The impact of COVID-19 on antimicrobial stewardship programme implementation in hospitals: an exploration informed by the consolidated framework for implementation research.

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The impact of COVID-19 on antimicrobial stewardship programme implementation in hospitals — an exploration informed by the Consolidated Framework for Implementation Research

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SUMMARY

Introduction and objectives: The disruption of antimicrobial stewardship programmes (ASPs) caused by coronavirus disease 2019 (COVID-19) has been recognized but not explored in depth. This study used a theoretical, qualitative approach to understand the impact of COVID-19 on ASP implementation in hospitals.

Methods: Semi-structured online interviews, informed by the Consolidated Framework for Implementation Research (CFIR), were conducted with ASP team members and non-members in hospitals. Participants were recruited via purposeful and snowball sampling with interviews video recorded, transcribed and analysed independently by two researchers based on mapping against CFIR constructs.

Results: Thirty-one interviews were conducted across 11 hospitals. The following themes were identified: (i) increased complexity of ASP implementation and changes in pre-scribing behaviour influenced by COVID-19; (ii) adaptations, networking and cosmopolitanism to enhance integration of COVID-19 management into ASP services; and (iii) adaptations and networking to support continuity of the ASP implementation process. A disruption to pre-pandemic ASP activities was reported, with complexity of COVID-19 overwhelming the healthcare system. ASP team members and services showed an ability to adapt and repurpose roles to respond to the pandemic. Interventions included developing national guidelines for treatment of patients with COVID-19 and contributing to guideline management and monitoring. A gradual restoration of ASP activities was perceived. Technological adaptations and enhancements in networking were reported as positive impacts of the pandemic.

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Conclusion: Despite the initial disruption of ASP implementation caused by the pandemic, successful adaptation and evolution of ASP services reflects the high value and adaptability of ASP implementation in hospitals in the United Arab Emirates.

Introduction

The disruption caused by coronavirus disease 2019 (COVID-19) to antimicrobial stewardship programmes (ASPs) has been acknowledged but not explored in depth [1,2]. Published research addressing the impact of COVID-19 on ASP implementation is in the form of letters [3], commentaries [2−4] and short communications [5]. A literature search retrieved one UK-based survey of all antimicrobial leads in UK hospitals. Results identified short-term disruption of ASP activities, including disregarding ASP team recommendations, interrupting ASP regular activities, and logistical difficulties in conducting ASP team meetings and rounds [1]. This had a negative impact on ASP outcomes, with the most concerning being a global surge in antimicrobial consumption associated with the management of patients with COVID-19 and subsequent emerging antimicrobial resistance [2,6]. A meta-analysis estimated that more patients have been prescribed antibiotics that are likely to have been co-infected with a bacterial infection [6].

In addition, the COVID-19 pandemic had a positive impact on the delivery of health care, such as accelerated development and reform including: adopting digital healthcare solutions; adapting the role of healthcare providers; closer collaboration between private and governmental sectors; and expanding the remit of primary care and family medicine [7−9]. This rapid reform also affected ASP activities, where efforts to resume ASP practices have been described through embracing technology to facilitate ASP meetings and rounds, upgrading existing electronic health systems, increasing use of procalcitonin to differentiate between viral and bacterial infection, and increased adoption of outpatient parenteral antimicrobial therapy (OPAT) [1,5]. ASP team members have contributed to the pandemic relief effort through their roles in novel antiviral clinical trials, COVID-19 disease management guideline development, repurposing prospective audit and feedback, formulary restriction, and pre-authorization to support patients with COVID-19 [2,10].

To date, studies addressing different aspects of the impact of COVID-19 on the healthcare system in Gulf Cooperation Council (GCC) states [Saudi Arabia, Bahrain, Kuwait, United Arab Emirates (UAE), Oman and Qatar] have been published. These include the psychological impact on healthcare workers [11,12], and clinical characteristics and outcomes of patients with COVID-19 [13]. However, to the authors' knowledge, no studies to date have addressed the impact of COVID-19 on ASP implementation in the GCC region.

This study aimed to improve understanding of ASP implementation in hospitals during the COVID-19 pandemic, and to identify facilitators and barriers to ASP implementation.

Methods

Study design

A qualitative, semi-structured interview approach was adopted.

Setting

Data generation was conducted in five of the seven UAE emirates: Abu Dhabi, Dubai, Sharjah, Fujairah and Ras Al Khaimah.

Inclusion and exclusion criteria

Recruitment aimed to include: (i) ASP team members who were expert implementation leaders; and (ii) non-ASP team members who were involved with prescribing antimicrobial therapy, such as physicians, nurses and pharmacists. Governmental and private hospitals, of different sizes and funding sources, across the five emirates, which are governed by different health authorities, were included to ensure maximum variation sampling [14].

Sampling and sample size

Purposeful sampling of ASP team leaders within each hospital was adopted initially, followed by snowballing, whereby participants recommended ASP members or non-members who could contribute effectively to data generation. Sampling from each hospital continued until the point of data saturation with no new emerging themes within the adopted analytical framework.

Recruitment and data generation

Purposeful sampling commenced in June 2020 and continued for 7 months. E-mails to ASP leaders or hospital leaders that could identify their local ASP leader were initiated by one of the authors (NAR), who co-chairs the UAE National Committee for Antimicrobial Resistance. Signed informed consent was obtained prior to commencing interviews. Interviews were conducted online, on a day and time suitable to the participants, using Zoom, Microsoft Teams or Blackboard Collaborate. Interviews were conducted in English, as this is commonly used among healthcare providers, by a trained qualitative researcher (NH) with pharmacy and academic expertise. Video-recorded interviews (approximately 45−60 min) were transcribed verbatim (NH), with participants offered the opportunity to review the transcripts to enhance credibility and dependability. Any identifiable data were removed prior to data analysis to protect participants' confidentiality.

Interview schedule development

The interview schedule was developed based on a recent systematic review mapping hospital ASP in GCC states to international standards [15] and the Consolidated Framework for Implementation Research (CFIR) [16].

CFIR was used to provide comprehensive coverage of factors which may impact ASP implementation. This is a meta-theoretical evaluation framework that has been successfully, and is increasingly reported in health care as a guide to evaluate different contextual factors that can impact implementation as facilitators or barriers before, during and after implementation [17–19]. It comprises 39 constructs distributed across five domains: intervention characteristics; outer setting; inner setting; individual characteristics; and process [20]. The use of CFIR allows comprehensive coverage and understanding of various contextual factors that affect implementation, and further reinforces the applicability of findings [16,21].

The interview guide was designed initially based on the interview guide tool provided by the CFIR Research Team [16], and reworded to suit ASP implementation, including input from ASP experts including a clinical pharmacist and an internal medicine physician. In this study, CFIR has been integrated holistically in a meaningful way, and has underpinned all stages of research including data generation, coding, analysis and reporting of results.

Following piloting of interviews with two ASP members and two non-ASP members, minor changes were made to the interview schedules; pilot interviews were included in the final dataset. The interview schedule included questions addressing the impact of COVID-19 on ASP implementation mapped to different CFIR constructs. Items focused on: domain (I) – intervention characteristics (impact of COVID-19 on adaptation of ASPs and complexity of implementation); domain (II) – outer setting (cosmopolitanism, external networking and influence of other hospitals, including guidelines to manage patients with COVID-19); domain (III) – inner setting (updating infrastructure such as the use of technology, new practices and guidelines, impact of COVID-19 on networking and communication, changes in implementation climate and relative priority, leadership support and readiness for implementation); domain (IV) – characteristics of individuals (knowledge and belief about ASPs); and domain (V) – process (future planning including recovery of ASPs following COVID-19, engaging healthcare providers, and ASP execution within the pandemic) (Table S1, see online supplementary material). Probes were added to allow in-depth exploration whenever required. A reduced version of the interview schedule was used for non-ASP members based on their level of involvement in ASP development and implementation (e.g. likely lack of knowledge about intervention source, cost and future planning).

Data analysis

All transcripts were inputted to NVivo software [22], and data were analysed thematically using the framework approach which comprises the following steps: transcribing; familiarizing with interviews; developing an analytical framework (CFIR domains and constructs); coding; charting data to framework matrix; and data interpretation [23]. CFIR domains and constructs were used deductively as an initial analytical framework for coding, followed by inductive analysis based on emerging themes, identifying constructs that were facilitators or barriers to ASP implementation. Analysis was conducted independently by two researchers (NH and one other from AT, DS, DP), and disagreement was resolved through discussion. Emerging themes were organized using Mind Manager software to enhance visualization and data analysis [24].

Ethical consideration

Ethical approval was obtained from: Robert Gordon University Research Ethics Committee (Reference S186), Ministry of Health and Prevention Research Ethics Committee (Reference MOHAP/DXB-REC/JAANo.32/2019), and Abu Dhabi Health Services Company Research Ethics Committee (Reference SEHA – 003). Private hospitals provided approval by e-mail notification (no reference numbers).

Results

Seventeen hospitals were approached (11 governmental and six private) across UAE; of these, 11 granted ethical approval, and six were unresponsive with no specific pattern identified or reason for declining provided (Table I). Through purposeful sampling, 11 participants were identified as ASP leaders and were able to nominate another 29 individuals (snowballing) who could contribute to data generation (Figure S1, see online supplementary material). Of these 29 individuals, 21 agreed to participate and eight declined, mainly due to lack of time or heavy workload. One of the 32 interviews was excluded due to recording failure. Participants were anonymized by providing identifiers based on their role description (Table I).

The following three overarching themes were identified reflecting participants' experience with ASP implementation during the COVID-19 pandemic: Theme 1, increased complexity of ASP implementation and changes in prescribing behaviour influenced by COVID-19; Theme 2, adaptations, networking and cosmopolitanism (external networking) to enhance integration of COVID-19 management in ASP services; and Theme 3, adaptations and networking to support continuity of the ASP implementation process. Within these overarching themes, participants described aspects that were mapped to multiple CFIR constructs and domains (Table S2, see online supplementary material). Details of the three overarching themes are presented in narrative below (CFIR constructs are emphasized in *italics* within the text). Themes, subthemes and corresponding illustrative verbatim quotes are summarized in Table S2 (see online supplementary material).

Theme 1. Increased complexity of ASP implementation and resulting changes in prescribing behaviour influenced by COVID-19

Multiple CFIR constructs were identified within this theme; the most prominent were *complexity, relative priority, implementation climate, evaluation* and *reflection*. Several ASP team members considered COVID-19 to be a major *disrupting factor* for ASP implementation due to increased *complexity* in maintaining ASP practices during the peak of the pandemic. The management of patients with COVID-19 was perceived as highest *priority* for hospital leadership compared with established pre-pandemic ASP activities. Consequently,

Table I

Characteristics of participating hospitals (*N*=11) and participant (*N*=31) demographics

Hospital characteristics	Number of hospitals (*N*)
Location (emirate)	
Abu Dhabi	4
Dubai	3
Sharjah	2
Fujairah	1
Ras Al Khaimah	1
Governing local health authority	
Department of Health − Abu Dhabi	4
Dubai Health Authority − Dubai	3
Ministry of Health and Prevention − Northern Emirates	4
Hospital funding	
Governmental	8
Private	3
Bed capacity	
>100	2
100−300	6
< 300	3

Participant demographics	Number of participants (*N*)
Role	
Clinical pharmacist	6
Clinical microbiologist	2
General practitioner	1
Intensive care unit consultant	3
Infectious diseases physician	3
Internist	1
Nephrologist	2
Nurse	3
Pharmacist	4
Quality officer	2
Surgeon	4
ASP team member	
Yes	23
No	8
Gender	
Male	15
Female	16
Age (years)	
21−30	3
31−40	7
41−50	10
51−60	10
<60	1
Country of last qualification related to profession	
Egypt	8
India	4
Iran	1
Iraq	1
Jordan	1
Lebanon	1
Saudi Arabia	1
United Arab Emirates	2
United Kingdom	8
United States of America	4

Table I (*continued*)

Hospital characteristics	Number of hospitals (*N*)
Years of experience at current hospital	
> 1	1
1−5	10
6−10	8
11−20	10
<20	2

ASP, antimicrobial stewardship programme.

this resulted in a change in *implementation climate*, and the efforts of ASP team members were diverted to the management of patients with COVID-19 based on clinical *patient needs*. The majority of participants also felt that the sheer number of patients with COVID-19 overwhelmed the healthcare system, and diverted the attention of healthcare providers away from pre-pandemic ASP activities (Table S2, Quotes 1−5, see online supplementary material).

An ASP team member also noted a reduction in antibiotic sensitivity and an increase in antimicrobial resistance while *evaluating and reflecting* on ASP implementation during the pandemic. Notably, *plans* for implementing new outcome measurements, such as measuring antimicrobial consumption using days of therapy, were delayed due to the pandemic (Table S2, Quotes 6 and 7, see online supplementary material).

The impact of COVID-19 on antimicrobial *prescribing behaviour* and on prescribers' decisions was evident where participants strongly endorsed the overwhelming increase in empirical antimicrobial prescribing for patients with COVID-19, especially when they presented with symptoms remarkably similar to septic shock. ASP team members also remarked on the fact that prescribers disregarded advice to de-escalate empirically prescribed antimicrobials (Table S2, Quotes 8 and 9, see online supplementary material).

Several reasons were identified by participants for this sudden change in prescribers' behaviour towards antimicrobial prescribing. Most prominent was their perception of physicians' *lack of knowledge* at the time about COVID-19, leading to indiscriminate prescribing due to concerns that secondary bacterial infection may develop (Table S2, Quote 10, see online supplementary material).

It was observed that physicians' lack of understanding of this novel viral infection led to several conflicting recommendations at the start of the pandemic. According to ASP members, initial guidelines recommended antimicrobial use, and this was viewed as a catalyst for increased empiric antimicrobial prescribing, again leading to changes in *prescribing behaviour*. Overall, *patient needs*, including severity of illness, and the burden of COVID-19 on the patient were reported by many participants as a cause for prescribing antimicrobials without evidence of bacterial infection (Table S2, Quotes 11 and 12, see online supplementary material).

Other causes identified by participants included difficulties in obtaining a microbial culture from patients with COVID-19, leading to unnecessary empiric antimicrobial prescribing as well as fear of blame in case of patient deterioration, reflecting changes in *prescribing behaviour* (Table S2, Quotes 13 and 14, see online supplementary material).

Despite the above reports of perceived high levels of empiric antimicrobial prescribing, other observed effects on antimicrobial consumption were reported, such as a decline in antimicrobial consumption for surgical antimicrobial prophylaxis suggested by some participants due to cancellation of elective surgeries at the peak of the pandemic. Antimicrobial prescribing for neonates was not perceived to be influenced by the COVID-19 pandemic due to strict isolation of neonates from COVID-19-positive mothers (Table S2, Quotes 15 and 16, see online supplementary material).

Theme 2. Adaptations, networking and cosmopolitanism (external networking) to enhance integration of COVID-19 management in ASP services

CFIR constructs identified within this theme included: *adaptability, networking and communication,* and *cosmopolitanism*. Participants reported that COVID-19 was a major detractor from pre-pandemic ASP implementation. They also noted that the existing ASP structures showed capacity for *adaptability*, and were repurposed to support COVID-19 relief efforts in various ways. Participants referred to the valuable contribution of ASP members in developing UAE national guidelines for the management of patients with COVID-19, supported by continuous meetings and consultation processes with external parties (ASP and infectious diseases experts), demonstrating *cosmopolitanism*. Furthermore, participants highlighted the important role of ASP members in *networking* and dissemination of national and hospital guidelines for the management of patients with COVID-19 to other hospital healthcare providers. This was based on their previous established work practice in developing and disseminating antimicrobial management guidelines as part of pre-pandemic ASP activities (Table S2, Quotes 17 and 18, see online supplementary material).

According to the majority of ASP team members, the role of ASP team members changed in comparison with the pre-pandemic era to accommodate COVID-19 management. This role in the continuous management and monitoring of patients with COVID-19 was evident throughout the interviews. Participants confirmed that ASP team members prioritized adherence to national guidelines for the management of patients with COVID-19, monitored dose optimization, and screened for drug—drug interactions as part of their ASP duties (Table S2, Quote 19, see online supplementary material).

Theme 3. Adaptations and networking to support continuity of ASP implementation process

CFIR constructs included *adaptability, networking and communication, access to knowledge and information,* and *cosmopolitanism*. Efforts to sustain and maintain ASP routine pre-pandemic activities during the pandemic were highlighted by many ASP team members. *Adaptability* was evident with regular face-to-face meetings being moved online to facilitate *networking and communication*, allowing continuity of ASP implementation. ASP team members described overwhelming numbers of patients and work overload as hurdles to conducting regular meetings, which added to the perceived *complexity* of maintaining previously established ASP activities

during the pandemic (Table S2, Quote 20, see online supplementary material).

Attempts made at *adapting communication* to maintain networks, that were well established pre-pandemic, were emphasized, and involved the use of WhatsApp to support conducting medical rounds. These were, however, perceived to be less effective than usual daily rounds. Participants described efforts to support maintenance of pre-pandemic ASP activities, including *adapting* the reporting infrastructure (e.g. adopting digital systems with evolution of paper forms to online pre-authorization forms to facilitate antimicrobial authorization) (Table S2, Quotes 21 and 22, see online supplementary material).

In an effort to reduce broad-spectrum antibiotic misuse, another participant highlighted successful restriction of the use of broad-spectrum antimicrobials for patients with COVID-19 based on *patient needs* (Table S2, Quote 23, see online supplementary material).

Physician participants showed a desire to resume previously established ASP activities, and this was perceived by ASP team members to be an endorsement of the importance of ASP implementation within the hospitals, and physicians' *knowledge and beliefs* about ASP. ASP team members considered restoration to the pre-pandemic level of ASP implementation to be a future priority at the time (Table S2, Quotes 24 and 25, see online supplementary material).

Many ASP team members observed a gradual decline in antimicrobial consumption, and this was perceived as evidence of success in restoration of pre-pandemic ASP activities. Multiple participants perceived that change in *prescribing behaviour* was due to *increased access to knowledge and information* about the pathophysiology of COVID-19 and antimicrobial requirements. According to those participants, this was gained through educational and awareness activities internationally and nationally, as well as the contribution of ASP members to the management of patients with COVID-19. Notably, subsequent changes in national guidelines for the management of patients with COVID-19 to recommend less use of antimicrobials in these patients supported the downward trend in antimicrobial prescribing, as perceived by some ASP members (Table S2, Quotes 26 and 27, see online supplementary material).

CFIR constructs identified as barriers or facilitators mapped to themes and subthemes with some illustrative quotes are illustrated in Table II.

Discussion

Statement of key findings

Participants overwhelmingly perceived pre-pandemic ASP activities to be greatly disrupted by the complexity of COVID-19, together with the acute patient needs and lack of resources. These were viewed as putting extreme strain on the healthcare system. ASP team members showed an ability to adapt and repurpose roles, responsibilities and processes. Interventions reported included developing national guidelines for the management of patients with COVID-19, and contributing to guideline management and monitoring by acting as a reference point. A gradual restoration to routine pre-pandemic ASP practices was perceived by participants, where enhancements of networking and technological adaptations were identified.

Impact on ASP practice	CFIR domain	CFIR construct	Corresponding overarching theme	Corresponding subtheme	Illustrative quotes
Facilitators	Intervention characteristics	Adaptability	Theme (2)	Adaptations for ASP activities to include management of patients with COVID-19	'... [the] Antibiotic Stewardship Committee follow the adherence of the physicians to this guideline and also the clinical pharmacists provide daily rounds for the critical care cases and the ICU [intensive care unit]' [Clinical pharmacist 6]
			Theme (3)	Adaptation of networking to facilitate continuity of ASP implementation during the pandemic	'..., everybody trying to work virtually to reduce contact with others, even our rounds, we used to do rounds, it's virtual rounds, we will do it through WhatsApp' [Clinical pharmacist 1]
			Theme (3)	Adaptation of pre-authorization forms to facilitate continuity of ASP implementation during the pandemic	'First we have this pre-authorization form.... during the COVID-19 time we change this form from paper form to electronic and it is sent through the email' [Nephrologist 1]
	Outer setting	Cosmopolitanism	Theme (3)	Cosmopolitanism and networking to support building national COVID-19 management guidelines	'Experience with ASP and having structure and having consultations and having meetings with different stakeholders really allowed us [to help in building national guidelines for COVID-19], a lot of the infectious disease people are clinical pharmacists and are actually quite solid' [Clinical pharmacist 2]
	Inner setting	Network and communication	Theme (3)	Cosmopolitanism and networking to support building national COVID-19 management guidelines	
		Access to knowledge and information	Theme (3)	Gradual decline in antimicrobial prescribing	'Many virtual conferences and virtual lectures released online at the national level and even at the international level. This helps to change the mind of the physician that no need for all these antibiotics for management of COVID-19' [Clinical pharmacist 6]
	Characteristics of individuals		Theme (3)	Desire to re-establish ASP implementation	'So, my aim now is at least to go back to the level we were

Table II (*continued*)

Impact on ASP practice	CFIR domain	CFIR construct	Corresponding overarching theme	Corresponding subtheme	Illustrative quotes
		Knowledge and belief about the intervention			before and to continue the educational activities and to continue talking to our doctors of course' [Intensive care unit consultant 2]
Barriers	Intervention characteristics	Complexity	Theme (1)	Disruption of ASP implementation	'I think we were not really looking at the ASP too much at this time, when we were in the peak, we were just like overwhelmed. Everybody is overwhelmed' [Internist 1]
			Theme (1)	Delay in ASP plans under the impact of COVID-19	'…., DOT [days of therapy] we started actually before COVID-19 then you know during the COVID-19, there were some delays in that one. But we will come back to it soon' [Clinical pharmacist 1]
			Theme (1)	Changes in antimicrobial resistance patterns	'We make a very big change, especially in the multi-drug-resistant organism. We have [had] very big improvement but due to this pandemic, we start accepting medical cases [not surgical only cases as before the pandemic] … And we start noticing the increase of certain resistance to beta lactams' [Quality officer 1]
	Outer setting	Patient needs and resources	Theme (1)	Severity of illness of patients with COVID-19	'Sometimes we are using an antibiotic without evidence of bacterial infection. Just for the seriousness of the case [COVID-19 patient]' [Nephrologist 1]
	Inner setting	Implementation climate	Theme (1)	Changes in antimicrobial prescribing behaviour	'We saw a lot of doctors who were just if a patient comes with COVID-19 they would start a lot of empirical antibiotics' [Clinical pharmacist 5]
		Relative priority	Theme (1)	Change in priority due to the impact of COVID-19 pandemic	'We haven't been doing the ASP rounds like we used to again in terms of prioritization, in terms of how much of your percentage [of workload] is down to ASP' [Clinical pharmacist 2]

Strengths and weaknesses

To the best of the authors' knowledge, this research is the first qualitative, theoretical exploration of the impact of COVID-19 on ASP implementation. The use of qualitative methodology generated rich data, which allowed in-depth exploration of participants' perspectives. The inclusion of maximum variation sampling and observing data saturation enhanced the rigour of findings. CFIR underpinned data generation, analysis and reporting which identified contextual factors impacted by COVID-19 and which functioned as barriers or facilitators to ASP implementation. It also helped to identify CFIR constructs that impacted implementation outcomes/effectiveness, such as antimicrobial consumption, prescribing broad-spectrum antimicrobials, and acceptance of ASP team recommendations. One of the challenges associated with CFIR use which has been described in the literature is the presence of constructs that do not match emerging themes [25]. To overcome this challenge and to ensure inclusion of emerging themes that are associated with CFIR constructs, both inductive and deductive analysis were employed. The main limitation of this study is that data were generated in UAE, which can affect the transferability of data to other countries; however, detailed description of the study context has been provided to allow readers to examine potential transferability to their own setting.

Interpretation of key findings

A UK-based survey investigated the negative and positive impacts of COVID-19 on ASP activities across hospitals [1]. Similar to the present study, a positive outcome was increased adoption of technology, while negative outcomes included interruption of ASP rounds and meetings, and a decline in acceptance of ASP team recommendations. Additionally, increased reliance on procalcitonin testing and OPAT were reported [1]; these issues were not considered in the present study.

Few CFIR constructs were identified as barriers to the continuity of ASP activities during the pandemic. These were primarily complexity of the interventions, prescribing behaviour, implementation climate, and complex patient needs and resources. ASP is a complex intervention that requires participation of individuals from multiple levels, and its implementation was already challenged by multiple factors including lack of policies, limited funding, need for training, and less time dedicated to ASP activities [26,27]. COVID-19 has added to this complexity given the strained healthcare system due to the pandemic being a higher priority, with increasing urgency and an overburdened healthcare task force. Within this implementation climate, changes in prescribing behaviour led to increased empiric prescribing of broad-spectrum antimicrobials for viral infections as perceived by the study participants.

Increased empirical use of broad-spectrum antimicrobials in patients with COVID-19 has been associated in the literature with causes such as lack of knowledge of COVID-19, complex pathophysiology, possibility of secondary bacterial infection and severity of illness [28]. A survey, investigating cause of antimicrobial prescribing for patients with COVID-19 in Italian hospitals, identified patient-related clinical and radiological findings, worsening of symptoms, intensive care admission and tracheal intubation as causes for increased empiric prescribing of broad-spectrum antimicrobials as a result of COVID-19 [29].

The present study further explored the impact of the pandemic on prescribing behaviour, where fear of consequences, rapid changes in the international and national guidelines for management of COVID-19 leading to confusion, and a lack of clear understanding of the disease caused increased empiric prescribing as perceived by the study participants.

Ongoing research and surveillance data are expected to explore the impact of the COVID-19 pandemic on other ASP outcomes, such as changes to antimicrobial resistance pattern, *Clostridioides difficile* infection rates, and potential increased use of antifungal agents secondary to increased broad-spectrum antimicrobial usage.

Adaptability, networking and communication, cosmopolitanism, and knowledge and belief of the importance of ASP were the constructs that emerged in this study as collectively strengthening and supporting the repurposing process of ASP personnel, processes and infrastructure, which reinforced alteration of previously discussed barriers. The literature has also discussed the adaptability capacity within ASP in response to COVID-19, where processes such as prospective audit and feedback, pre-authorization and formulary restriction were all employed to guide and monitor the use of novel antiviral agents, in addition to the established role of optimizing the use of antimicrobials [30,31]. Further roles have been identified in the literature in response to COVID-19 which did not emerge in the present study, such as ASP members' roles in clinical trials of novel antivirals, vaccination, and dealing with drug shortages [2]. The present research has clearly identified the complementary effect of cosmopolitanism with networking and communication, where networking between ASP team members and hospital healthcare providers as well as co-ordination with ASP members and healthcare leaders in different hospitals supported the rapid response and development of COVID-19-specific management guidelines. Years of experience, knowledge, and the reputation of ASP as a successful initiative to control the use of antimicrobials facilitated this transition of role, and added to the impact of ASPs during the pandemic.

Further research

Operating in the COVID-19 pandemic is the new reality, and this triggered rapid developments in healthcare delivery and implementation of services. As such, future research should be directed towards exploring successful ASP activities that can help foster and support this novel and accelerated development.

In conclusion, despite the initial disruption of ASP implementation due to the pandemic, successful restoration and evolution of ASP services reflects the high value and adaptability of ASP implementation in UAE hospitals. This value will further motivate investment in such programmes to ensure readiness for future pandemics, and to keep pace with global accelerated developments in healthcare systems.

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Conflict of interest statement
None declared.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jhin.2022.08.005.

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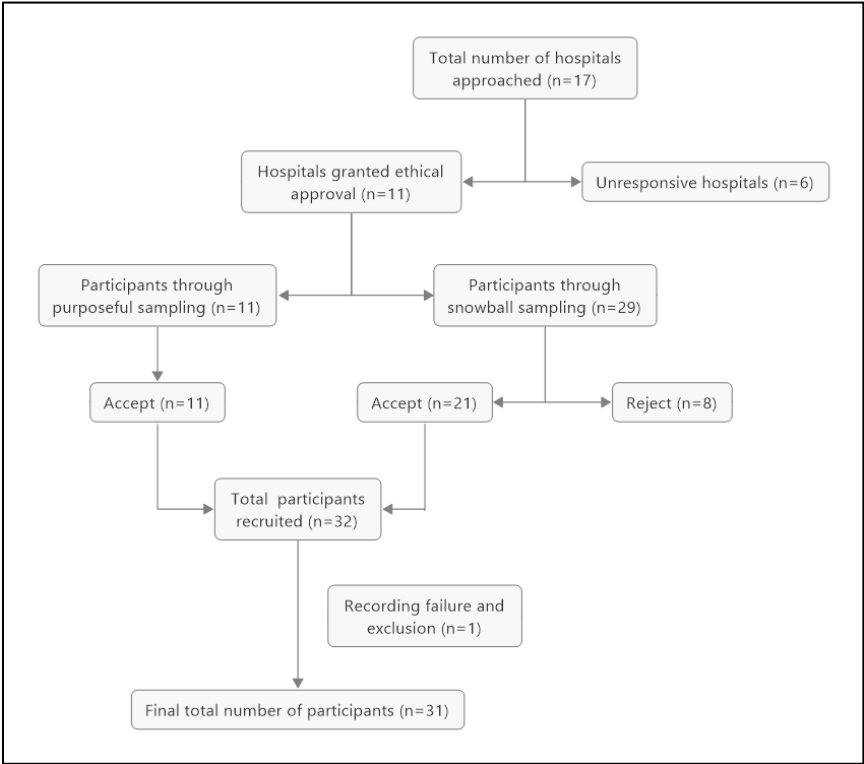**Figure S1.** Sampling strategy for data generation.

Table S1 Overarching themes and interview questions mapped to the Consolidated Framework for Implementation Research (CFIR) domains and constructs

Overarching theme	Interview questions	CFIR domain	CFIR constructs
(1) Increased complexity of ASP implementation and changes in prescribing behaviour influenced by COVID-19	• What are your thoughts on how complex the ASP was for your hospital? • How do you think your hospital culture affected ASP interventions? • How do you feel about the effectiveness of ASP implementation in your hospital?	Domain I; Intervention characteristics	Complexity (disruptiveness)
		Domain II; Outer setting	Patient needs and resources Cosmopolitanism
		Domain III; Inner setting	Implementation climate (relative priority)
		Domain IV; Characteristics of individuals	Knowledge and belief about intervention
		Domain V: Process	Reflection and evaluation
(2) Adaptations, networking and cosmopolitanism to enhance integration of COVID-19 management in ASP services	• Did you have to adapt or refine ASP practices to suit your hospital? Can you describe these changes required? • How did ASP practices from other hospitals influence your implementation? • Can you comment on the effect of formal and informal communication among teams inside your hospital on ASP implementation?	Domain I; Intervention characteristics	Adaptability
		Domain II; Outer setting	Cosmopolitanism
		Domain III; Inner setting	Structural characteristics Implementation climate (capacity for change) Network and communication
(3) Adaptations and networking to support continuity of ASP implementation process	• What steps have you taken to encourage individuals to commit to ASP implementation?	Domain I; Intervention characteristics	Adaptability Complexity (Intricacy)
		Domain II; Outer setting	Cosmopolitanism
		Domain III; Inner setting	Network and communication Readiness for implementation (access to knowledge and information)
		Domain IV; Characteristics of individuals	Knowledge and belief about the intervention
		Domain V; Process	Planning Reflection and evaluation

ASP, antimicrobial stewardship programme; COVID-19, coronavirus disease 2019.

Table S2 Selection of the most illustrative verbatim quotes reflecting participants' views

Main theme	Sub-theme	Verbatim quote
(1) Increased complexity of ASP implementation and changes in prescribing behaviour influenced by COVID-19	Disruption of ASP implementation as a result of COVID-19	**Quote 1** 'It halted everything, because we had to be pulled to cover the COVID-19 wards. Personally I have not been doing it [ASP activities] for quite a few months, because I was pulled to cover the COVID-19 wards' [Infectious diseases physician 1] **Quote 2** 'A lot of the things [ASP recommended practices] that we have implemented have gone out of the window when COVID-19 has hit' [Clinical pharmacist 5] **Quote 3** 'I think we were not really looking at the ASP too much at this time, when we were in the peak, we were just like overwhelmed. Everybody is overwhelmed' [Internist 1] **Quote 4** 'Unfortunately, we can't monitor ID [infectious diseases physician] approval or that antibiotic was restricted or reviewed by ID [infectious diseases physician]. It was huge workflow, unbelievable workflow' [Pharmacist 2]
	Change in priority under the impact of COVID-19	**Quote 5** 'We haven't been doing the ASP rounds like we used to again in terms of prioritization, in terms of how much of your percentage [of workload] is down to ASP' [Clinical pharmacist 2]
	Changes in antimicrobial resistance pattern	**Quote 6** 'We make a very big change, especially in the multi-drug-resistant organism. We have [had] very big improvement but due to this pandemic we start accepting medical cases [not surgical only cases as before the pandemic] … And we start noticing the increase of certain resistance to beta-lactams' [Quality officer 1]
	Delay in ASP plans under the impact of COVID-19	**Quote 7** 'The data [antimicrobial consumption] will be available on the system and anybody want [ing] to see can see it, but DOT [days of therapy] we started actually before COVID-19 then you know during the COVID-19, there were some delay in that one. But we will come back to it soon' [Clinical pharmacist 1]
	Change in antimicrobial prescribing behaviour	**Quote 8** 'We saw a lot of misuse of antibiotics. We saw a lot of doctors who were just if a patient comes with COVID-19 they would start a lot of empirical antibiotics' [Clinical pharmacist 5] **Quote 9**

'When this pandemic of COVID-19 started, everything got upside down. People [prescribers] did not even care about the comments of ASP. So they started all the broad-spectrum antibiotics you can imagine, although in many cases it was clear, clear viral infection' [Intensive care unit consultant 3]

Quote 10

'The picture was not so much clear, what is COVID-19 and what is other bacteria which can co-exist with this virus? Then we face a huge challenge to control the overprescribing of antibiotics at that time' [Clinical pharmacist 6]

Quote 11

'It [COVID-19 pandemic] ruined the ASP practice. Because from the first [national] guideline [for management of patients with COVID-19] it was mentioned, you can use tazocin [piperacillin with tazobactam] or meropenem for severe cases. So, there was a lot of administrations of antibiotics and then at the beginning of the COVID-19 there were stories about giving azithromycin with the chloroquine. So there was a lot of unnecessary azithromycin using' [Infectious diseases physician 3]

Quote 12

'Sometimes we are using an antibiotic without evidence of bacterial infection. Just for the seriousness of the case [patient with COVID-19]. It's in the critical area on mechanical ventilation although the culture is negative. Although we don't have by the book indication of antibiotic, sometimes we put under [i.e. prescribe] antibiotic. So we break the rules regarding ASP, especially in the critically ill patients' [Nephrologist 1]

Quote 13

'Maybe you know taking the culture also from COVID-19 patient, it was not easy, so we found sometimes patient on antibiotic without culture' [Clinical pharmacist 1]

Quote 14

'It was really over use [of antibiotics in COVID-19 cases] because people [prescribers] were also afraid if they did not give antibiotic and patient deteriorated they will be blamed' [Clinical pharmacist 1]

Quote 15

'Our hospital is mainly surgical hospital … The elective operations are reduced; in that case you know the antibiotic prescription issues also will go down. So for that part, we can say that the antibiotic usage became less [in surgical antimicrobial prophylaxis] because of the COVID-19 situation' [Surgeon 3]

Quote 16

'Our population [neonates] was definitely not [affected]. I think we were the least affected by the COVID-19 infection, because the babies born from COVID-19 moms will be going into strict isolation and once the swab come back negative … We were not really affected by it [COVID-19] from antibiotic point of view' [Nurse 2]

(2) Adaptations, networking and cosmopolitanism (external networking) to enhance integration of COVID-19 management in ASP services	Cosmopolitanism and networking to support building national COVID-19 management guidelines	**Quote 17** 'Experience with ASP and having structure and having consultations and having meetings with different stakeholders really allowed us [to help in building national guidelines for COVID-19], a lot of the infectious disease people are clinical pharmacists and are actually quite solid' [Clinical pharmacist 2] **Quote 18** 'People have had to listen to us with ASP in the past. It was easy for them to listen to us again when we were disseminating the national guidelines [for management of COVID-19] and our hospital guidelines [for management of COVID-19] as well as the corporate guidelines [for management of COVID-19] when it was COVID-19' [Clinical pharmacist 2]
	Adaptations for ASP activities to include management of patients with COVID-19	**Quote 19** '… [the] Antibiotic Stewardship Committee follow the adherence of the physicians to this guideline and also the clinical pharmacists provide daily rounds for the critical care cases and the ICU [intensive care unit] … to check the adherence to the guideline, optimizing the doses of the medication and if there is any drug–drug interaction and so on' [Clinical pharmacist 6]
(3) Adaptations and networking to support continuity of ASP implementation process	Adaptation on networking to facilitate continuity of ASP implementation during the pandemic	**Quote 20** 'Unfortunately, the COVID consumed most of our time, this is the point. We left behind our meetings, we skipped some meetings also the Microsoft meetings was not accessible for all the members. We already arranged for many meetings, but unfortunately many of us were busy in different issues so we cannot even have our regular meeting for the committee' [Nephrologist 1] **Quote 21** 'I think it [COVID-19] affect [ASP] a lot because the interaction itself between us as clinical pharmacist and the physician and the patient, everybody trying to work virtually to reduce contact with others, even our rounds, we used to do rounds, it's virtual rounds, we will do it through WhatsApp. We will try to find a way, another way, but it will not be efficient as before' [Clinical pharmacist 1]
	Adaptation of pre-authorization forms to facilitate continuity of ASP implementation during the pandemic	**Quote 22** 'First we have this pre-authorization form…. during the COVID-19 time we change this form from paper form to electronic and it is sent through the email. So anyone who wants to prescribe certain antibiotics from restricted list of antibiotic, he will fill this form and send it for the pharmacy to be approved before prescribing' [Nephrologist 1]
	Restrictions on broad-spectrum antimicrobials	**Quote 23** 'I started and I was successful to chip meropenem out because these [COVID-19] patients who are coming to the hospital, usually they don't have pseudomonas. At least on carbapenem sparing, I tried and I was successful' [Infectious diseases physician 3]

	Desire to re-establish ASP implementation	**Quote 24** 'I just had a conversation with my critical care head on Thursday. She was like, Oh, I think we're gonna [are going to] restart our ASP rounds. I didn't even have to remind her. She reminded herself, she wanted it. That's what I mean by value [of ASP]' [Clinical pharmacist 2] **Quote 25** 'So, my aim now is at least to go back to the level we were before and to continue the educational activities and to continue talking to our doctors of course' [Intensive care unit consultant 2]
	Gradual decline in antimicrobial prescribing	**Quote 26** 'Many virtual conferences and virtual lectures released online at the national level and even at the international level. This help to change the mind of the physician that no need for all these antibiotics for management of COVID-19. For us as an ASP member in our facility, we provide a daily feedback for the doctor, especially in the critical care area regarding the treatment plan of COVID-19 patients, so it was a huge challenge at the initial phase of COVID-19, but now starts to be stabilized and improved' [Clinical pharmacist 6] **Quote 27** 'Also the doctors I noticed in the beginning, there was over use of antibiotics in the beginning of the pandemic but after that maybe after 1 month or so, the [national] guidelines [for management of COVID-19 patients] changed and we came to practise less antibiotic, only when it is really required' [Clinical pharmacist 1] 'Right now we are settled. The guidelines, especially the national guidelines [for management of COVID-19 patients]. They played a very good role in regulating the management of COVID-19 positive and non-COVID-19 cases, in terms of antibiotic' [Surgeon 4]

ASP, antimicrobial stewardship programme; COVID-19, coronavirus disease 2019.