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ORIGINAL ARTICLE

Status of Antimicrobial Stewardship Implementation in Selected Egyptian Hospitals: A Cross-sectional Study

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ABSTRACT

Background: *Antimicrobial stewardship aims to stop or slow the emergence of antimicrobial-resistant strains. Following the launch of Egypt's National Action Plan on Antimicrobial Resistance, numerous hospitals took steps to adopt ASP, but no formal assessments were conducted.* ***Objectives:*** *The goal of this study is to determine the extent to which ASP is used, as well as stewardship understanding and implementation, in several Egyptian hospitals.* ***Methodology:*** *A cross-sectional study was carried out to measure stewardship knowledge and execution, from June to July 2020, in various Egyptian hospitals. The hospital description, ASP committee, ASP activities, reporting antibiotic use, antibiogram, information technology support, ASP restriction techniques, and future ASP application were all covered in the survey.* ***Results:*** *The study covered a variety of hospitals, the majority of which (61.8%) adopted an ASP program while others (38.2%) did not; at the time of the study, 71.4 % of the latter were planning to implement an ASP program in the future. Twenty-two institutions (48.5 %) said they routinely use facility-specific antibiograms. Antimicrobial reports were received on a regular basis by thirteen hospitals (37.1%). Fifteen hospitals (42.9%) said they were already using one or more computer applications. Resistance trends, infection rates, duration of stay, mortality rate, and reported adverse drug reactions were all monitored at the hospitals. Only 20% of the hospitals in this study had an ASP training program.* ***Conclusion****: Egyptian hospitals have a good ASP implementation; however, IT support programs, cooperation between healthcare members, monitoring outcomes, and infectious disease consultations are still needed.*

INTRODUCTION

Over the past few decades, the global antimicrobial resistance (AMR) rates have greatly increased. An estimated 700,000 deaths was reported globally on 2014 due to antibiotic-resistant bacterial infections [1]. The rate of AMR in Eastern Mediterranean and Middle East countries has dramatically increased in both hospital- and community-acquired infections. This increase endangers the hard-won achievements in health care and the sustainable antimicrobials utilization in many communicable disease such as tuberculosis, hospital acquired infections, AIDS, and pneumonia [2].

There is a strong reported correlation between the use of antibiotics and the rate of multi-drug resistant bacteria isolation. This has been attributed to the selective pressure misuse of antibiotics that increases the selection of the drug resistant bacteria because of the increase in antibiotic exposure [3-6].

Several studies have found that individualized programs aimed at changing antibiotic use can minimize antibiotic resistance, toxicity, and treatment costs.[7, 8]. Antimicrobial stewardship (ASP) attempts to prevent or delay the formation of antimicrobial-resistant strains while also improving medication selection, dose, and duration. ASP objectives also include improving every patient's safety profile, reducing morbidity, mortality, and length of stay in the hospital, and lowering total expenditures[9-11].

These objectives can be met by forming a work group tasked with enhancing and reducing the use of antimicrobial agents at the patient level, such as by reducing the amount and improving the quality of antibiotic prescriptions across all hospitals. Despite the challenges of quantifying ASP's impact on patients and overall antimicrobial resistance, there is substantial evidence that ASP can achieve the aforementioned objectives[10,12]. In light of this, the World Health Organization (WHO) is urging governments to implement antimicrobial stewardship programs with the aim of containing AMR[13]. The Egyptian government launched its National Action Plan on Antibiotic Resistance in 2018 in response to the growing issue of antimicrobial resistance[14].

The aim of this study was to assess the extent of ASP application in different Egyptian hospitals and to highlight weaknesses that need to be addressed to achieve a more rational use of antibiotics and better stewardship applications. The survey aimed to map the difference between stewardship programs and antimicrobial utilization guidelines and actual practice in Egyptian hospitals.

METHODOLOGY

In Egypt, a cross-sectional study was carried out to examine stewardship knowledge and implementation in a number of hospitals. The assessment was conducted through a survey developed by the research team, which comprised experts in the field of infectious disease and stewardship training and clinical pharmacy specialists.

Survey development:

The survey contained eight core elements and 30 items.

The hospital description, ASP committee and activities (including training, restriction techniques, and outcome evaluation), antibiotic usage reporting, antibiogram, IT assistance, ASP restriction methods, and ASP future application were all included in the key parts.

The survey was developed with the assistance of previous comparable studies[15-19]. Survey development was carried out by two of the authors from a clinical and microbiological background and reviewed by a clinical practice expert specialized in ASP application in Egyptian Hospitals to adapt the survey to antimicrobial practice in Egypt.

Local regulations allow surveys to be conducted if they are anonymous.

Setting and participants:

The sampling strategy applied was convenience sampling. The hospitals were carefully chosen to include different types of hospitals (general and specialized hospitals), different types of ownership (governmental or private and teaching or non-teaching), and different sizes (bed capacities).

Healthcare providers were invited to voluntarily contribute to this study. Data were assembled from physicians and pharmacists in the selected hospitals. Answers not delivered within one week were followed up with telephone reminders. No personal information was recorded. As per regulations, hospital data were collected anonymously to assure confidentiality. The study was conducted from June to July 2020.

The study was approved by the Ethical Committee of the Faculty of Pharmacy, Pharos University in Alexandria, Egypt.

RESULTS

A total of 35 healthcare facilities took part in the survey; of these, 20 (57.1%) hospitals were located in Alexandria, 3 (8.7%) in Cairo, 6 (17.1%) in the Delta region, and 6 (17.1%) in upper Egypt.

The surveys were filled out by different health care team members; only one member from each hospital responded to our questionnaire. The respondents included clinical pharmacists (57%), physicians (11.4%), infection control specialists (8.6%), and other members of the medical staff. The respondents had different responsibilities related to ASP policy application, including developing and reviewing antibiotic policies (57.1%), antibiotic prescription and infectious disease teaching (25.7%), administration (17.1%), and other.

The hospital specialties varied as follows: 18 (51.4%) were general community hospitals while 17 (48.6%) were specialized hospitals. Of the latter, 3 (8.6%) were acute care hospitals.

Hospital ownership was divided as follows: 18 (51.4%) were teaching hospitals, 12 (34.3%) were non-teaching governmental hospitals, and 5 (14.3%) were non-teaching private hospitals (Table 1).

Table 1. Hospital description

Location	
Alexandria	20 (57.1%)
Cairo	3 (8.7%)
Delta region	6 (17.1%)
Upper Egypt	6 (17.1%)
Hospital type	
General	18 (51.4%)
Specialized	17 (48.6%)
Acute care	3 (8.6%)
Hospital ownership	
Teaching hospital	18 (51.4%)
Governmental	12 (34.3%)
Private	5 (14.3%)
Hospital capacity	
Large (more than 300 beds)	14 (40%)
Medium (100-300 beds)	10 (28.6%)
Small (less than 100 beds)	11 (31.4%)

In terms of capacity, 14 (40%) were large hospitals with more than 300 beds, 10 (28.6%) were medium-sized hospitals with more than 100 beds, and 11 (31.4%) were small hospitals with less than 100 beds available.

Regarding ASP program implementation, 21 (61.8%) hospitals reported having a current ASP program, while 14 (38.2%) reported not having one. Among those 14 hospitals that did not have an ASP program, 10 (71.4%) reported planning for future ASP application (Table 2).

Table 2. ASP status, ASP team components & practice

ASP application	
Yes	21 (61.8%)
No	14 (38.2%)
Future ASM application among hospitals with no ASP programme	
Yes	10 (71.4%)
No	4 (28.6%)
ASP team	
Critical care physician	47.6%
Physician	33.3%
Clinical pharmacist	81%
Hospital pharmacist	33.3%
Hospital director	61.9%
Department head	47.6%
Clinical microbiologist	52.4%
Infectious disease specialist	47.6%
Nurse	38.1%
Hospital antibiogram availability & reporting intervals	
Every year	6 (17.1%)
Every 6 months	11 (31.4%)
No	18 (51.4%)
Antimicrobial susceptibility testing	
Yes	23 (65.7%)
No	12 (34.3%)
Antibiotics use Reports availability and intervals	
Monthly	6 (17.1%)
Every 3 months	1 (2.9%)
Every 6 months	1 (2.9%)
Every year	1 (2.9%)
Upon appointed	4 (11.3%)
Never	22 (62.9%)
Antimicrobial resistance monitoring	
Antimicrobial resistance patterns	45.7%
Infection rates	31.4%
Patient outcomes	28.6%
Adverse drug reactions	20%
No monitoring for the outcomes	25.7%

Of the 21 hospitals that had an active ASP program, 20 (95.2%) reported the presence of an ASP team. The team components and members varied among the hospitals: 81% of the hospitals had a clinical pharmacist on staff, 61.9% included a hospital director, 52.4% included a clinical microbiologist, 47.6% included a head of department, a critical care physician, and an infectious disease specialist, 38.1% included a nurse, and 33.3% reported a physician/hospital pharmacist. All hospitals with ASP teams reported the availability of infectious disease (ID) consultation: 33.3% hospitals reported that clinical consultation was available via a formal request, 28.6% reported having ID consultants available at all times on all wards, 4.8% had daily auditing in critical care units and consultation in wards, and 4.8% had consultation available three days per week. Moreover, in 23.8% of the cases, consultation was performed on a face-to-face basis, while in 4.8% of the cases, consultation was done over the phone.

Of the 35 hospitals that were a part of this research, 22 (48.5%) reported having an antibiogram unique to their hospital on a regular basis. Among these hospitals, 11 (31.4%) had hospital antibiogram reports updated every six months while 6 (17.1%) updated them every year. Meanwhile, 18 hospitals (51.5%) reported receiving no facility-specific antimicrobial data.

Twenty-three hospitals (65.7%) reported that their labs provided antimicrobial susceptibility data in addition to recognizing species in culture results, while 12 hospitals did not report performing such test.

In terms of monitoring AMR, several parameters were assessed in the hospitals. Among the surveyed hospitals applying ASP, 45.7% monitored AMR patterns as a total resistance indicator, 31.4% monitored infection rates, 28.6% reported patient treatment outcomes such as mortality rate and length of stay, 20% reported monitoring unfavourable drug effects, and 25.7% did not take any measures to monitor antibiotic resistance.

Regular reporting of antibiotic usage and resistance to physicians, nurses, and other relevant employees should be a part of ASP programs. Thirteen (37.1%) of the hospitals in our research stated that they receive antimicrobial reports on a regular basis, while 22 hospitals (62.9%) did not issue such reports at all. The interval for reporting activities varied among the hospitals, between monthly (46.2%) every 3 months (1.7%), 6 months (1.7%), 12 months (1.7%), or after being appointed (30.8%). The reporting behavior also differed between reporting to a committee (78.9%) or directly to a health care personnel (23.1%) (Table 3).

Table 3. Support & other activities related to ASP

IT support	
Present	15(42.9%)
Absent	20(57.1%)
Programmes available for ASP	
Clinical decision support for antimicrobial prescription/dosing	60%
Electronic medical records (EMRs)	26.6%
Computerized physician order entry (CPOE)	13.3%
Computer-assisted monitoring of antimicrobial prescriptions	13.3%
Hospital specific Computer-based surveillance	6.7%
ASP training availability	
Yes	7 (20%)
No	28 (80%)
Training Methods	
Written guidelines	33.3%
Rounds for students and hospital staff	33.3%
Conferences	33.3%

Regarding IT support, 20 hospitals (57.1%) in the study had no support from an IT department regarding ASP application, while 15 (42.9 %) said they were already using one or more computer programs in their hospitals.

Among the 15 hospitals that reported available IT support, Clinical Decision Support System for antimicrobial prescription/dosing was the most reported program used (60%), followed by Electronic Medical Records (EMRs) (26.6%), Computerized Physician Order Entry (CPOE) (13.3%), computer-assisted monitoring of antimicrobial prescriptions (13.3%), and hospital specific computer-based surveillance (6.7%).

Successful ASP application requires good staff training; however, according to the data, only 20% of the hospitals in this study had an ASP training program. In these hospitals, one or more techniques were used for ASP staff education and training, including written guidelines, rounds for hospital staff, and conferences.

Some of the obstacles to ASP application that the hospitals reported were insufficient cooperation from physicians/prescribers (20%) and insufficient support from the hospital administration (22.9%). Despite the AMR crisis in Egypt, many hospitals did not see the importance a formally organized program (31.4%). For the most part, the surveyed hospitals did not allocate enough funds to program application (23%). Moreover, the absence of IT support represented a main obstacle for ASP application (31.4%).

DISCUSSION

The goal of this research was to find out the extent to which ASP was used in various Egyptian hospitals. The study covered a diverse set of topics related to hospital descriptions; all the surveyed hospitals provided either general or specialized care, and 8.6% provided acute care services. Hospital ownership was either teaching, governmental, or private. There were also no restrictions regarding hospital size (large, medium, and small) inclusion in this research.

From the hospitals surveyed 61.8% used an ASP program, while 38.2% did not; 71.4% of the latter are planning to use antimicrobial stewardship in the future. The results among the Egyptian hospitals were similar to those reported in US hospitals, which demonstrated a widespread use of stewardship strategies [15]. Nhan *et al.*[19] reported in a survey that more than 80% of responding US hospitals had an ASP program. According to the research by Zhou and Ma,[20] China likewise had a successful implementation of ASP initiatives.

It has been suggested that having a dedicated ASP team is a vital aspect in having a successful ASP program, 61.8% of the hospitals examined have an active ASP program, out of which 95.2% had a designated ASP team. The ASP team consists of clinical or hospital pharmacists, the hospital director, clinical microbiologists, head of departments, critical care physicians, IT specialists, nurses, and physicians. Allenback *et al.*[15] stated that an ID physician and a clinical pharmacist with ID experience should be part of a multidisciplinary team, as well as a clinical microbiologist with training, an IT specialist, an infection control professional, and a hospital epidemiologist. Kallen *et al.*[17] stated that the team should include a hospital pharmacist and a clinical microbiologist, as well as an infectious disease specialist, and an IT specialist.

On a regular basis, the hospital antibiogram summarizes the antimicrobial susceptibilities of local bacterial isolates submitted to the hospital's clinical microbiology laboratory. Antibiograms are commonly used by clinicians to determine local susceptibility rates, assist in empiric antibiotic treatment selection, and track resistance trends over time within an institution [21].

In our research, 51.4% hospitals did not perform an antibiogram, 17.1% reported an updated antibiogram every year, and 31.4% issued an antibiogram on a six-month interval basis. Baubie *et al.*[22] also reported updating hospital antibiograms annually by hospital microbiologists and clinical pharmacists.

Although more than half of surveyed hospitals did not have an official antibiogram, 65.7% reported performing antimicrobial susceptibility testing. Mushtaque *et al.* [23] reported that 36% of hospitals produced a cumulative antibiotic susceptibility report based on national guidelines and local susceptibility patterns. They also mentioned that 68% of hospitals optimized doses according to pharmacokinetics/ pharmacodynamics principles in the treatment of organisms with reduced susceptibility.

Microbial culture is an essential component of the diagnostic process and ASP program, in that it offers useful data on isolates' susceptibility profiles to guide antibiotic selection. AMR monitoring is critical for a good ASP program, but only 25.7% of those polled said they do it. Hospitals took no precautions to detect resistance. In terms of monitoring efforts, 45.7% of the hospitals surveyed monitored AMR, 31.4% monitored infection rates, and 28.6% monitored infection rates. 20% followed up on patient outcomes such as length of stay and mortality rate. Our research was in concordance with another study that recommended monitoring the reduction in resistance and infection rates; however, this study also reported that applying an ASP program would lower the cost and included specific calculations[15]. Another study performed on hospitals in Karachi, Pakistan, recommended several measures like switching from IV to oral route, dose adjustments in organ dysfunction, and dose optimization based on pharmacokinetics/pharmacodynamics data in the treatment of resistant organisms[23]. Furthermore, a practical toolkit issued by WHO for antimicrobial stewardship in low- and middle-income countries included many items in the monitoring and surveillance section. Monitoring the appropriateness of antibiotic usage at the facility, the dose and type of antibiotic, antibiotic susceptibility, resistance rates, and committee compliance to treatments were among the most critical items [24].

In the present study, ID consultations were available in all surveyed hospitals with ASP programs, either through formal request for clinical consultation, daily, daily auditing, or three times a week. Face-to-face consultations were performed more often than phone consultations. In a study on two teaching hospitals, in Nice, France, and Dundee, Scotland, the French hospital reported that face-to-face or phone consultation were available at all times and on all wards. Meanwhile, the Scottish hospital reported that ID consultations were mostly available through request and that some consultations were done over the phone, but only during working hours [18].

For the successful implementation of an ASP program, regular reporting is mandatory. Antibiotic use and resistance were reported in only 37.1% of the surveyed hospitals. The interval for reporting was monthly in almost half the studied hospitals and mostly through either pharmacy and therapeutics or an ID committee. These results disagreed with a study of 116 tertiary hospitals in China, of which 98.3% provided reports on susceptibility data; these reports were updated every three months in 70% of the surveyed hospitals, every six months in 12%, and once a year in 9% [20].

ASP requires a large amount of timely information. The advancements in IT support are improving antibiotic use and thus patient care by enabling efficient, up-to-date reviews and the effective prioritization of patients receiving antibiotics. Computer-based surveillance and IT supports are best prescribed to facilitate an ASP program. In our study, 57.1% of the hospital did not have IT support, perhaps be due to the lack of computerized systems in government hospitals. EMRs, CPOE, computer-assisted monitoring of antimicrobial prescriptions, clinical decision support system and hospital surveillance were among the IT activities performed. In agreement with our study, Baubie *et al.*[22] found that electronic medical recordkeeping is a useful tool in an ASP program.

Unfortunately, in the current study, 80% of the hospitals did not receive any formal training, instead relying on information from newsletters/written instructions, grand rounds for students/house staff, and conference presentations. In a survey of 101 hospitals in the United States, 80 % said they had received training and education[19].

Finally, this survey uncovered several barriers to ASP implementation, including inadequate staff training, insufficient cooperation from physicians/prescribers, insufficient support from the hospital administration, lack of funds for program application, and lack of IT support. The findings of this study are in accordance with those of Allenback *et al.*[15] who stated that the most important barriers to ASP implementation were staffing constraints, inadequate administration and prescriber support, inadequate IT support, lack of funding, and not having volunteers to lead, and ASP not being considered a clinical priority.

CONCLUSION

Most of the hospitals included in our survey reported having a current ASP or planning for future application. ASP should be managed by a specific team trained and updated by recent guidelines. The presence of an ASP in and of itself is important, but the ASP activities performed are the most crucial, including restriction methods and outcome measurements. These should be performed in light of reporting antibiotic use and issuing antibiogram on a routine base. IT support is also helpful to ensure an organized program, it and should be established in healthcare institutions.

Moreover, ASP application requires cooperation from all the members of the healthcare team. The continuity of these stewardship activities, including monitoring outcomes and daily ID consultations, could be a turning point in maintaining a successful antimicrobial resistance-free healthcare setting.

Impact Statements:

- This cross-sectional study assesses the current stewardship application in some hospitals in Egypt.
- Most of the hospitals included in our study reported having a current ASP or planning for future application. Hospital labs provided antimicrobial

susceptibility data in addition to identifying species in culture results.

- Activities included training, restriction methods, and outcome measurement. Reporting antibiotic use and issuing antibiogram on a routine basis are activities that still need improvement.
- This study highlights the barriers to implementing ASP programs in order to achieve the rational use of antibiotics and better stewardship applications.
- Improvements need to include IT support programs, healthcare members cooperation, monitoring outcomes, and ID consultations.

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Authors' Contributions:

All authors participated equally in designing the study, performing the research, and preparing the article.

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REFERENCES

1. O'Neill J. Tackling drug resistance infections globally: final report and recommendations: the review on antimicrobial resistance 2016. Government of the United Kingdom, London, United Kingdom
2. Hajjeh R, Mafi A. The growing threat of antibiotic resistance in the Eastern Mediterranean Region–what does it take to control it? EMHJ-Eastern Mediterranean Health Journal. 2016;22(9):701-2.
3. Williams RJ, Heymann DL. Containment of antibiotic resistance. American Association for the Advancement of Science. 1998;279(5354):1153-4.
4. Cao J, Song W, Gu B, Mei Yn, Tang Jp, Meng L, *et al*. Correlation Between Carbapenem Consumption and Antimicrobial Resistance Rates of Acinetobacter baumannii in a University-Affiliated Hospital in China. The Journal of Clinical Pharmacology. 2013;53(1):96-102.
5. Lai C-C, Wang C-Y, Chu C-C, Tan C-K, Lu C-L, Lee Y-C, *et al*. Correlation between antibiotic consumption and resistance of Gram-negative bacteria causing healthcare-associated infections at a university hospital in Taiwan from 2000 to 2009. Journal of antimicrobial chemotherapy. 2011;66(6):1374-82.
6. Muraki Y, Kitamura M, Maeda Y, Kitahara T, Mori T, Ikeue H, *et al*. Nationwide surveillance of antimicrobial consumption and resistance to Pseudomonas aeruginosa isolates at 203 Japanese hospitals in 2010. Infection. 2013;41(2):415-23.
7. Davey P, Brown E, Charani E, Fenelon L, Gould IM, Holmes A, *et al*. Interventions to improve antibiotic prescribing practices for hospital inpatients. Cochrane Database of Systematic Reviews. 2013(4).
8. Malani AN, Richards PG, Kapila S, Otto MH, Czerwinski J, Singal B. Clinical and economic outcomes from a community hospital's antimicrobial stewardship program. American journal of infection control. 2013;41(2):145-8.
9. MacDougall C, Polk RE. Antimicrobial stewardship programs in health care systems. Clinical microbiology reviews. 2005;18(4):638-56.
10. Ohl CA, Luther VP. Antimicrobial stewardship for inpatient facilities. Journal of hospital medicine. 2011;6(S1):S4-S15.
11. Pope SD, Dellit TH, Owens RC, Hooton TM. Results of survey on implementation of Infectious Diseases Society of America and Society for Healthcare Epidemiology of America guidelines for developing an institutional program to enhance antimicrobial stewardship. Infection Control & Hospital Epidemiology. 2009;30(1):97-8.
12. Rybak MJ, Lomaestro BM, Rotscahfer JC, Moellering Jr RC, Craig WA, Billeter M, *et al*. Vancomycin therapeutic guidelines: a summary of consensus recommendations from the infectious diseases Society of America, the American Society of Health-System Pharmacists, and the Society of Infectious Diseases Pharmacists. Clinical infectious diseases. 2009;49(3):325-7.
13. Doron S, Davidson LE, editors. Antimicrobial stewardship. Mayo Clinic Proceedings; 2011: Elsevier.
14. World Health Organization. WHO country cooperation strategy at a glance: Egypt. 2018.
15. Allenback GL. A Survey of Antimicrobial Stewardship Practices in the Western United States: Successes and Challenges. 2014.

16. Charani E, Castro-Sanchéz E, Bradley S, Nathwani D, Holmes AH, Davey P. Implementation of antibiotic stewardship in different settings-results of an international survey. Antimicrobial Resistance & Infection Control. 2019;8(1):34.
17. Kallen M, Ten Oever J, Prins J, Kullberg B, Schouten J, Hulscher M. A survey on antimicrobial stewardship prerequisites, objectives and improvement strategies: systematic development and nationwide assessment in Dutch acute care hospitals. Journal of Antimicrobial Chemotherapy. 2018;73(12):3496-504.
18. Pulcini C, Williams F, Molinari N, Davey P, Nathwani D. Junior doctors' knowledge and perceptions of antibiotic resistance and prescribing: a survey in France and Scotland. Clinical microbiology and infection. 2011;17(1):80-7.
19. Nhan D, Lentz EJ, Steinberg M, Bell CM, Morris AM, editors. Structure of antimicrobial stewardship programs in leading US hospitals: findings of a nationwide survey. Open Forum Infectious Diseases; 2019: Oxford University Press US.
20. Zhou J MX. A survey on antimicrobial stewardship in 116 tertiary hospitals in China. Clinical Microbiology and Infection. 2019;25(6):759-e9.
21. Joshi S. Hospital antibiogram: a necessity. Indian journal of medical microbiology. 2010;28(4):277.
22. Baubie K, Shaughnessy C, Kostiuk L, Joseph MV, Safdar N, Singh SK, *et al*. Evaluating antibiotic stewardship in a tertiary care hospital in Kerala, India: a qualitative interview study. BMJ open. 2019;9(5):e026193.
23. Mushtaque M, Khalid F, Ishaqui AA, Masood R, Maqsood MB, Muhammad IN. Hospital Antibiotic Stewardship Programs-Qualitative analysis of numerous hospitals in a developing country. Infection Prevention in Practice. 2019;1(3-4):100025.
24. World Health Organization. Antimicrobial stewardship programmes in health-care facilities in low-and middle-income countries. A WHO practical toolkit,. Geneva: World Health Organization,2019. Report No.: 9241515481.