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PREVALÊNCIA, PERFIL DE SENSIBILIDADE AOS ANTIMICROBIANOS E EPIDEMIOLOGIA DE BACTÉRIAS PRODUTORAS DE BETA-LACTAMASES DE ESPECTRO ESTENDIDO (ESBL) EM INFECÇÕES DO TRATO URINÁRIO EM UM HOSPITAL TERCIÁRIO BRASILEIRO

PREVALENCE, ANTIMICROBIAL SUSCEPTIBILITY PATTERN, AND EPIDEMIOLOGY OF EXTENDED-SPECTRUM BETA-LACTAMASES (ESBL) PRODUCING BACTERIA IN URINARY TRACT INFECTIONS IN A BRAZILIAN TERTIARY CARE HOSPITAL

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Resumo

A prevalência das infecções do trato urinário (ITUs) causadas por *Escherichia coli* e *Klebsiella pneumoniae* produtoras de beta-lactamases de espectro estendido (ESBL) está aumentando em todo o mundo. Foi realizada uma análise retrospectiva de prontuários de pacientes com ITU internados em um hospital universitário terciário geral no Brasil, ao longo de um período de 1 ano (2022–2023). Entre 1.193 episódios de ITU, 179 (15%) foram causados por ESBL. Não foi observada diferença significativa entre os sexos nos casos de ITU causadas por ESBL, e a idade média dos pacientes foi de 55 anos (variação: 1–102 anos). A maioria das bactérias produtoras de ESBL (70%) foi isolada de pacientes hospitalizados, com tempo médio de internação de 27,5 dias. *Escherichia coli* e *Klebsiella pneumoniae* foram as espécies produtoras de ESBL predominantes. Mais de 99% dos isolados de ESBL demonstraram resistência às cefalosporinas de terceira e quarta gerações e ao aztreonam, enquanto a sensibilidade à amicacina e à polimixina B foi observada na maioria das cepas bacterianas, sendo os carbapenêmicos as drogas mais eficazes. Compreender os padrões de resistência antimicrobiana em cepas produtoras de ESBL associadas às ITUs é fundamental para orientar a terapia antimicrobiana empírica. A implementação imediata de medidas de controle de infecção e o uso racional de antibióticos são essenciais para prevenir o desenvolvimento e a disseminação de bactérias produtoras de ESBL.
Palavras-chave: Beta-Lactamases; *Escherichia coli*; Multirresistência; Infecções Urinárias.

Abstract

The prevalence of urinary tract infections (UTIs) caused by extended-spectrum beta-lactamase (ESBL)-producing *Escherichia coli* and *Klebsiella pneumoniae* is increasing worldwide. A retrospective analysis of medical records was conducted for patients with UTIs admitted to a general tertiary university hospital in Brazil, over a 1-year period (2022–2023). Among 1193 UTI episodes, 179 (15%) were caused by ESBL. No significant difference in sex was observed among cases of ESBL-causing UTI, and the mean age of the patients was 55 years (range: 1–102 years). Most ESBL-producing bacteria (70%) were isolated from hospitalized patients, with an average length of hospitalization of 27.5 days. *Escherichia coli* and *Klebsiella pneumoniae* were the predominant ESBL-producing species. Over 99% of ESBL isolates demonstrated resistance to third- and fourth-generation cephalosporins and aztreonam, whereas sensitivity to amikacin and polymyxin B was observed among the majority of bacterial strains, with carbapenems being the most effective drugs. Understanding antimicrobial resistance patterns in ESBL-producing strains associated with UTIs is crucial for guiding empirical antimicrobial therapy. Prompt implementation of infection control measures and rational use of antibiotics are essential to prevent the development and dissemination of ESBL-producing bacteria.
Keywords: Beta-Lactamases; *Escherichia coli*; Multidrug Resistance; Urinary Tract Infection.

Resumen

La prevalencia de las infecciones del tracto urinario (ITU) causadas por *Escherichia coli* y *Klebsiella pneumoniae* productoras de betalactamasas de espectro extendido (ESBL) está aumentando en todo el mundo. Se realizó un análisis retrospectivo de los registros médicos de pacientes con ITU ingresados en un hospital universitario terciario general en Brasil, durante un período de un año (2022–2023). Entre 1.193 episodios de ITU, 179 (15%) fueron causados por ESBL. No se observó una diferencia significativa entre los sexos en los casos de ITU causadas por ESBL, y la edad media de los pacientes fue de 55 años (rango: 1–102 años). La mayoría de las bacterias productoras de ESBL (70%) se aislaron de pacientes hospitalizados, con una duración promedio de hospitalización de 27,5 días. *Escherichia coli* y *Klebsiella pneumoniae* fueron las especies productoras de ESBL predominantes. Más del 99% de los aislamientos de ESBL mostraron resistencia a las cefalosporinas de tercera y cuarta generación y al aztreonam, mientras que se observó sensibilidad a la amikacina y a la polimixina B en la mayoría de las cepas bacterianas, siendo los carbapenémicos los fármacos más eficaces. Comprender los patrones de resistencia antimicrobiana en cepas productoras de ESBL asociadas con las ITU es fundamental para orientar la terapia

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antimicrobiana empírica. La implementación inmediata de medidas de control de infecciones y el uso racional de antibióticos son esenciales para prevenir el desarrollo y la diseminación de bacterias productoras de ESBL.
Palabras clave: Beta-Lactamasas; *Escherichia coli*; Resistencia Bacteriana Múltiple; Infecciones Urinarias.

1. Introduction

The relationship between antibiotic use and the emergence of resistant microbial strains is a critical global concern. Antibiotic selective pressure often results from inappropriate practices, including overuse, incorrect dosages, incomplete courses of treatment and the empirical administration of broad-spectrum antibiotics to critically ill patients (SALAM *et al*., 2023). These practices have contributed to the increasing prevalence of resistant microbial strains, leading to infections that are more difficult and costly to manage and that diminish the efficacy of standard treatments (ALMEIDA *et al.,* 2017; MUTEEB *et al*., 2023).

Beta-lactam antibiotics, such as penicillins and cephalosporins, act by inhibiting bacterial cell wall synthesis and are widely used to treat bacterial infections. However, their efficacy is compromised by the production of beta-lactamases, enzymes that degrade the beta-lactam ring and neutralize the bactericidal activity of these antibiotics. Among these enzymes, extended-spectrum beta-lactamases (ESBLs) confer resistance to a broad range of beta-lactam antibiotics, including penicillins, extended-spectrum cephalosporins, and monobactams (DENKEL, 2020). Infections caused by ESBL-producing organisms are particularly challenging to treat and are associated with higher risks of treatment failure, prolonged illness, increased healthcare costs, and greater likelihood of complications (LIMA *et al*., 2020).

Urinary tract infections (UTIs) are common bacterial infections that affect the urinary system, typically presenting with symptoms such as dysuria, polyuria, and lower abdominal discomfort (MANCUSO *et al*., 2023). UTIs are prevalent in both community- and hospital-acquired settings and, if inadequately managed, may result in complications such as kidney damage or systemic infections. The emergence of ESBL-producing pathogens in UTIs has exacerbated resistance rates, often necessitating the use of alternative antibiotics that are more potent

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and potentially more toxic (PULINGAM *et al*., 2022).

Given the limited and outdated national data on ESBL-producing bacteria in urinary tract infections, especially in tertiary healthcare settings, this study aimed to describe the prevalence, antimicrobial resistance patterns, and epidemiological profile of ESBL-producing bacteria in urinary tract infections in a Brazilian tertiary hospital.

2. Methodology

This was a descriptive, retrospective study that analyzed the medical records of patients diagnosed with both community- and nosocomial-acquired UTIs admitted to a tertiary hospital in Uberaba, Minas Gerais, Brazil, between September 2022 and September 2023. Medical records were accessed through the hospital database using a predesigned data collection form, and microbiological data were retrieved from the records of the clinical analysis laboratory. Data collection form included demographic data (age, sex, race), clinical variables (comorbidities, hospitalization status, use of urinary catheter, clinical outcome), and microbiological results (bacterial species, antimicrobial susceptibility).

All the patients with a confirmed diagnosis of UTI (defined as a urine culture showing ≥105 CFU/mL) and positive results for ESBL-producing bacteria were included in the study, regardless of sex, age, or department of admission/treatment. Bacterial identification and antimicrobial susceptibility testing were performed by the hospital laboratory using the Vitek® 2 system (bioMérieux Inc., Durham, NC). ESBL production was detected using the double-disc synergy test on Mueller-Hinton agar media, in accordance with Clinical and Laboratory Standards Institute (CLSI) guidelines (CLSI, 2023).

Quantitative and qualitative data analyses were performed to evaluate the profile of the affected patients, including the most prevalent bacterial species, antibiotic susceptibility profile of isolated ESBL-producing bacteria, length of hospitalization, and mortality rate.

Statistical analyses were performed using GraphPad Prism 5.0 software and a statistical significance level of $P<0.05$ was established. When the variable

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consisted of two groups, pairwise inferences were made using the nonparametric Mann-Whitney U test. The Nonparametric Kruskal-Wallis test, followed by Dunn's post-test, was used for three or more independent group comparisons. Ethical approval for this study was obtained from the university's Ethics Committee for Research with Human Beings (protocol number: 6.221.830).

As a retrospective observational study, all eligible cases identified during the defined study period were included, and no prior sample size calculation or statistical power analysis was performed. The analysis was based on the total number of available cases.

3. Results

During the study period, 10792 urine cultures were conducted at the hospital laboratory, of which 1193 (11,05%) were positive for bacterial growth. ESBL-positive isolates were detected in 179 (15,0%) cases, with an average of approximately 15 ESBL-producing UTI cases per month. The occurrence of ESBL infections did not differ between men (52.50%) and women (47.50%) (P=0.587); however, a predominance of white patients (55.87%) was observed (P=0.0004). The average age of patients with UTIs caused by ESBL-positive bacteria was 55 years (range, 1–102 years), with 50.30% of patients older than 60 years (P=0.0005) (Table 1).

Table 1 - Profile of patients with urinary tract infection caused by ESBL-producing bacteria

Variable	**N**	**%**	**p-value**
Sex			0.587
Female	94	52,5%	
Male	85	47,5%	
Race			0.0004
White	99	55,3%	
Mixed-race	66	36,9%	
Black	9	5%	

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Not reported	5	2,8%	
Age groups			0.0005
0 – 9 years	16	8,9%	
10 – 19 years	4	2,2%	
20 – 29 years	7	3,9%	
30 – 39 years	13	7,3%	
40 – 49 years	24	13,4%	
50 – 59 years	25	14%	
60 – 69 years	30	16,8%	
70 – 79 years	33	18,4%	
80 – 89 years	22	12,3%	
90 – 99 years	4	2,2%	
Over 100 years	1	0,6%	
Smoking status			0.0011
Non-smoker	97	54,2%	
Former smoker	44	24,6%	
Smoker	21	11,7%	
Not reported	17	9,5%	
Alcohol consumption			0.0049
Non-drinker	94	52,5%	
Former drinker	27	15%	

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Drinker	34	19%	
Not reported	24	13,4%	
Diabetes mellitus			0.090
Yes	51	28.49	
No	118	65.92	
Not reported	10	5.59	
Hypertension			0.854
Yes	87	48.60	
No	82	45.81	
Not reported	10	5.59	

Source: Elaborated by the authors.

Regarding lifestyle habits, most patients denied smoking (54.19%, P=0.0011) or alcohol consumption (52.51%) (P=0.0049). The presence of comorbidities such as diabetes or hypertension did not influence the occurrence of UTI caused by ESBL-producing bacteria (P>0.05) (Table 1).

Of the 179 ESBL-positive cases, 127 (70.9%) occurred in hospitalized patients and 52 (29.1%) in outpatient settings. The average length of hospitalization was 27.5 days. Patients with prolonged hospitalizations accounted for 5,03% of the ESBL cases, no significant difference was observed in the duration of hospitalization (P = 0.406) (Table 2).

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Table 2 - Length of hospital stay for patients with urinary tract infection caused by ESBL-producing bacteria.

Hospitalization days	n	%
Did not require hospitalization	52	29%
<7 days	26	22,2%
8 – 14 days	28	23,9%
15 – 30 days	33	28,2%
31 – 60 days	21	17,9%
>60 days	9	7,7%
Long-term hospitalization	10	5,6%

Source: Elaborated by the authors.

More than 70% of ESBL-producing bacteria were isolated from hospitalized patients. The mean length of stay was 27.5 days. Patients with prolonged hospitalizations accounted for 5.03% of ESBL cases, although no significant difference was observed in the duration of hospitalization (P = 0.406) (Table 2).

The use of a urinary catheter did not influence the occurrence of UTI caused by ESBL-producing bacteria (45.81% of patients used some type of urinary catheter) (Table 3) (P>0.05). In addition to bacterial UTI, other infections during hospitalization were reported in 31.20% of patients. Pneumonia was the most frequent complication (58.90%) followed by sepsis (12.80%). The main outcome observed was cure (77.65%). The mortality rate of 22.35% (P=0.015) represents overall in-hospital mortality among patients with ESBL-positive UTI, and was not specifically attributed to the urinary tract infection itself (Table 3).

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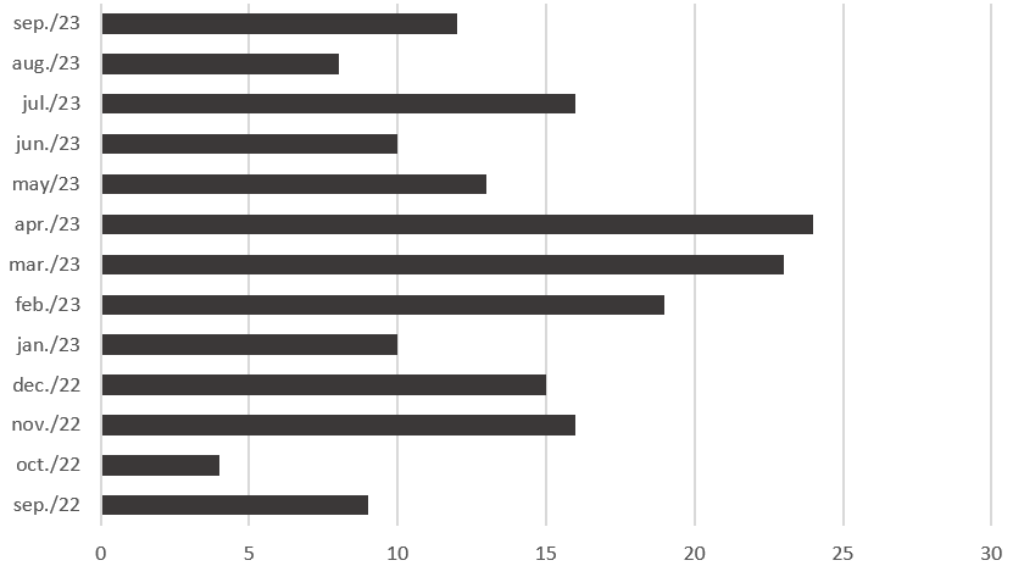
Table 3 - Clinical characteristics of patients with urinary tract infection caused by ESBL-producing bacteria

Variable	n	%	p-value
Urinary catheterization			0.303
Yes	82	45.81	
No	97	54.19	
Outcome of discharge			0.015
Cure	139	77.65	
Death	40	22.35	

Source: Elaborated by the authors.

The temporal distribution of ESBL-producing enterobacteria cases was evaluated monthly between September 2022 and September 2023 (Figure 1). The number of cases varied throughout the period, ranging from 4 cases in October 2022 to a peak of 24 cases in April 2023, showing a fluctuating pattern over time rather than a consistent upward or downward trend.

Figure 1 - Monthly distribution of urinary tract infection caused by ESBL-producing bacteria.



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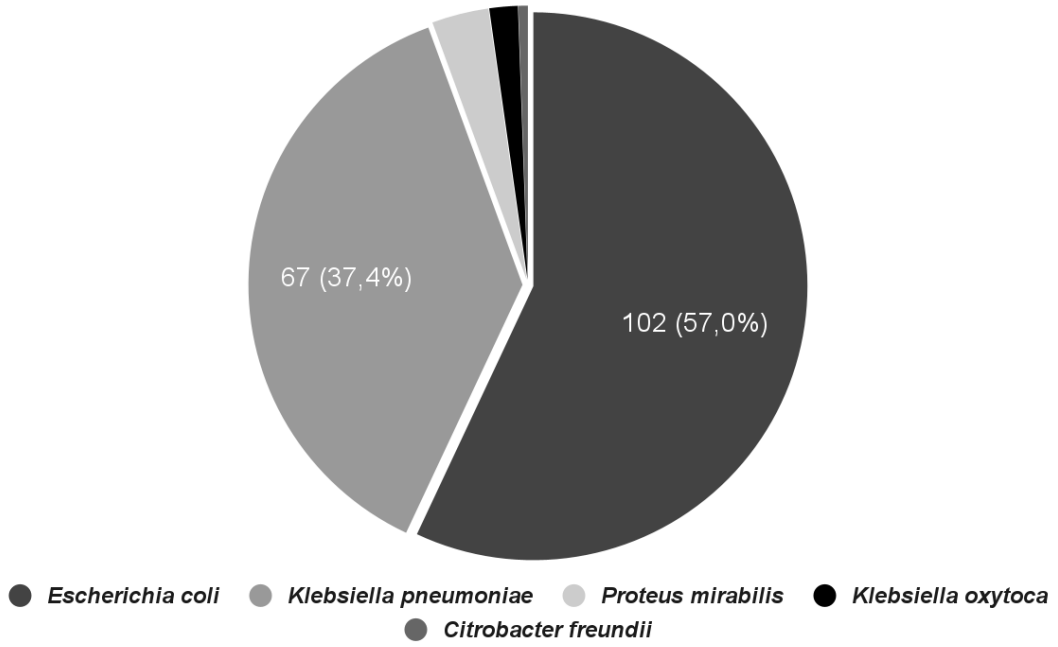
Escherichia coli was the most commonly isolated ESBL producer (102/179; 57.00%), followed by *Klebsiella pneumoniae* (67/179; 37.40%) (P<0.0001) (Figure 2). Despite being more commonly isolated among the ESBL-producing strains in this study, ESBL production among *E. coli* strains (14.9%, corresponding to 102 ESBL-positive *E. coli* among all 684 *E. coli* strains causing UTI in the evaluated period) was lower than that among the *K. pneumoniae* strains implicated in UTI (37.4%, corresponding to 67 ESBL-positive *K. pneumoniae* strains among 179 associated with UTI in the evaluated period).

Figure 2 - Identification of ESBL-producing bacteria among the cases of urinary tract infections evaluated (n=179)



Source: Elaborated by the authors.

Antimicrobial susceptibility testing was performed on 176 urine cultures (98.32%). All ESBL-producing *E. coli* and *K. pneumoniae* (n=169) were evaluated, although the panel of antimicrobial drugs tested varied. Considering the two main ESBL-positive bacteria found in the present study, all the strains showed resistance to three or more antibiotic classes and were classified as multi-drug resistant bacteria. Regarding susceptibility to cephalosporins, all ESBL isolates tested

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showed resistance to cefalotin (first generation), 99.37% were resistant to ceftazidime (third generation), 99.39% were resistant to ceftriaxone (third generation), and 99.40% were resistant to cefepime (fourth generation). Resistance to Ampicillin+Sulbactam, a semi-synthetic beta-lactam + beta-lactamase inhibitor, was observed in 92.98% of the bacterial isolates, and all ESBL-producing *E. coli* and *K. pneumoniae* were resistant to the monobactam aztreonam. Regarding quinolones and fluoroquinolones, 80.14% of the ESBL-producing strains were resistant to ciprofloxacin and 77.30% to norfloxacin. Resistance to Trimethoprim+Sulfamethoxazole was observed in 81.25% of the strains (Table 4).

Table 4 - Antimicrobial susceptibility pattern of ESBL-producing *E. coli* and *K. pneumoniae*

Antimicrobial	**ESBL-producing *E. coli***		**ESBL-producing *K. pneumoniae***		**Total**	
	Sensitive (%)	Resistant (%)	Sensitive (%)	Resistant (%)	Sensitive (%)	Resistant (%)
Cefalothin	0	100 (69/69)	0	100 (41/41)	0	100 (110/110)
Cefepime	0.99 (1/101)	99.01 (100/101)	0	100 (65/65)	0.60 (1/166)	99.40 (165/166)
Ceftazidime	1.05 (1/95)	98.95 (94/95)	0	100 (64/64)	6.3 (1/159)	99.37 (158/159)
Ceftriaxone	1.00 (1/100)	99.00 (99/100)	0	100 (64/64)	6.1 (1/164)	99.39 (163/164)
Amikacin	95.10 (97/102)	4.90 (5/102)	98.48 (65/66)	1.52 (1/66)	96.43 (162/168)	3.57 (6/168)
Gentamicin	65.63 (63/96)	34.38 (33/96)	46.77 (29/62)	53.22 (33/62)	58.23 (92/158)	41.77 (66/158)
Ampicilin +Sulbactam	10.00 (7/70)	95.71 (63/70)	2.27 (1/44)	97.72 (43/44)	7.02 (8/114)	92.98 (106/114)
Aztreonam	0	100 (68/68)	0	100 (44/44)	0	100 (112/112)
Ciprofloxacin	14.94 (13/87)	85.05 (74/87)	27.12 (16/59)	72.88 (43/59)	19.86 (29/146)	80.14 (117/146)

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Norfloxacin	16.33 (16/98)	83.67 (82/98)	32.31 (21/65)	67.69 (44/65)	22.70 (37/163)	77.30 (126/163)
Ertapenem	97.98 (97/99)	2.02 (2/99)	100 (65/65)	0	98.78 (162/164)	1.22 (2/164)
Imipenem	100 (91/91)	0	100 (63/63)	0	100 (154/154)	0
Meropenem	100 (98/98)	0	100 (64/64)	0	100 (162/162)	0
Nitrofurantoin	83.67 (82/98)	16.33 (16/98)	34.33 (23/67)	65.67 (44/67)	63.64 (105/165)	36.36 (60/165)
Polymyxin B	100 (12/12)	0	100% (14/14)	0	100 (26/26)	0
Trimethoprim +Sulfamethoxazole	17.44 (15/86)	82.56 (71/86)	20.69 (12/58)	79.31 (46/58)	18.75 (27/144)	81.25 (117/144)

Source: Elaborated by the authors.

ESBL-producing bacteria were most sensitive to the aminoglycoside amikacin (96.43%), followed by nitrofurantoin (63.64%) and gentamicin (58.23%). All bacterial isolates were sensitive to polymyxin B, carbapenems, imipenem, and meropenem. Two ESBL-producing E. coli strains were resistant to ertapenem (1.16%) (Table 4).

4. Discussion

According to the Antibiotic Resistance Threats Report published by the Centers for Disease Control and Prevention (CDC, 2024), ESBL–producing bacteria are listed among the seven antimicrobial-resistant pathogens typically found in healthcare settings. and are classified as a serious threat responsible for numerous infections and deaths worldwide. In most cases, ESBL-encoding genes are located on mobile genetic elements and are easily transferred between different bacteria, favoring the spread of beta-lactam resistance.

The prevalence and distribution of ESBL producing organisms vary geographically and among healthcare facilities, influenced by the infection site and

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population dynamics. In this study, the prevalence of UTI caused by ESBL-producing bacteria was 15%. Regional data from Latin America also indicate a substantial circulation of resistant strains: a systematic review of nosocomial ESBL-producing *Enterobacteriaceae* in Latin American hospitals reported that up to 32% of *Escherichia coli* and up to 58% of *Klebsiella pneumoniae* isolates were ESBL-positive, with these proportions generally higher than those observed in Europe or North America (GUZMÁN-BLANCO et al., 2014).

Naushad *et al*. (2022) reported a 25% prevalence of ESBL-producing *Enterobacteriaceae* among urine isolates from adult patients in a tertiary hospital in Qatar, reflecting considerable circulation of multidrug-resistant strains within the region. Similarly, Paumier *et al.* (2022) found that 21% of community-acquired Escherichia coli urinary tract infections in France were caused by ESBL-producing isolates, underscoring the emergence of resistance even in outpatient settings. More recently, Halldórsdóttir *et al.* (2024) observed an increasing trend in the prevalence of ESBL-producing *E. coli* causing urinary tract infections in Iceland between 2012 and 2021, with rates reaching 15–18% in recent years, highlighting the global expansion of these resistant pathogens.

Studies conducted in Brazil have reported lower rates of UTI caused by ESBL-producing bacteria compared to the findings of this study. For instance, Tano *et al.* (2022) analyzed 56555 urine cultures from women with suspected community-acquired UTIs in Southern Brazil and found that 4.70% of enterobacterial isolates were ESBL-producing, while Rios Neto *et al.* (2017) observed a prevalence of 4.90% of ESBL-producing enterobacteria in UTI cases in Parnaiba, Piaui, Brazil, over a 4 years period. Souza *et al.* (2021) identified an even lower prevalence of 4.50% in urine cultures from community-based patients analyzed over 1 year.

The occurrence of ESBL enzymes was initially associated with *Klebsiella pneumoniae* strains; however, these enzymes are currently detected in many pathogenic species of Gram-negative bacteria, especially those belonging to the *Enterobacteriaceae* family, including *Escherichia coli, Pseudomonas aeruginosa, Proteus mirabilis, Providencia*, and *Enterobacter* (ALMEIDA et al., 2017; LAUDY et al., 2015). As observed in this study, *Escherichia coli* is the most prevalent ESBL

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producer, followed by *Klebsiella spp* (RIOS NETO *et al*., 2017; SOUZA *et al*., 2021; NASCIMENTO *et al.,* 2023). Advanced age, female sex, and comorbidities such as diabetes, permanent urinary catheterization, immobilization, neurogenic bladder, and kidney transplantation are considered risk factors for UTIs (ALGHORAIBI *et al*., 2023). In this study, older age (> 60 years) was correlated with a higher incidence of UTI caused by ESBL-positive bacteria. Similarly, Souza *et al.* (2021) reported that 60% of patients with urine cultures positive for ESBL-producing pathogens were older than 60 years. The aging process is associated with impairment of the immune system, making older adults more susceptible to different types of infections (HALABI *et al*., 2021).

As expected, in this study, ESBL-producing strains isolated from urine cultures were resistant to extended-spectrum cephalosporins and monobactams. A major concern regarding ESBL-producing bacteria is the high rate of cross-resistance to non-beta-lactam antibiotics such as ciprofloxacin, aminoglycosides, nitrofurantoin, and trimethoprim-sulfamethoxazole. In this study, significant resistance to these antimicrobials was observed (80% of the strains tested), limiting therapeutic options.

Kim *et al*. (2017) reported 61.00% resistance to at least two non-beta-lactam antibiotics commonly used for UTI treatment. Halabi *et al*. (2021) reported significant resistance to ceftazidime (90%), cefotaxime (91%), norfloxacin (93%), and Trimethoprim-Sulfamethoxazole (80%), with high sensitivity to imipenem (97%) and ertapenem (99%), in ESBL-producing *E. coli* strains isolated from urine cultures. Similarly, Pantha *et al.* (2024) analyzed ESBL-producing *E. coli* strains from urine samples of hospitalized pediatric patients and found resistance rates of 90.20% to ceftazidime, 92.70% to ceftriaxone, and 73.20% to ciprofloxacin, in addition to high sensitivity to imipenem (100%), nitrofurantoin (95.10%), meropenem (70.70%), and gentamicin (68.30%).

The in-hospital mortality rate observed among patients with ESBL-producing UTI was 22.35%. However, this value represents overall all-cause in-hospital mortality and was not specifically adjudicated as directly attributable to the urinary tract infection or to ESBL production itself. Therefore, caution is warranted when

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interpreting this finding, as patients admitted to tertiary care hospitals often present with multiple comorbidities and severe underlying conditions that may independently influence clinical outcomes.

In this study, all evaluated ESBL-positive *E. coli* and *K. pneumoniae* strains were found to be sensitive to carbapenems, imipenem, and meropenem. However, resistance to ertapenem was detected in two *E. coli* strains. Carbapenem resistance among *Enterobacteriaceae* has become a critical public health concern, as this antibiotic class represents the last line of defense against multidrug resistant bacteria. The spread of carbapenem-resistant *Enterobacteriaceae* (CRE) is facilitated by horizontal gene transfer and poses a serious challenge for infection control and treatment strategies worldwide. This emergence of resistant strains highlights the urgent need for novel antimicrobial agents and effective surveillance systems.

5. Conclusion

This study provides important insights into the prevalence and resistance profiles of ESBL-producing enterobacteria in urinary tract infections at a tertiary Brazilian hospital. Significant resistance to commonly used antibiotics were observed, resulting in limited treatment options. These data underscore the challenge of antimicrobial resistance and the importance of antibiotic stewardship, infection control, and ongoing surveillance to mitigate its effect on UTI treatment outcomes.

This study has several limitations that should be considered when interpreting the findings. No comparison group of non-ESBL UTI cases nor formal stratification between community- and hospital-acquired infections were conducted, limiting the ability to assess the epidemiological differences between these groups. Moreover, molecular characterization of ESBL genes was not performed, limiting the understanding of the genetic background and transmission dynamics of ESBL-producing strains.

It is also important to mention that mortality data reflected overall in-hospital mortality observed in ESBL-related UTI, and could be attributable to other

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underlying clinical conditions associated, limiting causal interpretation of clinical outcomes.

The retrospective and single-center design are limitations that should be addressed in future multicenter and prospective studies to better elucidate the epidemiology and outcomes of infections caused by ESBL-producing bacteria. Despite all these limitations, the identification of local prevalence rates and resistance patterns provides valuable evidence for optimizing empirical antibiotic therapy and guiding infection prevention strategies. Continuous epidemiological monitoring remains crucial to mitigate the dissemination of ESBL-producing bacteria and preserve the effectiveness of available antimicrobial agents.

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