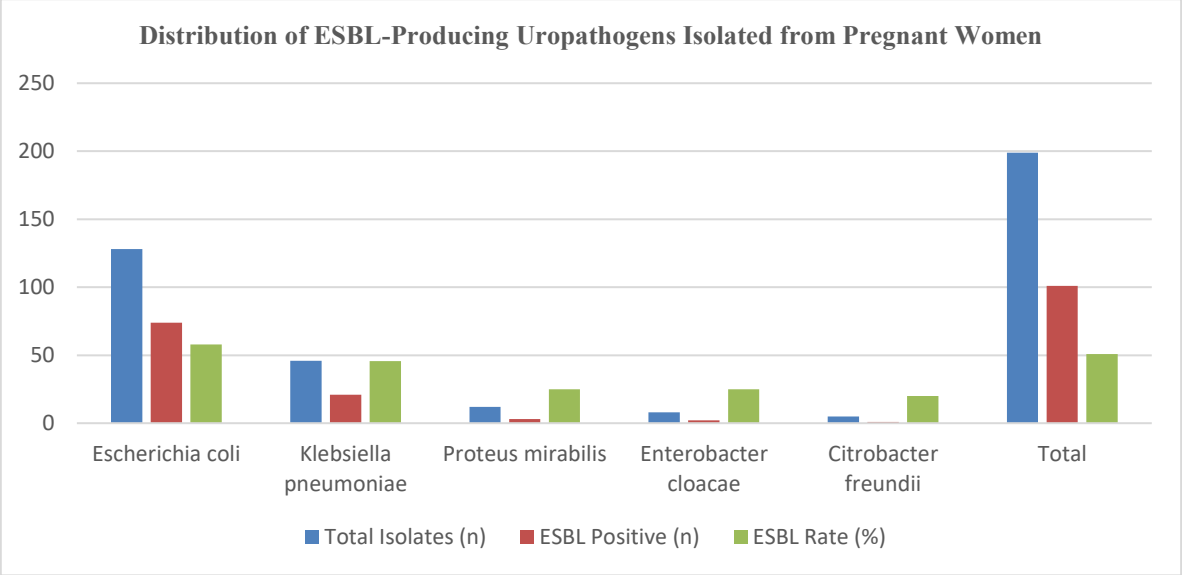

Table 5. ESBL-Producing Uropathogens' Antibiotic Susceptibility Pattern Removed from Expectant Mothers (n = 101)

Antibiotic	Sensitive, n (%)	Resistant, n (%)
Meropenem	99 (98.0)	2 (2.0)
Ertapenem	97 (96.0)	4 (4.0)
Imipenem	98 (97.0)	3 (3.0)
Fosfomycin	89 (88.1)	12 (11.9)
Nitrofurantoin	83 (82.2)	18 (17.8)
Amikacin	91 (90.1)	10 (9.9)
Piperacillin–Tazobactam	79 (78.2)	22 (21.8)
Gentamicin	62 (61.4)	39 (38.6)
Ciprofloxacin	24 (23.8)	77 (76.2)
Cefuroxime	18 (17.8)	83 (82.2)
Ceftriaxone	15 (14.9)	86 (85.1)
Trimethoprim–Sulfamethoxazole	32 (31.7)	69 (68.3)
Amoxicillin–Clavulanic Acid	41 (40.6)	60 (59.4)

The carbapenems (ertapenem, imipenem, and meropenem) showed the greatest vulnerability to isolates that produced ESBL. When appropriate, fosfomycin and nitrofurantoin may be used to treat simple lower urinary tract infections during pregnancy. The multidrug resistance of ESBL-producing organisms was confirmed by the high resistance seen against third-generation cephalosporins, especially ceftriaxone and cefuroxime.

Overall, the results show that carbapenems, especially Meropenem, were the most commonly utilized treatment for ESBL-producing infections, that Escherichia coli continued to be the primary source of ESBL-associated UTIs in pregnancy, and that the prevalence of infection rose with gestational age.

Discussion: The current study showed that Escherichia coli was the most common uropathogen, followed by Klebsiella pneumoniae, and that 17.5% of pregnant women had culture-confirmed UTIs. These results are in line with earlier research that identified E. coli as the primary cause of UTIs during pregnancy. As gestational age increased, the frequency of ESBL-producing UTIs rose, indicating that anatomical and physiological changes during pregnancy may make an individual more vulnerable to infection.Escherichia coli is the most common pathogenic microorganisms associated with both asymptomatic and symptomatic bacteriuria and accounting up 60–80% of all UTIs in pregnancy. (Azami, M.,et al)

Due to its excellent effectiveness against organisms' resistant to several drugs, meropenem was the most often given antibiotic for UTIs caused by ESBL. Because of their good safety profile during pregnancy and activity against susceptible isolates, fosfomycin and nitrofurantoin were frequently utilized for simple lower UTIs. In order to improve maternal and fetal outcomes while reducing the establishment of antibiotic resistance, the results highlight the significance of early urine culture, antimicrobial susceptibility testing, and appropriate targeted therapy.

Taking everything into account, this analysis highlights the necessity of regular screening, prompt diagnosis, and evidence-based antibiotic selection for the successful treatment of ESBL-producing UTIs in expectant mothers.

CONCLUSION:

Urinary tract infections during pregnancy are frequently caused by Escherichia coli and Klebsiella pneumoniae that produce ESBL.Antimicrobial susceptibility testing, early ESBL identification, and routine urine culture enable prompt, focused treatment. While fosfomycin and nitrofurantoin are useful therapy for sensitive lower UTIs, carbapenems continue to be the most dependable option for severe infections. Antimicrobial stewardship and maternal and newborn outcomes may be enhanced by integrating culture-guided management into prenatal treatment.

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