Original Article

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Antibiotic Resistance Profile of Uropathogenic Bacteria in a Tertiary Care Hospital, Chattogram, Bangladesh: A Focus on Multidrug-Resistant Strains

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Abstract

Background: In Bangladesh, Urinary Tract Infection (UTI) is the most common bacterial infection, and misuse of antibiotics is causing Antimicrobial Resistance (AMR) rapidly increasing. The purpose of this study is to identify the antibiotic resistance pattern of bacterial uropathogens in patients with multidrug resistance rates at a tertiary hospital in Chandanaish Upazilla, Chattogram.

Materials and methods: An institution-based cross-sectional study was done in the clinical laboratory for the diagnosis of patients attending BGC Trust Medical College and Hospital. The data of urine samples and their antibiotic sensitivity patterns were obtained from the laboratory register book. Secondary data were collected and entered into the SPSS version 22 computer software package for univariate and bivariate analysis.

Results: Out of 891 registered patient data sets, 886 results were taken and investigated. About 27% (239) people had a urinary tract infection, and the maximum count of the isolates, 81.6% (195) were from females. The highest prevalence was obtained among the age groups of 19–30 years (36.8%). Escherichia coli was the most prevalent organism, 64.9% (155). All the isolatesshowed the maximum resistance to cefuroxime and cefradin, ranging from 85-100%. The antibiotic resistant rate and multi-drug resistant rate were 97.9% and 65.81%, respectively. E. coli showed the highest drug resistance and multi-drug resistance 65.9% and 64.3%.

Conclusion: The study highlights a high prevalence of antibiotic resistance and multidrug resistance in bacterial uropathogens, notably Escherichia coli. Resistance to critical antibiotics like cefuroxime and cefradine underscores the need for enhanced antibiotic stewardship and control measures to combat Antimicrobial Resistance (AMR).

Key word: Antibiotic resistance; Bacteria; Multi drug resistance; Patient; UTI.

Introduction

Urinary Tract Infection (UTI) is one of the most common bacterial infections seen in medical practice, particularly in developing countries with a high rate of morbidity and financial expense.[1,2] Every year, about 150 million new cases are diagnosed resulting in 6 billion USD in health care cost.[3] Bacterial cystitis is the most common infectious disease in women. Every woman has a 60% lifetime experience with bacterial cystitis, which develops mostly before the age of 24.[4] The main primary organisms of UTI are Gram-negative bacteria like Escherichia coli (E. coli) Klebsiella, Proteus mirabilis, Pseudomonas aeruginosa, Acinetobacter and Serratia and Gram-positive bacteria like Enterococcus and Staphylococcus, with Escherichia coli being the most common pathogen in both community and hospital settings, which is responsible for more than 80% of cases.[5,1]

Increasing Antimicrobial Resistant (AMR) bacteria represent a growing threat to public health. Multidrug-Resistant (MDR) bacteria, which are gaining attention, are defined as having acquired non-susceptibility to at least one agent across three or more antimicrobial categories.[6] A surveillance study in 42 Eastern European centers revealed an increase in antibiotic resistance among E. coli isolates, with Turkey having the highest proportion of ESBL (Extended Spectrum Beta-Lactamase)-positive bacteria, followed by Russia, Switzerland, Croatia and Bosnia and Herzegovina.[7] Research from several parts of India hasdemonstrated that E. Coli has thehighest rates of antimicrobial resistance. The study also reported thatthe resistance rates of uropathogenic

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E. coli to various antibiotics were beta-lactams (57.4%) co-trimoxazole (48.5%) quinolones (74.5%) gentamicin (58.2%) amikacin (33.4%) cefuroxime (56%) and nalidixic acid (77.7%).[8]

Less than a century after Sir Alexander Flemming discovered Penicillium notatum, the increasing Antimicrobial Resistance (AMR) of most clinically important bacteria to antimicrobial drugs is a serious public health problem. AMR has spread all over the world, devastating all regions of the globe, including Europe, the Americas, Africa and Australasia.[9] In the United States, every year more than 2.8 million people contract an antibiotic-resistant infection, leading to more than 35,000 deaths, the similar statistic for Europe is 33,000 per year.[1] About 700,000 deaths are reported annually due to Antimicrobial Resistance (AMR).[10] According to the report of WHO, it is state that, the multidrug resistance accounts for about 45% of mortality in both South Asia and Africa.[11] By 2050, drug-resistant infections may cause 10 million deaths per year, with Asia and Africa accounting for almost 90% of these fatalities.[12]

In Bangladesh, antibiotic prescribing rates are increasing due to physicians prescribing antibiotics empirically before laboratory results are available, leading to increased misuse of antibiotics.[1] This issue is particularly prevalent in rural areas, where excess prescribing and inproper prescribing are common due to unethical practices by health professionals and drug manufacturers.[13] Due to the high prevalence of infectious illness morbidity and mortality, the absence of comprehensive research on antibiotic resistance patterns in Bangladesh often leads to the prescription of several antibiotics, including broad-spectrum antibiotics.[14] This study aimed to identify the bacteria causing UTI and determine the resistance profile of multidrug-resistant isolates using Antimicrobial Susceptibility Test (AST) data recorded in the laboratory register book of the microbiology department at BGC Trust Medical College.

Materials and methods

This was a cross-sectional study conducted in the Department of Microbiology, BGC Trust Medical College and Hospital, BGC Bidyanagar, Chandanaish, Chattogram. The data was obtained from the laboratory register book, which contains all the recorded reports. All the AST reports of patients attending the hospital from the period of January 2019 to January 2022 with suspected Urinary Tract Infections (UTIs) were included. Patients with incomplete data or reports of non-urinary tract infections were excluded. The sample size was not calculated, a total of 886 samples were analyzed from the record book.

Data collected for each patient included registration number, age, sex, urine culture results, identification of the bacterial strain causing UTI and corresponding Antimicrobial Susceptibility Test (AST) findings. Since this was secondary data, Institutional Review Board approval was not necessary, but written permission was obtained from the Principal and Head of the Department of Microbiology at BGC Trust Medical College Hospital. The culture data were analyzed using conventional standards, and a bacteriuria growth of 10^5 colony forming units/ml was considered significant.[15] The Rapid, Modified Kirby-Bauer Susceptibility Test with Single, High-Concentration technique was used to test antibiotic susceptibility and interpretations were produced for each bacterial isolate using interpretative criteria suggested by the National Committee for Clinical Laboratory Standards.[16,17]

Data variables included basic demographics (Age, gender) infectious agents identified, and individual sensitivity to 14 antimicrobials (Amoxicillin-clavulanic acid, Amikacin, Azithromycin, Cefuroxime, Ceftriaxone, Cefradin, Ciprofloxacin, Cotrimoxazole, Meropenem, Gentamycin, Nitrofurantoin, Piperacillin-tazobactam, Penicillin) used for the treatment. But we used all of those isolates where we found coliform bacteria. Gentamycin was used in the sample that found E. coli, Coliform bacteria, and Klebsiella. Meropenem was used in samples that found E. coli and Coliform bacteria. Colistin, Piperacillin-tazobactam and Penicillin were not used in the samples that found E. coli, Klebsiella, Pseudomonas and Acinetobacter. Data is password protected and secured by the organization policy. Only the authorized person can access it. Then data was coded in the software IBM SPSS Statistics V. 22.0.

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IBM SPSS Statistics V. 22.0 was used for univariate and bivariate analysis of the data. To summarize patient characteristics and other pertinent information, descriptive statistics such as frequency, percentage, mean, and standard deviation were used. The Chi-Square test was performed to examine the distribution of antibiotic resistance and MDR among different age and sexgroups and antibiotic sensitivities of uropathogens.

Results

Over the three-year period, we got 886 urine samples in total for culture and sensitivity test. The sex distribution was that females contributed 78.9% (699) and males were 21.1% (187). The largest age group in this study was 19–30 years old 371 (41.9%). The highest bacterial growth found in the age group 19-30 years was about 36.8% (88). Growth of bacteria in culture was highly prevalent in females, at 81.6% (195) (Table I).

Table I Demographic characteristics associated with UTI (n=886)

	Frequency (%) (n=239)	Positive % (n=647)	Negative %
Age group			
0-18	161 (18.17)	17.6 (42)	18.4 (119)
19-30	371 (41.88)	36.8 (88)	43.7 (283)
31-40	150 (16.93)	16.7 (40)	17 (110)
41-50	72 (8.13)	9.2 (22)	7.7 (50)
51-60	61 (6.88)	7.9 (19)	6.5 (42)
more than 60	71 (8.01)	11.71 (28)	6.6 (43)
Gender			
Male	187 (21.11)	18.4 (44)	22.1 (143)
Female	699 (78.89)	81.6 (195)	77.9 (504)

The isolated uropathogens were E. coli 64.9% (155) Coliform bacteria 31% (74) Klebsiella 2.9% (7) Pseudomonas 2 (0.8%) and Acinetobacter 0.4% (1). In the age group, E. coli was also highly prevalent in all age groups except 51–60 years, where coliform bacteria were prevalent.All the organisms were highly prevalent in females. E. coli was the highest percentage, both male and female, at 64.6% (126) and 65.9% (29). From the isolated bacteria, E. coli showed the highest antibiotic resistance (64.5%). The frequency of MDR isolates of E. coli was (64.3%) Coliform bacteria (32.5%) Klebsiella (1.9%) Pseudomonas (0.6%) and Acinetobacter (0.6%) (Table II).

Table II Percentage frequency of bacterial isolation from culture in different age and sex group and showing drug resistance and multi drug resistance

Bacteria Isolated from culture	Coliform bacteria % (n)	E. Coli % (n)	Klebsiella % (n)	Pseudomonas % (n)	Acinetobacter % (n)
%(n)	31 (74)	64.9 (155)	2.9 (7)	0.8 (2)	0.4 (1)
Age Group					
0-18	28.6 (12)	71.4 (30)	0 (0)	0 (0)	0 (0)
19-30	28.4 (25)	63.6 (56)	6.8 (6)	0 (0)	1.1 (1)
31-40	42.5 (17)	57.5 (23)	0 (0)	0 (0)	0 (0)
41-50	22.7 (5)	68.2 (15)	0 (0)	9.1 (2)	0 (0)
51-60	52.6 (10)	42.1 (8)	5.3 (1)	0 (0)	0 (0)
more than 60	17.9 (5)	82.1 (23)	0 (0)	0 (0)	0 (0)
Gender					
Male	31.8 (14)	65.9 (29)	0 (0)	2.3 (1)	0 (0)
Female	30.8 (60)	64.6 (126)	3.6 (7)	0.5 (1)	0.5 (1)
Drug Resistance (n=234)	31.6 (74)	64.5 (151)	2.6 (6)	0.9 (2)	04 (1)
Multi Drug Resistance (n=154)	32.5 (50)	64.3 (99)	1.9 (3)	0.6 (1)	0.6 (1)

Table III shows, the majority of the uropathogens that were isolated showed resistance to at least one of the tested antibiotics. Overall, antibiotic resistance rate was highest for cefuroxime (96.7%) followed by amoxicillin and clavulanic acid (47.7%). On the other hand, amikacin was found to be the most sensitive (79.9%) followed by ciprofloxacin (68.2%) nitrofurantoin (67.8%) cotrimoxazole (47.7%) and ceftriaxone (43.9%).

Table III Percentage frequency of antibiotic susceptibility test

AST	Sensitive %	Intermediate Sensitive %	Resistance %	Not done %
Amoxicillin + Clavulanic acid	37.2	12.1	47.7	2.9
Amikacin	79.9	5.9	3.3	10.9
Azithromycin	32.6	32.6	34.7	0
Cefuroxime (2nd Gen.)	0.4	2.5	96.7	0.4
Ceftriaxone (3rd Gen.)	43.9	14.2	38.5	3.3
Cephradine	0.8	0.4	47.3	51.5
Ciprofloxacin	68.2	7.9	20.5	3.3
Cotrimoxazole	47.7	12.1	40.2	0
Gentamycin	13.8	6.3	1.3	78.7
Meropenem	3.8	0	7.9	88.3
Nitrofurantoin	67.8	23	8.8	0.4
Colistin	1.3	0.4	0	98.3
Piperacillin + Tazobactam	0	0	0.4	99.6
Penicillin	0	0	0.4	99.6

A total of 239 samples showed 234 (97.9%) drug resistance, with the highest antibiotic resistance in the 19-30-year age group (36.3%) and females (81.2%) being most affected. Out of 234 drug resistance isolates, 154 (65.81%) were multidrug resistant, with the highest age group 33.38% being 19-30 years and MDR isolates were more common among females (79.9%) (Table IV).

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Table IV Percentage frequency of drug resistance and multi drug resistance different age and sex group

	Drug Resistance (n=234)		Multi Drug Resistance (n=154)	
	Yes % (n)	No % (n)	Yes % (n)	No % (n)
Age Group				
0-18	17.9 (42)	0 (0)	18.2 (28)	17.5 (14)
19-30	36.3 (85)	60 (3)	33.8 (52)	41.25 (33)
31-40	17.1 (40)	0 (0)	17.5 (27)	16.25 (13)
41-50	9 (21)	20 (1)	9.7 (15)	7.5 (6)
51-60	8.1 (19)	0 (0)	8.4 (13)	7.5 (6)
more than 60	11.6 (27)	20 (1)	12.3 (19)	10 (8)
Gender				
Male	18.8 (44)	0 (0)	20.1 (31)	16.25 (13)
Female	81.2 (190)	100 (5)	79.9 (123)	83.75 (67)

In the examination of associated risk factors, there was no significant relationship between antibiotic resistance and age group (p = 0.571) or sex group (p = 0.283).The age (p = 0.881) and sex (p = 0.356) groups were also not significant in relation to multidrug resistance (Table 05).

From Table VI, the antimicrobial resistance pattern of uropathogens, Escherichia coli exhibited a very high frequency of resistance to cefuroxime 96.10%, cefradine 95.50% low resistance to gentamycin 7.3%, amikacin 3%, low resistance to nitrofurantoin 1.3%.

Table V Demographic characteristics associated with drug resistance and multidrug resistance of samples undergoing urine AST

	Drug resistance		p-Value	Multi Drug resistance		p-Value
	Yes %	No %		Yes %	No %	
Age group			0.571			0.881
0-18	100%	0%		66.7%	33.3%	
19-30	96.6%	3.4%		61.18%	38.82%	
31-40	100%	0%		67.5%	32.5%	
41-50	95.5%	4.5%		71.42%	28.58%	
51-60	100%	0%		68.42%	31.58%	
more than 60	96.4%	3.6%		70.37%	29.63%	
Gender			0.283			0.356
Male	100%	0%		70.5%	29.5%	
Female	97.4%	2.6%		64.73%	35.27%	

Coliform bacteria showed antibiotic resistance highly to cefuroxime, cefradine, piperacillin and tazobactam and penicillin 100%, followed by meropenem 88.90% low resistance to ciprofloxacin 9.9%, amikacin 4.3% and no resistance to gentamycin and colistin.Klebsiella was 100% resistant to cefradine and followed by cefuroxime 85.7% low resistance to amikacin 14.3% and no resistance to nitrofurantoin, gentamycin. Pseudomonas was 100% resistant to cefuroxime, cefradine. Acinetobacter was 100% resistant to amoxicillin and clavulanic acid, cefuroxime, ceftriaxone, cefradine and cotrimoxazole (Table VI).

Table VI Antibiotic resistance pattern of different bacteria isolated from urine culture

Antibiotic	Coliform bacteria %	E. Coli %	Klebsiella %	Pseudomonas %	Acinetobacter %
Amoxicillin+ Clavulanic acid	41.7	54	28.6	0	100
Amikacin	4.3	3	14.3	0	0
Azithromycin	28.4	37.4	42.9	50	0
Cefuroxime (2nd Gen.)	100	96.1	85.7	100	100
Ceftriaxone (3rd Gen.)	35.1	43.2	16.7	0	100
Cephradine	100	95.5	100	100	100
Ciprofloxacin	9.9	26.7	28.6	0	0
Cotrimoxazole	37.8	40.6	42.9	50	100
Gentamycin	0	7.3	0	0	0
Meropenem	88.9	57.9	0	0	0
Nitrofurantoin	24.3	1.3	0	50	0
Colistin	0	0	0	0	0
Piperacillin + Tazobactam	100	0	0	0	0
Penicillin	100	0	0	0	0

Discussion

In the current investigation, urine samples were cultured to see growth of uropathogens, and about 239 (27%) of the urine had notable growth of bacteria. The findings of this research are consistent with those of Tuem et al. who found 28.5%.[18] The prevalence was lower than in other studies 48.6% in Bangladesh, 32% in Ethiopia.[19,20] Previous antibiotic therapy and clinical diseases like non-gonococcal urethritis can cause low bacteriuria or no growth in urine samples, emphasizing the need to inform patients about clean catch mid-stream urine specimens.[19]The prevalence of this study was higher than other study, 15.8% in Nepal.[21]

In our study, UTI is more prevalent in females (81.6%) than males (18.4%) whichis consistent withfindings from previous studies in Bangladesh and Portugal.[1,2] According to the study, female proximity to the anus, shorter urethra, sexual intercourse, incontinence and poor toilet habits are all contributing factor to the high prevalence of UTI in females.[1] Poor hygiene, particularly in menstrual age, is another contributing factor.[22] Another study by Linhares et al. found that the

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elderly is the most affected by UTI, which contradicts the current study's findings.[2] Conversely, men under 50 tend to have lower UTI rates, attributed to antibacterial properties of the prostate, though moderate multidrug-resistant rates in young males (63.63%) suggest a demographic less frequently treated with antibiotics for UTIs.[4]

Our study identified E. coli as the predominant strain causing Urinary Tract Infections (UTIs) with a prevalence of 64.9%. A similar study reported an even higher prevalence of E. coli at 85.16%.[23] Resistance patterns revealed that Acinetobacter exhibited 100% resistance to amoxicillin-clavulanic acid, ceftriaxone and cotrimoxazole, while E. coli, Coliforms and Klebsiella also showed significant resistance (54%, 41.7% and 28.6%, respectively) to amoxicillin-clavulanic acid. Pseudomonas spp. is particularly noted for causing hospital-acquired UTIs and is often resistant to traditional antimicrobials.[5]

The investigation revealed that uropathogens such as E. coli, Coliform bacteria, Klebsiella, Pseudomonas, and Acinetobacter showed high resistance (85-100%) to cefuroxime and cefradin, aligning with findings from Bangladesh.[24] Ceftriaxone exhibited low resistance to Klebsiella and none to Pseudomonas, with other bacteria showing resistance rates from 35-100%. The shift in ceftriaxone effectiveness is attributed to horizontal gene transfer leading to increased antibiotic resistance.[25] Additionally, resistance to piperacillin-tazobactam was noted among coliform bacteria, consistent with findings from Iraq.[26] Meropenem demonstrated resistance rates of 88.9% in coliform bacteria and 57.9% in E. coli, which contradicts a study from India that reported high sensitivity to this antibiotic.[27]

Ciprofloxacin showed resistance rates of 26.7% to E. coli and 28.6% to Klebsiella, but was 100% sensitive to Pseudomonas and highly sensitive to coliform bacteria. Its efficacy has diminished due to improper use, impacting treatment for UTIs and other infections.[24] Nitrofurantoin exhibited 50% resistance in Pseudomonas and 24.3% in coliforms, with highly sensitive against E. coli and Klebsiella. A study in Chittagong indicated high resistance of E. coli to third-generation antibiotics, with Nitrofurantoin showing only 10% resistance.[10] This medicine has been the first-line therapy for uncomplicated UTIs in adults for more than two decades, since its introduction in 1974.[27] In the study, 98% of samples exhibited resistance to at least one antibiotic, with 65.81% identified as Multidrug-Resistant (MDR) raising significant concerns. Previous reports by Asaduzzaman et al. and Begum et al. indicated MDR rates of 54.2% and 70.67%, respectively.[6] E. coli showed both the highest drug resistance and MDR, the rates were 64.5% and 64.3%, respectively. There is a theory thatthe Escherichia coli caused infections get aggregated and are difficult to eradicate due to the formation of "biofilms'.[28] Biofilms can be defined as a group of microbial colonies that are attached to a biotic or abiotic surface by producing an extra-polymeric matrix of their own or from the host's components.[3] Biofilm makes it harder for conventional antibiotics to penetrate the cells and makes the cells less responsive to antibiotics.[29]

Limitation

The study is limited by a lack of clinical data to ascertain the origin of infections (hospital or community-acquired) and their complexity (complicated or uncomplicated). It does not assess risk factors associated with multidrug resistance. Utilizing a secondary dataset from a single institution restricts data collection to patients attending the diagnostic center, impacting the study's population representation. Furthermore, it does not monitor patient health trends, outcomes, or diagnostic testing.

Conclusion

This study demonstrates a high frequency of antimicrobial and multidrug resistance among uropathogens, with E. coli showing the highest resistance rates. Commonly prescribed oral antibioticssuch as cefuroxime, cefradine, amoxicillin–clavulanic acid, azithromycin and cotrimoxazoleshowed very poor effectiveness and are unsuitable for empirical therapy in this setting. Ciprofloxacin and nitrofurantoin showed considerable resistance but preserved some action, suggesting diminished dependability. The most effective agents were the parenteral drugs amikacin and gentamicin, presenting a critical

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treatment gap due to the lack of potent oral antibiotics for empiric use. Further research, including genomic sequence of resistant strains, is needed to identify resistance mechanisms and guide improved antibiotic stewardship and treatment policies.

Recommendation

Awarness programs regarding safety guidelines and appropriate use of antibiotic should be put into action.

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Contribution of authors

MOF-Conception, acquisition of data, data analysis, drafting & final approval.

TN- Conception, design, critical revision & final approval.

MMRA-Conception, design, critical revision & final approval.

SR- Acquisition of data, data analysis, interpretation of data, drafting & final approval.

OF-Design, acquisition of data, interpretation of data, drafting & final approval.

AD-Acquisition of data, data analysis, drafting & final approval.

AS-Acquisition of data, data analysis, drafting & final approval.

Disclosure

All the authors declared no competing interests.

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