Uropathogens And Their Evolving Antimicrobial Resistance Patterns In Urinary Tract Infections: A Study From A Tertiary Care Hospital In Dhaka, Bangladesh

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KEYWORDS

Antimicrobial susceptibility, UTI, Uropathogens, Microbial surveillance, empirical antibiotic therapy

ABSTRACT:

Background: Urinary tract infections (UTIs) rank among the most prevalent bacterial infections in humans. The pathogens responsible for UTIs differ by region and also exhibit varying resistance patterns. Objective: This research aimed to identify the most frequent causative agents, assess their distribution, and analyze the resistance patterns of bacterial strains isolated from UTI patients at a tertiary care hospital in tertiary care hospital, Dhaka. ***Methods:*** Urinary isolates from symptomatic UTI patients were identified using conventional techniques. Antimicrobial susceptibility testing was conducted using the Kirby Bauer disk diffusion method. ***Results:*** Out of 17139 samples tested, 5266 demonstrated growth of organisms, with *E. coli* being the most common (53.97%), followed by *Klebsiella species* (17.89%). The majority of isolates were obtained from female patients within the reproductive age group. *E. coli* and *Klebsiella spp*. exhibited significant resistance to Amoxicillin, third-generation cephalosporins, and Ciprofloxacin, while showing the highest sensitivity to Meropenem and Nitrofurantoin. Among gram-positive bacteria, notable resistance was found against Amoxicillin, with all isolates being sensitive to Vancomycin. ***Conclusion:*** The findings of this study indicate that UTIs are more prevalent in females, particularly those of reproductive age. E. coli emerged as the leading bacterial pathogen. Urinary pathogens displayed resistance to commonly prescribed antibiotics such as Amoxicillin, third-generation cephalosporins and Ciprofloxacin. Given the good sensitivity observed for Nitrofurantoin across all organisms, it is recommended for use in empirical treatment of UTIs.

INTRODUCTION

Urinary tract infections (UTIs) are among the most prevalent bacterial infections globally, impacting millions of individuals each year [1]. In Bangladesh, particularly in densely populated urban centers like Dhaka, UTIs pose a considerable public health challenge. The most prevalent uropathogenic agents involved are E coli, Klebsiella spp., Proteus spp., and Pseudomonas aeruginosa [2]. Additionally, Gram-positive bacteria like Enterococcus fecalis, Staphylococcus saprophyticus, Staphylococcus aureus and Streptococcus agalactiae can also cause UTIs [3]. In recent years, the increase in antimicrobial resistance (AMR) among these pathogens has become a significant concern in clinical settings, frequently making standard empirical treatments ineffective [4]. The high population density in Dhaka, along with unregulated antibiotic access and insufficient antimicrobial stewardship programs, has facilitated the swift emergence of resistant strains [5]. UTIs are significantly more prevalent in women than in men due to anatomical and physiological factors; the positioning of the urogenital tract makes it more susceptible to bacterial infections [6]. Surveillance data from local healthcare institutions reveal a growing resistance to commonly prescribed antibiotics, including ciprofloxacin, cephalosporins, and even carbapenems

[7]. This preference is due to their high rates of bacteriological and clinical cure, along with low resistance rates among the most common uropathogens [8]. This concerning trend highlights the pressing need for ongoing monitoring of resistance patterns and the development of evidence-based treatment protocols.

This study aims to explore and analyze the trends in antimicrobial resistance among uropathogens in Dhaka, Bangladesh. By understanding local resistance patterns, healthcare providers can better tailor empirical therapies, reduce treatment failures, and mitigate the spread of resistant infections.

METHODOLOGY & MATERIALS

The current research was conducted at Department of Microbiology and Immunology, Bangladesh Medical University from July 2023 to June 2024. Patients visiting the OPD and IPD with any symptoms indicative of a UTI were included in the study. Freshly voided, clean-catch midstream urine samples were collected from each patient into sterile screw-capped universal containers. Specimens collected in unsterile containers, those that were delayed in transport for culture, not kept refrigerated at 4°C, and inadequate samples for urine culture were excluded from the study. Each specimen was labeled and transported to the microbiology laboratory for processing within 2 hours. A semi-quantitative urine culture was performed using a calibrated loop. A 4mm loopful of well-mixed un-centrifuged urine was inoculated onto the surface of MacConkey and blood agar media. The plates were then incubated aerobically at 37°C for 24 hours. After incubation, the plates were examined for bacterial growth. Significant growth is defined as a colony count of $\geq 10^5$ colony-forming units (cfu)/ml. The colonial appearance and morphological characteristics of the isolated bacteria were recorded, and the isolated colonies underwent preliminary tests such as Gram staining, motility assessment via hanging drop, catalase test, and oxidase test. These preliminary tests were followed by standard biochemical reactions to identify the isolated organisms. All the isolates were tested for antimicrobial susceptibility by disc diffusion methods according to the Clinical Laboratory Standard Institute (CLSI) guidelines [9,10]. Hi Media discs, which are commercially available, were utilized. A bacterial suspension was prepared by inoculating the tip of 2-3 well-isolated identical colonies in peptone water. After 2 hours of incubation, the turbidity was adjusted to the 0.5 McFarland standard. A sterile swab stick was then used to create a lawn culture on the Mueller-Hinton agar plates. The antibiotic discs were placed according to CLSI guidelines [10]. The inoculated plates were incubated at 37 ℃. Results were evaluated after overnight incubation and compared against a standard chart. The control strains employed included E. coli ATCC 25922, *Pseudomonas aeruginosa* ATCC 27853, and *S. aureus* ATCC 25923.

Statistical Analysis

Data obtained from this research were presented and analyzed using the Statistical Package for Social Sciences (SPSS) version 26.0 (IBM Inc., USA). Results were expressed in tables.

RESULTS

Table 1: Age- and gender-specific infection rates of urinary tract infections (UTIs).

Age Range	Male	Female	Total
0-10	11	49	60
11-20	31	63	94
21-30	301	1833	2134
31-40	405	527	932
41-50	701	537	1238
>50	302	506	808
Total	1751(33.25%)	3515(66.75%)	5266(100%)

During the study period, a total of 17139 urine samples were collected, with 5266 (30.73%) of these samples demonstrating significant growth. Among these, 3515 were from females and 1751 from males, as illustrated in (Table 1).

Table 2: The pattern of the microorganism with its percentage isolated from UTI

Organism	Number	Percentage
Klebsiella spp	942	17.89%
E. coli	2842	53.97%
Staphylococcus aureus	240	4.56%
Serratia	4	0.08%
Pseudomonas spp	239	4.54%
Acinetobacter spp	173	3.29%

Enterobacter	72	1.37%
Proteus spp	84	1.60%
Enterococci	457	8.68%
Streptococcus agalactiae	8	0.15%

E. coli was the most frequently isolated urinary pathogen (53.97%), followed by Klebsiella spp. (17.89%), Pseudomonas aeruginosa (4.54%), and Enterococcus faecalis (8.68%), as detailed in (Table 2).

Table 3: Antibiotic Resistance Pattern of Gram-Negative Bacteria isolated from study population

Antibiotics	*E. coli* (%)	*Klebsiella spp* (%)	*Pseudomonas spp* (%)	*Enterobacter spp* (%)	*Acinetobacter spp* (%)	*Serratia spp* (%)	*P. mirabilis* (%)
Amoxicillin	85	96		82	47		77
Cotrimoxazole	40	52		40	56	75	45
Ciprofloxacin	78	60	58	35	65	75	19
Nitrofurantoin	22	15		8			18
Gentamicin	22	26	59	37	64	50	29
Cefotaxime	76	72		42	79	25	22
Ceftazidime	75	74	74	40	72	25	25
Amikacin	20	24	48	62	48	25	40
Meropenam	11	6	15	4	16	0	0
Cefepime	72	76	46	40	70		12
TPZ	47	42	70	30	37	0	29

E. coli and Klebsiella spp. exhibited high resistance to Amoxicillin, third-generation cephalosporins, and Ciprofloxacin, while showing good sensitivity to Meropenem and Nitrofurantoin. While analyzing the data from Table 3, Pseudomonas aeruginosa demonstrated the best sensitivity to Meropenem (85%), but showed 74% and 70% resistance to Ceftazidime and Piparacillin-Tazobactam (TPZ), respectively (Table 3).

Table 4: Antibiotic Resistance Pattern of Gram-Negative Bacteria isolated from study population

Antibiotics	*S saprophyticus* (%)	*S aureus* (%)	*E faecalis* (%)
Amoxicillin	84	76	85
Cotrimoxazole	37	41	32
Ciprofloxacin	51	42	70
Nitrofurantoin	14	15	10
Cefoxitin	70	66	-
Gentamicin	33	27	67
Amikacin	35	14	-
Vancomycin	0.0	0.0	0.0
Linezolid	0.0	0.0	0.0

Enterococcus faecalis displayed high resistance to Amoxicillin (85%) ciprofloxacin (75%) and cotrimoxazole 40%, while exhibiting complete sensitivity to Vancomycin (100%). *Staphylococcus saprophyticus* was isolated from adult female patients and showed increased resistance to Amoxicillin (84%), Ciprofloxacin (45%), and cefoxitin (70%) (Table 4).

DISCUSSION

The effective management of patients with bacterial UTIs primarily depends on identifying the organisms responsible for the infection and selecting an appropriate antibiotic treatment. The diagnosis of UTIs exemplifies the necessity for close collaboration between clinicians and microbiologists. The study indicates that the prevalence of UTIs is significantly higher in females (66.75%) compared to males (33.25%). Within the female population, the highest occurrence is noted in the reproductive age group (54.14%). Our research revealed that urinary tract infections (UTIs) are more common in females compared to males, aligning with findings from similar studies [11-14]. The anatomical distinctions between male and female genitourinary systems, particularly the shorter urethra in women, along with various host factors—such as changes during sexual maturation, shifts in normal vaginal flora, pregnancy, and childbirth likely play a role in the elevated infection rates among females[14]. Moreover, research by Al-Badr and Al-Shaikh indicates that around 50 to 60% of women will experience a UTI at least once in their lives, particularly among the elderly [15].

In the present study, a higher prevalence of urinary tract infections (UTIs) was observed among males aged >40 years (40%), which may be attributed to an increased incidence of bladder outlet obstructions, including benign prostatic hyperplasia, prostatitis, and urolithiasis, all of which can contribute to urinary stasis and reduced voiding frequency [16]. Additionally, females aged >20 years demonstrated a higher UTI incidence compared to their male counterparts, likely due to physiological and hormonal factors associated with the reproductive age group, particularly pregnancy, which is a well-established risk factor for UTIs [17].

Escherichia coli accounted for 53.97% of all uropathogenic isolates, confirming its role as the leading etiological agent in urinary tract infections (UTIs), as documented in multiple epidemiological studies [11-14,17-20]. *Klebsiella* spp. represented the second most common pathogen, isolated in 17.89% of cases, which is consistent with prevalence rates reported in similar regional and global studies [11,14,21-23]. Combined, *E. coli* and *Klebsiella* spp. were responsible for approximately 71.86% of UTI cases in the analyzed sample. This finding supports the World Health Organization (WHO) estimate that these two pathogens contribute to nearly 80% of UTI infections globally [24].

Among Gram-negative isolates, *Escherichia coli* demonstrated the highest resistance rates to Amoxicillin (85%) and Ciprofloxacin (78%), while retaining pronounced susceptibility to Meropenem (98%). These findings are consistent with surveillance data from South India, which similarly attributed resistance to first-line antimicrobials such as Amoxicillin and Ciprofloxacin to their widespread empirical use and consequent selective pressure [25,26]. *Klebsiella spp.* exhibited comparable trends, showing marked resistance to Amoxicillin (96%) and Cefepime (76%), while maintaining high sensitivity to Meropenem (94%), in alignment with the results reported by Jubina et al. [27]. *Pseudomonas aeruginosa* displayed notable susceptibility to Meropenem (85%), a significant contrast to findings from Aligarh, India, where only 33% sensitivity was documented [28]. Furthermore, elevated resistance rates to Ceftazidime (74%) and Piperacillin–Tazobactam (70%) were observed, corroborating previous data from Aligarh and Barabanki [28-29]. Among Gram-positive isolates, *Enterococcus faecalis* and *Staphylococcus saprophyticus* exhibited the highest susceptibility to Vancomycin and Linezolid, findings that are consistent with those reported by Choudhary et al [29].

From our study, Nitrofurantoin revealed significant antimicrobial sensitivity against the majority of uropathogens implicated in urinary tract infections. These results align with previously published studies [27-31]. Consequently, Nitrofurantoin is recommended as a first-line empirical therapeutic agent pending definitive culture and susceptibility data.

The observed elevated rates of antibiotic resistance to broad-spectrum antibiotics in this study are attributable to multiple critical risk factors driving the proliferation of antimicrobial resistance. A primary contributor is the widespread overuse of antibiotics, facilitated by their easy accessibility as over-the-counter medications without the necessity of a physician's prescription. In Bangladesh, the prevalence of unregulated pharmacies dispensing antibiotics for minor ailments, combined with the affordability and convenient oral administration of these drugs, has led to pervasive inappropriate self-medication and misuse of antimicrobials [32]. Moreover, uropathogens isolated in this investigation demonstrated substantial resistance to third-generation cephalosporins, which remain commonly prescribed for various infections across the country [33]. Consequently, practices such as incorrect dosing regimens, unwarranted prescriptions of potent antibiotics to patients lacking clinical indications, and the indiscriminate use of antimicrobials for diverse infections collectively exacerbate the escalating antimicrobial resistance burden within both healthcare settings and the broader community.

The overall resistance profile underscores a concerning trend of declining efficacy of commonly prescribed antimicrobials and emphasizes the necessity for ongoing surveillance and rational antibiotic stewardship.

Limitations of the study

This study is limited by its retrospective design and reliance on data from a single tertiary care laboratory, which may restrict the broader applicability of the findings. The absence of clinical parameters such as comorbid conditions and catheterization status prevented differentiation between true infections and potential cases of colonization or asymptomatic bacteriuria. Without these clinical correlations may have led to the inclusion of cases involving colonization or asymptomatic bacteriuria.

CONCLUSION

Urinary tract infections (UTIs) represent a substantial healthcare burden due to their high incidence in the general population. In primary care settings, UTIs are predominantly observed among young females of reproductive age. Gram-negative bacteria constitute the majority of uropathogens, with *Escherichia coli* identified as the leading causative agent. These pathogens have exhibited considerable resistance to commonly prescribed antibiotics,

including Amoxicillin, third-generation cephalosporins, and Ciprofloxacin. The present study reveals alarmingly elevated resistance rates to these antimicrobial agents. Conversely, Nitrofurantoin maintains robust in vitro efficacy, thereby remaining a viable option for empirical therapy. Given the dynamic nature of antimicrobial resistance among uropathogens, ongoing regional surveillance and susceptibility monitoring are imperative to guide effective empirical treatment strategies. These findings underscore the urgent need for rational antibiotic use and strengthened antimicrobial stewardship programs to mitigate resistance development.

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