


Analysis of Antimicrobial Medications Consumption in Inpatient Units at North West (Tabuk) Region Hospitals, Saudi Arabia

Abeer Hussin Almasoudi, Director, Administration of Research and Studies, Ministry of Health, Tabuk, SAUDI ARABIA.

Yousef Ahmed Alomi , The Former General Manager of General Administration of Pharmaceutical Care, Former Head, National Clinical Pharmacy and Pharmacy Practice, Former Head, Pharmacy R&D Administration, Ministry of Health, Riyadh, SAUDI ARABIA.

Ghormallah Abdullah Alghamdi, Consultant Family Medicine, General Manager of Health Affairs in Tabuk Region, Ministry of Health, Tabuk, SAUDI ARABIA.

Rasha Saad Alshahrani, Clinical Pharmacy Staff, Ministry of Health, Riyadh, SAUDI ARABIA.

Correspondence:

Yousef Ahmed Alomi, (Bsc. Pharm, MSc. Clin Pharm, BCPS, BCNSP, DiBA, CDE) The Former General Manager of General Administration of Pharmaceutical Care, Former Head, National Clinical Pharmacy and Pharmacy Practice, Former Head, Pharmacy R&D Administration, Ministry of Health, Riyadh, SAUDI ARABIA.

Phone no: +966 504417712

E-mail: yalomi@gmail.com

Received: 05-02-2019;

Accepted: 27-03-2019

Copyright: © the author(s), publisher and licensee Pharmacology, Toxicology and Biomedical Reports. This is an open-access article distributed under the terms of the Creative Commons Attribution Non-Commercial License, which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

This is an open access article distributed under the terms of the Creative Commons Attribution-Non-Commercial-ShareAlike 4.0 License

Access this article online



www.ptbreports.org

DOI:
10.5530/PTB.2019.5.24

ABSTRACT

Background: This article aims to explore antimicrobial medication consumption and related cost among different age groups in inpatient units at North West Region Hospitals, Ministry of Health, and Saudi Arabia. **Objectives:** To explore the selected antimicrobial medication consumption in inpatient units at North West Region Hospitals, Ministry of Health, Saudi Arabia. To increase the awareness of antimicrobial medication consumption side effect. **Methods:** It is a 9-month study about antimicrobial drug use by inpatients at North West region hospitals. It included inpatient department for adults, pediatrics and neonates. The medications were selected by Central Antibiotics committee at MOH as part of the National Antimicrobial Stewardship program. The consumption is driven from pharmacy database and calculated based on off-stranded unit of antimicrobial per hospital. The antimicrobials consisted of antibacterial drugs, antifungal and antiviral medications. The cost of antimicrobial consumption was calculated by using Ministry of Health National Cost database. All cost used as US currency. **Results:** The total number of Antimicrobial standard units was (25,845) and average (5,169) per hospital. The highest drug consumption was Ceftriaxone 1 gm injection (3,712) followed by Ceftazidime 1 gm injection (1807) and Gentamicin IV 80 mg (1,011) at adult's inpatient wards. The total cost of Antimicrobial consumption was (6,829,003.42 USD) and (1,365,800.68 USD) per hospital. The highest cost medication consumption from Adults inpatient departments was 99.62% (6,803,229.92 USD) followed by pediatrics inpatient 0.24% (16,087.6 USD) and Neonatal inpatient departments 0.14% (9,685.9 USD). The highest medication cost was for very broad-spectrum antibiotics like Meropenem, Imipenem and Ceftriaxone. It consumed more than 50% of the cost burden. **Conclusion:** There was very high consumption of antimicrobial drugs inpatient department with huge cost burden. Urgent application of antimicrobial stewardship program especially adults' inpatients departments is a mandate and urgent.

Keywords: Antimicrobial, Medications, Consumption, Inpatient, North West (Tabuk), Hospitals, Ministry of Health, Saudi Arabia.

INTRODUCTION

During the 21st century, Antimicrobial Resistance (AMR) has appeared as one of the greatest public health challenges worldwide. AMR is defined as the capability of a microorganism to endure or grow in the occurrence of a concentration of antibiotics that should be sufficient to confine or kill that organism. Antimicrobials have been in use for thousands of years in a variety of formats, it's always considered one of the best and fascinating discoveries of the 20th century and it is the most active chemotherapeutic among drugs. Exacerbating factors responsible for the expansion of AMR include poor information, misunderstandings, views on infectious diseases, unsuitable prescription and medication use and patient request. They act as bacteriostatic agents, restricting growth and reproduction of bacteria and as bactericidal agents causing bacterial cell death. Infections were the primary cause of death during the nineteenth century, the discovery of antibiotics not only helped in the treatment of infections but also have the most significant role in decreasing mortality and morbidity since 1910.¹ In 1910, Paul Ehrlich developed the first antimicrobial arsphenamine for the treatment of syphilis, a disease that was almost incurable back then. In 1932 a sulfonamide antibiotic was discovered. During the second half of the nineteenth century

and before the critical discovery of Fleming many researchers recorded observations regarding the antibacterial properties of Penicillium fungi. In 1929, Alexander Fleming introduced "penicillin" as a compound with antibacterial properties and Pyocyanase was probably the first antibiotic to be used to treat human infections.¹

So, the exploration of antibiotic was of significant help in the medical world and pharmacology. There are also good historical events to discover antibiotics. It is very impressive how the discoverers developed raw materials to drugs and how we have moved from a clever use of agents available in the environment to chemically engineered agents to preserve human life. Unfortunately, antibiotic resistance in hospitals, communities and the environment concomitant with their use is in the rising. It created a new challenge for the doctors and pharmacists. The successful use of any therapeutic agent is compromised by the potential development of tolerance or resistance to that compound from the time it is first employed.¹ The antibiotic resistance has increased in the Kingdom of Saudi Arabia.²⁻⁴ The resistance could be and due to critical care bugs or inpatient and ambulatory care bugs. Usually, the patients regularly visit the emergency services at the hospitals to seek help for his or her illness condition.

If the patient does not go for critical care hospital admission, then he/she will be admitted to inpatient services. Most of the medical diseases that required inpatient hospital admission was an infectious illness. During inpatient admission, the patient is receiving antibiotics as empirical therapy. Several studies showed that antibiotics consumption was related to economic burden on the health care system at inpatient hospitals services.⁵⁻¹³ Also showed the determination of antibiotics consumption to measure mis use of antibiotics and financial burden on the health care system. Besides, to investigate the demand for antibiotics stewardship services.¹⁴⁻¹⁶ Based on the author's best knowledge they are not familiar with any investigation about antibiotics consumption and economic burden at inpatient hospital services in Saudi Arabia or Gulf and the Middle East countries. The goal of the study is to explore the antibiotics consumption at inpatient hospitals services in the North West region (Tabuk) in the Kingdom of Saudi Arabia.

METHODS

It is a 9-month antimicrobial drug used through inpatient wards at North West region hospitals which includes all adults, pediatrics and neonatal population. Five hospitals were included included of which hospital 1 has been establish in 1980 to serve 100 beds and its serves the maternities and pediatrics. Hospital 2 was hospital established in 1990, with the pharmacy care having many departments including, which they are inpatient, outpatient, narcotics, drug information center, clinics and emergency and serve 100 beds, also has most specialties (pediatrics, OR, ICU, ER, nursery, AKU, and SW). Hospital 3 build was built up in 1983, which is containing 100 beds, all also all specialties are available except chemotherapeutic department. The pharmacy have several departments, which they are inpatient, outpatient, narcotics and emergency pharmacy. Hospital 4 was started in 1991, the capacity of the hospital is 200 bed, which is the largest in the region and also it does contain verities of specialized and served 7 departments. The pharmacy care units containing five departments which are inpatient, outpatient, narcotics, information center, emergency and clinics department. Hospital 5 hospital was established in 2005, which is the newest although the pharmacy serves 100 beds with different departments, they are including inpatient inpatient, outpatient, information centers, narcotics, emergency and clinics, also cover 9 types of wards as the most hospitals in the region. Antibiotics committees were formulated at the above mentioned hospitals through a letter of recommendation which was sent by the General Administration of Pharmaceutical Care at the Ministry of Health for Tabuk Region on October 2013, which stipulates the importance of forming a specialized committee on antibiotics under the supervision and follow up of the department of pharmacy care in the region. Letters of formation of the Antibiotics Committee were sent to all hospitals in Tabuk region in January 2014. In March 2014, this committee was approved by the Director General of Health Affairs in Tabuk Region and guidance to start the application of antibiotics in all hospitals in the region. The actual implementation of the program began in January 2015. The objective of the antibiotic committees was to improve antimicrobial use for hospitalized adults and minimize the emergence and spread of antimicrobial resistance. The objective of the antibiotic committees was to improve antimicrobial use for hospitalized adult and minimizing the emergence and spread of antimicrobial resistance. While the functions of each committees were Supervising the assessment and application of antibiotic strategies in hospitals which are designed by the Antibiotics Committee of the Ministry. Preparation of quarterly reports on the implementation of strategies for the use of antibiotics in hospitals and discussed with the Committee of Pharmacy and therapeutics in the regions. Preparation of bacterial resistance statistics for antibiotics in the area and follow-up and updating. Supervising the training of medical staff (doctors, pharmacists, nurses, specialists, technicians) on the optimal use of antibiotics.

Visits to hospitals to ensure the accuracy and validity of the implementation of strategies. Review and analyze indicators of the application of strategies for the use of antibiotics and consider their development in the region of Tabuk. And writing the annual report on the performance, productivity and impact of the program in the region of Tabuk. The antibiotics medications were selected by Central Antibiotics committee at MOH as part of the National Antimicrobial stewardship program. The consumption is driven from pharmacy database and calculated based on off stranded unit of antimicrobial per hospital. The antimicrobials consisted of antibacterial drugs, antifungal and antiviral medications. The cost of antimicrobial consumption was calculated by using Ministry of Health National Cost database. All cost used was as US currency.

RESULTS

The total number of hospitals were five. Hospitals with (100-300 beds) represented 80 % while those with (50-99 beds) were 20 %. All hospitals (100 %) were accredited by Saudi Board of Hospital Accreditation (CBAHI) while none (0%) of the hospital was accredited by International Joint Commissions. The total response month's rate was 110 (81.48 %) that's included adults response rate 40 (88.88 %), pediatrics response rate 38 (84.44 %) and neonates response rate 32 (71.11 %) (Table 1). The total number of Antimicrobial standard units was (25,845) and average (5,169) per hospital. The highest units' consumption was adults inpatient wards 15,695 (60.73%) followed by pediatrics wards 7,408 (28.66%) and neonates wards 2,731 (10.57%). The highest drug consumption was Ceftriaxone 1 gm injection (3,712) followed by Ceftazidime 1 gm injection (1807) and Gentamicin IV 80 mg (1,011) at adult's inpatient wards. The highest drug consumption was Ceftriaxone 1 gm injection (4,268) followed by Azithromycin PO 200 mg/15 ml suspension (376) and Acyclovir IV 250 mg (257) at pediatrics' inpatient wards. The highest drug consumption was Ceftriaxone 1 gm injection (592) followed by Gentamicin IV 20 mg (429) and Vancomycin IV 500 mg (175) at neonates' inpatient wards. The total cost of Antimicrobial consumption was (6,829,003.42 USD) and (1,365,800.68 USD) per hospital. The highest cost medication consumption from Adults inpatient departments was 99.62% (6,803,229.92 USD) followed by pediatrics inpatient 0.24% (16,087.6 USD) and neonatal inpatient departments 0.14% (9,685.9 USD). The highest drug cost consumption was Ceftriaxone 1 gm injection (1,626,152.96 USD) followed by Meropenem IV 500mg injection (1,527,552.00 USD) and Imipenem + Cilastatin IV 500 mg (1,443,706.00 USD) at adult's inpatient wards. The highest drug cost consumption was Meropenem IV 1 g injection (3,813.81 USD) followed by Ceftriaxone IV 1 g (3,158.32 USD) and Imipenem + Cilastatin IV 500 mg (2,772.00 USD) at pediatrics' inpatient wards. The highest drug cost consumption was Meropenem IV 1 g (2,320.29 USD) followed by Meropenem IV 500 mg (2,121.60 USD) and Imipenem + Cilastatin IV 500 mg (1,507.00 USD) at neonates' inpatient wards. The highest medication cost was very broad-spectrum antibiotics like Meropenem, Imipenem and Ceftriaxone. It consumed more than 50% of the cost burden (Table 2).

DISCUSSION

The antibiotics stewardship program should be implemented at several departments including the intensive care services, ambulatory care clinics, emergency services and inpatient departments. Each service had particular requirements for antibiotics prescribing guidelines and infectious diseases management. Besides, the type of antibiotics with dosage forms is different from department to services. The necessary information of antibiotics consumption is essential to establish the antibiotics stewardship program at inpatient services. The study was conducted to explore the necessary information. It showed the high antibiotics consumption was adults followed by pediatrics and neonates. This is expected due to

Table 1: Hospitals demographic data.

	Hospital 1	Hospital 2	Hospital 3	Hospital 4	Hospital 5	Total
No of Beds						
<50						
50-99				YES		1 (20%)
100-300	YES	YES	YES		YES	4 (80%)
301-400						
401-500						
CIBAHI	Yes	Yes	Yes	Yes	Yes	5 (100%)
JCI	No	No	No	No	No	0 (0%)
Repose Rate						
ICU units						
Adults	9	9	4	0	9	31 (68.88 %)
Pediatrics	0	6	4	0	8	18 (40 %)
Neonates	2	4	4	0	9	19 (42.22 %)
Total	11	19	12	0	26	68 (50.37 %)
Inpatient wards						
Adults	9	9	4	9	9	40 (88.88 %)
Pediatrics	7	9	4	9	9	38 (84.44 %)
Neonates	3	9	4	9	7	32 (71.11 %)
Total	19	27	12	27	25	110 (81.48 %)
OPD clinics						
Adults	9	9	4	0	8	30 (66.66 %)
Pediatrics	6	8	4	1	7	26 (57.77 %)
Neonates	0	8	4	0	0	12 (26.66 %)
Total	15	25	12	1	15	68 (50.37 %)
ER units						
Adults	9	5	4	0	0	18 (40 %)
Pediatrics	0	9	4	9	0	22 (48.88 %)
Neonates	0	5	4	0	0	9 (20 %)
Total	9	19	12	9	0	49 (36.29 %)

different disease conditions with different quantity of doses. The most commonly used antibiotic was IV ceftriaxone for adult, pediatrics and neonatal patients that's similar to the previous study of third generation cephalosporin¹¹ and with Ceftriaxone usage in pediatrics,¹⁰ while it differed from other study of using Penicillin at first antibiotics consumption¹² or Fluoroquinolones or penicillin usage in the different study.¹³ The authors cannot clarify the justification of consumption because of missed diseases information. Besides, the common infectious diseases in adults or pediatrics and neonates admitted to the hospital. The very broad antibiotics like ceftazidime used in adult's patient maybe their gram-negative infection with *P. Aeruginosa*. Gentamicin is used much for adults and neonates as expected because the common diseases of pyelonephritis and neonatal septicemia and this drug is indicated for them. The costly medications are used for all types of patient's including adults, pediatrics and neonates. Few broad antibiotics consumed additional half of the budget like Meropenem, Imipenem and ceftriaxone. The utilization of expensive medications for inpatient services needs clarification and justification. That is different from the previous study that showed

Penicillin and Cephalosporin were high cost consumption¹² because not used expensive medications. Antibiotics stewardship program is very demanding for inpatient services of North West region hospitals in the Kingdom of Saudi Arabia.^{14,17}

CONCLUSION

The broad-spectrum antibiotics are highly used in the inpatient services at North West region in the Kingdom of Saudi Arabia. Targeting of implantation of Antibiotic stewardship program at inpatient services. Moreover, further studies about antibiotic utilization in such detail is required in the North West region of Saudi Arabia.

ACKNOWLEDGEMENT

None.

CONFLICT OF INTEREST

The authors declare no conflict of interest.


Table 2: Anti-infectious drugs consumption at inpatient general wards.

Quantity consumption Anti-infectious drugs	Dosage Forms	Neonates	cost (USD)	Pediatrics	cost (USD)	Adults	cost (USD)	Total Quantities	Total cost (USD)
Cloxacillin sodium IV 250mg	Vial or amp.	4	1.56	80	31.12	82	127.59	166	160.27
Flucloxacillin sodium IV 250mg	Vial or amp.	0	0.00	0	0.00	64	0.00	64	0.00
Piperacillin + Tazobactam IV 2.25 g	Vial	60	81.60	140	190.40	378	30,844.80	578	31,116.80
Piperacillin + Tazobactam IV 4.5 g	Vial	53	115.90	170	371.74	609	70,580.12	832	71,067.75
Ceftazidime IV 1g	Vial	134	100.06	206	153.82	1807	180,804.44	2147	181,058.32
Ceftriaxone IV 1g	Vial	592	438.08	4268	3158.32	3712	1,626,152.96	8572	1,629,749.36
Cefepime IV 1g	Vial	30	56.28	42	78.79	448	25,213.44	520	25,348.51
Cefepime IV 2g	Vial	119	412.54	168	582.41	393	162,127.16	680	163,122.10
Imipenem + Cilastatin IV 500mg+500mg	Vial	137	1,507.00	252	2772.00	958	1,443,706.00	1347	1,447,985.00
Meropenem IV 500mg	Vial	156	2,121.60	199	2706.40	720	1,527,552.00	1075	1,532,380.00
Meropenem IV 1g	Vial	87	2,320.29	143	3813.81	480	1,113,739.20	710	1,119,873.30
Tigecycline IV 50mg	Vial	0	0.00	0	0.00	10	500.00	10	500.00
Amikacin IV 100mg	Vial or amp.	51	16.52	77	24.95	110	1,817.64	238	1,859.11
Amikacin IV 500mg	Vial or amp.	70	31.50	130	58.50	696	21,924.00	896	22,014.00
Gentamicin IV 20mg	Vial or amp.	429	257.40	155	93.00	148	38,095.20	732	38,445.60
Gentamicin IV 80mg	Vial or amp.	120	72.00	127	76.20	1011	72,792.00	1258	72,940.20
Azithromycin PO 250mg	Tablet	0	0.00	130	9.36	797	0.00	927	9.36
Azithromycin PO 200mg/15ml	Suspension	94	89.29	376	357.16	0	0.00	470	446.45
Clindamycin IV 300mg	Ampoule	70	121.31	129	223.56	547	66,356.57	746	66,701.44
Vancomycin IV 500mg	Vial	175	236.25	237	319.95	666	157,342.50	1078	157,898.70
Linezolid PO 600mg	Tablet	0	0.00	0	0.00	60	0.00	60	0.00
Linezolid IV 600mg	Premixed bag	0	0.00	0	0.00	0	0.00	0	0.00
Linezolid PO 100mg	Suspension	0	0.00	0	0.00	0	0.00	0	0.00
Rifabutine PO 150mg	Tablet	0	0.00	0	0.00	246	0.00	246	0.00
Ciprofloxacin IV 200mg	Bottle	52	38.43	85	62.82	625	24,017.50	762	24,118.74
Moxifloxacin IV 400mg	Vial	5	167.50	17	569.50	120	20,100.00	142	20,837.00
Moxifloxacin PO 400mg	Tablet	0	0.00	20	22.60	302	0.00	322	22.60
Levofloxacin IV 500mg	Premixed bag	160	1,280.00	0	0.00	60	76,800.00	220	78,080.00
Amphotericin B liposomal 50mg	Vial	0	0.00	0	0.00	0	0.00	0	0.00
Amphotericin B 50mg	Vial	0	0.00	0	0.00	0	0.00	0	0.00
Voriconazole IV 200mg	Vial	0	0.00	0	0.00	0	0.00	0	0.00
Voriconazole PO 200mg	Tablet	0	0.00	0	0.00	0	0.00	0	0.00
Caspofungin IV 50mg	Vial	0	0.00	0	0.00	0	0.00	0	0.00
Micafungin IV 50 mg	Vial	0	0.00	0	0.00	0	0.00	0	0.00
Acyclovir IV 250mg	Vial	138	220.80	257	411.20	646	142,636.80	1041	143,268.80
Valaciclovir PO 500mg	Tablet	0	0.00	0	0.00	0	0.00	0	0.00
Artemisinin PO 250mg	Capsule	0	0.00	0	0.00	0	0.00	0	0.00
Artesunate PO 50mg	Tablet	0	0.00	0	0.00	0	0.00	0	0.00
Artesunate IV 60mg	Ampoule	0	0.00	0	0.00	0	0.00	0	0.00
Proguanil PO 100mg	Tablet	0	0.00	0	0.00	0	0.00	0	0.00
Artemether +Lumefantrine PO 20/120mg	Tablet	0	0.00	0	0.00	0	0.00	0	0.00
Artemether IV 20mg	Ampoule	0	0.00	6	0.00	0	0.00	6	0.00
		2,731	9,685.90	7,408	16,087.60	15,695	6,803,229.92	25,845	6,829,003.42

ABBREVIATIONS

AMR: Antimicrobial resistance; **AMS:** National antimicrobial stewardship program; **KSA:** Kingdom of Saudi Arabia; **MOH:** Ministry of Health; **OR:** Operation; **ICU:** Intensive Care Unit; **AKU:** Artificial Kidney Unit; **SW:** Surgical Wards; **UDS:** United State Dollars.

ORCID ID

Yousef Ahmed Alomi  <https://orcid.org/0000-0003-1381-628X>

REFERENCES

- Gould K. Antibiotics: From prehistory to the present day. *J Antimicrob Chemother.* 2016;71(3):572-5.
- AlYousef SA. Surveillance of antibiotic-resistant bacteria in King Khalid hospital, Hafr Al-Batin, Saudi Arabia, during 2013. *Jundishapur J Microbiol.* 2016;9(9):e19552.
- Lakshmana GK, Marie MAM, Al-Sheikh YA, John J, Gopalkrishnan S, Chikkabidare SP, *et al.* A 6-year surveillance of antimicrobial resistance patterns of *Acinetobacter baumannii* bacteremia isolates from a tertiary care hospital in Saudi Arabia during 2005-2010. *Libyan J Med.* 2014;9:24039.
- Aly M, Balkhy HH. The prevalence of antimicrobial resistance in clinical isolates from Gulf Cooperation Council countries. *Antimicrob Resist Infect Control.* 2012;1(25):1-5.
- European Centre for Disease Prevention and Control. Antimicrobial consumption 2016. Annual epidemiological report for 2016. 2018. Available from: https://ecdc.europa.eu/sites/portal/files/documents/AER_for_2016-AMC.pdf.
- European Centre for Disease Prevention and Control. Antimicrobial consumption 2015. Annual epidemiological report for 2015. 2018. Available from: https://ecdc.europa.eu/sites/portal/files/documents/AER_for_2015-HIV-AIDS.pdf.
- Al-Tawfiq JA. Changes in the pattern of hospital intravenous antimicrobial use in Saudi Arabia, 2006-2008. *Ann Saudi Med.* 2012;32(5):517-20.
- Soleymanzadeh-Moghadam S, Azimi L, Amani L, Rastegar LA, Alinejad F, Rastegar Lari A. Analysis of antibiotic consumption in burn patients. *GMS Hyg Infect Control.* 2015;10:Doc09.
- AlShimemeri A, AlGhadeer H, Memish Z. Antibiotic utilization pattern in a general medical ward of a tertiary medical center in Saudi Arabia. *Avicenna J Med.* 2011;1(1):8-11.
- Salehifar E, Nasehi M, Eslami G, Sahraei S, Navaei RA. Determination of antibiotics consumption in buali-sina pediatric hospital, sari 2010-2011. *Iran J Pharm Res.* 2014;13(3):995-1002.
- Hanberger H, Skoog G, Ternhag A, Giske CG. Antibiotic consumption and antibiotic stewardship in Swedish hospitals. *Ups J Med Sci.* 2014;119(2):154-61.
- Al-Jumaili AA, Hussein AH, Al-Rekabi MD, Raheem SA, Ernst EJ. Antimicrobial utilization in an Iraqi province: A comprehensive evaluation of antibiotic source and cost. *Int J Pharm Pract.* 2017;25(1):81-8.
- Bozkurt F, Kaya S, Tekin R, Gulsun S, Deveci O, Dayan S, *et al.* Analysis of antimicrobial consumption and cost in a teaching hospital. *J Infect Public Health.* 2014;7(2):161-9.
- Momattin H, Al-Ali AY, Mohammed K, Al-Tawfiq JA. Benchmarking of antibiotic usage: An adjustment to reflect antibiotic stewardship program outcome in a hospital in Saudi Arabia. *J Infect Public Health.* 2018;11(3):310-3.
- Lee CF, Cowling BJ, Feng S, Aso H, Wu P, Fukuda K, *et al.* Impact of antibiotic stewardship programmes in Asia: A systematic review and meta-analysis. *J Antimicrob Chemother.* 2018;73(4):844-51.
- Boyles TH, Whitelaw A, Bamford C, Moodley M, Bonorchis K, Morris V, *et al.* Antibiotic stewardship ward rounds and a dedicated prescription chart reduce antibiotic consumption and pharmacy costs without affecting inpatient mortality or re-admission rates. *PLoS One.* 2013;8(12):1-7.
- Enani MA. The antimicrobial stewardship program in Gulf Cooperation Council (GCC) states: Insights from a regional survey. *J Infect Prev.* 2016;17(1):16-20.