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Healthcare commissioners' experience with antibiotic resistance during the COVID-19 pandemic in Saudi Arabia: a qualitative study

Hadi Jaber Al Sulayyim [a,b], Rohani Ismail[a], Abdullah Al Hamid[c] and Noraini Abdul Ghafar[d]

[a]Interdisciplinary Health Unit, School of Health Science, Universiti Sains Malaysia (Health Campus), Kubang Kerian 11800, Kelantan, Malaysia; [b]Saudi Ministry of Health, Najran Health Affairs, Infection Prevention and Control Department, Najran, Saudi Arabia; [c]College of Clinical Pharmacy, Department of Pharmacy Practice, King Faisal University, AlAhsa, Saudi Arabia; [d]Biomedicine Program, School of Health Science, Universiti Sains Malaysia (Health Campus), Kubang Kerian, Kelantan, Malaysia

ABSTRACT

Introduction: The occurrence of antibiotic resistance (AR) has become a critical issue during the Novel coronavirus disease 2019 (COVID-19) pandemic. This study explores the experiences of healthcare commissioners with AR during the COVID-19 pandemic, identifies challenges, and provides recommendations for combating AR during pandemics.

Methods: This qualitative study was multi-centered and used a phenomenological approach. Semi-structured interviews were conducted between December 2022 and January 2023 among 11 health commissioners using video calls.

Results: Seven themes emerged from the data, including knowledge of AR and its consequences, the antibiotic prescription system, the future of AR and potential contributory factors, the impact of COVID-19 on AR and their relationship, the experience of AR during the COVID-19 pandemic in healthcare facilities, barriers that prevent the misuse of antibiotics during pandemics, and recommendations regarding antibiotic resistance during pandemics.

Conclusion: The findings of this study could be used to inform policy and practice for government healthcare workers (HCWs) and the public. Furthermore, this study identified the main challenges of AR during the pandemic, and the recommendations of health commissioners were provided accordingly. Such recommendations could be beneficial on a national and international scale to reduce the impact of future pandemics on AR.

Abbreviations: COVID-19: Novel coronavirus disease 2019; AR: Antibiotic Resistance; IPC: Infection prevention and control; MDRO: multi-drug resistant organism; ASP: Antimicrobial Stewardship Program; HCW: Healthcare worker; KSA: Kingdom of Saudi Arabia; WHO: World Health Organization; MOH: Ministry

CONTACT Noraini Abdul norainiag@usm.my Biomedicine Program, School of Health Science, Universiti Sains Malaysia (Health Campus), Kubang Kerian 11800, Kelantan, Malaysia

of Health; MOEWA: Ministry of Environment, Water, and Agriculture; AMR: Antimicrobial Resistance; PHCC: Primary Healthcare Center

KEYWORDS Health commissioners; perspective; antibiotic resistance; COVID-19; pandemic

Introduction

COVID-19 has a negative impact on the entire world in different aspects, and one vital issue that emerged during the COVID-19 pandemic is the increased level of AR occurrence. There has been a surge elevation in AR, particularly in terms of multidrug-resistant organisms (MDROs), during the pandemic (Lai et al., 2021; Tiri et al., 2020). Although the cause could be multifactorial, many scientists have related it to the high proportion of uses of antibiotics for COVID-19 patients. Nevertheless, studied COVID-19 patients have demonstrated very low rates of secondary bacterial infections (Chen et al., 2022; Wang et al., 2020; Guan et al., 2020).

Global organisations such as the World Health Organization (WHO), Animal Health World Organization, and United Nations Food and Agriculture Organization have made tremendous efforts to combat the issue of AR. Recently, these organisations adopted a joint approach called 'One Health' that is intended to control the issue of AR. This initiative is also designed to provide optimum health outcomes for human beings, animals, and the environment (Wernli et al., 2017). The Infectious Diseases Society of America launched the Antimicrobial Stewardship Program (ASP) in 2007 (WHO, 2017), which is intended to enhance the proper use of antibiotics, prevent the development of AR, promote patient safety and healthcare outcomes, and minimise healthcare expenses (WHO, 2017; Dellit, 2007). The ASP started in the Kingdom of Saudi Arabia (KSA) in 2014 in governmental hospitals and then in private sectors two years later. However, community pharmacies were prescribing antibiotics for customers without written request from physicians until the Saudi Ministry of Health (MOH) enforced fines for violation of these rules (Alomi, 2017; Abdulhak et al., 2011; Aljadhey et al., 2015).

Frontlines and leaders play an important role in the implementation of policies (Hawking et al., 2017; Lipsky, 1980). The success of the policies and guidelines relies on the adherence of the HCWs to these rules. However, the health sector is complex, has various organisational levels, and is served by HCWs with varied tasks, training, and accountabilities. Therefore, complying with these policies might not be easy and difficult to implement (Powell et al., 2009).

A study conducted in Sweden explored and reported how policymakers from various levels of healthcare perceive the national guidelines used to combat AR. The study showed the perceptions of efforts to contain AR; however, they highlighted some problems with HCWs in terms of attitude, behaviour, and awareness

of AR (Röing et al., 2020). Another study was conducted to assess whether there was an evaluation of implementation polices provided by the government to contain AR. The study revealed that there was no positive impact of these policies on AR (Van Katwyk et al., 2019). A recent study in Australia exploring healthcare executives' perception of the issue of AR stated that it is possible that persisting governance norms and interactions between political and institutions that provide health services have a considerable impact on how well AMS is implemented and how AMR is addressed (Broom et al., 2021).

Regarding healthcare commissioners' perceptions of AR during the pandemic in Saudi Arabia and other countries, previous studies have explored the perceptions of the public, pharmacists, nurses, and other HCWs regarding antibiotic use and resistance (Karuniawati et al., 2020; Akhtar et al., 2020; Saleh et al., 2021). Moreover, HCWs in the KSA were evaluated with regard to their knowledge, attitudes, and practices regarding AR during the COVID-19 pandemic. Therefore, given the importance of healthcare commissioners and ASP members in having good experience in this scope and ability to provide key recommendations to battle AR issues, particularly during pandemics, this study explores the experiences of healthcare commissioners regarding AR during the COVID-19 pandemic, identifies challenges, and provides recommendations for combating AR during the pandemic.

Material and methods

Study design

A qualitative multicenter study was conducted at four hospitals affiliated with Saudi MOH in Najran, KSA between November 2022 and January 2023. Of the four included hospitals, two hospitals were major, one was specialised in maternity and children, and the last one was general hospital. The phenomenological approach was used to explore healthcare commissioners' experience of AR during the COVID-19 pandemic, identify challenges, and provide recommendations for combating AR during the pandemic. Before this study was conducted, the Human Research Ethical Committee of Universiti Sains Malaysia (JEPeM Code USM/JEPeM/22040202) and the Institutional Review Board at the General Directorate of Health Affairs (IRB Log Number 2022-23E) granted ethical approval for this study.

Study participants and sampling method

Purposive and snowball sampling methods were used to recruit the study participants. Inclusion criteria of the participants were mainly: (a) being healthcare commissioner, (B) qualified, and (c) having an experience in the field of AR. On

the other hands, healthcare commissioners who were not eligible with above mentioned criteria and non-related healthcare categories were excluded.

Healthcare commissioners who were involved in activities that had a relation to the study aim were recruited from the following categories: hospital management as well as managers from departments of infectious disease, microbiology, pharmacy, and infection prevention and control (IPC). The sample size was determined through data saturation when the participants mentioned no new emerging themes.

Data collection and procedure

A semistructured, in-depth interview guide was developed based on a comprehensive literature review (Röing et al., 2020; Akhtar et al., 2020; Saleh et al., 2021; Liu et al., 2020; Influenza Vaccination and Antimicrobial Resistance: Strategic Recommendations, 2021; Tosepu et al., 2021). Three experts in the field reviewed and validated the interview guide. A few amendments were made based on their suggestions, and then a pilot interview was conducted with three participants (not included in the analysis). Therefore, one question in Section C was omitted because it produced similar findings to another question, and the final version has been approved by the experts.

The interview guide comprised three sections. Section A included demographic data, section B included antibiotic use/broad questions related to AR, and section C included broad questions related to AR during the COVID-19 pandemic, **Supplement A**.

The study participants were first invited through WhatsApp messages and phone calls. Appointments were then scheduled for the participants who accepted the invitation. The aim of the study was explained to the participants, and verbal consent was obtained before the interviews were conducted. In addition, the participants were informed that the interviews would be audio recorded and the verbal consent was obtained. The interviews were conducted via video calls, and each interview lasted between 40 and 45 min. A voice recorder was used to record the interviews, and the records were stored and preserved in a confidential manner. Prompt questions were used to encourage some participants to engage in a deep discussion. After completing each interview, it was promptly transcribed and coded to ensure accuracy. Following the analysis of each interview, the next one was conducted. After each interview, the transcriptions were promptly recorded in Microsoft Word.

Data analysis

Interpretative phenomenological analysis (IPA) aims to produce comprehensive details of individuals' lived experiences and how they make sense of their expertise. Figure 1 illustrates the steps used in the data analysis in this study.

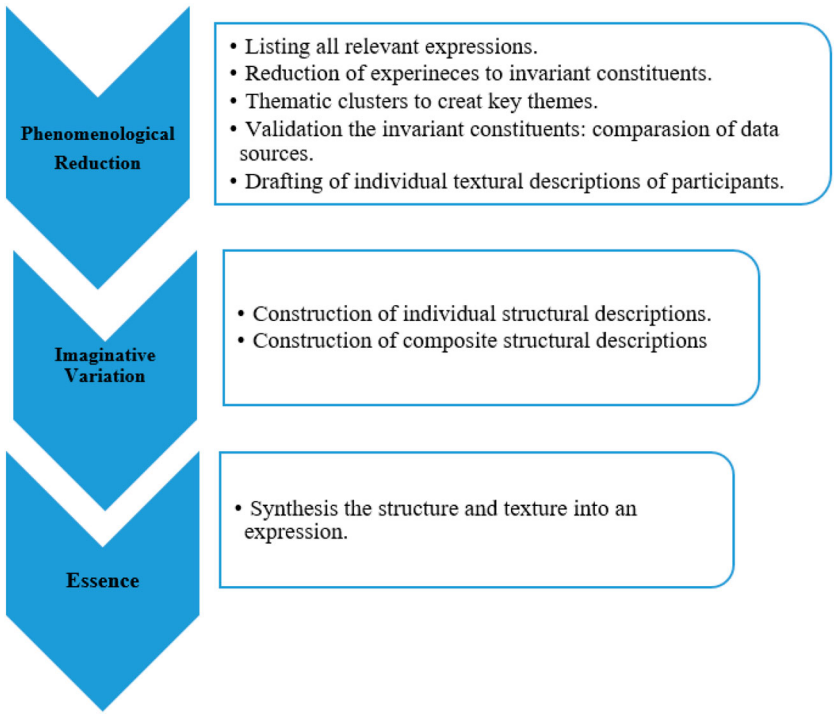

Figure 1. Steps of data analysis.

Data collection taken place concurrently with the data analysis process. The audio recordings were transcribed anonymously to ensure confidentiality. The authors read the transcripts several times to familiarise themselves with the data and clearly understand what the participants conveyed. After transcription process, each participant was shared with his/her answers to be checked and then sent back to first author to ensure the validity (credibility) of the data. The important phrases were identified and then rewritten in general terms to formulate codes and develop themes, which were approved through a consensus of the research team.

Results

Characteristics of the study respondents

Table 1 details the characteristics of the study respondents. Eleven health commissioners were interviewed. Ten of them were male, and one was female. The participants consisted of two hospital directors with medical backgrounds, two microbiologists, one IPC director, one regional IPC director, one tropical medicine and hygiene consultant/IPC director, two clinical pharmacists, one regional clinical pharmacist director, and one infectious disease consultant. The mean

Table 1. Characteristics of the study respondents.

Age	Gender	Position	Experience (years)	Hospital capacity
39	M	IPC director	10	50
38	M	Clinical pharmacist 1	15	50
60	M	Microbiologist 1	31	50
51	M	IPC regional directorate	21	-
49	M	Hospital director 1	27	200
52	M	Tropical medicine and hygiene consultant/ICP director	27	400
40	M	Hospital director 2	13	200
33	F	Clinical pharmacist 2	7	200
43	M	Microbiologist 2	12	400
40	M	Clinical pharmacist/regional director	15	200
41	M	Infectious disease consultant	12	400

(SD) age of the health commissioners was 44.1 years (7.8 years), and the mean of their work experience was 17.2 years (7.9 years). Redundant thematic achievement was reached with the ninth interview, and the thematic tendency was confirmed with the interviews of two additional participants.

Analysis of the interviews resulted in seven themes, each of which is described below: (Figure 2)

The above mentioned figure shows that seven general themes were emerged from data collection and analysis being: (1) Knowledge of antibiotic resistance and its consequences; (2) Antibiotic prescription system; (3) The future of antibiotic resistance and potential contributory factors; (4) The impact of COVID-19 on antibiotic resistance and their relationship; (5) Experience of antibiotic

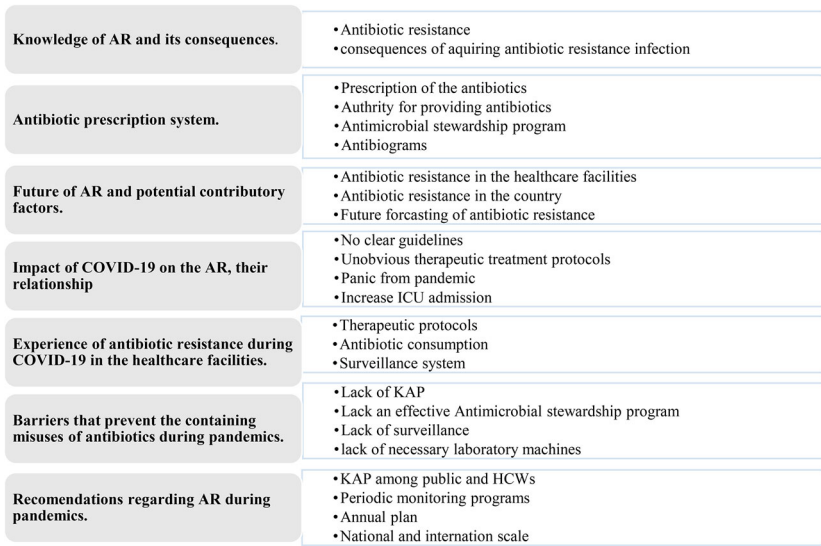

Figure 2. Codes and themes.

resistance during the COVID-19 pandemic in healthcare facilities; (6) Barriers that prevent misuse of antibiotics during pandemics; and (7) Recommendations regarding AR during pandemics.

Theme 1: Knowledge of antibiotic resistance and its consequences

Study informants described AR as a phenomenon where the ability of the antibiotic to inhibit or kill microorganisms such as bacteria becomes less effective or does not work. This happens through the development of different resistant mechanisms because of antibiotic misuse in either the hospital or the community, the use of antibiotics without guidelines, and improper diagnosis.

'Antibiotic is a medication prescribed to kill certain bacterial. The ability of antibiotics to kill bacteria is reduced through resistance. That is happened because of misuse of the antibiotics and inappropriate diagnosis.' (IPC director 1)

However, some participants mentioned that the development of resistance is an alarming public health and infection control problem. Resistant bacteria sometimes limit the treatment choice, which could be not treatable or even fatal.

'Resistant infection can sometimes be difficult to treat, and some of them are fatal.' (Clinical Pharmacist 1)

Theme 2: Antibiotic prescription system

All the informants described how the antibiotic prescription system is based on the guidelines and ASP. There are guidelines provided by the Saudi MOH demonstrating the uses of antibiotics and supported with examples. Despite the availability of these guidelines and programmes, most of the participants acknowledged that there is no proper implementation and that physicians are still prescribing based on their experiences. Moreover, during the COVID-19 pandemic, the ASP's and MOH's guidelines were almost neglected.

> 'There is a system of the prescription based on the guidelines and antibiogram, but the implementation is not strictly. We did not implement properly.' (Hospital director 2)

> 'The implementation of these programs on the paper is perfect … That means the ASP is not implemented properly.' (Infectious Disease Consultant)

Theme 3: The future of antibiotic resistance and potential contributory factors

Study participants highlighted that AR is a problem in their healthcare facilities. According to their comparisons with previous years, AR is increasing over time. AR has also increased since the COVID-19 pandemic. Moreover, new

resistance is emerging, and antibiotic choices are becoming fewer. Unfortunately, some cases with positive AR were not treatable.

> 'Every one-two years, we found new AR. We lose one choice of the treatment like this.' (IPC regional director)

> 'From our practice last time, one patient with brain abscess infected by klebsella, so we cannot find any agent to treat him because of the resistant bacteria.' (Infectious disease consultant)

Most respondents felt worried about the intensity of AR in the future. They anticipate that in the future, there will be fatal resistant bacteria and that more people might be killed by AR unless there is strong restriction and action. Respondents highlighted the lack of long-term facilities and cooperation from the MOH and the Ministry of Environment, Water, and Agriculture (MOEWA) as contributing factors.

> 'I think in the future, we will see fatal resistance and will kill many patients because of the enormous use of antibiotics and unlimited prescription antimicrobials without scientific evidence.' (Clinical pharmacist 1)

> 'It is a problem because of the safe water system, sewage system, and safe water supply for animals … There is no big eye upon the animal raisers, like chickens, cows, or camels, to see what type of antibiotic they are taking. They might take cow manure, camel manure, or chicken manure and put it on the green vegetables, and we will then pick up and eat … Otherwise, we will be killed by simple microorganisms like 200 years ago if we do not work together.' (Tropical medicine and hygiene consultant/IPC director)

> 'AR is needing cooperation not only from the hospitals; we need other organization to cooperate like MOEWA for the water hygiene, animal hygiene, and monitoring antibiotic prescription for animals.' (Microbiologist 2)

Theme 4: The impact of COVID-19 on antibiotic resistance and their relationship

All the participants mentioned that at the beginning of the COVID-19 pandemic, the disease was not well understood. There were no clear guidelines or therapeutic protocols, which were updated monthly, and physicians were worried about their patients. Therefore, there was a state of panic, and physicians intensively prescribed antibiotics to treat cases of COVID-19. Consequently, the lack of therapeutic treatment protocols and ineffective ASPs were beyond the effect of COVID-19 on AR.

> 'During that time, we are treating sick patients with lung infection, and we were throwing big gun (strong antibiotics) to help patients … The main cause in a simple way, let say we have a disease infection and we do not know how to treat it properly and were treating with big gun antibiotics or broad-spectrum antibiotics.' (Infectious Disease Consultant)

Most participants noted that there was a relationship between COVID-19 and AR. During the pandemic, a large number of patients were infected by the virus, and many patients were admitted to the intensive care unit (ICU), where a large number of patients had never previously been experienced. Patients were on mechanical ventilators, central lines, catheters, and other devices. Broad-spectrum antibiotics were frequently used for all patients. Therefore, the chance of infection increased, as did AR. In addition, discharged patients could be colonised with hospital-common microbes, which were exposed to intensive antibiotics and hence might spread in the community. This led to the transfer of genes in the community and the development of greater resistance.

> 'More patients, more devices, and more antibiotics. Of course, there will be a relation between COVID-19 and AR.' (Hospital director)

> 'During COVID-19, we were given antibiotics with approximately 100% to all inpatients … Therefore, when patients discharged from the hospital became colonized with this resistant bacteria, will transfer it to the community, and will spread there … These microorganisms having the gene if you give them strong antibiotic you will win the first battle; you will find them extensively drug-resistant (XDR) the next battle.' (Tropical Medicine and Hygiene Consultant/IPC director)

Theme 5: Experience of antibiotic resistance during the COVID-19 pandemic in healthcare facilities

All the participants agreed that there were no obvious therapeutic protocols and that antibiotics were overprescribed to COVID-19 patients during the pandemic. Respondents also observed that AR is now higher than it was before COVID-19. Most of the participants had a strong surveillance system for MDROs at their healthcare facilities, but there was an increased number of MDROs. One microbiologist from a general hospital observed high AR among *A. baumannii*, *P. aeruginosa*, *K. pneumonia*, and *E. coli*.

> 'Certain bacteria have particularly shown more resistance to certain antibiotics. For example, K. pneumonia showed more resistance to ampicillin, levofloxacin, cetfazidine, ceftriaxone, meropenem, and imipenem.' (Microbiologist 1)

> 'There was increased use of antibiotics in our hospital because it was a center for COVID-19 cases. All the patients were taking antibiotics except for the discharged patients.' (Tropical Medicine and Hygiene Consultant/IPC director)

Theme 6: Barriers that prevent misuse of antibiotics during pandemics

The study participants were unsatisfied with the knowledge and awareness of the physicians, pharmacists, other HCWs, and public regarding antibiotic

consumption. One clinical pharmacist was unsatisfied with pharmacists in both the governmental and private sectors because they still provide antibiotics for their friends, families, and even the patients whom they trust. The participants also noted that ASPs were not functioning during COVID-19 time. One hospital director mentioned the lack of technology for surveillance of the prescribed antibiotics, which can help improve the prescriptions. The tropical medicine and hygiene consultant/IPC director and one microbiologist noticed that during the COVID-19 pandemic, there was a lack of necessary laboratory machines to expedite some decisions regarding stopping or minimising antibiotic consumption. These machines identify positive COVID-19 cases and expedite bacterial identification. Moreover, some participants mentioned primary healthcare centres (PHCCs) as one of the barriers to prevent misuse of antibiotics because there are no fixed guidelines for antibiotic prescription.

> 'The top barrier is the knowledge and attitude of the physicians because they are responsible no. Actually, friendship is affect the regulation.' (Clinical pharmacist 1)

> 'Actually, it is the absence of the guidelines and therapeutic protocol for the COVID-19 patients and there is no electronic program and a lack of technology … I think there is also a gap regarding the implantation of the ASP guidelines as well as antibiogram. It is a big gap.' (Hospital director 2)

Theme 7: Recommendations regarding antibiotic resistance during pandemics

All the participants were keen to increase attention on either a national or international scale. They highly recommended an improvement in the knowledge and awareness of the public and HCWs, especially authorised persons such as antibiotic prescribers and dispensers in hospitals, PHCCs, or private hospitals and pharmacies. They highly recommended launching strict rules to implement and activate the ASP teams, particularly during difficult situations such as the previous COVID-19 pandemic. The participants also recommended effective periodic observation to succeed in these programmes because they were tailored to control the AR. Furthermore, some of the participants recommended a surveillance system arising from healthcare facilities and being connected to one central system at the MOH. Therefore, unnecessarily prescribed antibiotics would not be prescribed, and authorised physicians would be asked and advised to use the proper antibiotic in the event of an improper prescription. In addition, some participants suffered from inconsistent and unobvious diagnostic and therapeutic protocols during the COVID-19 pandemic, which led to improper use of antibiotics and triggered AR. Therefore, they recommend establishing fixed and clear diagnostic and

therapeutic guidelines during new emerging pandemics as what they experienced during the COVID-19 pandemic.

> 'The most important point is the education of HCWs and the community. This is very important; we need to educate them, give them guidelines, and then observe the implementation of these guidelines.' (IPC regional director)

> 'We need a monitoring electronic system connecting to a regional or national center. The central can call and ask why such patient is on this antibiotic and so on, and they can guide the doctors.' (Hospital director 1)

Moreover, regular monitoring of healthcare centres' IPC measures and prevention programmes is necessary to control the spread of AR. One IPC regional director stressed the importance of including preparedness plans in the annual plans of healthcare facilities. This will ensure that antibiotic prescriptions, tracking systems, IPC measures, and effective ASPs are implemented properly and that the facilities are prepared for sudden pandemics. To contain the issue of AR, additional measures mentioned by one microbiologist, such as screening admitted patients in hospitals using molecular methods and supporting diagnostic laboratories with automated machines, are important. The lack of automated machines in some hospitals is a challenge in quickly identifying all types of bacteria.

> 'We need to make preparedness before occurring any outbreak and include it as annual plan, so if any sudden outbreak happened, we have already made most of the work and our health facilities will be ready to face outbreak and deal with it with best practice.' (IPC regional director)

> 'For battling AR in our hospital, we can do additional measures to fight AR like screening patients admitted to ICU by molecular methods, which is not fully available in our hospital … Additionally, improve the laboratory diagnosis.' (Microbiologist 2)

Discussion

This study offers the views and experiences of healthcare commissioners regarding AR during the COVID-19 pandemic and the challenges and recommendations for combating AR during pandemics. Seven themes emerged from the data. The main findings were AR is alarming public health issue, improper implementation of the antibiotic prescription system, lack of cooperation between MOH and MOEWA, poor surveillance in healthcare settings and community, unobvious guidelines and therapeutic protocols during pandemic, poor knowledge among HCWs and public, ineffective ASPs, and lack of some necessary laboratory machines.

It has been reported that AR has negative impacts, such as increasing hospital length of stay, high mortality, and considerable economic burden. Thus, treatment of newly emerged AR bacteria has become limited and more

difficult (Dadgostar, 2019; Bush et al., 2014). Participants in the current study showed their scientific and updated knowledge about AR.

A qualitative study conducted in the United Kingdom indicated that ASP ward rounds had been implemented effectively before the pandemic, while during the pandemic, they were neglected due to staff pressure (Khan et al., 2022). Another study found that engagement of the ASP teams during the COVID-19 pandemic was affected by the pandemic or almost not functioning (Borek et al., 2021). Comparably, although the respondents in the current study explained that the antibiotic prescription system relies on the MOH's guidelines and ASPs, most of them acknowledged that there is ineffective implementation of ASPs, physicians are still prescribing antibiotics based on their experience, and during the pandemic, ASPs are almost completely lacking. A review study mentioned that approximately 10 million individuals could be killed by AR bacteria in 2050 (Antimicrobial Resistance: Tackling a crisis for the health and wealth of nations. The Review on Antimicrobial Resistance Chaired, 2014). Moreover, a recent systematic review involving studies from 204 countries reported approximately 4.95 million deaths associated with antimicrobial resistance (AMR) (Murray et al., 2022). Similarly, most of the health commissioners in the current study were worried about the gradual growth of AR over time and that resistant bacteria might kill many people in the future.

Using antibiotics in agriculture was found to be another contributor to AR in humans (Chang et al., 2015), and another crucial point for the dissemination of AR among human beings, animals, and the environment was the circulation of resistant bacteria via sewage, water, and foods (Walsh, 2018; Holmes et al., 2016). Antibiotics and AR can also be introduced into the environment by using animal manures in soil fertilisation (Spiehs & Goyal, 2007). In line with previous studies, two participants in the current study highlighted other contributing factors outside the healthcare facilities, such as water supply for both humans and animals, the use of manures by farmers, and antibiotics provided by veterinarians to animal raisers.

At the beginning of the COVID-19 pandemic, guidelines were lacking, and empirical antibiotics were overused regardless of the proven secondary bacterial infection or severity of the disease (Karami et al., 2021; Cong et al., 2021; Vaughn et al., 2021; Townsend et al., 2020). Delays and neglect of ASPs during the COVID-19 pandemic have been reported (Khan et al., 2022; Borek et al., 2021; Huttner et al., 2020), and a wide range of broad-spectrum antibiotics, such as gentamicin, azithromycin, amoxicillin-clavulanic acid, vancomycin, and piperacillin/tazobactam, are consumed at a high rate (Adebisi et al., 2021; Al-Hadidi et al., 2021). The study participants reported similar findings. They mentioned that at the beginning of the COVID-19 pandemic, the disease was not well understood and there were no clear guidelines or therapeutic protocols. Such protocols were updated monthly, and physicians

were worried about their patients. Consequently, such situations led physicians to intensively prescribed antibiotics to treat cases of COVID-19.

Regarding AR during the COVID-19 pandemic, a study found that AR at a tertiary hospital increased during the COVID-19 pandemic compared to the time before. In particular, *K. pneumonia* increased by 45% (Gaspar et al., 2021). Lai et al. reported a surge in MDROs, particularly *K. pneumonia Enterobacterales*, *A. baumannii*, and MRSA (Lai et al., 2021). Moreover, a systematic review explored a high proportion of AR during the COVID-19 pandemic, and the most common Gram-negative bacteria were *A. baumannii,* followed by *K. pneumonia*, *E. coli*, and *P. aeruginosa*. The most common Gram-positive bacteria were *S. aureus* and *E. faecium* (Al Sulayyim et al., 2022). Likewise, respondents in the current study observed a higher rate of AR during the COVID-19 pandemic.

According to respondents in the current study, the barrier that prevented the healthcare commissioners from containing misuses of antibiotics during the pandemic was the lack of knowledge among HCWs and the public. This is in line with previous studies, which showed that private pharmacies were still providing antibiotics without prescription during the COVID-19 pandemic (Khojah, 2022), and antibiotics were overprescribed for both COVID-19 inpatients and outpatients (Langford et al., 2021; Khan et al., 2022). In addition, the knowledge and awareness of the Saudi population and physicians regarding antibiotic use are still low and require further improvement (Alfalah et al., 2020; Althagafi, 2022). During the COVID-19 pandemic, the ASPs' activities declined and were sometimes suspended due to worsened situations, which resulted in disengagement of the ASPs' teams and overprescribing as well as unclear guidelines (Comelli et al., 2022; Khan et al., 2022), which are congruent with the findings of our study.

Discrimination of COVID-19 inflammation from secondary bacterial infection was clinically quite difficult, and starting broad-spectrum antibiotics in such situations was understandable. Additionally, confirmatory diagnostic tests of secondary bacterial infection via microbiological laboratories are not available in some healthcare facilities and are costly and time consuming, making rapid exclusion of secondary bacterial infection difficult and resulting in improper selection of antibiotics (Antibiotic use at veterans affairs' hospitals increases during COVID-19 pandemic, reversing a four-year downwards trend, 2022; Cong et al., 2021). A systematic review reported that information technology plays an important role in improving antibiotic prescription (Nabovati et al., 2021). In the current study, respondents highlighted other barriers, such as lack of technology for surveillance of the prescribed antibiotics and lack of necessary laboratory machines to expedite some decisions regarding stopping or minimising antibiotic consumption. The last barrier mentioned by some respondents in our study concerned PHHCs, where there is still a gap regarding guidelines for prescribing antibiotics. Physicians are still prescribing based on their

experience, which is in harmony with previous studies (Althagafi, 2022; Albahooth et al., 2021; Melaibari et al., 2019).

All the participants in the current study recommended an improvement in the knowledge and awareness of the public and HCWs. Similarly, the implementation of educational programmes for HCWs and the public will help to fill the knowledge gap (Tahoon et al., 2020). One of the fundamental elements of centres for disease control and prevention is education on antibiotic prescriptions, which could be provided on e-learning platforms to be better informed to people in community and HCWs (CDC, 2021). If prescribers were more aware of their prescribing habits, they would be more likely to improve their prescribing practices, particularly if the regulations apply to all HCWs across healthcare facilities (Lum et al., 2018). Increased collective efforts supported by national policies coupled with education will help to minimise antibiotic misuse and antibiotic misprescription (Avent et al., 2020).

ASPs' experts and members highlighted an issue of the lack of implementation of guidelines and policies provided by governmental and ministerial agencies (WHO, 2016). Experts have also discussed the existence of strategic plans with regard to the use of antimicrobial drugs in animal and human health; however, the implementation was hampered by weak high-authorised governance. In addition, there was no cooperation between other relevant sectors, such as the MOH and MOEWA, which resulted in poor and inappropriate understanding (Rizk et al., 2021). Defeating AR requires combined action among stakeholders around the world, including government and non-governmental organisations, HCWs, researchers, pharmaceutical companies, healthcare administrators, policy makers, leaders in agriculture fields, and patients (WHO, 2019; CDC: National action plan for combating antibiotic-resistant bacteria, 2015). Comparably, most participants in our study highly recommended cooperation in relevant sectors and communities as well as strict rules to implement and activate the ASP teams, particularly during difficult situations such as the previous COVID-19 pandemic. Findings from previous studies highlight the importance and benefits of technology in improving antimicrobial utilisation, prescription, and clinical decisions (Godman et al., 2021; Pamplin et al., 2020; Van Dort et al., 2022). Some participants in the current study recommended effective periodic observation for ASP and a robust technological surveillance system for tracking antibiotic prescription and AR. Similarly, Khan et al. experienced some challenges to ASPs during the COVID-19 pandemic and highlighted the importance of the existence of such electronic systems (Khan et al., 2022).

This study has a few limitations. First, the sampling method of involved participants limits the extrapolation of the findings because those who were not involved in this study may have different views. Second, the views and experiences of health commissioners regarding AR during the COVID-19 pandemic cannot be generalised to health commissioners in the

whole KSA because the study was conducted in four hospitals. Nevertheless, health commissioners shared their views, experiences, and key challenges during the pandemic regarding the global public health issue of AR, so they provided fundamental recommendations that can be considered on both a national and international scale.

Conclusion

This study identified seven themes from the data and provided in-depth understanding of the health commissioners' experiences of the AR during the COVID-19 pandemic. Moreover, health commissioners identified the main challenges of AR during the pandemic, and the recommendations were provided accordingly. The findings of this study could be used to inform policy and practice for the governmental HCWs and the public. Such recommendations could be beneficial on a national and international scale.

Ethics approval

This study was approved by the Human Research Ethical Committee of Universiti Sains Malaysia (JEPeM Code USM/JEPeM/22040202) and the Institutional Review Board at the General Directorate of Health Affairs (IRB Log Number 2022-23E).

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Availability of data and material

Support data for the findings of this study are available and can be obtained from the corresponding author upon reasonable request.

Consent for publication

Not applicable.

Competing interests

The authors declare no conflict of interest.

Author contributions

Conceptualization, H.A.S., N.A.G., and A.A.H; methodology, H.A.S., N.A.G., R.I., and A.A.H.; Transcribing and formal analysis, H.J.A. and N.A.G; writing—original draft

preparation, H.A.S.; writing – review and editing, H.A.S., N.A.G., R.I., and A.A.H.; visualization, H.J.A.; supervision, N.A.G, R.I.; project administration, H.J.A., N.A.G, A.A.H. All authors have read and agreed to the published version of the manuscript.

Disclosure statement

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Notes on contributors

Hadi Jaber Al Sualyyim is a PhD candidate, at the School of Health Sciences, Universiti Sains Malaysia. His research interest is in antimicrobial resistance and hospital infection.

Dr ***Rohani Ismail*** is a lecturer at the School of Health Sciences, Universiti Sains Malaysia. Her research interest is in mixed method study, and women and adolescent health.

Dr ***Abdullah Al Hamid*** is an Assistant professor at College of Clinical Pharmacy, Department of Pharmacy Practice, King Faisal University, Saudi Arabia. His research interest areas are mediation safety, patient safety, clinical pharmacy and healthcare system improvement. Dr Abdullah has a track record of publications in these areas and working for both academic and clinical organizations.

Dr ***Noraini Abdul Ghafar*** is lecturer in Epidemiology and Biostatistics at the School of Health Sciences, Universiti Sains Malayasia. Her research interest are epidemiology of infectious and non-infectious disease, disease modelling, and disease prevention.

ORCID

Hadi Jaber Al Sulayyim http://orcid.org/0000-0002-0307-2777

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