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The Pattern of Microorganisms for Urologic Patients in Urology Department of Military Hospital, Sanaa City

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Abstract

Background: Urinary tract infections (UTIs) are a common cause of hospital visits in Yemen, but treatment is increasingly complicated by widespread antimicrobial resistance. Reliable data from urology departments in Sana'a are scarce, making empirical therapy challenging for clinicians.

Aims: To determine the distribution of uropathogens and their antimicrobial resistance patterns among urologic patients in the Urology Department of the General Military Hospital, Sana'a, Yemen.

Methods: A prospective cohort study was conducted from June 2023 to February 2024, including 204 culture-positive urology patients. Midstream urine samples were processed using standard microbiological techniques. Antimicrobial susceptibility testing followed CLSI guidelines. Data were analyzed using descriptive statistics in SPSS v28.

Results: Gram-negative pathogens predominated (85.3%), with *Escherichia coli* (46.1%), *Pseudomonas aeruginosa* (15.7%), and *Klebsiella* spp. (11.8%) as the most frequent isolates. Resistance rates were highest for ceftazidime (86.7%), cefepime (81.8%), and ciprofloxacin (64.3%). *E. coli* showed 100% resistance to ceftazidime and 74.1% to amoxicillin–clavulanic acid. Carbapenems retained the highest activity (imipenem: 95.7% sensitivity; meropenem: 91.5%), while amikacin (72.6%) and gentamicin (68.0%) showed moderate efficacy.

Conclusion: Our findings show that commonly used agents such as cephalosporins and fluoroquinolones are no longer reliable for empirical treatment of UTIs in Sana'a. In contrast, carbapenems and aminoglycosides remain effective but should be used judiciously. These results highlight the urgent need to update local treatment guidelines and strengthen antimicrobial stewardship in Yemen's urology departments.

Keywords: Urinary tract infections, Antimicrobial resistance, Uropathogens, Gram-negative bacteria, Escherichia coli, Carbapenems, Yemen.

Introduction

Urinary tract infections (UTIs) are the most common bacterial infections and cause major morbidity worldwide [1]. They present as cystitis or pyelonephritis and are classified as uncomplicated or complicated [2]. Women are more susceptible due to anatomical and hormonal factors [3]. Escherichia coli is the leading cause, followed by Klebsiella spp., Proteus spp., and Pseudomonas aeruginosa; Gram-positive species are less frequent [4–6].

The rise of multidrug-resistant (MDR) uropathogens, often linked to antibiotic misuse, is a serious challenge [7]. Resistance rates above 20% for first-line drugs such as fluoroquinolones and trimethoprim-sulfamethoxazole have been reported in developing countries [8]. Local surveillance is therefore essential to guide empirical therapy [9], especially where urine culture results are delayed [10].

In Yemen, data on uropathogens and resistance patterns are scarce, particularly in urology departments of tertiary hospitals. Self-medication, unregulated antibiotic use, and the impact of prolonged conflict worsen the problem. This study identifies the main uropathogens and their resistance profiles in patients admitted to the urology department of the Military Hospital in Sana'a, providing evidence to guide empirical therapy and inform national surveillance.

Patients and Methods

Study Design and Duration

This was a prospective observational study conducted over a nine-month period, from June 2023 to February 2024, in the Urology Department (outpatient and inpatient services) of the General Military Hospital, Sana'a, Yemen.

Study Setting and Population

During the study period, a total of 695 patients presented to the Urology outpatient clinic or were admitted to the inpatient ward with symptoms suggestive of urinary tract infection (UTI). All patients underwent clinical evaluation and laboratory investigation, including urine culture. Of these, 204 patients (29.3%) had positive urine cultures and met the inclusion criteria; these patients constituted the study population.

Patients were eligible for inclusion if they presented with urinary symptoms such as dysuria, frequency, urgency, suprapubic pain, or flank pain, and had a positive urine culture showing growth of $\geq 10^5$ colony-forming units (CFU)/mL of a single bacterial species, with no antibiotic use within the preceding seven days. Patients were excluded if they had a negative urine culture or growth of mixed bacterial species suggestive of contamination, or if they refused or were unable to provide informed consent.

Specimen Collection and Processing

Midstream clean-catch urine samples were collected in sterile, screw-capped containers after instructing patients on proper collection technique to minimize contamination. Samples were transported to the hospital microbiology laboratory and processed within two hours of collection. Inoculation was performed on Cystine-Lactose-Electrolyte-Deficient (CLED) agar, MacConkey agar, and blood agar plates. Plates were incubated aerobically at 37°C for 24–48 hours. Significant bacteriuria was defined as growth ≥10^5 CFU/mL. Pure isolates were identified based on colony morphology, Gram staining, and standard biochemical tests. When required, identification was confirmed using automated systems.

Antimicrobial Susceptibility Testing

Antibiotic susceptibility testing was performed using the Kirby–Bauer disk diffusion method on Mueller–Hinton agar, according to Clinical and Laboratory Standards Institute (CLSI) guidelines. Antibiotics tested included ampicillin, amoxicillin–clavulanic acid, ceftriaxone, ceftazidime, ciprofloxacin, levofloxacin, nitrofurantoin, gentamicin, amikacin, imipenem, and meropenem. Extended-spectrum β-lactamase (ESBL) production was confirmed using the double-disk synergy test. Susceptibility results were categorized as susceptible, intermediate, or resistant according to CLSI breakpoints.

Data Collection and Variables

Data were collected consistently using a structured form. Information recorded included age, sex, clinical presentation, and risk factors. Midstream urine samples were obtained under sterile conditions. Samples were cultured on blood agar and MacConkey agar, and isolates were identified using standard microbiological techniques. Antimicrobial susceptibility was tested using the Kirby–Bauer disk diffusion method according to CLSI guidelines.

Statistical Analysis

Data were entered into SPSS version 28 for analysis. Descriptive statistics were used to summarize patient characteristics, bacterial isolates, and resistance patterns. Results were expressed as frequencies and percentages.

Ethical Considerations

The study protocol was approved by the hospital's ethical committee. Verbal informed consent was obtained from all participants. Patient confidentiality was maintained by anonymizing data and restricting access to research records to the study team.

Results

Study Population and Sociodemographic Characteristics

During the study period, 695 patients attended the Urology Department. Among them, 204 (29.3%) had positive urine cultures and were included in the study. Culture positivity was higher among males (20.4%) than females (8.9%).

The mean age of culture-positive patients was 36.6 ± 17.8 years (range: 3–77). Most patients were aged 20–40 years (44.1%), followed by >40 years (41.2%) and <20 years (14.7%). Over half (55.9%) were married, and 41.2% had no formal education. Outpatients contributed slightly more positive cases (52%) than inpatients (42%), with the ICU accounting for 6% of positives (Table 1).

Table 1: Sociodemographic characteristics of culture-positive patients (n = 204)

Characteristic	Count	% of positives	% of total patients (n=695)
Male	142	69.6%	20.4%
Female	62	30.4%	8.9%
Mean age (years ± SD)	36.6 ± 17.8		
Age < 20 years	30	14.7%	4.3%
Age 20–40 years	90	44.1%	12.9%

Age > 40 years	84	41.2%	12.1%
Married	114	55.9%	16.4%
No formal education	84	41.2%	12.1%

Distribution by Hospital Unit

More than half of culture-positive patients were from the outpatient clinic (**52.0%**, n=106), followed by the urology ward (**42.2%**, n=86). The ICU accounted for only **5.9%** (n=12) of positive cultures, (Figure 1).

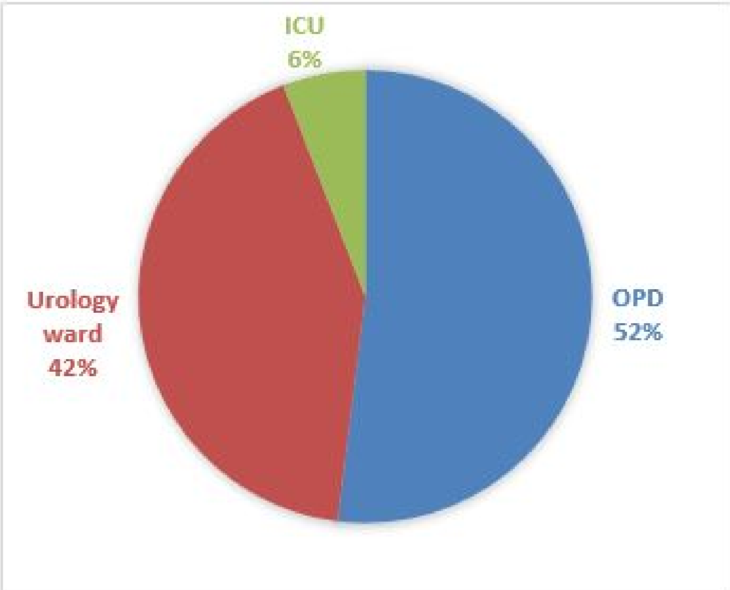

Figure 1: Department source of positive cultures (n = 204)

Microbiological Profile

Gram-negative bacteria dominated (85.3%), followed by Gram-positive bacteria (11.8%) and fungi (Candida spp., 10.8%). Escherichia coli was the most frequent isolate (46.1%), followed by *Pseudomonas* aeruginosa (15.7%) and Klebsiella spp. (11.8%). Other isolates included S. aureus (8.8%), Enterococcus faecalis (4.9%), Citrobacter spp. (2.9%), Proteus mirabilis (2.9%), Streptococci (2.9%), Morganella morganii (1.0%), and Candida albicans (10.8%) (Table 2).

Table 2: Microorganism class and distribution

Organism group	Count	% of positives (n=204)	% of total (n=695)
Gramnegative bacteria	174	85.3%	25.0%
Grampositive bacteria	24	11.8%	3.5%
Fungi (Candida spp.)	22	10.8%	3.2%
Species distribution			
Escherichia coli	94	46.1%	13.5%
Pseudomonas aeruginosa	32	15.7%	4.6%
Klebsiella spp.	24	11.8%	3.5%
Staphylococcus aureus	18	8.8%	2.6%

Enterococcus faecalis	10	4.9%	1.4%
Citrobacter spp.	6	2.9%	0.9%
Proteus mirabilis	6	2.9%	0.9%
Streptococci	6	2.9%	0.9%
Morganella morganii	2	1.0%	0.3%
Candida albicans	22	10.8%	3.2%

Antimicrobial Susceptibility

Carbapenems showed the highest activity: imipenem/cilastatin 95.7%, meropenem 91.5%. Aminoglycosides had moderate efficacy: amikacin 72.6%, gentamicin 68%. Levofloxacin was effective against 66.7% of isolates.

High resistance was observed for ceftazidime (86.7%), cefepime (81.8%), amoxicillin/clavulanic acid (78.6%), ciprofloxacin (64.3%), ceftriaxone (63.5%), and trimethoprim/sulfamethoxazole (50%). E. coli showed 100% resistance to ceftazidime and 74.1% to amoxicillin/clavulanic acid. P. aeruginosa was 100% resistant to amoxicillin/clavulanic acid and >60% resistant to ceftazidime and cefepime (Table 3).

Table 3: Overall antibiotic susceptibility (tested isolates per antibiotic)

Antibiotic	Tested (n)	Sensitive	Sensitive (of tested)	Resistant	Resistant (of tested)	Sensitive (of positives, n=204)	Resistant (of positives)
		(n)	%	**(n)**	%	%	%
Imipenem / cilastatin	92	88	95.7%	4	4.3%	43.1%	2.0%
Meropenem	118	108	91.5%	10	8.5%	52.9%	4.9%
Nitrofurantoin	92	70	76.1%	22	23.9%	34.3%	10.8%
Amikacin	146	106	72.6%	40	27.4%	52.0%	19.6%
Gentamicin	150	102	68.0%	48	32.0%	50.0%	23.5%
Levofloxacin	90	60	66.7%	30	33.3%	29.4%	14.7%
Trimethoprim / Sulfamethoxazole	48	24	50.0%	24	50.0%	11.8%	11.8%
Ceftriaxone	126	46	36.5%	80	63.5%	22.5%	39.2%
Ciprofloxacin	168	60	35.7%	108	64.3%	29.4%	52.9%
Amoxicillin / Clavulanic acid	112	22	19.6%	90	80.4%	10.8%	44.1%
Cefepime	88	16	18.2%	72	81.8%	7.8%	35.3%
Ceftazidime	60	8	13.3%	52	86.7%	3.9%	25.5%

Summary

Regarding to the sensitivity and resistance of specific uropathogens to tested antibiotics, *Escherichia coli* showed alarmingly high resistance Ceftazidime (100%), followed by Cefepime (87%), Amoxicillin/Clavulanic Acid 74.10%, and Ciprofloxacin

65.9%. The second most frequent uropathogens *Pseudomonas aeruginosa* showed the highest resistance to Amoxicillin/Clavulanic Acid (100%) followed by Ceftriaxone, Trimethoprim/ Sulfamethoxazole, Cefepime, and Ceftazidime with 75%, 71.4%, 66% and 60% respectively. Table 4 summarize the sensitivity and resistance to antibiotics of isolated uropathogens in this study.

Table 4: Summary of total number of antibiotics used with the sensitivity and resistance patterns of the Uropathogenic bacteria isolated in this study.

Antibiotic		Citrobacter		Enterococcus faecalis		Escherichia coli		Klebseilla spp		M. morganii,		Proteus mirabilis		Pseudomonas aeruginosa		Staphylococcus aureus		Streptococci	
		N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Amikacin	S	6	100.00	10	100.00	48	66.70	10	62.50	2	100.00	4	100.00	14	77.80	10	71.40	2	50.00
	R	0	0.00	0	0.00	24	33.30	6	37.50	0	0.00	0	0.00	4	22.20	4	28.60	2	50.00
Amoxicillin/Clavulanic Acid	S	0	0.00	0	0.00	14	25.90	0	0.00	0	0.00	2	50.00	0	0.00	6	50.00	2	50.00
	R	4	100.00	2	100.00	40	74.10	12	100.00	2	100.00	2	50.00	18	100.00	6	50.00	2	50.00
Cefepime	S	0	0.00	0	0.00	6	13.00	4	28.60	0	0.00	0	0.00	6	33.30	0	0.00	0	0.00
	R	0	0.00	2	100.00	40	87.00	10	71.40	0	0.00	2	100.00	12	66.70	2	100.00	4	100.00
Ceftazidime	S	0	0.00	2	100.00	0	0.00	2	20.00	0	0.00	0	0.00	4	40.00	0	0.00	0	0.00
	R	2	100.00	0	0.00	32	100.00	8	80.00	2	100.00	0	0.00	6	60.00	0	0.00	2	100.00
Ceftriaxone	S	0	0.00	6	100.00	22	42.30	4	28.60	0	0.00	4	66.70	6	25.00	4	40.00	0	0.00
	R	6	100.00	0	0.00	30	57.70	10	71.40	2	100.00	2	33.30	18	75.00	6	60.00	6	100.00
Ciprofloxacin	S	4	100.00	4	40.00	28	34.10	4	16.70	2	100.00	2	33.30	12	50.00	4	25.00	0	0.00
	R	0	0.00	6	60.00	54	65.90	20	83.30	0	0.00	4	66.70	12	50.00	12	75.00	0	0.00
Gentamicin	S	2	50.00	10	100.00	46	62.20	10	71.40	0	0.00	6	100.00	18	75.00	10	83.30	0	0.00
	R	2	50.00	0	0.00	28	37.80	4	28.60	2	100.00	0	0.00	6	25.00	2	16.70	4	100.00
Imipenem/cilastatin	S	4	100.00	4	100.00	36	100.00	14	100.00	2	100.00	4	100.00	18	81.80	6	100.00	0	0.00
	R	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	4	18.20	0	0.00	0	0.00
Levofloxacin	S	4	100.00	4	100.00	18	52.90	2	33.30	2	100.00	4	100.00	12	75.00	10	62.50	4	100.00
	R	0	0.00	0	0.00	16	47.10	4	66.70	0	0.00	0	0.00	4	25.00	6	37.50	0	0.00
Meropenem	S	2	100.00	4	100.00	58	93.50	12	100.00	0	0.00	6	100.00	20	83.30	4	100.00	2	50.00
	R	0	0.00	0	0.00	4	6.50	0	0.00	0	0.00	0	0.00	4	16.70	0	0.00	2	50.00
Trimethoprim/Sulfamethoxazole	S	4	100.00	4	100.00	16	40.00	4	50.00	2	100.00	2	100.00	4	28.60	4	50.00	2	100.00
	R	0	0.00	0	0.00	24	60.00	4	50.00	0	0.00	0	0.00	10	71.40	4	50.00	0	0.00
Nitrofurotoin	S	0	0.00	8	100.00	36	64.30	6	50.00	2	100.00	4	66.70	4	50.00	6	60.00	4	66.70
	R	4	100.00	0	0.00	20	35.70	6	50.00	0	0.00	2	33.30	4	50.00	4	40.00	2	33.30

Discussion

This study provides insight into urinary tract infections (UTIs) among patients attending the Urology Department of the General Military Hospital in Sana'a, Yemen. The overall culture positivity rate was 29.3%, with a predominance of males (69.6%), reflecting the male-heavy hospital population rather than general gender trends in UTIs [4,5]. Most affected patients were aged 20–40 years (44.1%), likely related to increased sexual activity, catheter use, and occupational exposure in this age group [4,14].

Gram-negative bacteria were the most frequent pathogens (85.3%), with Escherichia coli (46.1%) leading, followed by Pseudomonas aeruginosa (15.7%) and Klebsiella spp. (11.8%) [4–6]. The presence of Candida albicans in 10.8% of cases may reflect prior broad-spectrum antibiotic use, catheterization, or compromised immunity [11,12]. These findings suggest both community-acquired and hospital-associated infections contribute to the local UTI burden.

Antimicrobial resistance among isolates was notably high. Third- and fourth-generation cephalosporins (ceftazidime 86.7%, cefepime 81.8%) and fluoroquinolones (ciprofloxacin 64.3%) showed limited efficacy. E. coli exhibited complete resistance to ceftazidime and 74.1% resistance to amoxicillin/clavulanic acid. P. aeruginosa displayed high multidrug resistance, including 100% resistance to amoxicillin/clavulanic acid. These patterns likely arise from empirical antibiotic use without laboratory confirmation, over-the-counter availability of antibiotics, incomplete treatment courses, and limited antimicrobial stewardship in the Yemeni healthcare context [7,8,15].

Carbapenems remained highly effective (imipenem 95.7%, meropenem 91.5%), and aminoglycosides (amikacin 72.6%, gentamicin 68%) retained moderate activity. These drugs should be reserved for confirmed multidrug-resistant infections to prevent further resistance escalation [6,15]. Nitrofurantoin showed acceptable activity, making it a practical choice for uncomplicated outpatient UTIs [5].

These findings have several implications for Yemeni healthcare. Hospital-level interventions, such as implementing antimicrobial stewardship programs, updating empirical therapy guidelines using local susceptibility data, and training clinicians on rational antibiotic use, are urgently needed [13,14]. Strengthening laboratory capacity to enable culture-guided therapy and educating patients on adherence to prescribed treatments can further help curb the rise of resistance.

Limitations: As a single-center study, the findings may not represent national resistance trends. Molecular testing for ESBL and carbapenemase genes was not performed, limiting understanding of resistance mechanisms. Nevertheless, the study provides valuable data to guide local clinical decision-making and inform policy in Sana'a and similar healthcare settings.

Conclusion

This study provides Yemen-specific data on uropathogens in a tertiary urology department. Escherichia coli and Pseudomonas aeruginosa were the most common, showing high resistance to cephalosporins and fluoroquinolones. Carbapenems and aminoglycosides remain effective but require cautious use.

The findings emphasize the need for local antimicrobial stewardship, culture-guided therapy, and regular surveillance. Future research should explore resistance mechanisms and track trends to guide sustainable interventions in Yemen's healthcare system.

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