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Original article

Comparing antibiotic susceptibility profiles of urinary tract infection isolates in a university hospital in Burkina Faso: Community vs. hospital profiles

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ABSTRACT

Background: The emergence of antimicrobial resistance (AMR) within bacterial pathogens necessitates a local comprehension of the epidemiological context. This information is indispensable for both clinical therapeutic determinations and the reevaluation of prevailing care protocols. This study aimed to highlight the antibiotic susceptibility profile of uropathogenic bacteria isolated within a university hospital in Burkina Faso, with a focus on enhancing probabilistic antibiotic therapy for both community and hospital-based urinary tract infections (UTIs). **Methodology**: Data from cytological urine analysis and antimicrobial susceptibility testing spanning 29 months (January 2017 to May 2019) was retrospectively collected and systematically analyzed. **Results**: In both hospital and community based UTIs, Enterobacterales dominated, constituting 79.86% (81.27% vs. 79.11%) of isolates. This was followed by non-fermentative Gram-negative bacteria at 6.60% (6.35% vs. 6.88%) and Gram-positive cocci at 6.41% (7.98% vs. 5.57%). *Escherichia coli* (61.37%), *Klebsiella pneumoniae* (10.66%), and *Enterobacter* spp. emerged as the predominant pathogens in the same rank regardless of the origin of the ITUs. Imipenem (97.19%), amikacin (69.26%), ceftriaxone (58.44%), and ciprofloxacin (47.60%) displayed superior susceptibility against all uropathogens. Subtle but significant variations emerged between hospital and community strains' susceptibility to various antibiotics, including amoxicillin + clavulanic acid (26.05% vs. 32.26%), Imipenem (96.43% vs. 98.59%), and ciprofloxacin (45.51% vs. 51.41%). **Conclusion**: Penicillins showcased diminished efficacy against uropathogens, while resistance to fluoroquinolones escalated. The combined use of aminoglycosides and third-generation cephalosporins holds promise as an optimal probabilistic therapy for UTIs. Notably, the profiles of hospital and community UTIs showed substantial similarities in terms of implicated uropathogens, yet hospital strains demonstrated higher resistance levels.

Introduction

Urinary Tract Infections (UTIs) encompass a diverse range of infections within the urinary system [1]. Among bacterial infections in adults, UTIs stand out as the most prevalent, accounting for approximately 150 million cases annually worldwide. These infections manifest across both

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hospital and community settings, each potentially exhibiting distinct microbial profiles [2,3]. Despite this widespread prevalence, population-based incidence data remain scarce, particularly within sub-Saharan Africa, notably Burkina Faso. Biomedical laboratory investigations indicate that around one-third (1/3) of urine cytological and bacteriological analysis yield positive results, contributing to a hospital prevalence that can exceed 30% [4,5].

Resource-constrained regions, such as Burkina Faso, grapple with challenges related to the cost and accessibility of cytological and bacteriological urine analysis, particularly in primary and intermediate healthcare facilities [6]. These limitations propel the adoption of probabilistic antibiotic therapy due to the lack of local microbiological insights. Consequently, inappropriate antibiotic regimens might contribute to escalating antibiotic consumption, exacerbating the pervasive issue of antibiotic resistance [8,9]. Moreover, the potential for renal complications stemming from inadequately managed UTIs adds another layer of concern [7].

This study endeavors to delineate the antibiotic susceptibility profiles of uropathogenic bacteria isolated from UTIs within a university hospital in Burkina Faso. The primary objective is to enhance the precision of probabilistic antibiotic therapy for both community and hospital-based UTIs. By comparing and contrasting microbial susceptibilities, this research seeks to shed light on potential variations between these distinct settings, providing valuable insights into optimizing treatment strategies.

Methodology

Study site and design

This investigation was carried out within the bacteriology laboratory of the Sourô Sanou University Hospital (SSUH) in Bobo-Dioulasso. It constituted a cross-sectional study, spanning January 2017 to May 2019, and encompassing data derived from cytological and bacteriological urine analysis, along with records of antibiotic susceptibility testing. Patient categorization was based on hospitalization duration, classifying those admitted for more than two days as inpatients. Additionally, individuals transferred from other hospitals (of lower tier) and admitted within the preceding two days were also considered inpatients. All remaining cases were designated as community patients.

Collection of urine

Urine was collected using the midstream technique. Briefly, patients were advised to wash and dry their hands thoroughly before opening the container and collecting the midstream urine that had been in the bladder for at least 4 hours in the morning [10]. In some cases, urine samples were obtained from indwelling catheters. Urine samples were delivered to the laboratory within 1-2 hours for cytological and bacteriological urine analysis, and antibiotic susceptibility testing (AST).

Cytological and bacteriological urine analysis and interpretation

The cytological examination comprised both quantitative and qualitative analysis. Quantitative cytology was conducted using the KOVA cell method as per the manufacturer's guidelines. Qualitative cytology involved analyzing the urine pellet obtained through centrifugation at 3000 rpm for 5 minutes.

The interpretation of the analysis was conducted in accordance with the Kass criteria, as adapted by the French Society of Microbiology (FSM) [10]. The threshold for culture positivity was set at $\geq 10^3$ CFU/ml, following 18–48 hours of incubation on a media plate (CLED and EMB or URISELECT® agar media, depending on their availability) at 37°C under aerobic conditions. Cultures displaying 2 or more organisms were categorized as specimens contaminated. Bacterial identification relied on both cultural and biochemical characteristics employing the Analytical Profile Index (API bioMérieux, Marcy l'Étoile, France) and combined tests [11].

Antibiotic susceptibility testing

Antibiotic susceptibility testing (AST) was conducted using the Kirby-Bauer agar diffusion method. The interpretation of the results was carried out in accordance with the recommendations provided by the European Committee on Antimicrobial Susceptibility Testing and the antibiogram committee of the French Society of Microbiology (EUCAST/ACFSM) version 2015 [12]. The following antibiotic discs (ThermoFisher Diagnostics, Oxoid, France) were employed: PeniG 1UI, ampicillin (AM) 10µg, amoxicillin-clavulanic acid (AMC) 20-10µg, ceftriaxone (CRO) 30µg, ceftazidime (CAZ) 10µg, cefepime (FEP) 30µg,

cefoxitin (FOX) 30µg, imipenem (IMP) 10µg, gentamicin (GN) 10µg, amikacin (AK) 30µg, ciprofloxacin (CIP) 5µg, trimethoprim-sulfamethoxazole (SXT) 1.25/23.75 µg, nitrofurantoin (NR) 100µg, and fosfomycin (FOS) 200µg, erythromycin (ERY) 15 µg, lyncomycin (L) 15 µg, fusidic Acid (FA) 200 µg, lyncomycin (L) 15 µg.

The screening for extended-spectrum beta-lactamase (ESBL) production was conducted using a synergy test, involving the placement of a central disc of amoxicillin/clavulanic acid at a distance of 30 mm from a disc containing a third-generation cephalosporin (ceftazidime, ceftriaxone) or a fourth-generation cephalosporin (cefepime). The methicillin-resistant *Staphylococcus aureus* (MRSA) profile was screened using a cefoxitin (FOX) 30µg disc. Quality control measures included biweekly testing of susceptible reference strains in line with the EUCAST/ACFSM guidelines [12].

Variables and data analysis

The collection and organization of data were facilitated through the utilization of Microsoft Excel. The data was analyzed using Stata software version 15.1. Statistical comparisons were made using the chi-square test. A p-value less than or equal to 0.05 was considered statistically significant.

Ethical considerations

The study was conducted using laboratory data from routine analyses under anonymous conditions.

Results

Epidemiological distribution

During the study period, a total of 3854 requests were received by the bacteriology unit at SSUH for cytological and bacteriological urine analysis, of which 2312 were from inpatients and 1542 were from community patients. The average age of the study population was 45.84 ± 21.28 years, with a wide age range of 12 days to 95 years, and a sex ratio (M/F) of 1.23. Out of these requests, 1763 (45.74%) met the biological diagnostic criteria for cytological and bacteriological urine analysis. The prevalence of urinary tract infections (UTIs) was 39.42% among community patients and 49.70% among hospitalized patients. Stratifying by gender and age, the differences in prevalences were statistically significant (***p***<0.0001) with a prevalence of 48.24% in women and 41.12% in men aged older than 45 years.

Bacteriological patterns

A total of 1763 microorganisms (614 cases from outpatients vs. 1149 cases from inpatients) were isolated from the urine samples including 1639 bacterial isolates belonging to 14 distinct genera and 124 yeast isolates of the genus *Candida*. The bacteriological profiles of hospital and community-acquired UTIs were both dominated by Enterobacteriales (79.86%). *Escherichia coli* was the most predominant species (61.37%) followed by *K.pneumoniae* (10.66%), *Enterobacter* spp.(2.50%), *Citrobacter* spp. (1.30%), *Proteus* spp. (1.30%) as described in the following table **(Table 1)**. *Candida* spp, non-fermenting Gram-negative bacilli, and Gram-positive cocci represented 7.03%, 6.69%, and 6.24% of the bacterial isolates, respectively.

Antibiotic resistance profile of the main bacterial strains

Hospital-acquired isolates of Enterobacteriales and non-fermenting Gram-negative bacilli exhibited a higher degree of antibiotic resistance across various antibiotic families compared to community bacterial isolates. In vitro analysis revealed that among Gram-negative bacilli, imipenem (0-24.1%), ceftriaxone (32.7-43.4%), amikacin (0-45.5%), and ciprofloxacin (0-61.7%) displayed the lowest levels of resistance, as illustrated in **figure (1)**, and detailed in **table (2)**. Moreover, hospital-acquired strains of *S. aureus* consistently demonstrated elevated resistance levels in comparison to community *S. aureus* isolates. Notably, penicillins exhibited greatly reduced efficacy against these *S. aureus* isolates, with antibiotic-resistant strains ranging from 74.3% to 92.9%.

Prevalence of ESBL and MRSA resistance phenotypes in UTI

Out of 1526 Gram-negative bacilli isolates, 379 were ESBL producers giving a prevalence of 24.84%. This prevalence was higher among hospital bacterial isolates (27.53%) compared to community bacterial isolates (19.89%). This represented a 1.5 times rate more likely to contract a UTI with this enzyme-producing Gram-negative bacillus in a hospital setting. The proportion of ESBL-producing bacterial strains was higher for *E.coli* (27.82%), followed by *K.pneumoniae* (23.94%) and *P.aeruginosa* (15.69%). The prevalence of MRSA was 11.59%.

Overall activity of commonly prescribed antibiotics for UTIs treatment

Regarding the overall in vitro activity level of the different commonly used antibiotics on any bacterial strain isolated from UTIs **(Table 2)**, amoxicillin (4.86%), amoxicillin + clavulanic acid (28.36%), and ceftazidime (28.36%) represented the beta-lactams with the lowest in vitro activity level on the uropathogenic bacteria. Ceftriaxone (58.44%) and imipenem (97.19%) maintained relatively high levels of activity in vitro. The fluoroquinolones family, particularly ciprofloxacin, was active on 47.60% of the strains with higher activity on community strains.

Aminoglycosides, in particular, amikacin (62.88%) and gentamicin (69.26%) were the class of antibiotics with the best activity. The combination of ceftriaxone and amikacin could inhibit more than 86% of activity in vitro on bacterial uropathogenic isolates from community and hospital settings.

Table 1. Comparative distribution of germs isolated community and hospital acquired UTIs

	Isolated germs	Outpatients n **(%)**		Inpatients n **(%)**		**Total** n **(%)**		***p*-value**
Enterobacteriaceae GNB		**499**	**(81.27)**	**909**	**(79.11)**	**1408**	**(79.86)**	**0.14**
	E. coli	389	(63.36)	693	(60.31)	1082	(61.37)	
	K. pneumoniae	55	(8.96)	133	(11.58)	188	(10.66)	
	Enterobacter spp.	15	(2.44)	29	(2.52)	44	(2.50)	
	Citrobacter spp.	9	(1.47)	14	(1.22)	23	(1.30)	
	Proteus spp.	9	(1.47)	14	(1.22)	23	(1.30)	
	Klebsiella spp.	10	(1.63)	10	(0.87)	20	(1.13)	
	Seratia spp.	6	(0.98)	7	(0.61)	13	(0.74)	
	Shigella spp.	5	(0.81)	4	(0.35)	9	(0.51)	
	Providencia spp.	0	(0.00)	3	(0.26)	3	(0.17)	
	M. morganii	1	(0.16)	1	(0.09)	2	(0.11)	
	Salmonella sp.	0	(0.00)	1	(0.09)	1	(0.06)	
Non-fermentative GNB		**39**	**(6.35)**		**79(6.88)**	**118**	**(6.69)**	**0.66**
	P. aeruginosa	14	(2.28)	37	(3.22)	51	(2.89)	
	A. baumannii	18	(2.93)	17	(1.48)	35	(1.99)	
	Pseudomonas sp.	7	(1.14)	11	(0.96)	18	(1.02)	
	Acinetobacter sp.	0	(0.00)	14	(1.22)	14	(0.79)	
Gram-positive cocci		**49**	**(7.98)**	**64**	**(5.57)**	**113**	**(6.41)**	**0.02**
	S. aureus	35	(5.70)	29	(2.52)	64	(3.63)	<0.001
	S. epidermidis	6	(0.98)	22	(1.91)	28	(1.59)	
	S. saprophyticus	7	(1.14)	12	(1.04)	19	(1.08)	
	Streptococcus sp.	1	(0.16)	1	(0.09)	2	(0.11)	
Yeast		**27**	**(4.40)**	**97**	**(8.44)**	**124**	**(7.03)**	**1.00**
	Candida sp.	27	(4.40)	82	(7.14)	109	(6.18)	
	C. albicans	0	(0.00)	15	(1.31)	15	(0.85)	
Total		**614**	**(100.00)**	**1149**	**(100.00)**	**1763**	**(100.00)**	

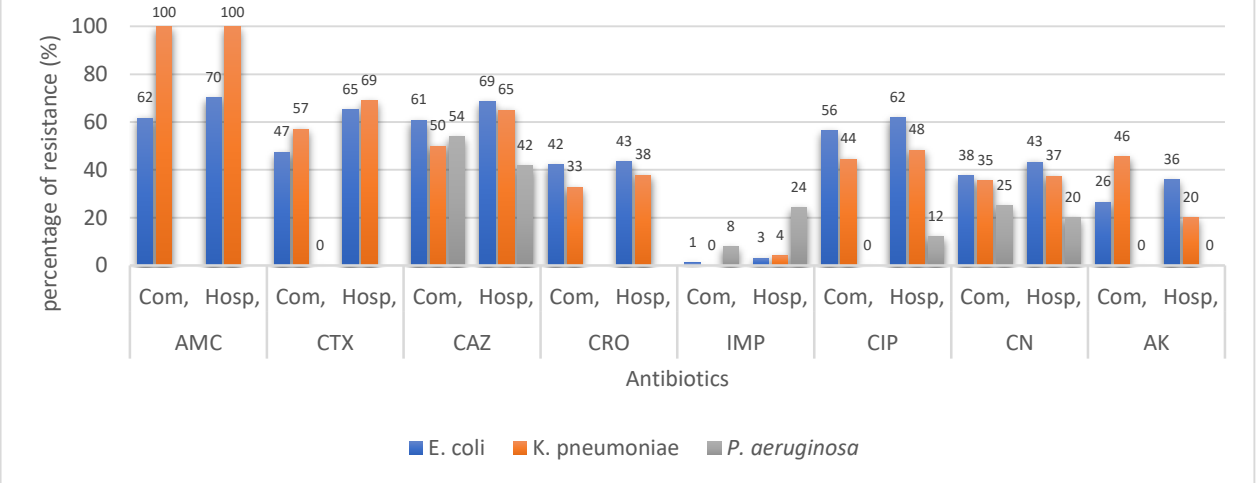
GNB: Gram-negative Bacilli

Table 2. Comparative overall level of susceptibility of causative bacteria to commonly used antibiotics

Antibiotic	Community strains N (%)		Hospital strains N (%)			Total N (%)	*p*-value
Beta-lactams							
Amoxicillin	27	(5.40)	36	(4.53)	63	(4.86)	0.239
Amoxicillin + clavulanic acid	160	(32.26)	218	(26.05)	378	(28.36)	0.007
Cefoxitin	34	(87.18)	23	(57.50)	57	(72.15)	0.002
Ceftazidime	134	(40.00)	250	(35.71)	384	(37.10)	0.091
Ceftriaxone (CRO)	285	(59.50)	480	(57.83)	765	(58.44)	0.278
Imipenem	420	(98.59)	756	(96.43)	1176	(97.19)	0.015
Fluoroquinolones							
Ciprofloxacin	236	(51.42)	380	(45.51)	616	(47.60)	0.021
Aminosides							
Amikacin (AMK)	97	(71.32)	90	(67.16)	187	(69.26)	0.229
Gentamicin (GM)	364	(66.30)	527	(60.71)	891	(62.88)	0.017
Other antibiotics							
Cotrimoxazole	96	(51.34)	70	(33.02)	166	(41.60)	<0.001
Erythromycin	17	(47.22)	14	(48.28)	31	(47.69)	0.534
CRO+Aminoside combination							
CRO+GM	373	(80.21)	580	(73.98)	953	(76.30)	0.006
CRO+AK	76	(86.36)	82	(87.23)	158	(86.81)	0.431
p-value (CRO+GM vs CRO+AK)		0.088	0.002		0.001		

AMK: Amikacin; GM: Gentamicin; CRO: Ceftriaxone

Figure 1. Comparative resistance of the main species isolated during community and hospital-acquired UTIs



Discussion

Urinary tract infections (UTIs) in developing countries constitute a prominent cause of antimicrobial consumption, prevalent in both hospital and community settings [15]. The choice of antibiotics in these regions has traditionally relied upon non-national guidelines due to the absence of local data [40]. The aim of this study was to bridge this information gap by delivering a comprehensive profile comparison between hospital-acquired and community-acquired uropathogenic infections. This endeavor seeks to enhance the management and treatment of UTIs in the region of Bobo-Dioulasso, Burkina Faso.

The overall prevalence of urinary tract infections (UTI) was 45.74% in this study. **Afriyie et al.** in 2014 [14], **Lahlou Amine et al.**[15] in 2009 and **Yusuf et al.** in 2016 [16] reported the prevalences of UTIs of 15.9% in Ghana, 12.2% in Morocco and 14.0% in Belgium, respectively. These prevalences are four times lower than the one found in this study. However, higher prevalences of UTIs were also found in Nigeria by **Oladeinde et al.** in 2011 (39.0%) [17] and **Otajevwo et al.** in 2013 (39.69%) [18], and in Bangladesh by **Akhtar et al.** in 2017 (58.9%) [19]. One of the highest UTIs prevalence (89%) was mentioned by **Karou et al**. [20] in their study on the positive urine culture in a hospital in Ouagadougou (Burkina Faso) in 2009. The high prevalence of UTI in our population could be partly explained by the structure of our study population characterized by the predominance of hospitalized and elderly patients. We could argue that there has been a resurgence of UTIs in the population of Bobo-Dioulasso and the surrounding localities. Previously, **Sanou et al.** in 2012 [5], indicated a high prevalence of UTIs (31.2%) from the same city. Prospective studies will be essential for confirmation of this upward trend in UTIs and an understanding of associated factors.

The bacteriological profile of UTIs shows a predominance of Enterobacteriales species (79.86%) in this study. The frequencies of Enterobacterales predominance vary from one study to another [21,22]. Indeed, the bacterial epidemiology of UTI remains largely dominated by enterobacteria, which are commensal microorganisms of the digestive system. This is consistent with the pathophysiology of UTI, in which the transmission of microorganisms occurs mainly through the ascending route due to poor hygiene as a contributing factor [23,24]. Among the enterobacteria, *E. coli* is the most predominant and represented 61.37% of the isolates. Regardless of the epidemiological subgroup, this bacterium alone can represent more than half of the isolated microorganisms in some circumstances [4,25,26]. This high frequency of *E. coli* in urinary tract infections is justified by its virulence factors such as fimbriae for adhesion, flagella for movement, and various mechanisms for evading host immune system defenses.

The proportions of resistant Gram-negative bacilli (GNB) isolates in hospitalized patients to all families of antibiotics, particularly for the penicillin family, were relatively high in this study. As reported by several authors, *E. coli* are often resistant to penicillins with a 94.8-95.3% resistance rate to amoxicillin and 61.6% to 70.2% resistance rate to amoxicillin + clavulanic acid [27-29]. These results are also in agreement with the findings of **Bernabé et al.** [27] who reported 75.4% and 97.0% resistance rates for *E. coli* and *K. pneumoniae* to amino-penicillins in their review on antimicrobial resistance in the West African region. **Kpoda et al**. [29] also reported a similar resistance profile in three hospitals in Ouagadougou (Burkina Faso). This high inactivity of penicillins and beta-lactamase inhibitors suggests either a high-level penicillinase production or an ESBL production (9). The second hypothesis seems more plausible in view of the cephalosporin resistance profile of these bacteria, which is marked by a resistance rate that can reach more than two-thirds of the bacterial isolates. Indeed, ESBLs are enzymes that hydrolyze all beta-lactams except cephamycins and carbapenems. The production of ESBL is the most common mechanism of multidrug resistance in Enterobacteriales [24,27,30]. In this study, this enzyme was produced by 19.89% and 27.53% of community and hospital bacterial isolates, respectively. This accounted for an overall frequency of 24.84% of ESBL-producing bacteria. In opposition to other studies, especially in Europe and North America, the frequency of ESBL is globally higher in this study with a worrying level of ESBL expression found among community strains. **Lahlou Amine et al.** [15] in Morocco reported a frequency similar to ours in hospitals (24%) but found a lower frequency in community settings (1.5%). Our results are also similar to those of **Sultana et al.** [28] in Bangladesh in 2018 who reported 25.84% of uropathogenic ESBL-producing

E. coli. This high rate of ESBL production in Burkina Faso correlate with the studies of **Ouédraogo et al.** [31], **Kpoda et al**. [29], and **Kafando et al.** [41] who found 58% , 52.72% and 51.5% uropathogenic ESBL-producing Enterobacteriales, respectively. **Ouédraogo et al.** also reported [32] a high prevalence (42%) of ESBL-producing Enterobacteriales species from fecal samples of hospitalized patients. These are germs that colonize the digestive flora and are often released in fecal materials, and invade the urinary tract through ascending pathways [23,33]. The production of ESBL by Enterobacteriales species is generally associated with their resistance to other families of antibiotics such as fluoroquinolones and aminoglycosides [15,31,34].

In our study, resistance to fluoroquinolones was higher, with more than half of the strains resistant to ciprofloxacin, compared to studies carried out by **Nautica** study in the USA [35] and **Abdelmalek et al.** [36] in Tunisia. The authors reported lower prevalences of antibiotic resistance, which represented 5.5% and 10%, respectively. **Afriyie et al.** [37] in Ghana (35.9%) and **Kpoda et al.** [29] in Ouagadougou (61.1%) reported similarly high frequencies, and of resistance respectively. Indeed, the resistance of uropathogenic *E. coli* and *K. pneumoniae* to ciprofloxacin is increasing in the West African regions [27]. This high level of resistance, particularly in Burkina Faso, could be explained by several factors. In fact, ciprofloxacin is formulated as tablet and marketed as an affordable generic drug, which makes it more accessible. The accessibility to this antibiotic among other factors is facilitated by the lack of enforcement of existing regulations on medical prescriptions [8]. As a result, there is abuse in the treatment of both suspected UTIs and salmonellosis. This overconsumption could constitute a strong selection pressure on the bacteria of the digestive flora with a high risk of selection of resistant mutants [27]. There were also resistant bacterial isolates to aminoglycosides such as gentamicin (20 to 43%) and amikacin (0 to 45%) but at a minimum level compared to other classes of antibiotics. However, amikacin displayed good activity on both hospital and community strains, unlike gentamicin which has a significantly lower activity on hospital strains. The aminoglycoside class of molecules is relatively unaffected, probably because of their galenic presentation as injectable drugs, and hence, only use in hospital settings. The overuse of gentamicin in the hospital setting due to its availability in generic form, with its low cost and accessibility to all levels of healthcare, may be the source of selection pressure, thus justifying the relative decline in its activity on uropathogenic isolates from hospitals compared with amikacin, which is not very affordable. As recommended by several consensuses [38,39,42], the combination of 3rd generation cephalosporins and aminoglycosides , in particular the combination of ceftriaxone and amikacin, could remain the best alternative for the treatment of complicated UTI in our context. Interestingly, the combination of these two molecules allowed to obtain an in vitro activity up to 86.81% on the bacterial isolates responsible of UTI in this study.

Regarding the antibiotic susceptibility profile of the uropathogens to carbapenems, this class of antibiotics generally maintains good activity as reported by other authors [15,19,29,31]. Furthermore, this class of antibiotics have been preserved against bacterial resistance due to its high cost, thus limiting its abusive consumption. However, in view of the increasingly frequent therapeutic impasses due to the growing inactivity of other molecules, particularly on nosocomial germs, its use is becoming unavoidable, thus justifying the high resistance found in *P. aeruginosa* isolates falling around 24%. In any case, imipenem could not be a better therapeutic alternative for probabilistic treatment, as it is the last resort antibiotic active on Enterobacteriales species available in our context. Therefore, other therapeutic alternatives could be considered accordingly to preserve as much as possible this last resort of antibiotics.

Considering the resistance of the Gram-positive cocci, Hospital isolates of *S. aureus* also showed a higher level of resistance compared to community strains regardless of the antibiotic family. The higher selection pressure in the hospital setting may explain this pattern. In this study, penicillins lost almost its activity (74.3%-92.9%), while lincomycin and gentamicin remained the most active antibiotics in vitro. The high level of resistance of *S. aureus* to penicillins limits their use as an empirical treatment for UTIs. Unlike aminoglycosides, the unrestrictive accessibility to penicillins in the West African context, due to their low cost and their preferential galenic preparation as tablets form facilitates their irrational use in hospital settings and communities (self-medication) [43].

Conclusion

This study highlights a persistent high prevalence of UTIs in Bobo-Dioulasso's referral hospital, primarily driven by Enterobacteriales, particularly *E. coli*, regardless of the infection source (hospital or community). Notably, hospital-acquired strains exhibit greater antibiotic resistance, especially with penicillins, posing a risk of treatment failure. Rising resistance trends with fluoro-quinolones and cephalosporins warrant attention. Aminoglycosides remain effective, possibly due to their formulation. Combining aminoglycosides with 3rd generation cephalosporins holds promise for improved probabilistic therapy in complex UTI management.

Conflicts of interest

The authors declare no conflict of interest

Contributions of the authors

Abdoul-Salam Ouédraogo: Initiation, conception, and scientific guarantor of the study; Mahamoud Issaka: File review, data entry, first basic data analysis; André NAGALO: Second data analysis, bibliographic research, and writing of the article. Odilon Kaboré, Senkaye-Lagom Aimée Kisso, and Boukary Kabré: first reading and reorientation of the manuscript; the other authors reread the manuscript and made corrections. All authors read and approved the final version of the manuscript.

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