SHORT COMMUNICATION

A Tempo-geographic Analysis of COVID-19 and Vaccination in EMRO Region: Joinpoint Regression in an Ecologic Study

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Abstract

Background: The rapid response of governments to overcome COVID-19 is increasingly important. In this study, we investigated the epidemiological changes of Covid-19 and the vaccination status of this disease in the Eastern Mediterranean Region (EMRO).

Methods: This research is a descriptive ecologic study. Data on vaccination status in the EMRO region were collected and Also the daily cases, daily COVID-19 mortality, the total number of deaths, and cases from January 3, 2020, to June 13, 2022.

Results: Iran had the highest number of known cases and deaths, while Bahrain and Tanzania had the highest cumulative rates of cases and deaths, respectively. The highest average monthly incidence rate changes were observed in Iraq, with 41.74%. Iran had the highest average monthly death rate changes with 25.75% and the highest number of known cases and deaths.The United Arab Emirates had the highest total vaccinations per 100 individuals and the highest percentage of persons fully vaccinated.

Conclusion: It appears that cooperation among countries in the region regarding vaccination can lead to a decline in the disease and ultimately control its spread. Furthermore, there is a noticeable decrease in the percentage of monthly changes after the start of vaccination in the EMRO countries. The gradual increase in some countries during the last segment highlights the importance of booster vaccinations.

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Introduction

Coronavirus (COVID-19) was initially reported on December 31, 2019, in Wuhan, China. Since then, it has rapidly spread rapidly around the world.[1] On January 30, 2020, WHO declared the coronavirus as the sixth public health emergency, following previous emergencies such as influenza (2009), polio (2014), Ebola in West Africa (2014), Zika (2016), and Ebola in Congo (2019).[2] Despite the Chinese government's significant efforts to control the disease, it quickly spread and affected people globally[3, 4] until it was offically declared a pandemic on March 11, 2020.[5]

Countries worldwide are striving to manage the potentially devastating impacts of COVID-19. National health organizations are working to mitigate the threat by disseminating information and implementing disease guidelines. Meanwhile, scientists across the globe are engaged in ongoing research to develop knowledge on transmission, disease mechanisms, clinical signs, diagnostic methods, and effective strategies for prevention and treatment.[5] Vaccination

campaigns have also commenced in various countries.[5] Given this context, governments' swift response to overcome COVID-19 is increasingly crucial.

Therefore, this study aims to examine changes in the epidemiological situation of the Eastern Mediterranean region following the initiation of vaccination. By acquiring and analyzing this data, not only can we enhance our understanding of disease trends, but we can also facilitate strategic planning and collaborations to swiftly control the disease in the region and prevent further outbreaks.[6] The application of the Joinpoint regression method will assist in reporting the trend using a smaller number of data points compared to time-series models. Additionally, this model enables the identification of significant trend changes during specific periods. Consequently, our study aims to investigate the spatio-temporal analysis of COVID-19 and vaccination in the EMRO region using the joinpoint regression model in an ecological study.

Methods

This ecological study provides information on daily COVID-19 cases and mortality from January 3, 2020, to June 13, 2022. Data on the total number of deaths and cases of COVID-19 in the Eastern Mediterranean Region during that period were collected from the following sources:

1. https://github.com/CSSEGISandData/COVID-19
2. https://www.worldometers.info/coronavirus/

he daily data of cases and deaths by country were converted into monthly data for joinpoint regression analysis. Information on vaccinations was obtained from the following source:

1. https://ourworldindata.org/covid-vaccinations

The collected information on vaccinations includes total vaccinations, persons vaccinated with one dose, persons fully vaccinated, persons with booster doses, and the number of vaccine types used. The sources' definitions indicate that "persons vaccinated with one dose" represents the share of the total population that received at least one dose of the vaccine. This metric may not represent a complete vaccination if a vaccine requires two doses. The metric increases by one if a person receives the first dose of a two-dose vaccine. If a second dose is administered, the metric remains the same. "Persons fully vaccinated" indicates the share of the total population that completed the primary vaccination protocol. This metric remains the same if a person receives the first dose of a two-dose vaccine. If they receive a second dose, the metric increases by 1. "Persons with booster doses" represents the number of additional doses administered beyond the original vaccination protocol, such as a third dose of the Pfizer/BioNTech vaccine or a second dose of the Johnson & Johnson vaccine.

Statistical Analysis

The collected data were analyzed using Joinpoint software (Version 4.9.0.0). Monthly percent change (MPC) and Average Monthly Percent Change (AMPC), along with their 95% confidence intervals (CI). The percentage of monthly changes in MPC reflects the constant rate of change compared to the previous month, while AMPC provides a general measure of the trend over a fixed period of time by specifying the average value of MPC values. The number of joinpoints ranged from 0 to 9, depending on the trend of each country. The formula for joinpoints regression is as follows:

$$y \quad i = B_0 + B_1 X_i + \delta_1 (x_i - \tau_1)^+ + \cdots$$
$$+ \delta_k (x_i - \tau_k)^+ + \varepsilon_i^{(k)} = \mu_i^{(k)} + \varepsilon_i^{(k)}$$

Total cases and death rates of COVID-19 (per 100,000) were plotted on a map. To account for population differences, the authors converted the total cases and deaths of COVID-19 into rates based on the population of each country in the years 2020, 2021, and 2022.

Eastern Mediterranean Region includes 21 countries: Afghanistan, Bahrain, Djibouti, Egypt, Iran (the Islamic Republic of), Iraq, Jordan, Kuwait, Lebanon, Libya, Morocco, Oman, Pakistan, Qatar, Saudi Arabia, Somalia, Sudan, Syrian Arab Republic, Tunisia, United Arab Emirates, and Yemen.

Results

The results are presented in Figures 1A and 1B, which show the total case and death rates. Bahrain has the highest rate of known cases, followed by Lebanon and Kuwait, while Yemen has the lowest rate, with 35.16 per 100000. The highest rate of deaths is observed in Tunisia, followed by Lebanon and Iran, with Yemen and Somalia having the lowest death rates, with 6.37 and 7.67 per 100000, respectively.

Figure 2 provides information on MPC for monthly cases and death rates in EMRO countries from January 3, 2020, to June 13, 2022. Table 1 shows the average monthly percent change (AMPC) and 95% confidence interval (CI) for monthly new cases and COVID-19 death rates in EMRO countries. Most of the average monthly incidence rate changes are related to the country of Iraq, with 41.74%. Iran initially experienced an increasing trend in monthly changes of the disease from January 2020 to August 2021, but showed a downward trend from August 2021 to November 2021, with a monthly decrease of 45.68%. As of June 1, 2022, 76.795% of Iranians had received at least one dose of the vaccine, and 68.827% were fully vaccinated.

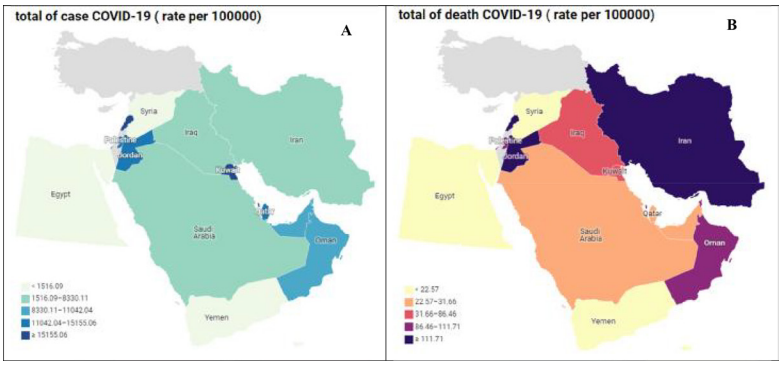
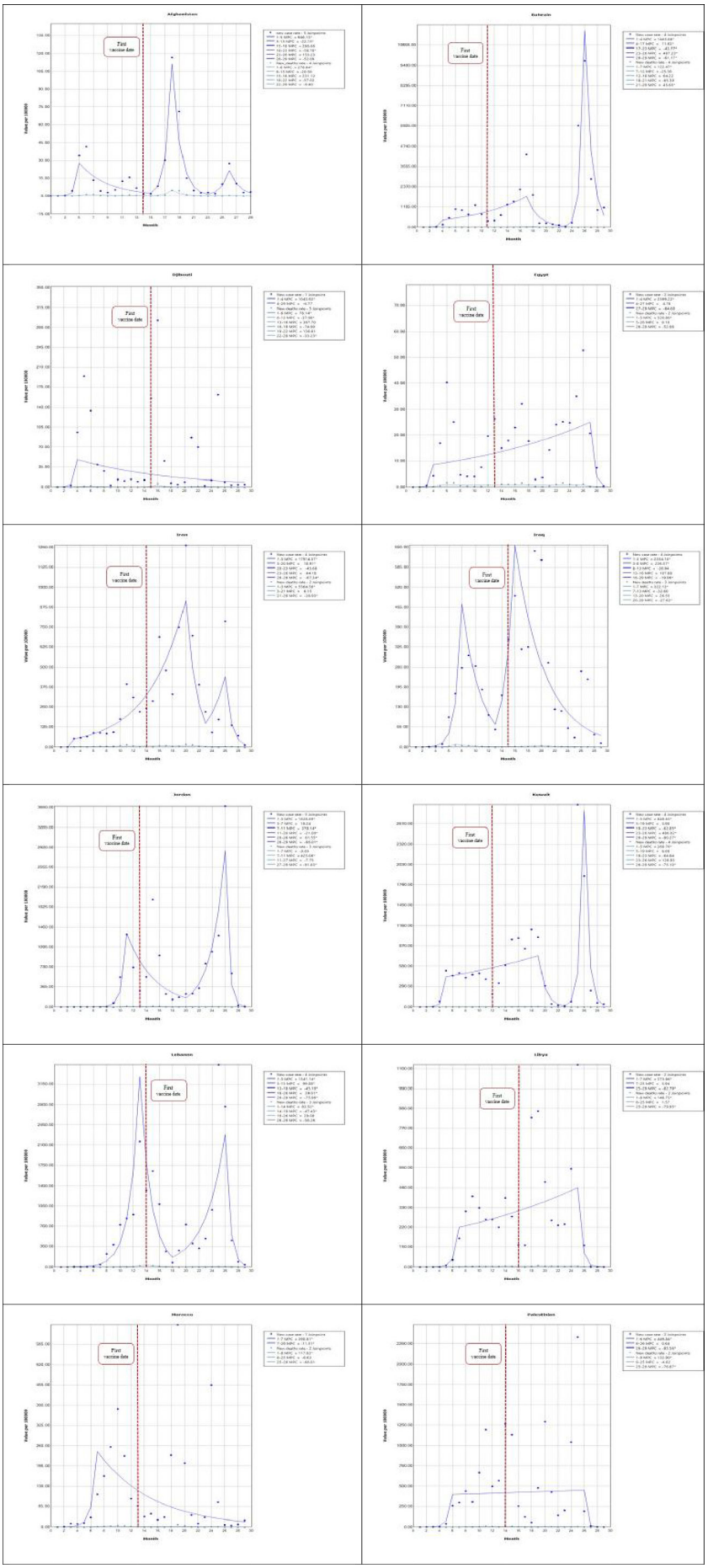


Figure 1: A and B: Total case rate and Total death rate COVID-19 (per 100000))created with Datawrapper)

Table 1: Average Month percent change (AMPC) and 95% confidence interval (CI) month case and death rate COVID-19 per 100000 in EMRO countries from 3 January 2020 to 13 June 2022 and total vaccinations, persons vaccinated 1 dose, persons fully vaccinated, persons booster add dose per 100 and number vaccines types used from the start of vaccination until 1 June 2022

Name of country	AMPC case (CI 95%)	AMPC death (CI 95%)	Total vaccinations (per 100)	Persons vaccinated 1 dose (per 100)	Persons fully vaccinated (per 100)	Persons booster add dose (per 100)	Number of joinpoint for case	Number of joinpoint for death	Number vaccines types used
Afghanistan	28.10 (-12.32, 87.14)	15.58 (-17.66, 62.23)	15.854	14.018	12.351	-	5	4	11
Bahrain	36.60 (9.67, 70.14)*	13.53 (-18.77, 58.68)	202.448	72.691	71.737	58.02	4	4	11
Djibouti	21.96 (-2.23, 52.13)	-0.84 (-27.67, 35.94)	30.576	17.315	13.261	-	1	5	11
Egypt	28.35 (2.78, 60.27)*	19.81 (3.45, 38.76)*	83.32	46.76	34.528	3.507	2	2	10
Iran	39.11 (17.02,65.37)*	25.75 (7.94, 46.50)*	177.822	76.795	68.827	32.201	4	2	12
Iraq	41.74 (3.58, 93.96)*	19.50 (4.56, 36.58)*	45.631	26.539	18.643	0.449	4	3	10
Jordan	31.83 (1.23, 71.69)*	1.02 (-18.01, 24.46)	97.537	46.944	44.19	6.444	5	3	10
Kuwait	23.96 (1.87, 50.84)*	2.01 (-25.44, 39.56)	188.358	80.234	77.528	30.596	4	4	10
Lebanon	31.10 (7.86, 59.35)*	14.71 (-2.86, 35.47)	82.551	39.356	34.618	8.577	4	3	10
Libya	11.26 (0.02, 23.77)*	0.77 (-9.41, 12.11)	50.358	32.257	16.632	1.469	2	2	10
Morocco	21.65 (3.31, 43.25)*	-1.44 (-18.96, 19.86)	148.111	67.542	63.427	17.408	1	2	10
Palestinian	-2.44 (-21.07, 20.58)	0.42 (-13.60, 16.71)	72.99	39.276	34.685	6.441	2	2	10
Oman	8.71 (-12.74, 35.45)	0.84 (-18.43, 24.67)	138.848	63.914	60.175	14.76	5	5	11
Pakistan	-21.21 (-35.49, -3.76)*	-11.24 (-27.28, 8.34)	116.025	65.185	55.002	3.519	2	3	11
Qatar	23.22 (-1.92, 54.81)	-0.73 (-28.16, 37.16)	239.182	91.375	91.375	56.431	5	5	10
Saudi Arabia	32.78 (-4.29, 84.21)	14.61 (3.53, 26.87)*	189.113	76.404	71.696	41.013	5	5	10
Somalia	5.78 (-19.42, 38.87)	-4.60 (-17.36, 10.13)	17.523	14.459	8.972	-	2	1	11
Sudan	17.74 (-7.75, 50.27)	17.34 (-8.80, 50.95)	21.892	13.523	8.282	0.087	5	1	11
Syrian Arab Republic	6.86 (-16.75, 37.16)	0.25 (-10.77, 12.62)	22.114	14.54	9.336	0.123	5	2	11
Tunisia	25.30 (9.02, 44.02)*	10.46 (-28.66, 71.05)	111.504	61.174	53.917	10.696	1	4	10
United Arab Emirates	23.15 (-1.43, 53.86)	1.02 (-18.03, 24.50)	251.854	101.018	99.008	51.828	4	2	11
Yemen	2.81 (-26.96, 44.71)	2.36 (-29.53, 48.69)	2.812	2.256	1.441	-	4	4	11

*P value≤0.005


First vaccine date
Months

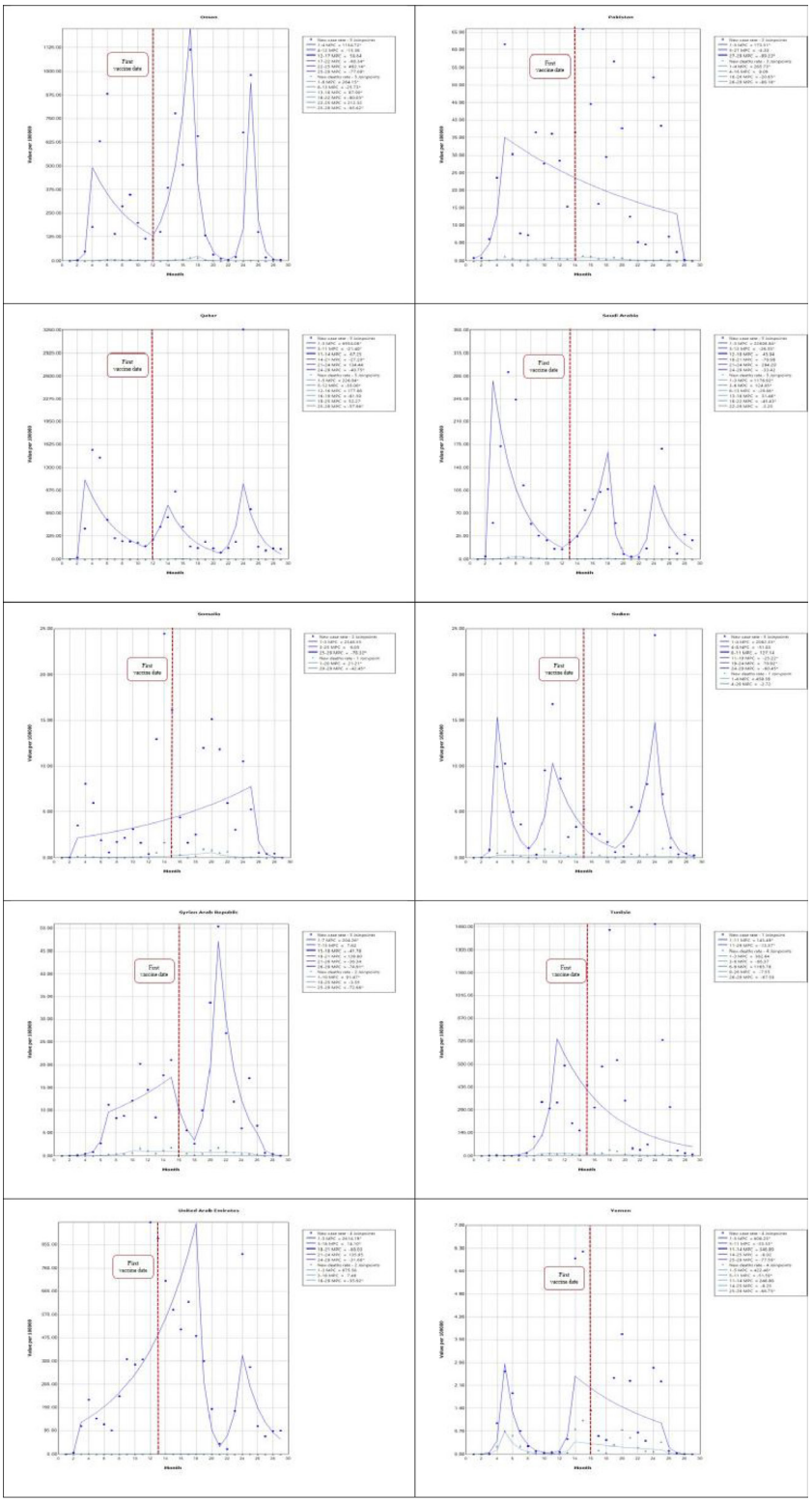


Figure 2: Trend of new case rate ans new death rate COVID-19 per 100000 in EMRO region from 3 January 2020 to 13 June 2022 (Month percent change (MPC) and first vaccine date in EMRO region

The United Arab Emirates exhibits four joinpoints, with an increasing trend in case rates in the first segment, followed by a decreasing trend five months after the start of vaccination (68.03%). Iran has two joinpoints with the most significant average monthly new death rate changes. It had an upward trend from January 2020 to September 2021, followed by a decrease seven months after the start of vaccination.

Figure 2 and Table 1 also present information on the vaccination status of EMRO countries. The United Arab Emirates has the highest percentage of people who received at least one dose of the

COVID-19 vaccine, followed by Qatar and Kuwait. Afghanistan, Sudan, and Yemen have the lowest vaccine percentages. United Arab Emirates, Qatar, and Kuwait report the highest percentage of fully vaccinated individuals, while Yemen, Sudan, and Somalia have the lowest percentage. Bahrain, Qatar, and the United Arab Emirates are at the top regarding booster doses, with Iran ranking fifth in the region with 32.20% of booster dose injections. Bahrain is among the first countries to start vaccination, followed by Kuwait and Oman. According to Table 1, most EMRO countries seem to use both mRNA-based vaccines and inactivated vaccines.

Discussion

The study emphasizes the importance of vaccination as a public health tool in controlling infectious diseases.[7] Therefore, a safe, highly effective, universally acceptable vaccination program, along with pre-existing preventive measures, is essential to control the outbreak effectively.[7] Vaccination has significantly reduced the mortality rate, especially in the United Arab Emirates, where the vaccination rate exceeded 70%. Incidence and new death rates decreased, especially in the last segment. Iran witnessed a decrease in the incidence and death rates six months after the start of vaccination. Iran is the sixth country in terms of persons fully vaccinated, and disease peak time took longer at the beginning of vaccination (first dose), and the number of patients and deaths is higher than the end of vaccination. This issue emphasizes the importance of completing the vaccine dose. This issue has also been emphasized in other studies.[8, 9] Bahrain, despite a high percentage of fully vaccinated individuals (71.73%), experienced an increasing incidence trend from November 2021 to February 2022, which could be attributed to factors such as waning vaccine effectiveness or reduced compliance with health protocols.[10]

But in any case, it seems that the type of vaccine has not affected this difference between countries, and countries should provide any vaccine that is approved by international organizations and is available to create safety in their country. However, in any case, it seems that the cooperation of countries in the region in vaccination can lead to a decline in the disease and ultimately control it. Howeverthe ecological study design used in this research has inherent limitations, including the ecological fallacy. It is important to consider that the quality of reporting and data accuracy may vary among countries, and there is a possibility of incorrect reporting or discrepancies in the data sources used. Access to healthcare facilities and variations in healthcare capabilities can also influence the reported numbers. Factors such as acceptance of vaccination, race, religion, literacy level, weather, political status, economic conditions, and healthcare capabilities can all potentially impact the number and trend of cases and mortality, but these factors were not specifically addressed in this study.It is also possible that many patients self-medicate[11] and do not go to medical centers, which can lead to a small number of reports, especially for the incidence. The impact of different variants in the EMRO area is also one of the other limitations of our study. Vaccines become effective after the second jab and cost-effective after being administered to a certain percentage of the population.[12] In addition, it should be noted that the vaccination ratio does not directly reflect herd immunity, and immunity in improved individuals or lack of immunity in vaccinated individuals for various reasons should not be overlooked. However, our study covers all EMRO countries, and a good time trend has been achieved for these countries. Also, in our study, we used the Joinpoint regression method, which can best show us the points of failure and change, and separate the points that have a significant trend for us. In this study, It is important to note that the study did not extensively examine the impact of vaccines on the severity of COVID-19 disease and hospitalization rates. Additionally, the study did not delve into disease prediction under different scenarios. The authors recommend further research in these areas.

Conclusion

Absolutely, cooperation among countries in the Eastern Mediterranean Region (EMRO) is crucial in controlling the spread of COVID-19. Sharing experiences and successful measures taken by EMRO countries in the fight against COVID-19 can provide valuable insights and guidance to other countries facing similar challenges. In the context of vaccination, countries with successful vaccination campaigns can share their experiences and guidelines with other countries in the region. Scientific cooperation in vaccine production technologies is another important aspect, leading to the reduction of COVID-19 disease and its death in this region.

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Conflicts of interest: None declared.

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