

Prevalence and Antibiotic Resistance Profiles of Uropathogens in Haldia, an Industrial City in Eastern India

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Abstract

Background: A significant health concern in the community with the highest morbidity is urinary tract infection (UTI). Moreover, age, comorbidity and bacterial drug-resistance worsen the situation. Changes in ecological and host factors plus misuse of drugs promote bacterial uropathogens becoming antibiotic-resistant.

Objectives: Presently, we evaluate UTI prevalence and causative bacterial antibiotic-resistance-patterns in an industrial-town with educational-hub situated in eastern part of India. Age- and gender- wise comparison of bacterial susceptibility-resistance was performed.

Materials and methods: A total 83 individuals (23 males and 60 females) from the city hospital and local pathological-centers provided urine samples maintaining proper norms. Routine microbiological/pathological tests and detailed drug-resistance screening were performed.

Results: The major infecting organisms *E. coli*, *K. pneumoniae* and *P. aeruginosa* are prevalent with approximately 25:6:1 ratio in all age groups. But age wise, 60% of >31 years group is infected by *E. coli* the rest two groups; 31-60 and >60 years are infected ~80% by *E. coli*. When compared to the WHO data, *E. coli* infection is more in the studied area (78% vs 67%). Genderwise, female is more affected by *E. coli* and male is more affected by *P. aeruginosa*.

Conclusions: Among patient-derived bacterial isolates, only 35.17% of antibiotics were effective against *E. coli*, and 23.66% were effective for *Klebsiella sp.* indicating a high level of resistance. In summary, *E. Coli* is resistant to the majority of medications. Nitrofurantoin and amikacin are found to be the most sensitive to the uropathogens

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Key words: Urinary tract infection (UTI), Eco-Industrial environment, *E. coli* and *K. pneumoniae*, Antibiotic resistance, Nitrofurantoin and amikacin.

Introduction

Because of the contagious nature of uropathogen, urinary tract infections (UTIs) are the most common diseases and a significant public health concern that affect individuals of all ages and genders. However, women have a higher incidence than men because of their biological makeup [1]. Worldwide, around 150 million individuals are affected yearly and being diagnosed/treated for UTIs. In a normal physiological system, wastes are filtered in the kidney and the output from the kidneys is eliminated via urinary tracts and in the urogenital system consisting upper and lower segments of the urinary tract.¹ The bacterial infection in this portion, however, predominates over other microorganisms.¹

While UTIs are said to affect people of all genders, women of younger ages are said to be more susceptible to the infection.^{2,3} A lower UTI can spread to the upper urinary system, potentially affecting the kidneys and ureters in advanced infection and, if timely treatment is not received.⁴ Comorbidity and antibiotic resistance are the direct factors that increase the severity of UTI.^{5,6} Other confounding factors are health-hygiene, sanitation, environmental pollution, socio-demographic profile, etc.⁷ Other disease or pandemic situation might have some influence on prevalence and/or severity of UTIs. It is noteworthy to mention Covid-19 influenced the severity of UTIs during its period because of immune-suppression, inflammation.⁸

Urinary obstruction, renal failure, calculi and invasive catheters are among the factors that can lead to complicated UTIs.^{9,10} Common symptoms of a lower urinary tract infection include burning or pain during urination, inflammation and irritation of the bladder and urethra lining. In contrast, upper UTIs include chills, trembling, nausea, and high fever.¹¹ Epidemiological data suggest that, in West Bengal, a state in eastern India, UTIs are a common health issue, similar to other regions in India.¹²⁻¹⁴ Introspective studies show unhygienic lifestyles and lower of sanitation-hygiene are the main causes of UTI, which primarily affects women.¹⁴ The most frequent microorganisms linked to urinary tract infections

are *Escherichia coli* and *Klebsiella pneumoniae*. Very few *Pseudomonas aeruginosa* infections in both males and females have been reported. *Escherichia coli* was the most abundant uropathogen with a prevalence rate of 67.1%, followed by *Klebsiella spp.* (22%) and *Pseudomonas spp* (6%).¹²

The growing resistance of uropathogenic bacteria to drugs is a worrying trend. The antibiotic resistance pattern of two principal UTI pathogens, *E. coli* and *Klebsiella spp.* in West Bengal appears to be like the other places. Higher than 50% resistance were noticed for broad-spectrum penicillin. Fourth-generation cephalosporin and macrolide seem to be the choice of drug in treating UTIs in eastern India.^{12,13} Misuse of antibiotics causes drug-resistant bacterial strains to evolve, which makes managing UTIs more difficult. To treat UTIs, multimodal approaches are needed, including promoting appropriate antibiotic use and increasing public awareness.

In this background, the objectivity of the current study was to evaluate the prevalence and drug resistance nature of major UTI causing bacteria's in Haldia, West Bengal, India. Biochemical and physiological identification was performed to screen the pathogen. Haldia is a river-sea coastal port city with a large number of heavy industries. The aim of this study was to assess the nature of drug-resistance of uropathogens and to develop public awareness about UTI and its post complications. First time, this type of evaluation is monitored in this region. Ecological-environmental impact in this economic zone is important for assessing the infection associated health issues.

Materials and Methods

Study area

Samples were procured from the town hospital and from some accredited regional pathological centers in Haldia, West Bengal. After preliminary studies, further analyses were conducted in the institute lab. The industrial port city, Haldia is located close to the mouth of the Hooghly River, one of the Ganges' distributaries (22.03°N 88.06°E) (fig 1). Haldia is famous for petrochemical companies

Bacteria culture maintenance

The isolates were sub cultured periodically according to the requirement in the following media. *E. coli*- Sorbitol-Macconkey agar media, *K. pneumoniae* strains developed as yellow mucoid colonies on an agar medium containing ornithine, raffinose, and Koser citrate at 24 hours, and there was a little increase in colony size at 48 hours. Cetrimide Agar serves as a selective medium in the process of isolating *Pseudomonas aeruginosa* from various sources such as pus, sputum, and drainage.

Antibiotic Susceptibility Testing

The VITEK2 Compact system (bioMérieux) was used to evaluate the bacterial isolates for antibiotic susceptibility. Pure bacterial colonies were suspended in sterile saline to create a bacterial solution that met the 0.5 McFarland turbidity requirements. Following

the manufacturer's directions, the standardized suspension was then inoculated into the relevant AST card, which was then put into the VITEK 2 Compact system. The Clinical and Laboratory Standards Institute (CLSI) 2024 recommendations were used in order to interpret the test results.

Statistical analysis

In the current study SPSS Statistics 22.0 program was used for several analysis. The distribution pattern of uropathogens in different age and gender groups were calculated and expressed as percentage. Those were compared with the corresponding WHO data and expressed as bar diagram. Age and gender wise occurrence rate of three uropathogens were analyzed by χ^2 analysis (95% CI). F value was derived from the ANOVA (Analysis of Variance) from the mean differences of the occurrence rate of the studied pathogens.

Table 1: Distribution and clinical manifestations of UTI cases with demographic features.

n=83	%
Gender	
Female	72.3
Male	27.7
Age	
<31 years	18.5
31-60 year	53.1
>60 years	28.4
Symptoms	%
Fever	12.3
Dysuria, polyurea	11.4
Cystitis	7.9
Haematuria	2.0
Comorbidity	5.8

Socio-economy and Demography

Rural and semi-urban, inadequate hygiene and sanitation, prevalent under-nutrition, mostly lower- and middle-income group.

Results

In the current study, a total 83 UTI patients were included. Out of which, 72.3% is female and 27.7% male (table 1). The majority belongs to rural and semi-urban with inadequate hygiene and sanitation. A significant number of patients were

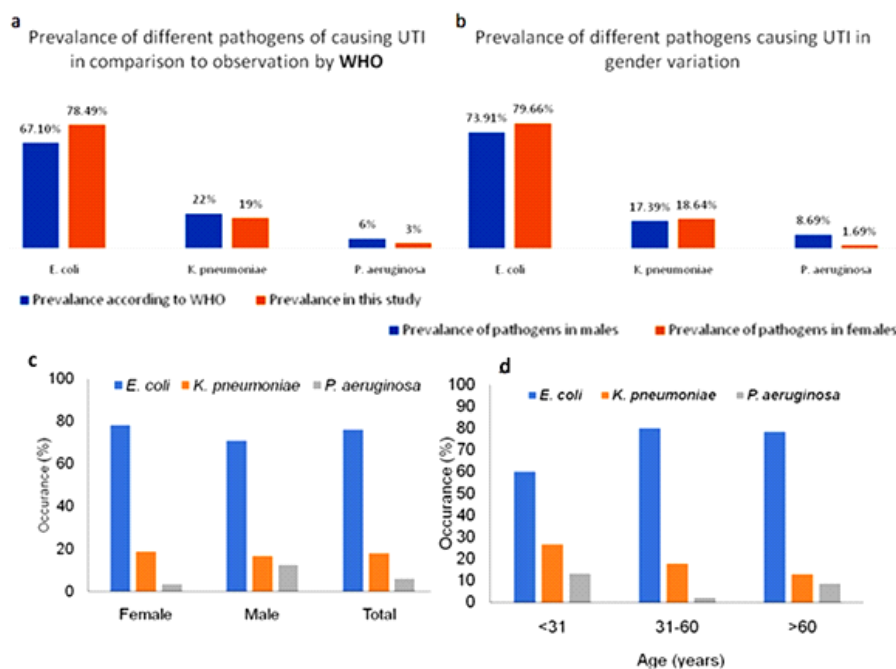
undernourished and came from mostly lower- and middle-income group family. Certain percentages of patients manifested different symptoms/ comorbidities (table 1).

Comparative prevalence of UTI in West Bengal (WHO) and Haldia, present study location

In this study, the dominance of *E. coli* is major than other organisms when it is compared to the rest part of the state. The same trend is also noticed when it is compared to WHO global data.¹² Our data indicate *E. coli* has 78.49%, *K. pneumoniae*, 18.51% and

P. aeruginosa has 3% of occurrence rate in the current study location. In comparison to the WHO, prevalence

of UTI pathogens in West Bengal are presented in the graphical representation in the following figure 2.



Gender-wise distribution of uropathogens

Figure 2. Gender- and age-wise distribution of uropathogens

Certain bacteria were more common in females than in males; for instance, the prevalence of *E. coli* infection was higher in females (79.66%) than in males (73.91%). *K. pneumoniae* infections accounted for 17.39% of UTIs in men and 18.64% in women. An 8.69% of UTIs in men and 1.69% in women were caused by *P. aeruginosa*. Males and females had different prevalence rates of various illnesses, as seen in Figure 2. It has been noticed that people in distinct age groups have variable infection prevalence. People’s age groups demonstrate their diverse immune systems and capacity to fend off illness. This explains why different age groups are impacted

by different infections. The prevalence of various illnesses and their age-wise distributions were statistically evaluated and found to be significant at a low level due to the smaller sample size, intra-individual variability, and bigger SD/SE (table 2). The χ^2 results suggest that there are significant differences among age-wise and gender-wise distribution pattern of different uropathogen infection (table-2). Present ANOVA results suggest that the mean ages (44 to 49 years) of the affected individuals by three uropathogens are not significantly different ($F=0.494$ and $p = 0.612$).

Table 2 Prevalence and statistical outcome of pathogen variations in different age groups. Superscript a designate the *t* value of the corresponding group mean.

Gender wise distribution		Female	Sex	Male		Total				
Causative_UTI_Pathogen	<i>E. coli</i>	46	77.97	17	70.83	63	75.9	2.502a	2	0.286
	<i>K. pneumoniae</i>	11	18.64	4	16.67	15	18.07			
	<i>P. aeruginosa</i>	2	3.39	3	12.5	5	6.02			
Total	Total	59	100	24	100	83	100			

Continue.....

Age wise distribution		<31	Age_ Cat 31-60			>60		Total				
Causative_ UTI_Pathogen	E. coli	9	60	36	80	18	78.26	63	75.9	4.236 a	4	0.375
	K. pneumoniae	4	26.67	8	17.78	3	13.04	15	18.07			
	P. aeruginosa	2	13.33	1	2.22	2	8.7	5	6.02			
Total	Total	15	100	45	100	23	100	83	100			

When different pathogen distribution pattern is studied it is noticed that *E. coli* is the most dominant in female, male and in total populations. But in male, *P. aeruginosa* is was found to be little more dominant (fig 2). When age-wise pattern is studied it is noticed that in lower age group (<31), infection appeared more uniformly distributed among younger individuals, with *E. coli* being the dominant pathogen (fig 2).

According to earlier national statistics on *E. coli* susceptibility, certain antibiotics, such as imipenem, gentamycin, and nitrofurantoin have higher sensitivity rates, which is consistent with the current investigation. Ipenem, fosfomycin, and gentamycin are more widely used and have demonstrated a significantly higher range of sensitivity against uropathogenic *E. coli* (UPEC) across all age groups (fig 3). The frequency of *P. aeruginosa* infection has been incredibly low in our investigation. Most of the people in the study were susceptible to levofloxacin, imipenem, and meropenem. The bacteria that cause UTIs are opportunistic. Ipenem, ofloxacin, nitrofurantoin, and netimicin are the

main medications that responders are vulnerable to, according to previous data from national research (fig 4). In addition, individuals under 30 years with *P. aeruginosa* have demonstrated significant susceptibility to cefoperazone-sulbactam. Individuals over 60 years and those between the ages of 31 and 60 have significant sensitivity against gentamycin (fig 4).

Discussions

Upon examining the findings, we observed a notable difference between the observed drug sensitivity patterns of the uropathogenic bacteria and previously reported national/global results. Our data corresponds WHO reported prevalence rate for West Bengal. *Escherichia coli* are a common uropathogenic bacterium in all age groups, including males and females. The WHO reported prevalence of uropathogens in West Bengal and eastern India is 67.10% for *Escherichia coli*, 27% for *Klebsiella pneumoniae*, and 6% for *Pseudomonas aeruginosa*¹² compared to that of our data 78.49%, 19%, and 3%, respectively.

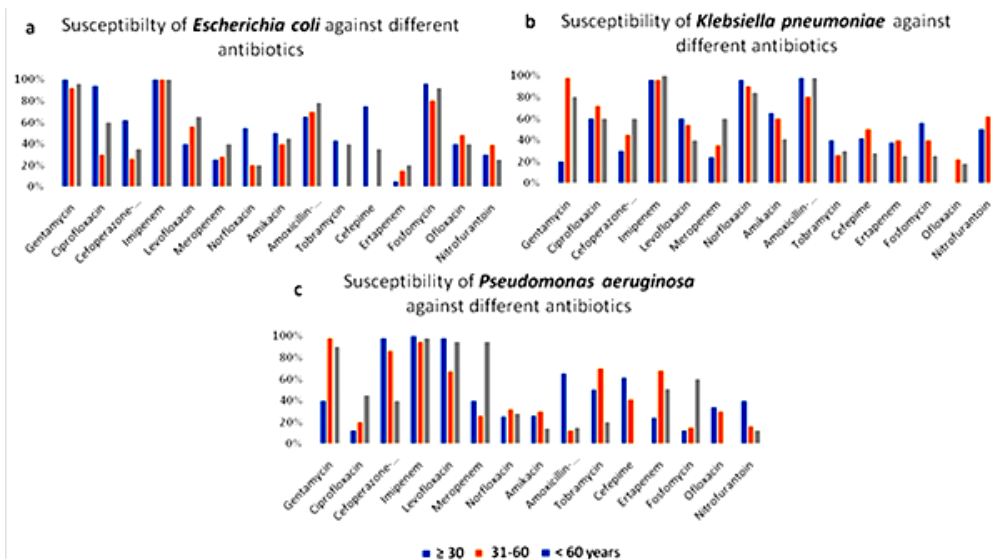


Figure 3. Age wise distribution of susceptibility pattern of three pathogens against different antibiotics

The studied eco-environmental status might have some influence of pathogen lifecycle and host-parasite interaction. UTIs caused by *Klebsiella pneumoniae*, particularly hospital-acquired typically exhibits the highest level of susceptibility to medications such tobramycin, ofloxacin, imipenem and netimicin at national level. We observed that ceftazidime, amikacin, ampicillin, amoxy-clav, trimethoprim/sulfamethoxazole demonstrate major sensitivity among all the age groups especially people less than 31 years and above 60 years. Report reveals weak polymorphic mutants of *E. coli* found in clinical isolates has no direct relation to its drug resistance.¹⁷

According to our research and a number of other studies, pathogenic *E. coli* has developed a variety of antibiotic resistances, which has led to an increase in its prevalence. This idea is consistent with another research that shows *Escherichia coli* virulence factors are frequently encoded by genetic components such plasmids, bacteriophages, transposons, and pathogenicity islands. And this adaptive strategy may be common for any pathogenic namely UTI and gastroenteritis causing *E. Coli*.¹⁸ Notwithstanding, hotspot mutations may be highly prevalent in *E. Coli* core genes, leading to short-term positive selection. This dynamic pattern is in line with the source-sink concept of virulence evolution.¹⁸

Usually, in a rural or semi urban care center, patients with UTI are prescribed and treated one or the other antibiotic until getting the urine culture-report. Long term misuse of antibiotics results in drug resistance.¹⁹ One earlier report suggested some point-of-care (POCT) rapid diagnostic kit (Rapidogram) has predicted validation report.²⁰ According to their report, which is consistent with our findings, *E. coli*, which has been found to be particularly sensitive to nitrofurantoin and amikacin, affects the greatest number of people. These people were initially given another medication in several instances, which led to a complex situation.

In extreme peripheral health care settings where some facilities are unavailable, empirical therapy might be helpful.¹² In conformity with this report our study indicates that *Escherichia coli* were the most prevalent and drug resistant uropathogen, followed by and *Klebsiella spp.* Penicillin was the least effective medication against *E. coli*, whereas fourth generation of cephalosporins showed the greatest susceptibility.²¹ Higher than 50% resistance were observed for broad-spectrum penicillin. Some women with recurrent UTIs may have inherited characteristics. The mechanical and/or physiological factors that impact bladder emptying are significantly linked to this recurrence.²² Infants, elderly and pregnant women, patients with catheters, patients with diabetes, and patients with urologic disorders are among the specific sub-populations with increased UTI risk.²³ Report suggests diverse resistance patterns indicating a heterogeneous population of uropathogenic *E. coli* isolates that circulate in this region of India and raise queries on significant concern on therapeutic and infection-control issues.

Globally, particular attention has been drawn to pathogens that are positive for extended spectrum beta lactamase (ESBL) and emerging threats such multi-drug-resistant (MDR) clones (e.g. *E. coli* 131 (ST131) and *K. pneumoniae* ST258). In these cases, the use of older antibiotics, like fosfomycin, is justified by the increased prevalence of MDR. It limits the treatment options available for infections, as well as the lack of new antibiotics.²⁴ Amikacin and nitrofurantoin ought to be designated as effective medications to treat this infection²⁵ which is in agreement with our current study. Finding the region specific drug resistance

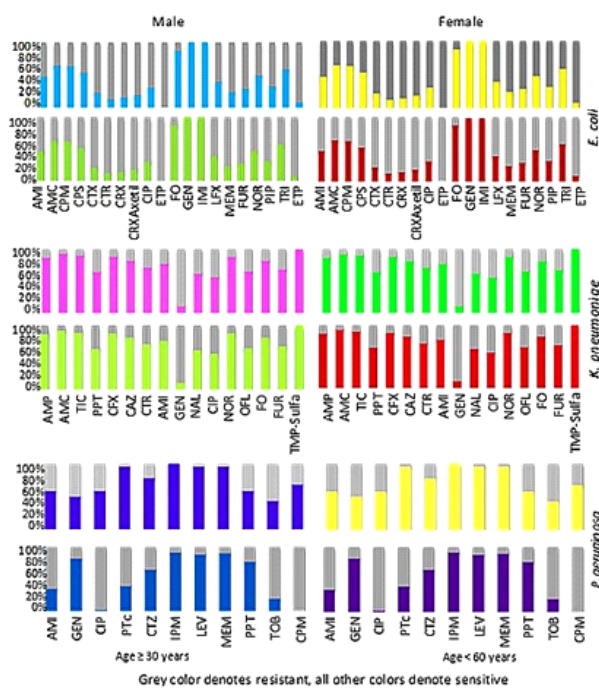


Figure 4. Susceptibility and resistance patterns of different drugs against different uropathogens in two different age groups ≥ 30 years and >60 years.

pattern is essential for customized antibiotic therapy in urgent situation.²⁶ When nitrofurantoin, amikacin, colistin have shown appreciable effects, amikacin, doxycycline, and nitrofurantoin have shown significant side effects in human.²⁷

To distinguish natures of hospital-acquired or community-acquired UTI further analysis is required. An estimate of patients suffering from UTI may rise to 75% in the female population by their age of 24, and 15–25% of this group will suffer from a relapse of this disease.²² Several birth control methods raise the risk of UTIs. Spermicides may irritate skin, which makes it possible for bacteria to infiltrate. Urinary flow may be slowed by diaphragms, which promotes bacterial growth. In addition to putting strain on the bladder and its regulating muscles, constipation and obesity can also result in or worsen UTIs.²⁸ *E. coli* showed high resistance to sulfonamide SXT (double-strength trimethoprim-sulfamethoxazole) and to fluoroquinolone ciprofloxacin in nine European countries, United States and in Brazil.²⁹ Regarding the diversity, different causative organisms have different mechanistic approach to manifest their pathogenicity. As for example, the most uropathogenic *E. coli* UPEC structure comprises type 1 and P fimbriae as well as additional fimbriae and non-fimbrial adhesions.³⁰ Despite the fact that UTI is the third most common infection found in India, only a few studies on UTI have been reported.³¹ Especially, in an industrial belt, the nature of infection and the drug resistance pattern has been less focused. When creating broad-spectrum treatment plans, it is helpful to know that no organism creates a clear outlier cluster. Resistance to amikacin and nitrofurantoin varies statistically significantly amongst organisms.

Regarding limitations, current sample size is small; larger sample sizes in future research could boost the statistical power. Additional research might be done on the pattern of antibiotic responses and clinical manifestations by individual patient who might reflect inter-individual variability and genetic factor. Public antibiotic campaigns and patient-facing materials should address UTIs, prevention, non-pharmaceutical “self-care” advice, and justification. As older are more vulnerable to UTI, our results highlight the necessity of better diagnostic and risk prediction strategy to direct the customized drug prescription for suspected UTIs in these groups.

Conclusion

In Haldia, Eastern India, urinary tract infections (UTIs) are common and affect people of all ages and genders. It is observed that women are more likely than men to develop UTIs. *Escherichia coli* is the most common cause of UTIs, which is more than the WHO data from the state and India. *Klebsiella pneumoniae* and *Pseudomonas aeruginosa* have also been identified as dominant uropathogens. These uropathogens exhibit a variety of antibiotic resistances, and worries about multidrug resistance (MDR) and extended-spectrum beta-lactamases (ESBLs) are growing on a global scale. Bacterial antibiotic resistance in patients is a result of improper use and misuse of antibiotics. Self-medication and the unrestrained availability of antibiotics are major causes of the increasing trend of antimicrobial resistance (AMR) of uropathogens. This case highlights the critical need for region-specific empirical treatment guidelines that take into account local patterns of antibiotic susceptibility in addition to national or international data.

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