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Original Research

Incidence of urinary infections and pharmacological sensitivity in elective urine samples in a prospective cohort from Luanda, Angola

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Abstract: This prospective cohort study evaluated 107 urine samples from patients suspected of urinary tract infection (UTI) treated at Cajueiros General Hospital in Angola from January to March 2023. Inclusion criteria involved obtaining urine samples for clinical examinations from adult patients with suspected UTI, regardless of gender, age, or previous clinical condition. The samples were transported to the reference laboratory of the National Institute of Health Research for microbiological evaluation and antibiotic sensitivity testing using the VITEK 2 system. Of the 107 patients evaluated, 39.3% (n= 42) showed bacterial growth in their urine. Escherichia coli was the predominant pathogen (23.8%), followed by Sphingomonas paucimobilis, Pseudomonas luteola, and Klebsiella pneumoniae. Antimicrobial resistance was observed, with ampicillin (90.5%) being the most resistant, while imipenem (95.2%) and ertapenem (90.5%) exhibited high sensitivity. Statistical analysis revealed common clinical characteristics, such as fever (61.7%) and dysuria (73.8%). This study provides a comprehensive understanding of microbial ecology in urinary infections, highlighting the prevalence of pathogens and antibiotic resistance patterns in a specific patient population in Angola. Importantly, this research represents the first prospective study of its kind in Angola.

Keywords: Urinary Tract Infection; Antibiotic Sensitivity; Antibiotic Resistance; Prospective Cohort Study; Angola.

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1. Introduction

Urinary tract infections (UTIs) encompass infections affecting various parts of the urinary tract, including the kidneys, ureters, bladder, and urethra. They are categorized based on the site of infection, causative agent, severity, and acquisition setting. The site of infection distinguishes upper tract infections involving the kidneys from lower tract infections affecting the bladder, urethra, and prostate. Symptoms and complications vary accordingly, with pyelonephritis causing fever and kidney damage, and cystitis resulting in dysuria and urgency. *Escherichia coli* is the primary cause, though other bacteria, fungi, viruses, or parasites can also be responsible [1].

The severity of UTIs is classified as uncomplicated or complicated, depending on risk factors for adverse outcomes. Uncomplicated cases occur in healthy individuals without urinary tract abnormalities, while complicated cases affect those with underlying conditions. The setting of acquisition distinguishes between community-acquired UTIs, often caused by *E. coli*, and hospital-acquired UTIs, associated with invasive procedures

and potentially resistant organisms. Accurate classification is crucial for effective diagnosis, treatment, and prevention. Empirical oral antibiotics suffice for uncomplicated cystitis, whereas complicated pyelonephritis may necessitate intravenous antibiotics and imaging studies. Prevention strategies range from behavioral measures for community-acquired UTIs to infection control practices, such as antimicrobial stewardship, for hospital-acquired cases [1, 2]

According to the Global Burden of Disease Study 2019, more than 404.6 million people had UTIs globally in 2019, and nearly 236,786 people died of UTIs, contributing to 5.2 million disability-adjusted life-years (DALYs) [3]. The age-standardized incidence rate of UTIs increased from 4715.0 per 100,000 population in 1990 to 5229.3 per 100,000 population in 2019, with the highest rates occurring in Tropical Latin America, South Asia, and Sub-Saharan Africa [3]. The age-standardized mortality rate of UTIs was 3.13 per 100,000 population in 2019, with the highest rates in Barbados, Angola, and Sierra Leone [3]. The age-standardized DALY rate of UTIs was 67.4 per 100,000 population in 2019, with the highest rates in Angola, Sierra Leone, and Liberia [4].

A comprehensive understanding of the economic burden of UTIs includes consideration of direct costs (such as those for diagnosis, treatment, and hospitalization), indirect costs (like loss of productivity and income, and quality of life impacts), and even intangible costs (such as pain and discomfort). In a study by Keating et al. [5], it was noted that there is a considerable societal burden from uncomplicated urinary tract infection, with approximately USD 1 billion in indirect and over USD 600 million in direct costs in 1995. This study highlights the need for more current insights on the burden of UTIs in terms of direct, indirect, and intangible costs. Furthermore, research has shown that recurrent UTIs have a significant impact on patients, not only in terms of healthcare costs but also in terms of quality of life. For instance, a study published in PubMed reports that the mean number of episodes of cystitis per patient was 4.5, with a mean duration from symptom onset of 9 years. This study also highlights that 78% of patients experienced an impairment in their sex lives due to UTIs [4, 5].

In terms of economic impact, the mean annual direct cost per patient due to UTI was estimated to be €229, with the mean direct cost per episode being €236. Interestingly, for women with recurrent UTIs, this cost was significantly lower at €142 per episode. These findings underscore the importance of effective management and treatment strategies for UTIs, not only to improve patient outcomes and quality of life but also to reduce the economic burden on healthcare systems and society [5]. The data reflects the ongoing need for research and healthcare policy that addresses both the clinical and economic aspects of UTIs, especially given their prevalence and impact.

Meanwhile, the treatment of UTIs is becoming more challenging due to the emergence and spread of antibiotic resistance, which is when bacteria become resistant to the medicines used to treat them. Antibiotic resistance is a result of the natural evolution of bacteria and the overuse and misuse of antibiotics in humans and animals. Antibiotic-resistant UTIs can cause more severe symptoms, longer duration of illness, higher risk of complications, and increased health care costs. Therefore, it is important to prevent UTIs by maintaining good hygiene, drinking plenty of fluids, and urinating frequently. It is also essential to use antibiotics appropriately, only when prescribed by a doctor, and to complete the full course of treatment. Furthermore, new strategies and therapies are needed to combat antibiotic resistant UTIs, such as developing novel antibiotics, improving diagnostics, and exploring non-antibiotic alternatives. Antibiotic resistance is a global threat that requires urgent action and collaboration from all stakeholders, including health professionals, researchers, policy makers, and the public. By working together, we can preserve the effectiveness of antibiotics and protect ourselves and future generations from antibiotic resistant UTIs [5].

Angola is a low-income country in Sub-Saharan Africa, with a population of about 32.9 million and a gross domestic product per capita of $2790 in 2019 [6]. The health system in Angola is weak and underfunded, with limited access to primary health care, es-

pecially in rural areas. The epidemiology and burden of UTIs in Angola are poorly documented, as there is a lack of reliable data and surveillance systems. However, in sub-Saharan Africa countries, some studies have reported bacterial aetiology and corresponding antimicrobial susceptibility patterns in outpatients with UTIs [8, 9].

In Bagamoyo, Tanzania, where UTIs are prevalent but microbiological data for treatment decisions are limited, a study was conducted to investigate the bacterial causes and antimicrobial susceptibility patterns in UTI outpatients. Among 270 individuals, 38.5% had positive urine cultures, with *Escherichia coli* being the most common (23%). *E. coli* exhibited high resistance to cotrimoxazole, ampicillin, piperacillin, and fluoroquinolones, but high susceptibility to meropenem, fosfomycin, piperacillin/tazobactam, and amoxicillin/clavulanic acid. Resistance patterns were confirmed in Germany, showing overall agreement except for piperacillin/tazobactam and ciprofloxacin. Considering significant resistance to commonly prescribed antibiotics, exploration of alternative treatments like fosfomycin for UTIs in Tanzania is warranted [8].

In Zambia, a retrospective review of medical records involving 380 pregnant women with a median age of 29 years showed that the UTI prevalence was 16.5%, and women with UTIs had a lower gestational age compared to those without UTIs. Logistic regression revealed that gestational age was independently associated with UTIs, emphasizing the importance of early screening for UTIs during pregnancy, especially among HIV-positive women [8]. The findings suggest a need for public health interventions promoting early antenatal visits and UTI screening for sub-Saharan Africa populations. Therefore, due to the scarcity of data, new studies are needed to assess the incidence of UTI and antibiotic resistant UTIs in Angola.

Thus, the aim of this study was to establish the incidence of urinary infections and pharmacological sensitivity in elective urine samples in a prospective cohort from Luanda, Angola, in the year 2023.

2. Material and methods

2.1 Study Design and Study Population

This study was conducted as a prospective cohort involving the evaluation of 107 urine samples from patients suspected of urinary tract infection (UTI) treated at Cajueiros General Hospital from January to March 2023. Inclusion criteria involved obtaining urine samples for clinical examinations from adult patients with suspected UTI, regardless of gender, age, or previous clinical condition.

2.2 Microbiological Evaluation

The collected samples were placed in closed thermal boxes and transported to the microbiology reference centre of the National Institute of Health Research. Subsequently, they were inoculated on MacConkey agar culture medium and incubated in an oven for 24 hours. After this period, samples showing growth underwent biochemical analysis using the VITEK 2 system and were transferred to TSA culture medium.

2.3 Antibiotic Sensitivity Profile

For the investigation of the antibiotic sensitivity profile, samples demonstrating growth underwent sensitivity tests using the VITEK 2 method. This process involved assessing the response of microorganisms to different antibiotics, enabling the identification of present pathogens, and determining the effectiveness of antibiotics such as Ampicillin (AMP), Nalidixic acid (NA), Amikacin (AK), Amoxacillin (AMC), Amoxacillin and clavulamic acid (AMC_AC), Carbecillin (CA), Cephalothin (CFL), Cefazolin (KZ), Cefepime (FEP), Cefuroxime (CXM), Cefotaxime (CTX), Cefoxitin (CFO), Ceftazidime (CAZ), Ciprofloxacin (CIP), Colistin (CT), Doxycycline (DXT), Ertapenem (ERT), Gentamicin (GN), Imipenem (IMP), Levofloxacin (LEV), Meropenem (MER), Metronidazole

(MTZ), Moxifloxacin (MFX), Nitroforantoin (NIT), Norfloxacin (NOR), Ofloxacin (OFT), Piperacycline (PRL), piperacycline-tazobactam (PIT), Polymycin b (PB), Tobramycin (TOB), Trimetropin - Sulfamethoxazole (SXT), Minocycline (MH), Ceftriaxone (CRO), Olindamycin (DA), Chloramphenicol (C), Erythromycin (E), Fosfomycin (EST), Linezolid (LNZ), Oxacillin (OX), Penicillin (P), Penicillin G/Benzylpenicillin (PEN), Quinupristin-Dalfopristin (KD), Rifampicin (RD), Teicoplanin (TEC), Tetracycline (T), Tigecycline (TIG), Cefotaxime CXT and Vancomycin (VA) against these microorganisms.

2.4 Statistical Analysis

Statistical analysis was performed using SPSS version 20. Categorical variables were presented as frequencies and percentages, while continuous variables were expressed as mean ± standard deviation.

3. Results and discussion

3.1 Clinical characteristics of patients with UTI

The present study evaluated a total of 107 urine tests in a prospective cohort of patients with suspected UTI treated at the Cajueiros General Hospital from January to March 2023. The evaluated patients were adults with a mean age of 30±11 years, predominantly female (n=61/57.0%), single (n=95; 88.8%), and with a completed high school education (n=39; 36.4%), originating from the Cazenga district (n=74; 69.2%) in Luanda (Table 1). It is noteworthy that 45.8% (n=49) of the assessed patients had access to water using cisterns (n=31; 29.0%) or tanker trucks (n=18; 16.8%) (Table 1).

Table 1. Clinical characteristics of patients with urinary infection (n=107).

Variables	Clinical data
Age (Years) (mean±sd)	30±11
Gender (n; %)	
Male	46 (43.0)
Female	61 (57.0)
Marital status (n; %)	
Single	95 (88.8)
Married	8 (7.5)
Divorced	3 (2.8)
Common-law marriage	1 (0.9)
Municipality (n; %)	
Luanda*	8 (7.5)
Viana	19 (17.8)
Cacuaco	1 (0.9)
Quissama	0 (0.0)
Icolo e Bengo	0 (0.0)
Belas	5 (4.7)
Cazenga	74 (69.2)
Education level (n; %)	
None	5 (4.7)
Primary education	26 (24.3)
I cycle	28 (26.2)

Second cycle	39 (36.4)
Higher education	9 (8.4)
Basic Sanitation (n; %)	
Piped water	58 (54.2)
Cisterns	31 (29.0)
Tanker trucks	18 (16.8)

* Unknown municipality. Legend. n. Absolute number. %. Percentage. Sd. Standard deviation.

Clinically, urine tests were obtained from patients with clinical symptoms of fever (n= 66; 61.7%), dysuria (n= 79; 73.8%), and hematuria in 4.7% (n=5) of cases. Seventy cases were associated with symptoms of lower back pain (n=83; 77.6%), urgency in urination (n=70; 65.4%), and vomiting (n=24; 22.4%) (Table 2). Out of a total of 107 urine samples evaluated, 39.3% of cases showed bacterial growth (n=42) (Table 2). Among these, 40 (95.2%) urine tests were from patients who exhibited some pharmacological sensitivity, and all showed some level of drug resistance (Table 2). It is noteworthy that none of the patients underwent any invasive procedures, had no immunological compromise, and did not use antibiotics in the last thirty days.

Table 2. Clinical characteristics of patients with urinary infection (n=107).

Clinical Symptoms	n	%
Fever		
Yes	66	61.7
No	41	38.3
Dysuria		
Yes	79	73.8
No	28	26.2
Urinary urgency		
Yes	70	65.4
No	37	34.6
Lower back pain		
Yes	83	77.6
No	24	22.4
Hematuria		
Yes	5	4.7
No	102	95.3
Vomiting		
Yes	24	22.4
No	83	77.6
Bacterial Growth (n; %)		
Yes	42	39.3
No	65	60.7
Pharmacological Sensitivity (n; %)		
Yes	40	37.4
No	67	62.6

Pharmacological Resistance (n; %)		
Yes	42	39.3
No	65	60.7

Legend. n. Absolute number. %. Percentage.

3.2 Description of Bacterial diversity in Urine Cultures with Bacterial Growth

Of the total urine samples that had bacterial growth (n= 42), the top ten microorganisms identified in urine cultures with bacterial growth encompass a spectrum of bacteria known for their involvement in urinary tract infections (Table 3). Escherichia coli emerges as the predominant pathogen (n=10; 23.8%), underscoring its significance in UTIs. Other notable microorganisms include Sphingomonas paucimobilis (n=9; 21.4), Pseudomona luteola (n=6; 14.3%), and Klebisiella pneumoniae spp. (n= 5; 11.9%). The detailed breakdown of these results provides a comprehensive understanding of the microbial ecology in urinary infections. Other pathogenic microorganisms were also identified in this series representing a single occurrence (2.4%) (i.e., Klebsiela spp., Pseudomona spp., Estafilococus spp., Shigela spp., Actineto bacillus ureae, Enterobacter cloacae spp., Citrobacter freundi, Pseudomonas fluorescens, Vibrio algimoliticus and Rhizobium radiobacter). It is noteworthy that one patient was diagnosed with the presence of 13 different pathogens.

Table 3. Description of Top 10 microorganisms identified in urine tests with bacterial growth.

Pathogenic microorganism	n	%
Escherichia coli		
Yes	10	23.8
No	32	76.2
Sphingomonas paucimobilis		
Yes	9	21.4
No	33	78.6
Pseudomona luteola		
Yes	6	14.3
No	36	85.7
Klebisiella pneumoniae spp.		
Yes	5	11.9
No	37	88.1
Acinetobacter baumanni complex		
Yes	3	7.1
No	39	92.9
Pantosa spp.		
Yes	3	7.1
No	39	92.9
Enterobacter aerogenes		
Yes	2	4.8
No	40	95.2
Aeromonas salmonicidas		

Yes	2	4.8
No	40	95.2
Klebsiella oxytaca		
Yes	2	4.8
No	40	95.2
Yersinia enterocolitica		
Yes	2	4.8
No	40	95.2

Legend. n. Absolute number. %. Percentage.

3.3 Description of Antibiotic Sensibility in Urinary Tract Infections

The top 11 antibiotics showcasing sensibility of microorganisms isolated from urine cultures provide critical insights into the current landscape of antibiotic efficacy in treating UTIs. Notably, IMP (n=40; 95.2%), ERT (n=38; 90.5%), MER (n=38; 90.5%), AMC AC (n= 33; 78.6%), AK (n= 32; 76.2%), CIP (n= 31; 73.8%), LEV (n=29; 69.0), NOR (n=29; 69.0%), FEP (n= 27; 64.3%), PIT (n=27; 64.3%) and CRO (n=27; 64.3%), highlighting the challenges posed by resistant strains commonly encountered in urinary infections (Table 4).

Table 4. Top 11 antibiotics showcasing sensibility of microorganisms identified in urine tests with bacterial growth.

Antibiotics	n	%
IMP		
Yes	40	95,2%
No	2	4,8%
ERT		
Yes	38	90,5%
No	4	9,5%
MER		
Yes	38	90,5%
No	4	9,5%
AMC_AC		
Yes	33	78,6%
No	9	21,4%
AK		
Yes	32	76,2%
No	10	23,8%
CIP		
Yes	31	73,8%
No	11	26,2%
LEV		
Yes	29	69,0%
No	13	31,0%
NOR		
Yes	29	69,0%

No	13	31,0%
FEP		
Yes	27	64,3%
No	15	35,7%
PIT		
Yes	27	64,3%
No	15	35,7%
CRO		
Yes	27	64,3%
No	15	35,7%

Legend. IMP. Imipenem, ERT. Ertapenem, MER. Meropenem, AMC_AC. Amoxicillin plus clavulamic acid, AK. Amikacin, CIP. Ciprofloxacin, LEV. Levofloxacin, NOR. Norfloxacin, FEP. Cefepime, PIT. Piperacycline tazorbatam, CRO. Ceftriaxone. Legend. n. Absolute number. %. Percentage.

The table 5 presents the stratification of pathogenic bacteria identified in urine tests by sensitivity to the top 11 antibiotic therapy. Based on the top 5 main types of infections identified in this cohort, we identified that Escherichia coli infections exhibited the highest sensitivity to AK (n=9; 28.1%), LEV (n=8; 27.6%), and NOR (n=8; 27.6%). Infectious diagnoses involving Sphingomonas paucimobilis demonstrated increased sensitivity to FEP (n=6; 22.2%), MER (n=8; 21.1%), and IMP (n=8; 20.0%). Pseudomonas luteola infections displayed heightened sensitivity to FEP (n=6; 22.2%), AK (n=6; 18.8%), and AMC_AC (n=6; 18.2%). Diagnoses of Klebsiella pneumoniae spp. exhibited higher sensitivity to AK (n=5; 15.6), PIT (n=4; 14.8%), and CRO (n=4; 14.8%). Lastly, Acinetobacter baumannii complex infections demonstrated yesilar sensitivity to FEP and PIT (n=3; 11.1%).

Table 5. Characterization of Bacteria pathogenic based on antibiotic sensitivity profiles.

Pathogenic	**Antibiotic sensitivity (n/%)**										
microorganism	**IMP**	**ERT**	**MER**	**AMC_AC**	**AK**	**CIP**	**LEV**	**NOR**	**FEP**	**PIT**	**CRO**
Escherichia coli											
Yes	10 (25.0)	9 (23.7)	9 (23.7)	7 (21.2)	9 (28.1)	8 (25.8)	8 (27.6)	8 (27.6)	3 (11.1)	4 (14.8)	5 (18.5)
No	30 (75.0)	29 (76.3)	29 (76.3)	26 (78.8)	23 (71.9)	23 (74.2)	21 (72.4)	21 (72.4)	24 (88.9)	23 (85.2)	22 (81.5)
Sphingomonas paucimobilis											
Yes	8 (20.0)	7 (18.4)	8 (21.1)	5 (15.2)	6 (18.8)	4 (12.9)	2 (6.9)	2 (6.9)	8 (29.6)	5 (18.5)	4 (14.8)
No	32 (80.0)	31 (81.6)	30 (78.9)	28 (84.8)	26 (81.3)	27 (87.1)	27 (93.1)	27 (93.1)	19 (70.4)	22 (81.5)	23 (85.2)
Pseudomona luteola											
Yes	6 (15.0)	6 (15.8)	5 (13.2)	6 (18.2)	6 (18.8)	2 (6.5)	2 (6.9)	2 (6.9)	6 (22.2)	5 (18.5)	4 (14.8)
No	34 (85.0)	32 (84.2)	33 (86.8)	27 (81.8)	26 (81.3)	29 (93.5)	27 (93.1)	27 (93.1)	21 (77.8)	22 (81.5)	23 (85.2)
Klebisiella pneumoniae ssp.											
Yes	5 (12.5)	5 (13.2)	5 (13.2)	5 (15.2)	5 (15.6)	4 (12.9)	4 (13.8)	4 (13.8)	3 (11.1)	4 (14.8)	4 (14.8)
No	35 (87.5)	33 (86.8)	33 (86.8)	28 (84.8)	27 (84.4)	27 (87.1)	25 (86.2)	25 (86.2)	24 (88.9)	23 (85.2)	23 (85.2)
Acinetobacter											

baumanni complex											
Yes	3 (7.5)	3 (7.9)	3 (7.9)	2 (6.1)	1 (3.1)	2 (6.5)	2 (6.9)	2 (6.9)	3 (11.1)	3 (11.1)	1 (3.7)
No	37 (92.5)	35 (92.1)	35 (92.1)	31 (93.9)	31 (96.9)	29 (93.5)	27 (93.1)	27 (93.1)	24 (88.9)	24 (88.9)	26 (96.3)
Pantosa spp.											
Yes	3 (7.5)	3 (7.9)	3 (7.9)	3 (9.1)	1 (3.1)	2 (6.5)	2 (6.9)	2 (6.9)	2 (7.4)	2 (7.4)	1 (3.7)
No	37 (92.5)	35 (92.1)	35 (92.1)	30 (90.9)	31 (96.9)	29 (93.5)	27 (93.1)	27 (93.1)	25 (92.6)	25 (92.6)	26 (96.3)
Enterobacter aerogenes											
Yes	2 (5.0)	2 (5.3)	2 (5.3)	2 (6.1)	1 (3.1)	0 (0.0)	0 (0.0)	0 (0.0)	1 (3.7)	1 (3.7)	1 (3.7)
No	38 (95.0)	36 (94.7)	36 (94.7)	31 (93.9)	31 (96.9)	31 (100.0)	29 (100.0)	29 (100.0)	26 (96.3)	26 (96.3)	26 (96.3)
Aeromonas salmonicidas											
Yes	2 (5.0)	2 (5.3)	2 (5.3)	1 (3.0)	2 (6.3)	1 (3.2)	1 (3.4)	1 (3.4)	2 (7.4)	2 (7.4)	1 (3.7)
No	38 (95.0)	36 (94.7)	36 (94.7)	32 (97.0)	30 (93.8)	30 (96.8)	28 (96.6)	28 (96.6)	25 (92.6)	25 (92.6)	26 (96.3)
Klebsiella oxytaca											
Yes	2 (5.0)	2 (5.3)	2 (5.3)	2 (6.1)	2 (6.3)	1 (3.2)	1 (3.4)	1 (3.4)	2 (7.4)	1 (3.7)	1 (3.7)
No	38 (95.0)	36 (94.7)	36 (94.7)	31 (93.9)	30 (93.8)	30 (96.8)	28 (96.6)	28 (96.6)	25 (92.6)	26 (96.3)	26 (96.3)

Legend. IMP. Imipenem, ERT. Ertapenem, MER. Meropenem, AMC_AC. Amoxicillin plus clavulamic acid, AK. Amikacin, CIP. Ciprofloxacin, LEV. Levofloxacin, NOR. Norfloxacin, FEP. Cefepime, PIT. Piperacycline tazorbatam, CRO. Ceftriaxone. Legend. n. Absolute number. %. Percentage.

3.4 Description of Antibiotic Resistance in Urinary Tract Infections

The table 6 presents the top 12 antibiotics, showcasing resistance of microorganisms isolated from urine cultures, providing critical insights into the prevalence of antibiotic resistance patterns and informing effective strategies for antimicrobial stewardship and infection control measures. In this context, it is noteworthy to highlight the predominant resistance rates observed for various antibiotics, with AMP (n=38; 90.5%), AMC (n=37; 88.1%), SXT (n=36; 85.7%), PB (n= 32; 76.2%), CFL (n= 32; 76.2%), ERT (n= 31; 73.8%), NA (n=26; 61.9%), KZ (n=26; 61.9%), FEP (n=26; 61.9%), MH (n=26; 61.9%), NOR (n=24; 57.1%), and CIP (n=24; 57.1%) exhibiting substantial resistance rates (Table 6).

Table 6. Top 12 antibiotics showcasing resistance of microorganisms identified in urine tests with bacterial growth.

Antibiotics	n	%
AMP		
Yes	38	90.5
No	4	9.5
AMC		
Yes	37	88.1
No	5	11.9
SXT		
Yes	36	85.7
No	6	14.3
PB		
Yes	32	76.2

No	10	23.8
CFL		
Yes	32	76.2
No	10	23.8
ERT		
Yes	31	73.8
No	11	26.2
NA		
Yes	26	61.9
No	16	38.1
KZ		
Yes	26	61.9
No	16	38.1
FEP		
Yes	26	61.9
No	16	38.1
MH		
Yes	26	61.9
No	16	38.1
NOR		
Yes	24	57.1
No	18	42.9
CIP		
Yes	24	57.1
No	18	42.9

Legend. AMP. Ampicilin, AMC. Amoxacilin, SXT. Trimethoprim plus sulphamethaxazole, PB. Polimicin B, CFL. Cephalothin, NA. Nalidixic acid, KZ. Cefazolin, ERT. Ertapenem, CIP. Ciprofloxacin, NOR. Norfloxacin, FEP. Cefepime, MH. Minociline. Legend. n. Absolute number. %. Percentage.

Table 7 presents the stratification of pathogenic bacteria identified in urine tests based on resistance to the top 9 antibiotic therapies. Examining the top 5 main types of infections in this cohort, it was found that Escherichia coli infections exhibited the highest resistance to ERT (n=9; 29.0%), CFL (n=9; 28.1%), and CIP (n=8; 25.8%). Infectious diagnoses involving *Sphingomonas paucimobilis* demonstrated increased resistance to FEP (n=8; 29.6%), MH (n=5; 29.4%), and KZ (n=5; 29.4%). *Pseudomonas luteola* infections displayed heightened resistance to FEP (n=6; 22.2%), PB (n=6; 18.8%), and CFL (n=6; 18.8%). Diagnoses of *Klebsiella pneumoniae spp.* exhibited higher resistance to MH (n=3; 17.6), ERT (n=5; 16.1%), PB, and CFL (n=5; 15.6%). Lastly, *Acinetobacter baumannii* complex infections demonstrated similar resistance to MH (n=3; 17.6%), KZ (n=2; 11.8%), and FEP (n=3; 11.1%).

Table 7. Characterization of Bacteria pathogenic based on antibiotic resistance profiles.

Pathogenic microorganism	Antibiotic Resistance (n/%)										
	AMP	**AMC**	**SXT**	**PB**	**CFL**	**ERT**	**NA**	**KZ**	**FEP**	**MH**	**CIP**
Escherichia coli											
Yes	10 (26.3)	9 (24.3)	9 (25.0)	8 (25.0)	9 (28.1)	9 (29.0)	6 (23.1)	2 (11.8)	3 (11.1)	3 (17.6)	8 (25.8)
No	28 (73.7)	28 (75.7)	27 (75.0)	24 (75.0)	23 (71.9)	22 (71.0)	20 (76.9)	15 (88.2)	24 (88.9)	14 (82.4)	23 (74.2)
Sphingomonas paucimobilis											
Yes	8 (21.1)	8 (21.6)	7 (19.4)	8 (25.0)	8 (25.0)	8 (25.8)	6 (23.1)	5 (29.4)	8 (29.6)	5 (29.4)	4 (12.9)
No	30 (78.9)	29 (78.4)	29 (80.6)	24 (75.0)	24 (75.0)	23 (74.2)	20 (76.9)	12 (70.6)	19 (70.4)	12 (70.6)	27 (87.1)
Pseudomona luteola											
Yes	6 (15.8)	6 (16.2)	5 (13.9)	6 (18.8)	6 (18.8)	6 (19.4)	2 (7.7)	3 (17.6)	6 (22.2)	1 (5.9)	2 (6.5)
No	32 (84.2)	31 (83.8)	31 (86.1)	26 (81.3)	26 (81.3)	25 (80.6)	24 (92.3)	14 (82.4)	21 (77.8)	16 (94.1)	29 (93.5)
Klebisiella pneumoniae spp.											
Yes	5 (13.2)	5 (13.5)	4 (11.1)	5 (15.6)	5 (15.6)	5 (16.1)	3 (11.5)	1 (5.9)	3 (11.1)	3 (17.6)	4 (12.9)
No	33 (86.8)	32 (86.5)	32 (88.9)	27 (84.4)	27 (84.4)	26 (83.9)	23 (88.5)	16 (94.1)	24 (88.9)	14 (82.4)	27 (87.1)
Acinetobacter baumanni complex											
Yes	3 (7.9)	3 (8.1)	2 (5.6)	3 (9.4)	2 (6.3)	1 (3.2)	2 (7.7)	2 (11.8)	3 (11.1)	3 (17.6)	2 (6.5)
No	35 (92.1)	34 (91.9)	34 (94.4)	29 (90.6)	30 (93.8)	30 (96.8)	24 (92.3)	15 (88.2)	24 (88.9)	14 (82.4)	29 (93.5)
Pantosa spp.											
Yes	1 (2.6)	1 (2.7)	0 (0.0)	1 (3.1)	0 (0.0)	0 (0.0)	1 (3.8)	2 (11.8)	1 (3.7)	2 (11.8)	2 (6.5)
No	37 (97.4)	36 (97.3)	36 (100.0)	31 (96.9)	32 (100.0)	31 (100.0)	25 (96.2)	15 (88.2)	26 (96.3)	15 (88.2)	29 (93.5)
Enterobacter aerogenes											
Yes	3 (7.9)	3 (8.1)	2 (5.6)	2 (6.3)	2 (6.3)	2 (6.5)	2 (7.7)	2 (11.8)	2 (7.4)	1 (5.9)	2 (6.5)
No	35 (92.1)	34 (91.9)	34 (94.4)	30 (93.8)	30 (93.8)	29 (93.5)	24 (92.3)	15 (88.2)	25 (92.6)	16 (94.1)	29 (93.5)
Aeromonas salmonicidas											
Yes	2 (5.3)	2 (5.4)	1 (2.8)	2 (6.3)	1 (3.1)	1 (3.2)	1 (3.8)	2 (11.8)	1 (3.7)	1 (5.9)	0 (0.0)
No	36 (94.7)	35 (94.6)	35 (97.2)	30 (93.8)	31 (96.9)	30 (96.8)	25 (96.2)	15 (88.2)	26 (96.3)	16 (94.1)	31 (100.0)
Klebsiella oxytaca											
Yes	1 (2.6)	1 (2.7)	0 (0.0)	1 (3.1)	2 (6.3)	1 (3.2)	1 (3.8)	1 (5.9)	2 (7.4)	1 (5.9)	1 (3.2)
No	37 (97.4)	36 (97.3)	36 (100.0)	31 (96.9)	30 (93.8)	30 (96.8)	25 (96.2)	16 (94.1)	25 (92.6)	16 (94.1)	30 (96.8)

Legend. AMP. Ampicilin, AMC. Amoxacilin, SXT. Trimethoprim plus sulphamethaxazole, PB. Polimicin B, CFL. Cephalothin, NA. Nalidixic acid, KZ. Cefazolin, ERT. Ertapenem, CIP. Ciprofloxacin, NOR. Norfloxacin, FEP. Cefepime, MH. Minociline. Legend. n. Absolute number. %. Percentage.

4. Discussion

Here, our findings highlight a significant prevalence of UTIs in Luanda, Angola, with a notable dominance of Escherichia coli, aligning with global trends where E. coli remains the primary UTI pathogen. However, the high resistance to ampicillin observed in this cohort is concerning, reflecting a growing global issue of antibiotic resistance. The reliance on ampicillin, despite its reduced effectiveness, points to the need for enhanced antibiotic stewardship programs in Angola. About this, when critically analyzed in the context of global research and trends in UTI management and antibiotic resistance, several key considerations emerge.

Firstly, the study's observation of a high prevalence of *Escherichia coli* in UTIs aligns with global patterns. *E. coli* is widely recognized as the primary pathogen in UTIs across different regions, including developed countries like the United States [10]. This commonality underscores the global nature of the challenge posed by *E. coli* in UTI management. However, the notable high resistance to ampicillin observed in the study raises significant concerns. This finding is reflective of the increasing antibiotic resistance worldwide, a phenomenon that complicates the treatment choices for UTIs and necessitates a careful reevaluation of empirical treatment protocols [11, 17, 18].

The issue of antibiotic resistance is particularly pressing, considering that UTIs account for a substantial portion of antibiotics prescribed in primary care settings, thereby contributing to the global rise in resistance. The study's findings on antibiotic sensitivity, specifically the high resistance to ampicillin and sensitivity to imipenem and ertapenem, should prompt a review of current prescribing practices in Angola. It's essential to consider the recommendations of recent research, which advocates for the use of antibiotics like nitrofurantoin, fosfomycin, and pivmecillinam. These antibiotics have shown a lower propensity to select for resistance, making them preferable choices in the context of rising antibiotic resistance globally [11,17,18].

This topic has extensive discussion about the impact of antibiotic resistance in the treatment of UTI. Cooper and colleagues [12] explored factors influencing the diagnosis and management of UTIs in primary care. It was identified gaps in knowledge and skills among healthcare providers, particularly regarding when to send urine cultures, second line and non-antibiotic management, and the need for more effective patient education and communication strategies. Additionally, Buttler et al. [13] found that infections resistant to antibiotics lead to longer symptomatic periods for patients and increased workload for healthcare providers. This underscores the clinical and operational challenges posed by antibiotic resistant UTIs in primary care settings [13]. These studies collectively highlight the importance of improving antimicrobial use in UTIs, considering the growing issue of antibiotic resistance. We suggest that healthcare providers in primary care need better tools and guidance for diagnosing and managing UTIs, including when and how to use antibiotics effectively. This is particularly relevant in the context of our findings, which points to the need for a review of current prescribing practices and the adoption of antibiotics with a lower propensity for resistance in Angolan [17,18].

Comparative analysis of UTIs and antibiotic resistance patterns across different regions reveals significant variations, underlining the importance of context-specific strategies for managing these infections. For instance, a study on antimicrobial resistance in primary care in the UK highlighted the challenges of accurately estimating antibiotic resistance due to biases in laboratory data and the need for more sustainable surveillance methods [14]. This suggests that resistance patterns and the associated challenges in primary care settings can vary significantly between regions, influenced by factors such as local healthcare practices and patient demographics.

In contrast, research from the United States on antibiotic-resistant E. coli UTIs in primary care settings found that these infections led to longer symptom durations and increased workload for healthcare providers [13]. This underscores the clinical burden of antibiotic resistance in primary care, a concern that is likely shared globally but may manifest differently based on local antibiotic prescribing practices and public health

policies. Furthermore, a study focusing on the diagnosis and management of UTIs in primary care in the UK emphasized the knowledge and skill gaps among healthcare providers, particularly regarding the appropriate use of urine cultures and non-antibiotic management strategies. recently published studies showed that in Angola the rate of resistance to antimicrobials is very high, especially to beta lactams [17,18].

This highlights the importance of tailored educational and guidance tools for healthcare providers in different regions to improve UTI management and antibiotic stewardship. Thus, comparing these findings with our data from Angola, it becomes evident that while the core challenges of UTI management and antibiotic resistance are globally consistent, regional variations in healthcare infrastructure, prescribing practices, and public health policies significantly influence the manifestation and management of these challenges. Thus, a comparative analysis across regions not only enriches our understanding of these issues but also underscores the need for region-specific strategies to effectively combat UTIs and antibiotic resistance.

The limitations and contextual factors of a study on UTIs in Angola, play a crucial role in interpreting its findings. Firstly, the geographic and hospital-specific focus of the study can significantly influence its applicability and generalizability. For instance, a study conducted in a single hospital, or a specific region may not accurately reflect the broader national or regional trends in UTI prevalence and antibiotic resistance [14]. This limitation is also highlighted in this which underscores the need for broader surveillance methods to obtain more accurate and generalizable estimates of antimicrobial resistance [14, 17].

Furthermore, socioeconomic factors such as access to healthcare, sanitation, and water quality greatly impact the prevalence and management of UTIs. In regions where access to healthcare is limited, or sanitation and water quality are poor, such in Angolan, the patterns of UTI occurrence and the development of antibiotic resistance might differ significantly from those observed in more developed settings. This is evident in studies like the one on antibiotic-resistant infections in primary care, which found that these infections lead to longer symptom durations and increased workload, particularly in settings with limited healthcare resources. About this, a study conducted across two large health systems in California highlighted how sociodemographic factors such as low socioeconomic status (SES), which may lead to increased residential crowding and inappropriate antibiotic prescribing, are associated with an increased risk of multidrug-resistant (MDR) UTIs [15]. This study found that factors like Medicaid use, the need for an interpreter, and community deprivation were all associated with a higher risk of MDR UTIs, indicating that socioeconomic disparities play a significant role in the epidemiology of UTIs [15, 17].

Additionally, a comprehensive analysis of the relationship between socioeconomic factors and antibiotic resistance in China revealed that factors like gross domestic product (GDP) per capita, out-of-pocket health expenditure, and physician density are linked with varying levels of antibiotic resistance [16]. The study found that higher GDP per capita and higher out-of-pocket health expenditures were associated with higher levels of certain antibiotic-resistant infections, while higher physician density was linked with a lower level of some resistances but a higher level of others [16]. These findings illustrate that socioeconomic factors can influence the prevalence and pattern of antibiotic resistance in different regions. These studies underscore the complexity of UTI management and antibiotic resistance, highlighting the need for a multifaceted approach that considers socioeconomic and demographic factors. This context is particularly relevant when considering UTI management strategies in countries like Angola, where socioeconomic conditions, access to healthcare, and environmental factors might significantly impact the prevalence of UTIs and the effectiveness of treatment strategies.

Finally, these factors emphasize the importance of considering the local context when analyzing study results. Understanding the nuances of the local healthcare system, socioeconomic status, and environmental conditions is vital for accurately interpreting

the findings and applying them in a way that is relevant to the specific region. In our study, while the findings provide valuable insights into UTIs in Angola, they must be contextualized within the country's unique healthcare landscape and socioeconomic conditions to inform effective UTI management and treatment strategies [17,18].

5. Conclusion

In conclusion, this study highlights a substantial prevalence of bacterial growth in urine samples in Luanda, Angola, with a notable resistance to commonly used antibiotics like ampicillin. The dominance of Escherichia coli as a pathogen and its antimicrobial resistance patterns emphasizes the urgent need for targeted antibiotic stewardship programs. These findings underscore the importance of understanding local microbial ecologies to inform clinical practices and policymaking, particularly in regions where antibiotic resistance poses a growing challenge to public health. This research contributes valuable insights to the Angolan and global discourse on antimicrobial resistance and sets the stage for future studies in similar settings.

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