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ANTIMICROBIAL SUSCEPTIBILITY PROFILE OF BACTERIAL PATHOGENS ISOLATED FROM URINARY TRACT INFECTIONS

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Abstract
Urinary tract infections (UTIs) are among the most prevalent bacterial diseases in the world and constitute a significant public health concern due to the increasing prevalence of antimicrobial resistance among uropathogens. The present study aimed to determine the antimicrobial susceptibility profile of bacterial pathogens isolated from patients with urinary tract infections and to identify the most prevalent uropathogens responsible for these infections. This retrospective observational study was conducted using microbiological laboratory records from patients suspected of UTIs. A total of 80 culture-positive urine samples were included in the analysis. Bacterial isolates were identified using standard microbiological techniques, and antimicrobial susceptibility testing was performed using the Kirby-Bauer disk diffusion method in accordance with Clinical and Laboratory Standards Institute guidelines. Descriptive statistical methods were used to determine the frequency and percentage distribution of bacterial isolates and antibiotic susceptibility patterns. Chi-square analysis was used to examine the association between gender and bacterial distribution, while Pearson correlation and linear regression analyses were performed to evaluate the relationship between patient age and antimicrobial resistance. The results showed that female patients accounted for the majority of cases (65%). Escherichia coli was the most predominant pathogen (45%), followed by Klebsiella spp., Proteus spp., Pseudomonas spp., and Staphylococcus aureus. Nitrofurantoin showed the highest sensitivity among tested antibiotics, whereas Ampicillin demonstrated the highest resistance rate. These findings highlight the importance of continuous monitoring of antimicrobial susceptibility patterns to guide appropriate antibiotic therapy and improve the management of urinary tract infections.

Keywords: *Urinary tract infection, antimicrobial susceptibility, bacterial pathogens, antibiotic resistance, uropathogens*

1. Introduction

UTIs are between the greatest prevalent forms of infections by bacteria that affect people all over the world and are a major health policy concern. UTIs are caused by invasions of pathogenic microorganisms in any area of the urinary system such as ureters, urethra, bladder, or kidneys. These infections may cause various clinical symptoms including dysuria, urinary urgency, increased frequency of urination and abdominal discomfort. In severe cases, UTIs that are not treated may cause complications such as pyelonephritis, kidney damage and systemic infections. UTIs occur in all age groups but are more common in women because of anatomical and physiological reasons that promote the colonization of bacteria in the urinary tract (Ahmed et al., 2019; Pardeshi, 2018). Globally, UTIs are responsible for millions of healthcare visits every year and are a major source of antibiotic prescription (Jean et al., 2016; Muhammad et al., 2020). A wide range of microorganisms can be responsible for urinary tract infection, although the most common etiological agents are gram-negative bacteria. Among these pathogens, Escherichia coli is known to be the leading causative organism for most infections, both community acquired and hospital acquired UTIs. Other organisms often isolated include S. aureus, Pseudomonas spp ,Proteus spp, and Klebsiella spp. The prevalence of these pathogens may vary depending on the geographic location, healthcare setting, and patient population (Bitew et al., 2017; Folliero et al., 2020). Several epidemiological studies have reported that E. coli is responsible for a large percentage of urinary infections, thus highlighting its importance as the most relevant uropathogen (Daoud et al., 2020; Said et al., 2021). Understanding the bacterial profile associated with UTIs is essential to properly contribute to treatment strategies and prevent complications. In the recent years, antimicrobial resistance (AR) in uropathogens has developed a major problem in clinical administration. The overuse and misuse of antibiotics in large amounts has caused the growing prevalence of resistant strains of bacteria. As a result, many of the commonly used prescription antibiotics are losing their effectiveness in treating UTIs. Studies conducted in different regions have reported increasing resistance in bacterial isolates to commonly used antimicrobial agents such as ampicillin, fluoroquinolones and cephalosporins (Ekwealor et al., 2016; Mohammed et al., 2016). The development of multidrug resistant organisms has further complicated the treatment options making it increasingly difficult to effectively manage infections (Gharavi et al., 2021; Bashir et al., 2021). Antimicrobial susceptibility testing plays a crucial part in determining the efficacy of the antibiotics against specific bacterial pathogens. This laboratory procedure is used by clinicians to help in choosing the appropriate choice of antimicrobial therapy and to avoid the misuse of ineffective drugs. By identifying the sensitivity and resistance patterns of uropathogens, healthcare providers can help to improve patient outcomes and reduce the spread of resistant organisms (Derese et al., 2016; Badhan et al., 2016). Continuous surveillance of antimicrobial resistance trends is therefore important to develop proper improved antibiotic stewardship initiatives and treatment recommendations.

In addition, the distribution of bacterial pathogens and their patterns of antimicrobial susceptibility can differ from one geographical location to another and healthcare setting to healthcare setting. Factors like local practices of antibiotic use, population and infrastructure of healthcare may have a great impact on the resistance trends. Several studies have highlighted the necessity of regional surveillance programs to allow monitoring the changes in the distribution of uropathogens and AR patterns (Gebremariam et al., 2019; Fenta et al., 2020). Such data give useful insights for clinicians and policymakers to create effective infection control approaches and optimize the use of antibiotics (i.e. antibiotics prescribing) (Gessese et al., 2017; Moyaert et al., 2017). With the growing urinary tract infection burden and the growing menace of AR, evaluating The susceptibility pattern and bacterial profile of uropathogens is important on a regular basis. The study was therefore done to analyze Bacterial infections isolated from patients and their susceptibility to antibiotics patterns having urinary tract infections utilizing the retrospective microbiological data. Understanding these patterns could help clinicians to choose the correct antibiotics and help in the better management of UTIs.

Objectives of the Study

1. To control the bacterial infections obtained from urinary tract diseases' antibiotic vulnerability profile.
2. To identify the most prevalent bacterial pathogens and evaluate their resistance patterns against commonly prescribed antibiotics used for UTI treatment.

2. Methodology

2.1 Study Design

The study was done on the retrospective observation design. Past history of urine culture reports and antimicrobial susceptibility findings were consulted to interpret the distribution pattern of urinary tract infections caused by bacterial infections and their pattern of resistance to frequently prescribed antibiotics. The retrospective method was used to assess previously existing lab data without having to interact with the patient and provide extra clinical care. It was a design that was deemed suitable in identifying dominant isolates of bacteria and their susceptibility to antimicrobials whilst reducing the amount of time and resources that are usually involved in prospective clinical studies.

2.2 Study Setting

The study was done at the microbiology laboratory of one healthcare facility, where the regular diagnostic urine cultures were done on patients having urinary tract infections. The laboratory was operated according to the standard requirements of microbiology and had extensive records of the culture results and antimicrobial susceptibility tests. The main source of data was these records that were used in the study. The controlled setting of the laboratory provided uniformity in the treatment of specimens, identification, and sensitivity of bacteria and hence gave consistent and accurate microbiological data to be used in retrospective study.

2.3 Study Population

The population of the study was the group of patients who had suspected infections of the urinary tract and submitted samples of the urine to be tested by means of the microbiological culture and analysis. The inclusion of patients in the study was restricted to the patients who had previously grown bacteria in culture. Demographic information of these patients such as age and gender was captured under the normal laboratory records. These documents were consulted to determine the occurrence of several bacterial pathogens known to cause UTI as well as to determine trends in antimicrobial resistance of the isolates of the microorganisms.

2.4 Inclusion Criteria

This study involved samples of urine which showed significant growth of bacteria on culture and had full results of antimicrobial susceptibility tests in the laboratory records. Culture-positive samples that could offer valid and full microbiological data were only deemed fit to be analyzed. The inclusion criteria also made sure that all the samples that were picked had adequate data to assess the patterns of bacterial identification and antimicrobial resistance. This was appropriate in ensuring uniformity and reliability of the dataset to be used in the statistical analysis.

2.5 Exclusion Criteria

Some of the samples have not been included in the study to preserve the quality and accuracy of data. Any contaminated urine samples that had mixed growth of microbes indicating poor collection methods were not to be analyzed. Moreover, laboratory data that did not have full details of the antimicrobial susceptibility were not taken into consideration. The duplication of isolates of the same patient was also avoided to avoid duplication of data in the analysis and biasness. These exclusion criteria were used to be sure that only valid and reliable microbiological records involved in the final dataset.

2.6 Sample Collection and Processing

The urine samples were collected under sterile conditions using the mid-steam clean-catch technique, which is a universal method for minimizing contamination during sample collection. The samples were promptly collected and delivered to the microbiological lab. Each material was put onto the appropriate medium for culture, such as MacConkey agar or blood agar, to guarantee that both of the organisms multiplied. In order to further identify and evaluate the bacterial colonies, the infected culture plates were incubated under standard microbiological conditions.

2.7 Identification of Bacterial Isolates

The conventional microbiological techniques were used to identify the bacterial isolates. Initially, the growth and shape of populations in culture media were examined. Gram staining was then used to distinguish between gram positive and gram negative organisms. To identify the test isolates, further biochemical investigation was carried out. In other cases, the lab may have automated identification techniques to help with accurate bacterial identification. The unified classification of uropathogenic substances that cause urinary tract infections was made possible by such approaches.

2.8 Antimicrobial Susceptibility Testing

Microbiological Standard practices were followed in conducting the antimicrobial susceptibility test by the use of the Kirby-Bauer disk diffusion technique. The bacterial isolates were inoculated on the Mueller-Hinton agar plates and the plates surface was positioned with antibiotic disks that contained the most common antibiotics used to treat UTIs. The rings of inhibition of the antibiotic disks were identified and interpreted after incubation according to the recommendations provided by the Clinical and Lab Standards Institute (CLSI). This standard method made it possible to identify the patterns of antibiotic resistance and susceptibility of bacterial isolates.

2.9 Data Collection

The retrospective gathering of the concerned data was performed using the laboratory registers and electronic medical records that are kept in the microbiology department. The received information included the demographic information on the patient, such as age and sex, the kind of bacterial pathogen that was detected, and the results of antimicrobial susceptibility analysis. All the data were entered in an organized manner in a structured form which would be analyzed statistically. The dataset did not contain personal identifiers to protect patient confidentiality and anonymity of the patients whose records were used in the research undertaken.

2.10 Statistical Analysis

Excel was used to analyze the collected data. Descriptive statistics were used to quantify bacterial isolates, antimicrobial susceptibility patterns, and demographic data in regard to frequencies, percentages, means, and standard deviations. The association between the distribution of bacterial infections and gender was examined using the chi-square test. Depending on how many drugs this microbe was resistant to, the isolate's antimicrobial resistance rating was calculated. To ascertain the connection between the patients' age and antibiotic resistance score, a Pearson correlational study was carried out. To ascertain the predicates of resistant antimicrobial bacteria, a straightforward linear regression model was conducted with age as a standalone variable and the resistance to antibiotics score as a factor that is dependent.

3. Results

3.1 Demographic Profile

The retrospective analysis used 80 culture-positive urine samples. The population demographic revealed that female patients were the highest proportion of UTI diagnosed patients with 65% (n = 52) of the study population with 35% (n = 28) of the male patients (Table 1). On the age structure, 31-50 years age group recorded the highest percentage of cases (40 percent), 18-30 years (25 percent), 51-65 years (22.5 percent), and above age structure (12.5 percent).

Table 1: Demographic Profile

Variable	Category	Frequency (n)	Percentage (%)
Gender	Male	28	35.0
	Female	52	65.0
Age Group (years)	18–30	20	25.0
	31–50	32	40.0
	51–65	18	22.5
	>65	10	12.5

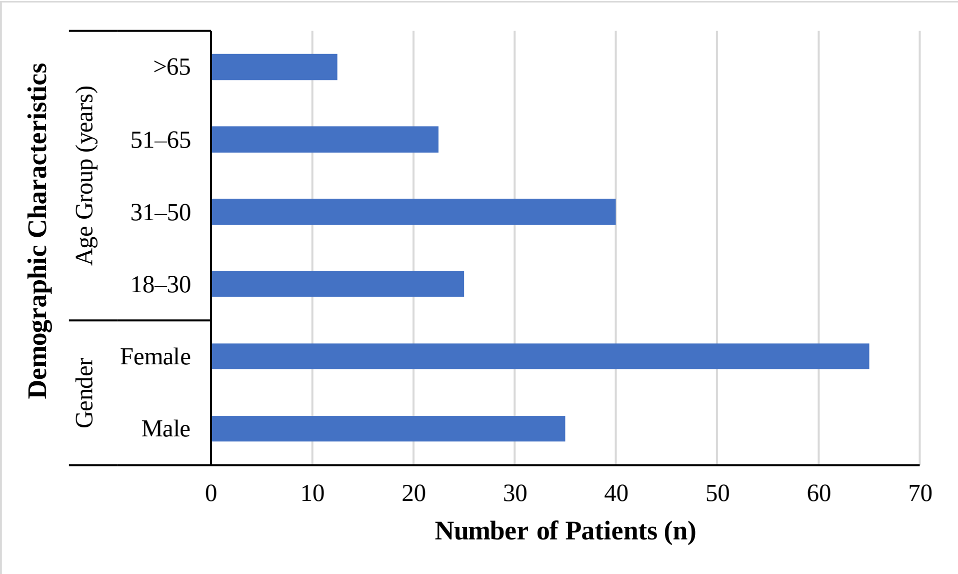

Figure 1: Distribution of UTI Patients by Gender and Age Group

Figure 1 shows the distribution pattern of the demographic of patients having urinary tract infections (n = 80). Most cases were among females as opposed to males. The greatest proportion of infections represented in the 31-50 years age bracket, then 18-30 years age bracket, and 51-65 years age bracket and patients above 65 years.

3.2 Distribution of Bacterial Pathogens

Five significant bacterial pathogens were obtained in the urine samples studied in the research. The most common of these was Escherichia coli (45/n=36) that was the uropathogen. Klebsiella spp. (20%), Proteus spp. (15%), Pseudomonas spp. (11.25%), and Staphylococcus aureus (8.75) followed behind. A high prevalence of E. coli emphasizes the established status of the frequently used organism in the urinary tract infection cases. Table 2 shows the detailed distribution of bacterial isolates.

Table 2: Distribution of Bacterial Pathogens (n = 80)

Bacterial Pathogen	Frequency (n)	Percentage (%)
Escherichia coli	36	45.0
Klebsiella spp.	16	20.0
Proteus spp.	12	15.0
Pseudomonas spp.	9	11.25
Staphylococcus aureus	7	8.75
Total	**80**	**100**

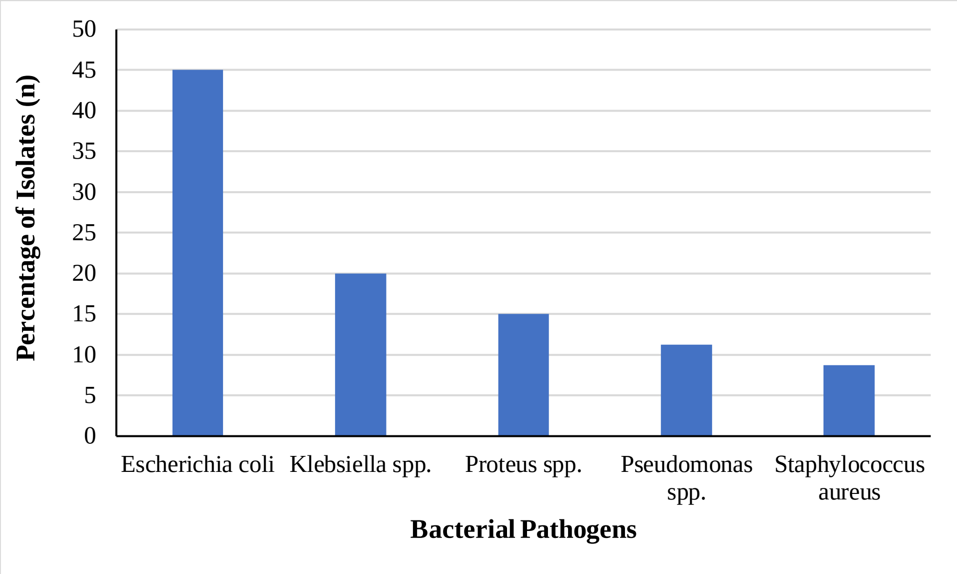

Figure 2: Distribution of Bacterial Pathogens Isolated from Urinary Tract Infections

Figure 2 shows the frequency distribution of bacterial infections found in urine samples. Escherichia coli, Klebsiella species, Proteus species, Pseudomonas species, and Staphylococcus aureus were the most prevalent bacteria. These findings suggest that one of the main causes of infections of the urine tract is gram-negative bacteria.

3.3 Antibiotic Susceptibility Patterns of Isolates

Sensitivity patterns of various isolated pathogens showed a variation upon antimicrobial susceptibility testing. The greatest susceptibility rate was recorded with Nitrofurantoin (77.5%), then with Gentamicin (67.5) and Ciprofloxacin (60%). Ampicillin, on the other hand, had the highest percentage of resistance (65%) which means that it is not effective on the isolates studied. Ceftriaxone was also found to have moderate resistance (47.5%). These results underscore the increased issue of antibiotic resistance in the therapy of UTIs. Table 3 shows the antimicrobial susceptibility profile in detail.

Table 3: Antibiotic Susceptibility Profile of Bacterial Isolates (n = 80)

Antibiotic	Sensitive n (%)	Resistant n (%)
Nitrofurantoin	62 (77.5%)	18 (22.5%)
Ciprofloxacin	48 (60.0%)	32 (40.0%)
Gentamicin	54 (67.5%)	26 (32.5%)
Ceftriaxone	42 (52.5%)	38 (47.5%)
Ampicillin	28 (35.0%)	52 (65.0%)

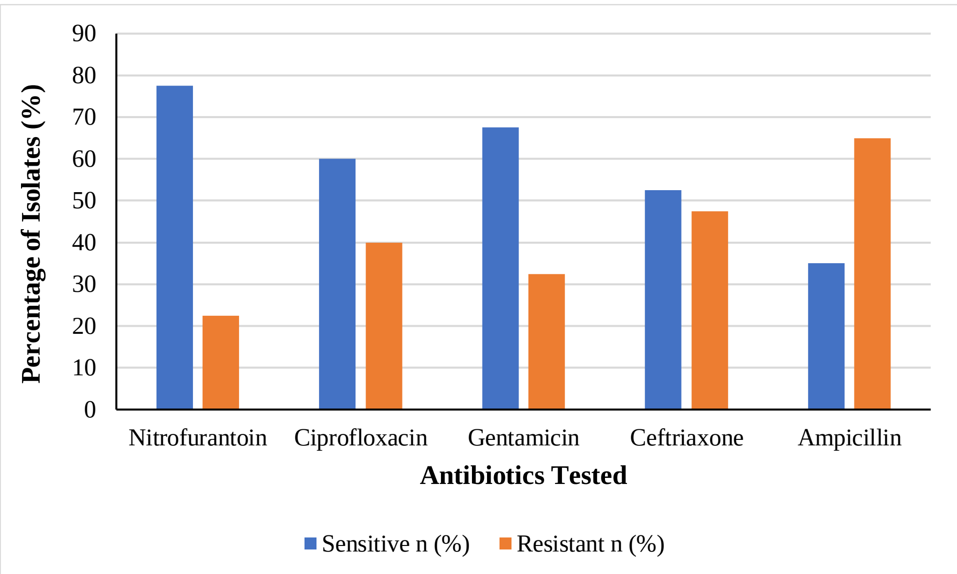

Figure 3: Antibiotic Susceptibility Patterns of Bacterial Isolates

The patterns of antibacterial susceptibility of the isolates of bacteria to the most commonly used antibiotics are given in Figure 3. The sensitivity to Nitrofurantoin was highest compared with Gentamicin and Ciprofloxacin. Ceftriaxone was only moderate and Ampicillin showed the greatest resistance level. These results show that there is growing antimicrobial resistance of uropathogens that result in urinary tract infections.

3.4 Association Between Bacterial Pathogens and Gender

The connection between the gender and distribution of bacterial pathogens were analyzed through the chi-square test. Despite the fact that E. coli was the most common isolate in both sexes, the proportion of infections was marginally higher with most of the pathogens in female patients. However, the statistical test revealed that the type of bacterial infection and gender did not significantly correlate (2 = 1.94, p = 0.74). This implies that the distribution of pathogens in both sexes was rather similar. Detailed gender comparison is demonstrated in Table 4.

Table 4: Distribution of Bacterial Pathogens by Gender (n = 80)

Pathogen	**Male (n)**	**Female (n)**	**Total**
E. coli	10	26	36
Klebsiella spp.	6	10	16
Proteus spp.	5	7	12
Pseudomonas spp.	4	5	9
S. aureus	3	4	7
Total	**28**	**52**	**80**

Chi-square test: $\chi^2 = 1.94$, df = 4, **p = 0.74**

3.5 Correlation Analysis Between Age and Antibiotic Resistance

The correlation among age of the patient and the Antibiotic resistance scores of the bacterial isolates was analyzed through correlation analysis to establish the relationship among the age of the patient and the scores of antibiotic resistance. This analysis showed that There was a somewhat favorable relationship among the age of patients and antibiotic resistance (r = 0.32, p = 0.004), where the tendency was to have a slight positive relationship (Table 5). This is an indication that the older people might be more exposed to antibiotics or frequent infections and this could be a cause of an augmented resistance pattern.

Table 5: Pearson Correlation Between Age and Antibiotic Resistance

Variables	**Correlation Coefficient (r)**	**p-value**
Age vs Antibiotic Resistance Score	0.32	0.004

3.6 Regression Analysis for Predictors of Antibiotic Resistance

A straightforward linear regression was used to further examine the predicted link between patient age with antibiotic resistance. The findings showed that age was statistically significantly predicting the presence of antibiotic resistance (0.27, p = 0.003). The regression model accounted about 10.2 percent of variability in resistance patterns (R 2= 0.102). These results indicate that though age is a contributory factor to resistance trends, other clinical or microbiological factors also could affect the antimicrobial resistance patterns. Table 6 summarizes the statistics of the regression model.

Table 6: Linear Regression Analysis Predicting Antibiotic Resistance

Variable	**β Coefficient**	**Standard Error**	**t-value**	**p-value**
Age	0.27	0.09	2.98	0.003
Constant	1.82	0.74	2.46	0.014

Model statistics: R^2 = **0.102**, F = **8.88**, p = **0.003**

4. Discussion

The research was utilized to evaluate the spread of bacterial pathogens, and pattern of patients' susceptibility to antibiotics diagnosed with urinary tract infections. The results showed that females were the most common cases of UTI with 65 percent of the study population. This observation has been reported in line with the established knowledge that urinary tract infection in women is more prone to rise because of the fact that the urethra is shorter and is located near the anal region, which promotes colonization of the urinary tract by bacteria. Regarding the age distribution, the rate of infections was the most significant in people aged between 31 and 50-years old, indicating that UTIs are widely prevalent among the adult population. The microbiological study showed that Escherichia coli was the commonly isolated uropathogen with a percentage of 45. This was succeeded by Proteus spp, Staphylococcus aureus, Pseudomonas spp and Klebsiella spp. This is in line with the fact that E. Coli has proved identified as the main cause of both hospital-associated and community-acquired UTIs. Antimicrobial susceptibility resulted in Nitrofurantoin, then Gentamicin and Ciprofloxacin being the most effective against the bacterial strains. Conversely, Ampicillin had the highest rate of resistance, which implies a poor response to UTI due to such pathogens.

It also determined the relationship between gender and the distribution of bacterial pathogens. In spite of the fact that most pathogens were more prevalent in the female patients, statistical analysis revealed that gender did not have a significant relationship with the type of bacterial isolate. Moreover, correlation and regression analyses were carried out to show that antimicrobial resistance was more likely to be higher with age of patients, thus, older patients may be more likely to carry resistant bacterial strains, maybe because of long time exposure to antimicrobial agents.

The Escherichia coli preponderance reported in this study is harmonious with those reported in various other past studies concerning urinary tract infections. As an illustration, Seifu and Gebissa (2018) found that E. coli was the most common uropathogen of UTI patients, and the proportion of their isolates was significant. In the same case, E. coli was also found as the most prevalent pathogen causing urinary infections in studies in Nepal and Lebanon (Shrestha et al., 2019; Sokhn et al., 2020). All these findings support the core issue that E. Coli is essential to the etiology of UTIs in various geographical locations. Antimicrobial susceptibility patterns that were determined in the current study are also consistent with the previous research. The use of nitrofurantoin has always been reported to be one of the best antibiotics against the treatment of uncomplicated urinary tract infection since It is very active against common uropathogens. Research on this topic performed in Ethiopia and other areas has also revealed a high level of sensitivity of uropathogens to Nitrofurantoin, and the Ampicillin resistance and other commonly used antibiotics have been reported extensively (Taye et al., 2018; Woldemariam et al., 2019). The growing resistance to Ampicillin and other antibiotics could be explained by the large scale of their usage in the clinical environment that favors the emergence of resistant bacterial strains.

The increasing problem of antimicrobial resistance in the treatment of bacterial infections has also been noted by other studies. As an example, Trojan et al. (2016) pointed at the growing resistance of bacterial isolates to multiple antibiotics that are actively prescribed to patients, which highlights the necessity of constant monitoring of the patterns of antimicrobial resistance. On the same note, Zúniga-Moya et al. (2016) indicated that monitoring resistance trends is critical in the administration of empirical antibiotic therapy and enhancing patient outcomes.

These findings of the study have very important clinical and population health implications. The identification of E. coli as the most widespread pathogen which provokes UTI predetermines the need of the specific antimicrobial therapy of the gram-negative microorganisms. The sensitivity of nitrofurantoin is high and this means that the antibiotic may be effective in the treatment of simple infections of the urinary tract. However, the resistance of Ampicillin is high, and this fact implies that the empirical use of this treatment in the management of UTIs needs to be reconsidered. The antimicrobial resistance patterns are to be followed regularly so as to guide the appropriate practices in prescribing antibiotics. Such surveillance can help clinicians to select suitable treatment regimes, reduce treatment failures and contain strains of bacteria that are resistance to treatment. The other theme that is brought out by the results of this paper is the importance of antibiotic stewardship programs that aim to promote the responsible use of antimicrobial agents.

Even though the research presents significant information on the prevalence of bacteria and pattern of antimicrobials resistance of uropathogens, the study has a number of limitations. To begin with, it was a retrospective study, which was based on the laboratory data documented in the previous year, limiting the availability of the detailed clinical information concerning the patients. Secondly, the magnitude of the study was not very large, so, it may be possible that the study results can not be applied to bigger groups. The research was conducted in a single laboratory setting as well and therefore the results may not be entirely reflective of the trends of antimicrobial resistance in other healthcare institutions or even even localities. The following study must resort to larger sample sizes and a variety of healthcare institutions to draw a more comprehensive image of the patterns of uropathogen distribution and antimicrobial resistance profile. Potential research designs would also allow collecting additional clinical data, including risk factors of patients, the impact of treatment, and comorbidities. They should establish permanent surveillance programs to tell the dynamics of change in the antimicrobial susceptibility trends with time. In addition, the improvement of the antibiotic stewardship interventions and the rational use of antibiotics are some of the most significant steps of reducing the incidence and spread of antimicrobial resistance among the uropathogens.

5. Conclusion

The aim of the investigation was to check the trend of antibiotic susceptibility and the distribution of microorganism pathogens in patients who have established UTIs. The results showed that female patients had higher UTIs. The most common uropathogen among bacterial isolates was Escherichia coli, which was identified followed by Klebsiella spp., Staphylococcus aureus, Pseudomonas spp., and Proteus spp. These findings indicate the prevalent nature of gram-negative bacteria in the etiology of urinary tract infection. Antimicrobial susceptivity testing exhibited that Nitrofurantoin had the highest sensitivity rate in the tested antibiotics meaning that it is still effective in treating urinary tract infections. Moderate rates of sensitivity were also observed with Gentamicin and Ciprofloxacin with Ampicillin showing the greatest rate of resistance among the isolates. These results highlight the increasing issue of antimicrobial resistance by the uropathogens and the importance of selection of antibiotics in clinical practice. In addition, statistical evidence revealed that there was no significant relationship between gender and bacterial pathogens distribution. Nevertheless, there was positive correlation among the age of the patients and antimicrobial resistance though indicating that there might be slight gains in resistance patterns with age. Overall, the provided research highlights that close monitoring of antimicrobial resistance trends is to be carried out on a regular basis to assist in the administration of empirical treatment and improved patient outcomes. The increasing threat of antimicrobial resistance in urinary tract diseases should be put under control through constant surveillance and judicious administration of antibiotics.

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