Risk Management and Healthcare Policy

Dovepress
Taylor & Francis Group

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ORIGINAL RESEARCH

Healthcare Professionals' Knowledge and Attitudes Toward Antimicrobial Stewardship Programs in Aseer, Saudi Arabia: A Cross-Sectional Study

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Background: Antimicrobial stewardship programs (ASPs) are initiatives designed to reduce the spread of antimicrobial resistance (AMR). ASPs enhance antimicrobial use, prevent errors, maintain guidelines, and monitor usage to reduce AMR.

Objective: This study aims to shed light on healthcare professionals' (HCPs) knowledge, experience, and attitudes regarding ASPs.

Methods: This quantitative cross-sectional study, approved by the Research Ethics Committee at King Khalid University (ECM#2022-2023) was conducted in the Aseer region, Saudi Arabia. A validated self-administered online survey was distributed through various social media channels using snowball sampling between September 2022 and June 2024. The data from the online survey was analyzed using IBM SPSS Statistics.

Results: The sample included 388 participants. Just over half (53.1%) were male, and the remainder (46.9%) were female. Although a slight majority (54.9%) reported familiarity with ASPs, a professional practice gap was found; only 143 (36.9%) of the participants had direct experience working with such programs, while 64.7% reported inadequate training opportunities as a barrier to effective ASP implementation followed by lack of resources, lack of internal policies and guidelines, time constraints and lack of manpower (54.1%, 52.1%, 48.2% and 45.9%, respectively). Despite the high level of awareness across both genders and all HCPs, only half of the participants correctly identified that cutting antibiotic costs is not the primary goal of ASPs. There were significant differences among participants' views toward repeated education and online resources ($p = 0.042$ and $p = 0.024$, respectively).

Conclusion: While HCPs have a good understanding of AMR, a professional practice gap was found. Thus, the study recommends offering ongoing education and training programs for HCPs. Addressing implementation obstacles, such as resource limitations and unclear guidelines, is also essential.

Keywords: antimicrobial resistance, antimicrobial usage optimization, antimicrobial stewardship, implementation barriers

Introduction

Antimicrobial agents are used to fight against infectious diseases and have saved millions of lives worldwide. The ability of microorganisms to withstand previously effective antimicrobial agents is defined as antimicrobial resistance (AMR).[1] AMR is a critical global issue[2–14] and causes over 23,000 deaths annually.[6,9] Some studies project that this mortality rate could reach over 10 million by 2050.[11,15] Although AMR develops naturally, it is accelerated by the misuse of antimicrobials in healthcare, agriculture, and aquaculture.[1,3,7,9,12,13,16,17] Inappropriate use of antibiotics and widespread AMR raise concerns that antimicrobials may lose their sensitivity to a range of microorganisms.[18]

Antimicrobial stewardship programs (ASPs) aim to reduce AMR.[19] Typically, a multidisciplinary team within a healthcare institution directs an ASP to ensure patient safety and promote optimum antimicrobial treatment by selecting

Received: 4 December 2024
Accepted: 3 March 2025
Published: 12 March 2025

the proper antibiotics and their dosage and length of treatment.[20] The ASP team may consist of a variety of healthcare professionals (HCPs), including physicians, pharmacists, infection control specialists, microbiologists, nurses, allied health professionals, insurers, researchers, and government representatives.[20]

ASP implementations in Saudi Arabia is in the initial phase and more mandates more attention to make awareness towards rational antibiotic use in this country, with various regions in the country showcasing unique approaches to advance their antimicrobial stewardship programs. While Riyadh has historically been at the forefront of ASP initiatives, other regions in this country have also made significant strides in recent years.[21]

Although ASP guidelines, methods, and policies have been clearly defined by global[19] and national organizations, such as the National Health Service[22] and the Centers for Disease Control and Prevention,[23] studies have revealed lacking implementation of ASPs.[24–26] Another study claims that Middle Eastern and Gulf countries' ASPs are underperforming due to a lack of clear guidelines.[27,28] Baraka et al conducted a valuable review of ASP knowledge among HCPs in Saudi Arabia's eastern region and discovered lacking of information about ASPs is one of the challenges preventing their implementation.[29]

The Saudi Arabian Ministry of Health (MOH) established a national ASP strategy in 2014 as part of the Arabian Gulf's strategy to minimize the risk of AMR.[26,27] Nonetheless, as Alghamdi et al have noted, despite efforts to reduce AMR, ASP implementation remains uncommon due to a lack of ASP knowledge and teams in Saudi hospitals.[26] Some studies claim that a lack of current information on ASPs hinders HCPs from adopting them.[24,29] More data should be collected to maximize the chances of ASP implementation success.[25]

Recent technological advancements have the potential to improve global ASP efforts significantly. Artificial intelligence (AI), for example, enhances the instant diagnosis of resistant bacteria by utilizing contemporary diagnostic techniques such as Kirby-Bauer disc diffusion and whole-genome sequencing. Moreover, AI can also help optimize pharmaceutical combinations, as proven by the enhanced efficacy of meropenem and polymyxin B against resistant bacteria.[30] Recognizing the potential of these technologies, the World Health Organization (WHO) and the Centers for Disease Control and Prevention (CDC) actively support using advanced data analytics and artificial intelligence in public health. Given the benefits of these technologies, they could be leveraged to boost ASPs.[31] Such applications may aid in optimizing antibiotic use and tracking resistance developments. To guarantee responsible implementation, the WHO has established regulatory frameworks such as transparency, data validation, cybersecurity, and data protection. These principles emphasize collaboration among regulators, healthcare experts, patients, industry, and governments to ensure that AI technology meets ethical norms and regulatory compliance.[31]

In Saudi Arabia, there is a dearth of literature on ASP awareness and perceptions among HCPs, especially regarding pharmacists in the Aseer region. It is evident that the involvement of all stakeholders in ASPs is vital, and their engagement in healthcare systems can help reduce inappropriate antibiotic usage.[20,32] Despite HCPs' knowledge of AMR, their awareness and practice of ASPs is limited.[24,33,34] Therefore, this study aims to assess HCPs' knowledge, awareness, and practice of ASPs in the Aseer region of Saudi Arabia, considering the perceived barriers, learning and training needs, and level of implementation.

Materials and Methods

Study Design and Site

This study employed a quantitative cross-sectional design. The data was collected between September 2022 and June 2024 using an anonymous online self-administered survey that was disseminated to various HCPs via social network platforms including WhatsApp, Telegram, and LinkedIn. Both male and female Saudi and non-Saudi HCPs were included in the study. We excluded healthcare students and interns as well as those outside the Aseer region.

Sample Size and Sampling Method

In 2023, the Saudi MOH estimated that the Aseer region had approximately 18,862 HCPs.[35] The OpenEpi website was used to calculate the sample size needed for this study.[36] To obtain a 95% confidence interval with a 5% margin of error,

the minimum required number of participants was found to be 377. We used the snowball sampling technique to recruit participants for the study.

Survey Development and Validation

The survey was created by adapting questions from a relevant study published earlier and the draft survey was validated.[29] To ensure its validity, two experts from King Khalid University's Department of Clinical Pharmacy independently assessed the relevance of each question to the study's objectives and provided feedback. Adjustments were then made based on their evaluations. Next, the initial survey was pilot-tested with 16 participants who met the inclusion criteria to confirm the clarity of the questions. Feedback from these respondents prompted further revisions. The data collected during the pilot test was not included in the final results or analysis.

The final survey consisted of five sections. The first section collected sociodemographic data. The second section determined whether the respondents had prior participation and expertise in ASPs. The third section included questions related to the presence and implementation of specific ASP policies in Aseer-region hospitals. The fourth section dealt with the identification of significant obstacles to ASP implementation. The last section survey assessed the HCPs' perceptions and attitudes regarding ASPs.

Data Collection

The survey was administered online (Google Forms) using social media platforms, including WhatsApp and Telegram, to facilitate data collection. We employed the snowball sampling technique to collect the data. Initially, the survey was distributed to the HCPs in the authors' circle, who were then asked to distribute the survey to their professional groups.

Data Analysis

The responses were exported from Google Forms to an Excel spreadsheet, cleaned and decoded, and then analyzed using IBM SPSS Statistics Version 29.0 for Mac. Descriptive statistics were used to analyze the demographic data and survey responses. A chi-squared test was used to compare the responses among the different healthcare professionals. A p-value of less than 0.05 was considered to indicate statistical significance.

Ethical Considerations

This study was approved by the Research Ethics Committee at King Khalid University (HAPO-06_B-001, ECM#2022-2023).

Results

Participant Characteristics

The demographics and professional backgrounds of the participants are summarized in Table 1. The study population consisted of 388 HCPs representing diverse cohorts of the medical community. The sample ages varied, with 37.4% being 30 years or younger, 39.4% between the ages of 31 and 40, and 23.2% aged 41 and above. Regarding nationality, about half of the participants (56.7%) were Saudi. Concerning profession, the majority were pharmacists (31.4%); physicians comprised 24.0% of the sample, followed by nurses at 19.1%. Pharmacy technicians accounted for 3.9%, dentists for 13.4%, allied medical scientists for 6.4%, and those in other healthcare-related fields for 1.8%. The Regarding gender, 53.1% were male, and 46.9% were female. The participants' experience levels varied, with 35.1% having over 10 years of experience.

Prior Participation and Expertise in AMR and ASPs

The participants' prior knowledge of and engagement with AMR and ASPs are presented in Table 2. The respondents were asked to provide "Yes" or "No" answers to the corresponding questions. While more than half of the respondents (54.9%) were familiar with ASPs and their components, only 36.9% had actual working experience with them. A high percentage of respondent (80.2%) reported increased AMR infections during the previous five years, with 64.2% reporting they had treated or dealt with patients with an antibiotic-resistant infection. Only 29.1% had received specific

Table 1 Demographic Information of the Participants (n = 388)

Characteristics	Frequency (n)	Percentage (%)
Age (years)		
30 or less	145	37.4
31–40	153	39.4
41 and above	90	23.2
Gender		
Male	206	53.1
Female	182	46.9
Nationality		
Saudi	220	56.7
Non-Saudi	168	43.3
Profession		
Physicians	93	24.0
Pharmacists	122	31.4
Pharmacy technicians	15	3.9
Nurses	74	19.1
Allied medical sciences	25	6.4
Dentists	52	13.4
Others	7	1.8
Experience (years)		
Less than 3	65	16.8
3–5	90	23.2
6–10	97	25.0
More than 10	136	35.1

Table 2 Participants' Prior Participation and Expertise in Antimicrobial Resistance and Antimicrobial Stewardship Programs

Items	Yes n (%)	No n (%)
1. Are you familiar with Antimicrobial Stewardship programs (ASPs) and their components?	213 (54.9)	175 (45.1)
2. Do you have previous Antimicrobial Stewardship experience?	143 (36.9)	245 (63.1)
3. In the past five years, have you observed an increase in antimicrobial-resistant infections?	311 (80.2)	77 (19.8)
4. Have you ever treated/dealt with patients having an antibiotic-resistant infection?	249 (64.2)	139 (35.8)
5. Have you ever felt forced to prescribe unsuitable antibiotics only because of the antibiotic policy of your institution?	104 (26.8)	284 (73.2)
6. Have you ever attended specific training related to ASPs?	113 (29.1)	275 (70.9)
7. Does your current institution have guidelines or policies for diagnosing and treating infectious diseases?	251 (64.7)	137 (35.3)
8. Have you worked at an institution that has/had ASPs?	205 (52.8)	183 (47.2)

training related to ASPs. Most respondents (64.7%) reported that their current institution had guidelines or policies for diagnosing and treating infectious diseases. When asked about experience with ASPs, 205 respondents (52.8%) affirmed having worked at an institution with an ASP, while 183 (47.2%) reported having no experience with such an institution.

Participant Knowledge of ASPs

The responses in Table 3 revealed a high knowledge level regarding the main aspects of ASPs. The vast majority of respondents (94.3%) believed that prescribers should specify the indication for antibiotic use on prescriptions. Similarly, 96.4% recognized that ASPs enhance individual patient care by ensuring appropriate antibiotic use. The survey also found that 93.3% of participants agreed seeking approval from an antibiotic stewardship team would enhance appropriate antibiotic prescriptions. Additionally, 91.5% of participants agreed that broad-spectrum antibiotic use exacerbates antibiotic resistance when more specific agents would suffice. Despite this high knowledge level, misconceptions existed,

Table 3 Participants' Knowledge Questions Regarding Antimicrobial Resistance and Antimicrobial Stewardship Programs

Knowledge Questions	Correct n (%)	Incorrect n (%)
1- Do you think that the prescribers should specify the indication for the antibiotic in the prescription?	366 (94.3)	22 (5.7)
(a) Yes		
(b) No		
2- An antibiotic stewardship program enhances individual patient care	374 (96.4)	14 (3.6)
(a) Yes		
(b) No		
3- Seeking approval from antibiotic stewardship team will enhance the rational antibiotic prescription.	362 (93.3)	26 (6.7)
(a) Yes		
(b) No		
4- The main objective of the antibiotic stewardship program is to curtail the hospital's antibiotic expenses.	190 (49.0)	198 (51.0)
(a) Yes		
(b) No		
5- Antimicrobial resistance is a global concern.	369 (95.1)	19 (4.9)
(a) Agree		
(b) Disagree		
6- Antibiotic resistance is exacerbated when broad-spectrum antibiotics are prescribed instead of more specific ones.	355 (91.5)	33 (8.5)
(a) Agree		
(b) Disagree		
7- It is always better to over-prescribe antibiotics than to under-prescribe.	246 (63.4)	142 (36.6)
(a) Agree		
(b) Disagree		
8- Antimicrobials can trigger fatal allergic reactions.	333 (85.8)	55 (14.2)
(a) Agree		
(b) Disagree		
9- Antimicrobial stewardship programs reduce problems of antimicrobial resistance	365 (94.1)	23 (5.9)
(a) Agree		
(b) Disagree		
10- Antimicrobial stewardship will help reduce hospitalization.	357 (92.0)	31 (8.0)
(a) Agree		
(b) Disagree		
11- Correct dosage adjustments for both children and adults are crucial.	368 (94.8)	20 (5.2)
(a) Agree		
(b) Disagree		
12- If symptoms improve before the full course of the antimicrobial is completed, the patient can stop taking it.	271 (69.8)	117 (30.2)
(a) Agree		
(b) Disagree		

Note: The correct answers are in bold.

with 51% incorrectly identifying the primary goal of ASP as curtailing hospital antibiotic expenses. A relatively low percentage of participants (63.4%) correctly identified whether it was always better to over-prescribe than under-prescribe antibiotics. A higher percentage (85.8%) recognized that antimicrobials can trigger fatal allergic reactions. Nearly all respondents (94.1%) recognized that ASPs reduce AMR problems. Additionally, 92% of them agreed that ASPs would help reduce hospitalization. A vast majority (94.8%) recognized that correct dosage adjustments for children and adults are crucial. A lower percentage (69.8%) correctly answered as to whether a patient can stop taking antibiotics if symptoms improve before the full course of treatment is completed.

Participant Attitudes Toward ASPs

The attitudes of the HCPs toward ASPs were overwhelmingly positive. A substantial majority of respondents (85.1%) agreed that repeated education and training on ASPs by infectious disease experts would be beneficial. Moreover, 81.2%

Table 4 Participants' Attitude Toward Antimicrobial Stewardship Programs (Highest in Bold)

Attitude-based Queries	Beneficial n (%)	Somewhat Beneficial n (%)	Not Beneficial n (%)
1- What is your opinion about having a hospital formulary, especially in selecting antimicrobials based on efficacy, toxicity, and cost?	303 (78.1)	80 (20.6)	5 (1.3)
2- What is your opinion about taking real-time feedback from other staff members regarding the proper usage of antibiotics?	315 (81.2)	71 (18.3)	2 (0.5)
3- What is your opinion about repeated education and training on ASP from infectious disease experts?	330 (85.1)	54 (13.9)	4 (1.0)
4- What is your opinion about the availability of online resources and clinical guidelines related to ASPs?	331 (85.3)	45 (11.6)	12 (3.1)
5- Making annual antibiograms available electronically to the prescribers and dispensers is	294 (75.8)	75 (19.3)	19 (4.9)
6- Making a specific ASP team readily available in your institution is	309 (79.6)	66 (17.0)	13 (3.4)
7- Getting a potential leadership support from your institution to implement ASP is	320 (82.5)	58 (14.9)	10 (2.6)
8- Having assistance from the computer application in the selection of individualized antibiotics based on the patient's characteristics is	299 (77.1)	79 (20.4)	10 (2.6)
9- Recommendations from pharmacists on alternative treatments for infections are	276 (71.1)	96 (24.7)	16 (4.1)
10- Easy access to the data on pathogens and their antimicrobial susceptibility testing results is	330 (85.1)	51 (13.1)	7 (1.8)

endorsed providing real-time feedback on proper antibiotic use from other staff members, and 78.1% considered hospital formularies based on efficacy, toxicity, and cost critical in antimicrobial selection. In addition, 85.3% of respondents advocated for the availability of online ASP resources and clinical guidelines as essential tools for improving stewardship practices. The details regarding the participants' attitudes toward ASPs are provided in Table 4.

Perceived Barriers to ASPs

The participants widely agreed on several barriers to ASP implementation (Figure 1). The most commonly mentioned barriers included inadequate training opportunities (64.7%), a lack of specialized ASP information resources (54.1%),

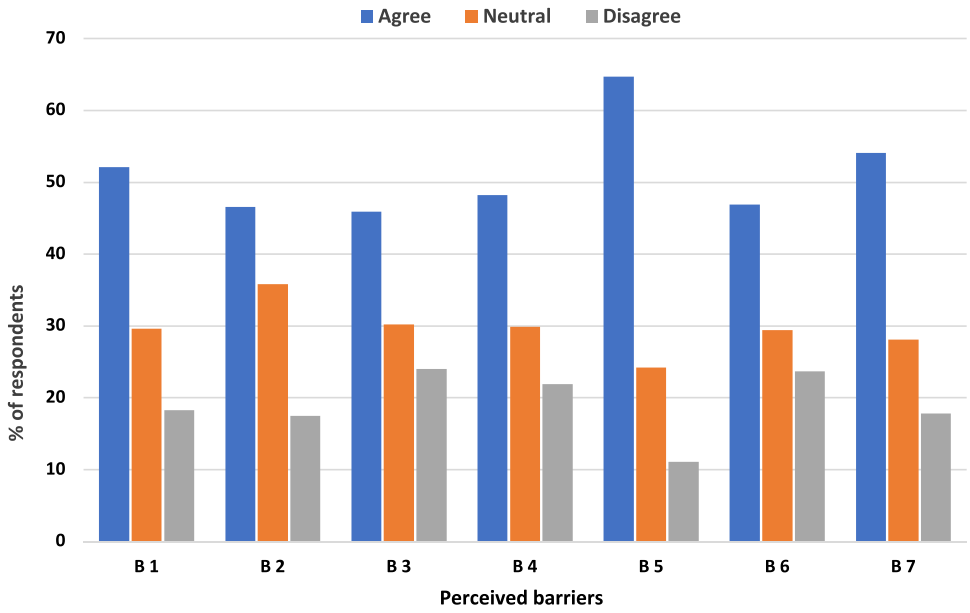

Figure 1 Perceived barriers to antimicrobial stewardship programs: (B1) Lack of internal policy/guidelines; (B2) Management is unfamiliar with ASPs; (B3) Lack of manpower; (B4) Lack of time, which identifies the time constraints faced by healthcare providers that can limit their ability to participate in and prioritize ASPs; (B5) Inadequate training opportunities; (B6) Financial issue or limited funding; (B7) Lack of specialized ASP information resources.

a lack of internal policies or guidelines (52.1%), time constraints (48.2%), and financial limitations (46.9%). In addition, approximately half of the respondents agreed that the management professionals of many institutions were unfamiliar with ASPs and that there was a lack of manpower (46.6% and 45.9%, respectively). Similarly, 54.1% of the respondents agreed that the lack of specialized ASP resources was a barrier to ASP implementation.

Participant Characteristics and Knowledge of ASPs

There were no significant differences across genders regarding knowledge of ASPs and their role in enhancing patient care, as shown in Table 5. However, significant differences were found among professions for certain items, including the belief that prescribers should specify the indication for an antibiotic in the prescription ($p = 0.028$) and the understanding of the global threat posed by AMR ($p = 0.047$). Other items, such as the beneficial effect of using more-specific

Table 5 Baseline Characteristics of Participants' Knowledge Regarding Antimicrobial Resistance and Antimicrobial Stewardship Programs

Knowledge Items	Correct Answers		p-value	Correct Answers							p-value
	Male (n=206), n (%)	Female (n=182), n (%)		Physicians (n=93), n (%)	Pharmacists (n=122), n (%)	Pharmacy technicians (n=15), n (%)	Nurses (n=74), n (%)	Allied medical sciences (n=25), n (%)	Dentists (n=52), n (%)	Other (n=7), n (%)	
1- Do you think that the prescribers should specify the indication for the antibiotic in the prescription?	196 (95.1)	170 (93.4)	0.46	91 (97.8)	117 (95.9)	15 (100)	68 (91.9)	24 (96.0)	44 (84.6)	7 (100)	0.028*
2- An antibiotic stewardship program enhances individual patient care.	197 (95.6)	177 (97.3)	0.393	92 (98.9)	115 (94.3)	15 (100)	71 (95.9)	25 (100)	50 (96.2)	6 (85.7)	0.307
3- Seeking approval from antibiotic stewardship teams will enhance rational antibiotic prescription.	196 (95.1)	166 (91.2)	0.122	87 (93.5)	115 (94.3)	14 (93.2)	69 (93.2)	22 (88.0)	48 (92.3)	7 (100)	0.929
4- The main objective of antibiotic stewardship programs is to curtail the hospital's antibiotic expenses.	97 (47.1)	93 (51.1)	0.43	47 (50.5)	62 (50.8)	7 (46.7)	29 (39.2)	13 (52.0)	30 (57.7)	2 (28.6)	0.427
5- Antimicrobial resistance is a global concern.	197 (95.6)	172 (94.5)	0.608	93 (100)	116 (95.1)	13 (86.7)	71 (95.9)	22 (88.0)	47 (90.4)	7 (100)	0.047*
6- Antibiotic resistance is exacerbated when broad-spectrum antibiotics are prescribed instead of more specific ones.	189 (91.7)	166 (91.2)	0.849	91 (97.8)	109 (89.3)	9 (60.0)	71 (95.9)	22 (88.0)	48 (92.3)	5 (71.4)	0.001*
7- It is always better to over-prescribe than to under-prescribe antibiotics.	129 (62.6)	117 (64.3)	0.734	56 (60.2)	80 (65.6)	7 (46.7)	42 (56.8)	15 (60.0)	42 (80.8)	4 (57.1)	0.092
8- Antimicrobials can trigger fatal allergic reactions.	176 (85.4)	157 (86.3)	0.816	86 (92.5)	105 (86.1)	13 (86.7)	60 (81.1)	19 (76.0)	44 (84.6)	6 (85.7)	0.339
9- Antimicrobial stewardship programs reduce problems of antimicrobial resistance.	194 (94.2)	171 (94.0)	0.927	87 (93.5)	117 (95.9)	14 (93.3)	70 (94.6)	22 (88.0)	48 (92.3)	7 (100)	0.782
10- Antimicrobial stewardship will help reduce hospitalization.	191 (92.7)	166 (91.2)	0.584	91 (97.8)	116 (95.1)	12 (80.0)	66 (89.2)	20 (80.0)	45 (86.5)	7 (100)	0.008*
11- Correct dosage adjustments for both children and adults are crucial.	196 (95.1)	172 (94.5)	0.776	91 (97.8)	118 (96.7)	14 (93.3)	67 (90.5)	21 (84.0)	50 (96.2)	7 (100)	0.061
12- If symptoms improve before the full course of the antimicrobial is completed, the patient can stop taking it.	141 (68.4)	130 (71.4)	0.523	65 (69.9)	87 (71.3)	11 (73.3)	47 (63.5)	18 (72.0)	39 (75.0)	4 (57.1)	0.825

Notes: For the chi-squared test, * indicates $p < 0.05$.

https://doi.org/10.2147/RMHP.S507235

antibiotics over broad-spectrum ones in reducing microbial resistance and the effectiveness of ASP in reducing hospitalization, showed significant differences among the professions (p = 0.001 and 0.008, respectively; Table 5).

Participant Characteristics and Attitudes Toward ASPs

The participants had positive attitudes toward several aspects of ASPs, without significant differences across genders (Table 6). Most participants recognized the importance of repeated ASP education and training, with a significant difference across professions (p = 0.042) and pharmacists giving the strongest endorsement (88.5%). Participants also

Table 6 Baseline Characteristics of Participants' Attitudes Regarding Antimicrobial Resistance and Antimicrobial Stewardship Programs

Attitude-based Queries	Baseline Characteristics										
	Male (n=206), n (%)	Female (n=182), n (%)	p-value	Physicians (n=93), n (%)	Pharmacists (n=122), n (%)	Pharmacy Technicians (n=15), n (%)	Nurses (n=74), n (%)	Allied Medical Sciences (n=25), n (%)	Dentists (n=52), n (%)	Other (n=7), n (%)	p-value
1. Hospital formulary											
Beneficial	159 (77.2)	144 (79.1)	0.701	83 (89.2)	92 (75.4)	12 (80.0)	56 (75.7)	18 (72.0)	36 (69.2)	6 (85.7)	0.067
Somewhat beneficial	45 (21.8)	35 (19.2)		9 (9.7)	29 (23.8)	3 (20.2)	18 (24.3)	7 (28.0)	13 (25.0)	1 (14.3)	
Not beneficial	2 (1.0)	3 (1.6)		1 (1.1)	1 (0.8)	0 (0.0)	0 (0.0)	0 (0.0)	3 (5.8)	0 (0.0)	
2. Real-time feedback											
Beneficial	168 (81.6)	147 (80.8)	0.380	74 (79.6)	99 (81.1)	11 (73.3)	60 (81.1)	20 (80.0)	44 (84.6)	7 (100.0)	0.560
Somewhat beneficial	36 (17.5)	35 (19.2)		18 (19.4)	23 (18.9)	4 (26.7)	14 (18.9)	4 (16.0)	8 (15.4)	0 (0.0)	
Not beneficial	2 (1.0)	0 (0.0)		1 (1.1)	0 (0.0)	0 (0.0)	0 (0.0)	1 (4.0)	0 (0.0)	0 (0.0)	
3. Repeated ASP education and training											
Beneficial	176 (85.4)	154 (84.6)	0.131	81 (87.1)	108 (88.5)	12 (80.0)	56 (75.7)	21 (84.0)	45 (86.5)	7 (100.0)	0.042*
Somewhat beneficial	26 (12.6)	28 (15.4)		9 (9.7)	14 (11.5)	2 (13.3)	18 (24.3)	4 (16.0)	7 (13.5)	0 (0.0)	
Not beneficial	4 (1.9)	0 (0.0)		3 (3.2)	0 (0.0)	1 (6.7)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	
4. Online ASP resources											
Beneficial	175 (85.0)	156 (85.7)	0.597	84 (90.3)	107 (87.7)	9 (60.0)	61 (82.4)	20 (80.0)	43 (82.7)	7 (100.0)	0.024*
Somewhat beneficial	26 (12.6)	19 (10.4)		7 (7.5)	12 (9.8)	4 (26.7)	11 (14.9)	2 (8.0)	9 (17.3)	0 (0.0)	
Not beneficial	5 (2.4)	7 (3.8)		2 (2.2)	3 (2.5)	2 (13.3)	2 (2.7)	3 (12.0)	0 (0.0)	0 (0.0)	
5. Making annual electronic antibiograms available											
Beneficial	150 (72.8)	144 (79.1)	0.136	73 (78.5)	96 (78.7)	10 (66.7)	56 (75.7)	15 (60.0)	39 (75.0)	5 (71.4)	0.083
Somewhat beneficial	42 (20.4)	33 (18.1)		13 (14.0)	23 (18.9)	2 (13.3)	17 (23.0)	8 (32.0)	11 (21.2)	1 (14.3)	
Not beneficial	14 (6.8)	5 (2.7)		7 (7.5)	3 (2.5)	3 (20.0)	1 (1.4)	2 (8.0)	2 (3.8)	1 (14.3)	
6. Making a specific ASP team available in your institution											
Beneficial	164 (79.6)	145 (79.7)	0.171	73 (78.5)	101 (82.8)	13 (86.7)	54 (73.0)	18 (72.0)	43 (82.7)	7 (100.0)	0.724
Somewhat beneficial	32 (15.5)	34 (18.7)		15 (16.1)	18 (14.8)	2 (13.3)	18 (24.3)	6 (24.0)	7 (13.5)	0 (0.0)	
Not beneficial	10 (4.9)	3 (1.6)		5 (5.4)	3 (2.5)	0 (0.0)	2 (2.7)	1 (4.0)	2 (3.8)	0 (0.0)	
7. Leadership support for ASP											
Beneficial	171 (83.0)	149 (81.9)	0.953	77 (82.8)	101 (82.8)	13 (86.7)	59 (79.7)	21 (84.0)	42 (80.8)	7 (100.0)	0.988
Somewhat beneficial	30 (14.6)	28 (15.4)		13 (14.0)	19 (15.6)	2 (13.3)	13 (17.6)	3 (12.0)	8 (15.4)	0 (0.0)	
Not beneficial	5 (2.4)	5 (2.7)		3 (3.2)	2 (1.6)	0 (0.0)	2 (2.7)	1 (4.0)	2 (3.8)	0 (0.0)	

(*Continued*)

Table 6 (Continued).

Attitude-based Queries	Baseline Characteristics										
	Male (n=206), n (%)	Female (n=182), n (%)	p-value	Physicians (n=93), n (%)	Pharmacists (n=122), n (%)	Pharmacy Technicians (n=15), n (%)	Nurses (n=74), n (%)	Allied Medical Sciences (n=25), n (%)	Dentists (n=52), n (%)	Other (n=7), n (%)	p-value
8. Computer-assisted antibiotic selection											
Beneficial	155 (75.2)	144 (79.1)	0.460	73 (78.5)	92 (75.4)	11 (73.3)	58 (78.4)	21 (84.0)	39 (75.0)	5 (71.4)	0.679
Somewhat beneficial	44 (21.4)	35 (19.2)		15 (16.1)	29 (23.8)	4 (26.7)	13 (17.6)	4 (16.0)	12 (23.1)	2 (28.6)	
Not beneficial	7 (3.4)	3 (1.6)		5 (5.4)	1 (0.8)	0 (0.0)	3 (4.1)	0 (0.0)	1 (1.9)	0 (0.0)	
9. Pharmacist recommendations											
Beneficial	138 (67.0)	138 (75.8)	0.074	62 (66.7)	98 (80.3)	12 (80.0)	48 (64.9)	17 (68.0)	33 (63.5)	6 (85.7)	0.224
Somewhat beneficial	56 (27.2)	40 (22.0)		27 (29.0)	20 (16.4)	3 (20.0)	23 (31.1)	8 (32.0)	14 (26.9)	1 (14.3)	
Not beneficial	12 (5.8)	4 (2.2)		4 (4.3)	4 (3.3)	0 (0.0)	3 (4.1)	0 (0.0)	5 (9.6)	0 (0.0)	
10. Easy access to pathogen data											
Beneficial	177 (85.9)	153 (84.1)	0.809	84 (90.3)	108 (88.5)	9 (60.0)	59 (79.7)	20 (80.0)	44 (84.6)	6 (85.7)	0.073
Somewhat beneficial	25 (12.1)	26 (14.3)		6 (6.5)	12 (9.8)	6 (40.0)	14 (18.9)	4 (16.0)	8 (15.4)	1 (14.3)	
Not beneficial	4 (1.9)	3 (1.6)		3 (3.2)	2 (1.6)	0 (0.0)	1 (1.4)	1 (4.0)	0 (0.0)	0 (0.0)	

Notes: For the chi-squared test, * indicates $p < 0.05$.
Abbreviation: ASP, antimicrobial stewardship program.

valued the availability of online ASP resources. However, there were significant differences among professions ($p = 0.024$), with physicians showing the highest support (90.3%; Table 6).

Discussion

Enhancing HCPs' knowledge and practice of ASPs can help curtail the frequency of antibiotic resistance and promote the responsible use of antibiotics.[37] Hence, it is essential to understand HCPs' current knowledge, attitudes, and practices regarding ASPs and their implementation. This study was conducted to assess these factors among HCPs in the southern region of Saudi Arabia. The study's participants demonstrated reasonable knowledge of ASPs and were willing to implement them in their clinical settings, similar to other HCPs worldwide.[38,39] A large proportion of our study participants also agreed that antibiotic resistance is a global problem, and that ASPs are a key strategy for containing it. It is a good sign that antibiotic resistance is perceived as a major health issue, as this is the first step in proper antibiotic use.[40] However, the participants reported a number of barriers to the implementation of ASPs. When compared with a similar study conducted recently in Jordan, which evaluated HCPs' practice of and attitudes toward ASPs,[41] the current study provides a deeper understanding and broader insights into how HCPs understand and perceive ASPs in addition to the barriers they experience in implementing them.

Despite exhibiting sufficient knowledge on some aspects of ASPs, a significant number of the participants demonstrated a deficiency in knowledge regarding antibiotic prescription and favored over-prescription of antibiotics and stopping the antibiotic course early if symptoms improve. Some of the participants also had the notion that the main objective of antibiotic stewardship was to curtail the hospital's antibiotic expenses. Over-prescription is an important health issue. Previous studies showed that restricting antibiotic use, a recommendation reinforced by ASPs, helps control potential antibiotic side effects and AMR.[42,43] According to the Infectious Diseases Society of America, optimizing the indication, selection, dosing, route of administration, and duration of antimicrobial therapy is an important aspect of maximizing the clinical cure or prevention of infection.[44] Multi-drug resistant microbial organisms—organisms that develop resistance to one or more of the antibiotics used to treat them—are another important concern.[45] These organisms tend to develop multi-drug resistance (MDR) as a result of the improper use of antibiotics, including the selection, dose, route of administration, and duration.[46]

Nearly half of the participants in the current study were unfamiliar with ASPs and had not had previous experience with them. Moreover, nearly two-thirds of the study population had not attended any specific training related to ASPs and their implementation. The majority of our participants were in strong agreement that MDR can be addressed only by implementing ASPs. Many studies support this view, stating that ASPs play a major role in promoting appropriate antimicrobial use.[47,48] We observed a highly positive attitude among our participants (85.1%) toward repeated education and training on ASPs from ASP experts. This finding is echoed by a previous study conducted among pharmacists, medical doctors, nurses, and medical laboratory scientists, which reported an improvement in knowledge on ASPs among those who received training (as demonstrated by the selection of appropriate and reduced empirical antibiotic prescriptions).[38] Given this finding and the responses of our participants, it is arguable that familiarizing HCPs with ASPs and providing continuing ASP training from infectious disease experts can assure the successful implementation of ASPs at healthcare institutions.[49]

Unfortunately, a considerable number of our participants had no prior ASP experience, and only 29.1% had attended specialist ASP training. This might be because ASPs are still being introduced in Saudi Arabia, and many institutions have not yet accepted them.[50] The majority of our respondents agreed that requiring prescribers to document indications for antibiotics is a vital strategy for implementing ASPs.

Based on the results of the current study, it is apparent that the participants had huge interest in electronic and online support to successfully overcome antibiotic resistance and implement ASPs. They showed positive attitudes toward improving the availability of online resources related to ASPs, obtaining an annual antibiogram electronically, receiving assistance from a computer application in the selection of individualized antibiotics based on patient characteristics, and providing easy access to data on pathogens and their antimicrobial susceptibility testing results. It has been reported by many studies that the failure to implement ASPs may be due to a lack of medical informatics resources, which results in limited timely information and an inability to monitor appropriate antimicrobial use and follow-up. Ensuring access to an information technology (IT) system for stewardship will greatly improve the quality of patient care.[51] The time leading up to appropriate antimicrobial therapy has also been directly correlated with successful treatment (ie, a longer time before effective therapy leads to higher mortality).[51,52] Therefore, ensuring access to information, such as on the microbiologic results of blood culture tests, and suitable antimicrobial agent selection would be highly beneficial. These results suggest that IT should be incorporated as a key component of ASPs to ensure their successful implementation. This aligns with a recent study conducted in Saudi Arabia highlighting the importance of interprofessional networks and collaborations among HCPs, such as on committee work and guideline composition, as facilitators for the implementation of ASPs.[53]

Hospital formularies are critical components of ASPs. Many of our study participants confirmed that rational antibiotic selection in the hospital formulary is a significant promoter of ASPs.[50] The hospital formulary provides guidelines on the appropriate use of antibiotics, including dosing, indications, and therapy duration, helping to avoid over-prescription. Moreover, the formulary can serve as a resource for clinician education on the latest evidence regarding antibiotic use and resistance. A well-managed formulary can also support infection control initiatives by guiding the choice of antibiotics that minimize the spread of resistant organisms. Therefore, providing a structured formulary plays a vital role in enhancing the effectiveness of ASPs, ultimately improving patient outcomes and combating antibiotic resistance.

Despite finding favorable attitudes toward ASPs, the current study revealed several barriers to their implementation. Most of the HCPs stated that a lack of ASP education and training programs, ASP specialist staff, specialized ASP information resources, internal policy/guidelines, and time were the most common barriers to ASP implementation, which aligns with previous findings.[50,53] Specialist training opportunities are needed to successfully develop and implement ASPs and initiate appropriate steps for the management of infectious diseases.[50] A lack of human resources, unfamiliarity with ASPs among management, and inadequate or limited funding were also reported as barriers to ASP implementation in the current study, supporting previous research findings.[54–57]

Limitations

This study's specific focus on the Aseer region means its findings might not apply across all healthcare settings in Saudi Arabia, potentially limiting its broader applicability. Its cross-sectional design also means it does not capture changes over time, such as shifts in policies or practices. The results could also be prone to biases, such as inaccurate recall. Sample imbalance is another possible limitation. Pharmacists and physicians together accounted for over half (55.4%) of the participants, which may have led to results more reflective of their perspectives and with limited representation of views from other HCPs. In particular, pharmacy technicians and allied health professionals were underrepresented, at just 10.3% of the sample. This imbalance could also limit the study's ability to fully grasp how ASPs are implemented across different healthcare roles and settings.

Conclusion

The findings demonstrate the substantial opportunities for improving the knowledge, experience and attitudes of ASPs among HCPs. Healthcare authorities and hospital management should take the initiative to provide periodical education programs and resources that address the knowledge gaps among HCPs and enhance ASP practices among HCPs. Furthermore, a rigorous effort is essential to overcome barriers to ASP implementation, including the establishment of clear guidelines, securing necessary manpower, and fostering more impactful response to this critical issue.

In light of these insights, we recommend initiating collaborative actions between healthcare institutions and professional organizations to develop and maintain a comprehensive database of ASP resources aimed at combating AMR and improving patient outcomes in Saudi Arabia.

Data Sharing Statement

The datasets are available from the corresponding author upon reasonable request.

Ethical Approval and Consent to Participate

Each participant signed a written informed consent form before enrolment. The survey was filled out anonymously, and the data was kept secret. There was no recognized danger to the trial subjects. Before the study began, the Research Ethics Committee of King Khalid University granted institutional ethical approval (E.C.M. #2022-2303).

Acknowledgment

The authors express their gratitude to King Khalid University, Saudi Arabia, for providing administrative and technical support.

Author Contributions

Each author significantly contributed to the project from its initial concept and study design to the actual execution and data collection. This included both conducting the analysis and interpreting the results. Furthermore, every author had a hand in either drafting or critically revising the manuscript. They also collectively agreed on the journal to which this article has been submitted. Every author reviewed and approved each version of the article before submission and during the revision process as well as the final version accepted for publication. Additionally, they agreed to any significant changes made during the proofing stage. All authors are committed to taking responsibility for the entire content of the article.

Funding

The authors extend their appreciation to the Deanship of Research and Graduate Studies at King Khalid University for funding this work through Large Research Project under grant number RGP2/391/45.

Disclosure

The authors report no conflicts of interest in this work.

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