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Original Article

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Bacteriological profile and antimicrobial susceptibility pattern of patients with urinary tract infections in a tertiary care hospital

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Abstract

***Background & Aims*:** Urinary Tract Infections (UTIs) are one of the most commonly occurring infections in medical practice despite the widespread availability of antibiotics. The emergence of antimicrobial resistance in uropathogens may lead to poor treatment outcomes in individuals with UTIs. The knowledge of the microorganism involves and antibiograms are important for the empirical treatment of UTIs. This study was aimed to evaluate the bacteriological profile of UTI patients and to know their antimicrobial susceptibility pattern in a tertiary care hospital.

Materials & Methods: A cross-sectional study was carried out over 6 months (from July 2021 to December 2021) with a focus on the identification of bacterial pathogens causing UTI and the evaluation of their antibiogram. Midstream urine samples were collected from a total of 2825 subjects with clinically suspected acute UTI and inoculated aseptically on to Hi-Chrome UTI agar. Isolation and identification of the bacterial strains were performed using standard microbiological protocols. Antibiotic susceptibility was carried out following CLSI recommended guidelines. Only culture proven cases were included in this study. Descriptive and inferential statistical methods were used. Data were analyzed using SPSS-15th version. A probability of <0.05 was accepted as significant.

***Results*:** A total of 2825 urine samples were processed for urine culture and sensitivity out of which 804 samples were found to be positive for bacterial infection (amounting to 28.46% positivity), gram-negative bacteria accounted for 58.5% (471/804), and gram-positive 33% (267/804) of the positive results. Among gram-negative isolates, *E. coli* (33.8%) and *K. pneumoniae* (10.8%) were the most prevalent microorganisms while as *Enterococcus sp* (26.3%) was the most common gram-positive organism isolated followed by *Staphylococcus aureus.* Gram-negative bacteria on the whole showed a high degree of resistance to cephalosporins and quinolones while as nitrofurantoin was the most effective antibiotic against *E. coli* and *K. pneumoniae*. In case of gram-positive bacteria linezolid and vancomycin were the most effective antibiotics.

***Conclusion*:** The results of this study revealed a great concern for emerging UTI-related multidrug-resistant strains of bacteria causing UTI. The need of the hour is continuous monitoring of susceptibility patterns of specific pathogens to commonly used antimicrobial agents before initiation of antibiotic therapy.

***Keywords*:** Antibiotic Susceptibility, Escherichia Coli, Urinary Tract Infection, Uropathogens

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Introduction

Urinary tract infection (UTI) is one of the most common bacterial infections encountered in clinical practice. It is estimated that 150 million cases of UTI occur globally per year resulting in more than 4 billion pounds (6 billion dollars) in direct health care expenditure (1).

Traditionally, UTIs are categorized as uncomplicated or complicated, or by the site of infection. Uncomplicated urinary tract infection (UTI) refers to infection in a structurally and neurologically normal urinary tract. The generally accepted definition of complicated UTI includes infection in the presence of factors that predispose to persistent or relapsing infection, such as foreign bodies (e.g., calculi, indwelling catheters or other drainage devices); obstruction; immunosuppression; renal failure; renal transplantation; and urinary retention from neurologic disease (2). Lower UTIs include urethritis and cystitis, and upper tract infections include pyelonephritis and renal abscesses. Acute infections are usually associated with a single pathogen; chronic infections are usually polymicrobial.

Urinary tract infections can be community acquired or nosocomial. Community-acquired urinary tract infections (CA-UTIs) are defined as the infection of the urinary system that takes place in one's life in the community setting or in the hospital environment with less than 48 hours of admission. Community-acquired UTI is the second most commonly encountered microbial infection in the community setting (3). Nosocomial urinary tract infections (N-UTIs) are the infections of the urinary tract that occurs after 48 hours of hospital admission, and the patient was not incubating at the time of admission or within 3 days after discharge (4). UTI can be asymptomatic or symptomatic, characterized by a wide spectrum of symptoms ranging from mild burning micturition to bacteremia, sepsis, or even death (5). Although UTI affects both genders, women of the reproductive age group (15-44 years) are the most vulnerable. Young, otherwise healthy, women are commonly affected with an estimated incidence of 0.5–0.7 infections per year (6). Of the women affected, 25%–30% will go on to develop recurrent infections not related to any functional or anatomical urinary tract abnormality. Women are particularly at risk of developing UTIs because of their short urethra, and certain behavioral factors which include delay in micturition, sexual activity and the use of contraceptives which promote colonization of the periurethral area with coliform bacteria (7).

E. coli is the most common organism causing UTI which accounts for up to 65 -90% of cases followed by K. pneumoniae, Staphylococcus, Proteus, Pseudomonas, Enterococcus, and Enterobacter (8). Next to respiratory tract infections UTI is the second most common bacterial disease encountered in the primary care settings (9). Global statistics revealed that 8.3 million outpatient clinic visits are due to UTI and annually emergency department deals with 1 million UTI cases and around 100,000 patients got admitted to the hospitals due to complicated UTI (10).

There are important medical and financial implications associated with UTIs. In the non-obstructed, nonpregnant female adult, acute uncomplicated UTI is believed to be a benign illness with no long-term medical consequences. However, UTI elevates the risk of pyelonephritis, premature delivery, and fetal mortality among pregnant women, and is associated with impaired renal function and end-stage renal disease among pediatric patients. Financially, the estimated annual cost of community-acquired UTI is significant, at approximately $1.6 billion (11).

Management of UTI is largely empirical without the use of a urine culture and susceptibility testing to guide therapy. This practice is a risk for development of antimicrobial resistance among uropathogens. The extensive and inappropriate use of empirical antimicrobial agents has resulted in development of antimicrobial resistance which in recent times has become a major problem worldwide. This emergence and rapid spread of multi-drug resistance among uropathogens has now become a global phenomenon, especially in Japan, China, the US, India, Brazil, Nepal, and Saudi Arabia (12).

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It is necessary therefore to have a prior knowledge of the causal organism and its antibiotic susceptibility pattern in order to start a proper empirical antibiotic therapy, and prevent a further rise of antibiotic resistance in uropathogens. Also, the data related to the causal organism and its antibiotic susceptibility pattern changes continuously from one hospital to others and from one region to another; careful monitoring, assembly, and updating of such data is highly recommended.

Thus, the aim of this study was to find out the clinical and microbiological profile of urinary tract infections and to provide knowledge about their etiology, antibiotic susceptibility and appropriate antibiotic treatment.

Materials & Methods

This was a cross-sectional analytical hospital-based study in which analysis of urinary culture results was done. This study was conducted in the Microbiology department of a tertiary health care hospital in Srinagar, from July 2021 to December 2021.

Both out and inpatients presenting or highly suspicious of having UTIs were recruited in the study. The details regarding patient's age, sex, literacy, socioeconomic status, residential area (rural/urban) were recorded along with the sample. Both male and female patients having clinically suspected symptoms of UTI were included in the study.

Culture and Identification: Midstream, clean catch urine samples from all suspected UTI patients were collected in a wide mouth sterile container. The samples were collected aseptically before the starting of antibiotic treatment. These sample were examined and processed within 24-28 hours.

The urine was examined macroscopically for the color and turbidity and wet mount of urine samples were prepared. The wet mounts were observed microscopically to identify the presence of pus cells, red blood cells, epithelial cells, crystals, parasites and yeast. All the findings were recorded. All urine samples were inoculated aseptically on to Hi-Chrome UTI agar using a calibrated wire loop of 28G with an internal diameter of 3.26 mm holding 0.004 ml of urine. The plates were incubated at 37 0 C aerobically and after overnight incubation, they were checked for significant bacteriuria as under by enumeration of colonies [growth of 100 colonies equals to 105 colony forming units (CFU) of bacteria /ml of urine] (13).

A presumptive identification of the isolates was made on the colony color on the Hi-Chrome UTI agar based on the manufacturer's instructions (Hi-media); Hi-Chrome UTI agar is a chromogenic medium designed to isolate and identify all uropathogens. An important aspect of Hi-Chrome UTI agar is that it allows an easy differentiation of various species from mixed cultures due to specific colony color (14).

Samples showing significant bacterial growth (>105/ml) were subjected to standard biochemical tests for identification and antimicrobial sensitivity testing by Kirby-Bauer disc diffusion method. Interpretation as 'Sensitive' or 'Resistant' was done on the basis of the diameters of zones of inhibition of bacterial growth as per CLSI guidelines (15).

Antimicrobial susceptibility testing: The antibiotics included in our study were co-amoxiclav (20/10 mcg), ampicillin (10 mcg), amikacin (30 mcg), trimethoprim/sulfamethoxazole (co-trimoxazole) (25/23.75 mcg), norfloxacin (5 mcg), ciprofloxacin (5 mcg), levofloxacin (5 mcg), nitrofurantoin (300 mcg), gentamicin (10 mcg), amikacin (30 mcg), cefuroxime (30 mcg), ceftriaxone (30 mcg), ceftazidime (30 mcg), cefotaxime (30 mcg), polymyxin B (2 mcg), piperacillin/tazobactam (100/10 mcg), cefoperazone/sulbactam (75/30 mcg), meropenem (10 mcg), imipenem (10 mcg), and vancomycin (30 mcg).

Descriptive and inferential statistical methods were used. Data were analyzed using SPSS-15th version. A probability of <0.05 was accepted as significant. For continuous variables having normal distribution, data were summarized using mean ± SD, range and median were used for all continuous variables having non-normal distribution (i.e., age).

Results

In our study, out of 2825 samples received in our microbiology laboratory for urine culture from patients

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suspected with UTI, 804 were reported as bacterial UTIs as per culture and sensitivity reports i.e., the positivity rate was 28.46% (Figure 1).

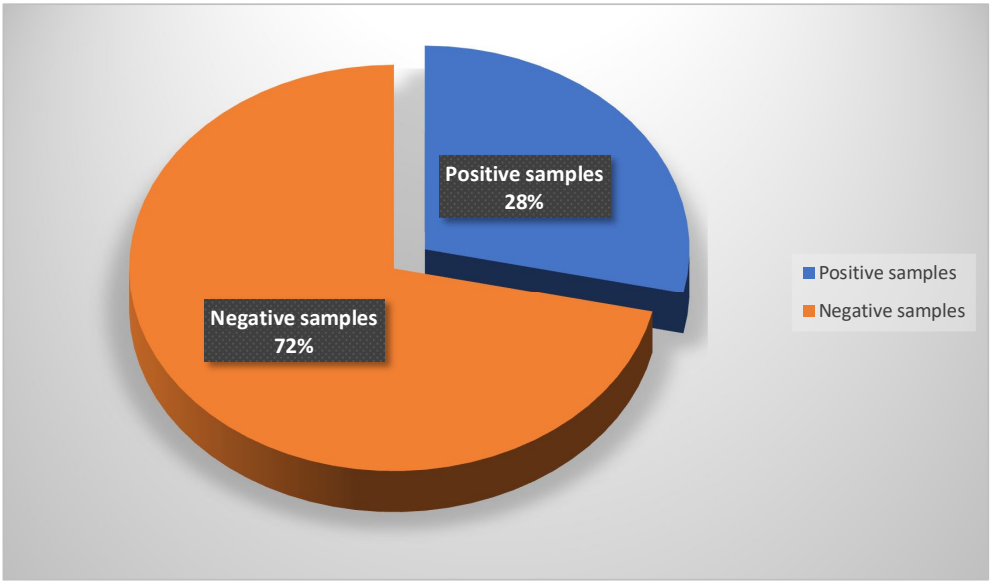

Fig. 1. The number of positive samples isolated (28%)

Gram-negative bacteria accounted for 58.5% (471/804) and Gram-positive 33% (267/804) of the positive results. Among Gram-negative isolates, *E. coli* (33.8%) and *K. pneumoniae* (10.8%) were the most prevalent microorganisms in UTI patients, while other gram negatives isolated included *Pseudomonas aeruginosa* (10.1%), *Acinetobacter* (1.2%), *Proteus sp* (1%), *Enterobacter sp (1%)* and *Citrobacter sp* (0.2%) as seen in Table 1.

Table 1. The age-wise distribution of study samples (n=804)

Age group	Males (353) (n, %)	Females (451) (n, %)
15-25 years	72 (20.4)	43 (9.5)
26-35 years	34 (9.6)	88 (19.5)
36-45 years	45 (12.7)	126 (27.9)
46-55 years	46 (13.0)	74 (16.4)
56-65 years	61 (17.3)	56 (12.4)
>65 years	95 (26.9)	64 (14.1)
Total	353	451

Enterococcus sp (26.3%) was the most common gram-positive organism isolated followed by *Staphylococcus aureus* (6.8%), most of which were methicillin resistant (Figure 2).

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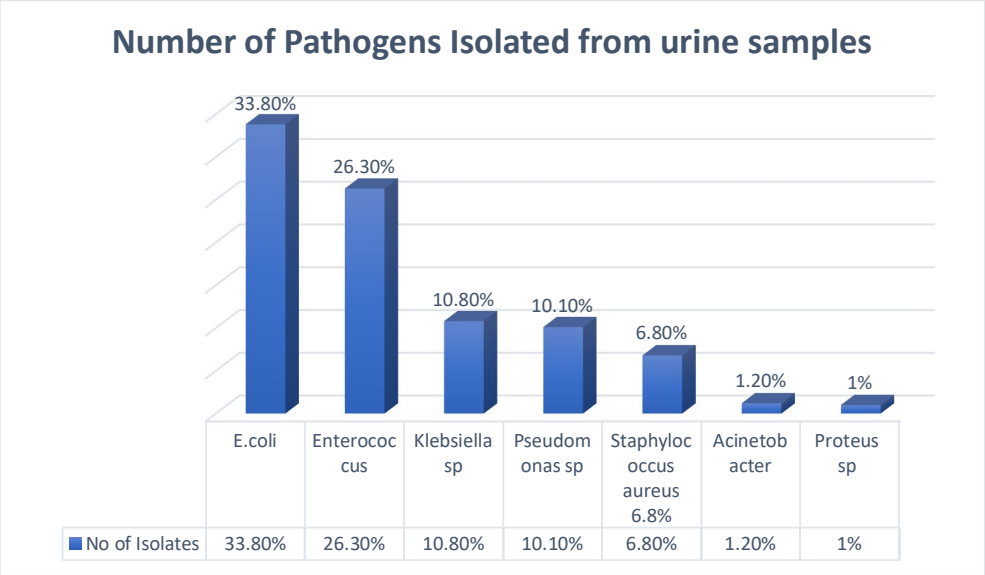

Fig. 2. Showing the frequency of uropathogens isolated

Urinary tract infection was higher in females,451/804 (56.1%) as compared to men, 353/804(43.9%) as shown in Figure 3.

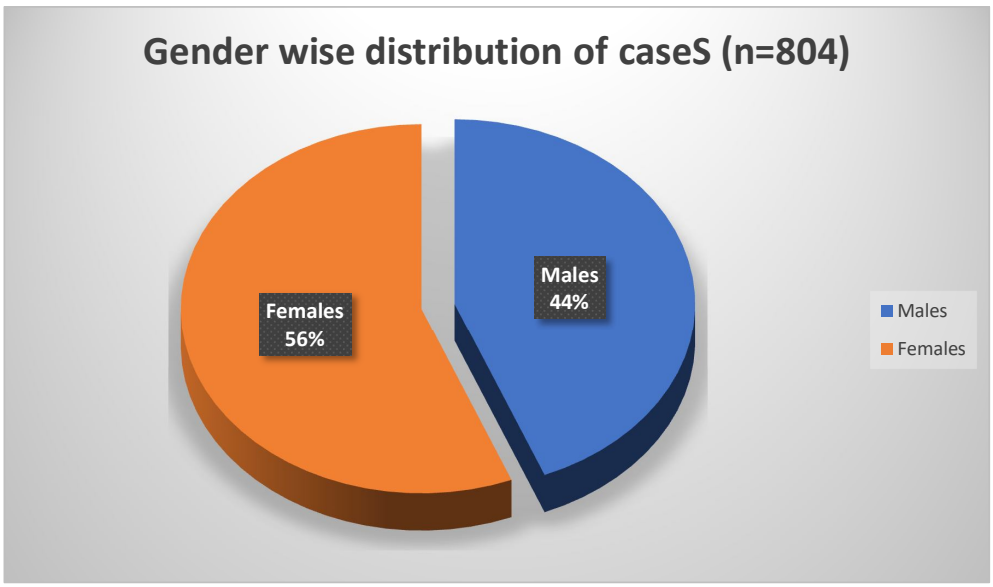

Fig. 3. Gender-wise distribution of study cases

As shown in Figure 4, the presence of uropathogens was most common in the age group 36-45 years in females (27.9%) and age group above 65 years in males (26.9%). E. coli was the most organism isolated from both males and females as shown in Figure 4.

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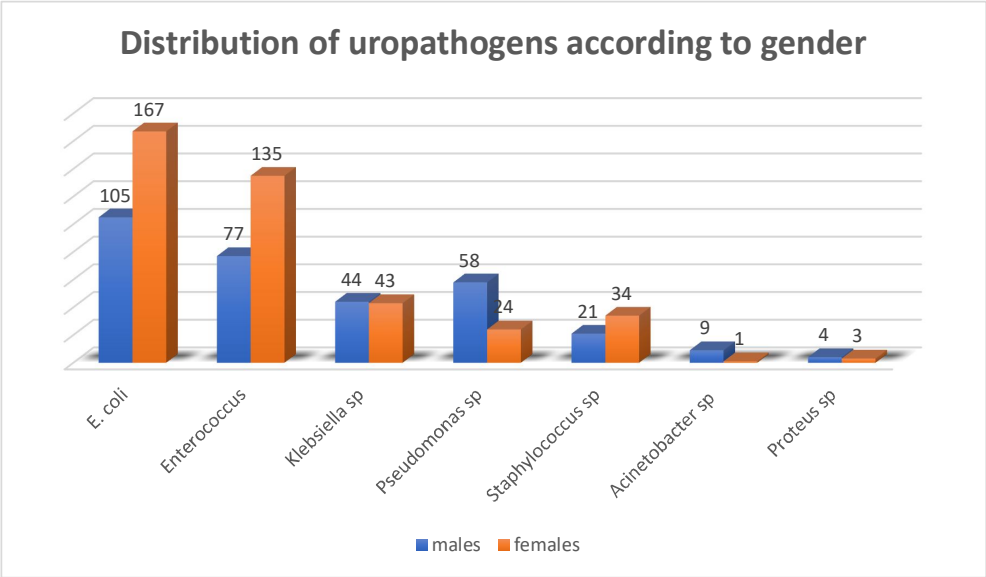

Fig. 4. Distribution of uropathogens according to gender.

Tables 2 and 3 are representative of the overall antibiotic sensitivity pattern of urinary bacterial isolates. *E. coli* was mostly sensitive to nitrofurantoin (79%%), cefoperazone/sulbactam (40.7%), piperacillin /tazobactam (39.3%). It showed significant resistance to quinolones and carbapenems. Among the isolates of *Klebsiella pnuemoniae*, nitrofurantoin (71.2%) was the most effective antibiotic while as ceftriaxone was the least effective (28.7%) as shown in Table 2.

Table 2: Number and percentage distribution of drug sensitivity of gram-negative uropathogen

Antibiotics	E. coli (272)	Klebsiella sp (87)	Pseudomonas aeruginosa (82)	Acinetobacter sp (10)
	n%	n%	n%	n%
Nitrofurantoin	215 (79.0)	62 (71.2)	8 (9.7)	4 (40.0)
Co-trimoxazole	106 (38.9)	46 (56.8)	7 (8.5)	2 (20.0)
Norfloxacin	71 (26.1)	31(35.6)	20 (24.3)	1 (10.0)
Ciprofloxacin	81 (29.7)	32(36.7)	30 (36.5)	2 (20.0)
Ceftriaxone	99 (36.3)	25 (28.7)	18 (21.9)	2 (20.0)
Amikacin	101 (37.1)	30(34.4)	19 (23.1)	3 (30.0)
Imipenem	56 (20.5)	29 (33.3)	18 (21.9)	2 (20.0)
Meropenem	102 (37.5)	46 (52.8)	20(24.3)	4 (40.0)
Ampicillin	4 (1.4)	-	0	0
Cefoperazone/sulbactam	109 (40.7)	55 (63.2)	21 (25.6)	3 (30.0)
Piperacillin/tazobactam	107(39.3)	54 (62.0)	25(30.4)	4 (40.0)
Aztreonam	-	-	13 (15.8)	-

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In gram-positive organisms Enterococcus had maximum sensitivity to linezolid (100%), followed by nitrofurantoin (61.7%) and vancomycin (61.7%). Most of the strains of Staphylococcus were methicillin resistant 51/55 (92.7%) against whom the most effective antibiotics were vancomycin and linezolid. (Table 3).

Table 3: Number and percentage distribution of drug sensitivity of gram-positive uropathogens

Antibiotics	Enterococcus sp (212) n (%)	Staphylococcus aureus (55) n (%)
Penicillin	14 (4.2)	2(3.9)
Ciprofloxacin	28 (13.2)	30(58.8)
Nitrofurantoin	160 (75.4)	41 (80.3)
Ampicillin	16 (7.5)	1 (1.5)
Tetracycline	117 (55.1)	22 (43.1)
Linezolid	212 (100)	51 (100)
Vancomycin	131 (61.7)	51 (100)
Ceftriaxone	-	4 (7.8)

Discussion

UTI is one of the most common diseases diagnosed worldwide and bacterial infection of the urinary tract is one of the common causes for seeking medical attention in the community. Effective management of patients suffering from bacterial UTIs commonly relies on the identification of the type of organisms that caused the disease and the selection of an effective antibiotic agent. The etiology and the antimicrobial susceptibility for urinary tract infection have been changing over the years. Knowledge of local susceptibility patterns is important for the selection of appropriate empirical therapy for UTI.

The present study shows the different types of bacterial pathogens isolated from urine sample of patients suffering from urinary tract infection (UTI) and their antibiotic sensitivity pattern. It focuses on the distribution of UTIs across both genders and various age groups, as well as the resistance patterns exhibited by various uropathogens in response to the antimicrobials.

The prevalence of UTI was found to be 28.46% in this study correlating to the prevalence rate of UTI with study done by Sharma et al. (27.3%) (16).

Some studies from India done by M. Dash et al. (17) and M. Mehta et al. (18) showed prevalence of 34.5% and 36.68%, respectively. Also, higher prevalence was seen in a study by Devanand et al. (53.82%) (19). The higher prevalence of UTIs in this study could have been probably due to the inclusion of a number of risk groups like diabetes, elderly, pregnant women, HIV, infants, and a high number of inpatients who are usually prone to UTIs.

We assessed the relationship between various risk factors and UTI. Sex was one of the considered factors and the result indicated that UTI prevalence was higher in females than males for each isolate. In the present study, 56% of the patients were females and 43.9% of the patients were males, with male: female ratio of 0.78: 1. Similar findings have also been reported by numerous authors in their studies (20,21). The reason behind this high prevalence of UTI in females is due to the proximity of the urethral meatus to the anus, shorter and wider urethra, sexual intercourse, incontinence, less acidic pH of vaginal surface, and poor hygienic conditions (22). On the other hand, some studies show contrary results and in these studies prevalence of UTI was higher in males due to prostate enlargement (23). Thus, it appears that the percentage of UTI in males and females can vary depending on the place of study or physiological characters of the patients.

Prevalence difference was also observed among various age groups. Increased incidence of UTI was seen among female patients in age groups from 36 -45 years (27.9%) followed by 19.5% in 26-35 years age group.

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The risk factors for recurrent UTI in premenopausal sexually active women include the onset of symptoms briefly after sexual intercourse, the use of spermicides for contraception, the emergence of new sexual partners, the age of the first UTI, maternal history of UTI and the dysfunction in voiding (24). This difference suggests that age is one risk factor associated with UTI. The high incidence of UTI amongst the old age group could be due to genito-urinary atrophy and vaginal prolapse after menopause in females which in turn increases the risk of bacteriuria by increasing vaginal pH and decreasing vaginal Lactobacillus thereby allowing gram-negative bacteria to grow and act as uropathogens (25). Moreover, some studies have indicated that UTI is more common infection in elderly populations (26).

Gram-negative bacteria accounted for 58.5% (471/804) and Gram-positive 33% (267/804) of the positive results which were in agreement with other studies also (27). *E. coli* was the most common organism isolated (33.8%) among the gram negatives followed by Klebsiella sp (10.8%) while other gram negatives isolated included *Pseudomonas aeruginosa* (10.1%), *Acinetobacter* (1.2%), *Proteus sp* (1%), *Enterobacter sp (1%)* and *Citrobacter sp* (.2%). These finding correlates with the findings of Bharti et al., where the prevalence of E. coli and Klebsiella was found to be 36.84% and 7.66%, respectively (28). This result is also consistent with reports from other studies by Devanand et al., (19), Arghya Das et al., (29) Ahmed Naeem et al. (30) where 42.58%, 53.69%, 34.1% cultures grew E. coli, respectively; and it was the most frequent pathogen causing UTI in all these studies. Higher incidence of gram-negative bacteria, related to Enterobacteriaceae, in causing UTI has many factors which are responsible for their attachment to the uroepithelium such as they are able to colonize in the urogenital mucosa with adhesins, pili, fimbriae, and P-1 blood group phenotype receptor (31).

In the present study E. coli was sensitive to nitrofurantoin, imipenem and amikacin which was contrary to the findings of Pattanayak C et al., (32) who found that the organism was mainly sensitive to polymyxin B, gatifloxacin and ceftriaxone. In this study, E. coli was mostly resistant to cephalosporins, which are consistent with the findings of other studies. (33).

In our study Klebsiella sp were sensitive to nitrofurantoin (71.2%), meropenem (52.8%) and ceftriaxone (56.8%). Study by Ahmed Naeem et al. (30) has reported highest sensitivity to

gentamicin (92.3%) followed by imipenem (90.2%) and less sensitivity was shown to cefotaxime. Arghya Das et al. (29) in his study observed highest resistance to ampicillin, fluoroquinolones and ceftriaxone whereas gentamicin and nitrofurantoin were the antibiotics to which organisms were most sensitive. Our findings are consistent with another study showing alarmingly high resistance for fluoroquinolones and third-generation cephalosporins. (34).

Enterococcus sp (26.3%) was the most common gram-positive organism isolated followed by Staphylococcus aureus (6.8%), most of which were methicillin resistant. These findings were similar to study of Chooramani et al. (35) who showed the incidence Enterococcus spp (20.7%) and Klebsiella spp (10.3%). The sensitivity pattern of Enterococcus revealed that the most effective drugs against it were linezolid (100%), Vancomycin (61.7%) and nitrofurantoin (75.4%). A study by Goel et al. in New Delhi (36) also revealed a high degree of resistance of Enterococcus to tetracycline and ciprofloxacin. Variations in sensitivity may be due to the inappropriate exposure of different localities as to antibiotics which can drive the development of resistance.

The increasing rates resistance to antibiotics such as ampicillin, cephalosporins, trimethoprim-sulfamethoxazole, and quinolones, especially in E. coli and Klebsiella strains, which are the most common pathological agents of UTI in our region, have limited the use of these treatments. Nitrofurantoin, one of the oldest oral antibiotics, emerged as the drug which showed high sensitivity in our study. It was effective against most of the uropathogens especially among the OPD patients. This may be because of localized action of this drug only on the urinary tract. So, nitrofurantoin can be considered as the first line, cost saving and effective oral therapy in UTI patients at OPD level.

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Conclusion

Urinary tract infections pose a major health problem for human society worldwide. The results of the present study reveal that UTI occurs in all age groups and both genders but prevalence was higher in females. The need of the hour is periodic assessment of the susceptibility pattern of urinary pathogens as it serves as a guide for antibiotic therapy as these organisms exhibit resistance to many first-line drugs used for UTI infection. In order to prevent resistance to antibiotics, appropriate therapy as per antibiotic sensitivity pattern needs to be initiated. The small size of the sample is the main limitation of this study, so it is recommended to do more studies in this case with more study populatiuon.

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Conflict of interest:

The authors declare that they have no conflicts of interest.

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Data Availability

The raw data supporting the conclusions of this article are available from the authors upon reasonable request.

Ethical statement:

The study was a retrospective analysis of existing data and did not involve any direct patient contact or intervention. All patient data were anonymized and de-identified to protect patient confidentiality.

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