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Pathogenic identification and antibiotic susceptibility of the microorganisms isolated from urine samples of UTI patients

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Urinary tract infection (UTI) is the infection that occurs in the urinary tract by the invasion of pathogenic bacteria, fungi, virus etc. under some circumstances only. Some common pathogenic bacteria associated with UTI include *Escherichia coli*, *Proteus* spp., *Streptococcus* spp., *Staphylococcus* spp., *Pseudomonas* spp. In the ongoing research work, about 30 UTI patients were selected randomly to detect the pathogen responsible for causing urinary tract infection and also to demonstrate their drug resistant traits. Among the 30 samples, about 14 samples were found to harbor *Proteus* spp. (1×10^4 cfu/ml to 1×10^5 cfu/ml). *Escherichia coli* was found to be the second predominant agent for UTI and recovered from 13 samples. Among the rest 3 samples, *Pseudomonas* spp. was found in 2 samples and *Klebsiella* spp. was found in one sample. Identified isolates showed resistance against different ranges of antibiotics. The study findings revealed the fact that emerging drug resistance of different pathogenic bacteria could become the major difficulties in the treatment of infectious diseases like UTI.

Key words: Urinary tract infection; Pathogenic bacteria, Antibiotic resistance

Urinary tract infection (UTI) is a common global problem and one of the major causes for which patients seek for medical treatments. Approximately 250 million people world-wide get infected with UTI (1-6). Females are more prone to UTI because of the easier and shorter access from the external of the urethra to the urinary bladder than the males who have much longer urethra. Females also get UTI easily during sexual intercourse and child birth (7, 8). The rate of UTI depends on age, sex, immune status, catheterization etc. Urinary tract infections are mainly caused by bacteria and occasionally by fungi and viruses. Most common bacteria causing such infections include *Escherichia coli*, *Klebsiella* spp., *Proteus* spp., *Pseudomonas* spp., *Streptococcus* spp., *Staphylococcus* spp., *Neisseria* spp. etc (7, 9, 10). Despite of many antibacterial mechanisms in the urinary bladder to have infection, the uropathogenic bacteria can invade such mechanisms and colonize in the urinary tract to start an infection (11-15). Different tests are in use to detect UTI such as urinalysis, Gram staining, urine culture and so on (15).

The treatment starts with the result of antibiotic resistance of the identified pathogen from urine sample of the patient. The physician prescribes the susceptible antibiotics from the result chart but the condition gets worse when patients use uncontrolled dosage without becoming aware of the drug resistant threats (14-27). Immuno-compromised patients are at a great risk of UTI and the drug resistant traits of the pathogens makes the phenomenon even more complicated. HIV infection, diabetes, patients undergoing surgery, organ transplant patients can easily caught by UTI (28, 29).

In the current study 30 patients were randomly selected seeking medical facilities and supposed to have urinary tract infection. Pathogenic bacterial identification along with their count was determined in this study. In the later part of the study, antibiotic drug susceptibility test was performed for the pathogenic isolates collected from the individual patients. Sensitive, moderate and resistant antibiotic drug list was prepared for the pathogenic isolates separately to get complete array of drug susceptibility result which will help to treat the patients with the best suited susceptible antibiotic.

MATERIALS AND METHODS

Study population and sampling. Suspected urinary tract infection (UTI) patients of various ages (ranging from 14 years to 66 years old) seeking for medical treatment were considered as a study population in this study. About 30 patients were randomly selected who came for microbiological analysis in the Dhaka locality. The study was conducted from March, 2016 to May, 2016. Urine samples were collected aseptically from the mid stream in the sterile bottles provided by the test centers and immediately transferred to different culture media. Standard laboratory procedures were strictly maintained to avoid any hazards and transmissions to healthcare workers and to others (14-16).

Determination of pathogenic bacteria responsible for the urinary tract infection. After collection of urine samples, they were inoculated onto MacConkey agar plates and CLED (cysteine-, lactose- and electrolyte-deficient) agar plates to detect mostly Gram negative bacteria (14-16). An aliquot of 10µl sample was spread over both the types of agar plates and incubated at 37 ^{o}C for 24 hours. After incubation period, the colonies were enumerated and subjected to biochemical identification.

Antibiotic susceptibilityity of the isolated pathogens. Pathogenic bacteria

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found in the urine samples were further subjected to determine their antibiotic sensitivity patterns against the commonly prescribed antibiotics (14-16, 21). About 11 antibiotics such as gentamicin (GEN, 10µg), cephradine (CED, 30µg), cefuroxime (CXM, 30µg), ceftadizime (CAZ, 30µg), amikacin (AMK, 10µg), nitrofurantoin (NIT, 300µg), ciprofloxacin (CIP, 05 µg), levofloxacin (LE, 5 µg), rifampin (RIF, 05 µg), ceftriaxone (CTR, 30 µg), cotrimoxazole (COT, 25 µg) were selected to be tested for this study. At first, Mueller Hinton agar plates were used to make lawn of the isolated pathogenic bacterial culture and the selected antibiotic discs were placed over the lawn culture. Afterwards, the plates were incubated at 37 ^{o}C for 24 hours. Following incubation, the plates were observed for the zone of inhibition around the antibiotic discs.

RESULTS AND DISCUSSIONS

Urinary tract infection has remained to be one of the prominent medical complications worldwide. Urinary tract is usually sterile but accidental bacterial invasion can occur causing upper and lower urinary tract infection which can be both symptomic or asymptomic (8, 11-33). Gram negative bacteria *Escherichia coli* and *Klebsiella* spp. are found to be the most common causes of UTI (14-16, 31-36). *Staphylococcus aureus* and *Klebsiella* spp. has also been reported in the urine samples of UTI patients (14-16, 37-42). In the present study, the most prevalent pathogenic bacteria were *Proteus* spp. and *Escherichia coli* which was found to be present in 14 samples and 13 samples, respectively out of 30 samples ranging from 10^4 cfu/ml to 10^5 cfu/ml. *Pseudomnas* spp. was found to be present in 2 samples ($1.5x10^4$ cfu/ml and $2.2x10^5$ cfu/ml) and *Klebsiella* spp. was present only in one sample ($1.8x10^4$ cfu/ml).

In the later part of the study, microbial resistance and sensitivity towards the commonly consumed antibiotics were experimented to understand the current conditions of the medical treatments and the risks caused by the drug resistance bacteria. This approach helps the physicians to prescribe the patients to use sensitive antibiotics with appropriate dosage. But the alarming situation is that the rapidly increasing drug resistance has made the treatment of patients a big challenge (14-16). More and more pathogenic bacteria are becoming resistant and seeking and developing new sensitive drugs is a must to recover such conditions (14-21).

Bacteria can become resistant by following a variety of mechanisms which help them to avid the deleterious effects of antibiotics. Mutation is a common way of developing drug resistance. *Neisseria gonorrhoeae* shows resistance towards cefixime and ceftriaxone caused by ribosomal mutation (43). *Pseudomonas aeruginosa* has multidrug efflux mechanism to survive in the presence of antibiotics (44-47). Methicillin resistant *Staphylococcus areus* is a common pathogen in the whole world (48).

Many deaths have been reported due to methicillin resistant *S. aureus* (49, 50). Multidrug resistant pathogenic bacteria cause serious health problems in the immune-compromised patients which encourages secondary and

TABLE 1. Pathogenic microbial load (cfu/ml) in urine samples

Sample No	Microbial load (cfu/ml)			
	Escherichia coli	***Proteus* spp.**	***Klebsiella* spp.**	***Pseudomonas* spp.**
01	$1.1x10^5$	0	0	0
02	$1.0x10^4$	0	0	0
03	$1.7x10^4$	0	0	0
04	0	$1.4x10^4$	0	0
05	$1.5x10^5$	0	0	0
06	0	$1.3x10^5$	0	0
07	0	$2.0x10^4$	0	0
08	0	$2.2x10^4$	0	0
09	0	$2.7x10^5$	0	0
10	$2.0x10^4$	0	0	0
11	$1.9x10^5$	0	0	0
12	0	$3.7x10^4$	0	0
13	0	0	$1.8x10^4$	0
14	0	$2.4x10^5$	0	0
15	0	$2.2x10^5$	0	0
16	$3.0x10^5$	0	0	0
17	0	$1.8x10^5$	0	0
18	0	$1.5x10^4$	0	0
19	0	0	0	$1.5x10^5$
20	$2.2x10^4$	0	0	0
21	$3.1x10^5$	0	0	0
22	0	$1.3x10^5$	0	0
23	0	$1.5x10^5$	0	0
24	$2.5x10^4$	0	0	0
25	0	$2.0x10^4$	0	0
26	0	$1.4x10^5$	0	0
27	0	0	0	$2.2x10^5$
28	$1.7x10^5$	0	0	0
29	$1.7x10^5$	0	0	0
30	$1.3x10^4$	0	0	0

TABLE 2. Antibiotic susceptibility pattern of the pathogenic bacterial isolates

Sample No	Bacterial isolate	Antibiotic Susceptibility from urine sample		
		Sensitive	**Moderate**	**Resistant**
1	*E. coli*	LE^{+}		GEN,CAZ,CIP,NIT,AMK,CXM,CED,CTR, COT,RIF
2	*E. coli*	GEN^{+}	COT	CAZ,CIP,LE,NIT,AMK,CXM,CED,CTR, ,RIF
3	*E. coli*	GEN^{+}		CAZ,CIP,LE,NIT,AMK,CXM,CED,CTR,C OT,RIF
4	*Proteus* spp.	LE^{+} GEN^{+}		CAZ,CIP,NIT,AMK,CXM,CED,CTR,COT, RIF
5	*E. coli*	LE+ GEN+ NIT+++	CED	CAZ,CIP,AMK,CXM, CTR,COT,RIF, NIT
6	*Proteus* spp.	LE+ GEN+ NIT+++ CAZ+++	CED, CXM	CIP,AMK,CTR,COT,RIF
7	*Proteus* spp.	LE,CIP	CXM	GEN,CAZ,NIT,AMK, CED,CTR,COT,RIF
8	*Proteus* spp.	LE,NIT,AMK GEN		CAZ,CIP,CXM,CED,CTR,COT,RIF
9	*Proteus* spp.	NIT,LE,CIP	RIF	GEN,CAZ,AMK,CXM,CED,CTR,COT
10	*E. coli*	AMK,NIT,RIF	COT	GEN,CAZ,CIP,LE,CXM,CED,CTR
11	*E. coli*	GEN,AMK,CTR		CAZ,CIP,LE,NIT,CXM,CED,COT,RIF
12	*Proteus* spp.	AMK++		GEN,CAZ,CIP,LE,NIT,CXM,CED,CTR,C OT,RIF
13	*Proteus* spp.	NIT++,RIF+		GEN,CAZ,CIP,AMK,CXM,CED,CTR,COT
14	*Proteus* spp.	NIT,RIF		GEN,CAZ,CIP,AMK,CXM,CED,CTR,COT
15	*E. coli*	AMK,NIT,GEN,CTR		CAZ,CIP,CXM,CED,COT,RIF
16	*Proteus* spp.	NIT,LE,CIP		GEN,CAZ,AMK,CXM,CED,CTR,COT,RIF
17	*Proteus* spp.	AMK+		GEN,CAZ,CIP,NIT,CXM,CED,CTR,COT, RIF,LE
18	*Pseudomonas* spp.	CTR,LE		GEN,CAZ,CIP,NIT,AMK,CXM,CED,COT, RIF
19	*E. coli*	CIP,LE		GEN,CAZ,NIT,AMK,CXM,CED,CTR,CO T,RIF
20	*E. coli*	CTR,CXM,AMK, GEN,NIT		CAZ,CED,COT,RIF
21	*Proteus* spp.	NIT,LE,CIP		GEN,CAZ,CIP,NIT,AMK,CXM,CED,CTR, COT,RIF
22	*Proteus* spp.	AMK,GEN,NIT		CAZ,CIP,CXM,CED,CTR,COT,RIF
23	*E. coli*	COT,CIP,LE,CTR,AMK,CAZ ,NIT,CXM,GEN		CED,RIF
24	*Proteus* spp.	LE+		GEN,CAZ,CIP,NIT,AK,CXM,CED,CTR,C OT,RIF
25	*Proteus* spp.	GEN,AMK,NIT		CAZ,CIP,CXM,CED,CTR,COT,RIF
26	*Pseudomonas* spp.	LE,AMK,CIP,GEN		CAZ,NIT,CXM,CED,CTR,COT,RIF
27	*E.coli*	NIT,LE,AMK		GEN,CAZ,CIP,CXM,CED,CTR,COT,RIF
28	*E. coli*	LE,CIP		GEN,CAZ,NIT,AMK,CXM,CED,CTR,CO T,RIF
29	*E. coli*	COT,NIT,LE,RIF		GEN,CAZ,CIP,AMK,CXM,CED,CTR
30	*Proteus* spp.	CTR,COT,NIT		GEN,CAZ,CIP,AMK,CXM,CED,RIF

Gentamicin= GEN, Cephradine= CED, Cefuroxime= CXM, Ceftadizime= CAZ, Amikacin= AMK, Nitrofurantoin= NIT, Ciprofloxacin= CIP, Levofloxacin= LE, Rifampin= RIF, Ceftriaxone= CTR, Cotrimoxazole= COT
+ = Degree of sensitivity

more fatal infections (51, 52). Drug resistant genes can be carried into other susceptible bacteria by plasmid, bacteriophage, transposons etc. If these elements are absent, resistance can also be occurred by random chromosomal mutations (53).

In our current research, multiple drug resistance were documented (Table 2) in cohort with the previous studies (14-21). 10 *Proteus* spp. isolates were found to be sensitive towards CTR, COT, NIT, GEN, AMK, LE, CIP and RIF antibiotics (Table 2). Among these antibiotics NIT, RIF and AMK showed better susceptibility than other antibiotics by showing larger clear zones in the Mueller Hinton agar medium. CED and CXM antibiotics were showed to be moderate and this indicates that these two antibiotics are going to be resistant in the upcoming days. One sample (sample no. 19) showed moderate activity for RIF. *E. coli* which wass the second predominant pathogen causing UTI in this study (found in 13 samples out of 30) showed susceptibility towards LE, GEN, NIT, AMK, CTR, CIP, CXM and RIF. All of the *Proteus* spp. were resistant to CAZ, COT etc. *E. coli* from sample no. 23 showed to most susceptibility towards most of the antibiotics and least resistance (resistant to 2 antibiotics only- CED, RIF). CTR, LE and AMK, GEN, NIT were best suited in killing *Pseudomonas* spp. from sample no. 18 and 26, respectively. *Klebsiella* spp. found only in sample no. 13 was sensitive to AMK, RIF, LE and resistant against GEN, CAZ, CIP, NIT, CXM, CED, CTR, COT (Table 2).

It is very important to prescribe antibiotics after antibiotic sensitivity test and it should be advised in appropriate dosage. The patients must be instructed correctly to take the medications just as prescribed and should also be informed properly about the deleterious effects of misuse of the antibiotics heading to the drug resistance which not only cause harm to the individual but also the people in surroundings (60).

CONCLUSION

Though urinary tract infection is a common phenomenon, the treatment procedure is becoming more complicated due to multi drug resistant pathogenic bacteria. Only a few antibiotics are still in susceptible condition. But the resistance toward these antibiotics could be an obvious condition for the future. Development of new drugs is a must and patients should be advised properly to take the antibiotic medication to control the condition of rapidly occurring resistance traits.

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REFERENCES

1. **Renuart AJ, Goldfarb DM, Mokomane M, Tawanana EO, Narasimhamurthy M, Steenhoff AP, et al.** 2013. Microbiology of urinary tract infections in Gaborone, Botswana. PLoS ONE. 8 (3): e57776.
2. **Schmiemann G, Kniehl E, Matejczyk KG, Pradier EH.** 2010. Diagnosis of urinary tract infection- A systematic review. Dtsch Arztebl. Int. 107 (21): 361–367.
3. **Rakaa L, Mulliqi-Osmani G, Berisha L.** 2004. Etiology and susceptibility of urinary tract isolates in Kosova. Int. J. Antimicrob. agents. 23S1S2–S5.
4. **Devillé WL, Yzermans JC, van Duijn NP, Bezemer PD, van der Windt DA, Bouter LM.** 2004. The urine dipstick test useful to rule out infections- A meta-analysis of the accuracy. BMC Urol. 4: 4.
5. **Raza S, Pandey S, Bhatt CP.** 2011. Microbiological analysis of the urine isolates in Kathmandu Medical College, Teaching Hospital, Kathmandu, Nepal. Kathmandu Uni. Med. J. 36 (4): 295-7.
6. **Garofalo CK, Hooton TM, Martin SM.** 2007. *Escerichia coli* from urine of female pateints with urinary tract infections is competent for intracellular bacterial community formation. Infect. Immun. 75: 52-60.
7. **El-Sweih N, Jamal W, Rotimi VO.** 2008. Spectrum and antibiotic resistance of uropathogens isolated from hospital and community patients with urinary tract infections in two large hospitals in Kuwait. Med. Principl. pract. 14: 401-407.
8. **Kolawale AS, Kolawale OM, Kandaki-Olukemi YT, Babatunde SK, Durowade KA, Kplawale CF**. 2009. Prevalence of urinary tract infections among patients attending Dalhatu Araf Specialist Hospital, Lafia, Nasarawa State, Nigeria. Int. J. Med. Med. Sci. 1 (5): 163-1 67.
9. **Abubakar EM.** 2009. Antimicrobial susceptibility pattern of pathogenic bacteria causing urinary tract infections at the Specialist Hospital, Yola, Adamawa state, Nigeria. Journal of Clinical Medicine and Research. 1 (1): 1-8.
10. **Farajnia S, Alikhani MY, Ghotaslou R, Naghili B, Nakhlband A.** 2009. Causative agents and antimicrobial susceptibilities of urinary tract infections in the northwest of Iran. Int. J. Infect. Dis. 13: 140-144.
11. **Cunha BA.** 2009. Urinary Tract Infection, Females. Available at: http:// emedicine.medscape.com/article/233101-overview. Accessed 25 January, 2010.
12. **Dulawa J.** 2004. Urinary tract infection-2003. Ann. Acad. Med. Bialostoc. 49: 182-184.
13. **Fihn SD.** 2003. Acute uncomplicated urinary tract infection in women. N. Engl. J. Med. 349: 259-266.
14. **Sarker UJ, Munna MS, Munshi SK.** 2013. Microbiological profile of symptomatic and asymptomatic bacteriuria recovered from female patients with urinary tract infection. Stamford Journal of Microbiology. 3 (1): 34-37.
15. **Noor AF, Shams F, Munshi SK, Rahman MM, Noor R.** 2013. Prevalence and antibiogram profile of uropathogens isolated from hospital and community patients with urinary tract infections in Dhaka city. Journal of Bangladesh Academy of Sciences. 37 (1): 57-63.
16. **Khan SA, Feroz F, Noor R.** 2013. Study of extended spectrum *β*-lactamase producing bacteria from urinary tract infection from Dhaka city, Bangladesh. Tzu Chi Medical Journal. 25 (1): 39-42.
17. **Hasan R, Acharjee M, Noor R.** 2016. Prevalance of vancomycin resistant *Staphylococcus aureus* (VRSA) in methicillin resistant *S. aureus* (MRSA) strains isolated from burn wound infection. Tzu Chi Medical Journal. DOI: 10.1016/j.tcmj.2016.03.002
18. **Noor R, Hasan MF, Rahman MM.** 2014. Molecular characterization of the virulent microorganisms along with theirdrug resistant traits associated with the export quality frozen shrimps in Bangladesh. SpringerPlus. 3: 469.
19. **Alam SMS, Kalam MA, Munna MS, Munshi SK, Noor R.** 2014. Isolation of pathogenic microorganisms from burn patients admitted in Dhaka medical College and Hospital and demonstration of their drug resistant traits. Asian Pacific Journal of Tropical Disease. 4 (5): 174-176.
20. **Ahmed T, Baidya S, Sharma BC, Malek M, Das KK, Acharjee M, et al.** 2013. Identification of drug resistant bacteria among export quality shrimp samples in Bangladesh. Asian J. Microbiol. Biotechnol. Envi. Sci. 15 (4): 31-36.
21. **Dutta S, Hasan MR, Rahman F, Jilani MSA, Noor R.** 2013. Study of antimicrobial susceptibility of clinically significant microorganisms isolated from selected areas of Dhaka, Bangladesh. Bangladesh Journal of Medical Science. 12 (1): 34-42.
22. **Kripke C.** 2005. Duration of therapy for women with uncomplicated UTI. Am. Fam. Physician. 72: 19-22.
23. **National Committee for Clinical Laboratory Standards.** 2000. Performance standards for antimicrobial disc susceptibility tests, 7th ed. Wayne, Pennsylvania, USA.

24. **Wilson ML, Gaido L.** 2004. Laboratory diagnosis of urinary tract infections in adult patients. Clin. Infect. Dis. 38: 1150–1158.
25. **Bonadio M, Meini M, Spetaleri P, Gilgi C.** 2001. Current microbiological and clinical aspects of urinary tract infections. Eur. J. Urol. 40: 439-445.
26. **Grude N, Tveten Y, Kristiansen BE.** 2001. Urinary tract infections in Norway: bacterial etiology and susceptibility, a retrospective study of clinical isolates. Clin. Microbiol. Infect. 7: 543-547.
27. **Sefton AM.** 2000. The impact of resistance on the management of urinary tract infections. Int. J. Antimicrob. Agents. 16: 489-491.
28. **Hendriksen RS, Trees EH, Pulsrikarn C, Pornruangwong S, Chaichana P, Svendsen CA, et al.** 2012. Characterization of *Salmonella enterica* serovar *Enteritidis* isolates recovered from blood and stool specimens in Thailand. BMC Microbiology. 12: 92.
29. **Mootsikapun P.** 2007. Bacteremia in adult patients with AIDS in the north east in Thailand. International Journal of Infectious Diseases. 11: 226-231.
30. **Ronald AR, Nicolle LE, Stamm E.** 2001. Urinary tract infection in adults: Research priorities and strategies. Int. J. Antimicrob. Agents. 17: 343-348.
31. **Obiogbolu CH, Okonko IO, Anyamere CO.** 2009. Incidence of urinary tract infections (UTIs) among pregnant women in Akwa metropolis, Southeastern Nigeria. Sci. Res. Essays. 4: 820-824.
32. **Scottish Intercollegiate Guidelines Network.** 2006. Management of suspected bacterial urinary tract infection in adults.
33. **Behzadi P, Behzadi E.** 2008. The Microbial agents of urinary tract infections at central laboratory of Dr. Shariati Hospital, Tehran, IRAN. Turk. Klin. Tip. Bilim. 28: 445-449.
34. **Howes DS.** 2009. Urinary tract infection, female. Available at: http:// emedicine.medscape.com/article/778670-print. Accessed 25 January, 2010.
35. **Ayhan N, Basbug N, Ozturk S.** 1988. Causative agents of urinary tract infections and sensitivity to antibiotics. Microbiol. Bull. 22: 215-221.
36. **Ebie MY, Kandakai-Olukemi YT, Ayanbadejo J.** 2001. Urinary tract infections in a Nigerian Military Hospital. Nig. J. Microbiol. 15: 31-37.
37. **Tessema B, Kassu A, Mulu A, Yismaw G.** 2007. Predominant isolates of urinary tract pathogens and their susceptibility patterns in Gonder Univesity Teaching Hospital, Northwest Ethiopia. Ethio. Med. J. 45: 61-67.
38. **Assefa A, Asrat D, Woldeamanuel Y, Hiwot Y, Abdella A, Melesse T.** 2008. Bacterial profile and drug susceptibility pattern of urinary tract infection in pregnant women at Tikur Anbessa Specialized Hospital Addis Ababa, Ethiopia. Ethiop. Med. J. 46: 227- 35.
39. **Dromigny JA, Nabeth P, Claude PGJD.** 2002. Distribution and susceptibility of bacterial urinary tract infections in Dakar, Senegal. Int. J. Antimicrob. Agents. 20: 339-47.
40. **Bi XC, Zhang B, Ye YK.** 2009. Pathogen incidence and antibiotic resistance patterns of catheter-associated urinary tract infection in children. J. Chemother. 21: 661-665.
41. **Khameneh ZR, Afshar AT.** 2009. Antimicrobial susceptibility pattern of urinary tract pathogens. Saudi J. Kidney Dis. Transpl. 20: 251-253.
42. **Chin BS, Kim MS, Han SH.** 2011. Risk factors of all cause in hospital mortality among Korean elderly bacteremic urinary tract infection (UTI) patients. Arch. Gerontol. Geriatr. 52 (1): e50-5.
43. **Zaheer R., Cook SR, Klima CL, Stanford K, Alexander T, Topp E, et al**. 2013. Effect of subtherapeutic vs. therapeutic administration of macrolides on antimicrobial resistance in *Mannheimia haemolytica* and enterococci isolated from beef cattle. Front. Microbiol. 4: 133.
44. **Morita Y, Tomida J, Kawamura Y.** 2012. MexXY multidrug efflux system of *Pseudomonas aeruginosa.* Front. Microbiol. 3: 408.
45. **Usui M, Nagai H, Hiki M, Tamura Y, Asai T.** 2013. Effect of antimicrobial exposure on AcrAB expression in *Salmonella enterica* subspecies enteric serovar *choleraesuis*. Front. Microbiol. 4: 53.
46. **Deng Z, Shan Y, Pan Q, Gao X, Yan A.** 2013. Anaerobic expression of the *gadE-mdtEF* multidrug efflux operon is primarily regulated by the twocomponent system ArcBA through antagonizing the H-NS mediated repression. Front. Microbiol. 4: 194.
47. **Baucheron S, Monchaux I, Le HS, Weill FX, Cloeckaert A.** 2014. Lack of efflux mediated quinolone resistance in *Salmonella enterica* serovars Typhi and Paratyphi A. Front. Microbiol. 5: 12.
48. **Roberts SA, Lawrence MS, Klimczak LJ, Grimm SA, Fargo D, Stojanov P, et al.** 2013. An APOBEC cytidine deaminase mutagenesis pattern is widespread in human cancers. Nature Genetics. 45: 970-976.
49. **Weinstein RA.** 2001. Controlling antimicrobial resistance in hospitals: infection control and use of antibiotics. Emerg. Infect. Dis. 7: 188–192.
50. **Anonymous.** 2002. European antimicrobial resistance surveillance system. EARSS Annual Report 2002.
51. **Arthur M, Courvalin P.** 1993. Genetics and mechanisms of glycopeptide resistance in enterococci. Antimicrob. Agents Chemother. 37: 1563-1571.
52. **Goossens H.** 1999. The epidemiology of vancomycin-resistant enterococci. Curr. Opin. Infect. Dis. 12: 537-541.
53. **Lee C, Cho IH, Jeong BC, Lee SH.** 2013. Strategies to minimize antibiotic resistance. Int. J. Environ. Res. Public Health. 10 (9): 4274-4305.