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Antibiotic susceptibility patterns of bacterial uropathogens at a private tertiary hospital in Uganda: a retrospective study

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Abstract

Background Urinary tract infections are disproportionately prevalent in low- and middle-income countries, where a significant portion of the population relies on over the counter and self-prescriptions to manage symptoms. This practice has contributed to a concerning shift in antimicrobial resistance trends, among the most recommended treatments.

Methods A cross-sectional retrospective study was conducted at Mengo Hospital's medical laboratory, utilizing data from the hospital management system between January 2019 and July 2023. A total of 1,091 urine samples were collected and cultured on Cysteine Lactose Electrolyte Deficient agar. Of the samples analyzed, 476 showed significant bacteria growth ($>10^5$ colony-forming units). Organisms were identified using Gram staining and other biochemical techniques. Antibiotic susceptibility testing was performed using the Kirby-Bauer disc diffusion method. Data was entered into Microsoft Excel, cleaned, and analyzed using STATA 15.0.

Results Among the 476 records with bacterial growth, 74.8% were females. The highest incidence of infection occurred in individuals aged 50 years and above (31.7%). The most isolated bacterial organisms were Gram-negative *Escherichia coli* (39.5%) and Gram-positive *Staphylococcus aureus* (25.6%). E.*coli* was most isolated among females (78.2%, $p<0.0001$). Imipenem (83.9%), amikacin (72%), and nitrofurantoin (65.5%) were the antimicrobial agents to which isolated bacteria exhibited the highest sensitivity. Conversely, bacteria showed highest resistance to ciprofloxacin and ofloxacin of 65.5% and 64.5%, respectively.

Conclusions The increasing resistance of uropathogens to commonly prescribed and affordable antibiotics is a growing concern. Ciprofloxacin, a widely used empirical treatment, has shown a significant shift towards resistance, highlighting the need for healthcare facilities to utilize bacteriology laboratories for culture and antimicrobial susceptibility testing, and surveillance to inform standard treatment guidelines.

Keywords Uropathogens, Urinary tract infections, Antimicrobial resistance, Sensitivity

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Introduction

The World Health Organisation (WHO) estimated that over 10 million deaths would occur by 2050 due to an increase in antimicrobial resistance and has since then been prioritized as a global public health threat [1]. High rates of antimicrobial resistance (AMR) have been found in Sub-Saharan Africa and argued to be caused by inappropriate prescriptions, over the counter dispensing of antibiotics, poor diagnostic capabilities and implementation of antibiotic stewardship programs [2]. Between 2000 and 2015 antibiotic use increased by 65% globally mainly observed in low- and middle-income countries [3]. Western Sub-Saharan Africa had the highest death rate in 2019 due to AMR of over 27.3 deaths per 100,000 followed by Eastern, Central and Southern Sub-Saharan Africa [4]. The most prevalence of multi-drug-resistant urinary tract infections in West Africa is noted to be 93.6%, with the highest rates in Ghana [5].

Urinary tract infections (UTIs) are among the prevalent bacterial infections, with an estimated annual incidence of more than 150 million cases globally [6]. The prevalence of UTIs in Africa is 10.1–76.6% [7]. Women are more susceptible to UTIs due to physiological and anatomical characteristics of the urethra, with over 60% experiencing at least one episode of UTI in their lifetime worldwide [8]. The UTI prevalence increases with age, rising to 20% among individuals aged 65 years and above, likely due to a weakened immune system [9]. The most common uropathogens are Gram-negative bacteria with *Escherichia coli*, causing over 80% of infections globally [10]. A study from Western Uganda reported mostly *E.coli* (61.9%), *Staphylococcus aureus (14.9%)*, *Klebsiella pneumoniae (5.9%)*, *Enterococcus* species *(5.6%)*, *Citrobacter* species (2.99%), *Acinetobacter* (1.49%), and *Pseudomonas aeruginosa* (1.5%) isolated in urine cultures of midstream samples [11]. In Northern Uganda, hospital-isolated *Enterococcus* species(57%) and *Escherichia coli*(28%) were the most prevalent uropathogens in the population [12].

Knowledge of common uropathogens and antimicrobial susceptibility patterns within the local population is essential to improve the management of UTIs in the era of increasing antimicrobial resistance. Due to the rapidly evolving strategies of bacteria and the aetiology of UTIs, the antibiotic resistance profile of pathogens has changed over the years, making it challenging to treat uncomplicated infections [13]. In Eastern Uganda, *E. coli* was the most prevalent, with high resistance to extended-spectrum penicillins like ampicillin, amoxiclav, and cephalosporins (74.2% to cefotaxime) [14]. Both Gram-negative and positive bacteria were highly resistant to beta-lactams in samples cultured in Mulago National Referral Hospital yet, these are the population's most readily available antimicrobial drugs [15]. However, in Northern Uganda, the highest resistance was found to amoxicillin (66.2%) and ciprofloxacin (44.6%) [12]. According to the European Center for Disease Control, from 2012 to 2015, there was a noted increase in the emergence of multidrug resistant *Escherichia coli* and *Klebsiella pneumoniae* with higher prescriptions of carbapenems and resistance to third-generation cephalosporins [16]. The resistance of carbapenems and nitrofurantoin was < 5% in most organisms isolated in urine cultures [17].

Given the rising resistance of organisms to commonly available oral and intravenous antibiotics in Uganda, documenting drug susceptibility patterns is crucial for optimizing treatment outcomes. The study's findings will provide valuable insights into the prevalent organisms causing UTIs and their sensitivity to commonly prescribed antibiotics, ultimately informing evidence-based treatment strategies.

The main objective of this study was to identify the common bacterial uropathogens and their antibiotic susceptibility patterns among patients attending Mengo Hospital.

Methodology

Study design

This was a cross-sectional retrospective study of urine samples collected for culture and sensitivity at Mengo Hospital from January 2019 to July 2023.

Study setting

The study was conducted at the microbiology laboratory department of Mengo Hospital, Uganda. The hospital has a catchment area in central Uganda and referrals from peripheral clinics and health centre IV a bed capacity of 700 with approximately 15,000 admissions per annum. It offers inpatient and outpatient services by qualified medical officers, nurses, pharmacists, pharmacy technicians, specialists, radiologists, and medical laboratorians. Mengo Hospital Laboratory is accredited to ISO 15189:2012 by the Kenya National Accreditation Service (KENAS), and its scope of accreditation includes microbial bacterial culture and antibiotic susceptibility testing. It is divided into microbiology, clinical chemistry, histopathology, haematology, outpatient department, and molecular laboratory. Over 2,000 urine cultures were ordered for between January 2019 to July 2023. The microbiology laboratory department deals with antimicrobial surveillance, culture, and sensitivity.

Study population

The study utilized medical records of patients whose urine was subjected to culture and sensitivity in the microbiology department of the hospital from January 2019 to July 2023. Patients with confirmed significant bacteriuria were included while those with no bacterial growth or growth of only candida species were excluded.

Sample collection and culture

The hospital laboratory system (Clinic master) was utilized to retrieve urine culture and antimicrobial susceptibility testing (AST) results conducted between January 2019 and July 2023. In summary, midstream clean urine samples are routinely collected for urine culture and AST. Significant microbial pathogens from urine samples are isolated through semi-quantitative urine culture performed on Cysteine Lactose Electrolyte Deficient (CLED) agar incubated aerobically at 37 °C for 24 h. Colony morphology on CLED with significant growth of $\geq 10^5$CFU was assessed and identified using Gram staining and conventional biochemical techniques like the Triple Sugar Iron test, Urease test, Oxidase test, Indole test, and Citrate Utilization test for Gram-negative bacteria, and the Catalase test and Coagulase test for Gram-positive cocci. Antibiotic susceptibility testing for positive cultures was conducted using the Kirby-Bauer disc diffusion method on Mueller-Hinton agar [4]. Interpretation of results adhered to the Clinical and Laboratory Standards Institute (CLSI) guidelines and recommendations from the Uganda Clinical Guidelines (UCG) by the Ministry of Health [3, 18]. The panel of antibiotics tested against Gram negative bacteria included: Nitrofurantoin 300 µg, Amoxicillin-Clavulanic Acid 20/10µg, Amikacin 30 µg, Cefotaxime 30 µg, Ofloxacin 5µg, Ciprofloxacin 5µg, Cefixime 5µg, Gentamicin 10 µg, Ampicillin 10 µg, Ceftriaxone 30 µg, and Imipenem 10 µg. The antibiotics tested against Gram Positive bacteria included Nitrofurantoin 300 µg, Ciprofloxacin 5µg, Ofloxacin 5µg and Gentamicin 10 µg.

Data collection

Permission was obtained from the administration, Health Management Information System (HMIS) manager and raw data extracted. The HMIS captures information of patient identification number, name, sex, gender, sample collected test requested, results, treatment, and diagnosis. The data was cleaned by one independent researcher and validated by another in preparation for data analysis.

Variables

The independent variable is the common bacterial uropathogens. Where common uropathogens is defined as the prevalent isolates in the study population. The dependent variable is antimicrobial susceptibility of the isolates.

Study flow chart

We extracted 1,091 records of urinary specimens from the electronic database. We excluded 472 records with no bacterial growth observed after 72 h of culturing. We further excluded 143 records due to the growth of *Candida species* and mixed bacteria, consequently including only 476 (43.6%) records with bacterial growth in the analysis as showed in Fig. 1.

Data analysis

Data was obtained from an electronic medical records database (Clinic Master International) and exported to a Microsoft Excel document. The data was then cleaned

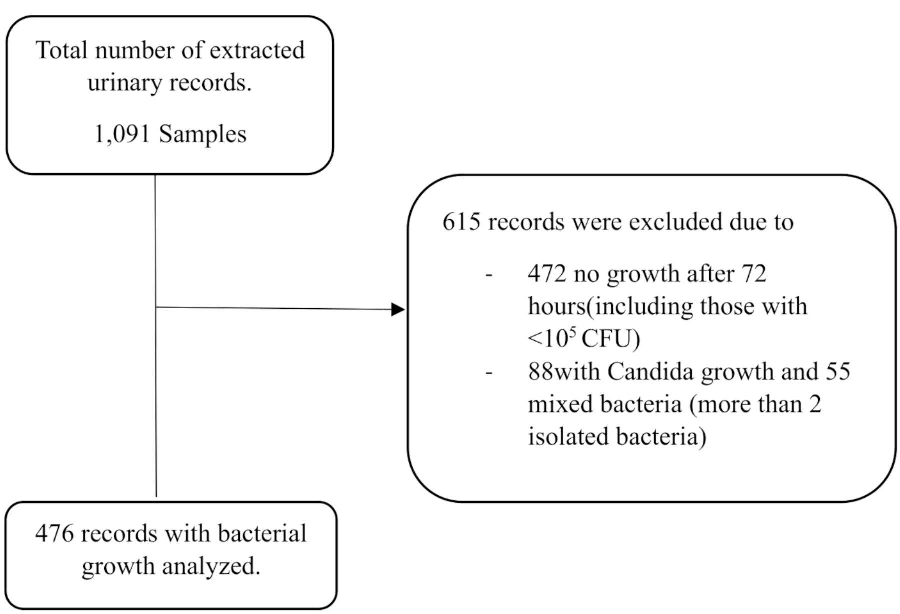

Fig. 1 Flow chart of how medical records were extracted and sorted

Table 1 Demographics of individuals with urinary tract infections

DEMOGRAPHICS	FREQUENCY $n=476$ (%)
AGE	
0–20 years	46 (10)
21–40 years	237 (50)
41–60 years	91 (19)
>60 years	102 (21)
SEX	
Female	356 (75%)
Male	120 (25%)

Table 2 Frequency of bacterial uropathogens isolated among patients in Mengo

ORGANISMS	Total (%)	Male (%)	Female (%)	*p*-Value
Escherichia coli	188 (39.5)	41 (21.8)	147 (78.2)	<0.0001
Staphylococcus aureus	122 (25.6)	31 (25.4)	91 (74.6)	<0.0001
Coagulase-negative *staphylococcus* species	42 (8.8)	10 (23.8)	32 (76.2)	<0.0001
Klebsiella pneumoniae	24 (5)	6 (25)	18 (75)	<0.0001
Enterobacter species	22 (4.6)	5 (22.7)	17 (77.3)	<0.0001
Serratia species	20 (4.2)	11 (55)	9 (45)	<0.0001
Enterococcus faecalis	10 (2.1)	1 (10)	9 (90)	<0.0001
Proteus mirabilis	8 (1.7)	2 (25)	6 (75)	<0.0001
Providencia species	8 (1.7)	3 (37.5)	5 (62.5)	<0.0001
Pseudomonas aeruginosa	6 (1.3)	2 (33.3)	4 (66.7)	<0.0001
Streptococcus agalactiae	6 (1.3)	3 (50)	3 (50)	<0.0001
Morganella species	5 (1.1)	1 (20)	4 (80)	<0.0001
Others	15 (3.2)	4 (26.7)	11 (73.3)	

and analyzed using STATA 15.0. demographic data was analyzed descriptively and presented using tables, frequencies, and graphs. Differences in the distribution of isolates by gender were determined using Chi-square or Fischer's exact test.

Results

Participant characteristics

Analysis of the 476 samples revealed that individuals aged 21–40 years had the highest prevalence of urinary tract infections, accounting for 50% of cases, followed by those aged 60 years and above (21%). Additionally, UTIs were found to be more prevalent among females (75%) compared to males (25%) as shown in Table 1.

Isolated bacterial uropathogens and antimicrobial susceptibility patterns

The predominant pathogens isolated in this study population were *Escherichia coli* (39.5%) and *Staphylococcus aureus* (25.6%). Other notable pathogens included Coagulase-negative *staphylococcal* species (8.8%), *Klebsiella pneumoniae* (5%), and *Enterobacter* species (4.6%), as well as several other organisms listed in the study findings. In the comparison of gender distribution, *Escherichia coli* (78.2%, $p<0.0001$), *Staphylococcus aureus* (74.6%, $p<0.0001$), and *Coagulase-negative staphylococcus* species (76.2%, $p<0.0001$) had higher proportions among females, while *Serratia* species showed a higher proportion in males (55%, $p<0.0001$) (Table 2).

The antibiotic sensitivity patterns revealed that imipenem (83.9%) had the highest overall sensitivity, followed by amikacin (72%), nitrofurantoin (65.5%), and other antibiotics in descending order. Conversely, the highest overall resistance was observed against ciprofloxacin (65.5%) and ofloxacin (64.5%), while imipenem (11.5%) and amikacin (12.5%) showed the lowest resistance rates (Table 3 provided as a supplementary material).

Regarding commonly used antibiotics against the five most isolated uropathogens, Ampicillin (75.7%) and Cefixime (71.1%) exhibited the highest overall resistance, while Gentamicin (46.1%) and Nitrofurantoin (22.5%) showed the lowest. Notably, Klebsiella pneumoniae and Enterobacter demonstrated 100% resistance to Ampicillin, whereas Nitrofurantoin consistently displayed resistance rates below 10% across most pathogens (Fig. 2).

Discussion

This study provides valuable insights into urinary tract infections (UTIs) among the semi-urban population of Uganda. Our findings reveal that *Escherichia coli* is the most isolated pathogen, with ciprofloxacin being the most resistant oral antibiotic and imipenem showing the highest sensitivity. These results have significant implications for the treatment protocol at Mengo Hospital, particularly considering rising antimicrobial resistance. Notably, our study also found that females had a higher prevalence of UTIs compared to males (Table 1), consistent with global trends where women have a high lifetime risk of up to 60% [8]. The most prevalent organisms in females were *E.coli*, *Staphylococcus aureus* and Coagulase negative *staphylococcus* species (Table 2) which can attributed to the hygiene practice causing cross contamination with the gastrointestinal tract [19].This disparity can be attributed to physiological and anatomical differences that facilitate easier colonization of the female urinary system [20]. Furthermore, our results show that the prevalence of UTIs was highest among individuals aged 21–40 years. This finding is consistent with previous studies, including one conducted at Mulago Hospital, which reported significant statistical relationships between age, female gender, and UTI prevalence among adults and outpatients [21]. Similarly, a South African study found that the 26–50 age group had the highest UTI prevalence (45.5%), with no significant difference in pathogen distribution across age groups [22]. The high prevalence in this age group may be attributed to

Table 3 Percentage sensitivity and resistance of uropathogens

ORGANISMS		ANTIBIOTICS (%)										
		NIT	AMC	CFX	OFL	CIP	CFM	GEN	AMP	CRO	AMK	IMP
GRAM NEGATIVES												
Escherichia coli	S	77	49.5	30.3	19.3	18.4	21.2	51.3	12.1	24.1	81.3	94
	I	5.9	7.5	3	3.5	1.8	3.8	7.5	1.7	5.4	10.7	0
	R	17.1	43	66.7	77.2	79.8	75	41.2	86.2	70.5	8	4
Klebsiella pneumoniae	S	33.3	35	0	42.1	36.8	33.3	42.1	0	25	73.3	100
	I	0	15	0	0	0	0	0	0	0	0	0
	R	66.7	50	100	57.9	63.2	66.7	57.9	100	75	26.7	0
Enterobacter species	S	25	23.1	0	12.4	14.3	0	44.4	33.3	43.7	60	88.9
	I	62.5	0	0	31.3	21.4	0	0	0	0	10	0
	R	12.5	76.9	100	56.3	64.3	100	55.6	66.7	56.3	30	11.1
Serratia species	S	37.5	55.6	0	22.2	40	50	38.5	0	55.6	100	100
	I	6.2	11.1	0	11.1	20	0	0	0	0	0	0
	R	56.3	33.3	100	66.7	40	50	61.5	100	44.4	0	0
Proteus mirabilis	S	75	0	50	16.7	25	0	14.3	NT	0	100	66.7
	I	25	0	0	0	0	0	28.6		0	0	0
	R	0	100	50	83.3	75	100	57.1		100	0	33.3
Pseudomonas aeroginosa	S	66.7	0	NT	0	33	0	0	0	0	100	100
	I	0	33		0	0	0	0	0	0	0	0
	R	33.3	67		100	67	100	100	100	100	0	0
Morganella species	S	75	75	50	0	33	NT	0	NT	50	100	100
	I	0	0	0	0	0		0		0	0	0
	R	25	25	50	100	67		100		50	0	0
Citrobacter species	S	0	0	0	50	0	0	33	0	0	50	100
	I	0	50	0	0	0	0	0	0	0	0	0
	R	100	50	100	50	100	100	67	100	100	50	0
Providencia species	S	67	34	NT	40	33	0	60	0	40	100	100
	I	17	33		0	0	0	20	0	0	0	0
	R	16	33		60	67	100	20	100	60	0	0
Sphingomonas paucimobilis	S	NT	NT	NT	0	0	NT	75	NT	75	100	NT
	I				0	25		0		0	0	
	R				100	75		15		15	0	
OVERALL RESISTANCE		**33**	**48**	**47**	**75**	**70**	**69**	**58**	**65**	**67**	**7**	**5**
GRAM POSITIVES												
Staphylococcus aureus	S	71	72	38	26	18	50	43	67	42	69	92
	I	16	0	5	11	12	13	16	0	12	3	0
	R	13	28	57	63	70	37	41	33	46	28	8
Coagulase negative staphylococcus species	S	96.8	40	0	12	11	0	54	33	14	71	100
	I	0	0	0	0	11	0	11	0	0	0	0
	R	3.2	60	100	88	78	100	35	67	86	29	0
Enterococcus faecalis	S	75	100	100	25	33	0	0	34	50	100	100
	I	0	0	0	0	0	0	0	33	0	0	0
	R	25	0	0	75	67	100	100	33	50	0	0

Table 3 (continued)

ORGANISMS		ANTIBIOTICS (%)										
		NIT	AMC	CFX	OFL	CIP	CFM	GEN	AMP	CRO	AMK	IMP
Streptococcus agalactiae	S	67	0	0	50	50	100	33	0	33	50	100
	I	0	0	0	0	0	0	0	0	0	0	0
	R	33	100	100	0	50	0	67	100	67	50	100
Kocuria species	S	100	67	NT	0	0	50	25	NT	0	NT	100
	I	0	0		0	0	0	25		0		0
	R	0	33		100	100	50	50		100		0
Streptococcus pyogenes	S	100	NT	0	100	NT	NT	NT	NT	NT	NT	NT
	I	0		0	0							
	R	0		100	0							
OVERALL RESISTANCE		**12**	**37**	**60**	**54**	**61**	**48**	**49**	**39**	**58**	**18**	**18**

Key: NT- Not tested, NIT- Nitrofurantoin, AMC- Amoxicillin/clavulanic acid, CFX- Cefotaxime, OFL- Ofloxacin, CIP- Ciprofloxacin, CFM- Cefixime, GEN- Gentamycin, AMP- Ampicillin, CRO- Ceftriaxone, AMK- Amikacin, IMP- Imipenem. S- Sensitive, I– Intermediate and R– Resistant

increased socializing and sexual activity, which elevate the risk of infection.

This study found *Escherichia coli* and *Staphylococcus aureus* to be the most common isolated organisms among others as shown in Table 2. Similar findings were reported in a tertiary care hospital, where *Escherichia coli* accounted for 58.2% of community cases and 47.6% of hospital-acquired UTIs [23]. Comparative studies in Uganda have yielded similar results. A retrospective study at Mulago National Referral Hospital isolated *Enterococcus* species and *Klebsiella pneumoniae*, categorizing them as hospital and community-acquired UTIs [24]. Another in Western Uganda found *E. coli* (61.9%), *S. aureus* (14.9%), and *K. pneumoniae* (5.9%) in urine cultures [11]. The high prevalence of *E. coli* may be attributed to cross-contamination with gut bacteria in urine samples. These findings suggest that the causative organisms and their resistance profiles are consistent across Ugandan populations. In contrast, Asia reported *E. coli* and *Klebsiella pneumoniae* as the most common bacteria across all age groups and genders [17]. Another study in Ethiopia found *Acinetobacter* and *Pseudomonas* species to be more prevalent in patients with indwelling catheters in an intensive care unit [25]. This disparity may be attributed to differences in hygiene practices and patient populations. These findings underscore the need for standardized treatment guidelines across Uganda, as advocated by the Ministry of Health. However, this study's retrospective design limited our ability to distinguish between community and hospital-acquired infections, which would have added more depth to our findings.

Ciprofloxacin exhibited the highest overall resistance across all isolated organisms, as shown in Table 3. This resistance pattern is alarming, considering that earlier studies in 2001 reported a sensitivity to ciprofloxacin of up to 90% for all uropathogens in Uganda [26]. As resistance exceeds 20%, ciprofloxacin is no longer suitable for empiric use [27]. According to antimicrobial surveillance data of Uganda in 2020, the resistance of ciprofloxacin was above 50% across all isolated organisms [28]. Resistance to UTIs in Tanzania was up to 70.8% which rendered it ineffective in the biggest population of the country [29]. The increased resistance can be attributed to factors such as self-prescription, over-the-counter purchases, and inadequate antimicrobial stewardship practices [30]. Some studies from other countries have reported lower resistance rates. For example, a study in South Africa reported a resistance rate of 18.5% [22], while an Indian study reported a sensitivity of 35.8% India [31]. These disparities highlight the need for tailored antimicrobial stewardship strategies in Uganda. The high resistance rate of ciprofloxacin in our study population warrants further research into the specific mechanisms of resistance and potential solutions. We

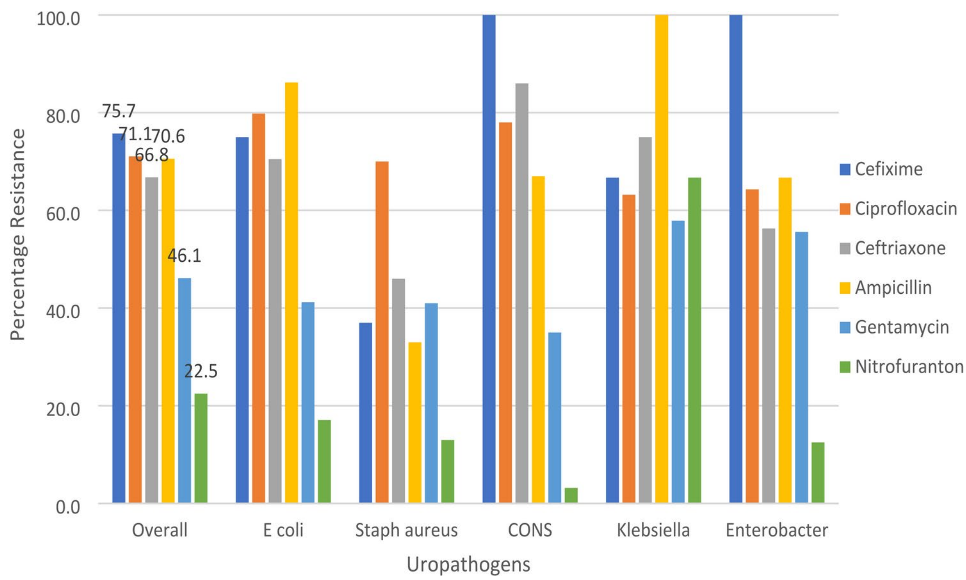

Fig. 2 Resistance patterns of commonly used antibiotics in Uganda against the most frequently isolated organisms

recommend exploring alternative treatment options and developing evidence-based guidelines for urinary tract infections in Uganda.

Ceftriaxone, a commonly used intravenous antibiotic for complicated UTIs, exhibited the highest resistance among all intravenous antibiotics tested, as shown in Table 3; Fig. 2. At Mengo Hospital, ceftriaxone was administered to 50.6% of patients admitted to the medical ward [32]. Its widespread use in low-income countries is attributed to its broad-spectrum activity, low toxicity, and cost-effectiveness [33]. However, recent studies have reported sky rocketing resistance rates to ceftriaxone. In Uganda, 85% of *Klebsiella pneumoniae* and 15% of *E. coli* strains were non-susceptible to ceftriaxone in 2021 [34]. Similarly, a study among immunocompromised patients in Uganda found significant resistance to ceftriaxone, ciprofloxacin, and gentamicin [35]. A systematic review in Sub-Saharan Africa reported a prevalence of over 50% inappropriate use of ceftriaxone [36]. Resistance patterns to ceftriaxone have also been reported in other regions like Pakistan in uncomplicated UTIs [37]. In the Asia Pacific Region, resistance to ceftriaxone ranged from 33 to 90% across 41 countries [38]. The evolving adaptation of bacteria through mutations has altered resistance patterns, reducing the efficacy of previously effective antibiotic treatments [13]. Easy access to ceftriaxone and its broad-spectrum activity has contributed to its high exposure and increased mutation, leading to widespread resistance.

The study revealed that imipenem exhibited the highest sensitivity to all organisms. This is consistent with a 2018 study in Northern Africa, which reported a relatively low resistance rate of 31.4% to carbapenems in multidrug resistant urinary tract infections [39]. Imipenem is primarily recommended for treating multi-drug resistant UTIs, rather than routine empirical management [40]. Notably, imipenem demonstrated high sensitivity to both Gram-negative and Gram-positive bacteria in Northern Uganda, with sensitivity rates of 74.5% and 94.2%, respectively [12]. This underscores the importance of preserving imipenem for complicated UTIs. In contrast, nitrofurantoin emerged as the oral drug with the highest overall sensitivity, despite a resistance rate above 20%. A study at Mulago Hospital's general outpatient clinic reported a higher sensitivity rate of 98.3% among women [24]. The limited use of nitrofurantoin due to its undesirable side effects, including nausea, vomiting, and abdominal pains [41], may contribute to its relatively high sensitivity. However, a 2023 study in the Netherlands reported a 25% treatment failure rate with nitrofurantoin in males highlighting the need for cautious use [42]. Nevertheless, nitrofurantoin remains a viable option for empirical management of uncomplicated urinary tract infections.

Conclusions

This study reveals a significant shift in the sensitivity of empirical drugs used to manage urinary tract infections (UTIs) in Uganda over the past five years, affecting both oral and intravenous treatments. Notably, resistance to ciprofloxacin has increased substantially, while imipenem remains highly effective. To address this evolving landscape, healthcare facilities must establish evidence-based antibiograms to inform treatment decisions and improve patient outcomes.

Limitations

The retrospective design of this study limited our ability to distinguish between hospital-acquired and community-acquired infections. Additionally, several demographic factors, such as residence, were not analyzed, which could have provided further insights. It was assumed that all patients collected mid-stream urine samples according to standard hospital procedure, although supervision was not ensured. Furthermore, molecular testing was not conducted to determine the mechanisms of resistance for each isolated organism, which would have provided valuable information on resistance patterns.

Abbreviations

AMR	Antimicrobial Resistance
AST	Antimicrobial Susceptibility Testing
CFU	Colony Forming Units
CLED	Cysteine Lactose Electrolyte Deficient
CLSI	Clinical and Laboratory Standard Institute
HMIS	Health Management Information System
KENAS	Kenya National Accreditation Service
UCG	Uganda Clinical Guidelines
WHO	World Health Organization

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Author contributions
RMN designed the study, collected data collection, did statistical analysis, and wrote the first manuscript RBK, AMK and RN worked on the proposal, collected data and wrote subsequent manuscripts. PK, RS, EN, RSL, RKMand FK actively supervised all the stages of the study DM, NRM, JKM and RN helped in developing of the study concept.RKM, AMK and KC did the data analysis All authors reviewed the manuscript.

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Data availability
The data used during the study is available from the corresponding author upon reasonable request.

Declarations

Competing interests
The authors declare no competing interests.

Conflict of interest
The authors declare no conflicting interests.

Ethical approval
The ethical principles of involvement of human research subjects as outlined in the Nuremberg Code and Declaration of Helsinki were strictly adhered to for this study. Ethical approval was obtained from the Mengo Hospital research and ethics committee under approval number MH-2023-27. Additional approval was obtained from the data manager to access patients' records from the hospital health management information system. A waiver of consent was written and approved for the use of patient information for the study by the ethics committee of the hospital. Patients' records were reviewed, and confidentiality was maintained. Clinical trial number: not applicable.

Clinical trial number
Not applicable.

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