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Assessment of drugs pressure on *Escherichia coli* and *Klebsiella* spp. uropathogens in patients attending Abobo-Avocatier Hospital, North of Abidjan (Côte d'Ivoire)

Innocent Allepo ABE[1,2], Mathurin KOFFI[2*], Paulin Didier SOKOURI[1], Bernardin Ahouty AHOUTY[1,2], Martial Kassi N'DJETCHI[2], Siriki SIMARO[2], Edwige Abla SOKOURI[2], Barkissa TRAORE[2], Thomas Konan KONAN[2], William YAVO[3], Sanogo Abiba TIDOU[2] and Simon-Pierre N'GUETTA[1]

[1]Laboratoire de Génétique, UFR Biosciences, Université Félix Houphouët-Boigny, 22 BP 582 Abidjan 22, Côte d'Ivoire.
[2]Unité de Recherche en Génétique et Epidémiologie Moléculaire (URGEM), Laboratoire de Biodiversité et Gestion durable des Ecosystèmes Tropicaux, UFR Environnement, Université Jean Lorougnon Guédé, BP 150 Daloa, Côte d'Ivoire.
[3]Institut National de Santé Publique (INSP), 01 BPV 34 Abidjan-Côte d'Ivoire.

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The problem of antibiotic resistance of uropathogens appears in Abobo municipality to be worsening because of the overuse and misuse of antibiotics. This study aims to assess the impact of drugs pressure on uropathogenic *Escherichia coli* and *Klebsiella* spp. strains isolated from patients attending Abobo-Avocatier Hospital. The study was conducted in patients suffering from urinary tract infection. Urine samples of patients were collected; culture and antibiogram using the Kirby-Bauer disc diffusion method were performed. The overall prevalence was 31.1% with a significant difference between males and females (p = 0.01). The highest susceptible age group of patients to UTI was 21-45 years (33%). *E. coli* and *Klebsiella* spp were the predominant bacteria among isolated Gram negative. Up to 70% of the isolates of both uropathogens were resistant to Penicillins, Tetracyclines and Ampicillin-Sulbactam. Imipenem was the most active antibiotic on these uropathogens. Quinolones showed a better activity on *Klebisiella* spp. strains than those of *E. coli*. The high value of the Multiple Antibiotic Resistance Index and the rate of multi-resistance from this site suggest the need for continuous monitoring of antibiotic susceptibility profile of bacteria implicated in UTI prior to antibiotic prescription in order to ensure optimal and desired treatment.

Key words: Urinary tract infections, uropathogens, multidrug resistance, Abidjan, Côte d'Ivoire.

INTRODUCTION

Urinary tract infection (UTI) is defined as a multiplication of microorganisms in the urinary tract with or without symptoms (Prakash and Saxena, 2013). This pathology usually starts by a bladder infection and can reach the kidneys to cause renal dysfunction or dissemination in the blood (Vejborg et al., 2011). Depending on the organ

and/or severity, UTI is classified as bacteriuria (urine), cystitis (bladder), pyelonephritis (kidneys) or urosepsy (blood) (Vejborg et al., 2011). UTI is a major public health problem in developing countries with a high morbidity rate and important financial cost (Prakash and Saxena, 2013; Eshetie et al., 2015). Worldwide, about 150 million patients are diagnosed each year for an estimated economic weight of over 6 billion dollars (Prakash and Saxena, 2013). In Africa, the burden of UTI is difficult to be evaluated because diseases notification is scarce. The most affected people are school age children, sexually active women and older adults of both gender (Foxman, 2014). The causative agents belong to Enterobacteriaceae family and *Escherichia coli* and *Klebsiella* spp species are the most commonly isolated (Indu and Deepjyoti, 2012; Melaku et al., 2012). Antibiotic therapy is the standard method for the treatment of bacterial infections. However, in recent years, a significant increase of antibiotic resistance in *Enterobacteriaceae* has been documented worldwide. In Côte d'Ivoire, few studies address the incidence of urinary tract infection and selection pressure induced by antibiotics on uropathogens, while UTI is common in daily practice (Boni et al., 2014; Cisse et al., 2017). This is due to the fact that in Côte d'Ivoire and even in Africa, urine culture and antimicrobial susceptibility testing are unavailable in most of hospital centers (Dosso et al., 2000; Eshetie et al., 2015; Cisse et al., 2017). In addition, cases of urinary tract infection are often treated empirically based on information determined from resistance profile of urinary pathogens (Ekwealor et al., 2016). This situation leads to wrong diagnosis and irrational antibiotic use in the treatment of urinary infection, promoting the emergence and spread of multidrug-resistant strains (Ouédraogo et al., 2017). In Abobo municipality, the antibiotic resistance appears to be worsening and no local database on the urinary infection incidence and resistance profile of strains involved is available. To effectively monitor antibiotic resistance, it is important to know the level of antibiotic resistance and to have a local database. This prospective study aims to investigate and to assess the drugs pressure on uropathogenic *E. coli* and *Klebsiella* spp. isolated from patients attending Abobo-Avocatier Hospital in the North of Abidjan.

MATERIALS AND METHODS

Study area

This study was carried out at Abobo-Avocatier Hospital located in the municipality of Abobo, in the North of Abidjan (Côte d'Ivoire). The Abobo municipality is one of the most populated areas of Abidjan with about 1,030,658 million inhabitants (RGPH, 2014). The hospital has a biomedical laboratory, but only the parasitology unit is functional. This research project opened the microbiology unit in order to implement bacterial diagnosis and optimize the antibiotic treatment of urinary tract infections.

Ethics statement

The study protocol was reviewed and approved by the national ethics committee of Life Sciences and Health in Côte d'Ivoire with the number: N/Ref:106-18/MSHP/CNESVS-KM, US DPT OF HHS REGISTRATION #: IORG00075 on 31st July 2018. This study is part of the ESTHER project which aims to a better diagnosis of urinary tract infections in outpatients in addition to microbiological surveillance of uropathogens and antimicrobial resistance. Consent was obtained from patients and/or guardians after explaining the objective of the study. The laboratory results were communicated to patients via physicians for better antibiotic prescription.

Study design, participants and data collection

It is a cross-sectional prospective study carried out between October 2018 and April 2019 in patients with symptomatic UTI. Only patients who met clinical criteria (algae, pollakuirie, urge urination, suprapubic pain) and urinary strip criteria (leukocyturia, positive nitrite and hematuria) were included in this study. These patients received good instructions on how to collect the urine sample aseptically. About 20 ml of midstream urine specimen was collected from each patient in the morning using a sterile bottle and labeled with the unique sample code, date and time of collection. Demographic characteristics such as gender and age, and clinical characteristics such as previous antibiotic treatment, symptoms, and pregnancy status for women were collected from patients.

Analysis procedure

Urine dipstick technique and microscopic examination

The biochemical test of the urine specimen using the urine dipstick technique was performed. It allowed to reveal metabolic, hepatic and renal disorders, such as urogenital infections by the significant presence of leukocytes and nitrite (Hay et al., 2016). Microscopic examination of the fresh urine was performed to confirm the results of the urine dipstick test by counting leukocytes, erythrocytes, urothelial cells and crystals (Ikhlas et al., 2018). The urine culture was systematically performed if at least a criterion of the dipstick test was positive or significant leucocyturia was observed (10 leucocytes / field) (Ekwealor et al., 2016).

Isolation and identification of uropathogens

Each urine sample was inoculated on the CHROMAgar medium using plastic loops for 10 µl (Ohkusu, 2000). The culture was incubated under aerobic conditions at 37°C for 24 h. After incubation, the growing *Escherichia coli* isolates were recognizable by large colonies dark pink to reddish with or without halo. Klebsiella, Enterobacter, Serratia and Citrobacter (KESC) group

*Corresponding author. E-mail: m9koffi@yahoo.fr. Tel: 00 225 40 18 56 02.

Table 1. Risk factors associated with urinary tract infections.

Factor	Status of urinary infection			Bivariate analysis	
	N	Positive (%)	Negative (%)	*p*	OR (CI 95 %)
Gender					
Males	57	11 (19.3)	48 (80.7)		1
Females	91	35 (38.5)	56 (61.5)	0.01	2.73 (1.25; 5.95)
Age groups (years)					
14 - 20	16	4 (25)	12 (75)		
21 - 45	91	30 (33)	61 (67)	0.528	1.48 (0.44; 4.96)
> 45	41	12 (29.3)	29 (70.7)	0.747	1.24 (0.33; 4.63)
Total	148	46 (31.1)	102 (68.9)		

N: total number; *p:* probability associated at χ^2 test; OR: odds ratio; $CI_{95\%:}$ 95% Confidence Interval.

colonies were colored in metallic blue and medium in size (Ohkusu, 2000). Identification of bacterial species was made based on reactions of Gram, morphology and biochemical characteristics using the gallery of the reduced rack of LEMINOR (Urea; Indol; Simmons' citrate agar; Kligler Hajna agar; iron Lysine agar), oxidase and catalase tests (Tahou et al., 2017). Clean catch urine samples were collected from patients and bacteriological analyses were performed using standard microbiological procedures.

Antibiotic susceptibility testing and drug resistance

Antibiotic susceptibility testing was done using the Kirby-Bauer disk diffusion method on Mueller Hinton (Oxoid) agar according to the guidelines of the Clinical Laboratory Standards Institute (CLSI, 2017). *E. coli* and *Klebsiella* spp strains were tested on 14 antibiotics (Oxoid) such as: Amoxicilin-Clavulanic acid (AMC; 20/10 µg), Ampicillin (AMP; 10 µg), Penicillin G (P; 1 µg), Tetracycline (TE; 30 µg); Ceftazidime (CAZ; 30 µg), Ceftriaxone (CRO; 30 µg), Cefuroxime (CXM; 30 µg), Nitrofurantoin (F; 300 µg), Gentamicin (CN; 10 µg), Imipenem (IMP; 10 µg), Nalidixic Acid (NA; 30 µg), Ampicillin-Sulbactam (SAM; 20 µg), Chloramphenicol (C; 30 µg) and Ciprofloxacin (CIP; 5 µg). Bacterial colonies from a pure overnight culture were suspended in 2 ml of 0.85% NaCl in order to maintain the bacterial strains in osmotic equilibrium and the bacterial suspension was standardized to 0.5 McFarland (10^8 UFC / ml). The suspension was inoculated on Mueller Hinton agar by striation using a sterile swab and antimicrobial agents are placed onto the surface of the agar and incubated at 37°C for 24 h. After incubation, the diameter of the inhibition zone of bacterial growth formed around the disc was measured and compared to the critical values d and D of each antibiotic disc according to CLSI. The target bacteria were qualified as sensitive (diameter of the inhibition > D) or resistant (diameter of the inhibition < d) or intermediate (d < diameter of the inhibition < D) (Moroh et al., 2014). In this study, isolates of intermediate phenotypes were considered resistant. Standard strains of *E. coli* ® ATCC 25922, *S. aureus* ATCC ® 25923 and *Klebsiella pneumoniae* ® ATCC 35657 (BBL) were used as quality controls for identification and antimicrobial susceptibility testing. Multi-resistant strains were divided into MDR (Multiple Drug-Resistant), XDR (Extensively Drug-Resistant) and PDR (Pandrug-resistant) according to the European Center for Disease prevention and Control (Magiorakos et al., 2012). MDR bacteria are defined as resistant at least to three different classes of antibiotics. XDR bacteria are characterized by their sensitivity to only one class of antibiotics and the PDR bacteria are resistant to all classes of antibiotics tested (Magiorakos et al., 2012).

Statistical analysis

The rate of resistant and multi-resistant isolates to antimicrobial reagents was calculated. The Multiple Antibiotic Resistance Index (MARI) calculation was done (Krumperman, 1983). Comparison between the rate of antibiotic resistance for *E. coli* and *Klebsiella* spp isolates was performed by Chi-Square or Fisher's exact tests according to the Cochran rule. Odds ratio (OR) was estimated to evaluate the occurrence of UTI from female. MAR Index mean of *E. coli* and *Klebsiella* spp were compared using Student's t-test for independent Samples. Heatmaps was carried out to evaluate the similarity between the strains of each bacterial population based on their resistance profiles. All statistics tests and graphs were performed using R software version 3.3.1 and differences were considered to be significant when *p -value* ≤ 0.05.

RESULTS

A total of 148 patients comprising 91 females and 57 males were included in this study. The overall prevalence of urinary infection was 31.1% with 19.3% for males and 38.5% for females (Table 1). Females were around 3 times more likely to be infected than males (OR: 2.73, 95% CI (1.25; 5.95); p = 0.01). No significant differential infection was observed (p > 0.05) among age groups despite the highest susceptible age group of patients was 21 - 45 years (33%) followed by ≥ 45 years (29.3%) and 14 -20 years (25%) in both Female and Male (Table 1).

Figure 1 shows the gender susceptibility to UTI regarding age groups. The results show that the significant differential infection observed between male and female was expressed among 21 - 45 years' age groups, with females 3 times more likely to be infected than males (OR = 3.18; 95% IC [1.14 - 8.87], p = 0.024). However, among the age groups of 14 to 20 and over 45 years of age, the difference in UTI prevalence between male and female was not statistically significant.

Distribution of uropathogenic bacteria isolated

The bacterial pathogens isolated were *E. coli*: 14

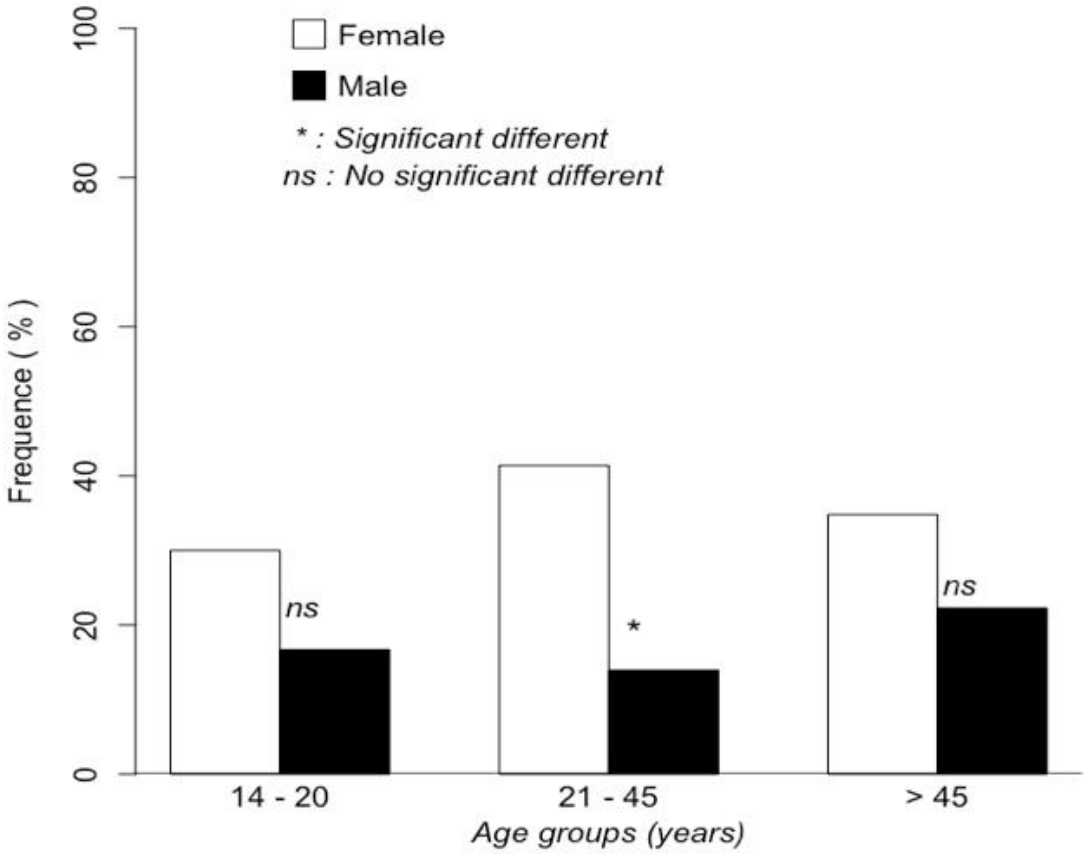

Figure 1. Gender susceptibility to UTI regarding age group.

Table 2. Frequency of uropathogenic bacteria isolated.

Gram	Bacteria isolate	Number of isolates	Prevalence (%)
		25	**54.3**
	Escherichia coli	14	30.4
Negative Gram	*Klebsiella* spp.	8	17.4
	Enterobacter spp	2	4.3
	Proteus spp.	1	2.2
		21	**45.7**
Positive Gram	*Staphylococcus* spp.	14	30.4
	Enterococcus spp	7	15.2
Total		**46**	**100**

(30.4%), *Staphylococcus* spp: 14 (30.4%), *Klebsiella* spp: 8 (17.4%), *Enterococcus* spp: 7 (15.2%), *Enterobacter* spp: 2 (4.3%) and *Proteus* spp.: 1 (2.2%). The most common uropathogenic bacteria were Gram-negative bacteria belonging to *Enterobacteriacea* family with a cumulative prevalence of 54.3%. *E. coli* and *Klebsiella* spp were the most dominant species from this family and each accounted for 56 and 32% respectively (Table 2).

Antibiotic resistance of *E. coli* and *Klebsiella* spp. strains

The assessment of antimicrobial resistance (AMR) was focused on *E. coli* and *Klebsiella* spp because they are the most common for antibiotic resistance monitoring regarding their high frequency and pathogenicity. The results showed strains from both bacteria species were

Table 3. Antibiotic resistance rates of *E. coli* and *Klebsiella* spp isolates.

Antibiotics class	Antibiotics	Bacteria species			Fisher's exact test
		Dose (µg)	*E. coli* (n=14)	*Klebsiella* spp. (n= 8)	*p*-value
Penicillins	Amoxicillin-clavulanic acid	20/10	13 (92.9)	6 (75)	0.527
	Ampicillin	10	14 (100)	8 (100)	1
	Penicillin G	1	14 (100)	8 (100)	1
Cephalosporin II (C2G)	Cefuroxime	30	7 (50)	3 (37.5)	0.675
Cephalosporin III (C3G)	Ceftriaxone	30	6 (42.9)	4 (50)	1
	Ceftazidime	30	6 (42.9)	2 (25)	0.649
Carbapenem	Imipenem	10	1(7.1)	1 (12.5)	1
Quinolones	Ciprofloxacin	5	8 (57.1)	0 (0.0)	**0.017**
	Nalidixic acid	30	12 (85.7)	3 (37.5)	**0.05**
Aminoglycosides	Gentamicin	10	3 (21.4)	2 (25)	1
Tetracyclines	Tetracyclin	30	13 (92.9)	6 (75)	0.527
Phenicols	Chloramphenicol	30	6 (42.9)	4 (50)	1
furantoins	Nitrofurantoin	300	2 (14.3)	3 (37.5)	0.309
Betalactam/betalactamase inhibitor	Ampicillin-Sulbactam	20	12 (85.7)	6 (75)	0.602

100% resistant to Ampicillin and Penicillin G. 92.9% of *E. coli* strains were resistant to Amoxicillin-Clavulanic acid and Tetracycline and the lowest resistance was obtained with Imipenem (7.1%) (Table 3). 75% of *Klebsiella* spp strains were resistant to Amoxicillin-Clavulanic acid and Tetracycline. In addition, all strains were susceptible to Ciprofloxacin and only 12.5% of strains were resistant to Imipenem (Table 3). The Fisher's exact test showed that *E. coli* and *Klebsiella* spp. strains present statistically identical resistance rates against commonly used antibiotics (Penicillins, Cephalosporins, Aminoglycosids, Tetracyclins, Phenicols, Furantoins, Betalactam / Betalactamase inhibitor) and to Carbapenems. However, the resistance rate against quinolones was statistically different between *E. coli* and *Klebsiella* spp strains ($p \leq 0.05$). Quinolones, especially Ciprofloxacin showed very good activity on *Klebisiella* spp strains than *E. coli*, in which resistance rate reached 85.7 and 57.1% for Nalidixic acid and Ciprofloxacin respectively (Table 3). The antibiotic resistance profile of *E. coli* and *Klebsiella* spp strains is indicated in Table 4. The result obtained suggests that the strains might be genetically different from a patient to another. The least multi-resistant strains of *E. coli* were resistant to 3 classes of antibiotic while the most multi-resistant strains were resistant to 9 classes of antibiotic with an average resistance to 6 classes of antibiotic for all isolated strains. Regarding *Klebsiella* spp, strains were resistant to an average of 5 different classes of antibiotic with a strain resistant to only one class of antibiotic (Table 4).

Regarding the heterogeneity of the strains presented by in Figure 2, two clusters were observed for each species of bacteria (*Klebsiella* spp and *E. coli*), demonstrating an intraspecific diversity among patients infected. Each cluster comprised about 50% of the isolates. In both bacterial populations, isolates from cluster I are characterized by resistance to a large number of antibiotics and isolates from cluster II characterized by susceptibility to most of the antibiotics tested (Figure 2).

Multi-resistance and multiple antibiotic resistance index

Multi-resistance and Multiple Antibiotic Resistance index (MARI) of *E. coli* and *Klebsiella* spp. strains are shown in Table 5. Based on their observed phenotypes and classes of multi-resistance defined previously, 100% *E. coli* strains and 87.5% *Klebsiella* spp strains were multi-resistant. No isolates in both *E. coli* and *Klebsiella* spp presented the Pan drug-resistant phenotype. Only a strain of *E. coli* (7.14%) presented extensively drug resistant phenotype. The average multiple antibiotic resistance index of *E. coli* and *Klebsiella* was 0.59 ± 0.2 and 0.51 ± 0.2 respectively (Table 5). The Student's t-test showed no statistically significant difference between the MARI of both bacteria species tested ($t = 0.86$; degree; $p = 0.397$).

DISCUSSION

This study provides valuable data for assessing drugs' pressure and monitoring the antimicrobial resistance among uropathogenic *E. coli* and *Klebsiella* spp to

Table 4. Antibiotic resistant profile of *E. coli* and *Klebsiella* spp isolates

Species	Bacteria strains	Antibiotic resistant profile	No. of ATB class
Escherichia coli	*E.coli1*	AMC, AMP, P, TE, CIP, CRO, CXM, NA, SAM, C	7
	E.coli2	AMP, NA, P, TE	3
	E.coli3	AMC, AMP, C, P, SAM,TE	4
	E.coli4	AMC, AMP, TE, NA, P, SAM	5
	E.coli5	AMC, AMP, TE, CAZ, CIP, CXM, NA, P, SAM	6
	E.coli6	C, CAZ, CN, CRO, CXM, F, AMC, AMP, CIP, NA, P, SAM, TE	9
	E.coli7	AMC, AMP, NA, P, SAM, TE	4
	E.coli8	AMC, AMP, C, TE, CAZ, CIP, CRO, CXM, NA, P, SAM	7
	E.coli9	F, AMC, AMP, TE , P	3
	E.coli10	AMC, AMP, TE, NA, P, SAM	4
	E.coli11	CAZ, CN, AMC, AMP, TE, CIP, CRO, CXM, NA, P, SAM	7
	E.coli12	AMC, CIP, SAM, AMP, NA, P, TE	4
	E.coli13	C, CAZ, CN, CRO, CXM, AMC, AMP, CIP, NA, P, SAM	7
	E.coli14	CAZ, CIP, CRO, CXM, IMP, AMC, AMP, TE, NA, P, SAM	7
	Mean (±Sd)		**6 ± 1.9**
Klebsiella spp.	*Klebsiella*1	AMC, AMP, P	1
	*Klebsiella*2	CAZ, CN, CRO, CXM, F, AMC, AMP, C, NA, P, SAM, TE	9
	Klebsiella 3	F, NA, AMP, P, SAM	4
	*Klebsiella*4	C, AMC, AMP, CRO, CXM, P, TE	5
	*Klebsiella*5	NA, AMC, AMP, C, P, SAM, TE	5
	*Klebsiella*6	IMP, AMC, AMP, P, SAM, TE	4
	*Klebsiella*7	CAZ, CN, CXM, AMC, AMP, CRO, P, SAM, TE	6
	Klebsiella8	AMC, C, CRO, F, SAM, TE, AMP, P	6
	Mean (± Sd)		**5 ± 2.3**

Amoxicillin-Clavulanic acid (AMC), Ampicillin (AMP), Penicillin G (P), Tetracycline (TE), Ceftriaxone (CRO), Ceftazidime (CAZ), Cefuroxime (CXM), Nitrofurantoin (F), Gentamicin (CN), Imipenem (IMP), Nalidixic acid (NA), Ampicillin-Sulbactam (SAM); Chloramphenicol (C), Ciprofloxacin (CIP).

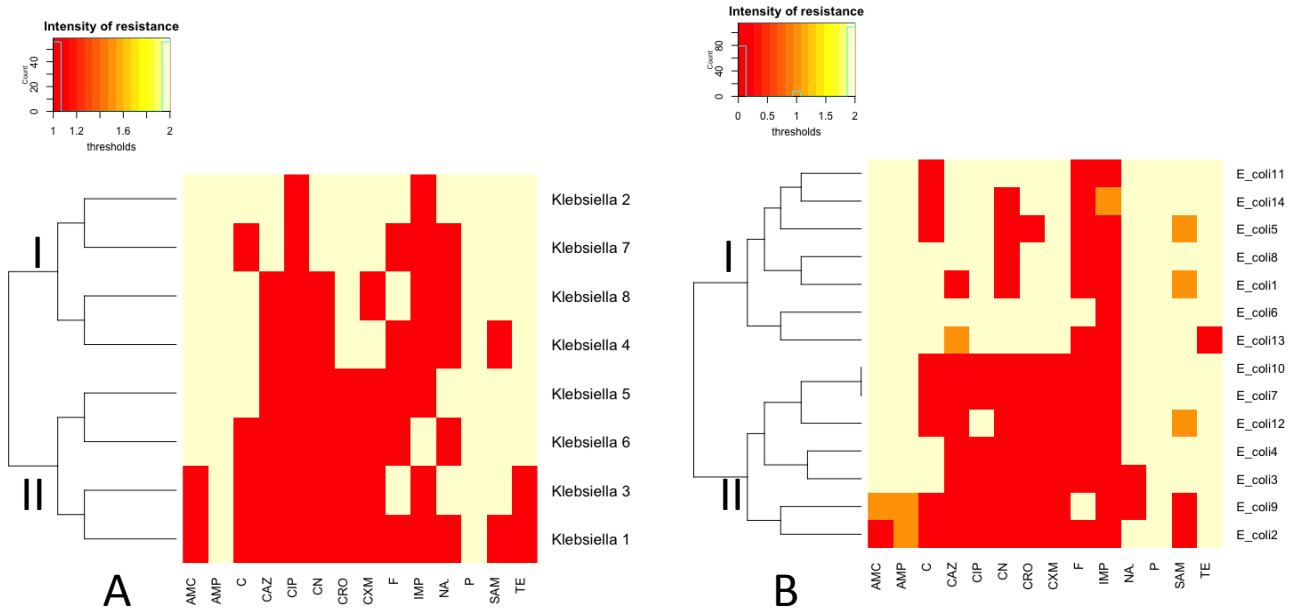

Figure 2. Heatmap showing the relationship and variation of antibiotic resistance profiles between isolates of *Klebsiella* spp. (A) and *E. coli* (B). Light color = area of resistance, red color = area of sensitivity, orange color = intermediate area.

Table 5. Multiresistance rate in *E. coli* and *Klebsiella* spp.

Bacteria species	Total	MDR (%)	XDR (%)	PDR (%)	Mean MARI
E. coli	14	14 (100)	1 (7.14)	0 (0.0)	0.59 ± 0.2
Klebsiella spp	08	7 (87.5)	0 (0.0)	0 (0.0)	0.51 ± 0.2
Student's T-test		--	--	--	t = 0.86; p = 0.397

MDR: Multiple Drug-Resistant; XDR: Extensively Drug-Resistant; PDR: Pandrug-resistant; MARI: Multiple Antibiotic Resistance Index.

improve patients' treatment. It is a first study on urinary infection in the municipality of Abobo. All infected patients had a community-acquired UTI with a high overall prevalence up to 31.1% but not significantly different than reported elsewhere in Côte d'Ivoire, at Treichville Teaching Hospital (25%) (Moroh et al., 2014). However, the obtained UTI prevalence was higher than those recorded in some West African countries: 9.5% in Ghana (Obirikorang et al., 2012) and 13.1% in Nigeria (Iregbu and Princewill, 2013). Contrary to those countries, our prevalence was lower than other sub-Saharan countries, 58.3 % in Cameroon (Prakash and Saxena, 2013), 51% in South Africa (Habte et al., 2009) and 41.4% in Ethiopia (Akoachere et al., 2014). Differences in UTI rates regarding areas could be explained by the disparities in location and health facilities in addition to patients' status (acute UTI or post-antibiotic treatment) (Shatalov, 2015). This study showed a significantly higher prevalence of urinary tract infection in females (38.5%) than in males (19.3%) with a 2.6 times higher risk compared to males. These results, is in agreement with those of Prakash and Saxena (2013), might be due to the close proximity of females' urethra to the anus, shorter urethra, incontinence, and bad female toilets (Orrett and Davis, 2006). No significant association between age and UTIs was observed in this study. But the highest rate of UTI was reported in patients aged 21 to 45 years with females three times more likely to be infected than males. Similar results were obtained by Eshetie et al. (2015) in northwestern Ethiopia, in which age was not associated with the development of urinary tract infection. The reason for the significant increase in urinary tract infection risk observed in females aged 21 to 45 years might be associated with high sexual activity in this age group. This factor is important in the exchange of microbial strains between individuals (Foxman, 2014; Vasudevan, 2014).

Gram negative bacilli accounted for 54.3% of the total number of bacterial isolated. *E. coli* and *Klebsiella* spp were the most predominant (Habte et al., 2009; Bao et al., 2013; Moroh et al., 2014; Ebongue et al., 2015). This high prevalence of *E. coli* and *Klebsiella* spp. might be due to their virulence and pathogenicity (Prakash and Saxena, 2013). In addition, these uropathogens are frequently difficult to treat because of their intrinsic and acquired resistance to multiple antibiotic families (Billy, 2003).

Antimicrobial susceptibility testing showed high resistance rates to penicillins, tetracyclines, ampicillin-sulbactam and to third generation cephalosporins (ceftriaxone) among *E. coli* and *Klebsiella* spp strains. This high level of expressed resistance could be attributed to the irrational use of these antibiotics and the lack of proper UTI diagnosis and antibiotic susceptibility testing in the municipality of Abobo. As reported by Ekwealor et al. (2016), the misuse of antibiotics in a society where people indulge in self-medication and the intensification of empirical and probabilistic prescriptions are practiced is an important way to promote antibiotic resistance. Resistance to penicillins and cephalosporins classes of antibiotic might be due to the production of beta-lactamases (penicillinases and cephalosporinases) encoded in the bacterial genome (Mpelle et al., 2019). Several studies worldwide have reported the emergence and dissemination of *E. coli* and *Klebsiella* spp strains producing extended spectrum of beta-lactamases (Moyen et al., 2014; Abujnah et al., 2015; Mpelle et al., 2019). The drug pressure induced might change the bacterial ecology, which favors an adaptation of the microbial agent to its new environment, developing resistance mechanisms transmissible by mobile genetic elements such as plasmids (Sbiti et al., 2017). Quinolones (ciprofloxacin and nalidixic acid) have shown an excellent activity on more than 60% of *Klebsiella* spp isolates, whereas high resistance to this antibiotic class was observed among *E. coli* isolates. The significant difference observed in quinolones resistance between *E. coli* and *Klebsiella* spp could be related to the frequency of isolation of uropathogenic *E. coli* and the intensive use of quinolones (e.g. Ciprofloxacin) in the treatment of infections (Dosso et al., 2000; Kim and Hooper, 2014) involving this pathogen at Abobo-Avocatier Hospital. Imipenem has shown excellent activity against both *E. coli* and *Klebsiella* spp isolates. This high susceptibility to imipenem could be explained by the fact that carbapenems are new broad-spectrum antibiotics, and their use is not yet widespread in developing countries such as Côte d'Ivoire (Kattan et al., 2008). Also, the high cost of this antibiotic might limit its use in self-medication treatment of bacterial infections. The prevalence of MDR strains in our study is higher than the one observed at the teaching hospital of Treichville in the southern Abidjan, where MDR prevalence for *E. coli* and *Klebsiella* were

14.4 and 23.1% respectively (Moroh et al., 2014). Multiple Antibiotic Resistance Index values are greater than 0.2 (0.59 for *E. coli* and 0.51 for *Klebsiella* spp.), showing that strains of *Klebsiella* spp. and *E. coli* are originating from an environment where the selection pressure due to excessive prescribing or abusive use of broad-spectrum antibiotics is alarming (Tambekar et al., 2006; Sbiti et al., 2017). This observed multi-resistance phenotype could be linked to an accumulation of several resistance mechanisms encoded in bacterial genome (Ekwealor et al., 2016). Otherwise, the variability of the antibiotic resistance profile between isolates of bacterial species could be due to the fact that patients from our study might have acquired UTI involving strains from diverse origin comprising domestic animals, where the pressure of the drugs was applied differently (Manges et al., 2001; Vincent et al., 2010; Jakobsen et al., 2011). Also, the medication behavior of the population in UTI treatment with under-dosage, non-respect of the treatment plan, use of the remaining drugs, excessive use of antibiotics without medical advice and taking antibiotics for viral infections (Alhomoud et al., 2017) could be some of the reasons behind variability of antibiotic resistance profiles observed.

Conclusion

In this study, the culture-positive rate of uropathogens was high with the majority coming from female patients. *E. coli* and *Klebsiella* spp were the most common Gram negative bacilli isolated. The antibiotic resistance profile of *E. coli* and *Klebsiella* spp. strains is alarming in patients attending Abobo-Avocatier Hospital with high levels of antibiotic resistance. The high value of Multiple Antibiotic Resistance Index and the rate of multi-resistance (MDR) from this site suggest the need for continuous monitoring of antibiotic susceptibility profile of bacteria implicated in UTI prior to antibiotic prescription in order to ensure optimal and desired treatment. Based on variations in antibiotic resistance profiles observed in the bacterial species studied, we plan to study the genetic relationships between bacterial strains and to characterize the different resistance mechanisms involved using molecular biology and bioinformatics tools.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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