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Original Article

# Pathogenic microorganisms and antimicrobial resistance patterns in the pediatric age group with urinary system infections

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## ABSTRACT

**Objectives:** Urinary system infections (UTIs) are among the most common infections affecting the pediatric age group. We aim to show the distribution of pathogenic microorganisms and antimicrobial resistance patterns of urinary tract infections (UTIs) and select the most appropriate antibiotherapy in the pediatric age group. Also, we wanted to determine signs and symptoms, predisposing factors, and imaging findings in UTIs.

**Material and Methods:** In this study, the Elazığ Fethi Sekin City Hospital health registry system was screened retrospectively to obtain data about the results of urinalysis, urine culture tests, and urinary imaging findings of patients, who presented to the pediatric nephrology clinic with signs and symptoms of UTI between January 2020 and September 2021. The study population consisted of children aged 1 month to 18 years.

**Results:** The study sample included 191 patients. Antimicrobial resistance of E. coli was seen at the highest level to ampicillin (55%), followed by amoxicillin (42%), trimethoprim-sulfamethoxazole (TMP-SMX) (36%), and cefuroxime (35%). The antimicrobial resistance of Klebsiella pneumoniae was seen most frequently in patients treated with ampicillin (100%), amoxicillin (50%), ceftazidime (31%), and nitrofurantoin (31%). The antimicrobial resistance of Proteus mirabilis was seen mostly in cases that received nitrofurantoin (88%), and TMP-SMX (55%). Enterobacter aerogenes demonstrated minimal antimicrobial sensitivity to ampicillin (66%), amoxicillin (33%), and nitrofurantoin (33%) in decreasing order of frequency.

**Conclusions:** The rate of resistance to ampicillin is very high in Klebsiella pneumoniae and in Enterobacter spp and rates of antimicrobial resistance to cephalosporin, TMP-SMX, and nitrofurantoin are increasing. The rational use of antibiotics is a globally important issue.

**Keywords:** Antimicrobial resistance, children, urinary tract infection, uropathogens

## INTRODUCTION

Urinary system infections (UTIs) are among the most common infections affecting the pediatric age group.[1] Although different rates have been cited in the literature, the average reported incidence rate of UTI is 11% in females and 7% in males up to the age of 16.[2] Upper urinary tract infections (pyelonephritis), if not detected and treated at an early stage, cause renal scarring, and in the long term hypertension and chronic kidney disease, especially in children under the age of two. Because of development of chronic complications of UTI, diagnosis, treatment, and use of advanced imaging methods have critical importance.[3] Urinary system ultrasonography (US) and voiding cystourethrography (VCUG) are recommended imaging modalities in the presence of an abnormality seen in the US in children with febrile UTIs.[4] The National Institute for Health and Care Excellence (NICE) and The Italian Society for Pediatric Nephrology (SINePe) recommend Tc-99m dimercaptosuccinic

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acid (DMSA) renal scintigraphy four months after the onset of atypical UTI.[1,5,6] Symptomatic patients are started on empirical antibiotherapy until urine culture and antibiotic susceptibility test results can be obtained. Despite regional differences, the incidence rates of antimicrobial resistance are increasing every day all over the world as in our country.[7,8] The risk factors for UTIs include constipation, dysfunctional voiding, enlarged bladder, weak urine flow, antenatal urinary anomalies, presence of spinal lesions, uncircumcised males, previous UTIs, and recurrent fever of unknown origin.[9]

*Escherichia coli* is the most common microorganism identified in pediatric UTIs, with a reported rate of approximately 80%.[9,10] Other pathogenic bacteria causing urinary tract infections are gram-negative *Klebsiella spp, Proteus spp., Enterobacter spp.*, and gram-positive *Citrobacter spp.*, *Staphylococcus saprophyticus*, *Enterococci*, and rarely, *Staphylococcus aerus.*[11,12] Empirical antibiotherapy administered should be effective against *Escherichia coli* and the antimicrobial resistance pattern in the region should be considered. In general, third-generation cephalosporins are preferred. More than 50% of the pathogenic microorganisms identified in UTIs are resistant to ampicillin and approximately 30% are resistant to TMP-SMX and the first-generation cephalosporins.[13,14] Ampicillin therapy maintains its importance in the treatment of UTIs caused by enterococci which constitute 6% of all cases of UTIs, especially in newborns. Enterococci are 100% resistant to cephalosporins. Resistance to amoxicillin-clavulanate and third-generation cephalosporins is increasing and the incidence of extended-spectrum beta-lactamase (ESBL) positive *E. coli* and multi-resistant microorganisms are on rise globally.[13-17]

Knowing the resistance of microorganisms to common antibiotics in the region is important for the initiation of appropriate empirical antibiotherapy and to increase the success of UTIs treatment. In our study, we wanted to draw attention to increasing antimicrobial resistance and the rational use of antibiotics.

## MATERIAL AND METHODS

Research and Publication Ethics: The study received the appropriate Institute Review Board (IRB) approval. This study was conducted under the approval of the Ethics Committee of Fırat University Hospital (date: 23.09.2021, number: 971328-52-100-92593). Informed consent was obtained from the participants or the parents of the participants under 18 years of age.

In this study, the Elazığ Fethi Sekin City Hospital health registry system was screened retrospectively for the results of urinalysis, urine culture tests, and urinary imaging modalities in patients, who presented to the pediatric nephrology clinic with signs and symptoms of UTI between January 2020 and September 2021. Children aged 1 month to 18 years and having a first episode of urinary tract infection were included in the study. Diagnosis of UTI was established based on the findings of leukocyte esterase positivity and nitrite positivity in urinalysis, the identification of $10^5$ CFU/ml of a single pathogen in cultures of midstream urine specimens collected from continent children. Urine samples of incontinent children collected in a sterile bag or obtained from a catheter port were used for antibiotic susceptibility tests in patients with pyuria.[4-6] Only the patients with symptoms and clinical signs of UTI were included in the study. Patients with other sources of febrile episodes or infection were excluded from the study.

The clinical distinction of acute pyelonephritis (upper UTIs) and cystitis (lower UTIs) was made according to the following criteria. Bacteriuria, flank pain/tenderness, and body temperature ≥ 38°C were considered as criteria for UTIs. Toilet-trained children with bacteriuria in the absence of systemic symptoms or signs with dysuria, frequency, and suprapubic pain were considered to have lower UTIs.[1]

### Microscopic analysis of samples

Urine samples were centrifuged at 2000 RPM for 5 minutes, and the urine sediment was examined under the light microscope at 40 x magnification for the identification of leukocytes and bacteria, and detection of ≥5 white blood cells per high-power field was evaluated as pyuria (4-6).

### Isolation and identification of microorganisms

Urine samples were quantitatively inoculated into 5% sheep blood agar and eosin-methylene blue (EMB) agar media using disposable loops with a volume of 0.001 ml and a diameter of 4 mm. The culture plates were incubated at 35±2°C for 24–48 hours under aerobic conditions and evaluated at 18–24th of incubation. A positive culture was defined as the growth of $\geq 10^5$ CFU/ml of a single microorganism in midstream urine cultures and ≥50,000 CFU/ml of a single microorganism in the cultures of the urine samples obtained from catheter ports.[4-6] Samples with suspected contamination were excluded from the analysis.

### Antibiotic susceptibility tests

Isolated microorganisms were identified by conventional methods such as Gram staining, catalase, oxidase, carbohydrate, and citrate tests, tryptophanase activity, urease production, and by using the VITEK® 2 (BioMérieux, Marcyl'Etoile, France) fully automated bacterial identification system. Antibiotic susceptibility test results were interpreted using the VITEK® 2 system based on the minimal inhibitory concentrations (MICs), in accordance with European Committee on Antimicrobial Susceptibility Testing (EUCAST) standards.[18] The extended beta-lactamase positivity of microorganisms was taken into account.

### Statistical analysis

The study data were analysed and basic statistical analysis was performed by using IBM SPSS Statistics for Windows (Version 24.0. Armonk, NY: IBM Corp.). Frequency and percentage distribution analysis was used to determine the distribution of the descriptive characteristics (gender, age, distribution of pathogenic microorganisms, and antimicrobial resistance patterns), presenting symptoms, imaging findings, etc. of the patients evaluated in the study.

## RESULTS

A total of 191 patients including 157 (82.2%) female and 34 (17.2%) male cases were enrolled in this study. The median age of the participants was 5 years (range 2 months -17 years). The presenting symptoms were abdominal pain in 4% and fever in 30.4%, constipation in 33%, and voiding dysfunction including inability to urinate, urgency, urinary incontinence, and enuresis in 49.2% of the patients. Additionally, there were no patients with systemic disease, immunodeficiency, history of urinary system surgery, or foreign body in the urinary system. The distribution of the microorganisms grown in the urine cultures of the patients is presented in Table 1. Lower UTIs were detected in 51.8% and upper UTIs in 48.2% of the patients. In addition, respective percentages of female patients had upper UTI (76.1%), and lower UTI (87.9%). Lower UTIs were detected more frequently (55.4%) in female patients, while upper UTIs were more common (64.7%) in male patients. In addition, 37% of the patients with upper UTIs and 60.6% of the patients with lower UTIs had voiding dysfunction which was more common in patients with lower UTIs. Patients with upper UTIs presented mostly with fever (60.9%) while patients with lower UTIs mostly with abdominal pain (91.9%). The US findings were normal in 59.7% of the patients. The abnormal US findings were increased bladder wall thickness in 23.6%, hydronephrosis in 13.1%, kidney stones in 2.6%, simple kidney cysts in 0.5%, and horseshoe kidneys in 0.5% of the patients. DMSA renal scintigraphy revealed renal scarring in 5.2% and vesicoureteral reflux (VUR) in seven (3.7%) patients. Grade II-III VUR was detected in four patients and grade IV-V VUR in three patients. Antibiotic prophylaxis was started in patients with VUR. The following microorganisms were identified in indicated percentages of culture specimens as follows: *E. coli* (79.6%), *Klebsiella pneumonia* (8.4%), *Proteus mirabilis* (4.6%) *Enterobacter aerogenes* (1.6%), and other microorganisms including *Klebsiella oxytoca*, *Pseudomonas aeruginosa*, *Enterococcus faecalis*, *Enterococcus faecium*, *Morganella morganii*, *Citrobacter amalonaticus*, and *Salmonella*, *Serratia odorifera* (5.8%).

**Table 1. Distribution of the microorganisms grown in urine cultures**

| Microorganisms | n | % |
|---|---|---|
| *E. coli* | 152 | 79.6 |
| *Klebsiella pneumonia* | 16 | 8.4 |
| *Proteus mirabilis* | 9 | 4.6 |
| *Enterobacter aerogenes* | 3 | 1.6 |
| *Klebsiella oxytoca* | 2 | 1.1 |
| *Pseudomonas aeruginosa* | 2 | 1.1 |
| *Enterococcus faecalis* | 2 | 1.1 |
| *Enterococcus faecium* | 1 | 0.5 |
| *Morganella morganii* | 1 | 0.5 |
| *Citrobacter amalonaticus* | 1 | 0.5 |
| *Salmonella* | 1 | 0.5 |
| *Serratia odorifera* | 1 | 0.5 |

ESBL-positivity was detected in 5.8% of culture specimens. The antimicrobial resistance patterns of the microorganisms grown in cultures according to the antibiotic susceptibility test results are presented in Table 2. Amikacin (90.1%) had the highest antimicrobial sensitivity, followed by nitrofurantoin (84.3%), fosfomycin (67.0%), TMP-SMX (62.3%), and cefuroxime (53.4%). The highest bacterial resistance developed against ampicillin (58.6%) then amoxicillin (41.4%). The highest antimicrobial resistance of *E. coli* developed against ampicillin (55%) followed by amoxicillin (42%), TMP-SMX (36%), and cefuroxime (35%). *Klebsiella pneumoniae* was mostly resistant to ampicillin (100%), followed by amoxicillin (50%), ceftazidime (31%), and nitrofurantoin (31%). *Proteus mirabilis* displayed maximum antimicrobial resistance to nitrofurantoin (88%), followed by TMP-SMX (55%). Ampicillin (66%), amoxicillin (33%), and nitrofurantoin (33%) demonstrated the lowest level of antimicrobial sensitivity against *Enterobacter aerogenes* in indicated percentage of isolates.

**Table 2. Antimicrobial resistance rates (%) of various pathogenic microorganisms**

| | *E. Coli* | *K. pneumonia* | *P. Mirabilis* | *E. aerogenes* | *E. faecalis* | *K. Oxytoca* | *P. aeruginosa* | *M. morganii* | *E. faceium* | *C. amalonaticus* | *Salmonella* | *Serratia odorifera* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **(n:152)** | **(n:16)** | **(n:9)** | **(n:3)** | **(n:2)** | **(n:2)** | **(n:2)** | **(n:1)** | **(n:1)** | **(n:1)** | **(n:1)** | **(n:1)** |
| Amoxicillin | 42 | 50 | 11 | 33 | 0 | 50 | 0 | 100 | 0 | 100 | 0 | 0 |
| Ampicillin | 55 | 100 | 33 | 66 | 50 | 100 | 0 | 100 | 100 | 100 | 0 | 0 |
| TMP-SMX | 36 | 25 | 55 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Amikacin | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Gentamicin | 6 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Cefuroxime | 35 | 37 | 11 | 0 | 0 | 50 | 0 | 100 | 0 | 100 | 0 | 0 |
| Ceftazidime | 30 | 31 | 11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Cefotaxim | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Cefoxitin | 13 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Cefixime | 34 | 31 | 11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Ertapenem | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Nitrofurantion | 0.65 | 31 | 88 | 33 | 0 | 0 | 0 | 100 | 0 | 0 | 0 | 0 |
| Ceftriaxone | 15 | 18 | 11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Fosfomycine | 1 | 12 | 0 | 0 | 0 | 0 | 0 | 100 | 0 | 0 | 0 | 0 |

## DISCUSSION

Urinary tract infections are common in childhood and cause long-term complications if not diagnosed early and treated appropriately.[18] Previous studies have demonstrated that UTIs were more frequently seen in females.[19] In line with the literature, in our study UTIs were detected in 82% of the female, and 18% of male patients. This study identified lower UTIs in 51.8% and upper UTIs in 48.2% of the patients. Female patients accounted for 76.1% of those with upper UTIs and 87.9% of those with lower UTIs. While 60.9% of the patients with upper UTIs presented mostly with fever, those with lower UTIs presented mostly (91.9%) with abdominal pain. Gürgöze et al. reported the presenting symptoms of UTIs as abdominal pain in 39.7%, fever in 35.7%, vomiting in 23.8%, and dysuria, pollakiuria and enuresis in relatively smaller proportion of patients.[20] Koçak et al. reported that their patients had presented with fever (71.1%), fatigue (19.7%), vomiting (14.8%), and abdominal pain (19%).[21]

In our study, the US findings were normal in 59.7% of the patients, while increased bladder wall thickness was detected in 23.6%, mild-to-moderate hydronephrosis in 13.1%, kidney stones in 2.6%, simple kidney cysts in 0.5%, and horseshoe kidneys in 0.5% of the patients. Increasing bladder wall thickness is a sign of voiding disorders especially voiding postponement and this habit predisposes to UTIs.[9] We detected renal scarring on DMSA renal scintigraphy in 5.2%, and vesicoureteral reflux in 3.7% (n:7) of the patients. While, Koçak et al. detected bilateral hydroureteronephrosis in 10%, kidney stones in 4.2%, and VUR in 26% of their patients.[21] Due to the high rate of spontaneous regression of vesicoureteral reflux in the first 5 years of age, voiding cystourethrography (VCUG) was performed only in patients with renal scarring detected in DMSA renal scintigraphy and urinary tract and kidney abnormalities in US. Consistent with this indication of VCUG we did not find high rate of VUR in our study like Gürgöze. Gürgöze et al. also identified caliectasis in four, VUR in three (1.7%), PUV, and ectopic kidney in one patient each.[20] *E. coli* was the most common microorganism identified in urine cultures in the world.[18-22] The detection rate of *E. coli* varies between 57% to 79.2% in the studies and in line with the literature *E. coli* growth was the most common (79.6%) finding in our study. *Klebsiella pneumoniae* growth was recorded as 8.4% in our study, this rate is changing between 7.2% and 22.8% in other studies. For *Proteus mirabilis*, the detection rate was 4.6% in our study, in the literature this rate varies between 4.5, and 12%.[22-25] Consistent with the literature data, *Enterobacter aerogenes* was detected in 1.6% of the isolates.[24] In our study, the antimicrobial resistance rates of *E. coli* to ampicillin (55%), amoxicillin (42%), TM-STX (36%), and cefuroxime (35%) were as indicated, while in other studies, these rates were reported as 42-88%, 12.2-34.8%, 26.5-38%, and 19-34%, respectively.[20-25] The antimicrobial resistance of *Klebsiella pneumoniae* was the highest in patients treated with ampicillin (100%), followed by amoxicillin (50%), ceftazidime (31%), and nitrofurantoin (31%) in our study, the respective rates have been reported as 77.8-97%, 37%, 4.5-35.7%, 11.2-11.9% in other studies.[9,20-24] The antimicrobial resistance of *Proteus mirabilis* to nitrofurantoin was at the highest level (88%), followed by TMP-SMX (55%), while the respective rates were reported as 85-100%, 8.3-70% in the literature.[9,20] *Enterobacter aerogenes* demonstrated maximum antibacterial resistance to ampicillin (66%), followed by amoxicillin (33%), and nitrofurantoin (33%), in other studies these rates were indicated as 83.4-91.3%, 53.9%, 5.6-28%, respectively.[8,18] Consistent with the literature data, in our study, the highest antimicrobial resistance of *E. coli* and *K. pneumoniae* was detected to ampicillin and lowest to amikacin.[22-24] Based on the results of our study, amikacin (90.1%) had the highest antimicrobial sensitivity, whereas the highest antimicrobial resistance developed against ampicillin (58.6%), amoxicillin (41.4%), TMP-SMX (34%), cefuroxime (33.5%), and cefixime (30.4%). Despite regional differences, antimicrobial resistance rates are increasing every day all over the world, as in our country.[7,8] NICE guidelines suggest that the individual resistance and antimicrobial resistance rates in the population should be considered when selecting empirical antibiotherapy for UTIs.[1] While we empirically preferred intravenous amikacin treatment in patients with pyelonephritis, we preferred oral nitrofurantoin or TMP-SMX treatments in patients with cystitis. Because Amikacin (90.1%) had the highest antimicrobial sensitivity, followed by nitrofurantoin (84.3%), and TMP-SMX (62.3%) in our study. It is recommended that the resistance rate should not exceed 10–20% to initiate empirical treatment.[25]

## CONCLUSION

We want to draw attention to the increasing antimicrobial resistance rates in society, especially the higher antimicrobial resistance to ampicillin, and the increasing resistance rates to cephalosporins. The rational use of antibiotics is globally important. When deciding on empirical treatment of UTI, the antimicrobial resistance patterns in the region should be considered and the most appropriate treatment should be determined.

### Study limitations

This is a retrospective, single-center study. Multicenter studies to be performed in the future will further contribute to the clarification of this issue.

### Ethical approval

This study has been approved by the Ethics Committee of Fırat University Hospital (approval date 23.09.2021, number 971328-52-100-92593). Written informed consent was obtained from the participants.

### Author contribution

Concept: GI, PÖ; Design: GI, PÖ; Data Collection or Processing: GI; Analysis or Interpretation: GI, PÖ; Literature Search: GI; Writing: GI. All authors reviewed the results and approved the final version of the article.

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### Conflict of interest

The authors declare that there is no conflict of interest.

## REFERENCES

1. Urinary tract infection in under 16s: diagnosis and management. London: National Institute for Health and Care Excellence (NICE); July 27, 2022.
2. Larcombe J. Urinary tract infection in children: recurrent infections. BMJ Clin Evid. 2015;2015:0306.
3. Tullus K, Shaikh N. Urinary tract infections in children. Lancet. 2020;395:1659-68. [Crossref]
4. Roberts KB, Wald ER. The Diagnosis of UTI: Colony Count Criteria Revisited. Pediatrics. 2018;141:e20173239. [Crossref]
5. Mattoo TK, Shaikh N, Nelson CP. Contemporary Management of Urinary Tract Infection in Children. Pediatrics. 2021;147:e2020012138. [Crossref]
6. Ammenti A, Alberici I, Brugnara M, et al. Updated Italian recommendations for the diagnosis, treatment and follow-up of the first febrile urinary tract infection in young children. Acta Paediatr. 2020;109:236-47. [Crossref]
7. Ahmed M, Long WNW, Javed S, Reynolds T. Rising resistance of urinary tract pathogens in children: a cause for concern. Ir J Med Sci. 2022;191:279-82. [Crossref]
8. Samancı S, Çelik M, Köşker M. Antibiotic resistance in childhood urinary tract infections: A single-center experience. Turk Pediatri Ars. 2020;55:386-92. [Crossref]
9. Yakubov R, van den Akker M, Machamad K, Hochberg A, Nadir E, Klein A. Antimicrobial Resistance Among Uropathogens That Cause Childhood Community-acquired Urinary Tract Infections in Central Israel. Pediatr Infect Dis J. 2017;36:113-5. [Crossref]
10. Esposito S, Biasucci G, Pasini A, et al. Antibiotic Resistance in Paediatric Febrile Urinary Tract Infections. J Glob Antimicrob Resist. 2022;29:499-506. [Crossref]
11. Marcus N, Ashkenazi S, Samra Z, Cohen A, Livni G. Community-acquired enterococcal urinary tract infections in hospitalized children. Pediatr Nephrol. 2012;27:109-14. [Crossref]

12. Yolbaş I, Tekin R, Kelekci S, et al. Community-acquired urinary tract infections in children: pathogens, antibiotic susceptibility and seasonal changes. Eur Rev Med Pharmacol Sci. 2013;17:971-6.

13. Dayan N, Dabbah H, Weissman I, Aga I, Even L, Glikman D. Urinary tract infections caused by community-acquired extended-spectrum β-lactamase-producing and nonproducing bacteria: a comparative study. J Pediatr. 2013;163:1417-21. **[Crossref]**

14. Tanaka Y, Oishi T, Ono S, et al. Epidemiology of urinary tract infections in children: Causative bacteria and antimicrobial therapy. Pediatr Int. 2021;63:1198-204. **[Crossref]**

15. The European Committee on Antimicrobial Susceptibility Testing. Breakpoint tables for interpretation of MICs and zone diameters. Version 9.0, 2019. Available at: https://www.eucast.org/fileadmin/src/media/PDFs/EUCAST_files/Breakpoint_tables/v_9.0_Breakpoint_Tables.pdf

16. Lugg-Widger FV, Angel L, Cannings-John R, et al. Long-term outcomes of urinary tract infection (UTI) in Childhood (LUCI): protocol for an electronic record-linked cohort study. BMJ Open. 2019;9:e024210. **[Crossref]**

17. Simões E Silva AC, Oliveira EA, Mak RH. Urinary tract infection in pediatrics: an overview. J Pediatr (Rio J). 2020;96(Suppl 1):65-79. **[Crossref]**

18. Çoban B, Ülkü N, Kaplan H, Topal B, Erdoğan H, Baskın E. Five-year assessment of causative agents and antibiotic resistances in urinary tract infections. Turk Pediatri Ars. 2014;49:124-9. **[Crossref]**

19. Moya-Dionisio V, Díaz-Zabala M, Ibáñez-Fernández A, et al. Uropathogen pattern and antimicrobial susceptibility in positive urinary cultures isolates from paediatric patients. Rev Esp Quimioter. 2016;29:146-50.

20. Gürgöze MK, Doğan Y, Kizirgil A, Aşçı Toraman Z, Aygün D. Antimicrobial sensitivities of bacteria isolated from urinary tract infections in children. Fırat Medical Journal. 2002;7:828-32.

21. Koçak M, Büyükkaragöz B, Çelebi Tayfur A, et al. Causative pathogens and antibiotic resistance in children hospitalized for urinary tract infection. Pediatr Int. 2016;58:467-71. **[Crossref]**

22. Nji CP, Assob JCN, Akoachere JTK. Predictors of Urinary Tract Infections in Children and Antibiotic Susceptibility Pattern in the Buea Health District, South West Region, Cameroon. Biomed Res Int. 2020;2020:2176569. **[Crossref]**

23. Ganesh R, Shrestha D, Bhattachan B, Rai G. Epidemiology of urinary tract infection and antimicrobial resistance in a pediatric hospital in Nepal. BMC Infect Dis. 2019;19:420. **[Crossref]**

24. Vazouras K, Velali K, Tassiou I, et al. Antibiotic treatment and antimicrobial resistance in children with urinary tract infections. J Glob Antimicrob Resist. 2020;20:4-10. **[Crossref]**

25. Beetz R, Westenfelder M. Antimicrobial therapy of urinary tract infections in children. Int J Antimicrob Agents. 2011;38(Suppl):42-50. **[Crossref]**