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Resistance profile of urine isolate enterobacteral strains at Donka University teaching hospital in Conakry, Guinea

Djiba KABA[1,2,3,4]*, Ousmane NIABALY[4#], Issiaga DIALLO[1,2,4#], Ibrahima Sory Nana SYLLA[2#], Castro G. HOUNMENO [3‡], Kadio Jean-Jacques Olivier KADIO[3‡], Aly Badara TOURE[3‡], Boubacar SALL[2], Emile BONGONO[3], Lancei KABA[3], Alpha Ousmane BARRY[2], Maladho DIABY[3], Thomas BALAMOU[2,4], Pascal KOIVOGUI[2,4], Ouo-Ouo Yaramon KOLIE[2,4], Mariama Sadjo DIALLO[1,2,4,5] and Mohamed CISSE[1]

[1]Faculté des Sciences et Techniques de la Santé, Université Gamal Abdel Nasser de Conakry, Guinée.
[2]Service de Laboratoire de Biologie Médicale, Centre Hospitalo-Universitaire de Donka, Conakry, Guinée.
[3]Centre de Recherche et de Formation en Infectiologie de Guinée (CERFIG), Conakry, Guinée.
[4]Laboratoire de Biologie Moléculaire Nestor BANGOURA/Helene LABROUSSE, Hôpital de jour Donka, CHU Donka, Conakry, Guinée.
[5]Centre d'Excellence Africain pour la Prévention et le Contrôle des Maladies Transmissibles, Conakry, Guinée.

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The objective of this study was to describe the resistance profile of enterobacterals isolated from urine samples at the laboratory of Donka National Hospital. Urine samples were collected from both outpatients and hospitalized patients. Cultures were performed using standard techniques, strains were identified using the API 20E kit, and antibiotic susceptibility testing was carried out using the ATB™ UR EU (08) kit. The results were interpreted according to the recommendations of the Antibiogram Committee of the French Society of Microbiology (CASFM v1 2023). Out of a total of 520 urine samples analyzed, 111 were positive for enterobacteral strains. Among them, 75 (67.57%) were of community origin. *Escherichia coli* was the most represented species (n=61, 55%), followed by *Klebsiella pneumoniae* (n=24, 22%). The resistance of *E. coli* strains to third generation cephalosporins (TGC) varied from 5.41% (n=6) to 25.23% (n=28) in the community and from 13 to 38% in the hospital. The profile for carbapenems was categorized as "susceptible to high dosage (SHP)," accounting for 16.22% (n=18). This study provided insight into the resistance profile to antibiotics used in urinary tract infections. The increasing resistance to carbapenems poses a threat to the management of strains producing extended-spectrum beta-lactamases (ESBL). It would be important to strengthen resistance surveillance in this context.

Key words: Enterobacteral, urinary tract infection, resistance, community, hospital, Guinea.

INTRODUCTION

Enterobacterals constitute a group of Gram-negative bacteria divided into seven groups (groups 0 to 6). They constitute most of the commensal flora in the intestine (Jenkins et al., 2017; Machado et al., 2013). They have

natural resistance to certain antibiotics based on their group membership due to the presence of ß-lactamase enzymes capable of hydrolyzing penicillins, carboxypenicillins, and first-generation cephalosporins (FGC) (Carattoli, 2009; Paterson, 2006; Philippon and Arlet, 2006). Secondary resistances can occur and spread within the groups through genetic supports (plasmids, integrons) (Carattoli, 2009; Machado et al., 2013). This phenomenon can lead to a therapeutic deadlock due to the acquisition of multidrug resistance, making enterobacterals redoubtable among the causative agents of urinary tract infections (Carattoli, 2009; Paterson, 2006; Philippon and Arlet, 2006). Among uropathogenic enterobacterals, *Escherichia coli* is the most frequent, followed by *Klebsiella* species (Matalka et al., 2021; Moges et al., 2021).

Multidrug resistance poses a challenge to the selection of antibiotics, impacting all prescribed classes of antibiotics. Various studies conducted in different locations highlight the extent of this phenomenon (Lee et al., 2018; Pasom et al., 2013; Sbiti et al., 2017) and its consequences, both at the individual and public health levels.

Thus, high proportions of multidrug resistance have been reported in various studies conducted in Africa, and these proportions vary from one region to another (Djim-Adjim-Ngana et al., 2023; Moges et al., 2021). The prevalence of multidrug-resistant bacteria can reach up to 85% (Moges et al., 2021). A review on the emergence and spread of resistance in West Africa described a particularly concerning situation regarding the production of extended-spectrum ß-lactamases (ESBLs) among Enterobacterales. The same trend has been observed for carbapenem resistance (Ouedraogo et al., 2017).

Guinea is not spared from the phenomenon of resistance. The prevalence of urinary tract infections accounts for between 16 and 60.2% of healthcare-associated infections, according to studies (Diallo et al., 2022; Keita et al., 2016). *E. coli* and *Klebsiella pneumoniae* are the most isolated pathogens. Resistance in Enterobacteral is characterized by high-level cephalosporinases (56%), extended-spectrum ß-lactamases (20%), and carbapenems (12%). Resistance to quinolones is reported at 36%, and 20% for aminoglycosides (Diallo et al., 2022). However, antibiotic susceptibility data are not always accessible, and treatments are often empirical. This study aimed to describe the resistance profile of Enterobacterales isolated from urine samples at the National Hospital of Donka laboratory.

MATERIALS AND METHODS

Study design, sites and samples collection

This is a cross-sectional study conducted at Laboratoire de Biologie médicale du Centre Hospitalier Universitaire de Donka (CHU Donka) over a period of 15 months (September 2022-December 2023). It is one of the level I hospital structures that reopened its doors after a renovation period. The laboratory service of the CHU consists of 7 technical units (Immunology, Biochemistry, Bacteriology, Parasitology, Haematology, Blood Transfusion, and the emergency laboratory) and a sample collection room. The assays were performed in the bacteriology unit.

Urine samples were collected from both outpatients and hospitalized patients at the University Teaching Hospital of Donka (Emergency Department and other services). Urine samples were collected in sterile containers and transported to the laboratory within 2 h of collection.

Isolation and identification

Upon receiving the samples, the conformity of the container was checked. The samples were macroscopically assessed for color and turbidity upon receipt. Microscopy using a Malassez cell allowed for the evaluation of the presence of leukocytes, red blood cells, crystals, and other elements. Culture media, Uriselect, and CLED (cystine lactose electrolyte deficient) were inoculated and incubated for 24 to 48 h at 37°C in aerobic conditions. Enumeration was performed with a threshold of 10^3 CFU/mL for *E. coli* and 10^4 CFU/mL for other Enterobacteral strains. Identification was conducted using the 23 biochemical tests (O-nitrophenyl-β-D-galactosidase, arginine dihydrolase, lysine and ornithine decarboxylase, citrate utilization, hydrogen sulfide, urease, tryptophan deaminase, indole, Voges–Proskauer, gelatin liquefaction, fermentation of glucose, mannitol, inositol, sorbitol, rhamnose, sucrose, melibiose, amygdalin and arabinose, nitrate reduction, and nitrogen gas production, and catalase production) available on the API 20E gallery (BioMérieux SA, Marcy-l'Étoile, France).

Antibiotics susceptibility test and detection of extended spectrum beta-lactamase producers

The antibiotic susceptibility testing was conducted using ATB™ UR EU (08) (BioMérieux SA, Marcy-l'Étoile, France) following the manufacturer's recommendations (*Lustiner - Galerie ATB™ UR EU [Antibiogramme/Norme NCCLS] Biomérieux®*, n.d). The ATB™ UR EU (08) gallery is a standardized qualitative technique for determining the sensitivity of urinary Enterobacterales to antibiotics in a semi-solid medium under conditions very close to reference dilution techniques in agar or microdilution. It consists of 16 pairs of wells. The first pair, without antibiotics, serves as a positive growth control. The next 15 pairs contain antibiotics at one or two concentrations (c and C). The bacteria to be tested are suspended and then transferred to the culture medium, inoculated into the gallery. After incubation, the growth in the wells is visually assessed. The obtained result categorizes the strain as Susceptible,

*Corresponding author. E-mail: djibakitagbe@yahoo.fr.

#Worked as second author.
‡Contributed equally

Table 1. Characteristics of patients.

Variable	Overall, N = 520[1]	Negative culture, n = 409[1]	Positive culture, n = 111[2]	*p-value*
Age	43 (28, 60)	**42 (27, 58)**	**44 (28, 63)**	**0.3**
Age range (years)				**0.7**
<5	5 (1.0)	5 (1.2)	0 (0)	
5-15	26 (5.0)	22 (5.4)	4 (3.6)	
16-25	76 (15)	61 (15)	15 (14)	
26-45	180 (35)	140 (34)	40 (36)	
46-60	104 (20)	85 (21)	19 (17)	
>60	129 (25)	96 (23)	33 (30)	
Gender				**<0.001**
Feminine	269 (52)	188 (46)	81 (73)	
Masculine	251 (48)	221 (54)	30 (27)	
Origin of strains				**<0.001**
Community	465 (89)	390 (95)	75 (68)	
Hospital	55 (11)	19 (4.6)	36 (32)	

[1]Median (IQR); n (%) [2]Wilcoxon rank sum test; Fisher's exact test; Pearson's Chi-squared test.

Intermediate, or Resistant. Since 2020, the EUCAST committee introduced the concept of "Susceptible at standard dosage" for the Susceptible category and "Susceptible at high dosage" for the Intermediate category. The "Resistant" category remains unchanged.

The most commonly used antibiotics were tested: Beta-lactams (Penicillins: ampicillin, ticarcillin, piperacillin, amoxicillin+clavulanic acid, piperacillin-tazobactam, Cephalosporins: Cephalexin, Cefoxitin, Cefuroxime, Cefixime, Cefotaxime, Ceftazidime, Cefepime, Carbapenems: imipenem, ertapenem, meropenem µg), Aminoglycosides (amikacin, gentamicin, tobramycin), Quinolones (nalidixic acid, ciprofloxacin, ofloxacin, norfloxacin, levofloxacin), Tetracyclines (tigecycline, tetracycline), and other antibiotics (nitrofurantoin, trimethoprim-sulfamethoxazole, fosfomycin). The results obtained were interpreted according to the recommendations of Comité de l'Antibiogramme de la Société Française de Microbiologie (CA-SFM 2023).

Statistical analysis

The data was extracted from the information system of CHU Donka, sent to Excel, and analysed using the R software. Chi-square test and Fisher's exact test were used for comparing proportions or estimating the association between variables when the conditions for use were met. Quantitative variables were compared using the Student's t-test.

Ethical consideration

The protocol was approved by the Research Committee of the University Gamal Abdel Nasser (Conakry, Guinea) and performed following the Declaration of Helsinki.

RESULTS

Table 1 describes the socio-demographic characteristics of the patients. Out of a total of 520 urine samples received and analyzed in the laboratory over a period of 15 months (September 2022 to December 2023), 111 were positive for Enterobacteral after culture on ordinary media. The median age of the patients was 42 (IQR: 28-63). The female gender was predominant with a ratio of 0.4.

Among the isolated Enterobacteral strains, 75 (67.57%) were of community origin, and 36 (32.43%) were of hospital origin (Table 1). The species *E. coli* was the most represented, whether of community origin (n=40) or hospital origin (n=21), followed by the species *K. pneumoniae*, with n=14 (58%) community strains and n=10 (42%) hospital strains.

Among the antibiotics tested on the 111 strains of Enterobacteral (Table 2), resistance to penicillin varied between 15.31% (n=17) and 81.08% (n=90). The resistance by antibiotic was distributed as follows: 72.97% (n=81) were resistant to ampicillin, 81.08% (n=90) were resistant to ticarcillin, 49.55% (n=55) were resistant to piperacillin, 39.64% (n=44) were resistant to amoxicillin/clavulanic acid, and 15.32% (n=17) were resistant to the piperacillin/tazobactam combination. The resistance for *E. coli* strains was (n=44), distributed in the community setting (n=23) and the hospital setting (n=21) (Table 2). For *K. pneumoniae* strains (n=17), seven were in the community setting and ten were in the hospital setting, and for *Klebsiella oxytoca* strains (n=5), all were in the community setting. Resistance to amoxicillin/ clavulanic acid varied between 4.5 and 52%, with a predominance in *E. coli* strains (52%, n=23), which were community-acquired. Resistance to carboxypenicillins was predominantly found in *E. coli*, with n=53 for ticarcillin and n=32 for piperacillin. Resistance to piperacillin/tazobactam ranged from 6.30 to 63.00%, and

Table 2. Distribution of enterobacteral species by origin.

Species	Overall (N = 111)[1]	Community strain, n=75	Hospital strain (n=36)
Citrobacter freundii	7 (6.3)	6 (86)	1 (14)
Klebsiella aerogenes	1 (0.9)	0 (0)	1 (100)
Enterobacter cloacae	4 (3.6)	3 (75)	1 (25)
Escherichia coli	61 (55)	40 (66)	21 (34)
Klebsiella oxytoca	6 (5.4)	6 (100)	0 (0)
Klebsiella pneumoniae	24 (22)	14 (58)	10 (42)
Proteus mirabilis	4 (3.6)	4 (100)	0 (0)
Proteus spp.	1 (0.9)	0 (0)	1 (100)
Serratia marcescens	1 (0.9)	0 (0)	1 (100)
Serratia odorifera	2 (1.8)	2 (100)	0 (0)

Fisher's exact test; p-value= 0.11.

Table 3. Resistance profile to Penicillin of enterobacteral strain according to their origin.

Species	N=111	Ampicillin		Ticarcillin		AMC	PipTaz	
		Com, n=45	Hosp, n=36	Com n=55	Hosp, n=35	Com n=44	Com n=1	Hosp, n=16
Citrobacter freundii	7	4 (8.9)	1 (2.8)	4 (7.3)	1 (2.9)	4 (9.1)	0 (0)	0 (0)
Klebsiella aerogenes	1	-	1 (2.8)	-	1 (2.9)	-	0 (0)	1 (6.3)
Enterobacter cloacae	4	2 (4.4)	1 (2.8)	2 (3.6)	1 (2.9)	2 (4.5)	0 (0)	0 (0)
Escherichia coli	61	23 (51)	21 (58)	31 (56)	21 (60)	23 (52)	0 (0)	10 (63)
Klebsiella oxytoca	6	5 (11)	-	4 (7.3)	-	5 (11)	0 (0)	0 (0)
Klebsiella pneumoniae.	24	7 (16)	10 (28)	10 (18)	10 (29)	6 (14)	1 (100)	5 (31)
Proteus mirabilis	4	2 (4.4)	0 (0)	3 (5.5)	0 (0)	2 (4.5)	0 (0)	0 (0)
Proteus ssp.	1	0 (0)	1 (2.8)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Serratia marcescens	1	-	1 (2.8)	0 (0)	1 (2.9)	-	0 (0)	0 (0)
Serratia odorifera	2	2 (4.4)	-	1 (1.8)	0 (0)	2 (4.5)	0 (0)	0 (0)

Com= Community, Hosp=hospital, AMC=amoxicillin + clavulanic acid, PipTaz=piperacillin+tazobactam.

this resistance was mostly encountered in hospital-acquired strains (14.41%, n=16).

Out of a total of 111 isolated Enterobacteral strains, resistance to cephalosporins (Table 3) varied between 7.21% (n=8) and 48.65% (n=54). Third generation cephalosporins (TGC) were affected, with proportions ranging from 36.94% (n=41) to 47.75% (n=53).

Resistance to fourth-generation cephalosporin (FGC) was around 7.2% (n=8). *E. coli* strains had resistance proportions to second and third generation cephalosporins ranging from 12.8 to 7.6%. Resistance to TGC (Table 4) ranged from 3.60% (n=4) to 23.42% (n=26) for hospital-acquired strains and from 42.34% (n=47) to 47.75% (n=53) for community-acquired strains. Resistance to FGC was 7.21% (n=8). The resistance of *E. coli* strains ranged from 5.41% (n=6) to 25.23% (n=28) in the community setting and from 13 to 38% in the hospital setting.

The profile for carbapenems (Table 5) was categorized as "Sensitive at High Dosage (SFP)," accounting for 16.22% (n=18). The SFP category varied from 8.5 to 100% depending on the Enterobacteral strains. The "Resistant (R)" category was 1.80% (n=2), involving resistance to Ertapenem, specifically 1.80% (n=2). The SFP category for *E. coli* strains was 8.5% (n=4.5).

Resistance to aminoglycosides varied from 6.31% (n=7) to 27.93% (n=31). This resistance fluctuated from 0.90% (n=1) to 18.01% (n=20) depending on the strains. Resistance based on the origin of Enterobacteral strains ranged from %(n=2) to %(n=6) for community-acquired strains and from 2.70% (n=3)
to 22.52% (n=25) for hospital-acquired strains.

Resistance to quinolones varied from 9.91% (n=11) to 53.15% (n=59). This resistance ranged from 36% (n=4) to 64% (n=18) for *E. coli* strains. Quinolone resistance according to the origin of the strain varied from 14.66% (n=11) to 37.33% (n=28) for community-acquired and from 72.22% (n=26) to 83% (n=30) for hospital-acquired strains.

Resistance to other tested antibiotics based on strains varied from 13 to 43% for nitrofurantoin, from 3.6 to 61% for trimethoprim-sulfamethoxazole, and from 13 to 75%

Table 4. Resistance profile to Cephalosporin of enterobacteral strain according to their origin.

Species	N=111	1st generation		2nd generation			3rd generation					4th generation
		Cefalotin		Cefoxitin		Cefuroxim	Cefixim	Cefotaxim		Ceftazidim		Cefepim
		Com, n = 53	Hosp, n = 1	Com, n = 20	Hop, n = 14	Com, n = 47	Com, n=53	Com, n=47	Hosp, n=4	Com, n=15	Hosp, n=26	Com, n=8
Citrobacter freundii		4 (7.5)	0 (0)	1 (5.0)	1 (7.1)	3 (6.4)	3 (5.7)	3 (6.4)	0 (0)	0 (0)	1 (3.8)	0 (0)
Klebsiella aerogenes		-	-	0 (0)	1 (7.1)	-	-	-	-	0 (0)	1 (3.8)	-
Enterobacter cloacae		3 (5.7)	0 (0)	1 (5.0)	0 (0)	0 (0)	3 (5.7)	0 (0)	0 (0)	0 (0)	1 (3.8)	0 (0)
Escherichia coli		27 (51)	1 (100)	6 (30)	8 (57)	23 (49)	28 (53)	23 (49)	3 (75)	6 (40)	15 (58)	3 (38)
Klebsiella oxytoca		5 (9.4)	0 (0)	3 (15)	0 (0)	5 (11)	5 (9.4)	5 (11)	0 (0)	2 (13)	0 (0)	1 (13)
Klebsiella pneumoniae		8 (15)	0 (0)	5 (25)	3 (21)	10 (21)	8 (15)	11 (23)	1 (25)	5 (33)	8 (31)	2 (25)
Proteus mirabilis		4 (7.5)	0 (0)	2 (10)	0 (0)	4 (8.5)	4 (7.5)	3 (6.4)	0 (0)	1 (6.7)	0 (0)	2 (25)
Proteus ssp.		-	0 (0)	0 (0)	0 (0)	-	-	-	-	0 (0)	0 (0)	-
Serratia marcescens		-	0 (0)	0 (0)	1 (7.1)	-	-	-	-	0 (0)	0 (0)	-
Serratia odorifera		2 (3.8)	0 (0)	2 (10)	0 (0)	2 (4.3)	2 (3.8)	2 (4.3)	0 (0)	1 (6.7)	0 (0)	0 (0)

Com= Community, Hosp=hospital.

Table 5. Resistance profile to Carbapenem of enterobacteral strain according to their origin.

Species	N=111	Imipenem		Imipenem		Ertapenem			Meropenem
		Com S, n=53	Hosp, s=33	Com SFP, n=17	Hosp, SFP n=1	Hosp R, n=2	Com S, n=2	Hosp S, n=31	Com S, n=18
Citrobacter freundii		2 (3.8)	1 (3.0)	3 (18)	0 (0)	1 (50)	1 (50)	0 (0)	0 (0)
Klebsiella aerogenes		0 (0)	1 (3.0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (3.2)	0 (0)
Enterobacter cloacae		3 (5.7)	1 (3.0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Escherichia coli		34 (64)	20 (61)	5 (29)	0 (0)	0 (0)	0 (0)	19 (61)	13 (72)
Klebsiella oxytoca		3 (5.7)	0 (0)	2 (12)	0 (0)	0 (0)	0 (0)	0 (0)	1 (5.6)
Klebsiella pneumoniae		7 (13)	10 (30)	5 (29)	0 (0)	1 (50)	1 (50)	9 (29)	2 (11)
Proteus mirabilis		3 (5.7)	0 (0)	1 (5.9)	0 (0)	0 (0)	0 (0)	0 (0)	2 (11)
Proteus ssp.		0 (0)	0 (0)	0 (0)	1 (100)	0 (0)	0 (0)	1 (3.2)	0 (0)
Serratia marcescens		0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (3.2)	0 (0)
Serratia odorifera		1 (1.9)	0 (0)	1 (5.9)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)

Com=Community, Hosp=Hospital, S=susceptible, SFP= susceptible to high posology. The strains categorized as SFP were 15.32% (n=17) at the community level and 0.90% (n=1) at the hospital level. Category R was 1.80% (n=2).

for fosfomycin.

Regarding the overall resistance profile (Figure 1), the most affected antibiotics were penicillins (aminopenicillin and carboxypenicillin), cephalosporins, and quinolones. Carbapenems retained their activity against the strains, while

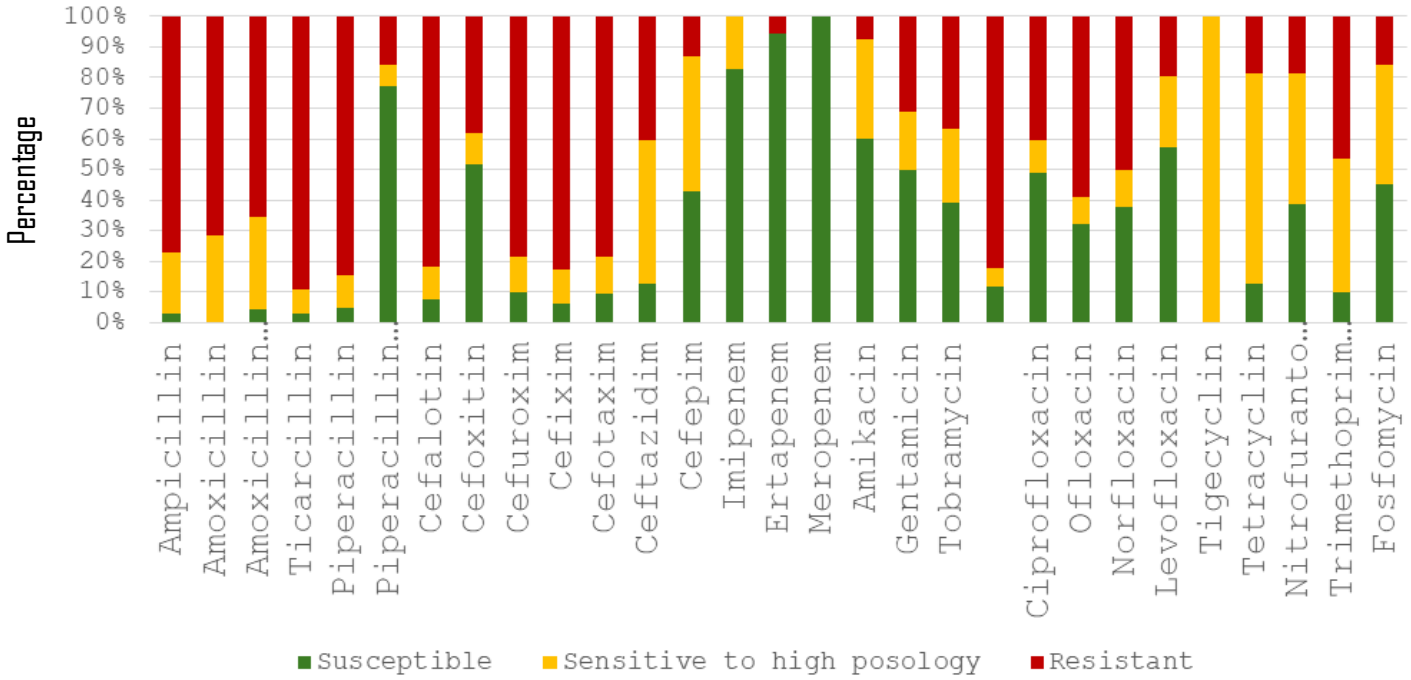

Figure 1. Overall resistance profile of enterobacteral to all antibiotics tested.

tetracyclines showed lower sensitivity.

DISCUSSION

A cross-sectional study was conducted over a period of 15 months (September 2022 to December 2023) with the aim of describing the resistance profile of Enterobacterales isolated from urine samples at the Laboratory of Medical Biology of CHU Donka. The limitation of this study was the duration and the size of the samples from the hospital setting This could be attributed, firstly, to the fact that the laboratory initially started receiving samples from outpatient consultations, and secondly, hospitalizations at CHU began only after 3 months of the facility's opening. However, this does not allow for generalization to the entire population. Nevertheless, the results obtained provide an idea of the current level of resistance and should help clinician for management of patient with urinary tract infection (UTI) and also to encourage the surveillance of antimicrobial resistance in hospital and community setting.

Out of a total of 520 urine samples received and analysed in the laboratory, 111 tested positive for Enterobacterales. This allowed us to outline a comprehensive resistance profile of Enterobacterales to various antibiotic classes commonly used in urinary infections. The antibiotics most affected by resistance were penicillins (amino-penicillins and carboxy-penicillins), cephalosporins, and quinolones (fluoroquinolones), accounting for more than half. It is important to note that with Enterobacterales, there is a risk of spreading these resistances within the group. They possess resistance carriers (plasmids, integrons) that can be shared among them, facilitating the spread of resistance (Partridge et al., 2018; Rozwandowicz et al., 2018).

The strains of *E. coli* were the most isolated, followed by *K. pneumoniae*. These species are considered the most commonly isolated around the world, both in community and hospital settings. Some studies conducted in Germany, Espana, Peruvia, Ethiopia, Tanzania, and Ghana highlighted the same constatation (Abubaker and Anwar, 2023; Alzahrani et al., 2022; Donkor et al., 2019; Moges et al., 2021; Rondon et al., 2023; Schmider et al., 2022; Stoltidis-Claus et al., 2023). However, this pattern may vary in certain areas, as seen in a study conducted in Sierra Leone, where samples from the community showed a predominance of *Citrobacter freundii* strains (Leski et al., 2016) and another study among elderly patients living in the community and in the nursing home showed that *Proteus mirabilis* was the second strains isolated after *E. coli* (Pulcini et al., 2019).

The resistance profile to penicillins was dominated by high resistance to amino-penicillins and carboxy-penicillins. *E. coli* strains showed high resistance to these groups of penicillins, extending to the amoxicillin-clavulanic acid combination. This resistance profile has been described in other studies with high prevalence,

ranging from 51 to 97.2% for ampicillin and 20.5 to 77.3% for amoxicillin-clavulanic acid (Ahmed et al., 2019; Bernabé et al., 2017; Matalka et al., 2021; Moges et al., 2021; Schmider et al., 2022; Stoltidis-Claus et al., 2023). However, their sensitivity was restored by the combination of penicillin/beta-lactamase inhibitor (tazobactam), as described in other studies with sensitivity rates reaching between 94 and 96.12% (Matalka et al., 2021; Nkont et al., 2023; Schmider et al., 2022).

Resistance to penicillins was similar in both hospital and community settings, with a predominance of *E. coli* strains. This profile has been previously observed in other studies with variable prevalence rates depending on the regions (Nkont et al., 2023). Study conducted among rural patients in Karnataka (India) showed the high prevalence over than 45% (Mardourian et al., 2023). However, study performed in two French centres describe that Temocillin showed a high level of activity against Enterobacterales strains from community acquired urinary tract infection (UTI) (Alexandre et al., 2018). An increase in resistance to the combination of amoxicillin-clavulanic acid and ticarcillin was described for *E. coli* strains. Nevertheless, this resistance can be either natural or acquired for certain strains. It corresponds to a group resistance for the wild-type phenotype (Chagneau et al., 2024). The combination of piperacillin-tazobactam could be an alternative for managing infections caused by multidrug-resistant strains (Bader et al., 2017; Long and Koyfman, 2018).

Resistance profile to cephalosporins was impacted with high rates for TGC. *E. coli* strains showed high rates for TGC, as reported in Benin with 100% resistance of *E. coli* strains to cefixime and ceftriaxone (Assouma et al., 2023). However, the resistance rate to TCF was about 12.6% for *E. coli, K. pneumoniae,* and *P. mirabilis* UTI in Northern California (USA) (Mark et al., 2021) and 18.4% for *E. coli*, 30.7% for *Klebsiella* spp. in a systematic review conduction in some west African countries (Nigeria, Senegal, Ghana, Benin, Burkina Faso, and Cote d'Ivoire) (Bernabé et al., 2017). In addition, the activity of FGC remains maintained for all Enterobacterales isolated in our study. Nevertheless, low resistance proportions to FGC, particularly for *E. coli* strains, were noted. This calls for their rational use. Hospital strains showed high resistances as described in other areas, with rates ranging from 43.9 to 77% for *E. coli* and 49.2 to 72% for *K. pneumoniae* being resistant to TGC (Abubaker and Anwar, 2023; Rondon et al., 2023). A low level of resistance to FGC for community strains, unlike other studies that reported high rates around 50% (Abubaker and Anwar, 2023). FGC could be an alternative for managing multidrug-resistant strains in our context.

Carbapenems are antibiotics that are effective against Enterobacteral secreting penicillinase and cephalosporinase (Nkont et al., 2023). Strains categorized as "sensitive at high dosage (SHD)" or resistant to at least one of the carbapenems can be considered suspicious of producing a carbapenemase. These strains are producers of significant resistance mechanisms, including carbapenemases (Comité de l'Antibiograme de la Société Française de Microbiologie, 2023). A low rate of resistance was observed to carbapenems and an increase in strains categorized as SHD. This profile has been described in other studies with prevalence rates of 0.9% for *E. coli* and 3.2% for *K. pneumoniae* to carbapenem (García-Castillo et al., 2018; Rondon et al., 2023). However, in a study on the confirmation of the carbapenem profile of Enterobacterales, only 8.9% were confirmed resistant (Steward et al., 2003). Another study conducted in Benin reported resistance rates ranging from 12.5 to 66.6% of Enterobacterales to imipenem (Assouma et al., 2023). This low resistance rate to carbapenems could make these antibiotics an option for managing multidrug-resistant bacteria in our context and Ceftazidime-avibactam could be used to manage UTI caused by carbapenemase producing Enterobacteral such as KPC and OXA-48 producers (García-Castillo et al., 2018). Nevertheless, the increase in strains categorized as SHD should alert and lead to the search for carbapenemases. Another study conducted over the 20-year period showed that except carbapenems, all the antibiotics tested showed increasing resistance rate (Milano et al., 2022).

The resistance to aminoglycosides was high, affecting a quarter of the strains. The main aminoglycosides affected were gentamicin and tobramycin. Twenty-five percent of hospital strains were affected by this resistance. Higher rates have been described in other studies. In Iran the resistance rate was 47.9% for tobramycin, 39.3% for kanamycin, and 27.8% for gentamicin (Yekani et al., 2018) and in India the rate was 31% for all aminoglycosides (Mardourian et al., 2023). In Nigeria, the study conducted among pediatric population found 96.9% of resistance to kanamycin (Oli et al., 2019). These molecules, often used in the management of urinary tract infections due to their good diffusion, could be limited by the emergence of resistance.

Resistance to quinolones was high, with an overall proportion of 53%. It involved nalidixic acid, which was higher in hospital strains, and fluoroquinolones with the same proportions in hospital and community strains. High rates have been described, ranging from 32 to 63.2% of *E. coli* strains resistant to fluoroquinolones (Lyonga et al., 2015; Mardourian et al., 2023; Moirongo et al., 2020; Rondon et al., 2023; Schmider et al., 2022). As described in some studies, the resistance to quinolones is mediated by plasmid and more examination should be conducted in case of strains exhibiting reduced susceptibility and intermediate phenotype (Pasom et al., 2013; Szabó et al., 2018). This increase in resistance for this group raises concerns about the rational use of these molecules, as they are used in the management of multidrug-resistant bacteria (MDR) (Bader et al., 2017).

All strains tested for tetracycline were categorized as sensitive to high dosage. A study conducted in four sub-Saharan African countries reported an overall prevalence of 17%, with rates varying from 7 to 23% depending on the countries (Moirongo et al., 2020). Concerning other antibiotics, resistance was high for fosfomycin and trimethoprim-sulfamethoxazole, with a predominance among *K. pneumoniae* strains in the community and *E. coli* strains in the hospital setting. In contrast to other authors who reported widespread sensitivity to fosfomycin and strong resistance to trimethoprim-sulfamethoxazole (Schmider et al., 2022), a study conducted in sub-Saharan Africa reported prevalence ranging from 42 to 100% (Moirongo et al., 2020).

Conclusion

This study provided insight into the resistance profile of enterobacteral to antibiotics used in urinary tract infections. The observed resistance is substantial in both hospital and community environments. Additionally, the increasing resistance to carbapenems presents a challenge to the management of strains producing extended-spectrum beta-lactamases (ESBL). It would be important to strengthen resistance surveillance in this context.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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