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# Research Article
# Implementation and Practice of the Antimicrobial Stewardship Program (ASP) in Various Healthcare Settings in Al Ahsa

[1]Lorina Ineta Badger-Emeka, [2]Promise Madu Emeka, [1]Sayed Abdul Qadar Quadri, [3]Hussein Yousef AlHelal, [4]Abdulrahim Alabdulsalam, [5]Mohammed Abdulwahab Buhalim, [6]Omer Abdullah Alrasheed and [7]Muktar Ali AlHelal

[1]Department of Biomedical Sciences, College of Medicine, King Faisal University, Al-Asha 31982, Saudi Arabia
[2]Department of Pharmaceutical Sciences, College of Clinical Pharmacy, King Faisal University, Al-Ahsa 31982, Saudi Arabia
[3]Prince Sultan Cardiac Centre, Ministry of Health, Prince Satam Street, Al-Ahsa, Saudi Arabia
[4]Department of Pathology and Laboratory Medicine, King Abdulaziz Hospital, Ministry of National Guard Health Affairs, Al-Ahsa, Saudi Arabia
[5]Department of Surgery College of Medicine King Faisal University Al-Ahsa, Saudi Arabia
[6]Department of Surgery Orthopedic Unit College of Medicine King Faisal University Al-Ahsa, Saudi Arabia
[7]Prince Saud Bin Jalawi Hospital, Ministry of Health, King Abdullah Road, Al-Ghassaniya-1, Saudi Arabia

## Abstract

**Background and Objective:** The threat of post-antibiotic-era challenges has created concern globally, leading to various education interventions aimed at controlling factors that influence the prescription and administration of antibiotics through policy formulation. The global institution of antimicrobial stewardship program (ASP) is to curtail antibiotic resistance and improve patient outcomes. The study looks at the extent of ASP implementation and practice in various fields of healthcare facilities since the inception of the program. **Materials and Methods:** A validated questionnaire with forty-one questions of ASP core elements, grouped into ten sections, developed with Google forms, was distributed online to physicians, pharmacists and nurses in hospital-based institutions within Al Ahsa. The questionnaire consisted of 10 segments of 41 questions, grouped into demography, familiarity with antimicrobial resistance and the antimicrobial stewardship program, leadership commitment, program commitment and pharmacist expertise amongst other questions. Data was analyzed using SPSS version 26 and GraphPad Prism 10 software. Significance was statistically taken as $p<0.05$. **Results:** There is increased knowledge on the seriousness of antimicrobial resistance in Saudi Arabia (94.8%) and various healthcare facilities (89.1%). Leadership commitment (49.1%), conducting daily reviews of antibiotics for treatment duration on definitive diagnosis (46.4%) and patient discharge with correct antibiotics and recommended duration (32.7%) were inadequate. The implementation level of the program performance (38.2%) in planned Outpatient Parental Antibiotic Therapy (OPAT) as well as tracking of antibiotic resistance by submissions to AMR and ASP (40.9%) was low. **Conclusion:** Nine years after ASP was inaugurated, we can conclude that awareness is good, but implementation of core elements of the program is low, thus requiring commitment to improve at every level of its operation.

Key words: Antimicrobial stewardship, antimicrobial resistance, antibiotic use, healthcare facilities, field of practice

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Corresponding Author: Promise Madu Emeka, Department of Pharmaceutical Sciences, College of Clinical Pharmacy, King Faisal University, Al-Ahsa 31982, Saudi Arabia



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Data Availability: All relevant data are within the paper and its supporting information files.

## INTRODUCTION

Antimicrobial resistance imputable to either inappropriate use or unnecessary prescription of antimicrobials is a worldwide healthcare challenge[1]. Proper use of antibiotics ensures that patients are given the right doses of medication suitable for eradicating susceptible bacteria with limited adverse effects[2]. Consequently, the development of resistance by pathogens will be reduced and in so doing, improve antibiotic effectiveness. Thus, for the aforementioned to be realized, the quality of antibiotic prescribing and its contents must be guided by therapeutic decisions. Generally, the factors influencing antibiotic prescribing and their administration have been put under global scrutiny by various studies as well as governmental policies[3,4]. This is because those prescribing and dispensing antibiotics play a crucial role either appropriately or inappropriately in the way bacterial infections are managed[5]. Thus, their behavior in the use of antibiotics for managing infections contributes to the challenge of bacterial response. Studies show that those who are at the forefront of prescribing and administering antibiotics are well aware of the challenges of antimicrobial resistance to infection management in clinical settings[6-8]. The witness in failure of most antibiotics due to bacterial resistance globally has necessitated an urgent re-evaluation of the way antibiotics are used. Consequences of antibiotic resistance that are notably of serious concern include long hospital stays, increased mortality and high medical costs[9]. Not exempted from the global health crisis, is the region of the present study, which has been scourged with multidrug resistance (MDR) and extensive drug resistance bacteria (XDR) infections during the past decade[10-12]. It goes therefore to emphasize that rational use of antibiotics through prescribing and administration is critical to the control of antibiotic resistance[13].

Therefore, the universal concern of facing a post-antibiotic era has culminated in various educational interventions such as that of the Antimicrobial stewardship program (ASP)[6,13,14]. These interventions were to find a way through policy formulations, to control some of the factors influencing healthcare practitioners in prescribing and administering antibiotics. For example, physicians' decisions in prescribing antibiotics can be affected by previous experiences, availability of microbial data, potential clinical complications and patient-specific factors[8,15]. For the pharmacist, a lack of holistic knowledge of patients' situation and not being aware of their role in giving professional advice about antibiotics that are prescribed. On the part of the nurses, they are not aware of recommended guidelines, coupled with a heavy workload and not being carried along by the Physicians and Pharmacists[16,17].

Thus, instituting ASP in various healthcare centers within the area of study by the Saudi Ministry of Health in 2014 was indeed a step in the right direction[18,19] to support global efforts in reducing antimicrobial resistance. It is of the view[19,20] that the implementation of ASP will help improve antimicrobial use, optimize therapy and consequently, reduce antibacterial resistance. Therefore, having been instituted and implemented, the outcome of the program is expected to reflect on the prescribers and administrators of antimicrobial agents in the various healthcare institutions. This is expected to be so, in terms of knowledge and attitude to improve the present way of prescribing as the administration of antibiotics in infection control and management.

The study, therefore, seeks to assess the knowledge of antimicrobial agents, resistance and the program since its inception among healthcare practitioners in this region of Southeast Saudi Arabia. Also, to explore the extent of ASP implementation in various fields of healthcare practice. Examine their knowledge of ASP core elements, leadership commitments, tracking/monitoring interventions, educational programs and the level of interventions aimed at reducing antimicrobial resistance.

## MATERIALS AND METHODS

**Study design, setting and site:** A questionnaire-based cross-sectional study amongst healthcare professionals in various fields of practice was carried out in Al-Ahsa. This included Physicians, Pharmacists and Nurses in hospital-based institutions within Al Ahsa, part of the Eastern Region of Saudi Arabia. The study spanned from June, 2021 to June, 2023.

**Inclusion and exclusion criteria:** All healthcare personnel involved in the prescription of and administration of antimicrobial agents. Therefore, hospital personnel who were not involved with patient care prescription and administration were excluded from the investigation.

**Development of the study tools:** The questionnaire was created based on the Centers for Disease Control and Prevention (CDC) ASP core elements. It was then discussions with practitioners in medicine, pharmacy and nursing faculties for validation. The questionnaire was divided into 10 sections comprising 41 questions, namely: Demography, knowledge

of antimicrobial resistance and antimicrobial stewardship program, leadership commitment, program commitment, pharmacist expertise, action implementation and intervention to improve the use of antibiotics, tracking and outcomes. Also included were the provision of education for the program and actions in terms of the implementation and interventions to improve antimicrobial use. Five physicians, five pharmacists and two nurses randomly tested the questionnaire to ensure clarity, readability and understanding. Minor modifications were made and the modified copy was then distributed via Google forms to eligible participants on a voluntary basis.

**Sample size determination:** A very conversant size sample formula employed for the unknown nature of the population size was used to calculate the study sample size using the previously used equation[21,22]:

$$n = \frac{\left[Z1 - \alpha/2\sqrt{2P(1-P)} + Z1-\beta \times \sqrt{\{P1(1-P1)+P2(1-P2)\}}\right]2}{(P1-P2)2}$$

Where:

$$P = \frac{P1+P2}{2}$$

Where:

| | | |
|---|---|---|
| n | = | Required sample size |
| Z | = | Degree of confidence: 1.96 |
| α | = | Level of confidence = 0.05 |
| P standard deviation | = | 0.5 |
| P1 expected proportion | = | 50% |
| P2 | = | 80% |
| 1-β at power of 90% | = | 1.24 |
| P1-P2 | = | Difference (%) |

The sample size for the study was calculated with a 95% confidence level and 90% power, giving an estimated size of 105. This is an adjusted sample size with a view of excluding non-response or incomplete responses.

**Sampling of participants' opinion and collection of data:** Having explained the purpose of the study, all those identified to be eligible to participate in this study were invited to complete the survey questionnaire. In addition, all given personal information was kept confidential and used for research purposes only. Those who were contacted to participate in the survey were from both public/private hospitals, namely, primary and tertiary healthcare settings other available social media networks. Constant reminders were sent monthly either through emails, one-on-one visits, WhatsApp messages or at other times through phone calls. A total number of one hundred and thirty-eight responses were received and subjected to data cleaning (questionnaires that are not complete, that is, responses were missing or omitted or wrongly filled out, were removed before analysis). Data was collected on an Excel sheet for the duration of the investigation and Consistency checks were carried out thereafter. Data cleaning was done to remove either a questionnaire with incomplete information or non-responses. They were subsequently transferred to SPSS for statistical analysis.

**Statistical analysis:** The SPSS Version 26 and Graphpad Prism Version 10.2 software were used to analyze collected data with results presented as numbers (proportions) and percentages. Descriptive statistics were used to analyze demographic information and categorical data were represented with percentages. Pearson Chi-Square test was used to compare responses from fields of practice and implementation of core elements of ASP to determine the significant difference. Knowledge assessment was in the form of a 5-point Likert scale and was analyzed using the Pearson correlation coefficient after responses were reduced to agree, neutral and disagree options. Significance was statistically taken as $p<0.05$.

## RESULTS

**Demography of respondents:** One hundred and ten completed responses obtained after data cleaning were used for the investigation. Figure 1a describes the demographic characteristics of respondents who are medical personnel and are within the inclusive criteria. Analysis of results revealed that males were more than females, with the majority being comparatively Saudi nationals. Age distribution, according to Fig. 1b, showed that the most encountered age group of respondents is 31-40 years (50%), this appears to be representative of a relatively young workforce. This also indicates that they participated voluntarily, meaning that the older age group did not participate much. Results also showed that there are 38.2% of public tertiary hospital personnel and 20% of those working at public regional hospitals, with less than 10% coming from public district hospitals and primary/community health centers (Fig. 1c). Therefore, it appeared that the respondents were fairly distributed within the region of study.

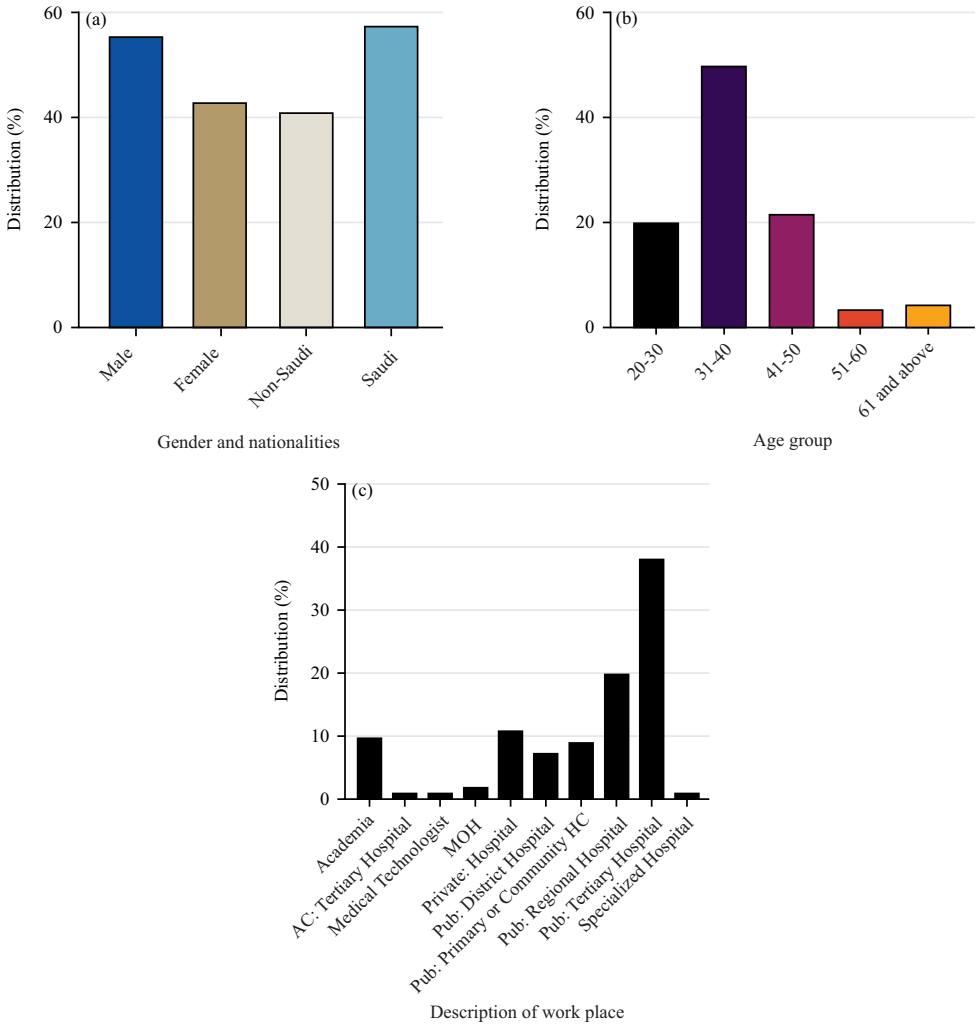


Fig. 1(a-c): Demographics of respondents and the description of their place of work, (a) Gender and nationality, (b) Age groups and (c) Different healthcare facilities

MOH: Ministry of Health, PUB: Public and HC: Healthcare centres

Also, as part of the demographics, Fig. 2 represents the qualifications of medical doctors, pharmacists and nurses who participated in the study. The figure shows that for the medical doctors' qualifications, respondents with specialists who are fellows of different specializations in medicine and MBBS holders constituted about 14.5 and 13.6%, respectively. This is in comparison to those with a master's in medicine/surgery. However, respondents with a doctorate in medicine were the 3rd highest in the percentage of respondents. Among respondents who are pharmacists, a Bachelor of Pharmacy was the highest in percentage of respondents followed by those with a master's degree holder in pharmacy. Nurses that participated followed a similar pattern as the pharmacists, in that the majority of them hold a bachelor of nursing as shown. Therefore, in terms of qualifications, responses were not evenly distributed, as shown in Fig. 2a-c.

**Information on antimicrobials, resistance and antimicrobial stewardship program (ASP):** This analysis describes respondents' knowledge of antimicrobials, resistance and their clinical seriousness, which is the reason for ASP institution and implementation. Table 1 describes the levels of knowledge on the seriousness of antimicrobial resistance globally, in the Gulf Region, in Saudi Arabia and the respondents' places of work in their respective assessments as analyzed in the present study. Also shown in Table 1, are their knowledge of antimicrobials and antimicrobial stewardship in different areas, including Saudi Arabia, to access their knowledge. The respondents claimed confidently that they

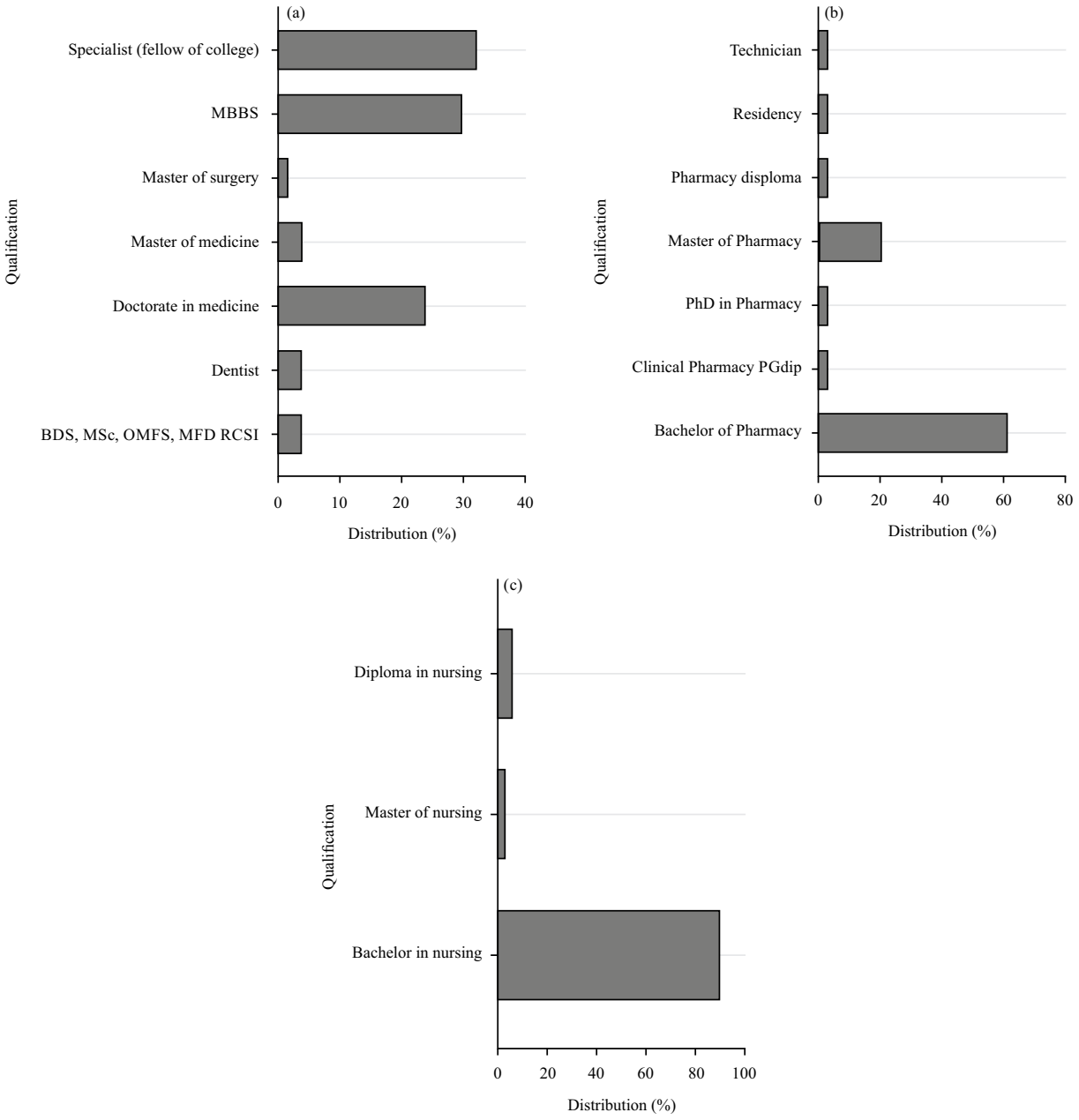


Fig. 2(a-c): Percentage distribution of the qualifications of medical doctors, pharmacists and nurses, (a) Qualifications for medical doctors, (b) Respondents who are pharmacists and (c) Qualifications for nurses

MBBS: Bachelor of Medicine, Bachelor of Surgery, BDS: Bachelor of Dental Surgery, MSc: Master of Sciences, OMFS: Oral and Maxillofacial Surgery, MFD: Membership of the Faculty of Dental Surgery and RCSI: Royal College of Surgeons in Ireland

know the seriousness of antimicrobial resistance globally (94.5%), in the Gulf (88.2%), in Saudi Arabia (94.8%), as well as in their healthcare facilities, 89.1% (Table 1).

Results here show an overall of 45.5% being confident of their knowledge of antimicrobials while 29.1% were not confident, with the remaining neutral (25.5%). However, only 41.3% confidently claimed to have knowledge of antimicrobial resistance in their assessment. Regarding the establishment of ASP, only a cumulative 30% of the respondents were confident that the program is available in their healthcare facilities.

In Fig. 3, the results on the knowledge of the respondents to antimicrobials, their resistance and ASP in the different fields of practice are presented. Analysis revealed that most of the fields of practice claimed knowledge of antimicrobials, but the public tertiary hospitals had the

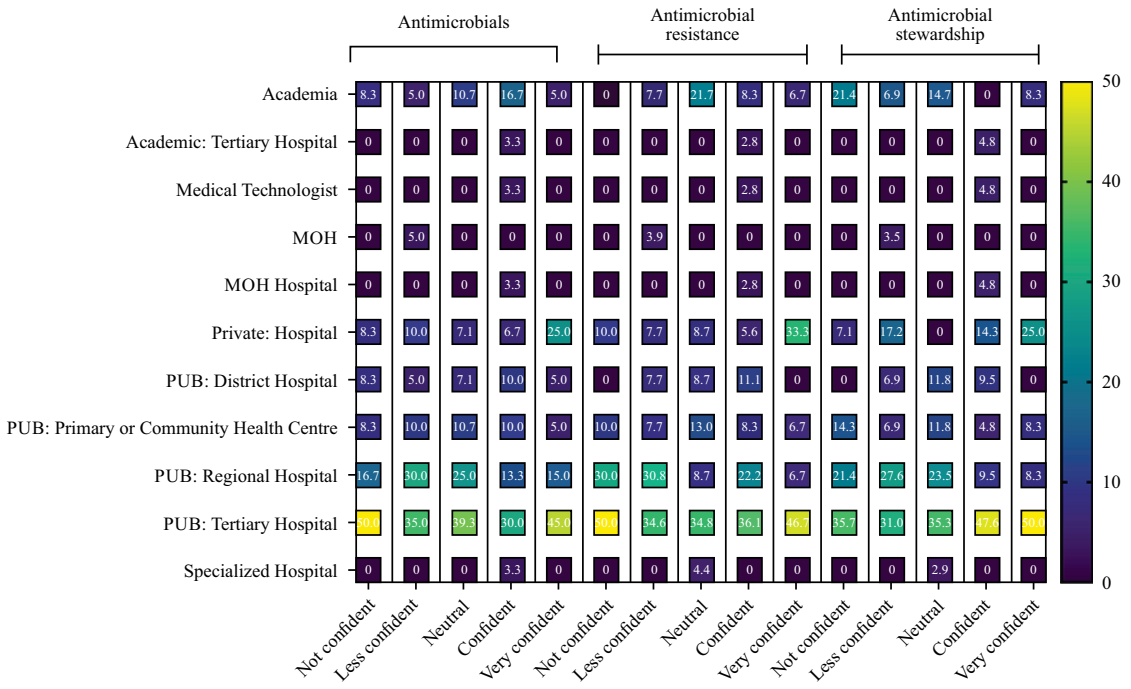


Fig. 3: Field of practice knowledge of antimicrobials, resistance and ASP

Figure reveals responses by all healthcare practitioners on their knowledge of antimicrobials, resistance to antimicrobials and that of the ASP program in their places of practice, MOH: Ministry of Health and PUB: Public

Table 1: Assessment of knowledge of the extent of antimicrobial resistance, antimicrobials and antimicrobial stewardship program implementation

| | | Globally | | | In the Gulf Region | | | In Saudi Arabia | | | In your hospital or practice | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Knowledge assessment | Likert scale | N | % | | N | % | | N | % | | N | % | |
| Would you consider antimicrobial resistance as a serious problem? | Strongly agree | 66 | 60 | 94.5 | 61 | 55.5 | 88.2 | 60 | 54.5 | 94.5 | 55 | 50 | 89.1 |
| | Agree | 38 | 34.5 | | 36 | 32.7 | | 44 | 40 | | 43 | 39.1 | |
| | Neutral | 4 | 3.6 | | 11 | 10 | | 4 | 3.6 | | 9 | 8 | |
| | Disagree | 1 | 0.9 | | 1 | 0.9 | | 1 | 0.9 | | 2 | 1.8 | |
| | Strongly disagree | 1 | 0.9 | | 1 | 0.9 | | 1 | 0.9 | | 1 | 0.9 | |
| | Total | 110 | 100 | | 110 | 100 | | 110 | 100 | | 110 | 100 | |

| | | Antimicrobials N (%) | | Antimicrobial resistance N (%) | | Antimicrobial stewardship N (%) | |
|---|---|---|---|---|---|---|---|
| Knowledge assessment | Likert scale | N (%) | | N (%) | | N (%) | |
| How confident are you in your knowledge of antimicrobials, antimicrobial resistance and stewardship? | Not confident | 12 (10.9) | 29.10% | 10 (9.1) | 36.30% | 14 (12.7) | 30% |
| | Less confident | 20 (18.2) | | 26 (23.6) | | 29 (26.4) | |
| | Neutral | 28 (25.5) | | 23 (20.9) | | 34 (30.9) | |
| | Confident | 30 (27.3) | 455% | 36 (32.7) | | 21 (19.1) | |
| | Very confident | 20 (18.2) | | 15 (13.6) | | 12 (10.9) | |

Results are presented as number (N) and percentages (%)

highest percentage. This is followed by Public Regional Hospitals. In terms of antimicrobial resistance, a similar pattern was seen as well. However, the assessment of knowledge of ASP in different fields of practice, results showed that all public fields of practice appeared to know ASP according to their response. Overall, the significant majority of the respondents can be said to know about antimicrobials, resistance and the workings of ASP in their various fields of practice.

**Leadership commitment to ASP:** On the score of leadership commitment (Table 2) for the ASP in respondents' institutions, analysis of results shows that most of the healthcare facilities have an ASP established. This represented a significant 66.4% positive response ($p = 0.001$). In conducting daily stewardship interventions, only 49.1% affirmed this action, but 34.5% of the respondents were not aware of whether this happens daily. In terms of support from the program, 56.4% agreed that there is the availability of monitoring teams that ensure that

Table 2: Shows responses on availability of an antimicrobial stewardship program and leadership commitment to the program

| Questions | Frequency in numbers of responses N (%) Yes | No | Not aware | p-value |
|---|---|---|---|---|
| **Availability of the antimicrobial stewardship program** | | | | |
| Would you consider antimicrobial resistance as a serious problem? | 106 (97.2) | 1 (0.9) | 2 (1.8) | 0.001 |
| If there is the availability of an antimicrobial stewardship program in the facility/hospital | 73 (66.4) | 37 (33.6) | 0 (0) | 0.001 |
| **Leadership commitment to the program** | | | | |
| Dedication to provision of stewardship program leader(s) in program management and conducting daily stewardship interventions | 54 (49.1) | 18 (16.4) | 38 (34.5) | 0.041 |
| Provision of resources to include IT support, training by the leader(s) to effectively operate the stewardship program | 54 (49.1) | 16 (14.5) | 40 (36.0) | 0.073 |
| Availability of committee monitoring teams that help to ensure the program has resources and support to accomplish its mission | 62 (56.4) | 15 (13.6) | 33 (30) | 0.004 |
| Commitment by the leadership to guarantee that antibiotic stewardship activities are included in other quality improvement and patient safety efforts, such as sepsis management and diagnostic stewardship | 61 (55.5) | 15 (13.6) | 34 (30.9) | 0.279 |
| Facility program support to enrolment and reporting into the National Antimicrobial Resistance Committee (AMR) and national antimicrobial stewardship program (ASP), including any necessary IT support | 43 (39.1) | 16 (14.5) | 51 (46.4) | 0.140 |

Results are presented as the number (N) of responses and percentages (%) with statistical significance difference taken at $p \leq 0.001$

resources and support are provided (49.1%). The table also showed that there is a commitment by leadership to ensure that ASP activities are integrated into diagnostic stewardship and this was by 55% of the respondents. However, 46.4% reported that they were unaware of this function.

Leadership commitment results, in terms of fields of practice, are described in Fig. 4a-b. Results in Table 2 show an overall agreement as to its availability with a record of 49.1%. However, out of this, the public tertiary hospitals had the highest "yes" responses (57.4%) followed by public regional hospitals with 13% (Fig. 4a). This indicates that overall "no" and "not aware" responses were recorded at 50.9% (Table 2), therefore, meaning that leadership commitment was not adequately managing the program in terms of conducting daily stewardship interventions. Concerning leadership providing resources such as IT support, the responses that affirmed this provision were 49.1%. Indicating that support was not given to almost half of the facility practices places. However, out of the agreed responses, 53.7% were from public tertiary hospitals, with 16.7% from public regional hospitals. Analysis of overall responses with Pearson Chi-Square revealed a statistical significance of 0.010. In terms of leadership commitment to monitoring the program to ensure the accomplishment of ASP mission/goals, 56.3% of respondents agreed compared to "no" responses, which gave a significance difference of 0.007. Again, Public Tertiary Hospital gave the highest positive response compared to other fields of practice sites (Fig. 4b). On the question of whether ASP integrates patient safety by improving the quality of treatment, only 55.7% of public tertiary hospitals had this aspect of provision. Indicating that 13.6% did not have this provision for their ASP and with 31% of them not being aware, it leaves a lot of room to improve upon.

**Utilizing a pharmacist's expertise in the ASP:** Following the role of pharmacists within the ASP, 66.4% agreed that they are leading implementation efforts to improve antimicrobial use and this is significant with $p = 0.001$ (Table 3) compared with the "no" response. However, the results in the table also showed that 36.4% of responders did not have any knowledge that the program provided any training experience for them, while 11.8% said "no" to the availability of the training program. Furthermore, 54.5% of them agreed that there is adequate provision needed to perform the prospective audit. Additionally, 58.2% significantly affirmed that there is a preauthorization for specific antibiotics which gave a significant difference in comparison to those who are not aware ($p = 0.004$). Moreover, 59.1% of respondents agreed that there is adherence to precise treatment recommendations centered on National guidelines and local susceptibilities of pathogens. This is to assist antibiotic selections for familiar clinical specifications to stem the tide of resistance (Table 3). The study also evaluated the role of utilizing Pharmacists' expertise in different facilities, like daily reports to the National Antimicrobial Resistance Committee (AMR) and ASP, antibiotic use, training, implementation and feedback. Results revealed that ASP at public tertiary hospitals has this provision in place with 48.3, 47.9, 47.4 and 43.3%, respectively compared to other fields of practice (Fig. 5a-b).

**Tracking antibiotic use and outcomes by the program:** Analysis of results by respondents showed a low percentage regarding ASP implementation in their facilities on the frequency by which patients are discharged on the correct antibiotics and for the advised durations. Again, 38.2% were not aware that this was in place. Less than 41% of the

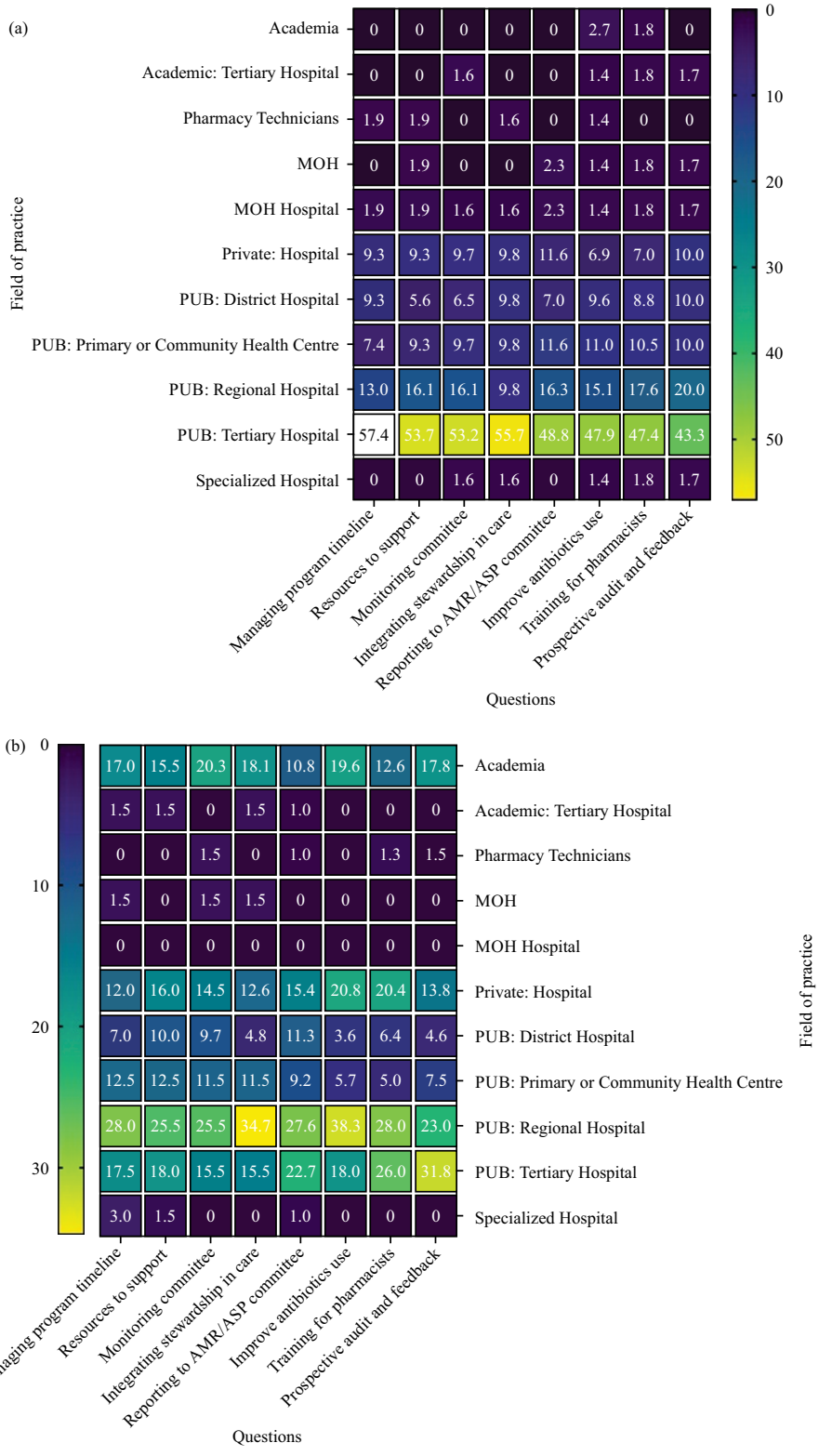


Fig. 4(a-b): Field of practice responses to leadership commitment to ASP and its' policy implementation, (a) Displays "yes" responses by various fields of healthcare practices for being aware of leadership commitment to the ASP program and the implementations of the policies and (b) Exhibits "no" responses by various fields of healthcare practices for to being aware of leadership commitment to the ASP program and the implementation of the policies

MOH: Ministry of Health and PUB: Public

Table 3: Responses on antimicrobial stewardship program policies regarding pharmacy expertise, improved antibiotic use and its' tracking with outcome

| | Frequency in numbers of responses N (%) | | | |
|---|---|---|---|---|
| Questions | Yes | No | Not aware | p-value |
| **Pharmacy expertise** | | | | |
| Availability of pharmacist(s) in the facility who are accountable for leading implementation efforts to improve the use of antibiotics | 73 (66.4) | 14 (12.7) | 23 (20.9) | 0.001 |
| Availability of specifically trained pharmacist(s) and/or with antibiotic stewardship experience that lead implementation attempts in the facility | 57 (51.8) | 13 (11.8) | 40 (36.4) | 0.041 |
| **Act of the implementation to improve antibiotic use** | | | | |
| Adequate provision in the facility of the requirements that are needed to carry out the potential audit and feedback for the given antibiotic agents | 60 (54.5) | 16 (14.5) | 34 (31) | 0.073 |
| Execution of preauthorization for antibiotic agents in the facility | 64 (58.2) | 7 (6.4) | 39 (35.4) | 0.004 |
| Specification in the facility of exact treatment approvals based on national guidelines and local susceptibilities of pathogens, to help with the selection of antibiotic selection aimed at customary clinical conditions | 65 (59.1) | 14 (12.7) | 31 (28.2) | 0.279 |
| **Tracking antibiotic use and outcomes** | | | | |
| Estimation by the ASP on how often patients are discharged on the correct antibiotics and for the duration recommended | 53 (48.2) | 15 (13.6) | 42 (38.2) | 0.140 |
| Tracking by ASP of resistance to antibiotic through submissions to the AMR and ASP | 45 (40.9) | 18 (16.4) | 47 (42.7) | 0.238 |
| Monitoring by prospective audit and feedback interventions in the ASP through tracking the types of interventions and reception of recommendations | 53 (48.2) | 12 (10.9) | 45 (40.9) | 0.026 |
| Does your antibiotic stewardship program supervise preauthorization intermediations through tracking agents being requested and for the conditions? | 57 (51.8) | 13 (11.8) | 40 (36.4) | 0.079 |
| Checking of adherence to facility-specific treatment recommendations through the stewardship program | 57 (51.8) | 13 (11.8) | 40 (36.4) | 0.079 |
| Tracking of CDI in the context of antibiotic use by the stewardship program track | 46 (41.8) | 11 (10.0) | 53 (48.2) | 0.265 |
| If the facility organizes an antibiogram (cumulative antibiotic susceptibility report) for the ASP | 56 (50.9) | 13 (11.8) | 41 (37.3) | 0.070 |

Results are presented in numbers (N) and percentages (%) and p-value represents significance using Pearson Chi-square analysis of percentage frequencies

respondents said that their facilities tracked antibiotic resistance by submitting reports to AMR and ASP (Table 3). On monitoring prospective audit and intervention tracking coupled with recommendations, only 48.2% affirmed that the practice is ongoing in their facilities. However, monitoring adherence to treatment recommendations and submitting an antibiogram report for antibiotics used recorded above 50% affirmative response. It is envisaged that ASP should share facilities reports on drug use and examine adherence to treatment recommendations. Also, it should perform medication use evaluation to assess the course of therapy to improve the management of infections.

On the assessment of responses from different fields of practice, public tertiary hospitals followed by public regional hospitals affirmed with 45.3 and 20.8%, respectively that patients are discharged on the correct antibiotics and for specified periods (Fig. 5a). Also, the tracking of antibiotic resistance by reporting into the AMR database as provided by ASP in public tertiary hospitals and public regional hospitals had 44.4 and 15.6%, respectively in agreement with these, more than that of other fields of practice as observed in the present study. Monitoring prospective audits and interventions tracking also showed that public tertiary hospital and public regional hospitals had the highest positive responses compared with other fields of practice. The same trend was observed by monitoring adherence to treatment recommendations and submitting an antibiogram report for antibiotics used. Furthermore, the practice of tracking *Clostridioides difficile* infection (CDI) in the context of antibiotic use appeared to have an overall 42% from all the fields of practice (Table 3), but more in the public tertiary hospitals than any other practice facilities as shown in Fig. 5a.

**Education of personnel to improve antimicrobial prescribing and reduce antibiotic resistance:** On ASP continuing education, which is an important aspect of implementation and effective monitoring to ensure the success of the program, 50% of the respondents stated that their facilities provided education to enlighten them on optimal prescribing, antibiotic resistance and adverse reactions (Table 4). However, 36.4% of respondents said they are not aware of any educational program that would help them enhance ASP in their healthcare facilities. Furthermore, the same percentage (41.8%) of the respondents either agreed to or were not aware of the education provided as part of a potential audit and feedback procedure (Table 4). Comparison of fields of practice responses concerning education to prescribers, on antibiotic resistance and adverse drug reactions, public tertiary hospitals and public regional hospitals ASP provided education to staff with 54.5 and 12.7%

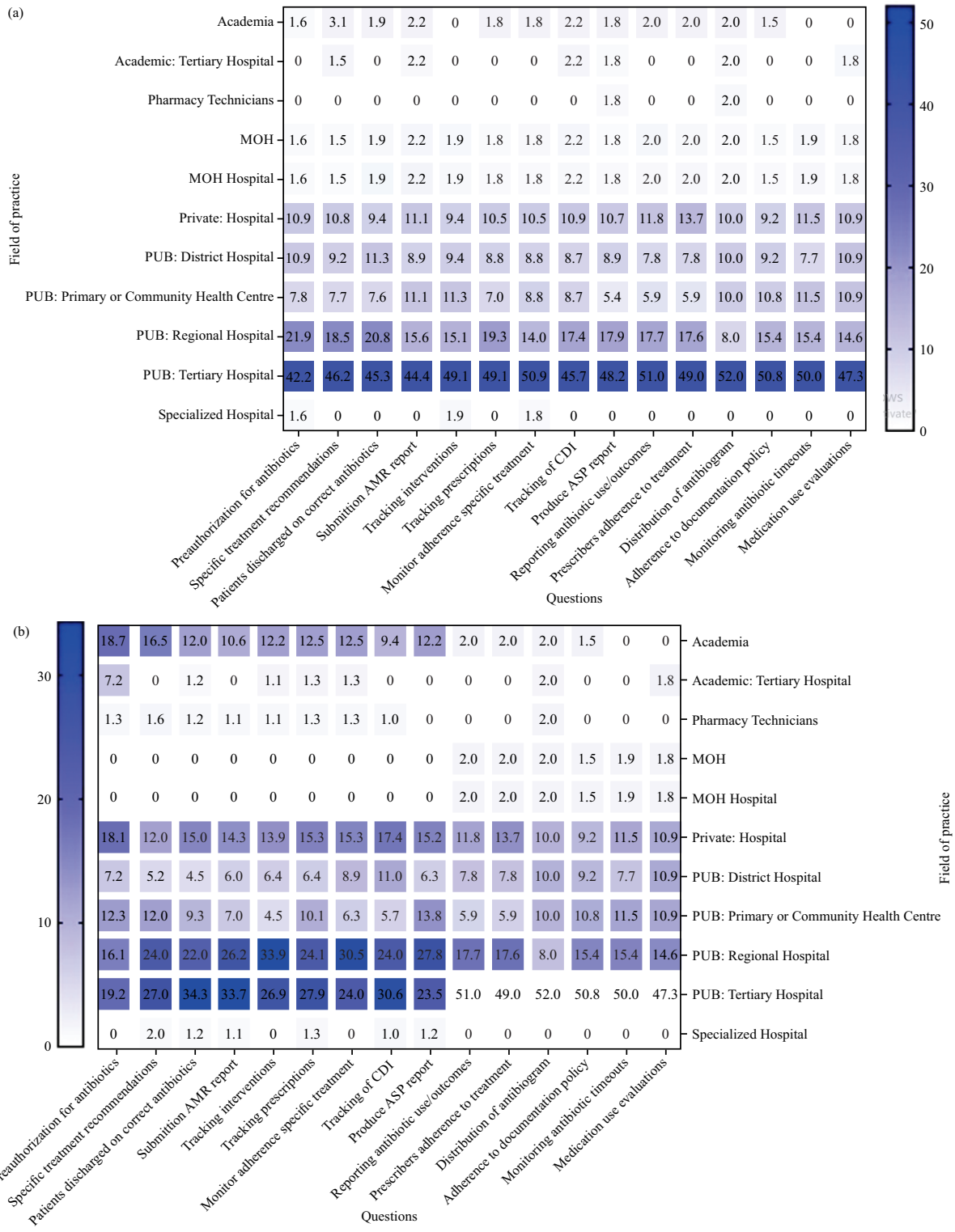


Fig. 5(a-b): Heatmap comparing field of practice responses to ASP actions in implementation, intervention and tracking of antibiotic use, (a) Different fields of practices for "yes" responses to being aware of various implementations, interventions and tracking of use of antibiotics and (b) Demonstrates different fields of practices for "no" or "not aware" of responses to being aware of various implementations, interventions and tracking of use of antibiotics

MOH: Ministry of Health, PUB: Public, AMR: Antimicrobial resistance and CDI: *Clostridium difficile* infection

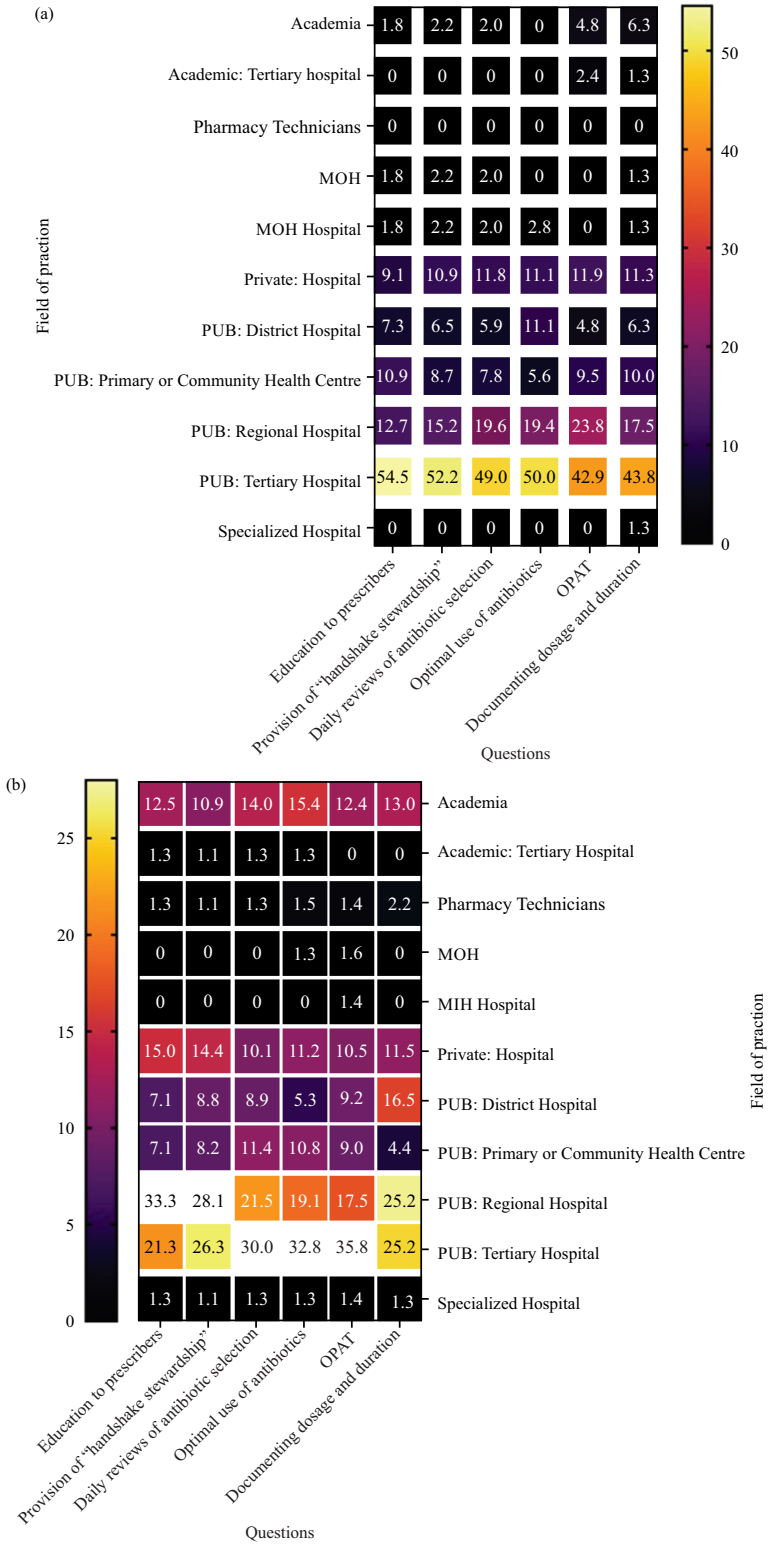


Fig. 6(a-b): Heatmap showing field of practice responses to ASP instituted educational program, daily reviews and documentation, (a) "Yes" responses by the different fields of healthcare practitioners to being informed of educational, daily reviews, and documentation programs implemented and (b) Respondents answers to "no/not aware" the availability of educational, daily reviews and documentation programs implemented for the ASP

MOH: Ministry of Health, PUB: Public and OPAT: Outpatient Parental Antibiotic Therapy

Table 4: Responses on tracking/monitoring implementation and interventions to improve antibiotics use and outcomes

| | Frequency in numbers of responses N (%) | | | |
|---|---|---|---|---|
| Questions | Yes | No | Not aware | p-value |
| **Tracking and monitoring of antibiotic use and outcomes** | | | | |
| If there is provision for sharing of and/or individual prescriber-specific reports on antibiotic use with prescribers in the ASP | 51 (46.4) | 15 (13.6) | 44 (40.0) | 0.125 |
| Reporting of adherence to treatment recommendations to prescribers (e.g., results from medication use evaluations, etc.) in the ASP | 51 (46.4) | 16 (14.5) | 43 (39.1) | 0.112 |
| Put in place a means by which the facility distributes current antibiogram to prescribers | 50 (45.5) | 17 (15.5) | 43 (39.1) | 0.002 |
| Performs the monitoring of adherence to documentation policy (dose, duration and indication) by the antimicrobial stewardship program | 65 (59.1) | 10 (9.1) | 35 (31.8) | 0.002 |
| If the antibiotic stewardship program monitors the performance of antibiotic timeouts, see how often these are done and if prospects to improve use are being acted on during timeouts | 52 (47.3) | 12 (10.9) | 46 (41.8) | 0.016 |
| Routine performance of medication use for evaluating assessment courses of selected antibiotic therapy and infections to identify opportunities to progress their use in the ASP | 55 (50.0) | 16 (14.5) | 39 (35.5) | 0.014 |
| **Provision of education** | | | | |
| Availability in the facility, a formal procedure for prescribers to conduct daily reviews of antibiotic selection up to establishing a definitive diagnosis and treatment duration (i.e., time out) | 51 (46.4) | 20 (18.2) | 39 (35.5) | 0.281 |
| Facility has specific interventions (e.g., ensuring correct discharge duration of therapy) to make sure of optimal use of antibiotics in treatment for most common infections in hospitals | 36 (32.7) | 39 (35.5) | 34 (30.9) | 0.320 |
| Performance by the facility in reviewing the planned outpatient parenteral antibiotic therapy (OPAT) | 42 (38.2) | 31 (28.2) | 37 (33.6) | 0.361 |
| Facility has in place policies that require prescribers to document in the medical record or during order entry, a dose, duration and indication for all antibiotic prescriptions | 80 (72.7) | 7 (6.4) | 23 (20.9) | 0.336 |

Responses on tracking/monitoring implementation and interventions to improve antibiotics use and outcomes

respective responses (Fig. 6a-b). In addition, in these two fields of practice, ASP appeared to have a better implementation in terms of prospective audit and feedback process sometimes called "handshake stewardship".

**Implementation and intervention to improve antibiotic use:** In implementing ASP as an effective tool, a formal procedure to conduct daily reviews of antibiotic selection will help in establishing treatment duration for a definitive diagnosis. In this regard, only 46.4% of the respondents (as shown in Table 4) affirmed that their institutional ASP facilities practice this aspect. While 35.5% were not aware of this, given an overall p-value of 0.281, an analysis also included the "no" respondents. Furthermore, respondents from different Health facilities agreed that no interventional practice was experienced in the program delivery. The interventions were to assist in making certain the optimal use of antibiotics for common infections. Their responses were 32.7% for "yes", 35.5% for "no" and 30.9% for "not aware" respectively with an overall p-value of 0.321 (Table 4).

From the results analysis (Table 4), it appears that the majority of respondents reported a low implementation level of the program performance in the area of planned Outpatient Parental Antibiotic Therapy (OPAT) 38.2, 28.2 and 33.6%, respectively. These observed negative affirmations are displayed in Table 4. However, on the practices of implementing medication records relating to dose, period and indication for antibiotic use, for all treatments, 72.7% responded in affirmative. Fields of practice responses in terms of ASP implementing formal procedures for all prescribers to direct daily reviews of antibiotic selection, timeout and planned Outpatient Parenteral Antibiotic Therapy (OPAT) were analyzed (Fig. 6). Results showed that only public tertiary hospitals and public regional hospitals recorded 42.9 and 23.8%, respectively out of an overall "yes" response of 38.2%, indicating that ASP of most facilities do not have these provisions to actualize the delivery of an effective program (Fig. 6a). However, this was in contrast with implementing prescribers' documentation of doses, duration and indication for antibiotic use. Therefore, it appears that with a 73% positive response, most ASPs are implementing this policy (Fig. 6a-b).

## DISCUSSION

The global perspective in actualizing optimal antibiotic prescribing through ASP is to see a reduction in antibiotic resistance development and improved patient outcomes. This is so because continued exposure to antibiotics without any form of control is critical to patients' safety, outcome and eventual loss of antibiotic efficacy. Therefore, it is envisaged that instituting and implementing ASP within all the core established elements in different fields of practice can improve antibiotic use. The study evaluated the extent of ASP implementation in various fields of healthcare practice by examining their knowledge and practice of ASP core

elements since the inception in this region of the Kingdom of Saudi Arabia (KSA). Results showed the respondent's claim of being highly aware of the universal challenges due to resistance to antimicrobial resistance, as well as those of the Gulf Region and Saudi Arabia. The high percentage (94%) of this affirmation was consistent with earlier reports of Baraka *et al.*[23] and Alanazi *et al.*[24]. Healthcare experts have generally been reported to be aware of the crisis faced globally as the result of antimicrobial resistance[8,17]. Thus, the results here are not unexpected and are in line with those of other reports. This realization of the gravity of the public health challenges due to AMR is probably the required impetus to tackle this global problem[25] and enhance the search for alternatives. However, that there are individual levels of confidence in antimicrobials with an overall 45.5% implies that there are still gaps that need to be bridged to attain the desired goals.

The cumulative 30% number of respondents who were confident that ASP was available in their healthcare facilities is considered low and in line with those of a previous report of Baraka *et al.*[23]. This could simply mean that more than half of the healthcare facilities in this region are yet to implement the ASP and this might be due to several contributory factors. Worthy of note is that the majority of the 30% who expressed confidence in ASP were respondents working in public tertiary and public regional hospitals, thus, showing variabilities between the different sectors of healthcare facilities, a view that had also been expressed previously[19]. Besides, the results here conform with those of earlier reports of Alghamdi *et al.*[19] and Baraka *et al.*[23], which means that since the inception of the ASP in the Kingdom in 2014, more than half of healthcare facilities in this region of KSA have not either instituted ASP or simply fallen behind in the implementation of the program. The reasons could be the lack of adequate resources needed for managing and monitoring the start of the program as well as its implementation[19,23]. The possibility of a lack of leadership commitment, as seen from the results analysis, could be a contributing factor. This has led to recommendations for the provision of internal policies and guidelines suitable for local ASP implementations[23].

The majority who expressed knowledge of both AMR and confidence in ASP is in the public field of practice, indicating that the program, besides being instituted in their workplaces, also shows the availability of the resources required for its implementation. It is therefore, pertinent that as AMR by bacterial pathogens is on the rise, all concerned healthcare policy managers will be required to step up the need for a successful implementation of the program. Therefore, to include primary and private hospitals as well as communities with smaller healthcare facilities that might not have the required resources. Besides, ASP in KSA, according to a recent report, ASP is considered to be at an early phase and, hence, needs a high level of commitment[26] that might accelerate the progress of implementation that would cut across both public and private sectors.

Therefore, in terms of leadership commitment to ASP, the significantly positive (66.4%) response seen here is in harmony with that of a recent report in Saudi Arabia[19]. However, the responses as regards the part of the program that supports reporting to the National Antimicrobial Resistance Committee and the national antimicrobial stewardship program as seen here, show that the overall leadership commitment is yet on the pedestal of excellence. Again, there might be barriers in human and technological resources[27]. In this report, 49.1% affirmed adequate provision of IT support, which shows that more than half of the facilities had no provision for this. The importance of adequate IT provision for the success in the implementation of ASP cannot be over-emphasized as the lack of such resources is said to be a hindrance to the program[28].

Another main objective of ASP is basically to optimize and improve antibiotic use by pharmacists. Hence, on the availability of pharmacists needed for running the program, the results here are similar to those of a previous report of Abdul Haseeb *et al.*[26] and Garau and Bassetti[29], which highlighted the need of expert pharmacists for improved use of antibiotics. The results about utilizing Pharmacists' expertise in ASP as recorded here showed that a response of 66.4% to the fact that they are being consulted because of their profession. This is because they are the drug experts as well as dispensers of all medications. This level of utilizing Pharmacists' expertise is still low considering the number of years the ASP has been instituted in the region of study. Particularly, with the American Society of Health Systems Pharmacists (ASHP-2010) who recommended that Pharmacists should be co-leaders in ASP[30]. From the foregoing, therefore, Pharmacists have a role to promote the most favorable use of antimicrobial agents and educate patients, the public and other healthcare professionals on how to use drugs[31]. Hence, the utilization and leading of Pharmacists in influencing antimicrobials prescribing will also help to minimize resistance development which is the main cornerstone of ASP. Current study shows that there is more room to increase the participation of Pharmacists to enhance the modest gain ASP has made so far. Generally, for ASP implementation and interventions to fully achieve its goals, Pharmacists should be co-leaders. For this to be realistic, training to help them perform tasks like prospective audit, preauthorization of specific antibiotic use and monitoring

adherence to treatment recommendations according to the National guidelines. This is because the National guidelines recommendations follow local pathogen susceptibility. Furthermore, the study found that Public tertiary hospitals (PTHs) and public regional hospitals (PRHs) appeared to have utilized Pharmacists' expertise in their ASP more as compared to other fields of practice in the region of study. Previous studies have shown that Pharmacists' role appeared to be limited according to Broom *et al.*[32], as most of the responsibilities are vested in Physicians.

Generally, implementation and monitoring of antibiotic use and outcome happen to be one of the major elements of the ASP according to reported studies of Chukwu *et al.*[33], which documented the CDC mandate to every acute care hospital in the US to establish the program. This aspect of the ASP element is to systematically measure and coordinate the improvement of antibiotic use in all its ramifications[34]. In the present study, the level of policy implementation and monitoring antibiotic use was low as many respondents were not aware of this policy. However, amongst different fields of practice, our results revealed that tracking implementation efforts to better the use of antibiotics was established in PTHs and PRHs compared to others. This finding is similar to those of a recent report, which documented implementing ASP in a tertiary hospital improved antibiotic use, indicating the positive effect of instituting the program[35].

Tracking of antibiotic use and patients' outcomes is another core element of ASP as listed by CDC[36]. The aim is to create a database of antibiotic use and outcomes and share such information across the spectrum of healthcare facilities within the local environment by the core element. In the present study, tracking of antibiotic use in terms of discharged patients, resistance, monitoring prospective audit and interventional tracking were below 50% positive responses. Hence, for ASP to be successful in combating antibiotic resistance in this region, tracking and monitoring antibiotic use and sharing such information is a key tool[37]. Although in the various Fields of Practice like PTHs and PRHs, ASPs are modestly implementing this element better than others, therefore the desired mark is yet to be met for a successful resistance reduction. Tracking *C. difficile* infections (CDI), with antibiotic use, is an important target for their use and outcomes. Improved antibiotic use prevents these infections[33]. This aspect of ASP tracking appeared to need improvement in the present study as achieving good patient outcomes depends on it. From our result analysis, only PTHs are in the forefront but still below 50% to responses received.

Additionally, education is a key element in delivering a sound ASP, that is to train, track, monitor and follow guidelines and recommendations. It is an effective ASP tool that provides the impetus for optimal prescribing and reporting of adverse drug reactions[34]. It also provides information for the prospective audit and feedback process[33]. The present study reveals that though present, in a small scale and therefore inadequate in the various healthcare facilities' responses. This is reflected in the fact that 36.4% were not aware of any educational program being given by ASP. The contemporary issue here is that patients need to be educated too as they also play key roles in stemming antibiotic resistance[35].

Therefore, ASP also ensures that regular updates in the form of education on all aspects of the core elements are disseminated. Particularly, providing updates on optimal prescribing, antibiotic resistance and feedback[37]. Furthermore, education helps to share hospital-specific data emanating from a prospective audit of antibiotic use. Through this medium, improved prescribing could be achieved, particularly from an antibiogram of a similar patient situation within the proximal location. The current study found that comparing responses with the different fields of practice, about ASP educating healthcare workers within the practice sites, PTHs and PRHs showed the highest positive response, indicating that this practice is ongoing within their facilities. It can, however, be concluded that educating healthcare personnel and patients could lead to interventions and eventually measured outcomes in the use of antibiotics.

The ASP, according to their charter, includes regularly implementing interventions to improve antibiotic use, which is usually anchored on recommendations and procedures. These interventions are to see a significant reduction in unnecessary antibiotic use[20]. Therefore, intervention as an upstream tool will improve antibiotic prescribing amongst healthcare practitioners and ultimately stem the tide of resistance as a downstream achievement[36]. According to a recent report of Davey *et al.*[35], implementing ASP intervention in a tertiary hospital setting led to a significantly improved antibiotic selection and patient outcome. In this regard, the implementation of daily reviews of antibiotic selection as an interventional measure is to ensure optimal antibiotic use, therefore is a priority for the present and the future. Regular reviews of antibiotic selections may be based on restricting certain drugs due to associated adverse effects or patients' special conditions, done usually by an expert. Hence, certain antibiotics may need preauthorization by experts, thus enhancing optimization, particularly in critically ill patients. Conducting daily reviews in certain patients' situations is critical and it is implicit to establish treatment durations, particularly for a definite diagnosis when using broad spectrum agents and in combination. In the present study,

the practice of the ASP components is low according to respondents. Specifically comparing the "yes" and "not aware" respondents did not show any significant difference. This indicates that considering the importance of this in patients' outcomes, the area of study needs improvement in various fields of practice. Furthermore, ASP implementation of Outpatient Antibiotic Therapy (OPAT) protocols as an interventional measure, has been reported to reduce inappropriate medication use[37]. Hence, appropriate selection of antibiotics and prescribing during OPAT can be enhanced by using the restricted antibiotic list to be included in ASP protocol[38]. From our result analysis in the present study, responses about planned OPAT were inadequate with low percentage responses, even in most of the fields of practice, especially with a high percentage response of "not aware" of 33.6% compared to 38.2% of the "yes" response.

## CONCLUSION

The outcome of this present study revealed a good knowledge of antimicrobials, antimicrobial resistance and ASP, therefore indicating a significant ASP activity in the various fields of practice as per the responses received. However, to bring to fruition the gains of ASP fully, significant improvement is needed in the various areas of the core elements of the program. Particularly, in the area of leadership commitment to the program, tracking and monitoring antibiotic use, educating prescribers and sharing microbial behavioral information within local proximities of similar infections. The study also found that a considerable number of respondents were not aware that certain aspects of the program were being practiced within their healthcare facilities. Therefore, the implementation of ASP in this area of study needs improvement to achieve the program objective of contending with antimicrobial resistance and improved patients' outcomes.

## SIGNIFICANCE STATEMENT

An antimicrobial stewardship program (ASP) is an instituted practical approach aimed at educating and training prescribers, with administrators in healthcare settings. The program aims to promote the appropriate use of antibiotics and enhance patients' outcomes. In this regard, the concept, if properly practiced, will stem the tide of antibiotic resistance. These reports have shown that nine years after ASP institution in the area of the present study, awareness of antibiotic resistance and its attendant problems is good. However, there is a slow pace observed in implementing the core elements of ASP, particularly in terms of leadership that should drive the program, due to a lack of commitment to the program. Hence, to combat the scourge of antibiotic resistance, healthcare providers and practitioners should be more committed to the program.

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