Review

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Saudi Arabia's Middle East respiratory syndrome Coronavirus (MERS-CoV) outbreak: consequences, reactions, and takeaways

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Background: Middle East respiratory syndrome (MERS) is a viral illness caused by the MERS-Coronavirus (MERS-CoV) that was first identified in Saudi Arabia in 2012. Saudi Arabia has reported most global MERS-CoV cases and deaths, with periodic outbreaks in other countries.

Objectives: This review aims to provide a comprehensive overview of the 2023 MERS-CoV outbreak in Saudi Arabia, including its epidemiology, public health response, impact, and lessons learned.

Methodology: This study utilized a narrative review approach, drawing on published literature and data from sources such as the WHO and the Centers for Disease Control and Prevention.

Results: The 2023 outbreak was centered in the Riyadh region, with 312 confirmed cases and 97 deaths reported. MERS-CoV primarily spreads from dromedary camels to humans, with human-to-human transmission, especially in healthcare settings. The outbreak exhibited seasonal and spatial trends, with most cases during camel calving season and in rural areas with high camel populations. The Saudi Ministry of Health implemented a multi-faceted response, including enhancing surveillance, improving infection prevention, providing clinical support, and conducting risk communication. Over time, the response showed a decline in the number of cases and deaths, indicating its effectiveness.

Conclusion: The outbreak has significant public health, economic, and social impacts, underscoring the ongoing threat of emerging zoonotic diseases. Key lessons include early case detection, efficient infection control, vaccine and treatment development, public engagement, and strengthening of regional and global collaboration to mitigate future outbreaks and safeguard public health.

Keywords: global health security, MERS-CoV, outbreak, public health response, Saudi Arabia

Introduction

Middle Eastern respiratory syndrome Coronavirus (MERIS-CoV) is a novel coronavirus that causes serious respiratory illnesses in humans. Dromedary camels are assumed to be the main reservoir and source of infection for humans, having presumably acquired the virus from bats[1]. Owing to its vast genetic diversity and swift evolution, the virus can spread as distinct strains and clusters over various countries and regions. Molecular epidemiology and phylogenetic studies have shown that MERS-CoV can spread from person to person through close contact, especially in medical environments, and that there have been multiple human-to-camel-transmission episodes. Additionally, breathing in infected air, touching contaminated things, and respiratory droplets can all spread it. The first case of a 65-year-old man dying from severe pneumonia and multiple organ failure[1]. Currently, most MERS-CoV cases originate in Middle Eastern countries, including Kuwait, Iran, Saudi Arabia, the United Arab Emirates, Qatar, Oman, and Kuwait[1–3]. MERS-CoV-associated clinical illness might range from mild upper respiratory symptoms to multisystem failure and fulminant pneumonia. MERS-CoV poses a larger risk than other coronaviruses. The incubation

HIGHLIGHTS

- The outbreak centered in the Riyadh region with 312 confirmed cases and 97 deaths.
- Middle East respiratory syndrome Coronavirus (MERS-CoV) primarily spreads from dromedary camels to humans, with human-to-human transmission in healthcare settings.
- Outbreak exhibited seasonal trends linked to camel calving season and spatial patterns in rural areas with high camel populations.
- Saudi Ministry of Health implemented a comprehensive response, including enhanced surveillance, improved infection control, and risk communication.
- Multi-faceted interventions led to a decline in new cases and deaths, underscoring the effectiveness of the response.

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period ranged from two to fourteen days, with those with underlying medical conditions being more likely to die. A novel coronavirus called MERS-CoV causes serious respiratory illnesses in patients[4]. Since 2012, MERS-CoV has been the source of several outbreaks in Saudi Arabia and other Middle Eastern countries. This presents a risk of fatalities and transmission, particularly in populations that are already at risk[3,5].

Our purpose for this literature analysis was to provide a thorough summary of Saudi Arabia's 2023 MERS-CoV outbreak, including epidemiological investigation, public health response, impact, and lessons learned. Based on the published studies and their contributions to the field. This study aims to lower the risk of MERS-CoV transmission, highlight the importance and relevance of this issue, and provide viable solutions for preventing future outbreaks. We hope that these findings will contribute to the ongoing discussion about MERS-CoV and affect Saudi Arabia's public health practices and policies.

Background

Middle Eastern Respiratory Illness The zoonotic virus known as MERS-CoV was discovered in Saudi Arabia in 2012[1,6]; It is believed to have started in bats and is transmitted to humans via camels. It differs genetically from both the SARS-CoV and the novel coronavirus that causes COVID-19[1,6,7]. MERS-CoV can spread from person to person through respiratory droplets, contact with contaminated bodily fluids, or exposure to contaminated environments[8,9]. Human respiratory tract cells that are susceptible to infection by the virus include the alveoli, bronchioles, and upper and lower airways[6]. Moreover, other organs that MERS-CoV may infect include the liver, spleen, and kidneys. MERS-CoV signs and symptoms include fever, coughing, shortness of breath, pneumonia, and organ failure[6,10].

MERS-CoV took, on average, 5 days to incubate, but might take up to 14 days[8]. In contrast to SARS-CoV (10%) and COVID-19 (2%), MERS-CoV has a mortality rate of roughly 35%[5,8,9,11,12]. Risk factors for catastrophic outcomes from MERS-CoV infection include older age, male sex, underlying medical illnesses, and comorbidities such as diabetes, hypertension, chronic lung disease, chronic kidney disease, and immunosuppression[3–5,13].

Most of the instances included travel to, residence in, or interaction with tourists from the Middle East. However, certain cases have also been reported in North America, Asia, Europe, and Africa, among other regions of the world (Fig. 1). Many of these infections were connected to visitors or medical professionals who had come into contact with MERS-CoV patients or camels in middle east.

Features of outbreaks

When the MERS-CoV outbreak began in March 2023, Riyadh, the capital and largest city of Saudi Arabia, was the primary target. Situated on an area of roughly 404 000 square kilometers, the Riyadh region is home to ~8.5 million people[3]. The first instance of MERS-CoV infection linked to this outbreak was a 65-year-old man who came into contact with camels on a farm near Riyadh. The patient died a few days after being admitted to the hospital due to fever, cough, and dyspnea[14]. The outbreak peaked in April and May of 2023, based on the highest number of cases (79) and deaths (28) reported in that month.

The Ministry of Health documented three additional incidents between 13 September 2022, and 12 August 2023, two of which were fatal. These instances happened in Asser, Makkah Al Mukaromah, and Riyadh (Fig. 2). In the lab, real-time polymerase chain reaction (RT-PCR) was employed[15,16]. The three patients did not work in the medical sector and had symptoms such as fever, coughing, and dyspnea. The patients also have underlying medical conditions. All three patients had consumed raw camel milk within 14 days of the onset of symptoms, and two had even had previous experiences with dromedary camels. The affected individuals were three males, ages 42, 83, and 85 (Table 1).

Twenty-seven nations across all six WHO regions have reported cases of MERS-CoV-related human infections since the virus was first discovered in Saudi Arabia in 2012[1,6,8]. Including these most recent cases, 2196 (84%) of the 2605 cases that were reported were from Saudi Arabia, which was responsible for 856 (91%) of the 937 deaths that were officially registered in these 27 countries—including the deaths that were just made public (Fig. 3). These cases highlight the continued risk of transmission and the ongoing presence of MERS-CoV in Saudi Arabia. Vigilance in surveillance, early detection, and fast response times are still critical in preventing the virus from spreading. Raising public awareness of the potential risks associated with handling dromedary camels and drinking raw camel milk ought to be the primary objective. By implementing effective preventative measures and supporting public health activities, we may endeavor to mitigate the impact of MERS-CoV and protect public health in Saudi Arabia and globally[17–19].

The outbreak followed a seasonal pattern, with the majority of infections occurring between March and June, when camels give birth. These findings suggest that camels have a significant role in the human-to-human spread of MERS-CoV. The outbreak also showed a spatial trend, with most illnesses occurring in rural areas where camel husbandry and trafficking is highly concentrated. About 85% of the patients had a history of either direct or indirect contact with camels or camel products, including milk, meat, or urine[4,5,14].

The MERS-CoV outbreak had a serious impact on public health and safety because it overtaxed the healthcare system, disrupted social and economic activities, and increased public anxiety and stigma[8–10]. Furthermore, the outbreak was concerning to neighboring countries and regions since some of the cases were linked to travel or contact with travelers from Saudi Arabia.

Clinical features and epidemiological studies of MERS-CoV

MERS-CoV is a zoonotic virus that passes from animals to humans. According to research, humans can get the disease by coming into direct or indirect contact with afflicted dromedary camels, but it is unclear how the virus spreads[2,8,10]. Human-to-human transmission can occur in clinical settings, but it is more likely during close encounters. Since the identification of MERS-CoV in 2012, 27 countries have reported MERS cases to the WHO in accordance with the International Health Regulations (2005): Algeria, Austria, Bahrain, China, Egypt, France, Germany, Greece, The Islamic

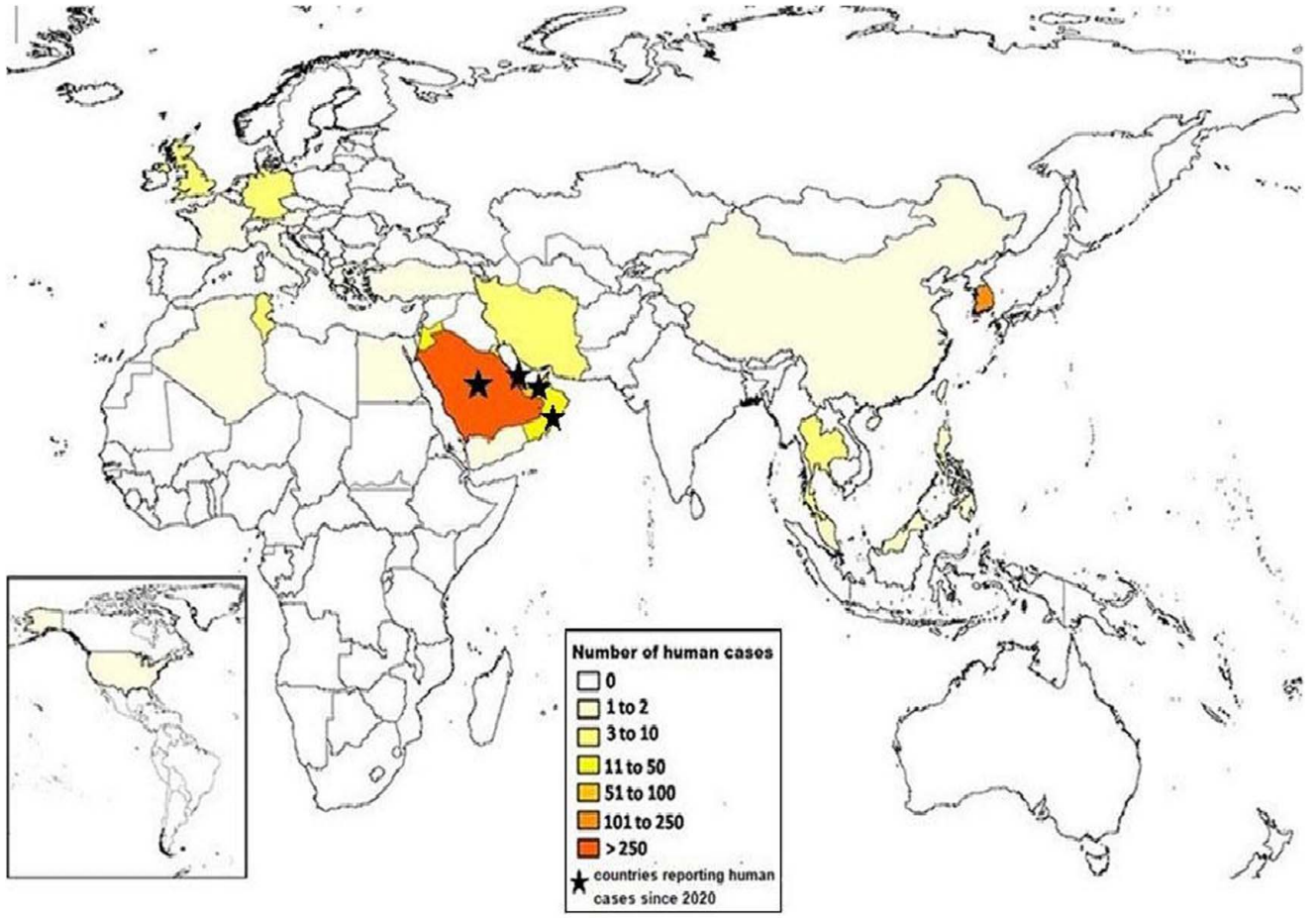

Figure 1. Global distribution of human cases of Middle East respiratory syndrome Coronavirus (MERS-CoV). The stars highlight countries reporting human cases since 2020 (Oman, Saudi Arabia, Qatar, and the United Arab Emirates).

Republic of Iran, Italy, Jordan, Kuwait, Lebanon, Malaysia, the Netherlands, Oman, the Philippines, Qatar, the Republic of Korea, the Kingdom of Saudi Arabia, Thailand, Tunisia, Türkiye, United Arab Emirates, the United Kingdom[2,4,8,9]. Middle Eastern countries report many MERS-CoV cases. The case fatality rate is 35%; however, because mild cases of MERS might go undetected by present surveillance systems, this statistic may be overstated rather than the true mortality rate. MERS-CoV infection can result in moderate or no respiratory symptoms, severe acute respiratory disease, or even death[1,6,20]. symptoms include shortness of breath, fever, and cough[1,8]. Pneumonia is a common finding in MERS patients, but it is not guaranteed. There have also been reports of stomach issues such as diarrhea[4,5,14]. Respiratory failure caused by severe disease may demand mechanical ventilation or supportive care in an intensive care unit[3,9,14,15,21]. Elderly people, people with weakened immune systems, and people with chronic illnesses like diabetes, hypertension, cancer, chronic lung disease, and renal disease are more prone to experience severe disease[5,9]. There are certain uncommon presentations that have been reported, like mild respiratory illness without fever and diarrhea that appear prior to the development of pneumonia. Possible radiographic abnormalities include unilateral or bilateral patchy densities or opacities, interstitial infiltrates, consolidation, or pleural effusion. Rapid progression to extrapulmonary consequences, such as acute respiratory failure, acute respiratory distress syndrome (ARDS), refractory hypoxemia, acute kidney injury requiring renal replacement therapy, hypotension requiring vasopressors, hepatic inflammation, and septic shock, has been reported[5,8,9]. Laboratory results at the time of admission included leukopenia, lymphopenia, thrombocytopenia, and elevated lactate dehydrogenase (LDH) values. Coinfections with various respiratory viruses and bacteria have been reported[2,8].

There is presently no recognized vaccine or targeted treatment; however, research is being done on several medications and vaccines that are specific to MERS-CoV. Considering the patient's symptoms and clinical condition, supportive treatment is provided. Saudi Arabia has reported most MERS-CoV infections to the WHO, accounting for 83.6% of all cases as of June 2020. Epidemiological investigations have identified age older than or equal to 65, underlying diseases, and more than or equal to ≥ 5 days of delayed diagnosis as risk factors for MERS-CoV infection-related deaths. However, patients who come into touch with animals who are female and younger than 65 years old are more likely to die, while patients who are male and older are less likely to die[2,8,16].

The primary driver of the spatial distribution of MERS-CoV is the transportation network, with Riyadh, Saudi Arabia, and Abu Dhabi, United Arab Emirates, serving as centers for both local

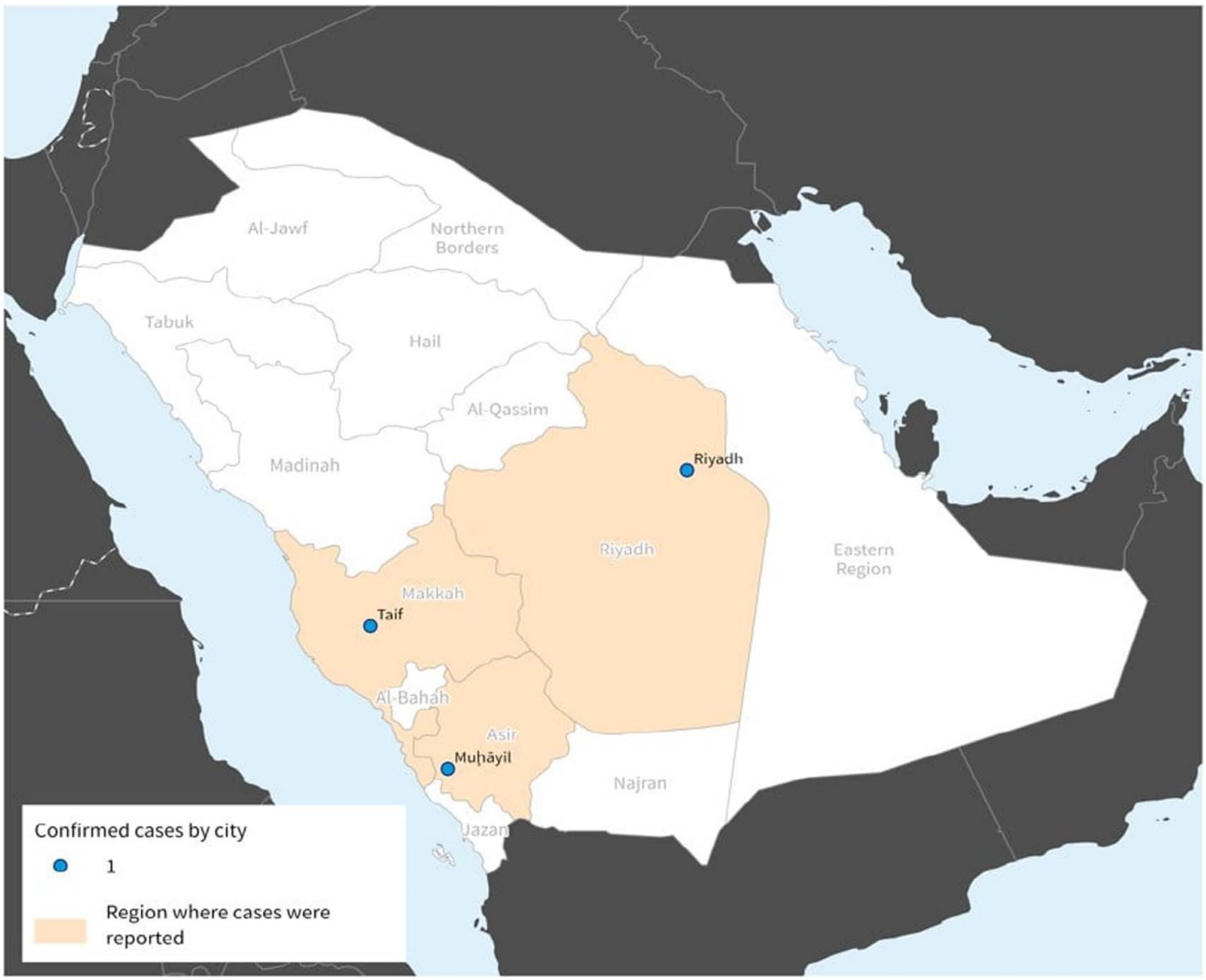

Figure 2. Geographical distribution of Middle East respiratory syndrome Coronavirus (MERS-CoV) cases between 13 September 2022 and 12 August by city and region in KSA ($n = 3$). [Source: WHO (29 August 2023)].

Table 1

MERS-CoV cases reported by the KSA between 13 September 2022, and 12 August 2023 [Source: WHO (29 August 2023)].

Case numbers	1	2	3
Date of reporting to WHO (year/month/day)	2022/11/29	2022/12/11	2023/03/06
Reporting country	Kingdom of Saudi Arabia	Kingdom of Saudi Arabia	Kingdom of Saudi Arabia
Region of residence	Taif city, Makkah	Riyadh City, Riyadh	Mahayel city, Asser
Age	42	83	85
Sex	M	M	M
Healthcare worker	Non healthcare worker	No healthcare worker	No healthcare worker
Commodities	Bronchial asthma	Diabetes mellitus, benign prostatic hyperplasia	Diabetes mellitus, hypertension
Exposure to camels	Not known	Yes	Yes
Camel milk consumption	Yes	Yes	Yes
Date of symptoms onset	2022/11/02	2022/12/01	2023/01/05
Date of first hospitalization	2022/11/16	2022/12/06	2023/01/10
Date of laboratory confirmation	2022/11/28	2022/12/11	2023/01/12
Status	Died on 2022/12/18	Survived	Died on 2023/01/26

M, male; MERS-CoV, Middle East respiratory syndrome Coronavirus.

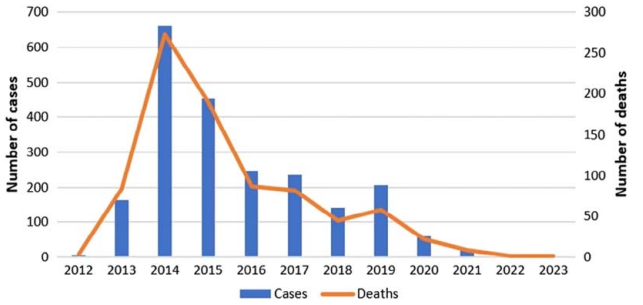

Figure 3. Epidemic curve of Middle East respiratory syndrome Coronavirus (MERS-CoV) cases and deaths reported in KSA between 2012 and 12 August 2023 [Source: WHO (29 August 2023)].

and worldwide spread. The disease has spread to close contact and hospital settings on other continents because of trade and travel[1,8,10].

This suggests a drop in the number of occurrences when compared to the previous period from December 2021 to October 2022, when four incidences were documented without any fatalities.

Public health responses

The WHO and other national and international players have helped the Saudi Arabian Ministry of Health (MOH) respond to the MERS-CoV outbreak in 2023. The comprehensive solutions covered techniques to enhance clinical management, risk communication, travel restrictions, surveillance, infection prevention and control, and coordination[18–20]. The response was evaluated using a variety of indicators that over time showed a decline in the number of cases and fatalities, and it was successful despite certain challenges.

One of the main goals of the MOH is to increase the capacity of the laboratory and monitoring systems. This included contact tracing, DNA analysis, environmental monitoring, animal observation, active case detection, and laboratory testing. The MOH shared the virus's genomic sequences with researchers worldwide and notified the WHO of all confirmed cases and deaths in compliance with the International Health Regulations (IHR, 2005). This ensured that accurate and timely information was given to guide response and decision-making actions. Enhancing the efficacy of protocols for preventing and controlling infections was an additional critical measure. The MOH has implemented standard, contact, and droplet precautions in community and hospital settings. The MOH provided training,

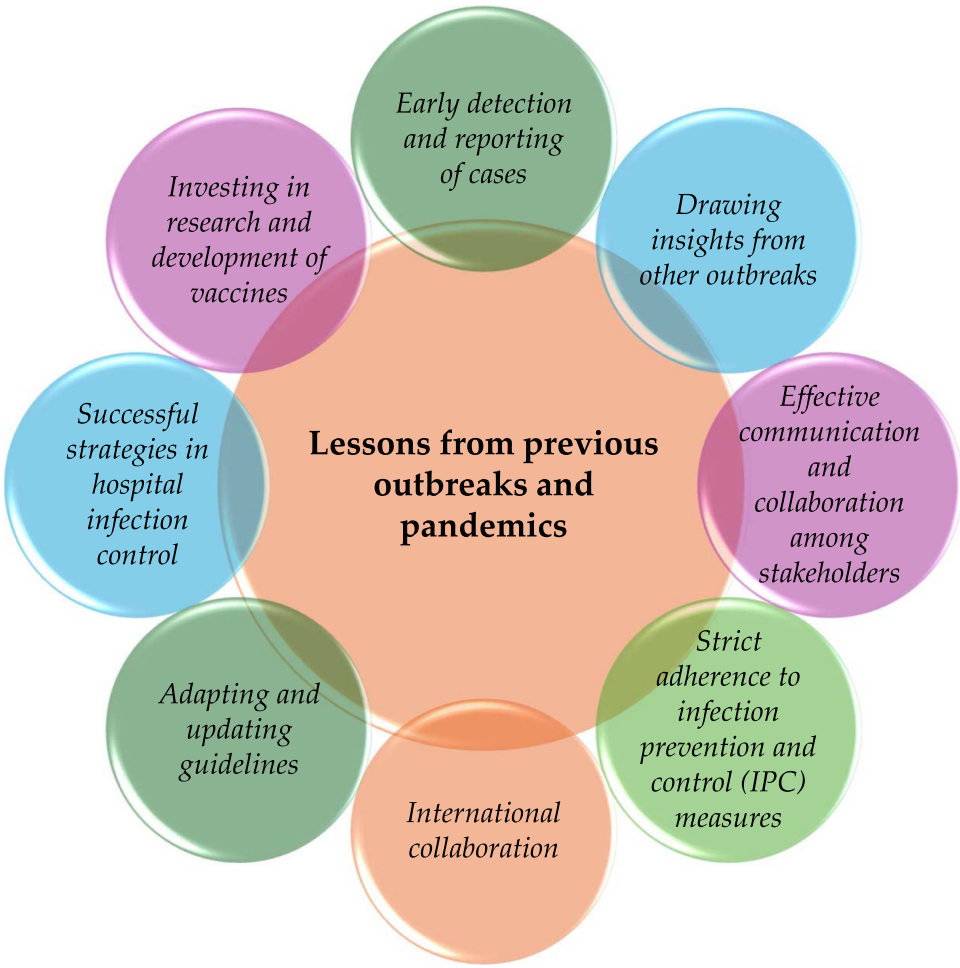

Figure 4. Summary of lessons learned from Middle East respiratory syndrome Coronavirus and other previous pandemics.

guidance, and personal protective equipment (PPE) to frontline responders, including healthcare workers. This helped to halt the virus's spread and protected medical staff from infection[19].

Priority was given to clinical management and patient aid. MERS-CoV cases had to be quickly identified, isolated, treated, and referred; this was a priority for the MOH. The MOH has also conducted clinical research on potential medicines and established treatment centers specifically for MERS-CoV. Both the standard of care and patient outcomes improved as a result[3].

To raise public awareness and promote risk communication, the MOH has disseminated accurate and current information about MERS-CoV and its symptoms, transmission, prevention, and control. The MOH also worked with a range of media outlets, social media platforms, religious leaders, community leaders, and civil society organizations to promote health education and behavioral change. This increased public knowledge and trust in medical professionals[9,21].

Restrictions on travel and screening protocols were also implemented to prevent the virus from spreading. The MOH advised visitors to avoid camels and camel products in affected areas and to seek medical attention if they showed any symptoms of MERS-CoV infection. The MOH also examined travelers' exposure histories and respiratory conditions at ports of entry and exit.

Despite several challenges, such as a shortage of labor and resources in isolated or rural areas, barriers to changing behavior stemming from cultural and religious convictions, local political and socioeconomic instability, and the introduction of novel viral strains, the response has proven effective. The CDR, CFR, R0, IAR, and VCR indices all showed a decline in cases and deaths with time. This finding suggests that the public health strategy is effective in preventing the spread of new illnesses. However, there remains room for improvement in terms of increasing immunization rates, enhancing infection prevention and control measures, and strengthening the global health security framework. To surmount these challenges and ensure a well-coordinated and enduring response to future outbreaks, the MOH should continue its strong cooperation with WHO and other organizations.

Effect, takeaways, post-epidemic analysis, and readiness

Hospital infection control protocols are being tested by several respiratory illness outbreaks, not just the MERS-CoV outbreak[17,18,22]. These outbreaks pose a threat to global health. Previous coronavirus outbreaks, such as the SARS outbreak in 2003 and the COVID-19 outbreak in 2019–2020, have demonstrated that new coronaviruses can spread swiftly across countries and continents, cause severe illness, and even be fatal[8,9,17]. These outbreaks have enhanced hospital infection control in addition to providing valuable lessons about lowering the transmission of nosocomial respiratory pathogens[7].

The MERS-CoV outbreak has a major influence on society, healthcare systems, and public health in Saudi Arabia and elsewhere. It influences the social and economic realms, puts strain on the healthcare system, and causes significant morbidity and mortality in those who are affected. However, it also provides valuable information for controlling infectious disease outbreaks in the future. The necessity of timely case detection and reporting, effective infection prevention and control protocols, community-based treatments, and transparent, regular risk communication to empower the public are a few of the lessons (Fig. 4) that have been learnt[15,21].

To control or prevent such epidemics and reduce the risk of MERS-CoV transmission, safe and effective MERS-CoV vaccinations and treatments must be created and put into practice[13,23]. It is also essential to improve multisectoral and multilateral collaboration and coordination to increase global health security and preparedness[17]. By providing financing for the research of MERS-CoV vaccines and therapies and ensuring their accessibility and affordability, we can better prepare for future outbreaks.

Conclusion

The MERS-CoV outbreak in Saudi Arabia has put a heavy burden on the nation's healthcare system and presents a serious threat to the general public's health. Notwithstanding several obstacles, including scarce resources, a lack of timely reporting, and inadequate coordination, the Ministry of Health and its partners showed excellent reaction times and advancements. Nonetheless, the outbreak had a significant effect on Saudi Arabian public health, institutions, and society. This outbreak serves as a sobering reminder of the ongoing risks to international health, security, and preparedness presented by new and reemerging infectious diseases. Enhancing laboratory and monitoring capabilities, putting in place efficient infection prevention and control measures, creating and implementing safe and effective vaccinations and treatments, empowering, and involving the public, and bolstering regional and international collaboration and coordination are all necessary to lessen these effects.

Early case detection and reporting, timely and transparent data sharing, effective risk communication, community-based treatments, and multisectoral collaboration are critical components of preventative measures. The MERS-CoV outbreak in Saudi Arabia highlights how crucial it is to foresee and respond to new infectious disease outbreaks to protect communities and ensure public health and well-being via coordinated efforts.

Ethical approval

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Consent

Not applicable.

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Author contribution

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Conflicts of interest disclosure

The authors declare no conflicts of interest.

Research registration unique identifying number (UIN)

Not applicable.

Guarantor

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Data availability statement

Not applicable.

Provenance and peer review

Not applicable.

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