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Antibiotic Susceptibility Pattern of *Escherichia coli* Isolated from Various Clinical Samples in Duhok City, Kurdistan Region of Iraq

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Abstract

Background: *Escherichia coli (E. coli)* is one of the most common causative agents of bacterial infections. The emergence of multidrug-resistant *E. coli* is a major public health threat worldwide.
Objectives: This study aimed to determine the antibiotic susceptibility profile of clinical isolates of *E. coli* from different samples.
Methods: A total number of 454 clinical samples, including urine, wound, cervical swab, blood, semen, ascetic, and cerebral spinal fluid samples were collected from patients between January 2017 and February 2020. Then, *E. coli* was confirmed and susceptibility to different antibiotics was determined using the Vitek-2 compact system.
Results: *Escherichia coli* isolates were more frequent in females (70.7%) than in males (29.3%). In the case of urine samples, *E. coli* was found to be highly susceptible to ertapenem (97.6%) and imipenem (96.4%) but resistant to ampicillin (87.8%). For wound and cervical swabs, *E. coli* was 100% resistant to ampicillin and cefepime but 100% sensitive to ertapenem and imipenem. It was found that *E. coli* isolates from blood samples were 100% resistant to ampicillin, ceftriaxone, and cefoxitin, and around 75% of them were sensitive to ertapenem, ciprofloxacin, and levofloxacin. Finally, *E. coli* isolated from other clinical samples were highly sensitive to ertapenem, imipenem, levofloxacin, nitrofurantoin, and cefazolin.
Conclusions: *Escherichia coli* isolated from various clinical specimens showed differences in antibiotic sensitivity patterns, with high resistance to commonly used antibiotics. The most effective antibiotics against *E. coli* isolates were ertapenem, imipenem, and nitrofurantoin. However, the clinical isolates of *E. coli* displayed high resistance rates to ampicillin, ceftriaxone, and cefepime. Therefore, it is proposed to perform antibiotic sensitivity testing by physicians to select the most effective antibiotics.

Keywords: *E. coli*, Clinical Samples, Antibiotics, Susceptibility, Duhok

1. Background

Escherichia coli is a Gram-negative, rod-shaped bacterium that typically resides in the lower intestinal tract of humans. It is also found in hospital environments and can cause nosocomial infections (1). *Escherichia coli* is one of the most frequent causes of urinary tract infection (2, 3) and is among the most important pathogens causing bloodstream infections (4), otitis media, wound infections, neonatal meningitis, and nosocomial pneumonia (5, 6). *Escherichia coli* is a major cause of waterborne and foodborne human diarrhea worldwide, especially in developing countries, causing several deaths, particularly in children under five-years-old (7).

Globally, antimicrobial resistance is a serious public health concern, particularly in developing countries where infectious diseases, malnutrition, and poverty are endemic (8-10). It is one of the main causes of failure in the treatment of infectious diseases, including infections caused by *E. coli*, resulting in increased morbidity, mortality, and cost of healthcare services (11). The emergence of multidrug-resistant *E. coli* is a growing problem around the world (12). The prevalence and susceptibility profile of clinical isolates of *E. coli* show substantial variations in geographical locations, as well as significant differences in various populations, clinical samples, and environments (13).

The periodic epidemiology of *E. coli* to determine antibiotic resistance patterns in patients with urinary tract infections has been studied thoroughly in the region (3, 14). However, investigating antimicrobial susceptibility patterns of *E. coli* isolated from various clinical samples in our region is spares. The routine monitoring of antibiotic resistance patterns of *E. coli* from different specimens

could help develop *E. coli* empirical treatment guidelines in the region.

2. Objectives

The present study was conducted to determine the sensitivity pattern of *E. coli* isolated from various clinical sources in Duhok city, Iraq.

3. Methods

3.1. Study Design and Specimen Collection

The study was conducted from January 2017 to February 2020 in Duhok city, Iraq. A total of 454 samples (418 urine, 18 wounds, 7 cervical, 4 blood, 3 semen, 2 ascitic fluid, and 2 cerebral spinal fluid samples) were collected from both genders (133 males and 321 females). The age of the participants ranged from 10 to 60 years. All clinical specimens were collected from participants referring to private health clinical centers in Duhok city, Iraq. All participants were chosen as clinically positive for *E. coli* and processed according to standard operating procedures.

Clean-catch midstream urine specimens were obtained using sterile disposable glass containers (5 mL) from patients to avoid contamination. Blood samples were taken from patients aseptically in blood culture tubes. Additionally, wound and cervical samples were collected using sterile cotton swabs. Semen, ascetic, and cerebral spinal fluid samples were collected in sterile wide-mouth containers.

3.2. Bacterial Identification and Antimicrobial Sensitivity

Escherichia coli isolates were initially identified by their morphological characteristics on MacConkey agar based on standard microbiological culture as per the Clinical and Laboratory Standards Institute (CLSI) guidelines (15). Identified *E. coli* was then confirmed using the Vitek-2 system (bioMerieux, US) following the manufacturer's instructions. Antimicrobial susceptibility testing was performed on Mueller-Hinton agar (Oxoid Limited, Hampshire, England) using the disk diffusion (Kirby Bauer's) technique following the CLSI guidelines. The inclusion criteria included patients from both genders, older than 10-years-old, with positive microbiological evidence of *E. coli* isolated from various samples, and agreement to participate in the study. Patients who did not agree to participate in the study were excluded.

3.3. Ethics

The study was approved by the Ethics Committee of the College of Medicine, University of Zakho, Kurdistan Region, Iraq. Written informed consent was obtained from all participants.

4. Results

Of the 454 clinical samples, the majority of the *E. coli* isolates were obtained from urine samples (418; 92.2%), followed by wound (18; 3.9%), cervical (7; 1.5%), blood (4; 0.9%), semen (3; 0.7%), ascitic (2; 0.4%), and cerebral spinal fluid (2; 0.4%) samples (Table 1). *Escherichia coli* isolates were more prevalent in females (70.7%) than in males (29.3%). In urine samples, the isolation of *E. coli* was higher in females (73.9%) than in males (26.1%) (Table 1). In wound samples, however, the incidence of *E. coli* was higher in males (55.6%) than in females (44.4%). The distribution of the isolates from other clinical samples in both genders is summarized in Table 1.

Table 1. The Occurrence of *Escherichia coli* Isolated from Various Clinical Specimens Based on Sex

Source of Isolation	No. (%)	Male (No.%)	Female (No.%)
Urine	418 (92.2)	109 (26.1)	309 (73.9)
Wound swab	18 (3.9)	10 (55.6)	8 (44.4)
Cervical swab	7 (1.5)	7 (100)	0 (0)
Blood	4 (0.9)	1 (25)	3 75)
Semen	3 (0.7)	3 (100)	0 (0)
Ascitic fluid	2 (0.4)	1 (50)	1 (50)
Cerebral Spinal Fluid	2(0.4)	2 (100)	0 (0)
Total	454 (100)	133 (29.3)	321 (70.7)

The antimicrobial sensitivity pattern in urine samples showed that *E. coli* isolates were highly sensitive to ertapenem (97.6%) and imipenem (96.4%) while resistant to ampicillin (87.8%), cefepime (61.5%), and ceftriaxone (61.0%) (Table 2). *Escherichia coli* isolates from wound samples were highly resistant to ampicillin (100%), cefepime (100%), and ceftriaxone (94.4%), whereas they showed 100% sensitivity to ertapenem and imipenem. *Escherichia coli* isolates from cervical samples were sensitive to ertapenem (100%) and imipenem (100%) (Table 2). In addition, 100% of *E. coli* isolates from blood samples were resistant to ampicillin, cefoxitin, and ceftriaxone and 75% of them were sensitive to ertapenem, ciprofloxacin, and levofloxacin (Table 2). The results of the antibiotic susceptibility pattern of isolates from other clinical samples are shown in Table 2.

The overall susceptibility patterns of *E. coli* isolates from various clinical sources are presented in Table 3. It was found that 88.3%, 63.3%, and 63.9% of the isolated *E. coli* strains were resistant to ampicillin, ceftriaxone, and cefepime, respectively. On the other hand, *E. coli* showed to be sensitive to ertapenem (97.6%), imipenem (96.1%), and nitrofurantoin (88.9%) (Table 3).

Table 2. Antibiotic Resistance Profiles of Multiresistant *Escherichia coli* Isolated from Various Clinical Sources

Antibiotic	Number of Isolates Recovered from Clinical Sources (Percent (%) of Resistance)					
	Urine (N = 418)	Wound Swab (N = 18)	Cervical Swab (N = 7)	Blood (N = 4)	Semen (N = 3)	Other Samples[a] (N = 4)
Ampicillin	367 (87.8)	18 (100)	5 (71.4)	4 (100)	2 (66.7)	4 (100)
Amoxicillin/clavulanic acid	144 (34.4)	9 (50.0)	3 (42.9)	3 (75)	2 (66.7)	3 (75)
Cefazolin	157 (37.6)	12(66.7)	3 (42.9)	3 (75)	0 (0)	0 (0)
Cefoxin	196 (46.9)	15 (83.3)	3 (42.9)	4 (100)	2 (66.7)	4 (100)
Ceftriaxone	255 (61.0)	17 (94.4)	4(57.1)	4 (100)	2 (66.7)	3 (75)
Cefeprine	257(61.5)	18(100)	4(57.1)	3 (75)	2 (66.7)	3 (75)
Ertapenem	10 (2.4)	0 (0)	0 (0)	1 (25)	0 (0)	0 (0)
Imipenem	15 (3.6)	0 (0)	0 (0)	3 (75)	0 (0)	0 (0)
Gentamicin	116 (27.8)	8 (44.4)	2 (28.6)	3 (75)	2 (66.7)	3 (75)
Tobramycin	156 (37.3)	12 (66.7)	3 (42.9)	2 (50)	2 (66.7)	2 (50)
Ciprofloxacin	186 (44.5)	12 (66.7)	4(57.1)	1 (25)	2 (66.7)	2 (50)
Levofloxacin	98 (23.5)	5 (27.8)	2 (28.6)	1 (25)	0 (0)	0 (0)
Nitrofurantoin	43 (10.3)	2 (11.1)	1 (14.3)	4 (100)	0 (0)	0 (0)
Trimethoprim/ Sulfamethoxazole	203 (48.6)	8 (44.4)	2 (28.6)	4 (100)	2 (66.7)	1 (25)

[a] Other clinical samples such as ascitic and cerebral spinal fluid

Table 3. Overall Antimicrobial Resistance Patterns of *Escherichia coli* Isolated from Various Clinical Specimens

Antibiotic	Susceptibility Patterns (N = 454)	
	Resistant No. (%)	Sensitive No. %
Ampicillin	400 (88.3)	54 (11.7)
Amoxicillin/clavulanic acid	164 (36.2)	290 (63.8)
Cefazolin	175 (38.6)	279 (61.4)
Cefoxin	224 (49.4)	230 (50.6)
Ceftriaxone	285 (63.9)	169 (37.1)
Cefepime	287 (63.3)	167 (36.7)
Ertapenem	11 (2.4)	443 (97.6)
Imipenem	18 (3.9)	436 (96.1)
Gentamicin	218 (48.1)	236 (51.9)
Tobramycin	177 (38.9)	277 (61.1)
Ciprofloxacin	206 (45.4)	248 (54.6)
Levofloxacin	106 (23.4)	348 (76.6)
Nitrofurantoin	50 (11.1)	404 (88.9)
Trimethoprim/Sulfamethoxazole	220 (48.5))	234 (51.5)

5. Discussion

Escherichia coli is one of the most common causative agents of bacterial infections (16). Antimicrobial resistance patterns of *E. coli* continue to pose a great threat to public health worldwide and lead to serious health problems such as prolonged hospitalization and treatment failure (8, 10). Therefore, this study aimed to detect the antibiotic susceptibility profile of *E. coli* isolates from various clinical sources in Duhok city, Iraq.

In the present study, a total of 454 *E. coli* isolates were collected from various clinical specimens. The frequency of clinical isolates of *E. coli* in urine samples was higher in females than in males. This result is consistent with other studies reporting a higher prevalence of *E. coli* in UTI in females (14, 17, 18). The reason for the high prevalence of this microorganism in females is that the urethra of females are short and this shortens the distance to be moved by bacteria to the bladder and sexual activities, which increases the inoculation of bacteria into the bladder (19). These predisposing factors of UTI are accelerated by poor hygiene and low socioeconomic status (17). Alteration in the vaginal microflora may play a major role in encouraging the colonization of the vagina with coliforms and this can be associated with UTI (20). In terms of wound swabs, the occurrence of clinical isolates of *E. coli* was higher in males than in females. In contrast, in a study conducted in Pakistan, the incidence of *E. coli* isolates from wound swabs was the same in both males and females (5). It is difficult to explain this variation, and further studies with larger sample sizes are needed to explore the reason.

In the current study, *E. coli* isolated from various clinical specimens, showed differences in antibiotic sensitivity

patterns. In the case of urine samples, the antibiotic sensitivity profile showed that *E. coli* isolates were extremely sensitive to ertapenem and imipenem and highly resistant to ampicillin. This result is in agreement with previous studies showing that *E. coli* isolates from urine samples were highly resistant to ampicillin (5) and highly sensitive to imipenem (21). In another study conducted in Iraq, the majority of clinical *E. coli* isolates from urine samples were resistant to amoxicillin/clavulanic acid (3). The same study found that *E. coli* isolates were sensitive to amikacin and imipenem (3). Other studies found that 100% of *E. coli* isolates were sensitive to gentamycin, amikacin, imipenem, meropenem, piperacillin-tazobactam, and tobramycin (22). Previous studies conducted in India and Kenya also showed high sensitivity to gentamycin (23, 24). Our findings are alarming and call for urgent measures to control the threatening development of antibacterial resistance, particularly to ampicillin, in the region.

In this study, ertapenem and imipenem were found to be the most effective antimicrobials against *E. coli* isolates from the wound and cervical swabs, whereas the microorganism showed high resistance to ampicillin and cefepime. Additionally, it was observed that the *E. coli* isolates had relatively high resistance to ciprofloxacin. The blood isolates were found to be 100% resistant to ampicillin, cefoxitin, ceftriaxone, and nitrofurantoin and about 75% of them were sensitive to levofloxacin, ertapenem, and ciprofloxacin. Our results are in agreement with a study conducted in Ethiopia (25) that found that *E. coli* isolates were resistant to ampicillin (100%). In all other clinical specimens, including semen, ascetic, and cerebral spinal fluid specimens, *E. coli* showed high sensitivity to cefazolin, ertapenem, imipenem, levofloxacin, and nitrofurantoin. These results are in agreement with other research (26).

Antimicrobial resistance rates obtained in this study were higher than the resistance patterns reported by previous studies (27, 28). This may be attributed to the prevailing use and misuse of antibiotics in the area under study. On the other hand, *E. coli* isolates from various sources were sensitive to ertapenem, imipenem, and nitrofurantoin. This is in contrast to previous studies performed in different countries that found gentamicin, nitrofurantoin, ciprofloxacin, norfloxacin, and chloramphenicol as the most effective antimicrobial agents against *E. coli* (29, 30). Other studies reported that the isolates showed a high level of resistance to ampicillin, cefuroxime, amoxicillin-clavulanic acid, ceftriaxone, ciprofloxacin, and cefepime (31). The same study found that the isolates were highly sensitive to imipenem, nitrofurantoin, amikacin, chloramphenicol, piperacillin-tazobactum, gentamicin, azetreonam, and norfloxacin (31). These differences in the sensitivity pattern of antibiotics could be attributed to the time difference between the two studies, population variations, and significant differences in the sample sizes and types,

5.1. Conclusion

The high prevalence and spread of infection in females can be reduced by proper hygienic and medical care. In this study, ertapenem, imipenem, and nitrofurantoin were found to be the most effective antibiotics against *E. coli* isolates from various clinical sources. However, *E. coli* isolates exhibited high resistance to ampicillin, ceftriaxone, and cefepime. Therefore, it is proposed to perform antibiotic susceptibility testing to ensure effective prescriptions.

Footnotes

Authors' Contribution: Conception of study idea: IN, AB, and NH; data collection and laboratory analysis; AB, NH, SY, and IN; interpretation of results: IN, KS, SA, and HA; writing the main manuscript text: IN and NH; all authors reviewed the main manuscript. We further confirm that the order of authors listed in the manuscript has been approved by all of the authors.

Conflict of Interests: We wish to confirm that there are no known conflicts of interest associated with this publication.

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References

1. Lausch KR, Fuursted K, Larsen CS, Storgaard M. Colonisation with multi-resistant Enterobacteriaceae in hospitalised Danish patients with a history of recent travel: A cross-sectional study. *Travel Medicine and Infectious Disease*. 2013;**11**(5):320–3. doi: 10.1016/j.tmaid.2013.06.004.
2. Kashef N, Djavid GE, Shahbazi S. Antimicrobial susceptibility patterns of community-acquired uropathogens in Tehran, Iran. *J Infect Dev Ctries*. 2010;**4**(4):202–6. doi: 10.3855/jidc.540. [PubMed: 20440056].
3. Hussein NR, Daniel S, Salim K, Saleh Assafi M. Urinary Tract Infections and Antibiotic Sensitivity Patterns Among Women Referred to Azadi Teaching Hospital, Duhok, Iraq. *Avicenna J Clin Microbiol Infect*. 2018;**5**(2):27–30. doi: 10.34172/ajcmi.2018.05.
4. Biedenbach DJ, Moet GJ, Jones RN. Occurrence and antimicrobial resistance pattern comparisons among bloodstream infection isolates from the SENTRY Antimicrobial Surveillance Program (1997-2002). *Diagn Microbiol Infect Dis*. 2004;**50**(1):59–69. doi: 10.1016/j.diagmicrobio.2004.05.003. [PubMed: 15380279].

5. Khan N, Noor us S, Abdus S, Qazilbash A. Incidence and Antibiogram Patterns of Escherichia coli Isolated from Various Clinical Samples from Patients at N.I.H. Islamabad. *Pakistan Journal of Biological Sciences*. 2002;**5**. doi: 10.3923/pjbs.2002.111.113.
6. Kim SA, Kim DW, Dong BQ, Kim JS, Anh DD, Kilgore PE. An expanded age range for meningococcal meningitis: molecular diagnostic evidence from population-based surveillance in Asia. *BMC Infect Dis*. 2012;**12**:310. doi: 10.1186/1471-2334-12-310. [PubMed: 23164061]. [PubMed Central: PMCPmc3519641].
7. Turner SM, Scott-Tucker A, Cooper LM, Henderson IR. Weapons of mass destruction: virulence factors of the global killer enterotoxigenic Escherichia coli. *FEMS Microbiol Lett*. 2006;**263**(1):10–20. doi: 10.1111/j.1574-6968.2006.00401.x. [PubMed: 16958845].
8. Okeke IN, Laxminarayan R, Bhutta ZA, Duse AG, Jenkins P, O'Brien TF, et al. Antimicrobial resistance in developing countries. Part I: recent trends and current status. *Lancet Infect Dis*. 2005;**5**(8):481–93. doi: 10.1016/s1473-3099(05)70189-4. [PubMed: 16048717].
9. Planta MB. The role of poverty in antimicrobial resistance. *J Am Board Fam Med*. 2007;**20**(6):533–9. doi: 10.3122/jabfm.2007.06.070019. [PubMed: 17954860].
10. Moges F, Endris M, Mulu A, Tessema B, Belyhun Y, Shiferaw Y, et al. The growing challenges of antibacterial drug resistance in Ethiopia. *J Glob Antimicrob Resist*. 2014;**2**(3):148–54. doi: 10.1016/j.jgar.2014.02.004. [PubMed: 27873721].
11. Bouza E, Cercenado E. Klebsiella and enterobacter: antibiotic resistance and treatment implications. *Semin Respir Infect*. 2002;**17**(3):215–30. doi: 10.1053/srin.2002.34693. [PubMed: 12226801].
12. El Kholy A, Baseem H, Hall GS, Procop GW, Longworth DL. Antimicrobial resistance in Cairo, Egypt 1999-2000: a survey of five hospitals. *J Antimicrob Chemother*. 2003;**51**(3):625–30. doi: 10.1093/jac/dkg101. [PubMed: 12615864].
13. Erb A, Stürmer T, Marre R, Brenner H. Prevalence of antibiotic resistance in Escherichia coli: overview of geographical, temporal, and methodological variations. *Eur J Clin Microbiol Infect Dis*. 2007;**26**(2):83–90. doi: 10.1007/s10096-006-0248-2. [PubMed: 17235554].
14. Assafi M, Ibrahim N, Hussein N, Taha A, Balatay A. Urinary Bacterial Profile and Antibiotic Susceptibility Pattern among Patients with Urinary Tract Infection in Duhok City, Kurdistan Region, Iraq. *Int. J. Pure Appl. Sci. Technol*. 2015;**30**:54–63.
15. Amin M, Mehdinejad M, Pourdangchi Z. Study of bacteria isolated from urinary tract infections and determination of their susceptibility to antibiotics. *Jundishapur Journal of Microbiology*. 2009;**2**(3):118–23.
16. Orrett FA, Shurland SM. Prevalence of resistance to antimicrobials of Escherichia coli isolates from clinical sources at a private hospital in Trinidad. *Jpn J Infect Dis*. 2001;**54**(2):64–8. [PubMed: 11427743].
17. Akram M, Shahid M, Khan AU. Etiology and antibiotic resistance patterns of community-acquired urinary tract infections in J N M C Hospital Aligarh, India. *Annals of Clinical Microbiology and Antimicrobials*. 2007;**6**(1):4. doi: 10.1186/1476-0711-6-4.
18. Yismaw G, Abay S, Asrat D, Yifru S, Kassu A. Bacteriological profile and resistant pattern of clinical isolates from pediatric patients, Gondar University Teaching Hospital, Gondar, Northwest Ethiopia. *Ethiop Med J*. 2010;**48**(4):293–300. [PubMed: 21280431].
19. Magliano E, Grazioli V, Deflorio L, Leuci AI, Mattina R, Romano P, et al. Gender and age-dependent etiology of community-acquired urinary tract infections. *ScientificWorldJournal*. 2012;**2012**:349597. doi: 10.1100/2012/349597. [PubMed: 22629135]. [PubMed Central: PMCPmc3351074].
20. Hooton TM, Stamm WE. Diagnosis and treatment of uncomplicated urinary tract infection. *Infect Dis Clin North Am*. 1997;**11**(3):551–81. doi: 10.1016/s0891-5520(05)70373-1. [PubMed: 9378923].
21. Adinortey C, Amewowor DHAK, Otwe E, Galyuon I, Asante DKA. Antibiotic Susceptibility Profile and Occurrence of Escherichia coli Isolated from Clinical and Environmental Samples in Cape Coast, Ghana. *Research Journal of Microbiology*. 2017;**12**:170–6. doi: 10.3923/jm.2017.170.176.
22. Akter T, Hossain M, Khan M, Sultana H, Fatema K, Al Sanjee S, et al. Isolation, Identification and Antimicrobial Susceptibility Pattern Analysis of Escherichia coli Isolated from Clinical Samples of Bangladesh. *Asian Journal of Biomedical and Pharmaceutical Sciences*. 2016;**6**:13–6.
23. Sabir S, Ahmad Anjum A, Ijaz T, Asad Ali M, Ur Rehman Khan M, Nawaz M. Isolation and antibiotic susceptibility of E. coli from urinary tract infections in a tertiary care hospital. *Pakistan journal of medical sciences*. 2014;**30**(2):389–92. [PubMed: 24772149].
24. Patil A, Patil K, Pawar P, Maheshwari V. Isolation and survey of antibiotic sensitivity in nosocomial infections in north Maharashtra region. *J Assoc Physicians India*. 2013;**61**(7):454–8. [PubMed: 24772747].
25. Abebe M, Tadesse S, Meseret G, Derbie A. Type of bacterial isolates and antimicrobial resistance profile from different clinical samples at a Referral Hospital, Northwest Ethiopia: five years data analysis. *BMC Research Notes*. 2019;**12**(1):568. doi: 10.1186/s13104-019-4604-6.
26. Krunal Shah. A Comparative Study of Antibiotic Sensitivity Pattern of Escherichia coli Isolated from Various Clinical Samples over a Period of 3 Years. *Int J Curr Microbiol App Sci*. 2019;**8**(10):1243–9.
27. Karlowsky JA, Kelly LJ, Thornsberry C, Jones ME, Sahm DF. Trends in antimicrobial resistance among urinary tract infection isolates of Escherichia coli from female outpatients in the United States. *Antimicrob Agents Chemother*. 2002;**46**(8):2540–5. doi: 10.1128/aac.46.8.2540-2545.2002. [PubMed: 12121930]. [PubMed Central: PMCPmc127340].
28. Zhanel GG, Hisanaga TL, Laing NM, DeCorby MR, Nichol KA, Palatnik LP, et al. Antibiotic resistance in outpatient urinary isolates: final results from the North American Urinary Tract Infection Collaborative Alliance (NAUTICA). *Int J Antimicrob Agents*. 2005;**26**(5):380–8. doi: 10.1016/j.ijantimicag.2005.08.003. [PubMed: 16243229].
29. Wariso BA, Ibe SN. Bacteriology of chronic discharging ears in Port Harcourt, Nigeria. *West Afr J Med*. 2006;**25**(3):219–22. doi: 10.4314/wajm.v25i3.28281. [PubMed: 17191422].
30. Kibret M, Abera B. Antimicrobial susceptibility patterns of E. coli from clinical sources in northeast Ethiopia. *Afr Health Sci*. 2011;**11 Suppl 1**(Suppl 1):S40–5. doi: 10.4314/ahs.v11i3.70069. [PubMed: 22135643]. [PubMed Central: PMCPmc3220125].
31. Kulkarni SR, Peerapur BV, Sailesh KS. Isolation and Antibiotic Susceptibility Pattern of Escherichia coli from Urinary Tract Infections in a Tertiary Care Hospital of North Eastern Karnataka. *Journal of natural science, biology, and medicine*. 2017;**8**(2):176–80. doi: 10.4103/0976-9668.210012. [PubMed: 28781483].