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Antibiotic Resistance of Enterobacteriaceae strains isolated from Urine at the Mother and Child University Hospital in N'Djamena, Chad

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A B S T R A C T

Infections caused by multidrug-resistant bacteria represent a major challenge to healthcare systems worldwide, particularly in the management of urinary tract infections (UTIs), which are among the most common bacterial infections in both community and hospital settings. This study aimed to investigate the antimicrobial resistance profile of Enterobacteriaceae isolated from urine samples collected at the Mother and Child University Hospital Center (CHU-ME), N'Djamena, Chad. A prospective descriptive study was conducted from June 2024 to February 2026, involving 7,051 urine samples. Bacterial isolation and identification were performed using conventional microbiological methods, the API 20E system, and antimicrobial susceptibility testing according to CA-SFM/EUCAST 2024 guidelines. Among the samples analyzed, 171 (2.4%) yielded positive cultures. Female patients accounted for 60% of cases, and the most affected age group was 21–40 years. High resistance rates were observed to ampicillin (70%), cefotaxime (48.2%), ceftriaxone (43.3%), and ciprofloxacin (44.2%). Resistance to carbapenems was detected in 6.4% of isolates, while multidrug-resistant and ESBL-producing strains were also identified. The findings highlight the emergence of antimicrobial resistance among uropathogens and emphasize the need for continuous surveillance and effective antibiotic stewardship programs.

Introduction

Antimicrobial resistance (AMR) is a major public health concern that threatens both human and animal health worldwide. It compromises the effectiveness of antibiotic therapies, leading to prolonged infections, severe complications, increased healthcare costs, and higher mortality rates. Infections caused by multidrug-resistant (MDR) bacteria challenge both hospital and community healthcare practices, making patient management increasingly difficult (1).

Urinary tract infections (UTIs) are among the most common bacterial infections encountered in clinical practice, both in community and hospital settings (2). They affect individuals of all age groups, with a higher prevalence among women due to anatomical and physiological factors (3). Members of the family Enterobacteriaceae, particularly *Escherichia coli*, *Klebsiella pneumoniae*, *Proteus mirabilis*, and *Enterobacter* spp., constitute the principal etiological agents of UTIs (4).

The emergence and dissemination of extended-spectrum β-lactamase (ESBL)-producing Enterobacteriaceae represent a major public health threat, particularly in sub-Saharan Africa, where diagnostic and therapeutic resources remain limited (5). ESBLs confer resistance to penicillins, first-, second-, and third-generation cephalosporins, and frequently to monobactams, thereby considerably restricting therapeutic options (6). Furthermore, these strains commonly exhibit co-resistance to fluoroquinolones and aminoglycosides, leading to multidrug-resistant phenotypes (7).

In Chad, data regarding the prevalence of UTIs and the antimicrobial resistance profiles of Enterobacteriaceae remain limited. A previous study conducted in N'Djamena in 2019 reported a high prevalence of ESBL-producing strains in Chadian hospitals, highlighting the urgent need for continuous surveillance (8). However, few recent studies have specifically documented the epidemiological situation of UTIs in maternal and child healthcare facilities.

The Mother and Child University Hospital Center (CHU-ME) in N'Djamena serves as a referral institution for the management of pregnant women, parturients, and children. Knowledge of the bacteriological characteristics and antimicrobial resistance profiles within this vulnerable population is essential for guiding empirical therapy, optimizing patient management, and preventing infectious complications.

Therefore, the present study aimed to characterize the antimicrobial resistance profiles of Enterobacteriaceae isolated from urine samples collected at the Mother and Child University Hospital Center in N'Djamena, Chad, in order to contribute to improved management of urinary tract infections and strengthen efforts to combat antimicrobial resistance in Chad..

Materials and Methods

Study Design and Study Period

This was a prospective and descriptive study conducted over a period of twenty-one (21) months, from June 2024 to February 2026.

Study Setting

The study was carried out in the laboratory of the Mother and Child University Hospital Center (CHU-ME) in N'Djamena, Chad. This tertiary referral hospital specializes in the management of maternal and pediatric diseases and serves as a major healthcare center for women and children.

Study Population

The study population comprised all outpatients and hospitalized patients attending the CHU-ME for whom a cytobacteriological examination of urine (CBEU) was prescribed by a physician during the study period. The patients originated from various hospital departments, including outpatient clinics, pediatrics, gynecological emergency services, maternity wards, and other specialized units.

Sampling

All urine specimens received by the laboratory during the study period were included in the study, thereby providing a representative overview of the epidemiological situation of urinary tract infections at the CHU-ME.

Data Collection

Sociodemographic data (age, sex, and hospital department) and clinical information were collected from

laboratory registers and urine examination request forms. Bacteriological findings and antimicrobial susceptibility results were recorded using standardized data collection forms.

Specimen Collection and Transportation

Urine specimens were collected according to standard laboratory procedures. For midstream urine samples, patients were instructed regarding appropriate hygienic procedures before specimen collection, including genital cleansing and discarding the initial urine stream.

Urine samples were collected in sterile, single-use containers and transported promptly to the laboratory within a maximum period of two hours after collection. In cases of delayed processing, specimens were stored at 4°C until analysis.

Bacteriological Analysis

Macroscopic and Microscopic Examination

The macroscopic characteristics of urine samples, including color, clarity, and the presence of deposits, were recorded. Cytological examination was performed using a Malassez counting chamber, and direct microscopic examination after Gram staining was carried out to determine leukocyte and erythrocyte counts and to detect the presence of bacteria.

Urine Culture

Urine samples were systematically cultured on Cystine Lactose Electrolyte Deficient (CLED) agar using a calibrated 10-µL inoculating loop to enable quantitative bacterial assessment. The inoculated plates were incubated aerobically at 37°C for 18–24 hours.
A culture was considered positive when significant bacteriuria of $\geq 10^3$ colony-forming units per milliliter (CFU/mL) was associated with leukocyturia ≥10 leukocytes/mm³.

Bacterial identification

The identification of Enterobacteriaceae isolates was performed through a stepwise approach:

Morphological Examination

Colony morphology, including colony size, shape, color, and hemolytic characteristics, was examined. Gram staining was subsequently performed to determine bacterial morphology and to confirm the presence of Gram-negative bacilli.

Biochemical Identification

Biochemical identification of Enterobacteriaceae was performed using the API 20E identification system (bioMérieux, France). This standardized system comprises 20 miniaturized biochemical tests that enable the identification of most Enterobacteriaceae species and other non-fastidious Gram-negative bacilli. Results were interpreted after 18–24 hours of incubation at 37°C using the API analytical profile index and the corresponding interpretation software.

Antimicrobial Susceptibility Testing

Antimicrobial susceptibility testing was performed using the agar disk diffusion method (Kirby–Bauer technique) according to the recommendations of the Antibiogram Committee of the French Society for Microbiology (CA-SFM) and the European Committee on Antimicrobial Susceptibility Testing (EUCAST), version 2024 (version 1.0).

Preparation of the Inoculum

A bacterial suspension was prepared from a pure culture aged 18–24 hours using sterile saline solution (0.9% NaCl). The suspension turbidity was adjusted to 0.5 McFarland standard, corresponding to approximately 1.5×10^8 colony-forming units per milliliter (CFU/mL).

Inoculation and Application of Antibiotic Disks

The standardized bacterial suspension was evenly inoculated over the entire surface of Mueller–Hinton agar using a sterile cotton swab. After allowing the surface to dry for no longer than 15 minutes, antibiotic disks were manually placed on the agar surface while maintaining a minimum center-to-center distance of 24 mm between adjacent disks.

Antibiotics Tested

Seventeen antibiotics belonging to four different antimicrobial classes were tested according to the CA-SFM/EUCAST 2024 recommendations.

Incubation and Interpretation

The inoculated plates were incubated aerobically at 37°C for 18–24 hours. The diameters of inhibition zones were measured using a caliper or an automated reading system. Isolates were categorized as susceptible (S) or resistant (R) according to the clinical breakpoints established by the CA-SFM/EUCAST 2024 guidelines.

Detection of Extended-Spectrum β-Lactamase (ESBL) Production

The production of extended-spectrum β-lactamases (ESBLs) was investigated using the double-disk synergy test. An amoxicillin–clavulanic acid disk was placed at the center of the agar plate and surrounded by third-generation cephalosporin disks (cefotaxime, ceftriaxone, and ceftazidime) as well as aztreonam disks positioned at a distance of 20–30 mm.

The presence of a characteristic enhancement of the inhibition zone, commonly referred to as the "champagne cork" or "keyhole" effect, between clavulanic acid and one or more cephalosporins was considered indicative of ESBL production.

Detection of Multidrug Resistance

An isolate was considered multidrug-resistant (MDR) when it exhibited acquired resistance to at least three different classes of antimicrobial agents among those tested.

Ethical Considerations

The study was conducted in accordance with established ethical principles. Patient information was anonymized, and the confidentiality of all collected data was strictly maintained. Authorization to conduct the study was obtained from the administration of the Mother and Child University Hospital Center (CHU-ME) and from the institutional ethics committee.

Results and Discussion

Prevalence of Urinary Tract Infections

Among the 7,051 urine samples subjected to cytobacteriological examination, 171 yielded positive cultures for at least one Enterobacteriaceae isolate, corresponding to an overall prevalence of 2.4%. The remaining 6,880 samples (97.6%) were either sterile, yielded non-Enterobacteriaceae organisms, showed insignificant bacteriuria ($<10^5$ CFU/mL), or were considered contaminated.

Sociodemographic Characteristics

The distribution of positive cases according to sex, hospital department, and age group is presented in Table II.

Sex distribution revealed a predominance of female patients, accounting for 59.1% (101 cases), whereas males represented 40.9% (70 cases), corresponding to a male-to-female ratio of 1:1.4.

The mean age of the patients was 36.5 years, with ages ranging from 1 to 72 years. The 21–40-year age group was the most represented, accounting for 33.9% of cases, followed by the 11–20-year and 6–10-year age groups, representing 21.1% and 16.4%, respectively.

Most positive samples originated from the outpatient department, accounting for 44.8% (81 cases), followed by the pediatric department with 23.6% (41 cases) and the gynecological emergency department with 12.8% (22 cases).

The distribution of positive samples according to hospital department and sex showed that 40.6% of positive isolates from the outpatient department were obtained from female patients compared with 32.7% from male patients. No positive samples from male patients were reported in the gynecological emergency or obstetric departments, while no female patients were represented in the intensive care unit. The distribution of patients according to department and sex is illustrated in Figure 1.

Distribution of Bacterial Species

Among the 171 positive cultures, several species of Enterobacteriaceae were identified. *Escherichia coli* was the predominant species, accounting for the majority of isolates, followed by *Klebsiella pneumoniae*, *Proteus mirabilis*, *Enterobacter* spp., and other less frequently isolated Enterobacteriaceae.

E. coli and *K. pneumoniae* together accounted for more than 80% of all isolates, consistent with the classical epidemiology of urinary tract infections.

Regarding the distribution of isolates according to hospital department, most isolates originated from the outpatient department (43.3%; n = 74), followed by the pediatric department (25.1%; n = 43) and the gynecological emergency department (13.5%; n = 23). The distribution of bacterial isolates according to hospital department is presented in Table II.

Antimicrobial Resistance Profiles

Analysis of resistance patterns against the 17 antibiotics tested revealed substantial variability according to bacterial species and antimicrobial classes.

Regarding phenotypic resistance profiles, extended-spectrum β-lactamase (ESBL)-producing isolates accounted for 47.3%, followed by wild-type phenotypes (17%), cephalosporinase-producing isolates (14%), carbapenem-resistant phenotypes (11.1%), and penicillinase-producing isolates (10%).

Concerning β-lactam antibiotics, a high resistance rate was observed for ampicillin (70%). Resistance to third-generation cephalosporins was also frequent, with resistance rates of 48.23% for cefotaxime and 43.3% for ceftriaxone, suggesting the presence of ESBL-producing strains.

Two isolates exhibited resistance to all tested β-lactam agents, including carbapenems, which is particularly concerning and suggests the possible production of carbapenemases.

Regarding fluoroquinolones, a high resistance rate to ciprofloxacin (44.2%) was observed. This level of resistance substantially limits the empirical use of this antimicrobial class for the treatment of urinary tract infections.

Among aminoglycosides, 2.5% of isolates exhibited resistance to all tested aminoglycosides (gentamicin and amikacin), reflecting severe multidrug resistance.

With respect to carbapenems, 6.4% of isolates demonstrated resistance to both imipenem and ertapenem. Such resistance represents an alarming public health concern, as carbapenems are considered last-resort antibiotics for the treatment of severe infections caused by multidrug-resistant Gram-negative bacteria.

One isolate exhibited resistance to nearly all commonly used antibiotics, remaining susceptible only to amikacin and tetracycline. This extensively drug-resistant isolate constitutes a major therapeutic challenge.

Conversely, one isolate of *Proteus mirabilis* was susceptible to all antibiotics tested, indicating that fully susceptible strains continue to circulate within the hospital environment.

Prevalence of Urinary Tract Infections

The present study revealed a prevalence of 2.4% positive urine cultures among the 7,051 samples analyzed at the CHU-ME in N'Djamena. This positivity rate is relatively low compared with several recent African studies. Although the prevalence of urinary tract infections varies considerably according to geographical settings, study populations, and diagnostic criteria, many studies have reported higher positivity rates.

A study conducted in Garoua, Cameroon, analyzed 144 Enterobacteriaceae isolates associated with UTIs without reporting the overall culture positivity rate (1). In Ethiopia, Abayneh et al. reported variable positivity rates across healthcare institutions, reaching up to 21.6% (3). In Mozambique, Estaleva et al. documented a high prevalence (24.1%) of multidrug-resistant isolates among clinical specimens (4).

The low prevalence observed in our study may be explained by several factors. First, because the CHU-ME is a specialized maternal and child healthcare center, a substantial proportion of urine cultures may have been requested as routine screening examinations among asymptomatic pregnant women rather than for clinically suspected symptomatic UTIs. Second, specimen quality and transport conditions may influence culture results, with delayed transport or inadequate storage potentially leading to false-negative cultures. Third, prior antibiotic use before urine sampling, a common practice in low-resource settings where self-medication is widespread, may reduce culture positivity rates (5).

Sociodemographic Characteristics

Our study demonstrated a female predominance, with a male-to-female ratio of 1:1.4 (59.1% females versus 40.9% males), which is consistent with the well-established epidemiology of urinary tract infections. Female predominance has been widely documented and may be explained by anatomical factors, such as the

shorter female urethra, as well as physiological factors including pregnancy and menopause (6). Additionally, the specialized maternal and pediatric nature of the study setting contributes to this predominance.

The 21–40-year age group represented the largest proportion of patients (33.9%), with a mean age of 36.5 years. This distribution reflects the patient population attending the CHU-ME, which primarily serves women of reproductive age and their children.

A study conducted in Rwanda by Kayinamura et al. similarly highlighted the influence of demographic factors on the distribution of urinary tract infections (7).

Distribution of Bacterial Species

Escherichia coli and *Klebsiella pneumoniae* were identified as the predominant Enterobacteriaceae species, accounting for more than 80% of all isolates. This distribution is consistent with both global and African epidemiological data regarding the etiological agents of urinary tract infections. Recent African studies confirm the predominance of *E. coli* in UTIs. In Garoua, Cameroon, *E. coli* accounted for 72.9% of the 144 isolates, followed by *K. pneumoniae* (20.1%), *Enterobacter* spp. (3.5%), and other less frequent species (1). In Burundi, Armstrong et al. reported that among 247 Enterobacterales isolates, *E. coli* (72.4%) and *K. pneumoniae* (14.5%) predominated (2). Similarly, Abayneh et al. in Ethiopia documented the predominance of *E. coli* (85.1%) in community-acquired UTIs (3).

In western Cameroon, Bayaba et al. also identified *E. coli* and *K. pneumoniae* as the principal uropathogens (9).

The predominance of these microorganisms may be explained by inadequate hygiene practices and the anatomical proximity between the urethra and the anus, particularly in women, which facilitates ascending bacterial contamination of the urinary tract.

Table.1 List of antibiotics used for the characterization of antimicrobial resistance profiles of Enterobacteriaceae isolates

Antibiotics	**Susceptibility Diameter (mm)**		**Antibiotics**	**Susceptibility Diameter (mm)**	
	S≥	R <		S≥	R <
Piperacilline 30µg	20	20	Cefoxitine 30µg	19	19
Acide-clavulanique-amoxic 30µg	19	19	Ceftriazone 30µg	25	22
Ticarcilline 75µg	23	20	Ertapéneme 10µg	25	25
Tetracycline 30µg	19	19	Imipenème 10µg	22	17
Aztréonam 30µg	26	21	Gentamicine 10µg	17	14
Céfotaxime 5µg	20	17	Amikacine 30µg	18	15
Ceftazidime 10µg	22	19	Ciprofloxacine 5µg	25	22
Céfépime 30µg	27	24	Ampicilline 10µg	14	14
Imipenème 10µg (*Proteus sp)*	50	17			

Table.2 Distribution of Isolated Strains According to Sex, Hospital Department, and Age Group

Variable	Category	Number (n)	Percentage (%)
Sex	Female	101	59.1
	Male	70	40.9
	Total	**171**	**100**
Hospital Department	Outpatient Department	81	44.8
	Surgery	3	1.5
	Neonatology	5	2.5
	Obstetrics	17	8.9
	Pediatrics	41	23.6
	Intensive Care Unit	1	0.5
	Gynecological Emergency Department	22	12.8
	Pediatric Emergency Department	11	5.4
	Total	**171**	**100**
Age Group (years)	0–5	44	25.7
	6–10	28	16.4
	11–20	36	21.1
	21–40	58	33.9
	>41	5	2.9
	Total	**171**	**100**

Table.3 Distribution of Bacterial Isolates According to Hospital Department

Bacterial Isolates	Outpatient Department (OPD)	Surgery	Neonatology	Obstetrics	Pediatrics	Intensive Care Unit (ICU)	Gynecological Emergency Department	Pediatric Emergency Department	Total
Citrobacter freundi	0	0	0	0	0	0	1	0	1
Citrobacter koseri	2	0	0	0	0	0	0	0	2
Enterobacter aerogenes	0	0	0	0	1	0	0	0	1
Enterobacter cloacae	3	1	0	0	1	0	0	0	5
Escherichia coli	52	1	2	9	33	1	15	7	120
Klebsiella oxytoca	5	1	0	2	2	0	0	0	10
Klebsiella pneumoniae	9	0	1	3	6	0	7	1	27
Proteus mirabulis	1	0	0	0	0	0	0	0	1
Serratia marcescens	2	0	0	2	0	0	0	0	4
Total	74	3	3	16	43	1	23	8	171
Pourcentage	43,3	1,8	1,8	9,4	25,1	0,6	13,5	4,7	100,0

Legend: OPD: Outpatient Department; Obs: Obstetrics; Neonat: Neonatology; ICU: Intensive Care Unit; Ped: Pediatrics; Gyn: Gynecology.

Figure.1 Distribution of patients according to hospital department and sex

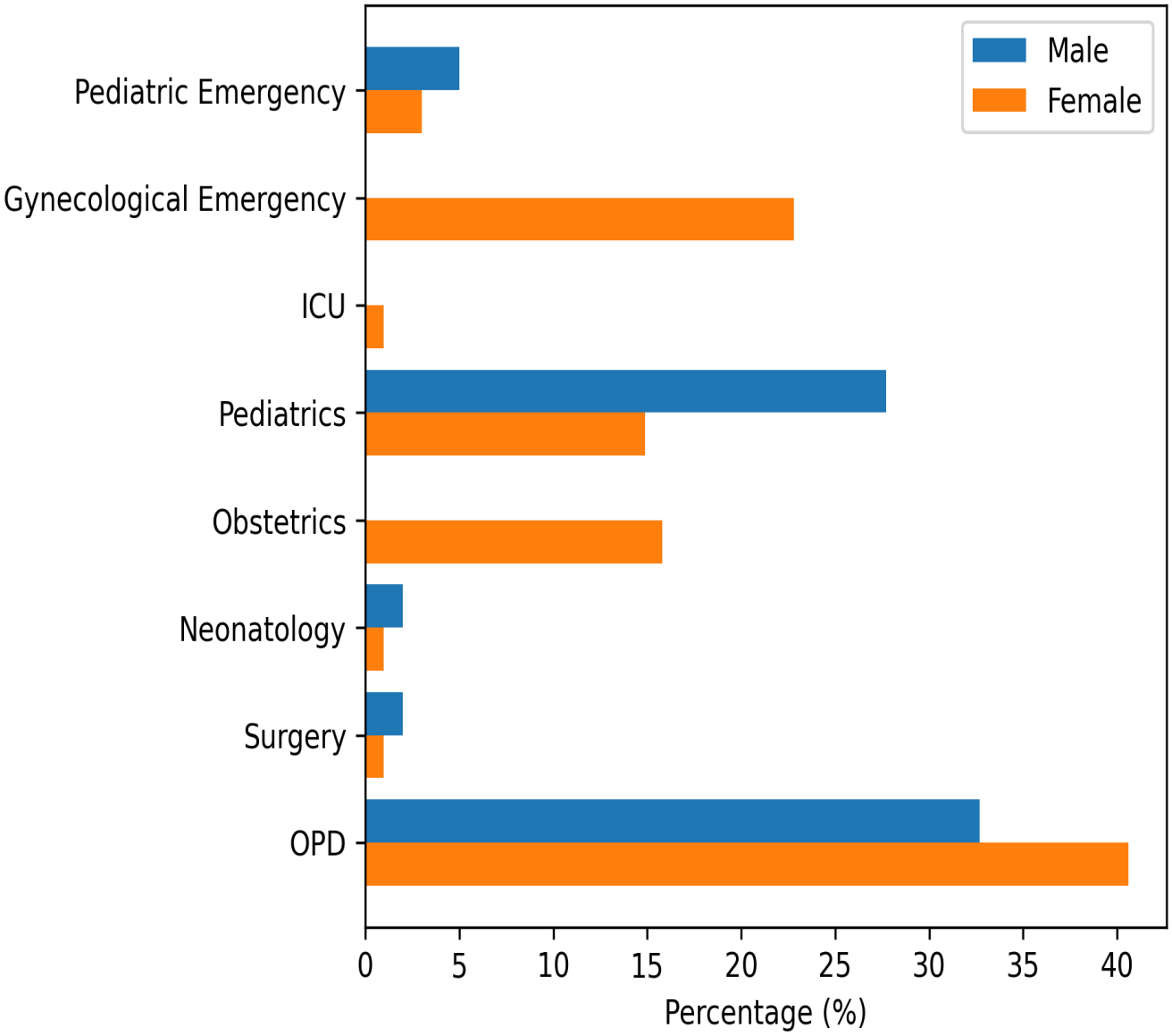

Figure.2 The Percentage of isolated strains

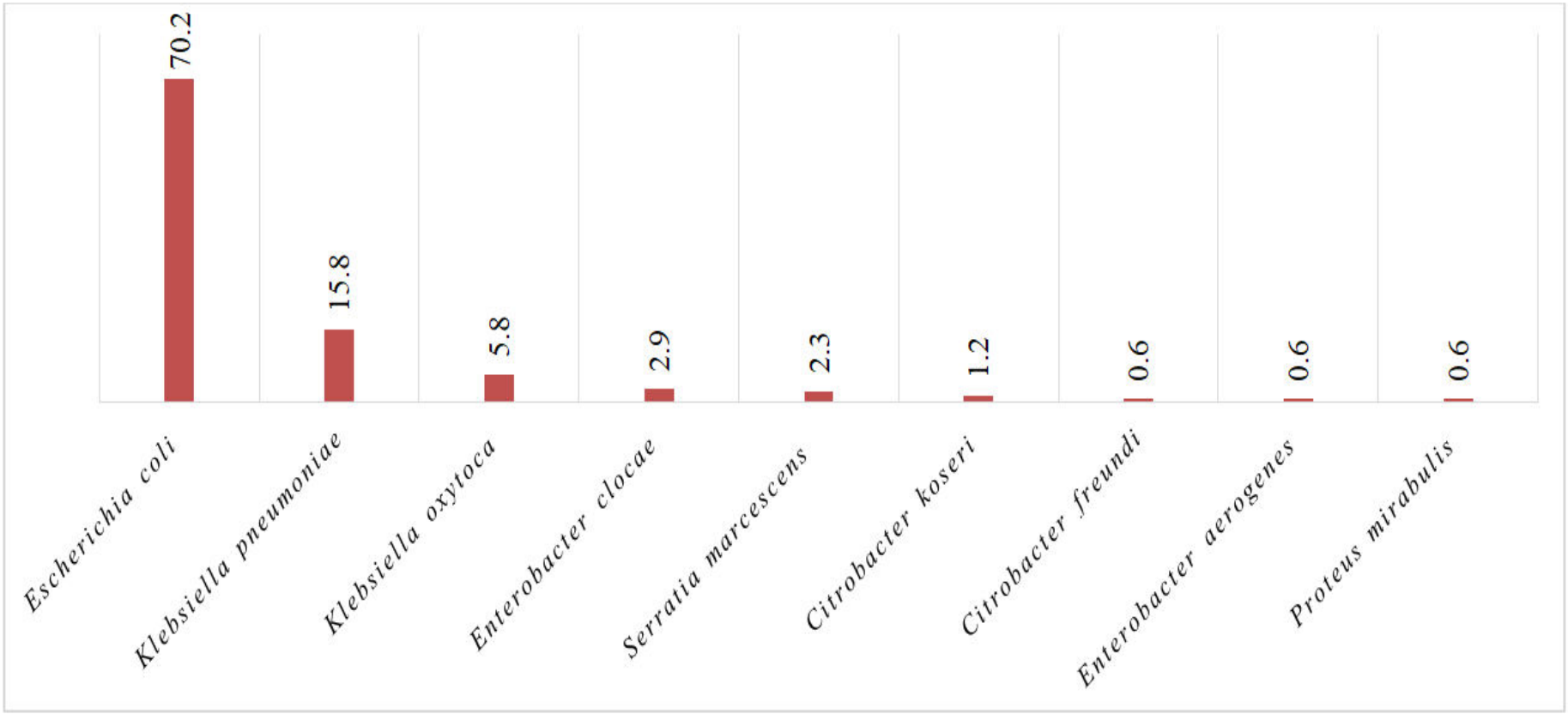

Table.4 Antimicrobial Susceptibility Profile of Enterobacteriaceae Isolates to Various Antibiotics

Strains	Beta-lactam												Aminoglycoside		Fluoroquinolone	Tetracycline
	AMP	AMC/AUG	TC	PRL	FOX	CTX	CRO	CAZ	FEP	ATM	ERT	IMI	AK	CN	CIP	TE
Citrobacter freundii	100 (1/1)	0 (0/1)	100 (1/1)	100 (1/1)	0 (0/1)	100 (1/1)	0 (0/1)	0 (0/1)	100 (1/1)	0 (0/1)	0 (0/1)	0 (0/1)	0 (0/1)	0 (0/1)	0 (0/1)	0 (0/1)
Citrobacter koseri	50 (1/2)	0 (0/2)	100 (2/2)	50 (1/2)	0 (0/2)	0(0/2)	0 (0/2)	0 (0/2)	0 (0/2)	0 (0/2)	0 (0/2)	0 (0/2)	0 (0/2)	0 (0/2)	0 (0/2)	0 (0/2)
Enterobacter aerogenes	100 (1/1)	100 (1/1)	0 (0/1)	0 (0/1)	100 (1/1)	0 (0/1)	0 (0/1)	0 (0/1)	0 (0/1)	0 (0/1)	0 (0/1)	0 (0/1)	0 (0/1)	0 (0/1)	0 (0/1)	0 (0/1)
Enterobacter clocae	40 (2/5)	100 (5/5)	100 (5/5)	60 (3/5)	100 (5/5)	60 (3/5)	60 (3/5)	40 (2/5)	40 (2/5)	60 (3/5)	40 (2/5)	40 (2/5)	0 (0/5)	20 (1/5)	60 (3/5)	40 (2/5)
Escherichia coli	64,2 (77/120)	25 (30/120)	64,1 (77/120)	20 (24/120)	18,4 (22/120)	48,3 (58/120)	43,3 (52/120)	21,66 (26/120)	29,1 (35/120)	30 (36/120)	4,1 (5/120)	5,8 (7/120)	3,3 (4/120)	8,3 (10/120)	44,1 (53/120)	13,3 (16/120)
Klebsiella oxytoca	70 (7/10)	40 (4/10)	90 (9/10)	40 (4/10)	20 (2/10)	50 (5/10)	40 (4/10)	0 (0/10)	40 (4/10)	20 (2/5)	10 (1/5)	0 (0/5)	0 (0/5)	40 (4/5)	40 (4/5)	20 (1/5)
Klebsiella pneumoniae	74,1 (20/27)	33,4 (9/27)	85,2 (23/27)	26 (7/27)	40,7 (11/27)	44,4 (12/27)	48,14 (13/27)	7,4 (2/27)	26 (7/27)	18,5 (5/27)	3,7 (1/27)	3,7 (1/27)	7,4 (2/27)	11,1 (3/27)	37 (10/27)	22,2 (6/27)
Proteus mirabulis	0 (0/0)	0 (0/0)	0 (0/0)	0 (0/0)	0 (0/1)	0 (0/1)	0 (0/1)	0 (0/1)	0 (0/1)	0 (0/1)	0 (0/1)	0 (0/1)	0 (0/1)	0 (0/1)	0 (0/1)	0 (0/1)
Serratia marcescens	75 (3/4)	50 (2/4)	100 (4/4°	75 (3/4)	0 (0/4)	25 (1/4)	50 (2/4)	25 (1/4)	50 (2/4)	25 (1/4)	0 (0/4)	0 (0/4)	0 (0/4)	0 (0/4)	75 (3/4)	50 (2/4)
Total	65,5 (112/171)	29,8 (51/171)	70,7 (121/171)	25,1 (43/171)	24 (41/171)	46,7 (80/171)	43,3 (74/171)	18,1 (31/171)	29,82 (51/171)	27,4 (47/171)	5,2 (9/171)	5,8 (10/171)	3,5 (6/171)	10,5 (18/171)	42,7 (73/171)	16,8 (28/171)

In infants, infrequent diaper changes and poor hygiene practices may facilitate the migration of these bacteria from the skin or feces to the urethra.

The presence of *Proteus mirabilis* in our study, with one strain susceptible to all tested antibiotics, is noteworthy. *Proteus* spp. is classically associated with complicated urinary tract infections (UTIs), urinary lithiasis, and nosocomial infections. The persistence of susceptible strains suggests that antibiotic selective pressure has not yet led to widespread resistance across all species, although this situation could change rapidly.

Furthermore, the diversity of isolated species (*Enterobacter* spp., *Citrobacter* spp., *Morganella morganii*, *Providencia* spp.) reflects the complexity of the microbial ecology of UTIs and highlights the importance of accurate species identification to guide appropriate treatment, as these species may exhibit distinct intrinsic resistance profiles.

Antibiotic Resistance Profiles

Our study revealed concerning resistance rates to first-line antibiotics, particularly ampicillin, third-generation cephalosporins (cefotaxime, ceftriaxone), and ciprofloxacin. These findings are consistent with global and African trends showing a progressive increase in antimicrobial resistance.

The high resistance rate to ampicillin (98.31%) observed in our study is widely documented in African literature. In Garoua, Cameroon, Djim-Adjim-Ngana et al. reported an ampicillin resistance rate of 98.31% (1). This high level of resistance renders ampicillin obsolete for empirical treatment of UTIs in sub-Saharan Africa. It is mainly explained by the widespread dissemination of resistance genes encoding beta-lactamases, particularly TEM- and SHV-type enzymes, often carried on conjugative plasmids that facilitate horizontal gene transfer (10).

Resistance to third-generation cephalosporins (cefotaxime, ceftriaxone) is a key marker of extended-spectrum beta-lactamase (ESBL) production. In this study, a high resistance rate (50%) to these antibiotics was observed. However, higher rates (64.41%) than ours were reported by Djim-Adjim-Ngana et al. (1). Lower resistance rates have also been reported by other authors. In Burundi, 28.74% of isolates were phenotypically positive for ESBL production (2). In western Cameroon, Bayaba et al. documented a high prevalence (40%) of ESBL-producing strains (9).

In Ethiopia, several studies have reported very high rates (82.4%) of ESBL production. Abayneh et al. isolated ESBL-producing *E. coli* and *K. pneumoniae* from community-acquired UTIs (3). Gebremedhin et al. investigated ESBL- and carbapenemase-producing strains in community and hospital infections (11). Seman et al. documented the extent of carbapenemase and ESBL production among Enterobacteriaceae isolated from UTI patients in Addis Ababa (12).

In Nigeria, Anorue et al. identified ESBL-producing *E. coli* strains that also carried resistance genes for aminoglycosides and fluoroquinolones (13). In Djibouti, Mohamed et al. reported a high prevalence of multidrug-resistant Enterobacteriaceae in community UTIs (14). In Burkina Faso, Kiemde et al. characterized beta-lactamase genes produced by uropathogenic community-acquired *E. coli* (15).

The high resistance rate (44.2%) to ciprofloxacin observed in our study is particularly concerning, as fluoroquinolones are widely used in UTI treatment. These findings may be explained by the misuse and overuse of these antibiotics, which promotes the emergence and spread of resistant strains.

We identified two strains resistant to all tested aminoglycosides (gentamicin and amikacin). This type of resistance is rare but extremely concerning, as aminoglycoside resistance is often mediated by aminoglycoside-modifying enzymes (AMEs) encoded by plasmid-borne genes. The circulation of such resistant strains in hospital and community settings may facilitate plasmid acquisition and further dissemination of aminoglycoside resistance.

In Conclusion, this study on the characterization of antimicrobial resistance profiles of Enterobacteriaceae isolated from urine samples at CHU-ME in N'Djamena reveals a concerning situation regarding antimicrobial resistance. Although the prevalence of bacterial UTIs was relatively low (2.4%), the resistance patterns observed are alarming, with high resistance to first-line antibiotics (ampicillin, third-generation cephalosporins, fluoroquinolones) and the emergence of multidrug-resistant strains, ESBL-producing strains, and carbapenem-resistant organisms.

Escherichia coli and *Klebsiella pneumoniae* remain the principal etiological agents of UTIs, consistent with global epidemiological data. The observed female predominance and age distribution are in line with the classical epidemiology of UTIs. The identification of strains resistant to all carbapenems and pan-resistant strains represents a major warning signal, indicating that Chad is not spared from the global threat of antimicrobial resistance. These strains pose a significant therapeutic challenge and a public health concern.

The results of this study highlight the urgent need to implement comprehensive and coordinated strategies to combat antimicrobial resistance in Chad, including surveillance, strengthening laboratory capacity, optimization of antibiotic use, infection prevention and control, awareness campaigns, and further research.

Author Contributions

Mahamat Koulbou Abdoulaye: Investigation, formal analysis, writing—original draft. Hassan Mahamat Ali: Validation, methodology, writing—reviewing. Oumar Ouchar Mahamat:—Formal analysis, writing—review and editing. Ali Haroun Hissein: Investigation, writing—reviewing. Fissou Henry Yandai: Resources, investigation writing—reviewing. Naibi Keitoyo Amede: Validation, formal analysis, writing—reviewing. Lodoum Josué: Conceptualization, methodology, data curation, supervision, writing—reviewing the final version of the manuscript. Mouktar Abaya: Investigation, formal analysis, writing—original draft. Djamaladine Mahamat Doungous: Validation, methodology, writing—reviewing. Mahamat Nour Djibrine Abakar:—Formal analysis, writing—review and editing. Abdelsalam Tidjani: Investigation, writing—reviewing. Mahamat Béchir: Resources, investigation writing—reviewing. Ali Mahamat Moussa: Validation, formal analysis, writing—reviewing.

Data Availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethical Approval Not applicable.

Consent to Participate Not applicable.

Consent to Publish Not applicable.

Conflict of Interest The authors declare no competing interests.

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