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Original Article

# OVERVIEW OF BACTERIA TYPES AND ANTIBACTERIAL RESISTANCE PATTERNS AMONG PATIENTS WITH URINARY TRACT INFECTIONS

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**ABSTRACT**

**Objective:** This study aimed to characterize bacterial types and antibacterial resistance patterns in UTI patients in Surakarta.

**Methods**: The study was conducted at PKU Muhammadiyah Surakarta Hospital using a descriptive observational design of demographic data and bacterial culture results that were tested for antibiotic resistance with a cross-sectional approach. A total of 56 UTI patients were included through total sampling of inpatients at PKU Muhammadiyah Surakarta Hospital. Patient demographic data were collected from medical records and antibiotic sensitivity test results were performed on urine bacterial culture results with bactec media using a VITEK 2 compact culture machine.

**Results:** Of the 56 patients, 43 were infected with Gram-negative bacteria and 13 with Gram-positive bacteria. Fourteen bacterial species were identified, with non-ESBL *Escherichia coli* being the most prevalent (33.9%), followed by *Klebsiella pneumoniae* (10.7%), ESBL strain *E. coli* (8.9%), *Staphylococcus aureus* (8.9%), *Enterobacter cloacae* (8.9%), *Streptococcus sp.* (7.1%), *Pseudomonas aeruginosa* (5.4%), and *Enterococcus faecalis* (5.4%). The remaining species, each representing 1.8% of the cases, included *Flavimonas oryzihabitans*, *Kluyvera sp., Raoultella ornitholytica*, *Proteus mirabilis*, *Aeromonas hydrophila*, and *Staphylococcus epidermidis*.

**Conclusion:** This study revealed diverse resistance patterns among different g-positive and g-negative bacterial species against the tested antibiotics based on local bacterial patterns. These findings emphasize the importance of ongoing surveillance and targeted antibiotic strategies in effectively managing UTIs with local antibiotic stewardship management.

**Keywords:** Antibacterial, UTI, Bacterial species, Antibacterial resistance patterns


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## INTRODUCTION

Urinary tract infections (UTIs) represent a significant global health challenge characterized by bacterial colonization of the urinary system, typically defined by bacterial counts ≥$10^5$ colony-forming units (CFU) per milliliter of urine [1]. Based on the Basic Health Research (2013), urinary system diseases are ranked among the top 10 diseases in Indonesia that cause hospitalization [2]. The Global Burden of Disease study revealed that interstitial nephritis and UTIs affected approximately 7.7 million individuals worldwide in 2019, with a mortality rate of 0.42% [3]. Notably, epidemiological data demonstrated a substantial increase in UTI prevalence, with a 60.40% rise in cases between 1990 and 2019, accompanied by a dramatic 140.18% increase in mortality rates [4]. UTI in Indonesia is a case that continues to increase, with an incidence of 180,000 cases per year and has reached 222 million patients [1].

The microbial etiology of UTIs predominantly involves *Enterobacteriaceae* family Gram-negative bacteria, with *E. coli, Klebsiella, Enterobacter*, and *Proteus* species being the most common causative agents. While Gram-negative bacteria dominate UTI infections, Gram-positive bacteria such as *Staphylococcus aureus, Staphylococcus saprophyticus*, and *Streptococcus agalactiae* also contribute to the pathogenesis, particularly in young women, albeit to a lesser extent [5].

Antibiotic therapy remains the primary treatment modality for UTIs, yet the approach is complicated by widespread antimicrobial resistance. Epidemiological investigations indicate that 30-80% of hospitalized infectious disease patients in developing countries receive antibiotic treatment, with 20-65% of these interventions being considered non-rational [6]. The World Health Organization has identified UTIs as a significant contributor to global antibiotic resistance [7]. In Indonesia, recent studies have reported increasing levels of antibiotic resistance among uropathogens causing UTIs, with *E. coli* being the most prevalent UTI etiology [8]. Based on the germ map in Indonesia in 2023, it was reported that the prevalence of *E. coli* ESBL strains in UTI has increased, which is cause for concern. Antibiogram data shows that generation III cephalosporine-resistant *E. coli* has increased from the previous year (62%; 4,835 isolates to 65%; 6,296 isolates) and Carbapenem-resistant *E. coli* increased by 7% (7,626 isolates) compared to the previous year (6%; 5,800 isolates) [9].

Resistance is a condition when infection-causing bacteria do not respond to drugs used to prevent or kill their development in the body. This leads to a decreased antibiotic's ability to treat infectious diseases. Antibiotic resistance causes prolonged treatment, increased cost of treatment, side effects, and mortality [10]. Resistance can suppress immunity formation, which extends the duration of the disease, and the resistance microbes will also propagate vigorously. As much as 20% of the source of antibiotic resistance comes from the pattern of antibiotic use in humans and 80% due to the use of antibiotic growth promoter (AGP) in livestock meat [11]. Local studies in Indonesia have highlighted critical deficiencies in antibiotic prescription, with rational antibiotic use documented at merely 2.5-20% of cases, characterized by inappropriate dosing, administration intervals, and treatment durations [12]. This emerging resistance presents a substantial clinical challenge, potentially increasing morbidity and mortality by compromising therapeutic effectiveness and creating difficulties in managing severe infections.

## MATERIALS AND METHODS

### Material

The study population consisted of all patients who underwent urine culture and received antibiotic therapy during hospitalization at PKU Muhammadiyah Surakarta Hospital between Jan 1 to Dec 31, 2022.

**Study design**

This study employed a cross-sectional, descriptive observational research design to characterize bacterial species and antibiotic resistance patterns in patients with urinary tract infections (UTIs). A total sampling method was used, including all eligible inpatients aged ≥18 y who were administered antibiotic regimens while excluding those with incomplete medical records or cultures without bacterial growth. Bacterial identification and antibiotic sensitivity testing of urine samples were performed with bactec media and using a VITEK 2 compact culture machine. Criteria for UTI culture results were determined from the number of bacteria $\geq 10^5$ colony-forming units (CFU) per milliliter from patient urine samples before antibiotic administration. From the sampling process, 56 patient samples were obtained and analyzed using a descriptive approach.

**Statistical analysis**

Analysis was performed on research variables; include identification of bacterial species, categorized as Gram-positive or Gram-negative, and evaluation of antibacterial resistance patterns based on antibiotic susceptibility testing results. Data were analyzed descriptively using Statistical Package for the Social Sciences (SPSS) 16.0 and Microsoft Excel with results in the form of number distribution and percentage of each variable. The results of the analysis were then used as a comparison table to map the germ pattern of isolates and antibiotic resistance patterns. All numbers from the percentage calculation are rounded with the provisions ≥ 0.5 rounded up, while<0.5 rounded down. The antibiotic resistance pattern table is explained by displaying the percentage of antibiotic sensitivity (%S). There is no standardized guideline for the percentages in the antibiogram table. The percentage criteria considers local conditions in Indonesia, with the provisions in this study, namely: antibiotic sensitivity 0-69% indicates antibiotic usage is not recommended, antibiotic sensitivity 70-90% indicates antibiotic usage can be considered, and antibiotic sensitivity 91-100% indicates antibiotic usage is recommended.

**Ethical approval**

This research received ethical approval from the RSDM Research Ethics Committee with number 2173/XII/HREC/2023.

## RESULTS AND DISCUSSION

**Characteristics of UTI patients**

High number of UTI cases shown in the female gender (64.3%) (Table 1). A similar study showed that the number of UTI patients was dominated by women (62.5%) [12]. This is because physiologically, the female urethral organ has a shorter size than men, making it easier for microorganisms to enter the urinary tract and the risk of infection increases [12, 13]. The structure of the male urethra is longer and the presence of prostate fluid can kill bacteria, while the urethral structure in women is shorter and the location of the urinary tract is closer to the rectum, making it easier for contaminant bacteria to enter the urinary tract [14].

Based on age, UTIs were mostly suffered by adults<60 y (53.6%). This is different from other studies that show more cases of UTI occur in elderly patients [12]. UTIs can be experienced by patients at any age, with an increased risk in individuals with poor personal hygiene, genetic roles, social activities, comorbid diabetes mellitus, hormonal, and people with poor immunity [15]. At a young age, reproductive hygiene, sexual intercourse, and contraceptive use often increase the risk of UTIs. This occurs due to changes in the normal vaginal flora and periurethral colonization by pathogenic bacteria [16].

The length of hospitalization of patients in the hospital is influenced by the presence of comorbidities in addition to the main disease [17]. Most patients were treated for 7-14 d as many as 39 people (69.6%), while patients who were treated>14 d were 3 people (5.4%). Based on the characteristic data, there was at least 1 comorbid disease in each patient (89.2%) and the majority of chronic non-pulmonary diseases were 19 patients (33.9%), including chronic heart failure, chronic renal failure, stroke, sepsis, ischemic heart disease, and hepatitis. The unbalanced interaction between agent, host, and environment will cause the replication of microorganisms resulting in infection. In patients with comorbidities, decreased immunity may occur and is one of the risk factors leading to UTI. The number of comorbidities in patients with UTI in this study shows that most patients have complications, so that combination therapy and longer treatment time are needed [16].

High comorbidity in patients in this study (89.2%) may affect antibiotic prescribing. In a study there was a significant increase in antibiotic prescribing before comorbidities were diagnosed. The dose of antibiotics increased higher than the baseline after the diagnosis of comorbidities was established, this shows how comorbidities are often mistaken for infections, so antibiotics are given inappropriately [18]. Giving antibiotics without proper indication risks causing antibiotic resistance. In line with the research of Shallcross *et al.* (2017), comorbid diseases are factors that affect the frequency of antibiotic administration. Patients with comorbidities such as chronic lung disease, diabetes, and heart disease have a tendency to get antibiotics [19]. The increasing use of antibiotics, especially irrational use of antibiotics is one of the factors causing antibiotic resistance worldwide [20, 21].

**Table 1: Characteristics of UTI patients**

| Variable | Patient (%) |
|---|---|
| Male | 20 (35.7) |
| Female | 36 (64.3) |
| Adult<60 y | 30 (53.6) |
| Elderly (≥ 60 y) | 26 (46.4) |
| Chronic pulmonary disease | 4 (7.1) |
| Diabetes mellitus+hypertension | 5 (8.9) |
| Hypertension | 6 (10.7) |
| Diabetes mellitus | 7 (12.5) |
| Malignancy | 9 (16.1) |
| Chronic non-pulmonary disease | 19 (33.9) |
| Intensive care unit | 14 (25) |
| Non-intensive care unit | 42 (75) |
| <7 d | 14 (25) |
| 7-14 d | 39 (69.6) |
| >14 d | 3 (5.4) |
| Alive | 45 (80.4) |
| Died | 11 (19.6) |

**Type of bacteria causing UTI based on culture results**

The results of bacterial culture in 56 UTI patients were dominated by g-negative bacteria with a total of 43 patients (76.8%), while 13 UTI patients were caused by g-positive bacteria (23.2%) (fig. 1). The bacteria causing UTI in the study were mostly caused by Gram-negative bacteria as many as 43 patients (76.8%), especially non-ESBL *Escherichia coli* (33.9%) (fig. 2). The results are in line with study in Surabaya which states that the most frequent causes of UTIs is Gram-negative bacteria (84.19%) with the most common bacteria found is *Escherichia coli* (42.33%) [8].

Uropathogenic *Escherichia coli* (UPEC) is a particular type of *E. coli* causing UTIs. The mechanism of UPEC in infecting the urinary tract is influenced by virulence factors such as fimbriae, which at the end of UPEC type 1 fimbriae there is a FimH adhesin molecule that can interact with receptors on the host and attach bacteria to the surface of the urinary tract epithelium [8]. A total of 5 patients were identified with *Escherichia coli* strain ESBL infection (8,9%). Extended-spectrum beta-lactamase (ESBL) is the result of mutation of the gene encoding the enzyme beta-lactamase in bacteria that is able to hydrolyze beta-lactam antibiotics such as penicillin, cephalosporine, and monobactam, has the capability to cause a resistance to these antibiotic classes [22]. ESBL is produced by *Enterobacteriaceae* bacteria, especially *E. coli* and *K. pneumoniae*. Patients with ESBL-producing bacterial infections are commonly associated with poor treatment outcomes. This is due to delays in administration and limited antibiotics available. This is also related to the length of hospitalization of UTI patients in hospitals due to ESBL strain bacterial infections [23].

Based on the distribution of germ patterns in all hospitals in Indonesia, it was found that ESBL-resistant *E. coli* strains of generation III cephalosporins and carbapenems in urine specimens showed an increasing pattern from 2021 to 2023. Data for 2023 shows how the distribution of generation III cephalosporine-resistant *E. coli* as much as 65% (6,296 isolates) has increased from the previous year (62%; 4,835 isolates) and Carbapenem-resistant *E. coli* as much as 7% (7,626 isolates) increased compared to the previous year (6%; 5,800 isolates) [9]. In comparison, the number of ESBL strains of *E. coli* identified in this study was 8.9% (5 isolates), indicating that the ESBL level in this study was lower than the national average. The lower prevalence of ESBL in this study could be due to differences in sample size, hospital level, and local antibiotic use patterns. The antibiogram of urine samples from all hospitals in Indonesia in 2023 showed that *E. coli* was still sensitive to Cefoperazone-Sulbactam, Ceftazidime/Sulbactam, Carbapenem, Amikacin, Tigecycline, Colistin, and Fosfomycin. In line with the antibiogram pattern, ESBL in this study was sensitive to Carbapenem and Amikacin, so the administration of these antibiotics can be considered.

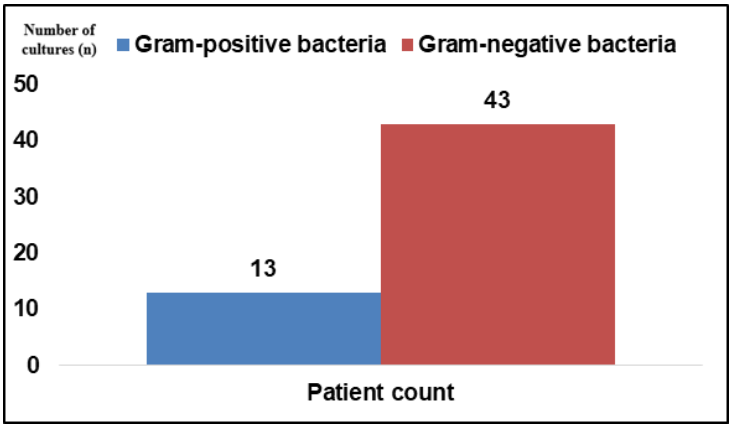


**Fig. 1: Type of bacteria cultured urine specimens of UTI patients**

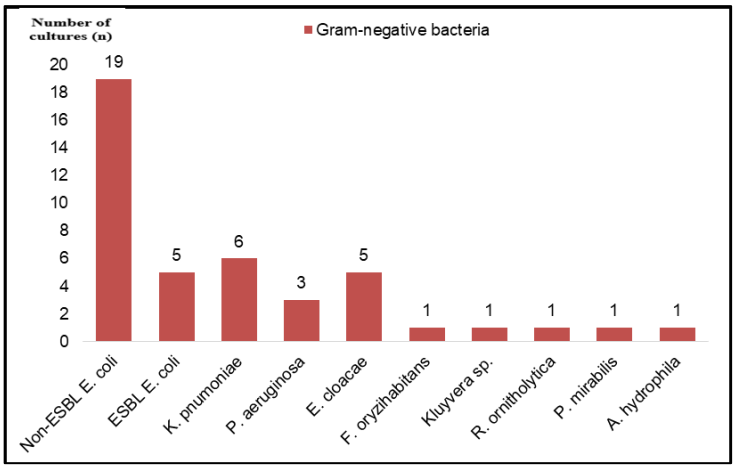


**Fig. 2: Culture results of g-negative bacteria from urine specimens of UTI patients**

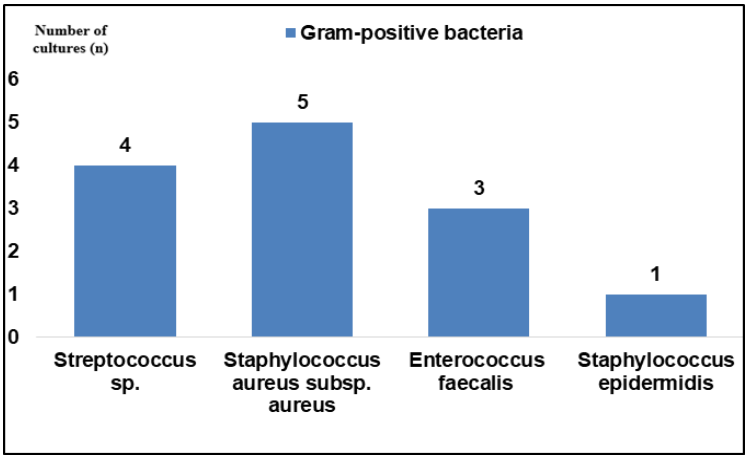


**Fig. 3: Culture results of g-positive bacteria from urine specimens of UTI patients**

Gram-positive bacteria are typically found in the urinalysis culture results of patients with UTIs. Staphylococcus *aureus* subsp. *aureus* is the most Gram-positive bacteria found in this study (8.9%) (fig. 3). This is in line with research at PKU Muhammadiyah Surakarta Hospital in 2016, which showed similar results, namely *Staphylococcus aureus* with a percentage of 36.36%. Gram-positive bacteria are a common cause of UTIs that infect pregnant women and the elderly. In line with this, *Staphylococcus aureus* infections in the urinary tract often occur in individuals with catheters and pregnant women [24].

**Antibacterial resistance patterns among patients with UTIs**

In this study, the most widely used empirical antibiotics were the cephalosporin group, namely ceftriaxone as many as 15 (26.8%), followed by cefuroxime 7 (12.5%), and the fluoroquinolone group, namely levofloxacin 6 (10.7%). Ceftriaxone is a group of 3rd generation cephalosporin antibiotics that have a broad spectrum. The use of ceftriaxone is usually used as empirical therapy when patients admitted to the hospital with indications of infection. The mechanism of action of ceftriaxone is to block the synthesis of the bacterial cell wall by inhibiting the transpeptidation rate of peptidoglycan synthesis in the bacterial cell wall, resulting in inhibited cell wall biosynthesis. Ceftriaxone is a broad-spectrum antibiotic that can resist g-positive and negative bacteria but predominantly against g-negative bacteria [2]. Based on table 2, 100% resistance was obtained in oxacillin, ciprofloxacin, moxifloxacin, and clindamycin against Gram-positive bacteria, while other high resistance was found in cephalosporins, fluoroquinolones, macrolides, cotrimoxazole, aminoglycosides, and penicillins against most Gram-positive bacteria. While in table 3, ampicillin resistance was 100% in Gram-negative bacteria, but most Gram-negative bacteria also showed high resistance to cephalosporins, penicillins, fluoroquinolones, cotrimoxazoles, polymyxins, and tetracyclines. The high resistance to these antibiotics indicates that the use of empirical therapy on these types of antibiotics should be stopped due to lack of effectiveness in overcoming infection.

The high level of ceftriaxone resistance in both types of g bacteria may be related to the use of ceftriaxone as an empirical antibiotic (26.8% use). A similar antibiogram pattern was found for *E. coli* bacteria to ceftriaxone, which showed a sensitivity rate of only 34% (6,296 isolates). The high resistance rate of levofloxacin could be due to a similar cause, due to more frequent empirical use than other antibiotics (10.7%) with 100% resistance rate in 3 identified g-positive bacteria (*Streptococcus sp., Staphylococcus aureus,* and *Staphylococcus epidermidis*).

Antibiotic administration in UTI is a therapy that must be adjusted to the results of bacterial culture with consideration of several things such as germ resistance patterns in local hospitals, antibiotic sensitivity test results, therapeutic effectiveness, tolerability and drug reactions, costs, and drug availability at the local location [25]. This needs to be considered to avoid widespread antibiotic resistance. The Ministry of Health (2021) stated that the therapeutic use of antibiotics is categorized into definitive and empirical therapy. Empirical antibiotics are given to infectious patients before the results of the culture of the causative bacteria are known, while definitive antibiotics are given based on the results of microbiological examinations [26].

According to the Ministry of Health (2021), antibiotics that can be given to patients with UTI are oral cotrimoxazole or ciprofloxacin for cystitis due to *Escherichia coli, Klebsiella pneumoniae*, and *Enterococcus faecalis*. Meanwhile, for acute pyelonephritis due to *Escherichia coli*, *Staphylococcus spp.* and *Klebsiella pneumoniae*, ciprofloxacin IV or ceftriaxone IV can be given. For urosepsis or pyelonephritis with complications due to *Escherichia coli, Enterobacteriaceae, E. faecalis* and group B *Streptococcus* can be given ampicillin sulbactam IV, ceftriaxone IV, or levofloxacin IV. Meanwhile, cases of CA-UTI due to *Escherichia coli, Pseudomonas aeruginosa, E. faecalis,* and *Klebsiella pneumoniae* can be given ciprofloxacin IV or amikacin IV [26]. However, based on the table 2 and 3 of resistance patterns in the results there are several antibiotics that have experienced resistance, so the use of antibiotics is returned to the local germ pattern [25]. Antibiotic selection for bacteria that have resistance can use alternatives that are still sensitive, such as ceftriaxone and cotrimoxazole in UTI due to *Staphylococcus aureus*, ampicillin and levofloxacin for *Enterococcus faecalis*, and amikacin for *Escherichia coli* and *Klebsiella pneumoniae*.

In ESBL strain *E. coli* infections, alternative antibiotics that are still 100% sensitive and recommended for use are amoxycillin/clavulanate, carbapenem, amikacin, kanamycin, chloramphenicol, and fosfomycin. According to the Ministry of Health (2021) and considering the antibiogram pattern of this study, *E. coli* bacteria can be given amikacin IV 750 mg every 24 h in CA-UTI, amikacin IV 750 mg-1 g every 24 h in HAI-related peritonitis [26].

**Table 2: Resistance patterns in g-positive bacteria**

| Antibiotic classes | Antibiotics | Gram-positive bacteria | | | |
|---|---|---|---|---|---|
| | | ***Streptococcus sp.*** | ***Staphylococcus aureus* subsp. *aureus*** | ***Enterococcus faecalis*** | ***Staphylococcus epidermidis*** |
| Penicillin | AMP | 100% | 20% | 100% | - |
| | OXA | 0% | 40% | 0% | 0% |
| | AMX | 100% | 20% | 100% | - |
| Cephalosporine | CFR | 0% | 20% | 0% | - |
| | CZO | 0% | 40% | 0% | - |
| | CTX | 0% | 20% | 0% | - |
| | FOX | 0% | 40% | 0% | - |
| | CAZ | 0% | 20% | 0% | - |
| | CRO | 0% | 80% | 0% | - |
| Aminoglycoside | GEN | 0% | 40% | 50% | 100% |
| Fluoroquinolone | CIP | 0% | 20% | 67% | 0% |
| | LVX | 0% | 40% | 100% | 0% |
| | MFX | 0% | 20% | 0% | 0% |
| Macrolide | CLI | 0% | 40% | 0% | 0% |
| | ERY | 0% | 20% | 100% | 0% |
| Cotrimoxazole | SXT | 33% | 80% | 50% | 0% |
| Tetracyclines | DOX | 100% | 100% | 100% | - |
| | TCY | 50% | 60% | 100% | 100% |
| Glycopeptides | VAN | 100% | 100% | 67% | 100% |

Note: AMX (Amoxycillin), AMC (Amoxycillin/Clavulanate), AMP (Ampicillin), OXA (Oxacillin), SAM (Sulbactam), CFR (Cefadroxil), CZO (Cefazolin), CTX (Cefotaxime), FOX (Cefoxitin), CAZ (Ceftazidime), CRO (Ceftriaxone), FEP (Cefepime), CFM (Cefixime), IPM (Imipenem), MEM (Meropenem), CIP (Ciprofloxacin), MFX (Moxifloxacin HCl), LVX (Levofloxacin), DOX (Doxycycline), TCY(Tetracycline), CLI (Clindamycin), ERY (Erythromycin), AMK (Amikacin), GEN (Gentamicin), KAN (Kanamycin), SXT (Cotrimoxazole), CHL (Chloramphenicol), COL (Colistin Sulphate), FOS (Fosfomycin), VAN (Vancomycin), TZP (Piperacillin/Tazobactam). Characteristics: Sensitivity 91-100%: antibiotics use recommended, Sensitivity 70-90%: antibiotics use considered, Sensitivity 0-69%: antibiotics use not recommended, (-): antibiotics not tested.

Looking at the severity of problem and present situation, the scientific community has advocated for the search for new antimicrobial agents. Herbal medicines have always been a rich source of drug discovery programs and many plant-derived compounds have shown promising activity against MDR bacteria and caused reversal of antibiotic resistance [27]. Another source has been found to have great effects in disrupting the bacterial membrane was essential oil. It is likely due to the presence of lipophilic compounds such as cyclic hydrocarbons, terpenes and aromatics, which are abundantly found in the aromatic plants [28]. Thus, there is a constant need of identifying novel curing agents that are more effective and non-toxic against multi resistant pathogen.

A study found that the antibacterial activity of essential oil in cinnamon bark had an effect on *Methicillin-Resistant Staphylococcus aureus* (MRSA) by inhibiting bacterial growth at high concentrations of essential oil. Ampicillin combined with essential oil has higher antibacterial activity than ampicillin alone by damaging cell membranes, inhibiting ATPase, and forming biofilms. The lipophilic process of essential oils can help the penetration process with bacterial cell membranes, then the active compounds of essential oils disrupt hydrogen bonds and lipid synthesis by accumulating and spreading in the lipid layer of bacteria, thus disrupting membrane function and membrane permeability [29].

**Table 3: Resistance patterns in g-negative bacteria**

| Antibiotic classes | AB | Gram-negative bacteria | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *E. coli* | | KP | EC | PA | K | FO | RO | PM | AH |
| | | Non-ESBL | ESBL | | | | | | | | |
| Penicillin | AMC | 83% | 100% | 100% | 25% | 100% | 100% | 0% | 100% | 100% | 100% |
| | AMP | 11% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| | SAM | 74% | 80% | 33% | 0% | 100% | 100% | 0% | 100% | 100% | 100% |
| Cephalosporine | CFR | 18% | 0% | 0% | 0% | 100% | 0% | 0% | 0% | 100% | 0% |
| | CZO | - | 0% | 33% | 0% | 0% | - | - | - | - | - |
| | CTX | 24% | 0% | 33% | 0% | 100% | 0% | 0% | 0% | 100% | 0% |
| | CAZ | 63% | 40% | 33% | 40% | 100% | 100% | 100% | 0% | 100% | 0% |
| | CRO | 42% | 0% | 33% | 40% | 100% | 0% | 0% | 0% | 100% | 0% |
| | FEP | 63% | 60% | 67% | 20% | 100% | 100% | 100% | 100% | 100% | 0% |
| | CFM | 22% | 0% | 33% | 0% | 100% | 0% | 0% | 0% | 100% | 0% |
| Aminoglycoside | AMK | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| | GEN | 47% | 25% | 83% | 20% | 100% | 100% | - | 0% | 100% | - |
| | KAN | 72% | 100% | 67% | 100% | 0% | 100% | 100% | 0% | 0% | 0% |
| Carbapenem | IPM | 100% | 100% | 100% | 100% | 100% | 100% | 0% | 100% | 100% | 100% |
| | MEM | 100% | 100% | 100% | 100% | 100% | 100% | 0% | 100% | 100% | 100% |
| Fluoroquinolone | CIP | 37% | 50% | 50% | 20% | 39% | 50% | 20% | 33% | 100% | 0% |
| Cotrimoxazole | SXT | 39% | 20% | 33% | 20% | 0% | 100% | 0% | 0% | 0% | 100% |
| Chloramphenicol | CHL | 83% | 100% | 33% | 0% | 0% | 100% | 0% | 0% | 100% | 100% |
| Polymyxins | COL | 38% | 50% | 0% | 0% | - | 0% | 0% | 0% | 0% | 100% |
| Tetracyclines | TCY | 33% | 0% | 0% | 0% | 0% | 100% | 0% | 0% | 0% | 100% |
| Others | FOS | 94% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| | TZP | 100% | 80% | 75% | 100% | 67% | 100% | 100% | 100% | 100% | 100% |

Note: ESBL (*Extended-Spectrum Beta-Lactamases*), KP (*Klebsiella pneumoniae* subsp. *pneumoniae*), EC (*Escherichia coli*), PA (*Pseudomonas aeruginosa*), K (*Kluyvera* sp.), FO (*Flavimonas oryzihabitans*), RO (*Raoultella ornitholytica*), PM (*Proteus mirabilis*), AH (*Aeromonas hydrophila*). Characteristics: Sensitivity 91-100%: antibiotics use recommended, Sensitivity 70-90%: antibiotics use considered, Sensitivity 0-69%: antibiotics not recommended, (-): antibiotics not tested.

## CONCLUSION

The type of bacteria that most commonly causes UTI is non-ESBL Gram-negative *Escherichia coli* (33.9%), while the most common cause of UTI due to Gram-positive bacteria was *Staphylococcus aureus* (8.9%). Antibacterial resistance patterns in patients with UTIs showed a diverse percentage where Gram-positive bacteria experienced high resistance to cephalosporine, aminoglycoside, fluoroquinolone, macrolide, and cotrimoxazole, while Gram-negative bacteria were predominantly resistant to ampicillin, cephalosporine, fluoroquinolone, cotrimoxazole, polymyxin, and tetracycline.

The limitations of this study include the research design carried out in a single hospital and limiting generalization, the limited number of samples and microorganisms so that the results do not represent a picture of antibiotic sensitivity patterns, and the growth of bacterial cultures cannot be ascertained whether they are not affected by previous antibiotics.

It is recommended that further research can be carried out longitudinal resistance tracking with more samples and deepen the pattern of antibiotic resistance in ESBL. We recommend routine ESBL screening in patients with UTI or previous antibiotic use in patients with high risk, especially those hospitalized. Clinical application is recommended for antibiotic cycling for the cephalosporine class to reduce selection pressure and suppress the resistance pattern found in this study.

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Nil

## AUTHORS CONTRIBUTIONS

INNM: conceptual or design of the work, supervision, methodology, formal analysis, critical for important intellectual content, and final approval of the version to be published. FNA; ASP; YIK; and INF: collecting data, interpretation of data, editing content and writing the original draft. TA and SW: supervision and reviewing the work.

## CONFLICT OF INTERESTS

No potential conflict of interest was reported by the authors.

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