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RESEARCH ARTICLE

URINARY TRACT INFECTIONS AND MULTIDRUG-RESISTANT BACTERIA IN INTENSIVE CARE UNITS: INSIGHTS FROM A REFERRAL HOSPITAL IN ANTANANARIVO, MADAGASCAR

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ABSTRACT: Introduction: The gradual increase in bacterial resistance to commonly used antibiotics is threatening the effective management of infections in intensive care units (ICUs). This study aimed to describe the microbial ecology of bacterial strains responsible for urinary tract infections (UTIs) in ICU patients at CHU-JRA, Antananarivo. Methods: A retrospective and descriptive study was conducted over a 29-month period, from January 2020 to May 2022, at the Microbiology Laboratory of CHU-JRA. All patients hospitalized in the ICU departments of CHU-JRA with a positive urine cytobacteriological examination (ECBU) were included. Results: During the study period, 1,130 ECBU samples were processed, of which 382 were positive. A total of 105 patients from ICUs were included in the analysis. The prevalence of UTIs among these patients was 58.01%, with a higher incidence in females (n = 62). The most frequently isolated bacterial species was Escherichia coli (25.36%), followed by Enterococcus spp. (18.66%) and Acinetobacter spp. (14.17%, n = 19). Antibiotic susceptibility testing revealed high levels of resistance to fluoroquinolones, beta-lactams, and sulfonamides. Conversely, carbapenems, amikacin, vancomycin, colistin, and nitrofurans were the most effective agents against the isolated strains. Conclusion: Antimicrobial resistance remains a critical public health issue in Madagascar. These findings emphasize the clinical importance of ongoing surveillance and tailored antibiotic stewardship to guide effective empirical therapy in ICU patients, thereby improving outcomes. This study provides valuable insights into resistance patterns of bacterial pathogens responsible for UTIs in ICU settings, highlighting the urgent need for strengthened antimicrobial stewardship.

Keywords: *Escherichia coli*; *Enterococcus* spp.; urinary tract infection; intensive care unit; antimicrobial resistance

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INTRODUCTION:

Urinary tract infections (UTIs) are among the most common bacterial infections encountered in both general practice and specialized hospital settings, affecting approximately 150 million people worldwide each year [1]. They represent the second most frequent site of bacterial infection after respiratory tract infections [2]. UTIs are also the second leading cause of antibiotic prescriptions, often leading to overuse or inappropriate use of antibiotics, which in turn accelerates the development of antimicrobial resistance (AMR) [3].

Globally, the increasing resistance of uropathogens to commonly used antibiotics poses a major public health challenge. According to the World Health Organization (WHO), AMR is now considered "a serious threat to global health, food security, and development" [4,5].

Hospitalized patients, particularly those admitted to intensive care units (ICUs), are at higher risk of acquiring UTIs. In ICU settings, UTIs are among the most prevalent healthcare-associated infections, and when caused by multidrug-resistant organisms (MDROs), they are associated with increased morbidity, prolonged hospital stays, higher healthcare costs, and poorer patient outcomes [6].

In Madagascar, data on the microbial ecology of UTIs and local resistance patterns—especially in critical care settings—remain scarce and fragmented. The lack of regular surveillance systems, limited diagnostic capacity in many hospitals, and insufficient local research have contributed to gaps in understanding the epidemiology of UTIs and antibiotic resistance across the country. As a result, empirical treatment is often guided by international guidelines that may not reflect local resistance profiles, increasing the risk of therapeutic failure and contributing further to resistance development.

In this context, the present study was conducted to determine the prevalence of UTIs among ICU patients at the Joseph Ravoahangy Andrianavalona University Hospital Center (CHU-JRA) in Antananarivo from 2020 to 2022; characterize the microbial profile of the uropathogens isolated; and assess their antimicrobial susceptibility patterns.

By providing updated local data, this study aims to support evidence-based clinical decision-making and contribute to the development of effective antibiotic stewardship strategies in Madagascar—a critical step toward addressing the growing threat of antimicrobial resistance in the country's healthcare system.

METHODS:

This was a retrospective and descriptive study conducted over a 29-month period, from January 2020 to May 2022, in the Microbiology Department of the Joseph Ravoahangy Andrianavalona University Hospital Center (CHU-JRA) in Antananarivo, Madagascar.

Study Setting and Population

The study included all adult patients admitted to the Medical, Surgical, and Emergency Intensive Care Units (ICUs) of CHU-JRA who had a positive urine cytobacteriological examination (ECBU) during their hospital stay. Patients were identified from laboratory registers.

The intensive care units manage critically ill patients requiring continuous monitoring and life-support interventions for organ failure (e.g., mechanical ventilation, vasopressors, renal replacement therapy). ICU admissions typically involve severe conditions such as septic shock, drug intoxication, coma, acute respiratory failure, cardiac arrest, or major postoperative complications.

At CHU-JRA, specialized units such as neonatal, pediatric, neurosurgical, cardiothoracic, and burn ICUs are incorporated into the Surgical ICU.

Definitions

A **urinary tract infection (UTI)** was defined according to the Infectious Diseases Society of America (IDSA) guidelines [1] as the presence of clinical symptoms (fever, dysuria, urinary retention, or suprapubic pain) and laboratory confirmation via:

- **leukocyturia ≥ 10^4 cells/mL**, and
- **significant bacteriuria**, defined as ≥ 10^3 colony-forming units (CFU)/mL for *Escherichia coli* in men and ≥ 10^4 CFU/mL for other uropathogens in women.

A **multidrug-resistant organism (MDRO)** was defined in accordance with the European Centre for Disease Prevention and Control (ECDC) and CDC criteria [2] as a bacterial isolate resistant to at least one agent in **three or more antimicrobial categories**.

Inclusion Criteria

- Adult patients (≥18 years) admitted to one of the three ICU departments (Medical, Surgical, or Emergency ICU),
- A positive ECBU result based on the criteria above,
- A complete medical record available for data extraction.

Exclusion Criteria

- Patients admitted to non-ICU departments or treated as outpatients,
- Patients admitted to the Nephrology ICU (due to distinct underlying pathology and microbiological profile),
- ECBU results with negative findings (leukocyturia < 10^4/mL and bacteriuria below defined thresholds),
- Non-interpretable samples (e.g., polymicrobial cultures with >2 distinct morphotypes, suggestive of contamination),
- Incomplete or missing microbiological or clinical data.

The flowchart of the study population inclusion is shown in Figure 1.

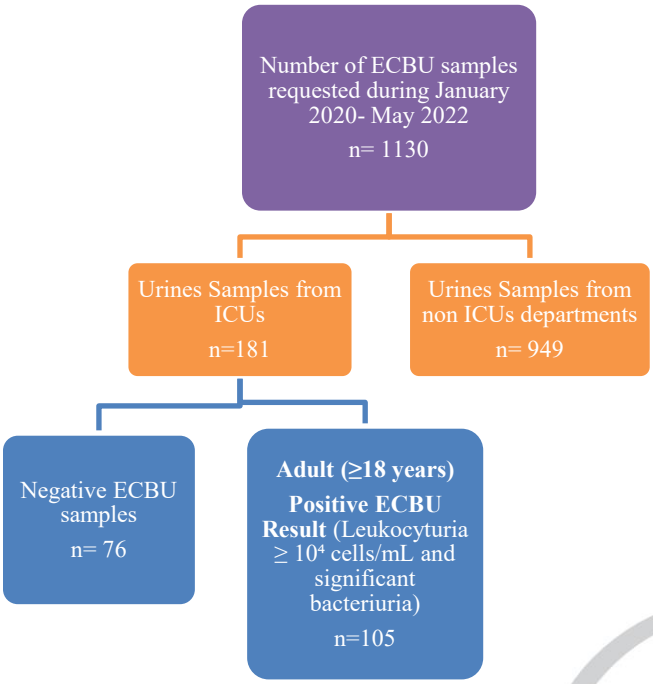

Fig 1: Flowchart of patient selection and inclusion in the study

Microbiological Procedures

Urine specimens were processed according to standard microbiological protocols. Quantitative culture and microscopic analysis were performed for leukocyte and bacterial count. Antibiotic susceptibility testing was conducted using the disk diffusion method on Mueller-Hinton agar, following the guidelines of the Comité de l'Antibiogramme de la Société Française de Microbiologie (CA-SFM/EUCAST standards at the time of testing). Interpretative reading was performed to identify resistance phenotypes, including extended-spectrum beta-lactamases (ESBLs) and carbapenem-resistant strains, where applicable. Results were reviewed and commented on by clinical microbiologists prior to being reported.

Statistical Analysis

All relevant clinical and microbiological parameters were transcribed from patient records onto pre-established data collection forms, which were kept confidential throughout the study. Data entry, cleaning, and analysis were performed using Epi Info version 7 (CDC, Atlanta, GA, USA).

Descriptive statistics were used to summarize patient demographics, bacterial isolates, and resistance patterns. Categorical variables were expressed as frequencies and percentages. Continuous variables (e.g., age, length of ICU stay) were presented as means with standard deviations or medians with interquartile ranges, depending on the distribution.

To compare proportions between groups (e.g., resistance rates by bacterial species or sex), the **Fisher's exact test** was employed. A **p-value < 0.05** was considered statistically significant.

Study Limitations

This study has several limitations that should be acknowledged:

- **Single-center design**: Conducted in a single tertiary hospital in Antananarivo, the findings may not be generalizable to other healthcare facilities in Madagascar or internationally.
- **Retrospective nature** : The reliance on laboratory records and patient charts may have introduced information bias, particularly due to incomplete or missing data regarding clinical symptoms and prior antibiotic exposure.

- **Lack of molecular characterization**: No molecular typing or resistance gene detection (e.g., ESBLs, carbapenemases) was performed, which limits the depth of understanding regarding resistance mechanisms.
- **Limited statistical analysis**: The study relied primarily on descriptive statistics. Confidence intervals were not calculated, and no multivariate analyses were performed to explore potential associations or confounding factors related to resistance patterns or patient characteristics.

Despite these limitations, this study provides valuable baseline data on the microbial ecology and antimicrobial resistance of uropathogens in ICU settings in Madagascar, addressing a significant data gap in the region and supporting the need for enhanced antimicrobial stewardship efforts.

RESULTS:

During the study period, a total of 1,130 urine cytobacteriological examinations (ECBU) were requested. Among these, 181 samples originated from the Intensive Care Units (ICUs) of CHU-JRA Antananarivo, of which 105 (58.01%) were positive (Tab 1) (Fig 01). These 105 positive ECBU samples constituted the study population.

There was a female predominance of 59.05% (n=62) among the infected patients. The most affected age groups were patients aged 45–59 years (29.52%, n=31) and those over 60 years old (34.29%, n=36). Additionally, patients hospitalized in the Surgical ICU accounted for 50.48% (n=53) of cases.

Among the 105 patients with urinary tract infection, 57 (54.29%) were receiving antibiotic therapy at the time of sampling, and 22 patients (20.95%) had an indwelling urinary catheter.

Fever was the most frequently observed clinical sign, present in 61.90% of patients (n=65), followed by urinary and renal symptoms, reported in 24% (n=25).

Microscopic examination of urine revealed that 83.81% of patients (n=88/105) had turbid urine.

Among the 105 patients, the majority presented with monomicrobial infections, while 26 patients (24.76%) had polymicrobial infections involving two bacterial species.

Table 1: Demographic, Clinical, and Treatment Features of ICU Patients Diagnosed with UTIs (2020–2022), CHU-JRA, Antananarivo

N=105		
Parameters	**N**	**%**
Department		
Surgical Intensive Care	53	50,48
Medical Intensive Care	44	41,90
Emergency Intensive Care	8	7,62
Clinical information		
Fever	65	61,90
Urinary and renal disorders	25	24,00
Other	15	14,10
Age group		
0-14 years	8	7,62
15-29 years	17	16,19
30-44 years	13	12,38
45-59 years	31	29,52
≥60 years	36	34,29
Previous antibiotic use		
Yes	57	54,29
No	48	45,71
Urinary Catheter		

Yes	22	20,95
No	83	79,05
Urine appearance		
Turbid urine	88	83,81
Clear urine	11	10,48
Hematuria	6	5,71

Escherichia coli was the most frequently isolated bacterium, accounting for **25.36% (n=34)** of all isolates, followed by *Enterococcus* spp. and *Acinetobacter* spp. In addition, positive urine cultures for *Candida* spp. were also observed (Tab2).

Table 2: Distribution of Isolated Strains in Urinary Tract Infections

Types of germs	Number (N= 134)	Frequency (%)
Escherichia coli	34	25,36
Enterococcus sp	25	18,66
Acinetobacter sp	19	14,17
Klebsiella sp	12	8,96
Candida sp	10	7,46
Enterobacter sp	7	5,22
Staphylococcus aureus	3	2,24
Staphylococcus non aureus	6	4,48
Pseudomonas aeruginosa	6	4,48
Serratia sp	5	3,73
Proteus mirabilis	3	2,24
Citrobacter sp	1	0,75
Pantoea sp	1	0,75
Hafniasp	1	0,75
Burkholderia cepacia	1	0,75

Antimicrobial Resistance Patterns of Isolated Pathogens

A total of 134 bacterial strains were isolated from the 105 positive urine cultures. Among them, 70 isolates (52.24%) were identified as multidrug-resistant organisms (MDROs). The resistance burden was predominantly driven by Enterobacteriaceae, led by *Escherichia coli*, which accounted for 28.57% (n=20) of all MDROs, followed by *Acinetobacter baumannii* at 22.85% (n=16).

The most commonly observed resistance phenotype was extended-spectrum beta-lactamase (ESBL) production, detected in 46.15% of the resistant strains — a highly concerning figure, particularly in ICU settings with limited therapeutic alternatives.

Enterobacteriaceae Resistance Profil (Table 3)

A wide range of antibiotic classes were tested against Enterobacteriaceae isolates (Tab 03). *Escherichia coli* strains showed high resistance rates to several commonly used antibiotics: Amoxicillin: 70.58% (n=24), Amoxicillin-clavulanic acid: 64.70% (n=22), Tetracyclines: 61.76% (n=21), and Trimethoprim-sulfamethoxazole (cotrimoxazole**)**: 50.00% (n=17).

By contrast, amikacin (0% resistance) and imipenem (2.94%, n=1) remained the most effective agents, underscoring their critical role in the management of severe infections caused by resistant uropathogens.

Among the *Enterobacter* spp. (n=7), complete resistance was noted to amoxicillin-clavulanic acid, first- and second-generation cephalosporins (Cephalotin, Cefuroxim,Cefoxitin). Furthermore, **85.71%** of isolates were resistant to third-generation cephalosporins (Cefixim, Ceftazidim)

and gentamicin. Nonetheless, colistin, imipenem, and amikacin retained high activity against these strains.

The *Klebsiella* species isolated included *Klebsiella pneumoniae* (n=10), *Klebsiella oxytoca* (n=1), and *Klebsiella rhinoscleromatis* (n=1). These isolates showed significant resistance to beta-lactams, while amikacin, imipenem, and colistin remained consistently effective across all tested strains.

Among Gram-positive cocci, *Enterococcus* spp. were the most frequently isolated pathogens. Nitrofurantoin demonstrated notable activity, with 8% (n=2) of isolates remaining susceptible. Importantly, vancomycin resistance was rare, identified in only one isolate (4%) out of 25 tested strains — a finding of both clinical and epidemiological significance in light of the global rise of vancomycin-resistant enterococci (VRE).

Acinetobacter baumannii (n=19), a well-known multidrug-resistant pathogen, exhibited **extensive resistance** to nearly all antibiotic classes tested. Alarmingly, resistance was observed even against some last-resort agents: Imipenem: 21.05% (n=4), Amikacin: 21.05% (n=4), Colistin: 5.26% (n=1). Among the six urinary tract infections caused by *Pseudomonas aeruginosa*, only imipenem and colistin remained effective, with all isolates showing susceptibility to these agents (Tab 04).

These findings highlight *A. baumannii* as a critical priority pathogen, particularly in ICU settings, where therapeutic options are extremely limited and associated with higher morbidity and mortality.

Table 3: Antibiotic Resistance Profiles of Enterobacteria Isolated in Urinary Infections

	E. coli		*Enterobacter sp*		*Klebsiella sp*	
	(n=34)		(n=7)		(n=12)	
Antibiotics	N	%	N	%	N	%
Amoxicillin	24	70,38	7	100,00	12	100,00
Amoxicillin-clavulanic acid	22	64,70	7	100,00	9	75,00
C1G	20	38,82	7	100,00	9	75,00
C2G	15	44,11	7	100,00	9	75,00
C3G	12	35,29	6	85,71	8	66,67
Cefepime	10	29,41	5	71,42	7	58,33
Gentamicin	10	29,41	6	85,71	7	58,33
Amikacin	0	0,00	0	0,00	0	0,00
Imipenem	1	2,94	0	0,00	0	0,000
Colistin	1	2,94	-	-	0	0,00
Chloramphenicol	4	11,76	3	42,85	5	41,67
Nitrofurantoins	6	17,64	2	28,57	1	8,33
Fluoroquinolones	16	47,05	5	71,42	6	50,00
Tetracycline	21	61,76	6	85,71	7	58,33
Sulfamethoxazol-Trimethoprim	17	50,00	4	57,14	8	66,67

Table 4: Antibiotic Resistance Profiles of other bacteria Isolated in Urinary Infections

	Enterococcus sp		*Acinetobacter sp*		*P. aeruginosa*	
	(n=25)		(n=19)		(n= 6)	
Antibiotics	N	%	N	%	N	%
Amoxicillin	14	56,00	19	100,00	6	100,00

Amoxicillin-clavulanic acid	10	40,00	19	100,00	6	100,00
C1G	-	-	19	100,00	6	100,00
C2G	-	-	19	100,00	6	100,00
C3G	-	-	19	100,00	6	100,00
Cefepime	-	-	15	78,94	5	88,33
Gentamicin	24	96,00	17	89,47	4	66,67
Amikacin	16	54,00	4	21,05	3	50,00
Imipenem	2	8,00	4	21,05	1	16,67
Colistin	1	4,00	1	5,26	0	0,00
Chloramphenicol	8	32,00	5	26,31	3	50,00
Nitrofurantoins	2	8,00	6	31,57	3	40,00
Fluoroquinolones	20	80,00	14	73,68	4	66,67
Tetracycline	25	100,00	18	94,73	1	16,67
Sulfamethoxazol-Trimethoprim	15	60,00	16	84,21	2	33 33
Vancomycin	1	4,00	NT	NT	NT	NT
Lincosamides	13	52,00	NT	NT	1	16,67
Makrolides	25	92,00	NT	NT	NT	NT
Nalidixic Acid	3	12,00	5	26,31	NT	NT

C1G: first-generation cephalosporin, C2G: second-generation cephalosporin, C3G: third-generation cephalosporin, NT: not tested Lincosamides: lincomycin, clindamycin Makrolide Erythromycin, Clarithromycin

DISCUSSION:

This study provides a comprehensive overview of the microbial ecology and antibiotic resistance patterns of urinary tract infection (UTI) pathogens among critically ill patients admitted to the intensive care units (ICUs) at CHU-JRA in Antananarivo. It highlights not only the high burden of UTIs in this high-risk population but also the alarming levels of multidrug resistance, raising serious concerns about treatment options in low-resource settings.

The prevalence of UTIs among ICU patients in our study was 58.01%, which is significantly higher than what has been reported in other studies, where prevalence rates range between **7%** and 31% [7]. This discrepancy may be attributed to several ICU-specific risk factors, including prolonged hospital stays, frequent use of invasive devices (e.g., urinary catheters), exposure to broad-spectrum antibiotics, and the immunocompromised status of many patients. Moreover, ICUs are recognized as epicenters for antimicrobial resistance, making infections not only more frequent but also more challenging to treat [6].

The female predominance (59.05%) observed in our cohort aligns with existing literature. This pattern is often attributed to anatomical differences, including a shorter urethra and the proximity of the urethral opening to the anal and vaginal regions, which facilitate bacterial colonization and ascension [8]. Additionally, factors such as poor hygiene practices, sexual activity, and pregnancy further increase UTI susceptibility in women.

Older age was another significant risk factor, with 34.29% of infections occurring in patients over 60 years. This finding is consistent with prior research, which shows that the urinary tract is the most commonly infected site in elderly individuals, accounting for up to 35% of infections in this population [9]. Contributing factors include urinary

retention, decreased immune response, and frequent use of indwelling catheters [10].

In our study, 54.29% of patients had received antibiotic treatment at the time of urine collection. Prior antibiotic exposure is a well-documented risk factor for multidrug-resistant infections, as it disrupts the normal microbiota and selects for resistant strains [11–14]. This is especially true in ICU settings, where empirical and prolonged use of broad-spectrum antibiotics is common, further accelerating the emergence of multidrug-resistant organisms (MDROs) [15].

Fever (61.90%) and urinary or renal symptoms (24%) were the most frequently observed clinical signs in our study. These symptoms, though non-specific, often lead to empirical antibiotic therapy, which can contribute to antimicrobial overuse if not confirmed by microbiological evidence. Therefore, early diagnostic tools such as urine dipsticks, followed by urine culture and susceptibility testing, are essential to guide appropriate therapy and avoid complications.

Catheter-associated urinary tract infections (CAUTIs) were observed in 20.95% of cases. This is consistent with global data indicating that 65–80% of nosocomial UTIs are linked to indwelling urinary catheters [16]. Catheters facilitate bacterial colonization through biofilm formation, which not only promotes infection but also contributes to antimicrobial resistance [17]. Although catheterization is often necessary in ICUs for close monitoring of urine output, its prolonged use should be critically evaluated to minimize infection risk.

The microbiological profile in our study was dominated by *Escherichia coli* (25.36%), followed by *Enterococcus* spp. (18.66%), *Acinetobacter* spp. (14.17%), and *Klebsiella* spp. (8.95%). A **polymicrobial infection** was identified in 24.76% of patients (26 out of 105), which is considerably higher than the typical rate of **5–12%** reported in the literature [19]. This increased polymicrobial incidence can be explained by the critical condition of ICU patients, who often have multiple comorbidities, prolonged hospitalization, and repeated exposure to invasive procedures.

While *E. coli* remains the most commonly isolated uropathogen, its relative frequency tends to decrease in hospital-acquired infections compared to community-acquired UTIs, as other organisms such as *Enterococcus*, *Pseudomonas*, *Staphylococcus*, and yeasts become more prevalent [18]. This shift is largely due to the ascending nature of UTIs and perineal colonization with enteric bacteria, particularly in catheterized or critically ill patients.

Our susceptibility data revealed alarming resistance rates among the isolated uropathogens. *E. coli* strains showed high resistance to amoxicillin (70.58%), amoxicillin-clavulanic acid (64.70%), tetracyclines (61.76%), and SXT (50.00%), findings that mirror previous studies conducted in low-income settings [20–22]. These resistance levels are likely driven by **over-**the-counter antibiotic availability, widespread empirical prescribing, and limited antimicrobial stewardship policies [6]. As a result, aminopenicillins are no longer appropriate for empirical UTI treatment in hospital settings [20].

Third-generation cephalosporins (C3G) were also compromised, with 35.29% of *E. coli* strains resistant, while *Pseudomonas aeruginosa* and *Acinetobacter baumannii* exhibited even higher resistance rates (85.71% and 100%, respectively). Though cefepime retained some activity against *E. coli* (only 29.41% resistant), its declining efficacy compared to older studies [23] suggests increasing enzymatic degradation by extended-spectrum β-lactamases (ESBLs). Indeed, 46.15% of the Enterobacteriaceae isolates in our study were confirmed as ESBL **producers**, making this phenotype the most commonly detected among β-lactam-resistant strains. ESBL-producing bacteria hydrolyze most β-lactams except carbapenems and cephamycins, further narrowing therapeutic options [24].

Fluoroquinolone resistance (Ciprofloxacin and Levofloxacin) was particularly worrisome, with 47.05% of *E. coli* strains resistant, and resistance rates ranging from 50–80% among other isolated species, including *Pseudomonas* (60%). These findings are consistent with prior Malagasy studies [25], although in contrast, Ramilitiana et al. reported good fluoroquinolone activity against *E. coli* [21]. In Europe, resistance rates among *E. coli* are lower (25.7%), but still concerning, especially for *P. aeruginosa* (20.3%) [26]. In Asia, fluoroquinolone resistance in UTIs among hospitalized patients reaches up to 50% [27]. This global trend is likely associated with widespread empirical outpatient use of ciprofloxacin and other fluoroquinolones, often without microbiological confirmation [28–29].

Resistance to SXT was also remarkably high, with more than 90% of isolates affected. Specifically, 50% of *E. coli* isolates were resistant to this combination. These findings are consistent with data from Africa and South America, where SXT resistance reaches up to 70% [27]. European studies report lower but still significant resistance rates, ranging between 14.6% and 60% depending on the country [28]. The extensive use of SXT due to its low cost and ease of administration, often in self-medication, has likely contributed to this trend, making it unsuitable for empirical treatment of UTIs.

As for aminoglycosides, *E. coli* showed 29.41% resistance to gentamicin, while resistance among other isolates exceeded 70%. However, amikacin remained highly effective, with nearly all *E. coli* strains susceptible. Similar findings have been reported by Ramilitiana et al. [23] and Ravahatra et al. [25], where amikacin demonstrated superior efficacy compared to gentamicin. International studies echo these results, with *E. coli* resistance rates to gentamicin ranging from 28% (Mexico) to 29% (Pakistan), while amikacin resistance remains low (10% and 4%, respectively) [28].

Imipenem and colistin stood out as the most effective agents, retaining activity against nearly all Gram-negative isolates. Furan derivatives also preserved moderate activity, with only 17.64% of *E. coli* strains showing resistance. Conversely, 50% of *P. aeruginosa* isolates were resistant to furanes (3 out of 6). While carbapenems remain highly active, their judicious use is essential, given the increasing detection of carbapenemase-producing organisms, even in Madagascar [25]. Resistance rates of 7.2% for *Klebsiella pneumoniae* and 17.4% for *P. aeruginosa* to carbapenems were already reported globally in 2017 [26].

CONCLUSION:

Urinary tract infections (UTIs) remain among the most common healthcare-associated infections, particularly in intensive care units (ICUs), where critically ill patients are highly vulnerable due to the use of invasive procedures, immunosuppression, and prolonged hospital stays. In our study, over half of the urine cultures from ICU patients were positive, with a significant proportion involving multidrug-resistant (MDR) bacteria.

The most frequently isolated organisms were *Escherichia coli* and *Enterococcus* spp., with polymicrobial infections occurring in nearly one-quarter of cases. Notably, more than 50% of the isolates were MDR pathogens, and ESBL-producing Enterobacteriaceae were prevalent. These findings reflect a growing threat in Madagascar's hospital settings, where AMR surveillance and infection control practices are still developing.

In this context, effective strategies must be urgently implemented to prevent the spread of resistant pathogens and improve patient outcomes. Regular monitoring of local bacterial ecology and antibiotic resistance profiles is essential for optimizing empirical therapy and reducing inappropriate antimicrobial use.

To strengthen the management and prevention of MDR-UTIs in ICU settings in Madagascar, we recommend: strengthening Infection Prevention and Control (IPC) measures (Enforce hand hygiene protocols, aseptic catheter insertion, and maintenance techniques. And implement care bundles for urinary catheter use and review catheter indications daily), then establishing routine microbiological surveillance and implementing Antimicrobial Stewardship Programs (ASPs**)**

Perspectives

Future research should explore molecular mechanisms of resistance, evaluate the impact of stewardship interventions, and assess the cost-effectiveness of IPC strategies in low-resource settings. Strengthening laboratory capacities and fostering collaboration between hospitals and public health institutions will be key to reducing the burden of MDR infections in Madagascar.

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REFERENCES:

[1]. Hooton TM. Uncomplicated urinary tract infection. *N Engl J Med*. 2012;366(11):1028–37.

[2]. Larabi K, Masmoudi A, Fendri C. Étude bactériologique et phénotypes de résistance des germes responsables d'infections urinaires dans un centre hospitalo-universitaire de Tunis: à propos de 1930 cas. *Med Mal Infect*. 2003;33:348–52.

[3]. Holmes AH, Moore LS, Sundsfjord A, Steinbakk M, Regmi S, Karkey A, et al. Understanding the mechanisms and drivers

of antimicrobial resistance. *Lancet*. 2016;387(10014):176–87.

[4]. Olowe OA, Grobbel M, Büchter B, Lübke-Becker A, Fruth A, Wieler LH. Detection of bla(CTX-M-15) extended-spectrum beta-lactamase genes in *Escherichia coli* from hospital patients in Nigeria. *Int J Antimicrob Agents*. 2010;35(2):206–7.

[5]. Ouedraogo AS, Jean Pierre H, Bañuls AL, Ouédraogo R, Godreuil S. Emergence and spread of antibiotic resistance in West Africa: contributing factors and threat assessment. *Med Sante Trop*. 2017;27(2):147–54.

[6]. Auboyer C. Infections urinaires en réanimation: diagnostic et traitement. *Med Mal Infect*. 2003;33:474–82.

[7]. Bagshaw SM, Laupland KB. Epidemiology of intensive care unit-acquired urinary tract infections. *Curr Opin Infect Dis*. 2006;19(1):67–71.

[8]. Gonsu Kamga H, Nzengang R, Toukam M, Sando Z, et al. Phénotypes de résistance des souches d'*Escherichia coli* responsables des infections urinaires communautaires dans la ville de Yaoundé (Cameroun). *Afr J Pathol Microbiol*. 2014;3:1–4.

[9]. Bouvenot G. *Guide du bon usage du médicament*. 2e éd. Paris: Lavoisier; 2012.

[10]. Société de Pathologies Infectieuses de la Langue Française. *Diagnostic et antibiothérapie des infections urinaires bactériennes communautaires de l'adulte: Actualisation 2017 des recommandations de 2014*. Paris: SPILF; 2017.

[11]. Société de Pathologie Infectieuse de Langue Française, Association Française d'Urologie. *Infections urinaires nosocomiales*. Paris: Institut Pasteur; 2002 Nov.

[12]. Brun-Buisson C, Guillemot D, Watier L. Résistance bactérienne aux antibiotiques: épidémiologie et prospective. *SPS*. 2018;(325):1–8.

[13]. Randriatsarafara FM, Ralamboson J, Rakotoarivelo R, Raherinandrasana A, et al. Consommation d'antibiotiques au Centre Hospitalier Universitaire d'Antananarivo: prévalence et défis stratégiques. *CAIRN*. 2015;27:249–55.

[14]. Clerc O, Prod'hom G, Petignat C. Traitement des infections urinaires simples: impact des résistances antibiotiques croissantes dans la communauté. *Rev Med Suisse*. 2012;8:878–81.

[15]. Agence Nationale de Sécurité du Médicament et des Produits de Santé. *Emergence des bactéries multi-résistantes – Importance renforcée du bon usage des antibiotiques*. Paris: ANSM; 2010.

[16]. Nicolle LE. Catheter associated urinary tract infections. *Antimicrob Resist Infect Control*. 2014;3:23.

[17]. Stickler DJ. Bacterial biofilms in patients with indwelling urinary catheters. *Nat Clin Pract Urol*. 2008;5(11):598–608.

[18]. Société de Pathologie Infectieuse de Langue Française, Association Française d'Urologie. *Infections urinaires nosocomiales*. Paris: Institut Pasteur; 2002 Nov.

[19]. Galinski M, Gauzit R. Infections urinaires en réanimation. *SFAR Conférences d'actualisation*. Paris: Elsevier; 1998. p. 665–78.

[20]. El Bouamri MC, Arsalane L, Kamouni Y, Yahyaoui H, et al. Profil actuel de résistance aux antibiotiques des souches d'*Escherichia coli* uropathogènes et conséquences thérapeutiques. *Prog Urol*. 2014;24(16):1058–62.

[21]. Nadmi H, Elotmani F, Talmi M, Zerouali K, et al. Profil de résistance aux antibiotiques des entérobactéries uropathogènes communautaires à El Jadida (Maroc). *Med Mal Infect*. 2010; 40:303–5.

[22]. Ben Haj Khalifa A, Khedher M. Fréquence et résistance aux antibiotiques des bactéries uropathogènes à l'hôpital universitaire de Tahar Sfar de Mahdia. *Rev Tun Infectiol*. 2010;4(2):57–61.

[23]. Ramilitiana B, Rakotoarivelo RA, Razafimahefa SH, Vololontiana D, et al. Prévalence de la résistance des bactéries aux antibiotiques dans les infections urinaires de l'adulte en milieu hospitalier à Antananarivo. *Med Afr Noire*. 2014;61(10):514–8.

[24]. Zahar JR, Lortholary O, Martin C, Potel G, Plesiat P, et al. Addressing the challenge of extended-spectrum beta-lactamases. *Curr Opin Investig Drugs*. 2009;10(2):172–80.

[25]. Rakotovao Ravahatra ZD, Randriatsarafara FM, Rasoanandrasana S, Raverohanta L, et al. Phénotypes de résistance des souches d'*Escherichia coli* responsables d'infection urinaire au laboratoire du Centre Hospitalo-Universitaire de Befelatanana Antananarivo. *Pan Afr Med J*. 2017; 26:166–75.

[26]. European Centre for Disease Prevention and Control. *Surveillance of antimicrobial resistance in Europe: Annual report of the European Antimicrobial Resistance Surveillance Network 2017*. Stockholm: ECDC; 2018.

[27]. López Romo A, Quirós R. Appropriate use of antibiotics: an unmet need. *Ther Adv Urol*. 2019; 11:1756287219832174.

[28]. Kot B. Antibiotic resistance among uropathogenic *Escherichia coli*. *Pol J Microbiol*. 2019;68(4):403–15.

[29]. Merensa A, Servonneta A. Mécanismes et épidémiologie de la résistance aux fluoroquinolones en 2010. *EMC RFL*. 2010;40(422):33–41.

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