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Evaluation of Antimicrobial Stewardship Programs (ASPs) and their perceived level of success at Makkah region hospitals, Kingdom of Saudi Arabia



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ABSTRACT

Antimicrobial stewardship programs (ASPs) are collaborative efforts to optimize antimicrobial use in healthcare institutions through evidence-based quality improvement strategies. The general administration of pharmaceutical care in the Saudi ministry of health (MOH) is putting outstanding efforts in implementing antimicrobial stewardship in Saudi health care settings. Several surveys have been conducted globally and reported many types of antimicrobial stewardship strategies in health institutions and their effectiveness. This study aims to identify ASPs in Makkah region hospitals and their perceived level of success. We administered a regional survey to explore current progress and issues related to the implementation of ASPs in Makkah region hospitals at the pharmacy level (n = 25). Among responding hospitals, 19 (76%) hospitals, the most commonly reported ASP were as following: formulary restrictions (90%) for broad-spectrum antimicrobials and use of prospective feedback on antimicrobial prescribing (68%), use of clinical guidelines and pathways (100%), and use of automatic stop orders (68%) to limit inappropriate antimicrobial therapy. The study outcomes will also be of pivotal importance to devise policies and strategies for antimicrobial stewardship implementation in other non-MOH settings in the Makkah region. Based on our results, all reported institutions have at least one antimicrobial stewardship program in a process with a high success rate. A multidisciplinary ASP approach, active involvement of drug & therapeutic committee, formulary restrictions, and availability of education & training of pharmacists and physicians on ASP are the primary elements for perceived successful antimicrobial stewardship programs in the Makkah region hospitals.

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1. Introduction

Antimicrobial resistance is a global threat to healthcare and one of the leading causes of morbidity and mortality as well as increased medical cost. This concern about resistance has also been raised by the WHO in its guidelines on core components of infection prevention and control programs. The main reason for resistance is excessive and irrational antimicrobial use at hospitals and at the community level. (Smith and Coast, 2002; Dean et al., 2002; Ho and Melvani, 2007; Storr et al., 2017; O'Neill, 2014). Inappropriate use of antibiotics is also common in settings in the KSA and strengthens this concern at the global level (Belkina et al., 2014; Al-Ghamdi et al., 2002).

Leading organizations and experts have recommended antimicrobial stewardship as an evidenced-based solution to control excessive antimicrobial use in medical institutions (Dellit et al., 2007; Goff et al., 2012; Barlam et al., 2016; Knobler et al., 2003). The main impact of ASPs is to restrict the overuse of antimicrobials and to improve patient care by promoting rational antimicrobial use in an institution and preventing antibiotic-related adverse effects, e.g., *Clostridioides difficile* infections. There are two core antimicrobial stewardship strategies: formulary restrictions and prospective auditing and feedback. In addition to these strategies, there are supplemental programs to augment single core strategies (Owens et al., 2004; MacDougall and Polk, 2005).

Globally, several studies highlight established ASPs and their components. Howard et al. conducted a worldwide survey to report global efforts in ASPs in healthcare institutions. The authors reported that up to 58% of hospitals had ASPs, and the major barriers were the lack of sufficient funds and personnel as well as physician disagreement. Formulary restriction (81%) and prospective auditing and feedback (64%) were the most common ASP strategies worldwide (Howard et al., 2015). Similarly, a national survey by Doron et al. in the United States reported that regardless of the proper implementation of ASP strategies in hospitals, 96.4% of the hospitals used some antimicrobial stewardship techniques. The authors also reported the same barrier as previously reported: a lack of funds and personnel to implement successful ASP in the hospital (Doron et al., 2013). Sunenshine et al. indicated that 50% of the ID consultants surveyed reported practices in their hospitals that required approval by or consultation with an ID physician (Sunenshine et al., 2004). In Italy, in a national survey of 448 hospitals, 89.9% of respondents reported having formulary control but only 28% used a combination of formulary control, pharmacy committee, written justification for use and routine analysis of antimicrobial data (Moro et al., 2003).

A multidisciplinary stewardship committee is an important organizational component of an appropriate ASP. In Kansas, United States, Poteete et al. revealed in a state-wide survey that 48% of the institutions had a multidisciplinary stewardship committee to supervise stewardship programs (Poteete and Scaletta, 2017). In Australia, Chen et al. reported that 80 pharmacy directors had a variety of ASP strategies with different levels of success to guide rational antimicrobial use in healthcare settings (Chen et al., 2010a). The most common ASP strategies were the existence of a multidisciplinary drug and therapeutic committee, formulary restriction, clinical pharmacy services, infectious disease consultation and education- and training-related activities.

In the KSA, antimicrobial stewardship is in the initial phases and requires attention to promote rational antibiotic use in the region. A regional survey at Gulf Cooperation Council states (GCC) conducted by Enani et al. on the current status of ASP in GCC states countries reported Prospective audit & feedback, formulary restrictions, and antimicrobial prescribing guidelines as three common successful ASP strategies in most of the states. Eighty-one percent of the respondents in this survey were from Saudi Arabia

(Enani, 2016). A recent study in the Eastern province of Saudi Arabia on ASP in region hospitals revealed that the majority of clinicians were aware of ASP components and reported lack of role of administration and lack of funds and training in antimicrobial stewardship in institutions. (Baraka et al., 2019). In another qualitative study by Alghamdi et al. conducted in three hospitals in Saudi Arabia reported lack of enforcement of antimicrobial prescribing policies and guidelines, physicians fear and concerns influence their acceptance of ASP interventions (Alghamdi et al., 2019).

To the best of our knowledge, there is no published information describing the proportion of healthcare institutions with ASP Makkah-wide. Recently, a study by Alomi described the antimicrobial stewardship initiatives and MOH plans for ASP implementation at the national level (Alomi, 2017). There have been few well-conducted studies in the KSA to record antimicrobial consumption and cost to date (Bozkurt et al., 2014) but not the level of ASP in hospitals and their success rate. Some studies performed in the Riyadh region of the KSA regarding the assessment of consumption of antibiotics highlight the importance of ASPs in the Kingdom (Mohajer et al., 2011; Al-Tawfiq, 2012). A study by Al-Tawfiq reported ciprofloxacin as the most prescribed intravenous agent in healthcare settings (Al-Tawfiq, 2012). There is a paucity of data on antimicrobial use in Makkah. Amer et al. highlighted the success of a prospective audit and feedback ASP strategy in an intensive care unit in a tertiary care hospital (Amer et al., 2013). Therefore, we have conducted this multi-centre cross-sectional survey to assess the current level of ASPs in Makkah region hospitals and their perceived level of success rate.

2. Methods

2.1. Study design & settings

It was a multicenter cross sectional survey with focus on one response from each representative hospital. Firstly, a web based survey adopted from Chen et al. (2010a) was distributed in all Makkah hospitals and selected hospitals in Jeddah and Taif city. Only tertiary care hospitals in Taif and Jeddah region were selected under the Ministry of Health and other public health sectors for generalizability. Each pharmacy director or assigned personnel from him, filled survey and returned to research team.

2.2. Survey Development

We modified the questionnaire from a study conducted by Chen et al. to fit the context in the KSA (Chen et al., 2010b). Most survey questions were closed ended with few open-ended choices regarding the type of hospitals and type of antimicrobial stewardship programs not listed in each section. The study was formatted into five main sections. Section 1 explored the demographic characteristics of the respondents. Section 2 explored administration-related antimicrobial stewardship activities. Section 3 explored antimicrobial use and prescription-related activities. Section 4 covered education- and training-related ASP activities in healthcare settings and Section 5 consisted of data about infection control and surveillance-related activities in the hospital.

2.3. Survey administration

The survey was sent to all directors of hospital pharmacy/nominees at 25 hospitals, including primary care and tertiary care settings across the Makkah region (Makkah, Jeddah and Taif). The 1st reminder to all the recipients of the survey was sent three weeks after the initial notification. A 2nd reminder was sent 6 weeks after the initial notification. Non-respondents to both reminders were

then contacted by telephone approximately eight weeks after the second mailing to urge them to complete and return the survey. In all, 19 (76%) replied after all reminders, and their responses were included in the final analysis.

2.4. Statistical analysis

In this study, we have emphasized subjective assessment of the success of antimicrobial stewardship programs in each participating hospital. Trained research assistants transcribed data from the paper survey to an Excel spreadsheet for final analysis. SPSS version 22 was used to analyse the data. An independent reviewer checked the range and consistency of the transcribed data. Simple descriptive statistics were used to represent the data in each category. Frequencies and proportions were used to represent study findings.

2.5. Study ethical approval

This study was initially approved by Al Noor Specialist Hospital Ethics board, and based on this approval, the study was finally approved by the Directorate Journal of Health, MOH, Makkah region. The ethics committee waived the requirement for informed consent. The personal details of respondents and their institution were kept anonymous, and each hospital was assigned a specific code for data analysis purposes.

3. Results

Responses were received from 19 (76%) directors of pharmacies from all hospitals to which the survey was sent ($n = 25$). Demographic characteristics of the respondents are described in [Table 1](#). More than half of the respondents were from tertiary care hospitals (68.4%), the majority belonging to the MOH (68.4%). All respondent hospitals were accredited by the Joint Commission International (JCI) (57.9%) and the Central Board for Accreditation of Healthcare Institutions (CBAHI) (42.1%).

The classification of ASPs was adopted by an Australian survey conducted by Chen et al. ASPs are classified as administrative ([Table 2](#)), antimicrobial use and prescription ([Table 3](#)), education and training and infection control and surveillance ([Table 4](#)) ([Chen et al., 2010b](#)).

3.1. Administration related activities

The most common ASP strategies were restricted formulary (89.4%), pharmacy and therapeutic Committees (78.9%) and multidisciplinary antimicrobial stewardship committees (52%). Approximately 50% of the ASP committees were successful according to the respondents and were working well in their institutions. Inter-

estingly, locally developed guidelines were the least common (10%) in all settings.

3.2. Antimicrobial use and prescription related activities

Use of clinical guidelines and pathways was reported by all 19 participating hospitals as antimicrobial use and prescription-related activity. Most ($n = 14$) perceived this service as somewhat to moderately successful ([Table 3](#)). The streamlining or de-escalation (step-down) of antimicrobial therapy and use of automatic stop orders occurred at 13 hospitals. These approaches were perceived as somewhat to moderately successful by all 12 respondents and very to extremely successful by 12 (out of 13 responses) respondents respectively.

3.3. Education and training related activities

Education and training-related activities were the most commonly reported activities at all institutions. The most interesting finding was that education and training on antimicrobial stewardship related activities was provided in every institution. However, it is somewhat surprising that the least level of education and training on antimicrobial stewardship programs was offered to nursing staff (15.7%) compared to physicians and pharmacists.

3.4. Infection control and surveillance related activities

Under “infection control and surveillance”, all 19 respondents had a hand hygiene program to minimize AMR, and over 50% ($n = 12$) perceived the activity as extremely successful. Thirteen out of 19 respondents did not have a provision for antibiograms to support infection control and surveillance. Six respondents who had antibiograms perceived them to be very to extremely successful.

4. Discussion

This study provides valuable data on the existence of ASPs across hospitals in the Makkah region, Saudi Arabia. Hospitals in the Saudi Arabia optimize antimicrobial stewardship with varying levels of perceived success, as the data from the present study show. There are several common antimicrobial stewardship initiatives in hospitals in the Makkah region, such as formulary restrictions, use of drug and therapeutics committees or the equivalent, use of clinical guidelines and pathways and streamlining or therapy de-escalation. These initiatives were somewhat to very successful and are supported by other stakeholders, as perceived by most respondents in previous studies ([Dellit et al., 2007](#); [Ho et al., 2006a](#)).

Interestingly, we found formulary restrictions (89%) and feedback on prescribing to physicians (68%) as most common ASP interventions with high suggested success in hospitals. These findings are consistent with previous surveys conducted in Saudi settings ([Baraka et al., 2019](#); [Enani, 2016](#)).

This study result indicates that the provision of clinical pharmacy services, use of clinical guidelines and pathways and streamlining or de-escalation of therapy were the highly implemented antimicrobial stewardship activities with various level of perceived success. This finding broadly supports the work of other authors with similar results along with clinical pharmacy services ([Chen et al., 2010a](#); [Ho et al., 2006b](#); [Paskovaty et al., 2005](#); [von Gunten et al., 2007](#); [Taubman et al., 2009](#)). Similarly, our study findings supports evidence from antimicrobial stewardship initiatives in New South Wales, where contribution of infectious diseases clinicians were related with success of ASPs ([Cruickshank et al., 2009](#)).

Table 1
General information on responding hospitals.

	N (%)
Type of Hospitals	
Primary Care	6 (31.6)
Tertiary Care	13 (68.4)
Hospital Sectors	
Ministry of Health	15 (78.9)
Armed Forces Hospitals	2 (10.5)
Other Governmental Hospitals	2 (10.5)
Total	19 (100)
Hospital Accreditation Level	
Joint Commission International Accreditation (JCIA)	11 (57.9)
Central Board for Accreditation of Health Care Institutions (CBAHI)	8 (42.1)

Table 2
Administration-related antimicrobial stewardship activities (not all respondents completed every item).

Administration-related activities	No. of respondents			Perceived success of the activity (only those who answered yes to having the activity at their institution)				
	Don't know	No	Yes	Unsuccessful	Somewhat successful	Moderately successful	Very successful	Extremely successful
Drug and Therapeutic Committee or equivalent approving antimicrobials listing on the formulary and its associated use	0	4	15	0	5	3	5	2
Restricted formulary for antimicrobial prescribing	0	2	17	2	5	3	5	2
Locally formulated antimicrobial policy	0	17	2	0	1	1	0	0
Regular audit on the prescribing and use of antimicrobials	0	8	11	2	2	4	3	0
Regular feedback to doctors on antimicrobial prescribing and use	0	6	13	0	0	2	7	4
Regular feedback to pharmacists on antimicrobial prescribing and use	0	11	8	0	0	2	4	2
Established mechanism for conflict resolution in event of disagreement with respect to use of antimicrobial between practitioners	0	10	9	0	0	3	5	1
Participation in the National Antimicrobial Utilisation Surveillance Program	0	11	8	0	6	2	0	0
Multidisciplinary antimicrobial stewardship team or equivalent to coordinate activities in hospital	0	9	10	0	0	2	3	5
Regular feedback to nurses on antimicrobial prescribing and use	0	10	9	0	1	4	3	1

Table 3
Antimicrobial use and prescribing-related antimicrobial stewardship activities (not all respondents completed every item).

Antimicrobial use and prescribing-related activities	No. of respondents			Perceived success of the activity (only those who answered yes to having the activity at their institution)				
	Don't know	No	Yes	Unsuccessful	Somewhat successful	Moderately successful	Very successful	Extremely successful
Provision of clinical pharmacy services	0	10	9	0	2	1	5	1
Provision of consult service by Infectious Diseases clinicians	0	8	11	2	3	1	2	3
Streamlining or de-escalation of therapy (i.e. treatment is directed after culture results have been obtained)	0	6	13	0	5	7	0	0
Use of clinical guidelines and pathways to guide antimicrobial prescribing	0	0	19	0	4	10	3	2
Use of Specialized order forms for prescribing	6	4	9	0	0	3	4	2
Program for timely conversion of IV to oral antimicrobials	0	10	9	0	0	3	4	2
Regular multidisciplinary antimicrobial stewardship ward round to some wards or for certain patient groups	0	13	6	0	0	0	2	4
Regular multidisciplinary antimicrobial stewardship ward rounds	6	8	5	0	0	2	2	1
Use of automatic 'stop orders' for antimicrobials prescribed	0	6	13	0	0	1	6	6
Use of electronic antimicrobial prescribing approval systems	6	5	8	0	0	0	6	2

Table 4
Education & training related and Infection control and surveillance related activities.

Antimicrobial stewardship activities		No. of respondents			Perceived success of the activity (only those who answered yes to having the activity at their institution)				
		Don't know	No	Yes	Unsuccessful	Somewhat successful	Moderately successful	Very successful	Extremely successful
Education and training-related	Education and training pharmacists on some or all aspects of antimicrobial stewardship	6	6	7	0	0	2	2	3
	Education and training junior doctors on some or all aspects of antimicrobial stewardship	6	3	10	0	0	3	5	2
	Education and training nurses on some or all aspects of antimicrobial stewardship	0	16	3	0	0	0	1	2
	Education and training senior doctors on some or all aspects of antimicrobial stewardship	6	2	11	0	0	3	2	6
Infection control and surveillance-related	Hand hygiene program to minimise antimicrobial resistance	0	0	19	0	0	3	4	12
	Provision of local antibiogram	0	13	6	0	0	0	2	4

Education and training were observed as very important for successful ASPs in hospitals in the Saudi Arabia. The results of the current study show the variation in the education of senior/junior doctors, pharmacists and nurses on antimicrobial stewardship across the responding hospitals. Workshops, lectures, posters, lunchtime talks, and face-to-face interventions were common strategies suggested to educate doctors, pharmacists and nurses (Dellit et al., 2007; MacDougall and Polk, 2005; Chen et al., 2010b; Ho et al., 2006a, 2006b; von Gunten et al., 2007; Tauman et al., 2009; Cruickshank and Ferguson, 2008; Fishman, 2012).

Health professionals have different levels and groups that require tailored education and training. These findings are in agreement with the reports published by Alomi et al., who explained the implementation of educational strategies as supportive measures to deliver successful ASPs in the KSA (Alomi, 2017).

Studies indicated that a hospital should have a multidisciplinary approach for the successful implementation of antimicrobial stewardship activities (Paskovaty et al., 2005; Nathwani and Christie, 2007; Pestotnik, 2005). In the present study, only six respondents reported multidisciplinary antimicrobial stewardship

ward rounds to specific patient groups, while over 50% of respondents did not have the regular multidisciplinary ASP ward rounds in institution. This implementation will escalate acceptance and support from doctors, pharmacists, and nurses in hospitals.

The study offers some critical insights into the current level of existing antimicrobial stewardship programs in Makkah region hospitals. There are several important areas where this study contributes to the advancement of antimicrobial stewardship programs in Makkah region hospitals. Development of locally formulated antimicrobial guidelines, regular multidisciplinary ASP ward rounds, specialized order forms for common infections and education and training of nursing staff on antimicrobial stewardship are the primary recommendations based on study findings to add in current ASP interventions in Makkah hospitals. We highly recommend a unique continuous medical education (CME) program targeting all healthcare providers on antimicrobial stewardship programs in every institution for the successful implementation of ASP.

One of the limitation of the study that we could not achieve full responses from hospitals besides multiple reminders. In addition, respondent bias may be a factor, pharmacy supervisors who feel most strongly about ASPs may have been more likely to respond, potentially biasing the results. Our findings were mainly subjective and depends on pharmacy perspective on success of ASP interventions. These findings need further verification by evaluating impact of ASP interventions on antimicrobials consumption, clinical outcomes and microbial outcomes. Moreover, this study cannot provide a comprehensive review on barriers towards successful implementation of antimicrobial stewardship programs in hospitals.

5. Conclusion

It has been concluded by surveying Makkah region hospitals that all reported institutions have at least one antimicrobial stewardship intervention in a process with high indicated perceived success. A multidisciplinary ASP approach, active involvement of drug & therapeutic committee or equivalent, formulary restrictions and availability of education & training of pharmacists and physicians on ASP are the primary elements for perceived successful antimicrobial stewardship programs in Makkah region hospitals.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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References

Al-Ghamdi, S., Gedebo, M., Bilal, N., 2002. Nosocomial infections and misuse of antibiotics in a provincial community hospital, Saudi Arabia. *J. Hosp. Infect.* 50, 115–121.

- Al-Tawfiq, J.A., 2012. Changes in the pattern of hospital intravenous antimicrobial use in Saudi Arabia, 2006–2008. *Ann. Saudi Med.*, 32, 517.
- Alghamdi, S., Atef-Shebl, N., Aslanpour, Z., Berrou, I., 2019. Barriers to implementing antimicrobial stewardship programmes in three Saudi hospitals: Evidence from a qualitative study. *J. Global Antimicrobial Resistance* 18, 284–290.
- Alomi, Y.A., 2017. National antimicrobial stewardship program in Saudi Arabia; initiative and the future. *Open Access J. Surg.* 4, 1–7.
- Amer, M.R., Akhras, N.S., Mahmood, W.A., Al-Jazairi, A.S., 2013. Antimicrobial stewardship program implementation in a medical intensive care unit at a tertiary care hospital in Saudi Arabia. *Ann. Saudi Med.* 33, 547–554.
- Baraka, M.A., Alsultan, H., Alsalman, T., Alaitan, H., Islam, M.A., Alasser, A.A., 2019. Health care providers' perceptions regarding antimicrobial stewardship programs (AMS) implementation—facilitators and challenges: a cross-sectional study in the Eastern province of Saudi Arabia. *Ann. Clin. Microbiol. Antimicrob.* 18, 26.
- Barlam, T.F., Cosgrove, S.E., Abbo, L.M., Macdougall, C., Schuetz, A.N., Septimus, E.J., Srinivasan, A., Dellit, T.H., Falck-Ytter, Y.T., Fishman, N.O., 2016. Implementing an antibiotic stewardship program: guidelines by the Infectious Diseases Society of America and the Society for Healthcare Epidemiology of America. *Clin. Infect. Dis.* ciw118.
- Belkina, T., Al Warafi, A., Eltom, E.H., Tadjieva, N., Kubena, A., Vlcek, J., 2014. Antibiotic use and knowledge in the community of Yemen, Saudi Arabia, and Uzbekistan. *J. Infect. Develop. Count.*, 8, 424–429.
- Bozkurt, F., Kaya, S., Tekin, R., Gulsun, S., Deveci, O., Dayan, S., Hoşoglu, S., 2014. Analysis of antimicrobial consumption and cost in a teaching hospital. *J. Infect. Public Health* 7, 161–169.
- Chen, A.W., Khumra, S., Eaton, V., Kong, D., 2010. Snapshot of antimicrobial stewardship in Australian hospitals. *J. Pharm. Pract. Res.* 40, 19–26.
- Cruickshank, M., Ferguson, J., 2008. Part E – Preventive Measures. Reducing Harm to Patients from Health Care Associated Infection: the Role of Surveillance. Australian Commission on Safety and Quality in Health Care, Sydney.
- Cruickshank, M., Ferguson, J., Bull, A., 2009. Reducing harm to patients from health care associated infection: the role of surveillance. Chapter 3: Surgical site infection—an abridged version. *Healthcare Infect.* 14, 109–114.
- Dean, B., Lawson, W., Jacklin, A., Rogers, T., Azadian, B., Holmes, A., 2002. The use of serial point-prevalence studies to investigate hospital anti-infective prescribing. *Int. J. Pharmacy Practice* 10, 121–125.
- Dellit, T.H., Owens, R.C., McGowan, J.E., Gerding, D.N., Weinstein, R.A., Burke, J.P., Huskins, W.C., Paterson, D.L., Fishman, N.O., Carpenter, C.F., 2007. Infectious Diseases Society of America and the Society for Healthcare Epidemiology of America guidelines for developing an institutional program to enhance antimicrobial stewardship. *Clin. Infect. Dis.* 44, 159–177.
- Doron, S., Nadkarni, L., Price, L.L., Lawrence, P.K., Davidson, L.E., Evans, J., Garber, C., Snyderman, D.R., 2013. A nationwide survey of antimicrobial stewardship practices. *Clin. Ther.* 35, 758–765. e20.
- Enani, M.A., 2016. The antimicrobial stewardship program in Gulf Cooperation Council (GCC) states: insights from a regional survey. *J. Infect. Prevent.* 17, 16–20.
- Fishman, N., 2012. Policy statement on antimicrobial stewardship by the Society for Healthcare Epidemiology of America (SHEA), the Infectious Diseases Society of America (IDSA), and the Pediatric Infectious Diseases Society (PIDS). *Infection Control Hospital Epidemiol.* 33, 322–327.
- Goff, D.A., Bauer, K.A., Reed, E.E., Stevenson, K.B., Taylor, J.J., West, J.E., 2012. Is the “low-hanging fruit” worth picking for antimicrobial stewardship programs? *Clin. Infect. Dis.* cis494.
- Ho, L., Melvani, S., 2007. Serial point-prevalence studies to investigate hospital antimicrobial prescribing. *J. Pharm. Pract. Res.* 37, 190–193.
- Ho, P., Cheng, J., Ching, P., Kwan, J., Lim, W., Tong, W., Wu, T., Tse, C., Lam, R., Yung, R., 2006a. Optimising antimicrobial prescription in hospitals by introducing an antimicrobial stewardship programme in Hong Kong: consensus statement. *Hong Kong Med. J.*
- Ho, P.L., Cheng, J.C.F., Ching, P.T.Y., Kwan, J.K.C., Lim, W.W.L., Tong, W.C.Y., Wu, T.C., Tse, C.W.S., Lam, R., Yung, R., 2006b. Optimising antimicrobial prescription in hospitals by introducing an antimicrobial stewardship programme in Hong Kong: consensus statement. *Hong Kong Med. J.* 12, 141–148.
- Howard, P., Pulcini, C., Hara, G.L., West, R., Gould, I., Harbarth, S., Nathwani, D., 2015. An international cross-sectional survey of antimicrobial stewardship programmes in hospitals. *J. Antimicrob. Chemother.* 70, 1245–1255.
- Knobler, S.L., Lemon, S.M., Najafi, M., Burroughs, T., 2003. A Public Health Action Plan to Combat Antimicrobial Resistance. The Resistance Phenomenon in Microbes and Infectious Disease Vectors: Implications for Human Health and Strategies for Containment: Workshop Summary, 2003. National Academies Press (US).
- Macdougall, C., Polk, R.E., 2005. Antimicrobial stewardship programs in health care systems. *Clin. Microbiol. Rev.* 18, 638–656.
- Mohajer, K.A., Al-Yami, S.M., Al-Jeraisy, M.I., Abolfotouh, M.A., 2011. Antibiotic prescribing in a pediatric emergency setting in central Saudi Arabia. *Saudi Med. J.* 32, 197–198.
- Moro, M., Petrosillo, N., Gandin, C., 2003. Antibiotic policies in Italian hospitals: still a lot to achieve. *Microbial Drug Resistance* 9, 219–222.
- Nathwani, D., Christie, P., 2007. The Scottish approach to enhancing antimicrobial stewardship. *J. Antimicrob. Chemother.* 60, i69–i71.
- O'Neill, J., 2014. Review on antimicrobial resistance. *Antimicrobial Resistance: Tackling a Crisis for the Health and Wealth of Nations*, 2014.

- Owens, R.C., Fraser, G.L., Stogsdill, P., 2004. Antimicrobial stewardship programs as a means to optimize antimicrobial use insights from the Society of Infectious Diseases Pharmacists. *Pharmacotherapy* 24, 896–908.
- Paskovaty, A., Pflomm, J.M., Myke, N., Seo, S.K., 2005. A multidisciplinary approach to antimicrobial stewardship: evolution into the 21st century. *Int. J. Antimicrob. Agents* 25, 1–10.
- Pestotnik, S.L., 2005. Expert clinical decision support systems to enhance antimicrobial stewardship programs: insights from the society of infectious diseases pharmacists. *Pharmacotherapy* 25, 1116–1125.
- Poteete, C., Scaletta, J.M., 2017. Antimicrobial stewardship in Kansas: Results from a statewide survey. *Am. J. Infect. Control* 45, 42–45.
- Smith, R.D., Coast, J., 2002. Antimicrobial resistance: a global response. *Bull. World Health Organ.* 80, 126–133.
- Storr, J., Twyman, A., Zingg, W., Damani, N., Kilpatrick, C., Reilly, J., Price, L., Egger, M., Grayson, M.L., Kelley, E., 2017. Core components for effective infection prevention and control programmes: new WHO evidence-based recommendations. *Antimicrobial Resistance Infect. Control* 6, 6.
- Sunenshine, R.H., Liedtke, L.A., Jernigan, D.B., Strausbaugh, L.J., & Infectious Diseases Society of America Emerging Infections Network 2004. Role of infectious diseases consultants in management of antimicrobial use in hospitals. *Clin. Infect. Dis.*, 38, 934–938.
- Tauman, A., Robicsek, A., Roberson, J., Boyce, J., 2009. Health care-associated infection prevention and control: pharmacists' role in meeting national patient safety goal 7. *Hospital Pharmacy* 44, 401–411.
- von Gunten, V., Reymond, J.-P., Beney, J., 2007. Clinical and economic outcomes of pharmaceutical services related to antibiotic use: a literature review. *Pharm. World Sci.* 29, 146–163.