

Investigating the Prevalence of Pathogens and Drug Sensitivity in Catheter-Associated Urinary Tract Infections among ICU Patients: Insights from a Hospital-Based Cross-Sectional Study

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ABSTRACT

Background: Catheter-Associated Urinary Tract Infections (CAUTIs) pose a major concern in Intensive Care Units (ICUs) due to their association with prolonged catheterization and severe underlying conditions. These infections often contribute to significant complications, lengthy hospitalizations, and higher medical expenses. Understanding pathogens' prevalence and antibiotic resistance profiles is pivotal for appropriate management and therapy. **Aim:** This study aims to investigate the Prevalence of Pathogens and Drug Sensitivity in CAUTIs among ICU Patients. **Materials and Methods:** A hospital-based cross-sectional observational research was carried out in Medicine ICU over six months. The study included 753 patients catheterized for more than 24 hr. Urine samples were collected until discharge, expiration, catheter removal, or bacteriuria development, and processed according to standard protocols. Data were analyzed using a CAUTI surveillance form to confirm diagnoses based on signs and symptoms. **Results:** Among 753 catheterized patients, 17% were aged 41-80, with a nearly equal gender distribution (51% female, 49% male). The most prevalent pathogen in urine culture was *E. coli* (40%) followed by *Enterococcus fecium* (24%), with *Pseudomonas aeruginosa*, *Acinetobacter baumannii*, and *Klebsiella pneumoniae* (12% each) following. Patients (0.132%) tested positive for CAUTI over three 7-day periods. Fosfomycin, Amikacin, and Nitrofurantoin were highly effective against *E. coli*, while Meropenem, Amikacin, and Imipenem were most effective for *Klebsiella pneumoniae*. Teicoplanin and vancomycin were most effective against *Enterococcus* spp., with fluoroquinolones showing the least sensitivity overall. **Conclusion:** Although CAUTI was rare (0.132%) in this study, it poses a significant risk for severely ill patients. Implementing strict catheter management and a routine antibiogram framework can improve infection control and treatment outcomes.

Keywords: Hospital-acquired infections, Prevalence Rate, Catheter-Associated Urinary Tract Infection, Urinary Tract Infection.

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INTRODUCTION

Healthcare-Associated Infections (HAIs) have become a significant worldwide health concern that has been linked to an elevated incidence of morbidity and death (Alamer *et al.*, 2022). Bloodstream infections from central lines, ventilator-associated pneumonia, surgical site infections, hospital-associated pneumonia, Urinary Tract Infections (UTI) linked with catheters, and *Clostridium difficile* infections are examples of HAIs (Dadi *et al.*, 2021). According to a prevalence assessment carried out by the World Health Organisation (WHO) in 55 hospitals across

14 countries that comprise the four WHO Regions (Eastern Mediterranean, Europe, Western Pacific, and Southeast Asia), the average number of hospital patients with nosocomial infections was 8.7% (Raoofi *et al.*, 2023). In acute care and long-term care institutions throughout the European Union, there were an estimated 8.9 million distinct HAI events that occur annually” (Puro *et al.*, 2022). The seven institutions that comprise the global infection control consortium demonstrated total CAUTI infection rates of 1.41 per 1000 catheter days across seven Indian cities (Vincent *et al.*, 1995). As per a 2015 point-prevalence survey in the US, in acute hospital settings, the top causes of HAIs were pneumonia, bloodstream infections, UTI, Gastrointestinal (GI) infections, sexually transmitted infections, and other systemic diseases (Mehta *et al.*, 2007). In 2011, point-prevalence surveys showed that the leading diseases were SSI (21.8%) and pneumonia (21.8%), with bloodstream (9.9%), UTI (12.9%), and GI (17.1%),



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and other infections following closely behind. The frequency of these illnesses has changed since then (Werneburg, 2022). Urinary tract infections related to catheter usage accounted for 40 to 50% of all hospital infections. Every year, more than five million people have urinary catheters placed in acute-care and long-term care institutions in the United States alone (Jacobsen *et al.*, 2008). In 70-80% of instances, catheter usage remains the main source of nosocomial-acquired UTIs or CAUTI (Shen *et al.*, 2023). These studies have led to the conclusion that CAUTI is the highly prevalent infection source related to hospitals and has been linked to higher rates of morbidity and death.

A patient has been considered to have symptomatic CAUTI if they have an indwelling catheter for at least 24 hr and then develop UTI symptoms (Letica-Kriegel *et al.*, 2019). If the catheter had been taken out after two days and the UTI characteristics were satisfied the same day or the following day, it was also regarded as a CAUTI (Cortes-Penfield *et al.*, 2017). The symptoms can be limited to the urinary tract, or they can involve systemic manifestations that are inexplicable, such as fever. For bacteriuria, several acceptable levels vary from 10³ to 10⁵ cfu/mL (Obaid *et al.*, 2023). The most frequent bacteria that cause CAUTIs in hospitalized patients have been associated are *E. coli*, *K. pneumoniae*, *P. aeruginosa*, and *E. faecalis* (Huang *et al.*, 2023). The high incidence may be caused by several factors, including the patient's gender, aseptic task regulations, catheter care, and catheterization time (Ahmed *et al.*, 2019). The increased antibiotic resistance in uropathogens has been a sign that signifies the need to have hospital-acquired and therefore found challenging to cure (Salam *et al.*, 2023).

In these situations, high microbial exposure levels frequently resulted in the isolation of organisms resistant to antibiotics. CAUTIs have been revealed as a significant contributor of antibiotic resistance, and patients requiring catheters were more vulnerable to cross-infections when medications were mistakenly utilized (Doctoroff *et al.*, 2020). Longer hospital stays and greater healthcare expenses result from this, which affects the hospital as well as the patients (Teng *et al.*, 2023; Perdana *et al.*, 2023). By assisting in the development of efficient infection control measures, this study will help lower the prevalence of CAUTI.

MATERIALS AND METHODS

Study design

A cross-sectional observational study was carried out in the intensive care unit (ICU) of the medicine department, Maharishi Markandeshwar Institute of Medical Sciences and Research Hospital (MMIMSR) in Mullana, Ambala. This one-year study (2022-23) assessed the prevalence of CAUTIs and the antibiotic susceptibility of pathogens in ICU catheterized patients, after informed consent and acceptance from the Institutional Ethical Committee of MMIMSR with approval number (ethical approval no. 2339) and following declaration of Helsinki.

Inclusion Criteria

The study population included adult patients with a urinary catheter for at least 24 hr, where samples were collected until discharge; death; resolution from the indication of antibiotic treatment (if suspicious or documented bacterial infection) within the first 48 hr after sampling; loss of function of the anatomical site from which samples were collected; Progression may exhibit signs such as CAUTI, bacteriuria, and bacteremia in catheterized adult patients.

Exclusion criteria

Exclusion Criteria included previous UTI diagnoses, recent antibiotic treatment, and immune-compromised.

Study Procedure

A systematic surveillance form was used to collect demographic and clinical data, as well as signs and symptoms, from all catheterized patients. Name, age, gender, residence, IP number, date of admission, physical examination results, clinical diagnosis information, and clinical data (past medical history, personal history, high-risk factors, presenting complaints, and immunocompromised condition) were all documented. There was a noted indication for Foley's catheter. Every day, the patients were checked for symptoms of UTI, including fever, pain in the suprapubic region, and tenderness in the costovertebral angle. Until they experienced bacteriuria, were discharged, expired, or had their catheter removed, patients were monitored. Both the length of catheterization and the date of catheter removal were noted. For up to 48 hr, patients who were switched to a separate ward were watched for the onset of CAUTI symptoms.

Statistical analysis

Descriptive statistics, prevalence calculations, and inferential statistics like the Chi-Square test (Pearson's chi-square test) and logistic regression have been used for data analysis to determine the predictors of CAUTIs and organisms isolated with a *p*-value < 0.05 as significant and were presented as frequencies and percentages.

RESULTS

The incidence of CAUTI in 911 ICU patients was assessed over three survey periods, out of which 753 patients were observed to be catheterized. In a one-week prevalence survey in the study site's ICU, 290 patients were screened in the first survey, with 231 being catheterized. This resulted in a catheterization rate of 79.7%. This initial survey reflects a significant reliance on catheters within this patient population. The second Survey showed a slight decline in the overall number of patients to 266, but the number of catheterized patients remained relatively high at 216, yielding a catheterization rate of 81.0%. This suggests consistent catheter use, despite a decrease in overall patient volume. Finally,

the third Survey indicated an increase in total patients to 355, with 306 catheterized, resulting in the highest catheterization rate of 86.2%. This increase may be linked to a higher incidence of severe cases requiring catheterization, potentially influenced by seasonal changes. The overall percentage of catheterized patients across all surveys stood at 82.6%, indicating a consistent trend in the use of catheters among ICU patients.

The data highlights the urgent need for efficient infection control methods to lower the potential of CAUTI, especially as the percentage of catheterized patients has significantly increased over the survey periods. With only 0.132% of patients testing positive for CAUTI over three 7-day periods, this figure may be attributed to underreporting or the lack of routine examination of catheter cultures as overall inclusion process depicted in consortium flowchart in Figure 1. While all patients received conventional treatment and recovered, two patients left against Medical Advice (LAMA) and two deaths, which were significantly unrelated to catheterization, ongoing monitoring and intervention strategies always essential to enhance patient safety and care quality in intensive care settings.

The flow diagram Figure 1 presents the subject enrollment outcomes of patients in the study group ($n=753$) based on various factors, including catheterization duration of less than 3 days, cultures not performed, lack of patient consent, discharge, leave against medical advice (LAMA), and death. Among the 753 patients, 272 were catheterized for less than 3 days, 227 had no cultures conducted, and 158 did not provide consent. Additionally, 46 patients were discharged in less than 3 days. Ultimately, 50 patients remained eligible for the study, including 2 who were noted as LAMA (left against medical advice) and 2 who passed away three days after hospitalization.

In this study *E. coli* emerged as the most frequent isolate, accounting for 40% of the total cases included in Table 1, which highlighted its predominant role in urinary tract infections associated with catheter use. Following *E. coli*, *Enterococcus faecium* was the second most common isolate, representing 24% of the infections. This bacterium was often noted for its resilience and ability to cause serious infections, particularly in immunocompromised patients. On the other side significant isolates included *Klebsiella pneumoniae*, *Acinetobacter baumannii*, and *Pseudomonas aeruginosa*, each comprising 12% to the overall isolates. *Klebsiella pneumoniae* was known for its role in various hospital-acquired infections, while *Acinetobacter baumannii* was notorious for its multidrug resistance, making it a challenging pathogen in clinical settings. Similarly, *Pseudomonas aeruginosa* was recognized for its opportunistic infections, especially in patients with weakened immune systems.

Table 2 shows the value of the Pearsons Chi-square test is 200.000^a at the degree of freedom 196 with significance of 0.407.

In Figure 2, the X-axis represents the various organisms isolated from the sample ($n=50$) in the study, and Y-axis shows the frequency of organisms retrieved.

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Figure 3 depicts the Sensitivity pattern of *E. coli* towards various antibiotics in which Fosfomycin was most effective towards *E. coli*, whereas Ciprofloxacin and Cefixime were least effective. The X-axis shows the various antibiotics used in treatment against *Escherichia coli*. The sensitivity pattern of *Klebsiella* spp. to several antibiotics is depicted in Figure 4. Meropenem demonstrated the most efficiency against *Klebsiella* spp., whereas ciprofloxacin demonstrated the highest resistance. On the X-axis, several antibiotics employed to cure *Klebsiella* spp, are displayed.

Figure 5 shows the sensitivity pattern of *Enterococcus* species to different antibiotics; the highest sensitivity levels were noted for Vancomycin and Teicoplanin, while the highest resistivity levels were shown for ciprofloxacin. The X-axis illustrates the various antibiotics used for managing *Enterococcus* spp. Collectively, these findings underscored the diverse array of pathogens responsible for CAUTI and the importance of ongoing surveillance and antibiotic stewardship in healthcare environments.

DISCUSSION

In our study, we found that UTI caused by catheter use was the most prevalent device-associated nosocomial infection. We included 50 ICU patients who were placed on Foley catheters and exhibited signs of CAUTI. The emergence of CAUTIs was tracked in these patients, and we collected urine samples at various points, including upon catheter expiration, removal, or when bacteriuria developed. Among the 50 catheterized patients analyzed, 17% were aged between 41 and 80 years, with a nearly equal gender distribution (51% female and 49% male).

Our microbiological analysis revealed that *E. coli* was the extremely widespread pathogen, accounting for 40% of the infections, followed by *Enterococcus faecium* at 24%. Other pathogens identified in urine cultures included *Pseudomonas aeruginosa*, *Acinetobacter baumannii*, and *Klebsiella pneumoniae*, each representing 12% of the isolates. Notably, 0.132% tested positive for CAUTI over three 7-day periods, suggesting a relatively low incidence of these infections within the monitored time frame. Another investigation at the same study site indicated that *E. Coli* was the most widespread bacteria (31.3%). The next most prevalent bacteria were 8.4% (*Acinetobacter baumannii*), 15.7% (*Enterococcus faecalis*), 16.9% (*K. pneumoniae*), and 7.2% (*Enterococcus faecium*) (Teng *et al.*, 2023). The same study was carried out in another study site where it was found that out of 28 participants, The most frequently identified bacteria were *E. Coli* (31.3%), followed by *Klebsiella* (16.9%) and *E. faecalis* (15.7%),

A. baumannii (8.4%), and *E. faecium* (7.2%) (Perdana et al., 2023). Similar research was carried out by Vishwajit et al., who observed *Pseudomonas aeruginosa* (16.6%) and *Candida species* (16.6%) were the most frequent uropathogens from CAUTI cases, followed by *E. Coli* (30.5%) and *Klebsiella pneumoniae* (30.5%) (Vishwajith et al., 2021).

Regarding antibiotic effectiveness, we found that Fosfomycin, Amikacin, and Nitrofurantoin were highly effective against *E. coli*. For *Klebsiella pneumoniae*; Meropenem, Amikacin, and Imipenem proved to be the most effective treatments. Teicoplanin and vancomycin showed the greatest effectiveness against *Enterococcus spp.* However, fluoroquinolones demonstrated the least sensitivity overall, indicating caution in their use for treating infections associated with catheterization. A study was conducted and discovered that *E. coli* was responsive to meropenem, gentamicin, ertapenem, tigecycline, and nitrofurantoin (Teng et al., 2023). The *K. pneumoniae* isolate was amikacin, meropenem, tigecycline, and ertapenem susceptible. In contrast, *E. faecalis* demonstrated sensitivity to piperacillin/tazobactam, ampicillin,

amoxicillin/clavulanic acid, nitrofurantoin, tigecycline, vancomycin, linezolid, imipenem, and piperacillin/sulbactam (Teng et al., 2023). *Escherichia coli* and *Klebsiella* were resistant to ciprofloxacin and nitrofurantoin but responsive to the third and fourth generations of aminoglycosides, cephalosporins, and carbapenems in another study (Perdana et al., 2023). Another study shows similar findings that revealed *Pseudomonas aeruginosa* and *Acinetobacter species* were the most resistant uropathogens, which demonstrated great resistance to several

Table 1: Organism Isolated in Group Study [n=50].

Organism Isolated	Frequency	Percentage (%)
<i>E. coli</i>	20	40
<i>Klebsiella pneumoniae</i>	6	12
<i>Acinetobacter baumannii</i>	6	12
<i>Enterococcus faecium</i>	12	24
<i>Pseudomonas Aeruginosa</i>	6	12
Total	50	100

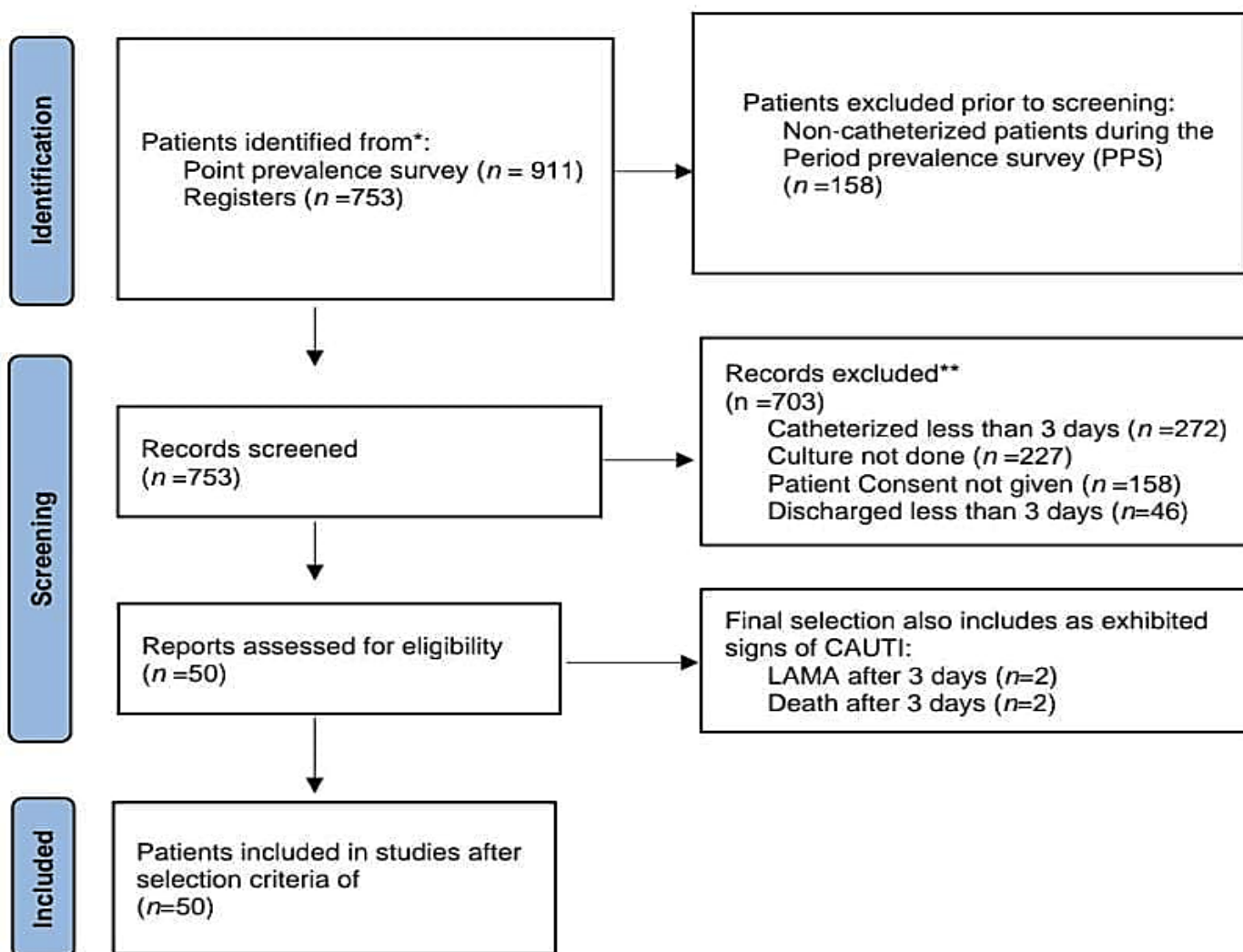


Figure 1: Post-Selection criteria for the study group.

Table 2: Chi-Square Test of organism isolated in study group [n=50].

	Value	D _f	Asymptotic Significance(2sided)
Pearson Chi-Square	200.000 ^a	196	0.407
N of Valid Cases	50		

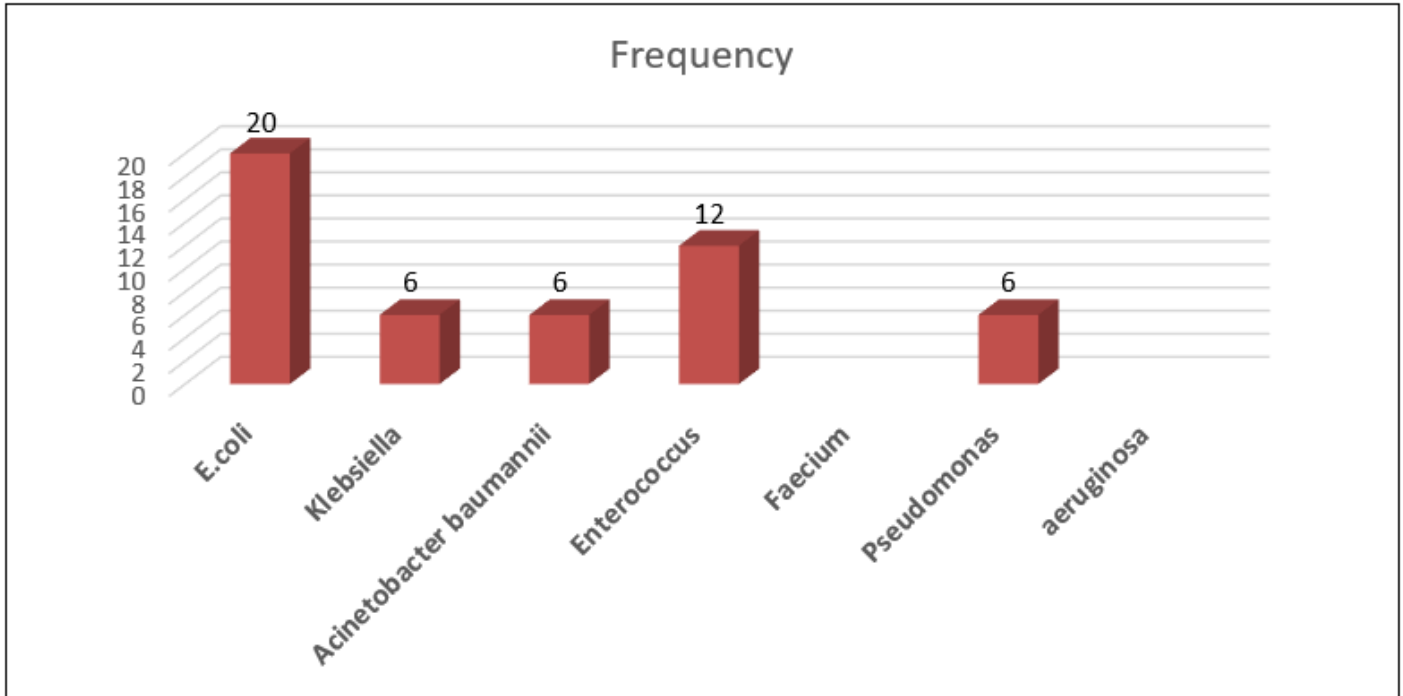


Figure 2: Bar graph of the organism isolated.

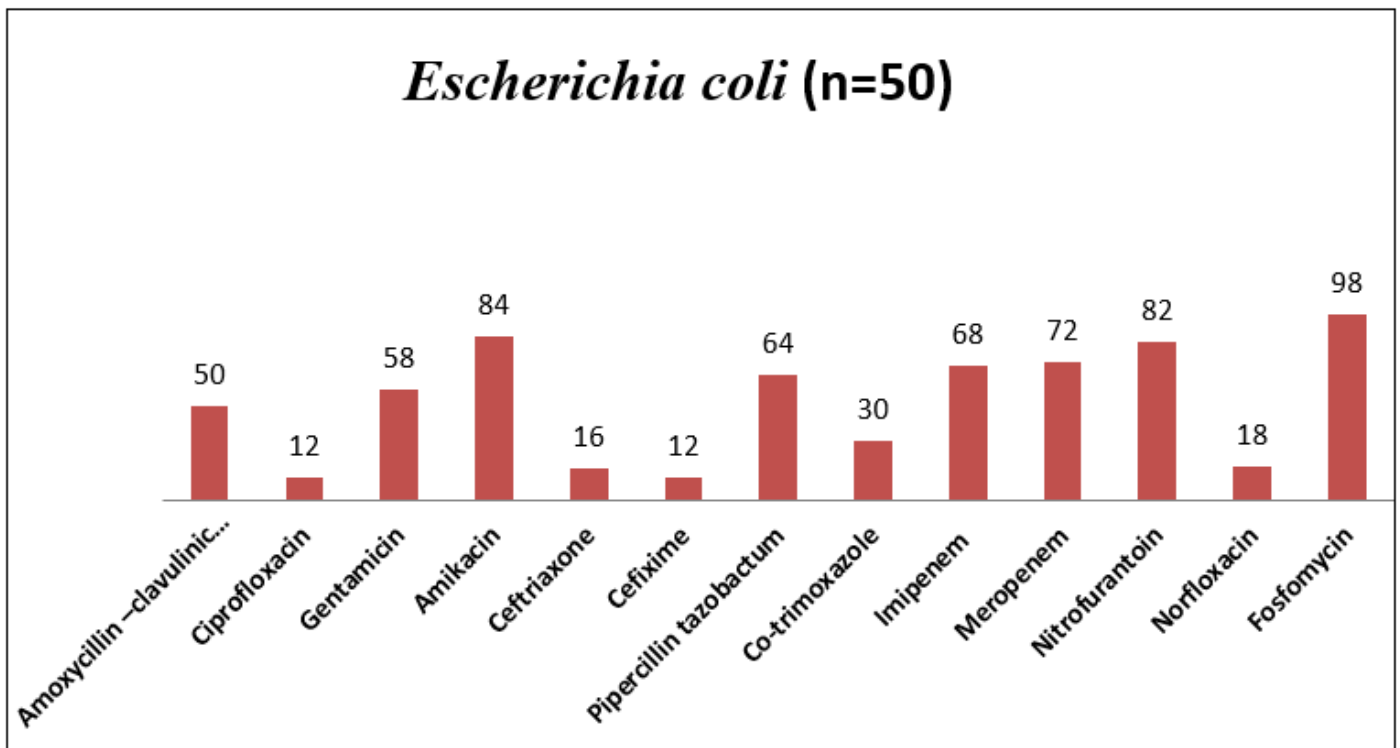


Figure 3: Antibiotic Sensitivity Profile of *E. coli*.

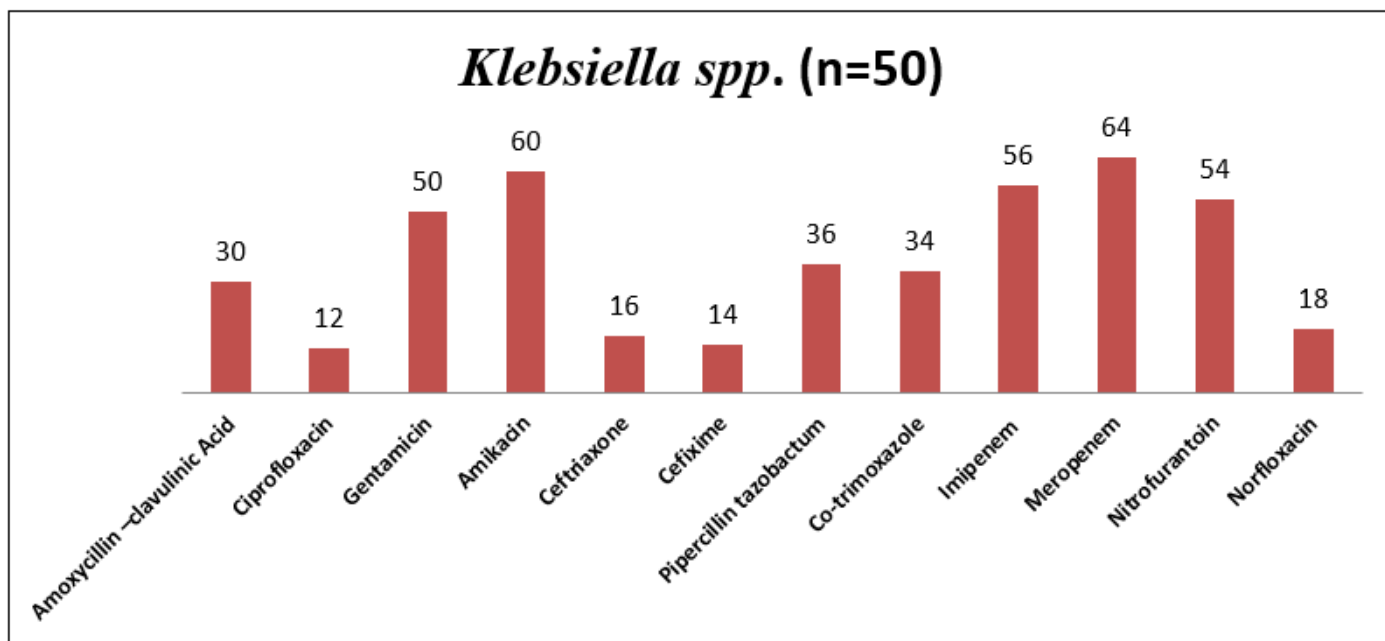


Figure 4: Antibiotics Sensitivity pattern of *Klebsiella spp.*

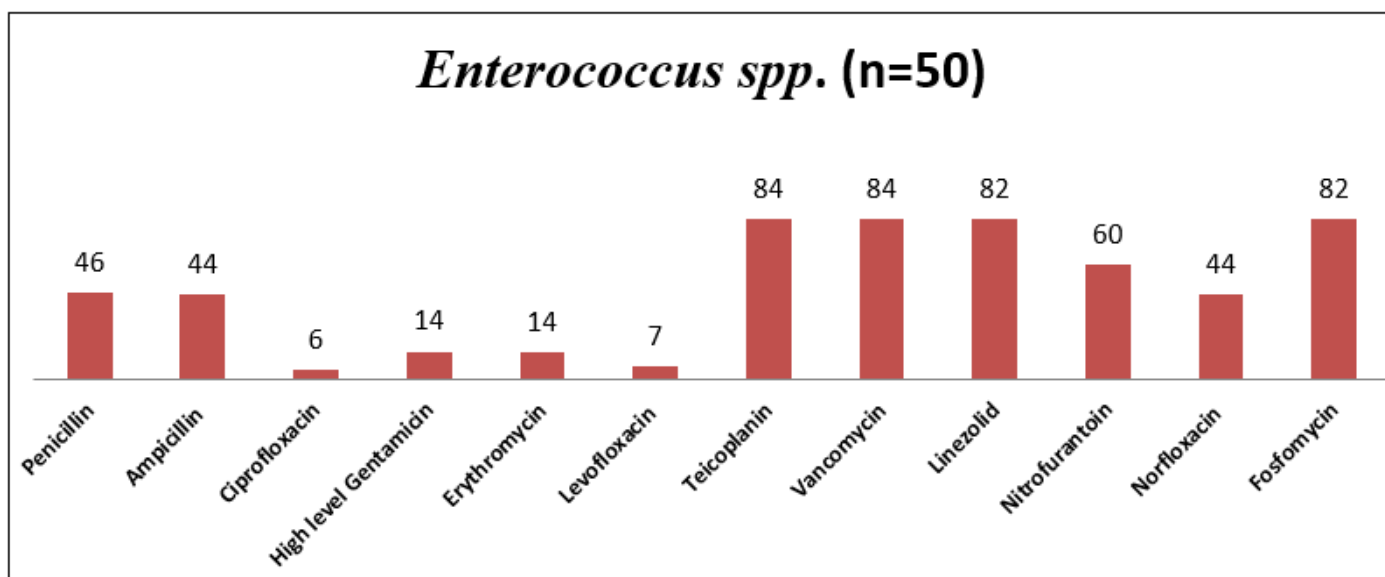


Figure 5: Antibiotic Sensitivity Patterns of *Enterococcus spp.*

medicines, such as meropenem and imipenem (Vishwajith *et al.*, 2021).

These results highlight the necessity of ongoing surveillance and the necessity for targeted antibiotic therapy in managing CAUTI in ICU settings. Our study emphasizes the significance of adopting efficient infection prevention strategies to minimize the incidence of CAUTIs and improve patient outcomes.

Case Study

A 62-year-old man with a confirmed diagnosis of CA urinary bladder with diabetes mellitus was hospitalized in the urology ward of a tertiary care hospital in February 2023. The patient was afterward sent to the ICU to have an ileal conduit and

radial cystectomy. The patient was placed on a Foley catheter following the cystectomy. After the catheter was inserted, the patient complained of a slight fever. After obtaining a urine sample to establish the diagnosis of CAUTI, it was discovered that *Escherichia coli* was the causative bacteria. Additionally, a tip sample was obtained for the Antimicrobial Susceptibility Test (AST) report assessment. The AST report concluded that the patient had sensitivity to amikacin, gentamycin, fosfomycin, and nitrofurantoin. It was recommended to continue the patient's CAUTI treatment with injectable amikacin. Following a root cause analysis, it was found that other patients were using the urine pot while the urban was emptied and that sufficient hand washing had not been done while the patient was receiving care.

Conventional processes were also followed for the correction and prevention of errors

CONCLUSION

To lower the incidence of catheter-related UTIs, focus should be kept on appropriate catheter maintenance and reducing the duration of catheterization rather than prophylactic. It is important to consider the danger and the need for catheterization. When it is no longer necessary, it should be eliminated. The threat posed by antimicrobial resistance has been expanding globally. Antibiotic usage as a preventative should be avoided to reduce the prevalence of drug resistance. In the future, this study will have a beneficial societal impact by serving as a reference for developing policies that are facility-specific, gender-specific, and age-appropriate to lower the risk of CAUTI and by aiding healthcare professionals in developing projects to do so. It could also assist in delivering cost-effective care to patients.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

ABBREVIATIONS

HAIs: Healthcare-associated infections; **UTI:** Urinary tract infections; **WHO:** World Health Organisation; **CAUTI:** Catheter-Associated Urinary Tract Infection; **GI:** Gastrointestinal; **SSI:** Surgical site infection; **ICU:** Intensive care unit; **LAMA:** Left against medical advice.

ETHICAL APPROVAL

Ethical approval for this study was obtained from Institutional Ethical Committee of MMMSR, Mullana, Ambala (Approval number: 2339).

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