

Trends in Antimicrobial Resistance among *Enterobacteriaceae* Uropathogenic Strains in Burkina Faso: Insights from Six Years of Laboratory Data

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Abstract

Introduction: The increasing incidence of urinary tract infections (UTIs) caused by multidrug-resistant organisms represents a pressing global health challenge. The current study aims to investigate longitudinal trends in antibiotic resistance among *Enterobacteriaceae* isolated from urine samples in Burkina Faso. **Methods:** A retrospective study was conducted at three medical laboratories in Burkina Faso over 6 years (January 1, 2017, to December 31, 2022). Data extracted from laboratory registers included patient demographics (age and sex), bacterial species identified, and antimicrobial susceptibility testing results. **Results:** Data from 5,310 positive patient urine cultures were extracted and analyzed in this study. *Escherichia coli* (67.12%) and *Klebsiella pneumoniae* (25.99%) were the predominant species. There was a marked increase in resistance to key antibiotic classes: amoxicillin resistance rose from 50.6% to 92.7%, ciprofloxacin from 43.2% to 60.2%, and third-generation cephalosporins from 36.0% to 53.4%. Multidrug resistance (MDR) prevalence increased from 80.9% to 92.1% over the study period. **Conclusions:** The study highlights a critical escalation in antimicrobial resistance among uropathogens in Burkina Faso. Incorporating local resistance data into empirical treatment guidelines and investing in diagnostic stewardship are essential to preserve treatment efficacy and prevent the spread of resistant strains.

Keywords

Antimicrobial Resistance, Urinary Tract Infections, *Enterobacteriaceae*, Multidrug Resistance, Burkina Faso

1. Introduction

Urinary tract infections (UTIs) remain among the most prevalent bacterial infections worldwide, accounting for nearly 40% of all reported bacterial infections [1]. Each year, approximately 150 million cases are diagnosed globally, contributing to a substantial public health burden both clinically and economically, with annual costs exceeding six billion US dollars [2] [3].

The causative agents of UTIs include a spectrum of Gram-negative and Gram-positive bacteria, as well as some fungal pathogens. Notably, members of the *Enterobacteriaceae* family are implicated in more than 90% of both community and hospital-acquired UTIs [1]. *Escherichia coli* is the primary etiological agent, responsible for approximately 40 - 70% of cases, followed by other species such as *Klebsiella pneumoniae*, *Proteus mirabilis*, *Acinetobacter baumannii*, and *Citrobacter* spp. [4] [5].

Clinically, UTIs present with a variety of symptoms, including dysuria, increased urinary frequency and urgency, suprapubic discomfort, fever, chills, nausea, and vomiting [6]. Epidemiological data indicate that 50 - 60% of women will experience at least one UTI episode in their lifetime [7]. This increased vulnerability is associated with anatomical and physiological factors—such as a shorter urethra, lack of prostatic secretions, and the proximity of the urethral meatus to the vaginal and anal areas—as well as additional risk factors including age, hygiene practices, socioeconomic status, catheterization, hospitalization, sexual activity, pregnancy, and diabetes [6].

In many low- and middle-income countries (LMICs), empirical antibiotic therapy is frequently administered without microbiological confirmation [8]. This practice contributes to the inappropriate use of antibiotics and accelerates the emergence of antimicrobial resistance (AMR), which is recognized as a significant public health challenge, particularly in sub-Saharan Africa [9]. Recent studies from Africa have reported high prevalence rates of multidrug-resistant uropathogenic bacteria, including strains producing extended-spectrum β -lactamases (ESBLs), which significantly limit therapeutic options and underscore the need for robust resistance surveillance [10] [11]. Resistance patterns can differ widely by region due to local variations in healthcare practices and pathogen dynamics. Therefore, ongoing surveillance and longitudinal data collection on AMR among uropathogens are crucial for guiding empirical treatment and informing public health strategies [12]. Despite the global relevance of AMR surveillance, data remain scarce in many LMICs.

In Burkina Faso, systematic monitoring of AMR has been hindered by limited

laboratory capacity, infrastructural challenges, and inconsistent data reporting [12]. Consequently, national-level resistance data across human, animal, and environmental reservoirs remain fragmented. The present study addresses this gap by evaluating the prevalence and trends of AMR in uropathogenic *Enterobacteriaceae* over a six-year period, using data collected from three major medical laboratories in Ouagadougou.

2. Materials and Methods

2.1. Study Design and Period

A retrospective study was conducted using data from routine urine microbiological examinations performed between January 1, 2017, and December 31, 2022. The dataset was compiled from three clinical laboratories in Ouagadougou, Burkina Faso: Yalgado Ouédraogo University Hospital Center (CHU-YO), the National Agency for Health and Safety in Environment, Food, Work, and Health Products (ANSSEAT), and Saint Camille Hospital of Ouagadougou (HOSCO). The analysis focused on antimicrobial susceptibility testing (AST) results of *Enterobacteriaceae* isolated from urine samples collected from adult inpatients and outpatients of both sexes.

2.2. Bacterial Identification and Antimicrobial Susceptibility Testing

In all participating laboratories, sample processing, bacterial identification, and AST were performed in accordance with standardized operating procedures (SOPs). Urine samples were initially examined microscopically, then cultured on both non-selective Cystine Lactose Electrolyte-Deficient (CLED) agar and selective Eosin Methylene Blue (EMB) agar, and were incubated at 37°C for 18 - 24 hours. After incubation, suspected colonies underwent Gram staining, followed by identification using the API 20E identification system (bioMérieux). Pure colonies were suspended in 0.9% NaCl solution to achieve a turbidity equivalent to a 0.5 McFarland standard. AST was then performed on Müller-Hinton agar using the disk diffusion method, with antibiotic discs applied directly to the inoculated plates. Plates were incubated at 37°C, and inhibition zones were measured after 24 hours. Susceptibility was interpreted annually using the clinical breakpoints defined by the Antibiogram Committee of the French Society of Microbiology (CA-SFM).

2.3. Data Inclusion Criteria

Data extracted from laboratory registers included patient demographics (age and sex), bacterial species identified, and AST profiles. All data were anonymized and transferred to Microsoft Excel (2016). Only records with complete demographic and phenotypic AST data were included. Duplicate cultures from the same patient and isolates with incomplete antibiograms—*i.e.*, insufficient to determine multidrug resistance (MDR) status—were excluded. Bacterial isolates were classified as suscep-

tible or resistant (including intermediate resistance) for each antimicrobial tested. MDR was defined as acquired non-susceptibility to at least one agent in three or more antimicrobial categories, following internationally accepted criteria [13].

2.4. Statistical Analysis

Data were processed using Microsoft Excel and analyzed with R software (version 4.3.3). Descriptive statistics, including means and standard deviations, were calculated for continuous variables. Categorical variables were presented using frequency distributions. For proportion-based calculations, records with missing data for specific antibiotics were excluded from the denominator. A p-value < 0.05 was considered statistically significant.

3. Results

3.1. Socio-Demographic Characteristics

Out of 6533 positive urine cultures collected across three medical laboratories, 5310 met the inclusion criteria. Females accounted for 53.7% of cases, yielding a male-to-female ratio of 0.86. The mean age of patients was 46.2 years (± 23.2), with a median of 41 years and a maximum of 103 years. The 21 - 50-year age group represented the largest proportion of cases (38.7%), followed by individuals over 60 years (34.8%). A detailed demographic distribution is presented in **Table 1**.

Table 1. Demographic data of patients and distribution of *Enterobacteriaceae* strains.

Variable	Modality	Frequencies (%)
Sex N = 5069	Male	2343 (46.3)
	Female	2726 (53.7)
Age in years N = 4767	Mean age \pm SD	46.2 \pm 23.2
	≤ 1 year	193 (4.0)
	2 - 10 years	176 (3.7)
	11 - 20 years	233 (4.9)
	21 - 30 years	813 (17.1)
	31 - 40 years	592 (12.4)
	41 - 50 years	437 (9.2)
	51 - 60 years	665 (14.0)
	61 - 70 years	860 (18.0)
	71 - 80 years	609 (12.8)
	≥ 81	189 (4.0)
<i>Enterobacteriaceae</i>	<i>Cedecea lapagei</i>	1
	<i>Citrobacter spp.</i>	30
	<i>Cronobacter sakazakii</i>	1
	<i>E. coli</i>	3564

Continued

<i>Enterbacter cloacae</i>	89
<i>Enterbacter spp.</i>	20
<i>Klesiella pneumoniae</i>	1380
<i>Klesiella spp.</i>	58
<i>Klyvera spp.</i>	1
<i>Morganella morganii</i>	5
<i>Pluralibacter gergovioe</i>	2
<i>Proteus spp.</i>	141
<i>Providencia spp.</i>	5
<i>Raoultella ornithinolytica</i>	1
<i>Salmonella spp.</i>	3
<i>Serratia spp.</i>	6
<i>Shigella boydii</i>	2
<i>Yersinia enterocolitica</i>	1

3.2. Distribution of Enterobacterial Isolates

A total of 18 *Enterobacteriaceae* species were identified from urine cultures (**Table 1**). *E. coli* was the most frequently isolated species, accounting for 67.12% of cases, followed by *K. pneumoniae* (25.99%), *Proteus* spp. (2.7%), *E. cloacae* (1.7%), *Klebsiella* spp. (1.09%), and *Citrobacter* spp. (0.56%). Rarely isolated species included *Cedecea lapagei*, *Cronobacter sakazakii*, *Kluyvera* spp., *Raoultella ornithinolytica*, and *Yersinia enterocolitica*, each comprising 0.02% of isolates.

3.3. Antimicrobial Susceptibility Profiles

The highest resistance rates across all *Enterobacteriaceae* were recorded for ampicillin (84.0%), cotrimoxazole (72.8%), amoxicillin (64.9%), tetracycline (59.2%), ciprofloxacin (52.8%), and amoxicillin-clavulanate (50.6%) (**Table 2**). Resistance to third-generation cephalosporins ranged from 44.3% to 49.7%. Among aminoglycosides, gentamicin and tobramycin resistance was reported at 27.2% and 33.0%, respectively. The lowest resistance rates were observed for colistin (11.0%) and imipenem (7.5%).

- *E. coli* showed pronounced resistance to ampicillin (85.5%), cotrimoxazole (80.2%), and amoxicillin (66.7%), while resistance to imipenem (7.2%) and colistin sulfate (8.0%) remained low.
- *K. pneumoniae* isolates exhibited high resistance to ampicillin (84.9%) and amoxicillin (54.8%). Resistance to third-generation cephalosporins was moderate (ceftazidime: 43.7%, ceftriaxone: 35.8%), and similar trends were observed for cotrimoxazole (58.5%), tetracycline (46.3%), ciprofloxacin (31.7%), tobramycin (28.0%), and gentamicin (25.3%). Lower resistance was recorded for imipenem (5.8%), colistin (12.8%), and chloramphenicol (18.8%).

Table 2. Percentage of antibiotic resistance of the most frequent bacterial pathogens isolated from patient urine samples.

	Resistance rates in %					Total
	<i>E. coli</i>	<i>K. Pneumoniae</i>	<i>Proteus</i> spp.	<i>Enterbacter cloacae</i>	Other species	
Penicillins						
Ampicillin	85.5 (495/579)	84.9 (73/86)	57.7 (15/26)	60.0 (3/6)	81.8 (9/11)	84.0 (596/710)
Amoxicillin	66.7 (944/1415)	54.8 (154/281)	41.5 (17/41)	71.4 (10/14)	82.2 (30/34)	64.9 (1163/1793)
Penicillin/beta-lactam inhibitor						
Amoxicillin/ clavulanic acid	50.0 (1517/3032)	48.8 (502/1029)	34.7 (35/101)	60.3 (35/58)	83.3 (100/120)	50.6 (2214/4373)
Cephalosporins						
Ceftriaxone	47.6 (1294/2716)	35.8 (353/986)	14.4 (13/90)	48.8 (20/41)	56.1 (64/114)	44.3 (1760/3977)
Ceftazidime	53.0 (475/897)	43.7 (139/318)	16.7 (1/6)	35.0 (14/40)	46.2 (30/65)	49.7 (661/1329)
Carbapenems						
Imipenem	7.2 (128/1776)	5.8 (30/517)	8.6 (3/35)	8.6 (3/35)	19.7 (17/86)	7.5 (184/2453)
Folate pathway inhibitors						
Cotrimoxazole	80.2 (1379/1720)	58.5 (377/633)	55.2 (37/67)	56.5 (26/46)	56.4 (53/94)	72.8 (1881/2583)
Fluoroquinolones						
Ciprofloxacin	63.1 (1499/2375)	31.7 (299/942)	21.7 (18/83)	39.5 (15/38)	36.0 (40/111)	52.8 (1889/3578)
Norfloxacin	50.3 (232/461)	23.1 (27/117)	25.0 (4/16)	14.3 (1/7)	NA	44.0 (265/602)
Polymyxins						
Colistin	8.0 (13/163)	12.8 (23/179)	66.6 (2/3)	NA	NA	11.0 (38/347)
Phenicol drugs						
Chloramphenicol	15.4 (63/409)	18.8 (36/192)	25.0 (7/25)	NA	NA	16.9 (107/632)
Aminoglycosides						
Gentamicin	28.0 (520/1860)	25.3 (181/715)	12.0 (6/50)	12.0 (6/50)	30.6 (26/85)	27.2 (753/2768)
Tobramycin	34.8 (619/1779)	28.0 (199/711)	15.0 (9/60)	51.7 (15/29)	43.4 (23/53)	33.0 (874/2650)
Cyclins						
Tetracycline	65.2 (688/1056)	46.3 (224/484)	61.7 (29/47)	NA	NA	59.2 (943/1592)

- NA: not available.

3.4. Trends in Antimicrobial and Multidrug Resistance (MDR)

Resistance trends over the six-year study period revealed significant increases across key antibiotics (Table 3). Amoxicillin resistance rose sharply from 50.6% in 2017 to 92.7% in 2022 ($p < 0.001$), with a transient dip in 2020. A similar trend was observed for amoxicillin–clavulanate, increasing from 44.1% to 64.8% ($p < 0.001$). Ciprofloxacin resistance rose from 43.2% to 60.2% ($p < 0.001$), and ceftriaxone from 36.0% to 53.4% ($p < 0.001$). Resistance to ceftazidime remained relatively stable (36.0% to 44.8%, $p = 0.975$). Imipenem resistance declined significantly between 2017 (17.9%) and 2021 (2.6%) ($p < 0.001$), before increasing slightly to 6.0% in 2022 ($p = 0.003$). Cotrimoxazole resistance showed a moderate decline (72.6% in 2017 to 70.3% in 2022, $p = 0.5584$), while gentamicin resistance remained relatively unchanged (22.7% to 23.8%, $p = 0.7077$).

The proportion of MDR *Enterobacteriaceae* increased steadily from 80.9% in 2017 to 92.1% in 2022 (Figure 1), with *E. coli* and *K. pneumoniae* as the most frequently encountered MDR species (Figure 2).

Table 3. Trends in AMR of bacteria isolated from patients' urine samples (2017-2022).

Years	2017	2018	2019	2020	2021	2022
Penicillin						
Ampicillin	34/41 (82.9)	50/70 (71.4)	14/33 (42.4)	148/171 (86.5)	306/349 (87.7)	42/44 (95.5)
Amoxicillin	397/785 (50.6)	203/232 (61.1)	53/90 (58.9)	29/71 (40.8)	153/161 (95.0)	328/354 (92.7)
Penicillin/beta-lactam inhibitor						
Amoxicillin/clavulanic acid	345/783 (44.1)	471/825 (57.1)	183/271 (62.9)	372/871 (42.7)	391/906 (43.2)	452/697 (64.8)
Cephalosporins						
Ceftriaxone	230/639 (36.0)	268/812 (33.0)	115/210 (54.8)	339/672 (50.4)	417/912 (45.7)	391/732 (53.4)
Ceftazidime	74/167 (44.3)	131/240 (54.6)	73/117 (62.4)	56/133 (42.1)	105/177 (59.3)	222/495 (44.8)
Carbapenems						
Imipenem	45/252 (17.9)	35/366 (9.6)	9/104 (8.6)	43/433 (9.9)	20/766 (2.6)	32/532 (6.0)
Folate pathway inhibitors						
Cotrimoxazole	410/565 (72.6)	375/484 (77.5)	139/174 (79.9)	394/573 (68.8)	56.4 (53/94)	398/562 (70.3)
Fluoroquinolones						
Ciprofloxacin	306/709 (43.2)	317/707 (44.8)	114/175 (65.1)	343/579 (59.2)	404/735 (55.0)	405/673 (60.2)

Continued

	Aminoglycosides					
Gentamicin	104/459 (22.7)	101/497 (20.3)	31/102 (30.4)	156/498 (31.3)	218/612 (35.6)	143/600 (23.8)
Tobramycin	130/631 (19.7)	249/675 (36.9)	64/169 (37.9)	141/348 (40.5)	86/227 (37.9)	204/570 (35.8)

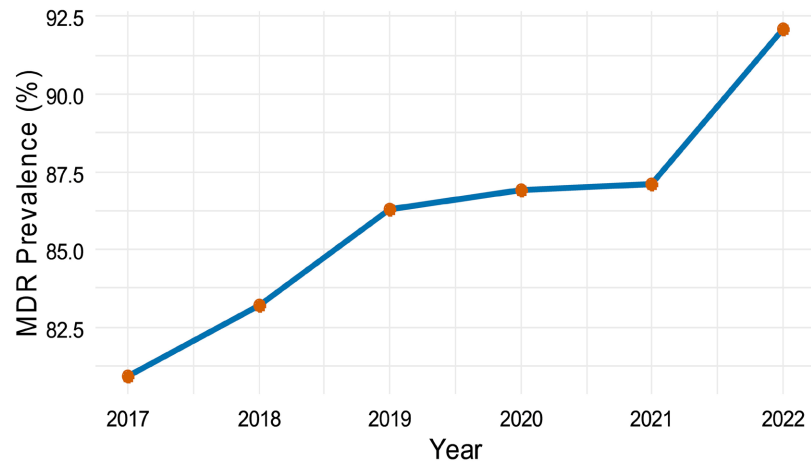


Figure 1. Trends of MDR uropathogenic strains isolated from patients' urine samples (2017-2022).

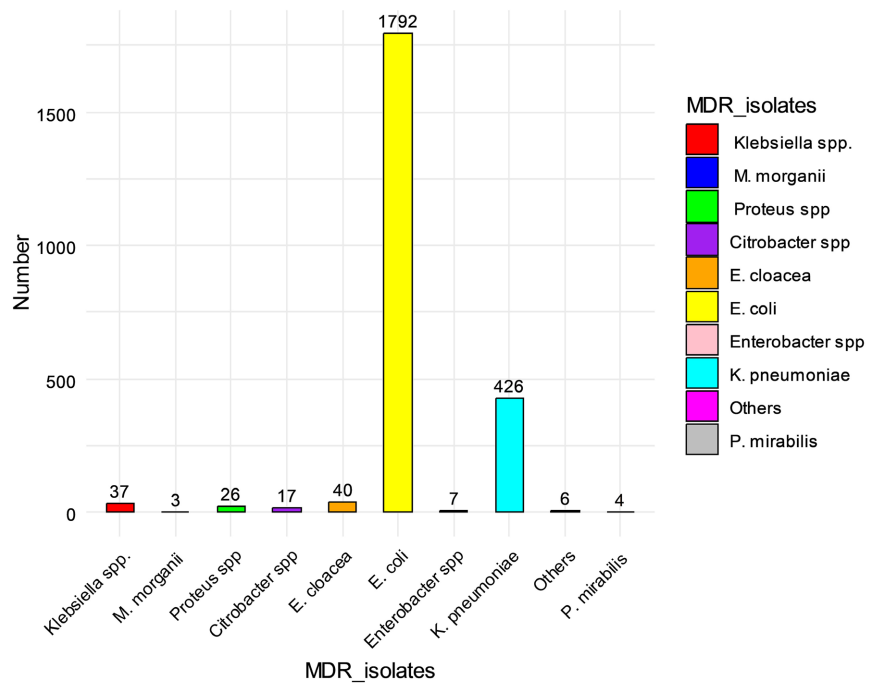


Figure 2. Frequency of MDR in individual bacterial pathogens isolated from 2017-2022.

4. Discussion

UTIs are among the most common bacterial infections worldwide, contributing

significantly to both community and hospital-acquired disease burdens [14]. In LMICs, empirical antibiotic therapy is still the standard approach, largely due to limited access to culture and susceptibility testing. While practical in resource-limited settings, this procedure increases the risk of inappropriate antimicrobial use, thereby accelerating the development and spread of AMR [8]. AMR surveillance of UTI pathogens is thus essential to improving empiric antibiotic selection.

This retrospective study evaluated data from 5310 urine cultures, identifying a slight predominance of female patients (53.7%), consistent with studies from Ethiopia and Mali [12] [15]. The higher UTI prevalence among women is primarily due to anatomical and physiological factors—including a shorter urethra, hormonal variation, and the proximity of the urethra to vaginal and anal regions—which promote ascending uropathogen colonization [16] [17]. Among the various age groups, individuals aged 21 - 50 years exhibited the highest prevalence of positive urine cultures, with a notable proportion occurring in patients over 60 years (34.8%). These findings align with established risk factors: behavioral and sexual activity patterns contribute to higher rates among younger adults, while age-related physiological decline, comorbidities, and diminished immune function explain the increased susceptibility among older individuals [18].

In the current study, *E. coli* was the most prevalent uropathogen, present in 67.6% of positive cultures, aligning with studies from Togo, Gambia, Tunisia, and the United States [4] [19]-[22]. This predominance is attributed to its gastrointestinal origin and capacity for urothelial colonization via multiple virulence factors [8] [23] [24].

Antibiotic resistance continues to escalate globally [9] [12]. In this study, isolates demonstrated high resistance to common oral antibiotics: ampicillin (84%), cotrimoxazole (72.8%), amoxicillin (64.9%), and tetracycline (59.2%). These patterns mirror findings across sub-Saharan Africa and highlight the impact of widespread antibiotic overuse [12] [14] [25]. Ciprofloxacin (52.8%) and third-generation cephalosporins—ceftriaxone (44.3%) and ceftazidime (49.7%)—showed moderate resistance, narrowing the scope of effective treatments. Resistance to last-resort antibiotics such as imipenem (7.5%) and colistin (11.0%) remained low, yet their use should be reserved for confirmed MDR/extensively drug-resistant (XDR) infections due to their toxicity and limited availability [26]. XDR bacteria are strains that exhibit nonsusceptibility to at least one agent in all but two or fewer antimicrobial categories—meaning they remain susceptible to only one or two classes of antimicrobial agents [27].

In this study, *E. coli* isolates demonstrated notably high resistance to penicillin-class antibiotics, with 85.5% of isolates resistant to ampicillin and 66.7% to amoxicillin. Furthermore, resistance to the β -lactam/ β -lactamase inhibitor combination (amoxicillin-clavulanic) was observed in 50% of isolates. Such high resistance rates likely reflect longstanding issues with inappropriate or excessive antibiotic use, as well as inadequate dosing practices in clinical settings. Resistance was also substantial for third-generation cephalosporins: 47.6% of *E. coli* isolates were re-

sistant to ceftriaxone and 53% to ceftazidime. Ciprofloxacin resistance was similarly high at 63.1%. Cotrimoxazole, a commonly prescribed agent in urinary tract infections, was ineffective against 80.2% of isolates, highlighting a concerning lack of viable oral options. By contrast, *E. coli* exhibited lower resistance rates to aminoglycosides, with 28% and 34.8% of isolates resistant to gentamicin and tobramycin, respectively. Carbapenem resistance remained relatively rare (7.2% for imipenem), possibly due to these agents' more judicious use in hospital environments, thereby minimizing selective pressure.

K. pneumoniae displayed resistance across multiple classes: 48.8% to amoxicillin-clavulanic acid, 58.5% to cotrimoxazole, and up to 43.7% for third-generation cephalosporins. Ciprofloxacin resistance was 31.7%, and aminoglycoside resistance remained under 30%. These resistance patterns likely reflect their frequent clinical use in both community and hospital settings

Over six years, AMR trends escalated. Amoxicillin resistance increased from 50.6% (2017) to 92.7% (2022). Similar growth was observed for amoxicillin-clavulanate and ciprofloxacin. Ceftriaxone resistance rose to 53.4%, and ceftazidime peaked at 62.4% in 2019. These shifts—paralleling trends in Cameroon and Ethiopia [12] [28]—may indicate increasing ESBL production [29]. Although ESBL-producing strains were not directly screened in this study, elevated resistance to third-generation cephalosporins strongly suggests their presence. Further research is warranted to characterize resistance mechanisms and inform stewardship strategies. Fluoroquinolone resistance, especially to ciprofloxacin, reached 60.2% in 2022. While national antibiotic consumption data are unavailable, the unregulated use of fluoroquinolones for conditions such as pyelonephritis, prostatitis, and suspected multidrug-resistant infections likely contributed to this trend [30]. Notably, resistance to imipenem increased from 2.6% in 2021 to 6% in 2022, underscoring concerns about carbapenem overuse—particularly given its importance in treating severe or multidrug-resistant infections [31]. Resistance to aminoglycosides remained substantial, with gentamicin and tobramycin resistance rates exceeding 30% in recent years.

MDR rates climbed steeply from 80.9% (2017) to 92.1% (2022), far exceeding rates in comparable settings (e.g. 44.1% in Ethiopia [12]). This underscores the seriousness of the AMR crisis in our context.

AMR is increasingly viewed as a multisectoral issue involving human, animal, and environmental vectors. The One Health framework promotes integrated surveillance and intervention strategies, crucial for LMICs facing compounding pressures from agricultural antibiotic use, environmental contamination, and under-resourced healthcare systems [32].

Overall, this study offers valuable insights into the antimicrobial resistance profiles of uropathogens in Burkina Faso, contributing essential evidence to guide empirical treatment and inform public health strategies. However, this study has several limitations. First, it was laboratory-based and limited to cases for which urine cultures were requested, which may introduce selection bias and exclude

milder or asymptomatic infections. Second, the absence of patient-level clinical data precluded stratification by inpatient versus outpatient status, as well as differentiation between healthcare-associated and community-acquired resistance. Third, data on comorbidities were unavailable, thereby restricting analysis. Furthermore, susceptibility testing did not include key antimicrobials such as nitrofurantoin, fosfomicin, and amikacin—agents recommended by the Infectious Diseases Society of America (IDSA) and the European Society of Clinical Microbiology and Infectious Diseases (ESCMID) for the empiric treatment of uncomplicated UTIs [33]—thereby limiting assessment of their potential utility. Given that the data were sourced exclusively from three laboratories in Ouagadougou, the findings may not fully reflect antimicrobial resistance patterns across Burkina Faso, particularly in rural regions where diagnostic resources, healthcare access, and antibiotic use practices can vary considerably. Caution is therefore warranted in generalizing these results to the entire country. Lastly, the lack of information on prior antibiotic use, treatment received, and clinical outcomes limited the ability to contextualize the resistance data within prevailing diagnostic and therapeutic practices.

5. Conclusions

This six-year retrospective analysis highlights a concerning upward trend in antimicrobial resistance among *Enterobacteriaceae* isolated from urinary tract infections in Ouagadougou, Burkina Faso. *E. coli* and *K. pneumoniae* remain the dominant pathogens, both exhibiting high levels of resistance to commonly used antibiotics, notably amoxicillin, cotrimoxazole, ampicillin, and amoxicillin—rendering these agents unsuitable for empirical UTI treatment in this setting. Although last-resort drugs such as imipenem and colistin maintain relatively low resistance rates, their increasing usage necessitates cautious stewardship to preserve their clinical utility.

These findings call for urgent action. Policymakers and healthcare authorities must prioritize the establishment of a robust, nationwide AMR surveillance network, investment in laboratory capacity, and reinforcement of antibiotic stewardship programs at all levels of care. Cross-sectoral collaboration under a One Health framework is also essential to addressing AMR at the human-animal-environment interface.

Data Availability

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

Ethical Approval

Our investigation represents a retrospective study of urine results collected from laboratory databases and is not directly associated with patients. Additionally, the

data were analyzed anonymously. Therefore, ethics approval was not required from the Human Research Ethics Committee for this study.

CRediT Authorship Contribution Statement

Conceptualization: CZ; Supervision: CZ; Data Curation: SO, DSK, APS; Formal Analysis: SO, DSK, APS; Writing—Original Draft: SO, DSK, APS; Writing—Review & Editing: All authors; Approval of Final Manuscript: All authors

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Conflicts of Interest

The authors declare that they have no conflict of interest.

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