Clinical, etiological and antimicrobial susceptibility profile of pediatric urinary tract infections in a tertiary care hospital of Nepal

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Abstract

Background: Urinary tract infection (UTI) is one of the most common pediatric infections. The study was designed to assess the clinical profile, common bacterial microorganisms causing UTI and their antimicrobial susceptibility patterns at B. P. Koirala Institute of Health Sciences (BPKIHS) hospital.

Methods: This is a prospective cross-sectional study conducted at Department of Microbiology and Infectious Diseases for 6 months (January to June 2018). A total of 1962 non-repetitive urine specimens (midstream, nappy pad, catheter aspirated) of pediatric patients (0–14 years age) suspected of UTI were obtained in the Microbiology laboratory. Clinical data was obtained from requisition form and hospital software. Culture and bacterial identification was done by using standard microbiological guidelines. Antimicrobial susceptibility testing was done by Kirby-Bauer disc diffusion method following clinical and laboratory standards institute (CLSI) guidelines. Resistance to methicillin and vancomycin were confirmed by calculating minimum inhibitory concentration using broth dilution method.

Results: Among 1962 samples, 314 (16%) were positive for bacterial infection. Fever, irritability and poor feeding was the most common symptoms in neonates while older children presented with fever and urinary symptoms. E. coli was reported the most common etiological agent (53%), followed by Enterococcus faecalis (22%), Klebsiella pneumoniae (7%) and Staphylococcus aureus (7%). Multidrug resistant (MDR) isolates accounted for 32% of isolates, while 5% were extensively drug resistant (XDR). Forty percentage of gram-negative bacilli were ESBL producer, 38% of S. aureus were methicillin resistant Staphylococcus aureus (MRSA) and 5% E. faecalis were vancomycin resistant enterococci (VRE). E. coli was highly resistant to Ampicillin (87%), Ceftriaxone (62%) and Ofloxacin (62%). Amikacin (11% resistance) and Nitrofurantoin (5% resistance) are the most effective drugs for gram-negative bacilli (GNB) while vancomycin and linezolid are functional against gram-positive cocci.

Conclusions: High-level antimicrobial resistance was observed in pediatric UTI with alarming incidence superbugs like MDR, XDR, ESBL and MRSA. Regular surveillance should be carried out to determine the local prevalence of organisms and antimicrobial susceptibilities in order to guide the proper management of children.

Keywords: UTI, Antimicrobial resistance, MDR, MRSA
Background
Urinary tract infection (UTI) are one of the commonest cause of febrile illness in pediatric population with a worldwide prevalence of 2–20% [1, 2]. They can be associated with high morbidity and long-term complications such as renal scarring, hypertension, and chronic renal failure [3, 4]. Pediatric UTI cases remain under-diagnosed in many instances due to absence of specific symptoms and signs, especially in infants and young children [5]. It has been estimated that around 50% of UTI in children are missed [2, 6]. Timely diagnosis and targeted treatment decrease the risk of renal scarring and other complications [7, 8]. For this purpose, empirical antibiotic is often prescribed even before the culture results are available. On the other hand, antibiotic resistance of urinary tract pathogens has been increasing globally [9].

In Nepal, pediatric UTIs are usually treated empirically because of the unavailability of standard therapeutic guidelines and local susceptibility data [10]. In this perspective, the present study was designed to investigate the prevalence, clinical profile, organism spectrum and antimicrobial resistance profile in pediatric UTI in a tertiary care teaching hospital in Nepal.

Methods
Study design and setting
This is a cross-sectional study conducted in the Department of Microbiology, B.P. Koirala Institute of Health Sciences (BPKIHS), Dharan, Nepal, for a period of 6 months (1st January-30th June 2018). Patient’s information was collected from requisition form, laboratory records and medical records.

Laboratory methods
A total of 1962 non-repetitive urine specimens (Midstream clean catch, nappy pad, catheter aspirated) of pediatric patients (0–14 years age) suspected of UTI were obtained in the Microbiology laboratory. To minimize contamination, clean catch midstream method was employed wherever possible. In neonates and early infants, nappy pad method, described by Liaw et al. [11] was used. In case of catheterized patients, urine specimen were collected either through the catheter collection port or through puncture of the tubing with a sterile needle [12]. The samples were then processed by semi-quantitative streaking method using a calibrated inoculating loop (holding 0.001 ml urine) onto the cystine lactose electrolyte deficient (CLED) agar. The inoculated plates were incubated for 24 h at 37 °C in aerobic atmosphere. The isolates were identified using standard microbiological methods that includes colony morphology, gram-stain, catalase, oxidase and an in-house set of biochemical tests [13].

Antimicrobial susceptibility testing
Antimicrobial susceptibility was tested by modified Kirby-Bauer disc diffusion method on Mueller Hinton agar (Hi-Media, India) following standard procedures recommended by the Clinical and Laboratory Standards Institute (CLSI) [14]. Antibiotics that were tested in our study include: ampicillin (10 μg), amoxicillin clavulanate (20/10 μg), amikacin (10 μg), high level gentamicin (120 μg), co-trimoxazole (1.25/23.75), cephalexin (30 μg), ceftriaxone (30 μg), ceftazidime (30 μg), cefotaxime (30 μg), colistin (10 μg), ofloxacin (5 μg), piparacillin (100 μg), piperacillin tazobactam (100/10 μg), imipenem (10 μg), penicillin G (10 units), vancomycin (30 μg), linezolid (30 μg). Interpretations of antibiotic susceptibility results were made according to the zone size interpretative standards of CLSI.

Table 1 Clinical presentation according to age category

|                      | Neonate (n = 24) | Infant (n = 74) | Pre-school (n = 80) | Children (n = 136) | Total (n = 314) |
|----------------------|-----------------|----------------|--------------------|--------------------|----------------|
|                      | n               | %              | n                  | %                  | n              |
| Fever                | 21              | 87%            | 64                 | 86%                | 70             | 87%            | 110            | 80%            | 265            | 84%            |
| Dysuria              | –               | –              | 35                 | 47%                | 50             | 62%            | 85             | 62%            | 170            | 54%            |
| Frequency            | –               | –              | 30                 | 40%                | 52             | 65%            | 72             | 52%            | 154            | 49%            |
| Urgency              | –               | –              | 40                 | 54%                | 50             | 62%            | 74             | 54%            | 164            | 52%            |
| Abdominal pain       | –               | –              | 40                 | 54%                | 45             | 56%            | 65             | 47%            | 150            | 47%            |
| Vomiting             | 8               | 33%            | 34                 | 45%                | 40             | 50%            | 40             | 30%            | 122            | 38%            |
| Poor feeding         | 18              | 75%            | 60                 | 81%                | 30             | 37%            | 20             | 14%            | 128            | 40%            |
| Irritability         | 18              | 75%            | 62                 | 83%                | 25             | 31%            | 30             | 22%            | 135            | 42%            |
Disease Prevention and Control (ECDC) and the Centers for Disease Control and Prevention (CDC) [16].

**Screening and confirmation for ESBL production**

Gram-negative bacilli were screened for ESBL production by using third generation cephalosporins discs i.e. ceftazidime (30 μg), cefotaxime (30 μg) and ceftriaxone (30 μg). If the zone of inhibition (ZOI) was ≤25 mm for ceftriaxone, ≤22 mm for ceftazidime and/or ≤27 mm for cefotaxime, the isolate was considered a potential ESBL producer and confirmed by Combination disc test (CDT) method. In this method, the organism was tested against ceftazidime (30 μg) disc alone and ceftazidime+clavulanic acid (30/10 μg) combination disc. Isolate that showed increase of ≥5 mm in the ZOI of the combination discs in comparison to that of the ceftazidime disk alone was considered an ESBL producer [14].

**Results**

During the study period (1st January 2018-30th June 2018), a total 1962 urine samples from children with suspected UTI were obtained among which 314 samples (16%) yielded significant bacteriuria. Among 314 positive samples, 168 (54%) were male and 146 (46%) were females. The positivity rate of UTI from clean catch, nappy pad and catheter aspirated urine were 16% (272/1712), 14% (28/200) and 28% (14/50) respectively. The prevalence rates of febrile UTIs in neonates, infants, pre-school and children was 18.6% (28/150), 19% (88/462), 14.9% (80/534) and 14.4% (118/816) respectively.

**Table 2** Distribution and frequency of uro-pathogens according to age category

| Uro-pathogens | Frequency among age-group | Total (n = 314) |
|---------------|--------------------------|----------------|
|               | Neonate (n = 24) | Infant (n = 74) | Pre-school (n = 80) | Children (n = 136) | n | % |
| E. coli       | 12 50%            | 35 47%          | 53 66%              | 71 52%             | 168 53% |
| K. pneumoniae | 5 21%             | 7 10%           | –                   | 20 15%             | 23 7% |
| C. freundii   | – –               | – –             | – –                 | – –                | 2 1% |
| E. aerogenes  | 1 4%              | 1 1%            | – –                 | 5 4%               | 5 2% |
| P. mirabilis  | – –               | – –             | 4 5%                | 5 4%               | 10 3% |
| P. aeruginosa | – –               | – –             | – –                 | 2 1%               | 5 2% |
| A. anitratus  | 1 4%              | 2 3%            | 3 4%                | 2 1%               | 8 3% |
| S. aureus     | 2 8%              | 4 5%            | 5 6%                | 12 9%              | 22 7% |
| E. faecalis   | 3 13%             | 25 34%          | 315 19%             | 14 10%             | 68 22% |
| Microorganism | Antimicrobial agents |
|---------------|----------------------|
|               | Amikacin | AMC | Ampicillin | Cephalexin | Ceftriaxone | Cefoxitin | Ofloxacin | Nitrofurantoin | HLG | Imipenem | Piperacillin | PIT | Colistin | Cotrimoxazole | Penicillin | Vancomycin | Linezolid |
| E. coli       | 11       | –   | 87         | –          | 62          | –          | 62        | 5          | –         | 15       | 71          | 14  | 0       | 54          | –          | –          | –         |
| K. pneumoniae | 13       | 100  | –          | –          | 41          | –          | 20        | 11         | –         | 14       | 58          | 20  | 0       | 40          | –          | –          | –         |
| C. freundii   | 0        | 50   | 50         | –          | 50          | –          | 0         | 0          | –         | 50       | 0           | 0   | –       | –           | –          | –          | –         |
| E. aerogenes  | 0        | 100  | 100        | –          | 50          | –          | 0         | 0          | –         | 0        | 67          | 0   | 0       | –           | –          | –          | –         |
| P. mirabilis  | 0        | 100  | 75         | –          | 0           | –          | 22        | 75         | –         | 0        | 0           | 0   | 0       | –           | –          | –          | –         |
| P. aeruginosa | 0        | –    | –          | –          | 67          | –          | 50        | 80         | –         | 0        | 50          | 0   | 0       | –           | –          | –          | –         |
| A. anitratus  | 22       | 33   | –          | 62         | –          | 22        | 75        | –          | 14       | 33       | 0           | 0   | –       | –           | –          | –          | –         |
| S. aureus     | 21       | –    | –          | 60         | 38         | 38        | 42        | 0          | –         | –        | –           | 54  | 95      | 95          | 0          | 0          | –         |
| E. faecalis   | 93       | –    | –          | –          | –          | –         | 68        | 10         | 40        | –        | –           | –   | –       | –           | –          | 69         | 5         |

[–: not tested]
Fever was the most common clinical presentation followed by dysuria and urgency [Table 1]. Among neonates, fever (87%), poor feeding (75%) and irritability (75%) were the most common clinical features.

Escherichia coli \((n = 168, 53\%)\) was the most common organism followed by Enterococcus faecalis \((n = 68, 22\%)\) and Klebsiella pneumonia \((n = 23, 7\%)\). The details of organism profile is elicited in Fig. 1. The organism profile on the basis of age category has been detailed in Table 2.

Antimicrobial susceptibility test showed variable degree of resistance [Table 3]. Eighty-seven percentage of E. coli were resistant to ampicillin, 62% to ceftriaxone and ofloxacin. Regarding gram-positive bacteria, 95% of S. aureus were resistant to penicillin, 60% to cephalaxin and 54% to co-trimoxazole. MDR isolates accounted for 32% \((n = 100)\) of the 314 isolates, while 5% \((n = 16)\) of them were XDR. Forty percentage of gram-negative bacilli were ESBL producers. Thirty-eight percentage of S. aureus were methicillin resistant Staphylococcus aureus (MRSA), while none of them were resistant to vancomycin. Among E. faecalis, 5% \((n = 5)\) of them were VRE (Fig. 2).

Multi drug resistant isolates were studied on the basis of the type of sample. MDR was seen in 71.4% isolates from catheter-aspirated urine, while only 30.4% isolates from clean catch urine and 28.5% isolates obtained from nappy pad method were MDR (Table 4).

**Discussion**

UTI is a common health problem in children and it is an important cause of morbidity and mortality, especially in the first 2 years of life [17]. In our study, 16% of total samples were positive for UTI. The finding is similar to studies done by Parajuli et al. [18] in Kathmandu, Nepal and Kaur N et al. [19] in India. However, study done by Badhan et al. [20] in India showed a higher (26.7%) culture positivity and some studies showed very low rate of UTI among children i.e. 7.87% in Iran and 9% in USA [6, 9]. UTI is one of a common bacterial infection in children in the world [21].

Children with UTI usually present with non-classical clinical features and these are difficult to diagnose [22]. In our study, fever, poor feeding and irritability were the common clinical features in neonates while the older children presented with fever and urinary symptoms.

| Table 4 Multi-drug resistant isolates with respect to the type of samples |

| Clean catch | Nappy pad | Catheter aspirated |
|-------------|-----------|-------------------|
| Total samples =1712 Growth = 272 | Total samples = 200 Growth = 28 | Total samples = 50 Growth = 14 |
| MDR 30.14% \((n = 82)\) | 28.5% \((n = 8)\) | 71.4% \((n = 10)\) |
| XDR 3.6% \((n = 10)\) | 7.1% \((n = 2)\) | 28.5% \((n = 2)\) |
| ESBL 40% \((n = 78\) of 195 GNB) | 40.9% \((n = 9\) of 22 GNB) | 28.5% \((n = 2\) of 7 GNB) |
| MRSA 37.5% \((n = 3 of 8 S. aureus)\) | 33.3% \((n = 2 of 6 S. aureus)\) | 50% \((n = 2 of 4 S. aureus)\) |
| VRE 3% \((n = 2 of 65 E. faecalis)\) | 0 | 33.3 \((n = 1 of 3 E. faecalis)\) |
Our data agree with other reports, where fever, abdominal pain, vomiting, dysuria, poor feeding, and irritability are reported as frequent signs and symptoms of UTIs [23, 24]. Diagnosis of UTI is really challenging due to its vague presenting symptoms, especially in young children. Thus, a high index of suspicion is appropriate when a young child presents with fever [22].

The most common organism associated with Pediatric UTI was E. coli (53%). The finding of our study is consistent with many studies [18, 20, 25, 26]. E. coli is the most common etiological agent responsible for UTI irrespective of age, sex, community or country and accounts for 50–90% of cases. Uropathogenic E. coli (UPEC) originate from the faecal flora, spread across the perineum, and invade the bladder through the urethral opening [20, 22]. In this study, E. faecalis comprised of 22% of causative agent and S. aureus 7%. Other studies have concluded similar results [19, 27, 28]. Although gram-negative bacteria is responsible for majority of UTI, gram-positive organisms have become important cause of UTI in recent years [29].

The most striking finding of our study is the alarming prevalence of multi drug resistance organisms. Thirty-two percentage of organisms were MDR and 5% were XDR. The finding is similar to study done by Baral et al. [28] and Parajuli et al. [18] in Kathmandu, Nepal. A very high rate of MDR (76.5%) has been reported in India [30]. Among gram-negative bacilli, 40% were ESBL producers. Similar results were reported by Akram et al. (42%) [31], Taneja et al. (36.5%) [32], Parajuli et al. (38.9%) [18] and Fatima et al. (33.5%) [33]. Higher rates of ESBL producers have been reported in other studies [28, 34]. However Wu et al. [35] reported very low prevalence of ESBL producer (14%) in pediatric UTI. Pediatric UTIs due to ESBL-producing bacteria are an important part of the problem as they limit therapeutic choices and increases morbidity of infection [35].

Eighty-seven percentage of E. coli were resistant to Ampicillin, 62% to Ceftriaxone and ofloxacin, 54% to cotrimoxazole. The finding is similar to other studies [6, 9, 28]. Our study shows that nitrofurantoin is still the most effective antimicrobial agent for the treatment of UTI. The finding is in agreement with studies done elsewhere [26, 36–38]. Nitrofurantoin remains a reliable first-line agent for the empirical treatment of acute uncomplicated cystitis [39].

Among gram-positive bacteria, 38% of S. aureus were MRSA; 95% of were resistant to penicillin, 60% to cephalaxin and 54% to cotrimoxazole. A study conducted in Ireland concluded that 27.8% of S. aureus isolated from urine samples were MRSA [40]. Recent studies have reported the increasing prevalence of multi drug resistant S. aureus especially MRSA in UTIs [40, 41]. Among E. faecalis, 95% were resistant to amikacin, 69% to penicillin and 68% towards ofloxacin. Five percentage were resistant to vancomycin (VRE). All the isolates were susceptible to vancomycin and linezolid. The finding is similar to study done by Kaur et al. [19] in India. MDR, XDR and MRSA and VRE were noted in higher numbers in case of catheter aspirated urine as compared to clean catch and nappy pad method. Several studies have suggested that isolates obtained from catheterized patient are highly resistant [42, 43]. Previous hospitalization, long-term broad spectrum antimicrobial therapy, co-morbidity, frequent instrumentation, cross transmission of pathogens in catheterized patients might explain the higher antimicrobial resistance [44].

**Conclusion**

High-level antimicrobial resistance was observed in pediatric UTI with alarming incidence superbugs like MDR, XDR, ESBL and MRSA. Regular surveillance should be carried out to determine the local prevalence of organisms and antimicrobial susceptibilities in order to guide the proper management of children.

**Abbreviations**

- ESBL: Extended spectrum β-lactamase
- MDR: Multi drug resistant
- MRSA: Methicillin Resistant Staphylococcus aureus
- TDR: Total drug resistant
- UTI: Urinary tract infection
- XDR: Extensively drug resistant

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**Availability of data and materials**

The datasets used and/or analyzed during the study are available from the corresponding author on reasonable request.

**Authors’ contributions**

Conceptualization: LBS. Methodology: LBS, RB, PP. Resources: RB, PP, BK. Laboratory tests: LBS. Supervision: RB, PP, BK. Writing original draft: LBS. Writing-review and editing: BK, PP. All authors read and approved the final manuscript.

**Ethics approval and consent to participate**

- Was obtained from Institutional review committee (IRC), B. P. Koirala Institute of Health Sciences (BPKIHS)
- Code number: IRC/1015/017
- Consent to participate: Written informed consent was obtained from each patient/guardian.

**Consent for publication**

Not applicable.

**Competing interests**

The authors declare that they have no competing interests.

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References

1. Shaikh N, Morone NE, Bost JE, Farrell MH. Prevalence of urinary tract infection in childhood: a meta-analysis. Pediatr Infect Dis J. 2008;27(4):302–8.
2. Dowling H, Thomas-Jones E, Gal M, Waldron CA, Sterne J, Hollingsworth W, et al. The diagnosis of urinary tract infections in young children (DUTY): protocol for a diagnostic and prospective observational study to derive and validate a clinical algorithm for the diagnosis of UTI in children presenting to primary care with an acute illness. BMC Infect Dis. 2012;12:158 [3575241].
3. Zorc JJ, Kiddoo DA, Shaw KN. Diagnosis and management of pediatric urinary tract infections. Clin Microbiol Rev. 2005;18(2):417–22 [1082801].
4.Montserrat G, Tullius K, Hewitt I. Febrile urinary tract infections in children. N Engl J Med. 2011;365(3):239–50.
5. Desai DJ, Gilbert B, McBride CA. Paediatric urinary tract infections: diagnosis and treatment. Aust Fam Physician. 2016;45(8):558–63 [PMID: 27610444].
6. Zorc JJ, Levine DA, Platt SL, Dayan PS, Macias CG, Kiefert W, et al. Clinical and demographic factors associated with urinary infection in young febrile infants. Pediatrics. 2005;116(3):644–8 [PMID: 16140703].
7. Ammenti A, Cataldi L, Chimenz R, Fanos V, La Manna A, Marra G, et al. Febrile urinary tract infections in young children: recommendations for the diagnosis, treatment and follow-up. Acta Paediatr. 2012;101(5):451–7 [PMID: 22122295].
8. Madhi F, Jung C, Timsit S, Levy C, Biscardi S, Lorrot M, et al. Febrile urinary tract infection due to extended-spectrum beta-lactamase-producing Enterobacteriaceae in children: a French prospective multicenter study. PLoS One. 2018;13(1):e0190910 [PMID: 2970234].
9. Mirsoleymani SR, Salimi M, Shareghi Brojeni M, Ranjbar M, Mehtarpoor M. Bacterial pathogens and antimicrobial resistance patterns in pediatric urinary tract infections: a four-year surveillance study. Int J Pediatr. 2014; 2014 [PMID: 24959183].
10. Rai GK, Uperti HC, Rai SK, Shah KP, Shrestha RM. Caustive agents of urinary tract infections in children and their antibiotic sensitivity pattern: a hospital based study. Nepal Med Coll J. 2008;10(2):89–90 [PMID: 18828428].
11. Liaw LC, Nayar DM, Pedler SJ, Couthard MG. Home collection of urine for culture from infants by three methods: survey of parents’ preferences and bacterial contamination rates. BMJ. 2000;320(7245):1312–3 [27376].
12. Hooton TM, Bradley SF, Cardenas DD, Colgan R, Greerlings SE, Rice JC, et al. Diagnosis, prevention, and treatment of catheter-associated urinary tract infection in adults: 2009 international clinical practice guidelines from the Infectious Diseases Society of America. Clin Infect Dis. 2010;50(5):625–63.
13. Winn W, Allen S, Janda W, Koneman E, Woods G. Koneman’s color atlas and textbook of diagnostic microbiology. Baltimore: Lippincott Williams & Wilkins; 2006.
14. CLSI. Clinical and laboratory standards institute. Document No M100S. Performance Standards for Antimicrobial Susceptibility Testing. 26th ed. Wayne: CLSI; 2016.
15. CLSI. Clinical and laboratory standards institute. CLSI document no M07-A10. Methods for dilution antimicrobial susceptibility tests for Bacteria that grow Aerobically. 10th ed. Clinical and Laboratory Standards Institute: Wayne; 2015.
16. Magiorakos AP, Srinavasan A, Carey RB, Carmeli Y, Falagas ME, Giske CG, et al. Multidrug-resistant, extensively drug-resistant and pandrug-resistant bacteria: an international expert proposal for interim standard definitions for acquired resistance. Clin Microbiol Infect. 2012;18(3):268–81. [21799988].
17. Habib S. Highlights for management of a child with a urinary tract infection. Int J Pediatr. 2012;2012:943653 [PMID: PMC3408663].
18. Parajuli NP, Maharjan P, Parajuli H, Joshi G, Paudel D, Sayami S, et al. High rates of multidrug resistance among uropathogenic Escherichia coli in children and analyses of ESBL producers from Nepal. Antimicrob Resist Infect Control. 2017;6:9 [PMID: PMC5225645].
19. Kaur N, Sharma S, Malhotra S, Madan P, Hans C. Urinary tract infection: aetiology and antimicrobial resistance pattern in infants from a tertiary care hospital in northern India. J Clin Diagn Res. 2014;8(10):DC01–3 [PMID: PMC4253157].
20. Badhan R, Singh DV, Badhan LR, Kaur A. Evaluation of bacteriological profile and antibiotic sensitivity patterns in children with urinary tract infection: a prospective study from a tertiary care center. Indian J Urol. 2016;32(1):50–6 [PMID: 26941405].
21. Jayaweera J, Reyes M. Antimicrobial misuse in pediatric urinary tract infections: recurrences and renal scarring. Ann Clin Microbiol Antimicrob. 2018;17(1):27 [6016131].
22. Korbel L, Howell M, Spencer JD. The clinical diagnosis and management of urinary tract infections in children and adolescents. Paediatr Int Child Health. 2017;37(4):273–9 [PMID: 28972868].
23. Garrido D, Garrido S, Gutierrez M, Calvopina L, Harrison AS, Fuseau M, et al. Clinical characterization and antimicrobial resistance of Escherichia coli in pediatric patients with urinary tract infection at a third level hospital of Quito, Ecuador. Bol Med Hosp Infant Mex. 2017;74(4):265–71 [PMID: 29382515].
24. Ojha AR, Ayalur UR. Profile of children with urinary tract infection and the utility of urine dipstick as a diagnostic tool. J Nepal Health Res Counc. 2014;12(28):151–5.
25. Singh SD, Madhupuk SP. Clinical profile and antibiotics sensitivity in childhood urinary tract infection at Dhalbhiel hospital. Kathmandu Univ Med J (KUMJ). 2013;11(44):319–24 [PMID: 24899328].
26. Pape L, Gunzer F, Ziesing S, Pape A, Offner G, Ehrich JH. Bacterial pathogens, resistance patterns and treatment options in community-acquired pediatric urinary tract infection. Klinische Padiatric. 2004;216(2):83–6.
27. Soflozano-Puerto A, Gonzalez-Lujue JM, Luna-Del-Castillo JD, Navarro-Mari JM, Gutierrez-Fernandez J. Etiological and Resistance Profile of Bacteria Involved in Urinary Tract Infections in Young Children. Biomed Res Int. 2017;2017:4909452 [PMID: PMC5405357].
28. Baral P, Neupane SP, Marasini BP, Ghimire KR, Lekhak B, Shrestha B. High prevalence of multidrug resistance in bacterial uropathogens from Kathmandu, Nepal. BMC Res Notes. 2012;5:38 [PMID: 2296386].
29. Kline KA, Lewis AL. Gram-Positive Uropathogens, Polymicrobial Urinary Tract Infection, and the Emerging Microbiota of the Urinary Tract. Microbiology spectrum. 2016;4(2) [PMID: 4888879].
30. Niranjani V, Mallini A. Antimicrobial resistance pattern in Escherichia coli causing urinary tract infection among inpatients. Indian J Med Res. 2014; 139(6):945–8 [4160050].
31. Akram M, Shahid M, Khan AU. Etiology and antimicrobial resistance patterns of community-acquired urinary tract infections in J N M C hospital Aligarh, India. Ann Clin Microbiol Antimicrob. 2007;6(4) [PMID: 1852324].
32. Taneja N, Rao P, Arora J, Dogra A. Occurrence of ESBL & amp-C beta-lactamases & susceptibility to newer antimicrobial agents in complicated UTI. Indian J Med Res. 2008;127(1):85–8.
33. Fatima S, Muhammad IN, Usman S, Jamil S, Khan MN, Khan SI. Incidence of multidrug resistance and extended-spectrum beta-lactamase expression in community-acquired urinary tract infection among different age groups of patients. Indian J Pharmacol. 2018;50(2):69–74 [PMID: 3044131].
34. Masud MR, Afroz H, Falakuddin M. Prevalence of extended-spectrum beta-lactamase positive bacteria in radiologically positive urinary tract infection. Springerplus. 2014;3:216 [PMID: 4022967].
35. Wu CT, Lee HY, Chen CL, Tuan PL, Chiu CH. High prevalence and antimicrobial resistance of urinary tract infection isolates in febrile young children without localizing signs in Taiwan. J Microbiol Immunol Infect. 2016;49(2):243–8.
36. Borsari AG, Bucher B, Brazzola P, Simonetti GD, Dolina M, Blanchetti MG. Susceptibility of Escherichia coli strains isolated from outpatient children with community-acquired urinary tract infection in southern Switzerland. Clin Ther. 2008;30(1):2005–6.
37. Garau J. Other antimicrobials of interest in the era of extended-spectrum beta-lactamases: fosfomycin, nitrofurantoin and tigecycline. Clin Microbiol Infect. 2008;14(Suppl 1):198–202.
38. Bryce A, Hay AD, Lane IF, Thornton HV, Woonton M, Costelloe C. Global prevalence of antibiotic resistance in paediatric urinary tract infections caused by Escherichia coli and association with routine use of antibiotics in primary care: systematic review and meta-analysis. BMJ. 2016;352:i3059 [4793155].
39. Sanchez GV, Baird AM, Karlovyks JA, Master RN, Bordon JM. Nitrofurantoin retains antimicrobial activity against multidrug-resistant urinary Escherichia coli from US outpatients. J Antimicrob Chemother. 2014;69(12):3259–62.
40. Looney AT, Redmond EJ, Davey NM, Daly PJ, Troy C, Carey BF, et al. Methicillin-resistant Staphylococcus aureus as a uropathogen in an Irish setting. Medicine. 2017;96(14):e4635 [5411178].
41. Akortha EE, Ibadin OK. Incidence and antibiotic susceptibility pattern of Staphylococcus aureus amongst patients with urinary tract infection (UTI) in UBTH Benin City, Nigeria. Afr J Biotechnol. 2008;7:1637–40.
42. Bardoloi V, Yogeesha Babu KV. Comparative study of isolates from community-acquired and catheter-associated urinary tract infections with reference to biofilm-producing property, antibiotic sensitivity and multi-drug resistance. J Med Microbiol. 2017;66(7):927–36.
43. Michno M, Sydor A, Walaszek M, Sulowicz W. Microbiology and drug resistance of pathogens in patients hospitalized at the nephrology Department in the South of Poland. Pol J Microbiol. 2018;67(4):517–24.
44. Iwuafor AA, Ogunsola FT, Ofadele RO, Oduyebo OO, Desalu I, Egwuatu CC, et al. Incidence, clinical outcome and risk factors of intensive care unit infections in the Lagos University teaching hospital (LUTH), Lagos, Nigeria. PLoS one. 2016;11(10):e0165242 [5077115].