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Original Article

Community and healthcare-associated UTIs: antimicrobial resistance patterns in a Tunisian emergency-intensive care unit

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Abstract

Introduction: Urinary tract infections (UTIs) are a leading cause of antibiotic use globally, with rising antimicrobial resistance (AMR) complicating management—particularly in healthcare settings.

Methodology: This cross-sectional study compared community-acquired (CA-UTI) and healthcare-associated UTIs (HA-UTI) at the Habib Thameur Hospital's emergency–intensive care unit in Tunis during 2022–2023.

Results: Out of a total of 4,474 urine samples, 446 (10%) were culture-positive. The patients were predominantly elderly (73.3% were ≥ 60 years). More females had CA-UTI (M:F = 0.57) than HA-UTI (M:F = 0.78). *Escherichia coli* was the main pathogen causing both CA-UTI (57.4%) and HA-UTI (44.6%), while *Klebsiella pneumoniae* was the more common pathogen in HA-UTI (26.1% vs. 23.3%). Gram-negative bacteria accounted for 90.6% of isolates. Among the *K. pneumoniae* isolates, resistance to imipenem was significantly higher among HA-UTI isolates (29.2% vs. 5.9%; $p = 0.02$). Among the *E. coli* isolates, resistance to nitrofurantoin was significantly higher among HA-UTI isolates (3.7% vs. 12.5%; $p = 0.01$). Extended-spectrum β-lactamase (ESBL)-producing Enterobacteriaceae were detected in 8.5% of isolates (mostly *E. coli* and *K. pneumoniae*), and carbapenem-resistant Enterobacteriaceae (CRE) in 8.7% (predominantly *K. pneumoniae* in HA-UTI). CRE showed near-complete β-lactam resistance and high non-β-lactam resistance in HA-UTI.

Conclusions: Rising UTI rates and alarming AMR trends, particularly in HA-UTIs, highlight the need for enhanced antibiotic stewardship and tailored empirical therapy. The predominance of multidrug-resistant strains underscores the urgency for infection control measures in Tunisian healthcare settings.

Key words: infection; resistance; antibiotic; intensive-care-unit; ICU.

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Introduction

Urinary tract infections (UTIs) represent one of the most common bacterial infections worldwide and constitute a major public health concern due to their high incidence, associated morbidity, and substantial healthcare costs [1]. Over the past decades, the global burden of UTIs has increased considerably, with estimates exceeding 400 million cases in 2019 [2]. As a result, UTIs remain among the leading indications for antibiotic prescription in both community and hospital practice.

The widespread and often inappropriate use of antibiotics for UTIs has contributed significantly to the emergence and dissemination of antimicrobial resistance (AMR) among uropathogens, particularly Enterobacteriaceae [3]. Increasing resistance to commonly prescribed antibiotics; including β-lactams, fluoroquinolones, and trimethoprim–sulfamethoxazole; has progressively limited empirical treatment options and complicated clinical management. This situation is of particular concern in healthcare-associated UTIs (HA-UTIs), which are frequently linked to invasive procedures, prolonged hospitalization, and vulnerable patient populations, and are associated with increased morbidity, mortality, and healthcare expenditure [4].

HA-UTIs are defined as infections that are neither present nor incubating at the time of hospital admission and that occur at least 48 hours after hospitalization [5]. They account for a substantial proportion of healthcare-associated infections and are commonly related to urinary catheterization and intensive care exposure. In contrast, community-acquired UTIs (CA-UTIs) generally affect otherwise stable patients but increasingly involve multidrug-resistant organisms, reflecting antibiotic selective pressure beyond hospital settings [3]. Distinguishing between the treatment of CA-UTIs and HA-UTIs is therefore essential, as these entities differ in epidemiology, microbial ecology, and resistance patterns [6].

In recent years, numerous studies have documented

the rising prevalence of extended-spectrum β-lactamase (ESBL)-producing and carbapenem-resistant Enterobacteriaceae (CRE) in UTIs worldwide. However, the epidemiology and resistance profiles of these pathogens vary substantially across regions and healthcare systems [3]. In low- and middle-income countries, including those in North Africa, healthcare delivery is often challenged by limited resources, heterogeneous antibiotic prescribing practices, and constrained infection prevention and control measures. These factors may accelerate the emergence and dissemination of multidrug-resistant organisms, particularly in high-risk hospital environments such as emergency departments and intensive care units [5].

Despite the clinical relevance of UTIs and associated AMR, comparative data analyzing CA- versus HA-UTIs within the same institutional setting remain limited in Tunisia [5,7]. In particular, there is a paucity of studies focusing on emergency–intensive care contexts, where patients present with varying degrees of illness severity and are frequently exposed to broad-spectrum antibiotics. Local epidemiological data are therefore crucial to inform empirical treatment strategies, guide antimicrobial stewardship interventions, and support infection control policies tailored to specific healthcare settings [6].

In this context, the present study was conducted in the emergency intensive care unit of Habib Thameur Hospital in Tunis, Tunisia. The objectives were to describe the epidemiological and microbiological characteristics of UTIs and to compare AMR patterns between community-acquired and healthcare-associated infections. This study aimed to contribute to evidence-based antibiotic prescribing and to support local efforts to mitigate the growing burden of AMR by providing setting-specific data.

Methodology

Study design and setting

A cross-sectional study was conducted over a two-year period, from January 2022 to December 2023, at the clinical bacteriology unit of Habib Thameur Hospital, Tunis, Tunisia. The study included urinary isolates obtained from patients admitted to the emergency intensive care department, which comprises the emergency consultation unit, the short-stay unit, and the medical intensive care unit.

Case definitions

CA-UTIs were defined as infections diagnosed in outpatients at the time of presentation. HA-UTIs were defined as infections occurring at least 48 hours after hospital admission, in accordance with the Centers for Disease Control and Prevention/National Healthcare Safety Network (CDC/NHSN) criteria [5].

A symptomatic UTI was defined by the presence of clinical signs suggestive of infection, including fever, symptoms of cystitis, suprapubic pain, flank pain, or epididymo-orchitis, in association with a positive urine culture yielding ≥ 10^5 colony-forming units (CFU)/mL, with no more than two uropathogenic microorganisms [8].

Bacterial identification and antimicrobial susceptibility testing

Bacterial identification was performed using conventional microbiological methods and API® identification systems (bioMérieux®, Marcy-l'Étoile, France), including API 20E for Enterobacteriaceae, API 20NE for non-fermenting Gram-negative bacilli, and API STAPH and API STREPTO for Gram-positive cocci.

Antimicrobial susceptibility testing was carried out using the disk diffusion method (Bioanalyse®, Ankara, Turkey; Oxoid®, Basingstoke, United Kingdom) and interpreted according to the European Committee on Antimicrobial Susceptibility Testing and Comité de l'Antibiogramme de la Société Française de Microbiologie (EUCAST/CA-SFM) guidelines for the years 2022–2023.

Extended-spectrum β-lactamase (ESBL) production and carbapenem resistance were determined based on phenotypic susceptibility profiles in accordance with the EUCAST/CA-SFM recommendations.

Data collection

Demographic, clinical, microbiological, and antimicrobial susceptibility data were retrospectively extracted from the hospital laboratory information system (Santé-Lab®).

Statistical analysis

Statistical analyses were performed using SPSS® software (version 22. IBM Corp 2013, Armonk, NY, USA). Categorical variables were expressed as frequencies and percentages. Comparisons between community-acquired and healthcare-associated infections were conducted using the Chi-square test. A p value < 0.05 was considered statistically significant.

Results

Epidemiological characteristics of UTIs

During the study period, a total of 4,474 urine

Table 1. Distribution of UTI pathogens in CA-UTIs versus HA-UTIs.

Pathogen	CA-UTI (%)	HA-UTI (%)	*p* value
Escherichia coli	57.4 (54/94)	44.6 (157/352)	**0.03**
Klebsiella pneumoniae	23.3 (22/94)	26.1 (92/352)	0.58
Non-fermenting Gram-negative bacilli	4.3 (4/94)	7.4 (26/352)	0.27
Gram-positive bacteria	5.3 (5/94)	10.5 (37/352)	0.12
Enterococcus spp	3.2 (3/94)	9.4 (33/352)	-
Staphylococcus aureus	5.3 (5/94)	1.7 (6/352)	-
Total Gram-negative bacteria	90.4 (85/94)	78.1(272/352)	0.08

UTI: urinary tract infection; CA-UTI: community-acquired UTI; HA-UTI: healthcare-associated UTI; *p values < 0.05 were considered statistically significant.*

samples were analyzed from patients admitted to the emergency–intensive care department. Of these, 446 samples were positive for UTI, corresponding to an overall positivity rate of 10%, with rates of 8.3% (198/2380) in 2022 and 11.8% (248/2094) in 2023.

UTIs predominantly affected older adults, with 73.3% of cases occurring in patients aged 60 years or older. The mean age of the patients was 66 years (range: 4–101 years). Elderly patients were more frequently represented among CA-UTIs (86.2%) than among HA-UTIs (69.9%). The male-to-female ratio was 0.57 in CA-UTIs and 0.78 in HA-UTIs.

Seasonal distribution of UTIs

A seasonal variation in UTI occurrence was observed, with an increased number of cases during the autumn in both community and healthcare settings (Figure 1).

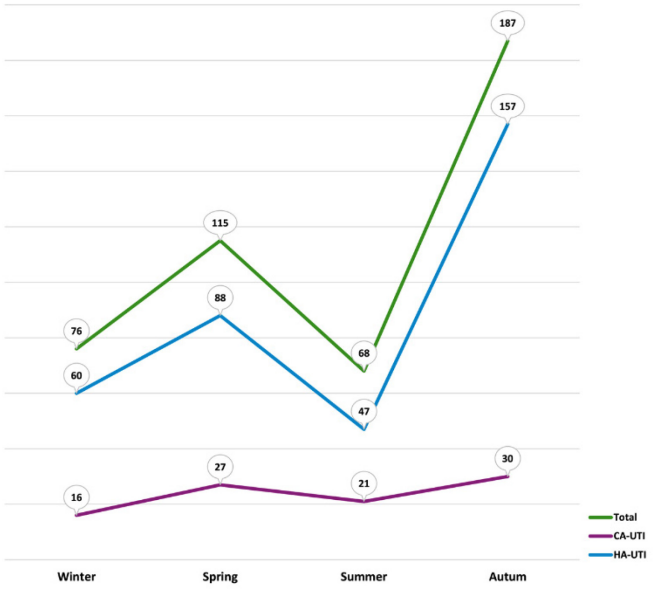
Microbiological profile of UTI pathogens

Gram-negative bacilli predominated among the 446 positive urine cultures, accounting for 90.6% (404/446) of isolates. Enterobacteriaceae represented the majority of Gram-negative isolates (378 strains), while non-fermenting Gram-negative bacilli, including *Pseudomonas aeruginosa* and *Acinetobacter baumannii*, accounted for 28 isolates.

Gram-positive cocci constituted 9.4% (42/446) of isolates, with *Enterococcus faecalis* being the most frequently identified species (26 isolates).

Comparative analysis of uropathogens demonstrated differences between CA- and HA-UTIs, as detailed in Table 1.

Figure 1. Seasonal variation of urinary tract infections.



CA-UTI: community-acquired urinary tract infection; HA-UTI: healthcare-associated urinary tract infection.

Table 2. Comparative antibiotic resistance patterns in CA-UTIs versus HA-UTIs.

Antibiotic	*E. coli*			*K. pneumoniae*		
	CA-UTI n = 54	HA-UTI n = 156	*p* value	CA-UTI n = 22	HA-UTI n = 92	*p* value
Amoxicillin	42 (77.4)	126 (80.8)	0.60	–	–	–
Amoxicillin–clavulanate	28 (52.3)	81 (52.0)	0.97	16 (72.7)	56 (61.4)	0.33
Piperacillin–tazobactam	17 (31.4)	31 (20.0)	**0.048**	10 (45.5)	47 (50.6)	0.67
Cefotaxime	6 (11.3)	22 (13.8)	0.65	7 (30.0)	43 (47.1)	0.14
Imipenem	1 (2.0)	1 (0.7)	0.44	1 (5.9)	27 (29.2)	**0.02**
Ertapenem	1 (2.0)	2 (1.4)	1.00	3 (15.8)	32 (35.0)	0.08
Amikacin	2 (4.6)	2 (1.5)	0.21	4 (16.7)	30 (32.9)	0.12
Gentamicin	3 (6.0)	5 (3.4)	0.41	4 (18.2)	34 (37.4)	0.09
Ciprofloxacin	16 (29.8)	38 (24.1)	0.42	14 (65.0)	42 (45.6)	0.11
Nalidixic acid	23 (43.2)	53 (33.7)	0.20	–	–	–
Cotrimoxazole	18 (33.3)	56 (36.1)	0.74	9 (41.2)	51 (55.0)	0.24
Nitrofurantoin	7 (12.5)	6 (3.7)	**0.01**	–	–	–
Fosfomycin	0 (0)	1 (0.8)	1.00	10 (46.4)	49 (52.9)	0.63

UTI: urinary tract infection; CA-UTI: community-acquired UTI; HA-UTI: healthcare-associated UTI; *p values < 0.05 were considered statistically significant.*

Table 3. Antibiotic resistance rates (%) of ESBL-producing Enterobacteriaceae in CA-UTIs versus HA-UTIs.

Antibiotic	CA-UTI (%) (n = 8)	HA-UTI (%) (n = 30)	*p* value
Amoxicillin–clavulanate	100 (8/8)	78.6 (24/30)	0.31
Piperacillin–tazobactam	85.7 (7/8)	39.3 (12/30)	**0.042**
Cephalothin	100 (8/8)	93.8 (28/30)	1.00
Cefoxitin	14.3 (1/8)	10.0 (3/30)	1.00
Cefotaxime	100 (8/8)	92.9 (28/30)	1.00
Cefixime	100 (8/8)	93.3 (28/30)	1.00
Cefepime	100 (8/8)	92.3 (28/30)	1.00
Aztreonam	100 (8/8)	88.9 (27/30)	1.00
Ertapenem	0 (0/8)	0 (0/30)	1.00
Amikacin	12.5 (1/8)	11.5 (3/30)	1.00
Gentamicin	14.3 (1/8)	24.1 (7/30)	0.66
Nalidixic acid	100 (8/8)	68.4 (21/30)	0.16
Ciprofloxacin	100 (8/8)	68.2 (20/30)	**0.08**
Cotrimoxazole	83.3 (7/8)	73.7 (22/30)	0.65
Fosfomycin	20.0 (2/8)	15.8 (5/30)	0.62
Nitrofurantoin	50.0 (4/8)	16.7 (5/30)	0.07

ESBL: Extended-spectrum β-lactamase; UTI: urinary tract infection; CA-UTI: community-acquired UTI; HA-UTI: healthcare-associated UTI; *p values < 0.05 were considered statistically significant.*

AMR patterns

Antimicrobial susceptibility testing of Enterobacteriaceae isolates revealed significant differences in resistance profiles between CA-UTIs and HA-UTIs. The resistance rates to commonly used antibiotics, including β-lactams, fluoroquinolones, aminoglycosides, nitrofurantoin, and fosfomycin, are summarized in Table 2.

Epidemiology of multidrug-resistant organisms

ESBL–producing Enterobacteriaceae were identified in 38 isolates, corresponding to a prevalence of 8.5%. These isolates were predominantly *Escherichia coli* (65.8%) and *Klebsiella pneumoniae* (26.3%). ESBL-producing strains were more frequently isolated from HA-UTIs. Their antibiotic resistance profiles are presented in Table 3.

CRE were detected in 39 isolates (8.7%), with *K. pneumoniae* accounting for 74.4% of cases. All CRE isolates exhibited resistance to β-lactam antibiotics, including carbapenems. Resistance rates to non-β-lactam antibiotics among CRE isolates are summarized in Table 4.

Discussion

UTIs are among the most frequently investigated bacterial infections in clinical microbiology, accounting for approximately one-third of routine laboratory analyses [9]. In this study, the overall UTI prevalence was 10%, which is consistent with recent reports from both low- and middle-income and high-income countries [10,11]. Variations in prevalence across studies likely reflect differences in population characteristics, healthcare settings, diagnostic criteria, and study design.

UTIs were more frequent in women in the case of both CA- and HA-UTIs; a finding consistent with well-established anatomical and physiological risk factors [12]. The gender disparity was more pronounced in CA-UTIs, whereas it was attenuated in hospital-acquired infections, likely due to the predominance of shared risk factors such as urinary catheterization, comorbidities, and prolonged hospitalization [13]. Advanced age was strongly associated with UTI occurrence, with individuals over 60 years accounting for the majority of cases in both settings. This observation aligns with previous European studies and reflects age-related factors, including functional urinary disorders, increased exposure to healthcare interventions, and immunosenescence [14,15].

A seasonal variation in UTI occurrence was observed, with an autumnal peak, particularly in healthcare-associated infections. Although seasonal patterns of UTIs have been inconsistently reported,

Table 4. Antibiotic resistance rates (%) of carbapenem-resistant Enterobacteriaceae in CA-UTIs versus HA-UTIs.

Antibiotic	CA-UTI (%) (n/N)	HA-UTI (%) (n/N)	*p* value
Beta-lactams (including carbapenems)	100 (5/5)	100 (34/34)	—
Amikacin	40.0 (2/5)	73.3 (25/34)	0.29
Gentamicin	40.0 (2/5)	78.1 (27/34)	0.15
Ciprofloxacin	75.0 (3/4)	80.0 (28/35)	1.00
Nalidixic acid	75.0 (3/4)	86.4 (19/22)	0.59
Cotrimoxazole	66.7 (2/3)	89.3 (25/28)	0.22
Fosfomycin	66.7 (2/3)	53.9 (14/26)	1.00
Nitrofurantoin	100 (5/5)	85.7 (30/35)	1.00

UTI: urinary tract infection; CA-UTI: community-acquired UTI; HA-UTI: healthcare-associated UTI; *p values < 0.05 were considered statistically significant.*

climatic factors such as dehydration and reduced urinary frequency may contribute to bacterial ascension and infection risk [16]. The heterogeneity of seasonal trends across studies underscores the multifactorial nature of UTI epidemiology.

E. coli was the predominant uropathogen in both CA- and HA-UTIs, followed by *K. pneumoniae*, reflecting the classic ascending pathophysiology of UTIs and intestinal colonization by Enterobacteriaceae. The relatively lower proportion of *E. coli* and the higher representation of *K. pneumoniae* in hospital-acquired infections are consistent with patterns reported in settings characterized by higher antibiotic pressure and invasive procedures [17,18].

The AMR patterns observed in this study highlight a substantial burden of resistance among Enterobacteriaceae, particularly in HA-UTIs. Aminoglycosides retained relatively good activity in community-acquired infections, likely reflecting their restricted use and parenteral route of administration. In contrast, nitrofurantoin and fosfomycin demonstrated sustained effectiveness against *E. coli* in CA-UTIs, supporting their role as first-line empirical agents in accordance with international recommendations [19,20]. The observed resistance profiles are broadly consistent with regional reports, although notable geographic variability persists [21].

ESBL–producing Enterobacteriaceae accounted for 8.5% of isolates and were significantly more prevalent in healthcare-associated infections. These isolates exhibited high resistance to β-lactams, fluoroquinolones, and cotrimoxazole; severely limiting therapeutic options. The markedly elevated fluoroquinolone resistance observed in CA-UTIs exceeds international thresholds for empirical use and likely reflects widespread antibiotic misuse in outpatient settings. The frequent co-occurrence of ESBL production and fluoroquinolone resistance may be explained by the co-localization of resistance determinants on mobile genetic elements. In contrast, fosfomycin maintained favorable activity, reinforcing its value as a carbapenem-sparing option for uncomplicated CA-UTIs [22,23].

CRE were more frequently identified in HA-UTIs, with *K. pneumoniae* as the dominant species. This finding is consistent with regional and global data identifying hospital environments as key reservoirs for carbapenem resistance, often mediated by bla_OXA-48 and bla_NDM carbapenemases in North Africa [24,25]. The high rates of aminoglycoside resistance among healthcare-associated CRE isolates, particularly to amikacin, likely reflect intense antibiotic selective pressure in severe infections, such as septic shock and critical illness. These patterns underscore the challenges of empiric therapy in hospital settings and the need for continuous reassessment of treatment strategies [26].

Several limitations should be acknowledged. This was a single-center study conducted in an emergency–intensive care setting, which may limit the generalizability of the findings. Nevertheless, the study provides robust epidemiological and phenotypic resistance data that are highly relevant for local clinical practice.

Overall, the observed differences in pathogen distribution and resistance profiles between CA- and HA-UTIs highlight the dynamic interplay between antimicrobial exposure, healthcare practices, and bacterial adaptation. These findings support the need for context-specific empirical therapy guidelines informed by local surveillance data [27,28].

Conclusions

This study provides a comprehensive comparison of CA- and HA-UTIs in a Tunisian emergency–intensive care setting, highlighting substantial differences in pathogen distribution and AMR patterns. The high prevalence of multidrug-resistant Enterobacteriaceae, particularly ESBL- and carbapenem-producing *K. pneumoniae* in healthcare-associated infections, underscores the critical role of hospitals as reservoirs for AMR.

The findings support the use of setting-specific empirical treatment strategies, with nitrofurantoin and fosfomycin remaining appropriate first-line options for CA-UTIs, while emphasizing the need for cautious antibiotic use and early de-escalation in hospital settings. Strengthening antimicrobial stewardship programs, reinforcing infection prevention and control measures, and maintaining continuous local surveillance are essential to mitigate the escalating burden of AMR in Tunisia.

Authors' contributions

ME: manuscript writing; SB: statistical data analysis; SC: validation of the results.

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Conflict of interest

No conflict of interest is declared.

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