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Original Research Article

Comparative Study of Antibiotic Sensitivity Pattern in Clinical Versus Environmental Strains of Escherichia Coli

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Abstract

Background: Escherichia coli is a leading pathogen in both hospital and community settings and a well-recognized indicator organism in environmental surveillance. The emergence of multidrug-resistant (MDR) strains in clinical as well as environmental reservoirs poses a serious public health challenge.

Aim: To compare the antibiotic susceptibility patterns of clinical and environmental E. coli isolates and to evaluate the prevalence of multidrug resistance between the two groups.

Methods: A cross-sectional comparative study was conducted at Darbhanga Medical College & Hospital from February 2025 to November 2025. A total of 100 E. coli isolates were included (50 clinical isolates from patients and 50 environmental isolates from water and hospital surroundings). Identification was done by standard microbiological techniques. Antibiotic susceptibility testing was performed using Kirby–Bauer disc diffusion method as per CLSI 2024 guidelines. Statistical analysis was performed using Chi-square test with $p < 0.05$ considered significant.

Results: Clinical isolates showed significantly higher resistance to third-generation cephalosporins (68%), fluoroquinolones (72%), and aminoglycosides (46%) compared to environmental isolates (38%, 44%, and 22% respectively; $p < 0.05$). Carbapenem resistance was observed in 14% of clinical isolates and 4% of environmental isolates. MDR prevalence was significantly higher in clinical strains (58%) than environmental strains (28%) ($p = 0.002$).

Conclusion: Clinical isolates demonstrated significantly higher multidrug resistance compared to environmental strains. However, emerging resistance in environmental isolates highlights the need for integrated antimicrobial stewardship and environmental surveillance strategies.

Keywords: Escherichia coli, Antibiotic resistance, Multidrug resistance, Clinical isolates, Environmental strains.

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Introduction

Escherichia coli is a Gram-negative bacillus belonging to the family Enterobacteriaceae and is both a commensal organism of the human intestine and a major opportunistic pathogen [1]. It is one of the most common causes of urinary tract infections (UTI), septicemia, wound infections, and neonatal meningitis [2]. Simultaneously, E. coli serves as an important indicator organism for fecal contamination in environmental samples, particularly water sources [3].

The rapid emergence of antimicrobial resistance (AMR) in E. coli has become a global concern [4]. The World Health Organization has identified extended-spectrum beta-lactamase (ESBL)-producing and carbapenem-resistant Enterobacteriaceae as critical priority pathogens [5]. Resistance to commonly used antibiotics such as cephalosporins, fluoroquinolones, and aminoglycosides has been increasingly reported in India and worldwide [6,7].

Clinical isolates are often exposed to high antibiotic pressure in hospital settings, resulting in increased resistance rates [8]. However, environmental strains are also emerging as reservoirs of resistant genes due to antibiotic contamination of water bodies, hospital effluents, and agricultural runoff [9,10]. Studies have demonstrated the transmission of resistance genes

between environmental and clinical strains through horizontal gene transfer mechanisms [11]. In India, rising antimicrobial misuse and poor sanitation contribute to dissemination of resistant E. coli strains [12]. Comparative analysis between clinical and environmental isolates helps in understanding the epidemiology and transmission dynamics of resistance patterns [13]. Although several studies have separately evaluated resistance in clinical or environmental strains, limited research directly compares both populations within the same geographical region. This study aims to comparatively evaluate antibiotic sensitivity patterns between clinical and environmental E. coli isolates in a tertiary care hospital setting in Bihar, India.

Materials and Methods

Study Design and Setting: This hospital-based cross-sectional comparative study was conducted in the Department of Microbiology at Darbhanga Medical College & Hospital over a period of eleven months, from 05 February 2025 to 25 November 2025. The study was designed to compare the antibiotic susceptibility patterns of clinical and environmental strains of Escherichia coli isolated during the study period. Institutional ethical approval was obtained prior to commencement of the study, and patient confidentiality was strictly maintained.

Study Population and Sample Collection: A total of 100 non-duplicate E. coli isolates were included in the study. Among these, 50 isolates were obtained from clinical samples collected from patients attending inpatient and outpatient departments, while 50 isolates were recovered from environmental sources within and around the hospital premises. Clinical samples included urine, blood, pus, sputum, and wound swabs submitted to the microbiology laboratory for routine diagnostic purposes. Only one isolate per patient was included to avoid duplication. Environmental samples were collected from hospital wastewater outlets, nearby surface water bodies, drainage systems, and high-contact hospital surfaces. Water samples were collected in sterile containers and transported immediately to the laboratory for processing. Surface samples were obtained using sterile swabs moistened with normal saline and inoculated onto culture media within one hour of collection.

Isolation and Identification of E. Coli: All samples were cultured on MacConkey agar and blood agar plates and incubated aerobically at 37°C for 18–24 hours. Lactose-fermenting colonies showing characteristic morphology were further processed. Identification of E. coli was performed using standard microbiological techniques, including Gram staining, motility testing, and biochemical reactions such as Indole, Methyl Red, Voges–Proskauer, and Citrate (IMViC) tests. Only confirmed E. coli isolates were included in the final analysis.

Antibiotic Susceptibility Testing: Antimicrobial susceptibility testing was performed using the Kirby–Bauer disc diffusion method on Mueller–Hinton agar as per Clinical and Laboratory Standards Institute (CLSI) 2024 guidelines. A standardized inoculum equivalent to 0.5 McFarland turbidity was prepared for each isolate and uniformly inoculated onto the agar surface.

Antibiotic discs tested included ampicillin (10 µg), amoxicillin-clavulanate (20/10 µg), ceftriaxone (30 µg), ceftazidime (30 µg), ciprofloxacin (5 µg), gentamicin (10 µg), amikacin (30 µg), piperacillin–tazobactam (100/10 µg), and imipenem (10 µg). After incubation at 37°C for 16–18 hours, zone diameters were measured and interpreted as sensitive, intermediate, or resistant according to CLSI breakpoints.

Detection of Multidrug Resistance and ESBL Production: Multidrug resistance (MDR) was defined as resistance to at least three different classes of antimicrobial agents. Screening for extended-spectrum beta-lactamase (ESBL) production was performed in isolates showing reduced susceptibility to third-generation cephalosporins. Phenotypic confirmation was done using the combined disc method with cefotaxime and cefotaxime-clavulanate discs.

A ≥5 mm increase in zone diameter in the presence of clavulanate was considered confirmatory for ESBL production. Carbapenem resistance was determined based on resistance to imipenem according to CLSI interpretive criteria.

Quality Control: Quality control for antimicrobial susceptibility testing was maintained using standard reference strain Escherichia coli ATCC 25922. All media and antibiotic discs were quality-checked before use.

Statistical Analysis: Data were entered into Microsoft Excel and analyzed using statistical software. Categorical variables were expressed as frequencies and percentages. The Chi-square test was applied to compare resistance patterns between clinical and environmental isolates. A p-value of less than 0.05 was considered statistically significant.

Results

Table 1: Distribution of Isolates

Source	Number (n=100)	Percentage (%)
Clinical	50	50%
Environmental	50	50%

Table 2: Antibiotic Resistance Pattern (%)

Antibiotic	Clinical (%)	Environmental (%)	p-value
Ampicillin	84	62	0.01
Amox-Clav	70	48	0.02
Ceftriaxone	68	38	0.003
Ciprofloxacin	72	44	0.004
Gentamicin	46	22	0.01
Amikacin	28	22	0.04
Piperacillin-Tazobactam	18	8	0.09
Imipenem	14	4	0.08

Table 3: MDR Prevalence

Category	Clinical (n=50)	Environmental (n=50)	p-value
MDR	29 (58%)	14 (28%)	0.002
Non-MDR	21 (42%)	36 (72%)	

Table 4: ESBL and Carbapenem Resistance

Parameter	Clinical (%)	Environmental (%)
ESBL Producers	40	18
Carbapenem Resistant	14	4

Discussion

The present study demonstrated significantly higher antimicrobial resistance in clinical E. coli isolates compared to environmental strains. Ampicillin resistance was highest among both groups, consistent with global reports of widespread beta-lactam resistance [4,6].Ceftriaxone resistance in clinical isolates (68%) aligns with previous Indian studies reporting 60–75% resistance rates [7,12]. Environmental isolates showed comparatively lower resistance (38%), though still substantial, indicating dissemination of resistant strains beyond hospital settings [9].

Fluoroquinolone resistance (72% clinical vs 44% environmental) reflects heavy empirical use in UTIs and systemic infections [8]. Similar findings were reported in multicentric surveillance studies in India [6].MDR prevalence was significantly higher in clinical isolates (58%), comparable to findings from tertiary care centers reporting 50–65% MDR prevalence [7,13]. Environmental isolates demonstrated 28% MDR rate, which is concerning and suggests contamination of environmental reservoirs [10].

Carbapenem resistance was relatively lower (14% clinical), consistent with emerging but not yet dominant carbapenemase spread in eastern India [12]. However, detection in environmental samples (4%) suggests potential community dissemination pathways.The findings support the hypothesis that hospitals act as amplifiers of resistance due to antibiotic selection pressure [8]. Nevertheless, environmental contamination plays a contributory role, acting as a reservoir and transmission bridge [9,11].

The study reinforces the importance of antimicrobial stewardship programs and environmental monitoring. Integrated “One Health” approaches targeting hospital waste management and rational antibiotic use are urgently needed. Limitations include single-center design and lack of molecular characterization of resistance genes.

Conclusion

Clinical *E. coli* isolates exhibited significantly higher resistance and MDR prevalence compared to environmental strains. However, the presence of resistant environmental isolates indicates growing public health risks. Continuous surveillance and antimicrobial stewardship are imperative to prevent further spread.

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