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Coronavirus Pandemic

Antibiotic resistance in community-acquired urinary tract infections. Did the COVID-19 pandemic cause a change?

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Abstract
Introduction: This study aimed to evaluate the antimicrobial resistance rates before and during the coronavirus disease 2019 (COVID-19) pandemic.
Methodology: 897 positive urine cultures collected from outpatients of all ages between January 1, 2017, and December 31, 2022, were analyzed. The antibiotic susceptibility tests (AST) were analyzed by using an automated VITEK 2 (Biomerieux, Marcy-l'Étoile, France) compact system. AST results were interpreted according to the European Committee on Antimicrobial Susceptibility Testing (EUCAST) criteria. The significance of resistance rates was tested with the Pearson's Chi-squared test and risk factors of extended-spectrum beta-lactamases (ESBL) positiveness were identified with binary logistic regression.
Results: *E. coli* (n = 774) and *K. pneumoniae* (n = 123) were isolated in 86.3% and 13.7% of the patients, respectively. During this period of six years before and during pandemic, the highest resistance rate was found for cefuroxime axetil (49.8%) and the lowest for nitrofuratoin (6.0%). Statistically significant increases in resistance compared to the pre-pandemic period were only determined for cefixime (37.2 vs 46.0%) and ceftriaxone (37.6 vs 46.1%) (p = 0.010). ESBL positivity was the most important factor that statistically increased resistance for all antibiotics ($p < 0.001$ for all). Being male [OR (95% CI) 1.56 (1.13-2.15)] and presenting to the clinic after the pandemic period [1.4 (1.1-1.8)] were found to increase ESBL positiveness significantly.
Conclusions: Ceftriaxone and Cefixime resistance rates and ESBL positivity among the uropathogens *E. coli* and *K. pneumoniae* increased during the pandemic compared with the pre-pandemic period. ESBL positivity was higher in males.

Key words: uropathogen; COVID-19; resistance; pandemic.

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Introduction

Urinary tract infections (UTIs) are among the most common bacterial infections accounting for about 150-200 million cases globally each year [1]. Based on the site of the infection UTIs are classified as being upper or lower UTIs [2,3]. Gram-negative bacteria, predominantly *Escherichia coli* (*E. coli*), followed by *Klebsiella pneumoniae* (*K. pneumoniae*), are the leading causes of UTIs [1]. These bacilli are responsible for over 80% of community-onset UTIs [4,5]. A variety of antibiotics including nitrofurantoin, trimethoprim-sulfamethoxazole (TMP-SMX), fluoroquinolones, aminoglycosides, and beta-lactams have been recommended by international guidelines for the treatment of UTIs [6]. However, inadequate use of antibiotics has caused antimicrobial-resistant pathogens, thus leading to ineffective treatment [7]. According to the European Antimicrobial Resistance Surveillance Network, *E. coli* and *K. pneumoniae* are the most common pathogens showing resistance to commonly used antimicrobials in clinical practice [8,9].

Enzyme production to metabolize and inactivate the antibiotic is a well-known mechanism of antimicrobial resistance (AMR) of bacteria. *E. coli* and *K. pneumoniae* can acquire genes to produce enzymes including extended-spectrum beta-lactamases (ESBLs), which are considered the key mechanism for resistance to beta-lactam antibiotics [10,11]. ESBL encoding genes are usually found on a large transferable plasmid, which often contains resistance genes for other classes of antibiotics such as aminoglycosides, fluoroquinolones, and sulphonamides [12,13]. Thus, ESBL producing bacteria are generally resistant to most of the available antibiotics except the carbapenem group [7]. The prevalence of ESBL-producing *E. coli* and *K. pneumoniae* has been increasing globally [14,15].

Antibiotic exposure is the driving factor for the selection of AMR [16]. The use of cephalosporins, quinolones, and long-term use of antimicrobials have been identified as risk factors for infections caused by ESBL-producing *E. coli* and *Klebsiella* spp. [17,18]. Excess use of antimicrobials that can potentially lead to an increase in the incidence of AMR was observed during the coronavirus disease 2019 (COVID-19) pandemic [19]. Antibiotics have been widely used in the treatment of COVID-19 through their blind prescription, over-the-counter availability, and self-medication as a result of anxiety, uncertainty, and absence of antiviral agents [20]. Recent studies have demonstrated that the use of antimicrobial agents and the incidence of multidrug-resistant organisms significantly increased during the pandemic compared with the previous years [19,21]. Accumulating data suggest that the pandemic could amplify AMR in the near future [22-24]. It has been noted that antimicrobial agent use in hospitalized patients had reached up to 80%, even when the rates of bacterial secondary and co-infection were low (6-8%) [19]. However, the real burden of antibiotic consumption in outpatient visits is still unknown.

Studies suggest that by 2050, over 10 million deaths are likely to occur because of multidrug-resistant bacterial infections [25]. Overconsumption of antibiotics during the pandemic, together with the current status of AMR reported previously [26,27] may directly affect patient outcomes causing higher rates of mortality and morbidity.

UTIs continue to represent a major health problem that requires the pathogens in the urinary tract and their susceptibility to be analyzed to avoid the misuse of antibiotics. To establish effective antimicrobial stewardship guidelines, it is important to determine local surveillance of bacterial resistance [28]. The best way to treat UTIs is to choose optimal antibiotics instead of a blind prescription, if possible, depending on culture results [29]. However, current guidelines do not recommend urine culture and antimicrobial susceptibility testing for patients with acute cystitis [30]. Additionally, the pandemic may have changed the AMR patterns of uropathogens. Although few studies have been conducted in this regard, a new study has found that the resistance patterns of various bacteria have changed due to the misuse of antibiotics during the COVID-19 pandemic [31]. It is extremely important that the resistance patterns of pathogens in the urinary tract are understood to combat UTIs while minimizing the risk of AMR.

Therefore, the present study was designed to investigate and compare the ESBL positivity and AMR rates of commonly used antimicrobials for *E. coli* and *K. pneumoniae* isolated from outpatient urine samples over a period of six years, divided into two groups comprising the pre-pandemic and pandemic periods.

Methodology

This was a retrospective descriptive study of *E. coli* and *K. pneumoniae* positive urine cultures collected from outpatients of all ages between January 1, 2017, and December 31, 2022. A total number of 897 positive urine samples (774 *E. coli* and 123 *K. pneumoniae*) were examined. Only the first positive urine culture collected per patient on admission was included in the analysis. Patients with urinary catheterization and a history of hospitalization within three months before sampling were excluded. Basic demographic information of the patients was recorded. Samples were assigned to two different groups as pre-pandemic and pandemic. The pre-pandemic period group was composed of patients admitted from January 2017 to December 2019 and the remaining were included in the pandemic group. The first case of COVID-19 in Northern Cyprus was reported on March 9, 2020. However, a retrospective study analyzing severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) RNA in nasopharyngeal samples collected from patients with respiratory symptoms suggested that the virus was in circulation earlier. A combination of strict preventive measures was put in place for around three months after the index case.

Midstream clean catch urine samples were cultivated on eosin-methylene blue (EMB) and 5% sheep blood agars. The cultivated cultures were left to incubate at 35 °C for 24-48 hours. The presence of ≥ 100,000 CFU/mL bacterial colonies was considered positive. The antibiotic susceptibility tests were analyzed by using an automated VITEK 2 (Biomerieux, Marcy-l'Étoile, France) compact system. VITEK 2 GN cards were used for identification. Antimicrobial susceptibility test results were interpreted according to the European Committee on Antimicrobial Susceptibility Testing (EUCAST) criteria and antibiotics detected as intermediate were considered resistant [8]. The descriptive statistics were presented with numbers, percentages, means, standard deviations, medians, and interquartile ranges. The statistical differences between percentages of the related groups were tested with the Pearson's Chi squared test. Changes in resistance rates over the years were tested with Chi square for trend. Risk factors of ESBL positiveness were identified with a binary logistic regression. The significance of the model was tested with the omnibus test and model fit was assessed using the Hosmer-Lemeshow test. A p value under 0.05 was accepted to indicate statistical significance. The tests were performed with SPSS 23.0 [32].

Results

The mean age of the patients was 40.6 ± 27.2 years, 77.4% (n = 694) were female, and 79.9% (n = 717) were adult. The gender distribution among adults and children was not significantly different (p = 0.294). 53.4% (n = 479) of the admissions occurred before the pandemic period (2017-2019). The characteristics of the patients are presented in Table 1.

E. coli (n = 774) and *K. pneumoniae* (n = 123) were isolated in 86.3% and 13.7% of the patients, respectively. *E. coli* was the most common bacteria to be isolated. The culture positivity of *K. pneumoniae* was higher among children compared to adults (23.3% vs 11.3%), and *E. coli* positivity was higher among adults than children (88.7 vs 76.7%) (p < 0.001). *K. pneumoniae* was isolated more frequently in males than females (21.2% vs 11.5%), and *E. coli* was more common in females than males (88.5% vs 78.8%) (p < 0.001 for both).

The culture positivity of *E. coli* and *K. pneumoniae* did not significantly change between the periods before and after the pandemic (p = 0.474). The percentage of ESBL positiveness in patients was not significantly different between *E. coli* and *K. pneumoniae* (p = 0.665). The isolated bacteria and related characteristics are shown in Table 2.

During the period of six years before and during the pandemic, the highest resistance rate was found for cefuroxime axetil (49.8%) and the lowest for nitrofurantoin (6.0%). A statistically significant increase in resistance compared to the pre-pandemic period was determined only for cefixime (37.2% vs 46.0%) and ceftriaxone (37.6% vs 46.1%) (p = 0.010); whereas there was a significant decrease for cefuroxime axetil (100.0% vs 47.6%) (p < 0.001). No significant association was found for other antibiotics.

ESBL positivity is the most important factor that statistically increases resistance for all antibiotics (p < 0.001 for all). The lowest resistance rate was found for nitrofurantoin with 9.7% and gentamicin with 32.2%. The highest resistance was determined for cefuroxime

Table 1. Characteristics of the patients.

Characteristics		
Age (year)	**Mean ± SD**	**Median (IQR)**
All patients	40.6 ± 27.2	35 (45)
Adults	49.8 ± 22.3	48 (43)
Children	4.2 ± 4.7	2.2 (6.7)
Develpoment stage	**n**	**%**
Children	180	20.1
Adult	717	79.9
Gender distribution of patients		
All Patients		
Male	203	22.6
Female	694	77.4
Children		
Boy	46	25.6
Girl	134	74.4
Adults		
Male	157	21.9
Female	560	78.1
Number of patients by year of admission		
2017	138	15.4
2018	251	28.0
2019	90	10.0
2020	28	3.1
2021	86	9.6
2022	304	33.9
Numbers of hospital admissions according to pandemic status		
Before pandemic (2017–2019)	479	53.4
After pandemic (2020–2022)	418	46.6

SD: standard deviation; IQR: interquartile range.

Table 2. Characteristics of isolated bacteria and numbers of each type.

	***E. coli* (n,%)**	***K. pneumoniae* (n,%)**	***p***
Isolated bacteria	774, 86.3	123, 13.7	
Patient age			< 0.001*
Child	138, 76.7	42, 23.3	
Adult	636, 88.7	81, 11.3	
Patient gender			< 0.001*
Male	160, 78.8	43, 21.2	
Female	614, 88.5	80, 11.5	
Year of admission			0.969**
2017	112, 81.2	26, 18.8	
2018	223, 88.8	28, 11.2	
2019	82, 91.1	8, 8.9	
2020	26, 92.9	2, 7.1	
2021	68, 79.1	18, 20.9	
2022	263, 86.5	41, 13.5	
Pandemic status			
Before (2017–2019)	417, 87.1	62, 12.9	0.474*
After (2020–2022)	357, 85.4	61, 14.6	
ESBL			0.665*
Positive	305, 39.4	51, 41.5	
Negative	469, 60.6	72, 58.5	

*Pearson Chi-square, **Chi-square for trend. ESBL: extended-spectrum beta-lactamases.

axetil in specimens growing *K. pneumoniae* (61.9%). Gentamicin had the lowest resistance in *K. pneumoniae* growing samples (11.6%). A statistically significant difference between adults and children was determined only for ciprofloxacin. Ciprofloxacin resistance in adults was significantly higher than in children (33.4% vs 13.3%, $p < 0.001$). Ceftriaxone, gentamicin, TMP-SMX, and ciprofloxacin resistance were significantly higher in women than in men ($p < 0.05$ for all).

Before the pandemic period (2017-2019), 36.1% of all patients were ESBL positive, while 43.8% were positive after the pandemic period (2020–2022). This increase was statistically significant ($p = 0.019$).

Being male [OR (95% C.I.), 1.56 (1.13-2.15)] and presenting to the clinic after the pandemic period [1.4 (1.1-1.8)] increased ESBL positiveness significantly. Being an adult or child and the type of bacteria did not significantly affect ESBL positiveness.

Discussion

UTIs represent a common pathology affecting millions of people each year [31]. The increased incidence of antibiotic-resistant microorganisms is a growing concern globally. High resistance rates among uropathogens have already been reported in previous studies [33,34]. These resistant microorganisms complicate the empirical treatment of UTIs causing mortality and morbidity. Hospital-acquired uropathogens are more resistant to antibiotics than community-acquired ones [35]. However, the prevalence of outpatient UTIs due to resistant microorganisms is also increasing [4,5].

Recent reports demonstrated that the use of antimicrobial agents has increased significantly during the COVID-19 pandemic [19]. More importantly, it has been observed that the prevalence of bacterial co-infection or superinfection among these patients is considerably lower compared to the frequency of antimicrobial use. More than 70% of the inpatients were treated with at least one antimicrobial agent, despite there being less than 10% accompanying bacterial infections [19,36,37]. Accumulating data suggest that the pandemic could amplify AMR soon [19,22,38]. This study provides comparative data on the current resistance status of uropathogens before and during the pandemic. Although it is hard to assess the real effects of COVID-19 on uropathogens, we believe that the excess use of antibiotics during the pandemic may have contributed to the current status of AMR in these isolates. This is quite possible as antibiotic exposure is the key driver of resistance. Moreover, the association between antibiotic exposure and AMR indicates a dynamic mechanism in which a short time delay between exposure and resistance is involved. A time delay of 1–3 months between antibiotic use and resistance to those antibiotics in *E. coli* and other Gram-negative bacteria was reported in previous studies [39-41]. It was indicated that the use of certain antibiotics and resistance to them increases over time proportionally. There is a powerful link between high resistance levels in *E. coli* and increased antimicrobial use in winter with a 1-2 months' time delay. More importantly, this link was mainly described in

Table 3. Antibacterial resistance rates of isolated pathogens for cefixime, ceftriaxone, cefuroxime axetil, gentamicin, nitrofurantoin, TMP-SMX, and ciprofloxacin during our study period of six years.

	Antibacterial resistance (n/N, %)						
	Cefixime	**Ceftriaxone**	**Cefuroxime axetil**	**Gentamisin**	**Nitrofurantoin**	**TMP/SMX**	**Ciprofloxasin**
	344/831, 41.4	342/830, 41.2	202/406, 49.8	133/893, 14.9	49/818, 6.0	337/893, 37.7	263/895, 29.4
Age							
Child	60/161, 37.3	64/170, 37.6	37/81, 45.7	19/180, 10.6	9/159, 5.7	58/179, 32.4	24/180, 13.3
Adult	284/670, 42.4	278/660, 42.1	165/325, 50.8	114/713, 16.0	40/659, 6.1	279/714, 39.1	239/715, 33.4
*p**	0.236	0.291	0.412	0.067	0.845	0.100	< 0.001
Gender							
Male	84/179, 46.9	89/182, 48.9	48/89, 53.9	48/202, 23.8	15/176, 8.5	92/201, 45.8	78/202, 38.6
Female	260/652, 39.9	253/648, 39.0	154/317, 48.6	85/691, 12.3	34/642, 5.3	245/692, 35.4	185/693, 26.7
*p**	0.090	0.017	0.372	< 0.001	0.110	0.008	0.001
Year of admission							
2017	42/97, 43.3	64/133, 48.1	11/11, 100.0	30/137, 21,9	7/98, 7.1	64/137, 46,7	50/138, 36.2
2018	72/249, 28.9	66/251, 26.3	-/-, -	30/250, 12.0	11/250, 4.4	80/250, 32.0	47/251, 18.7
2019	47/87, 54.0	48/90, 53.3	6/6, 100.0	19/90, 21.1	4/74, 5.4	46/89, 51.7	37/88, 42.0
2020	26/26, 100.0	28/28, 100.0	18/18, 100.0	10/28, 35.7	1/25, 4.0	19/28, 67.9	20/28, 71.4
2021	79/79, 100.0	80/80, 100.0	77/78, 98.7	16/85, 18.8	9/77, 11.7	44/85, 51.8	40/86, 46.5
2022	78/293, 26.6	56/248, 22.6	90/293, 30.7	28/303, 9.2	17/294, 5.8	84/304, 27.6	69/304, 22.7
*p***	0.847	0.745	< 0.001	0.016	0.541	0.015	0.660
Pandemic status							
Before (2017-2019)	161/433, 37.2	178/474, 37.6	17/17, 100.0	79/477, 16.6	22/422, 5.2	190/476, 39.9	134/477, 28.1
After (2020-2022)	183/398, 46.0	164/356, 46.1	185/389, 47.6	54/416, 13.0	27/396, 6.8	147/417, 35.3	129/418, 30.9
*p**	0.010	0.014	< 0.001	0.134	0.334	0.151	0.364
Isolated bacteria							
E. coli	293/716, 40.9	290/715, 40.6	163/343, 47.5	119/772, 15.4	26/708, 3.7	301/771, 39.0	240/772, 31.1
K. pneumoniae	51/115, 44.3	52/115, 45.2	39/63, 61.9	14/121, 11.6	23/110, 20.9	36/122, 29.5	23/123, 18.7
*p**	0.489	0.346	0.036	0.269	< 0.001	0.044	0.005
ESBL							
Positive	308/312, 98.7	323/335, 96.4	176/179, 98.3	114/354, 32.2	29/299, 9.7	211/352, 59.9	190/354, 53.7
Negative	36/519, 6.9	19/495, 3.8	26/227, 11.5	19/539, 3.5	20/519, 3.9	126/541, 23.3	73/541, 13.5
*p**	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001

ESBL: extended-spectrum beta-lactamases; TMP-SMX: trimethoprim-sulfamethoxazole.

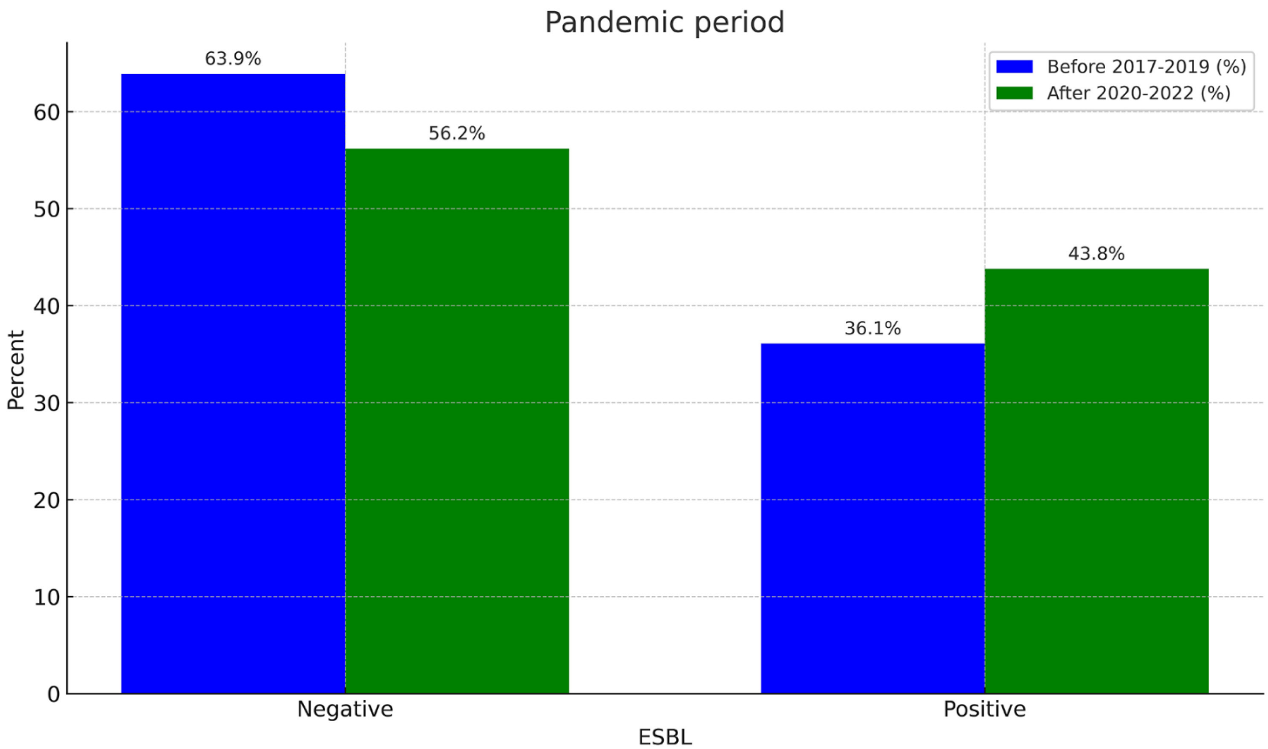
antibiotics like beta-lactams which are frequently prescribed for respiratory tract infections [40-42].

E. coli (80-90%) and *K. pneumoniae* (3-10%) were reported to be the most frequent pathogens responsible for UTIs in all ages [43-45]. UTIs have an increased prevalence in women with an overall occurrence of approximately 80% in females and the prevalence increases with age [31,45,46]. Similarly, the results of our study showed that 77.4% of patients were female and 79.9% were adults in the overall population. Additionally, the distribution of age and gender did not significantly change after the pandemic. Considering that women have a shorter urethra compared to men and shorter distance between the urethral opening and perianal area, the lower urinary tract anatomy is more susceptible to UTIs in women [47-49]. Comparably, *E. coli* and *K. pneumonia* were isolated in 86.3 % and 13.7% of the patients, respectively, and the culture positivity of both bacteria did change significantly before and after the pandemic period (Table 2). As these pathogens account for up to 90% of UTIs, both should be targeted when choosing empirical antimicrobial agents. AMR among community isolates of *E. coli* and *K. pneumonia* is increasing and challenging the outcomes of UTIs due to the limited treatment options [30,50,51]. Therefore, we should reconsider our principles of treating community-onset UTIs.

The resistance rates of isolated pathogens for cefixime, ceftriaxone, cefuroxime axetil, gentamicin, nitrofurantoin, TMP-SMX, and ciprofloxacin during our study period of six years are shown in Table 3. The results of our study on the resistance rates of these antibiotics were similar to other studies [33,34,50]. The highest resistance rate was for cefuroxime axetil (49.8%) and the lowest was for nitrofurantoin (6.0%). Compared to the pre-pandemic period, a significantly increased resistance was determined for ceftriaxone (37.6% versus 46.1%) and cefixime (37.2% versus 460%) in the pandemic period. Studies report that cephalosporines, particularly third-generation cephalosporines and quinolones, were overused during the pandemic [52-54]. The increase in resistance to ceftriaxone and cefixime could partly be explained by the overconsumption of these antibiotics due to the clinical characteristics of COVID-19 overlapping with bacterial respiratory tract infections.

In terms of resistance to nitrofurantoin, gentamicin, ciprofloxacin, and TMP-SMX, there was no significant association between the pre- and post-pandemic period in our study. The first-line treatment for acute cystitis includes nitrofurantoin and TMP-SMX in regions

Figure 1. Status of ESBL before and after periods of COVİD-19 pandemic.



ESBL: extended-spectrum beta-lactamases; COVID-19: coronavirus disease 2019

where the resistance prevalence for the latter is less than 20%. However, TMP-SMX is no longer an option in many geographical locations because of high resistance rates of more than 20% [19]. During our study period, the resistance rate for TMP-SMX was detected to be 37.7% which excludes the drug as an alternative.

Despite discouraging results regarding the AMR trends of *E. coli* and *K. pneumoniae*, promising sensitivity profiles were still noted for aminoglycosides and nitrofurantoin in European countries [55,56]. In line with the literature, lower resistance rates were observed in our study for nitrofurantoin (6%) and gentamicin (14.9%). Therefore, these antibiotics represent an option for treating community-onset UTIs. Nitrofurantoin has been used to treat uncomplicated UTIs since the 1950s. The baseline resistance to nitrofurantoin has always been low (0-5%) as it has a multifactorial mechanism of action damaging vital processes in the bacteria. Another reason for low resistance rates may be that nitrofurantoin resistance genes are not located on mobile genetic elements in the microorganism [16]. Aminoglycosides are not used widely because of their potential side effects; but these drugs are still important choices for infections caused by resistant uropathogens [30].

According to Lee *et al.*, the resistance of Gram-negative bacteria to ciprofloxacin was much higher in patients more than 20 years old than in those less than 20 years old [57]. Similarly, a significant difference in resistance rates between adults and children was determined only for ciprofloxacin in our study (33.4% versus 13.3%) This observation may closely be related to lower fluoroquinolone exposure in children as these drugs are not recommended for this age group [57].

Long-term antibiotic use, particularly quinolone and cephalosporine, has been identified as the main risk factor for ESBL-producing isolates [4,5,16,30]. Compared to the pre-pandemic period, a significant increase in the ESBL positivity rate was observed in the pandemic period in our study (36.1% vs 43.8%) (Figure 1). Additionally, male gender was identified as an important risk factor for increased ESBL positivity. A possible reason for this increased incidence of ESBL positivity could be the excessive use of both quinolones and cephalosporines during the pandemic. Complicated UTI more likely to occur in males, is an underlying factor for ESBL production and this could partly explain the association between the male gender and ESBL [58]. A recent systematic review revealed that, depending on some behavioral factors, COVID-19 is more prevalent in men than in women [59]. This could represent another link between ESBL positivity and male gender. ESBL positivity was determined as the most important factor that increased the resistance rates

Table 4. Risk factors of being ESBL positive analysed by binary logistic regression.

Risk factors	B	SE	Wald	*p*	OR	95% CI
Constant	-0.637	0.110	33.632	0.000		
Age	-0.247	0.177	1.955	0.162		
Adult					ref	
Child					0.78	0.55-1.10
Gender	0.445	0.163	7.457	0.006		
Female					ref	
Male					1.56	1.13-2.15
Bacteria	0.051	0.203	0.063	0.802		
E. coli					ref	
K. pneumoniae					1.05	0.71-1.57
Pandemic period	0.331	0.138	5.749	0.016		
Before pandemic (2017–2019)					ref	
After pandemic (2020–2022)					1.4	1.1-1.8

Omnibus test of coefficient $p = 0.005$; Hosmer and Lemeshow test $p = 0.084$. B: beta; CI: confidence interval; ESBL: extended-spectrum beta-lactamases; OR: odds ratio; SE: standard error.

for all antibiotics tested in the current study. This may be because ESBL encoding genes are usually located on large plasmids carrying genetic determinants of resistance for other groups of antimicrobials such quinolones, sulfonamides, and aminoglycosides [12,50]. Alarmingly, patients infected with ESBL-producing organisms are more likely to have poor clinical outcomes and suffer from complications [50,60]. In our study, logistic regression analysis showed that there was a 1.4-fold increase in ESBL positivity after the pandemic (Table 4).

On the other hand, some authors have claimed that the pandemic could lead to an improvement in infection control practices, and in addition to international travel restrictions, it may have partly stopped the spread of resistant bacteria, causing a decline in the AMR [60]. We observed such a result for cefuroxime axetil, but this result should be approached with caution as the number of observations was relatively small, especially in the pre-pandemic period.

Limitations

This study investigated AMR before and during the COVID-19 pandemic and is a valuable addition to the literature. From a research design perspective, it can be difficult to determine causal relationships because this is a methodologically data-based and descriptive research. Community onset UTIs were defined as cases with no history of hospitalizations within the last three months at our hospital; however, patient information regarding other healthcare exposures was lacking. Additionally, it will remain unknown what the rates of AMR would have been if the pandemic had not occurred.

Conclusions

The resistance rates for both ceftriaxone and cefixime, and ESBL positivity among the uropathogens *E. coli* and *K. pneumoniae* increased significantly during the pandemic compared to the pre-pandemic period. Pandemic-period admissions and male gender were identified as important factors associated with increased ESBL positivity. As data from comparative analyses of resistance patterns of other microorganisms before and after the COVID-19 pandemic are limited, further investigations are needed to guide antimicrobial stewardship programs.

Authors' contributions

All authors have contributed equally.

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