Review

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Reflections on the Saudi Experience With COVID-19: Challenges, Lessons and Missed Opportunities

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The novel coronavirus disease 2019 (COVID-19) pandemic took the world by storm. Saudi Arabia (SA) made significant efforts to limit the impact of the pandemic. As COVID-19 is no longer a pandemic, it is necessary to reflect on the lessons, challenges, and missed opportunities from the Saudi experience with COVID-19. SA implemented extensive measures to mitigate the pandemic's impact. This study analyzed the measures taken on three major fronts: public health, scientific research, and clinical practice. This reflection is structured around three key fronts: public health, scientific research, and clinical practice. It was found that SA adopted progressive public measures that succeeded in curbing the number of cases, along with mass testing and vaccination programs, further facilitated by technology. Nevertheless, vaccine hesitancy and ineffective educational campaigns hindered such efforts. While SA rapidly allocated research funds, the lack of strategic direction limited the applicability of the research outputs. The clinical management of COVID-19 in SA was evidence-based; however, the North American and European guidelines heavily influenced it and did not benefit from the local academic studies, nor were national clinical trials conducted to inform its clinical practice. These lessons, challenges, and missed opportunities should be carefully considered by healthcare policymakers in order to advance Saudi preparedness for future outbreaks.

Keywords: clinical practice; COVID-19; Saudi Arabia; health policy; vaccination; health education

Introduction

The novel coronavirus disease 2019 (COVID-19) was undoubtedly the most significant healthcare crisis of the 21st century up until the publication of this work. In December 2019, a severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) that caused severe disease clusters was first reported in Wuhan, the capital of China's Hubei province [1]. The declaration of COVID-19 as a pandemic led to an emergency status in many countries on several fronts.

On a public health level, governments took various measures to limit the spread of the virus, such as imposing limited access to public venues indoors and closed buildings [2]. Social distancing measures were also enforced in many countries, such as maintaining safe distances between individuals, requiring face masks indoors, and encouraging contactless interactions [3,4]. However, the application of these measures varied significantly between countries, and consequently so did COVID-19 morbidity and mortality.

Scientifically, scientists from all disciplines rushed to investigate various key aspects of this novel infection. This includes its nature, transmission routes, effects on humans, and complications for the human body. The speed at which such progress was achieved was phenomenal. Such discovery expanded from the isolation and identification of the causative organism, severe acute respiratory SARS-CoV-2 [5], to the elucidation of its structure and the development of effective vaccines [6].

Clinically, physicians were trying to understand the disease course of this novel infection, its predictors, and the risk factors associated with severe cases and mortality. Furthermore, clinicians were also occupied with exploring possible medical treatment options. Significant progress has been made in understanding COVID-19 risk factors, from theoretical background to clinical studies, and in identifying predictors of its severity and mortality.

Saudi Arabia (SA), one of the biggest countries in the Middle East, has also been affected by COVID-19. Most notably, SA was among the earliest countries to implement a series of public, progressive measures to counter the spread of COVID-19 [7]. Similarly, academics, scientists, and clinicians in SA redirected their research to tackle the COVID-19 pandemic to the best of their capabilities. This narrative review reflects on Saudi efforts across three main fronts: public health, science, and clinical care. This review aims to identify the challenges, lessons, and future directions that could be learned from the Saudi experience with COVID-19.

Reflecting on the Public Health Front

The Saudi government was one of the earliest to respond to the COVID-19 pandemic. SA implemented a

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number of progressive and rapid measures across several aspects of public life. These measures included travel restrictions into and out of the country, suspending religious activities and gatherings, and imposing 24-hour curfews on some days. The detailed breakdown of these measures can be further explored in these previously published papers [7,8], and summarized in Fig. 1 (Ref. [7]).

Fig. 1. The measures taken to tackle COVID-19 in Saudi Arabia. The diagram illustrates the steps taken by the Saudi government to address COVID-19 infections and curb transmission. These actions encompass restrictions on both inbound and outbound travel, the suspension of religious activities—especially those leading to large gatherings—closure of non-essential businesses, modifications to workplace settings (including the adoption of distance learning in educational institutions), and the implementation of curfews. With the initiation of mass vaccination programs, new regulations have been implemented to facilitate a gradual and safe return to pre-COVID-19 lifestyles. These guidelines mandate the use of face masks in public and enclosed spaces, temperature checks before entering enclosed areas, and adherence to social distancing measures. The figure is adapted from [7] (Licensed under CC BY 4.0).

The application of these measures, especially at such a rapid rate, has been a resource-demanding process. Firstly, the closure of non-essential shops and the restriction of people's movement have severely affected the country's economy, both at the government and worker levels [9,10]. Secondly, the application of curfews was only possible with additional manpower beyond the civil forces, e.g., divisions of the army were deployed in cities to enforce curfews and movement restrictions [11].

Despite these measures having a heavy financial burden on the country, affecting businesses and individuals, they actually yielded positive results. These measures were effective in tackling the spread of the viral infection, reducing the morbidity and mortality resulting from COVID-19 infections [8,12]. Moreover, these measures were important during the early phases of vaccine enrollment, as the first dose of 2-dose anti-COVID-19 vaccines was not sufficient to protect against infection [13].

Mass Testing and Vaccination: Successes and Hurdles

The Saudi government adopted a free-for-all policy for COVID-19 testing and vaccination, regardless of age, nationality and citizenship status. The testing was key to monitoring the spread of the infection and to limiting the movement of those affected.

The COVID-19 vaccination campaign was gradually opened to the public in several stages. Firstly, it was directed to those at high risk of contracting the infection, e.g., healthcare workers, and/or those at higher risk of developing severe cases of COVID-19, such as the elderly and those with comorbidities. Secondly, the vaccination expanded the remaining population [11]. By October 2023, Saudi Arabia had administered over 68 million vaccine doses, achieving a high coverage rate of 73% of the total population vaccinated with a complete primary series of COVID-19 vaccines [14].

At first, the COVID-19 vaccination was offered on a voluntary basis. However, it has become apparent that COVID-19 posed a serious risk to healthcare systems, leading to strain on well-established healthcare infrastructures [15,16]. Therefore, the Saudi public health policymakers did not take the risk of allowing such an infection to strain the Saudi healthcare system, and the COVID-19 vaccines have become mandatory [17]. The enforcement of such a mandate was also gradual, with the first dose followed by the second, and lastly the booster dose. Once a person receives a vaccination dose, they are issued an electronic vaccination certificate, which is now required to enter any building.

The Persistent Challenge of COVID-19 Vaccine Hesitancy

As in many countries worldwide, vaccine hesitancy and resistance to COVID-19 vaccines in SA were prevalent. In fact, it has been estimated that vaccine hesitancy in SA ranged from 5% to 80% among the sampled population [18]. Several factors contributed to such hesitancy. Personal and social characteristics, such as gender, age, and levels of income and education, that were shown to influence COVID-19 vaccine hesitancy varied significantly across studies. Such a finding was further influenced by the lack of a standardized tool that was used between these studies [19].

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On the other hand, other factors were found to be common among hesitant subjects toward COVID-19 vaccinations. These included mass misinformation, e.g., conspiracy theories, found on social media platforms [20], concerns about vaccine safety and possible side effects [21], and a lack of trust in healthcare systems [19]. This highlights a unique shortcoming: despite a centralized health communication system, the messaging was not sufficiently targeted to address these specific, widespread concerns, a lesson for future campaigns.

Such hesitancy and resistance toward COVID-19 vaccines were not exclusive to subjects objecting to the uptake of the vaccine by themselves. Once the COVID-19 vaccines were approved for emergency use in children aged 5 years and older, the vaccine was required for children as a requirement for their return to school. However, parents were also common and reported to vary between 28% and over 80% of the sampled populations in SA [22,23]. The parents' prior experience with COVID-19 vaccines influenced their decision to vaccinate their children [24], as well as the type of vaccine administered in some instances [25].

Vaccine hesitancy and resistance, like in many countries around the world, do not take place in a vacuum. In fact, many studies, both globally and in SA, have highlighted the various factors contributing to this phenomenon. However, this seemed to be a missed opportunity by the Saudi Ministry of Health that was not capitalized upon. The Ministry of Health held daily press briefings in which the ministry's spokesperson reviewed the daily numbers of COVID-19 morbidity and mortality, both national and regional figures, with updates on best practices against the virus and advice on how to manage various COVID-19 scenarios [26]. While these press releases were useful for informing the public about the changing magnitude of the pandemic locally, they were not tailored to the target audience. The ministry did not make use of the abundant, available literature at the time to deliver a targeted educational campaign on COVID-19 and address the main drivers of vaccine hesitancy and resistance. Such a targeted campaign could correct misconceptions about the vaccine and increase its uptake and acceptability [27].

The Effective Leveraging of Technology in Tackling COVID-19

The COVID-19 pandemic forced a halt to almost all aspects of daily life, including but not limited to clerkship work, education, and trade. While such a halt was acceptable as a contingency measure, it was not sustainable, and alternatives had to be found. Fortunately, several technologies were available before the pandemic began. And while they were not intentionally made to tackle COVID-19, they were directed to serve the Saudi population at such a challenging time.

A key mobile application that was instrumental in the Saudi public health response to COVID-19 was Tawakkalna [28]. The application contained updated information on the person's COVID-19-related status, i.e., infection and vaccination, as well as other relevant services. So, when a person tests positive for COVID-19, the application would turn red (infected) for 7 days, then yellow (recovery) for another 14 days, before turning green (uninfected). The application also shows the vaccination information, i.e., date and type of the vaccine received. The application was also used to obtain permits for movement during the curfews imposed in the early stages of the pandemic. The application had become a permit to enter buildings, provided the person was uninfected and vaccinated, which was required to be checked by the government prior to entry [29,30].

Most educational institutions already have electronic platforms and suites that supplement the delivery of various educational programs, such as Blackboard and Microsoft Office. However, these technologies were not fully utilised, and their use was very limited. Once physical attendance and on-campus teaching were halted due to COVID-19, the switch to online teaching was the only sensible move until the government outlined the next steps in tackling the infection.

Similarly, the pandemic has driven many government entities to shift their activities online. For example, the Ministry of Justice has established its online platform "Najiz" through which it provides all of its judicial services to the public [31], including conducting virtual court sessions.

Legacy Infrastructure for Future Outbreaks

COVID-19 presented us with the invaluable lesson that the public health measures taken to tackle it could also be used for other conditions.

As part of the Saudi national campaign "we return with caution", several measures were in place to limit the spread of the infection, including social distancing, facemasks, and mandatory temperature checks at entry points to buildings, e.g., shopping centers.

Currently, all these measures have been lifted in SA following the World Health Organisation (WHO) declaration of the end of the global pandemic status of COVID-19 [32]. Despite the lifting of these measures, the infrastructure required to apply these public health measures remained. Hence, it would be a massive waste to leave them unused after COVID-19, which is why some entities have adapted to the new measures and continued to make use of them as their new norm. For example, educational entities have returned to on-campus teaching, but when a weather alert indicates a period when the weather could pose a danger to those travelling to schools, teaching activities are switched to online for that period.

Reflecting on the Research Front

Research Funding and Bureaucratic Hurdles

Once the country went into a total lockdown, we rushed into exploring and answering key issues related to the new infection. Expectedly, such studies would require significant funding to deliver these research projects.

In response, several funding bodies announced research funding calls, with awards of up to 2 million Saudi Riyals (around 533K USD) per project [33]. The total research funding allocated by major bodies like King Abdulaziz City for Science and Technology (KACST) and the Ministry of Education was substantial, though a precise national aggregate figure is not publicly available. The General Authority for Statistics announced that a total of SAR 29.48 billion (around USD 7.85 billion) has been spent on research and development in the Kingdom, of which 19.9%, i.e., SAR 5.85 billion (around USD 1.56 billion) was spent on personal and social issues [34]. This rapid mobilization of resources was a key strength. These funding agencies include King Abdulaziz City for Science and Technology, the Ministry of Education via its affiliated public universities, and internal funding calls at healthcare facilities.

The provision of such research funds in SA, apart from their significant amount, has been satisfactory in terms of delivery. These funds were established and distributed from the early phases of the infection and through the second year of the pandemic. Furthermore, the funding was wide enough to include researchers from various backgrounds, including but not limited to clinical, biomedical, engineering, life sciences, and social sciences.

Despite efforts to facilitate scientific research through funding, the delivery of these funds, especially through universities, was a significant obstacle to the completion of these projects. If a researcher is awarded a research grant through his university, he will be able to access the research fund through one of two possible ways. The researcher can cover his research expenses, e.g., lab equipment and consumables, from his own pocket. He will then need to make a claim that requires the original receipt and, if the original was in a different language, a translation into Arabic. Furthermore, he will need to provide evidence that the transaction was made from a local bank account. Alternatively, the researcher can obtain a purchase order from his university, provided he presents price quotations from three different suppliers of the supplies he wants to acquire. Such bureaucracy hindered researchers' ability to maximise their research output and wasted their effort in meaningless paperwork that could have been better utilised elsewhere [35].

The Strategic Gap in Research Direction

While the overall theme of the provided funding was COVID-19, the objectives of these funding calls were broad and did not directly address COVID-19-related challenges. For example, some funding bodies only focus on studies that fulfil one or more of the Saudi Vision 2030 goals, such as offering a fulfilling and healthy life. However, none of them is directly linked to addressing a challenge presented by the COVID-19 pandemic.

Other funding agencies have announced objectives, including the discovery of novel diagnostic techniques and the development of novel therapeutics to treat COVID-19 [30]. However, none of the technologies used in SA to diagnose COVID-19, or the therapeutics used to treat it, were discovered or made in SA. In fact, there was a project to produce the first "Halal" COVID-19 vaccine locally. However, it turned out to be no more than a publicity stunt and was never produced [35]. This example, while anecdotal, is indicative of a broader issue where ambitious announcements were not backed by a clear, practical research roadmap.

The key lesson here is that funding agencies should have specific research directions, which are to be addressed by proposals submitted by researchers. And these funded projects are to be closely monitored and held accountable for their outcome based on the agreed proposals. For example, A research fund could be allocated to study the determinants of COVID-19 vaccine hesitance and resistance among the population of a given region. Once a project proposal has been chosen and funded, and the study has been conducted, the results should be provided to the funding agency, even before publication in peer-reviewed journals. These results are then to be used by the public health policymaker to tailor their vaccine educational campaign. To optimize for the future, Saudi Arabia should establish a National Infectious Disease Research Fund with a clear strategic agenda, fast-tracked funding mechanisms, and mandatory pathways for translating findings to policy.

Reflecting on the Clinical Practice Front

Over-Reliance on International Guidelines

The current medical practice, both locally and globally, has become evidence-based. In other words, clinical practices and how certain conditions are approached are optimised based on published studies, trials, meta-analyses, and follow-up monitoring of treatments. The current state of technology and the online medical journals, and how physicians can publish their findings from anywhere in the world and have them viewed by the rest of the world, greatly facilitates the spread of knowledge and the development and updating of clinical guidelines.

However, the assessment of the clinical decisions taken and the guidelines issued during the COVID-19 pandemic clearly demonstrates a significant Western influence, i.e., North American and European, on the Saudi healthcare system. While these Western healthcare policies may be based on thorough examination of evidence, they may not necessarily be applicable to the Saudi population, and Saudi Arabia could have benefited from practices

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from other scientifically advanced countries, such as China, South Korea, and Russia. A prominent example of such a missed opportunity was the COVID-19 vaccines used in SA. China and Russia were the first countries to produce anti-COVID-19 vaccines, Sinopharm and Sputnik V, respectively [36,37]. While some questioned their efficacy given their rapid development and distribution [38], these vaccines demonstrated good efficacy and were distributed globally to over 20 countries, including neighbouring countries to SA such as the United Arab Emirates, Egypt, and Jordan, with no reports of serious adverse reactions [39–41]. However, SA refrained from using these two vaccines and adopted only the American/German and British vaccines, Pfizer/BioNTech (BNT) and AstraZeneca (AZ), when they were developed and approved for use [42,43]. The other American Johnson and Johnson (J&J) vaccine was also approved for use in Saudi Arabia after its U.S. Food and Drug Administration (FDA) approval [44].

Although the initial pieces of evidence may indicate that the Russian and Chinese vaccines may not be as effective as the other Western vaccines, these pieces of evidence did not demonstrate serious side effects of taking the Sputnik V and Sinopharm vaccines. Hence, SA could have benefited from their use, even if the benefit is minor, by providing some immunity against serious COVID-19 infections during the gap between the development and delivery of these vaccines, compared to BNT, AZ, and J&J vaccines in SA, which lasted almost 6 months.

The Absence of National Clinical Trials

Several steps were taken in SA before the pandemic began that laid the foundation for establishing scientific infrastructure in SA. King Abdulaziz City for Science and Technology (KACST) is an independent entity overseeing the research landscape in SA and provides funding for researchers across the kingdom. As part of its effort to standardise research ethics, the national bioethics committee was established, which oversees all biomedical and clinical research activities in the kingdom. These activities are governed by the requirements published by the committee, which are applied and monitored by local institutional research board ethics committees [45].

In response to COVID-19, similar to the Saudi response to MERS, established a command-and-control center which closely monitors COVID-19 morbidity and mortality across the Kingdom. This center was also responsible for distributing COVID-19 vaccines across the country based on population needs.

These described entities and the available research infrastructure could have easily facilitated the conduct of national multicenter clinical trials. COVID-19 posed a significant challenge to physicians, with many attempting to assess the efficacy of certain medications against it. For example, several agents have been suggested as treatment options for COVID-19, such as hydroxychloroquine [46] and the antiviral Remdesivir [47]. These 2 medications were already widely available in SA, and they could have been tested locally in clinical trials. However, no reported clinical trial in SA has assessed their efficacy and use, nor those of any other medication, in the management of COVID-19. This stands in contrast to countries like the UK (RECOVERY trial) [48], and the USA, which rapidly established large national trials, and represent a significant missed opportunity to generate local evidence. On the contrary, Saudi healthcare officials opted not to assess them nationally, despite reports indicating their variable efficacy and safety profiles [49].

Such a missed opportunity could have been easily addressed by establishing a command-and-control center, similar to the one monitoring COVID-19 cases and mortalities, to coordinate clinical trials. Additionally, some of the COVID-19 funding could have been directed to conducting such clinical trials at the national level, rather than to research projects that did not necessarily address a specific clinical challenge or dilemma. On a brighter note, SA has established the Saudi National Institute of Health (NIH), with the aim of overseeing the translational research and clinical trials in Saudi Arabia [50]. This is an important step in the right direction to tackle any future outbreaks, provided policies and procedures have been in place to establish how multi-centre national studies could be implemented when needed.

The Disconnect Between Local Research and Clinical Guidelines

Despite the challenges that faced the clinical management of COVID-19 in SA, the Saudi Ministry of Health did not benefit from the clinical studies conducted locally.

For example, the Neutrophil-to-Lymphocyte ratio (NLR) can be calculated from the rapid, widely available, and cost-effective blood test, the complete blood count [51,52]. NLR was found to be a sensitive marker to predict the severity and mortality among COVID-19 [53]. After its first description in SA [54], it was further validated in several national [55,56], regional [57,58], and international studies [59–62] and meta-analyses [63,64]. Furthermore, it was found to be superior to other parameters, e.g., the systematic inflammatory index (SII) [65], and was later incorporated into other tools that were evidently useful in the management of COVID-19, e.g., the SII [66–69] and the COVID-19 Mortality Prediction (CoMPred) tool [70].

Despite all the validation and the usefulness of the NLR, as evidenced by subsequent studies since its first description in SA, NLR remains outside the Saudi Ministry of Health clinical guidelines for the management of COVID-19. Namely, the Coronavirus Disease COVID-19 Guidelines (version 3.2), published in March 2023 [71], and the Saudi MoH Protocol for Patients Suspected of/Confirmed with COVID-19 (version 3.9), published in April 2023 [72], did not include NLR in the set of investigations relevant to

COVID-19. On the contrary, they depended on fewer study markers, such as interleukin 6, which are only available in very well-equipped healthcare facilities. Furthermore, the references in these 2 clinical guidelines/protocols are entirely based on studies and guidelines from outside SA, despite the body of clinical studies conducted in SA related to COVID-19.

This missed opportunity should prompt healthcare policymakers to begin building relationships with academic institutions and to establish collaborations to address clinical challenges. As in the previous section, clinical studies can, when directed and properly conducted, solve clinical dilemmas and inform clinical practice. These collaborations between the healthcare system and academia can further streamline local and national clinical trials and, subsequently, contribute to the advancement of clinical practice in SA. A key recommendation is to create a formal 'National Guideline Adaptation Committee' with representation from the MoH, academia, and research centers. This committee would be tasked with systematically reviewing local evidence and rapidly incorporating validated findings into national guidelines. Fortunately, SA has taken positive steps, as part of its newly formed Saudi NIH, it has established the Knowledge Translation Unit [73]. The Knowledge Translation Unit has 6 main objectives, which are as follows: to transform health knowledge into practical and applicable practices, to enhance the integration of research findings with decision-makers to improve healthcare quality, to contribute to the development of guidelines and the formulation of health policies, to encourage collaboration between researchers and healthcare providers to implement health research outcomes, to build knowledge translation Networks that connect researchers with beneficiaries, and to empower outstanding researchers to enrich medical knowledge and practice. Such efforts are promising and would bridge the effort between academic research, medical guidelines, and clinical practice.

Based on these reflections, several concrete recommendations to optimize Saudi Arabia's response to future health crises are proposed here:

- Public Health: Develop and pre-approve targeted, multi-format communication campaigns for different demographic groups to rapidly counter misinformation and vaccine hesitancy in future outbreaks.

- Research: Establish a National Infectious Disease Research Fund with a clear strategic agenda, fast-tracked funding mechanisms to bypass bureaucratic delays, and mandated pathways for the translation of research findings into policy briefs.

- Clinical Practice: Fully activate the role of the Knowledge Translation Unit of the Saudi NIH with representation from the MoH, academia, and research centers. This committee would be tasked with systematically reviewing local evidence and rapidly incorporating validated findings into national guidelines, reducing over-reliance on international protocols.

- Clinical Trials: Mandate that the command-and-control center, i.e., the Saudi NIH, for future pandemics have a dedicated wing to coordinate national, multi-center clinical trials and ensure local generation of evidence for therapeutics and diagnostics.

By implementing such structured changes, Saudi Arabia can transition from a reactive to a proactive and self-reliant posture in global health security.

Conclusions

SA is not new to infectious outbreaks. For example, SA was exposed to the Middle East Respiratory Syndrome (MERS), which prompted a number of measures to counter it. That experience should not be forgotten, and lessons learnt are to be built upon. Similarly, SA's experience with COVID-19 was longer and more significant. The lessons, challenges, and missed opportunities described here should help the country prepare for future outbreaks, such as the recently reported spread of the Human Metapneumovirus (HMPV). Hence, learning and building upon such an experience is mandatory for the progress of the Saudi healthcare system.

Availability of Data and Materials

Not applicable.

Author Contributions

AAS contributed to the conception and design of the manuscript, drafted the work, and performed critical revisions for important intellectual content. He approved the final version to be published and agrees to be accountable for all aspects of the work, ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Ethics Approval and Consent to Participate

Not applicable.

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Conflict of Interest

The author declares no conflict of interest.

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