

Effect of temperature and humidity on the dynamics of daily new cases and deaths due to COVID-19 outbreak in Gulf countries in Middle East Region

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Abstract. – **OBJECTIVE:** Weather-related dynamics have an impact on the pattern of health and disease. The present study aimed to investigate the effect of temperature and humidity on the daily new cases and daily new deaths due to COVID-19 in Gulf Cooperation Council (GCC) countries in the Middle East.

MATERIALS AND METHODS: We selected all the six GCC countries, including Saudi Arabia, United Arab Emirates, Bahrain, Kuwait, Qatar and Oman. This region has a relatively high temperature and humidity, and has homogeneous Arab ethnicity with a similar socioeconomic culture. The data on the global outbreak of COVID-19, including daily new cases and deaths were recorded from World Health Organization. The information on daily temperature and humidity was obtained from world climate web “Time and Date”. The daily basis, mean temperature and humidity were recorded from the date of appearance of first case of COVID-19 in the region, Jan 29, 2020 to May 15, 2020. We also evaluated the growth factor, “a ratio by which a quantity multiplies itself over time; it equals daily cases divided by cases on the previous day”.

RESULTS: In GCC countries, the daily basis mean temperature from Jan 29, 2020 to May 15, 2020 was $29.20 \pm 0.30^\circ\text{C}$ and humidity was $37.95 \pm 4.40\%$. The results revealed that there was a negative correlation and decrease in the number of daily cases and deaths from COVID-19 with increase in humidity in Oman, Kuwait, Qatar, Bahrain, United Arab Emirates and Saudi Arabia. The correlation coefficient between temperature with daily cases shows that an increase in temperature was associated with an increase in daily cases and deaths due to COVID-19, however, the temperature is still gradually rising in the region. The growth factor result for daily cases was 1.09 ± 0.00 and daily deaths was 1.07 ± 0.03 for COVID-19, and shows declining trends in GCC region.

CONCLUSIONS: An increase in relative humidity was associated with a decrease in the number of daily cases and deaths due to COVID-19 in GCC countries. The daily growth factor for patients and deaths shows a declining trend. However, the climate is swiftly changing in the region; further studies may be conducted during the peak of summer season. The findings have outcomes for policymakers and health officials about the impact of temperature and humidity on epidemiological trends of daily new cases and deaths due to COVID-19.

Key Words:

COVID-19, Climate, Temperature, Humidity, Prevalence, Mortality.

Introduction

The “Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2)” also called COVID-19 pandemic has swiftly spread all over the world and had devastating consequences on human health, lives and economies¹. COVID-19 has been more prevalent than other pandemics, such as “Severe Acute Respiratory Syndrome Coronavirus (SARS-CoV-1), and Middle East Respiratory Syndrome Coronavirus (MERS-CoV)”². COVID-19 has spread to 217 countries and has infected 4889205 people with a mortality rate of 318789 (6.52%)³.

The severe contagious nature of COVID-19 has developed an unprecedented and unpredictable situation in the world. The world’s population is 7.6 billion⁴, and approximately half of the world’s population, 3.9 billion

people, are under lockdown and quarantined in their homes⁵. However, the transmission of the disease and its subsequent mortalities have continued.

COVID-19 has “animal to animal, animal to human and human to human” transmission⁶. There are some meteorological factors in relation to transmission and magnitude of spread of viruses^{7,8}. More recently, a few published studies^{3,9} demonstrated that warm weather and humidity may slow down the COVID-19 global pandemic, which has already infected about 5 million people worldwide.

The effect of change in climate, mainly temperature and humidity, on the spread of COVID-19 is poorly understood at various regional levels; hence, clarification of such relationships in literature needs further scientific evidence. Therefore, the present study aimed to investigate the impact of temperature and humidity on the daily new cases and daily new deaths due to COVID-19 in Gulf Cooperation Council (GCC) countries, including “Saudi Arabia, United Arab Emirates, Bahrain, Kuwait, Qatar, and Oman”.

Materials and Methods

We selected all the six “Gulf Cooperation Council (GCC) countries, including Saudi Arabia, United Arab Emirates, Bahrain, Kuwait, Qatar, and Oman”. This region has relatively high temperature, homogenous Arab ethnicity and same socioeconomic culture. The data on the global outbreak of COVID-19, including daily new cases and daily new deaths were collected from the World Health Organization (WHO)³. The daily information on meteorological conditions, temperature and humidity was recorded from climate web, “Date and Times”¹⁰, and the mean values were calculated. In GCC countries, the daily basis mean temperature and humidity were recorded from the date of appearance of first case of COVID-19 in the GCC region, Jan 29, 2020 to May 15, 2020. The daily mean temperature during this period was $29.20 \pm 0.30^\circ\text{C}$ and humidity was $37.95 \pm 4.40\%$. We also evaluated the growth factor, “a ratio by which a quantity multiplies itself over time; it equals daily cases divided by cases on the previous day. A growth factor of more than 1.0, indicates an increasing pattern, whereas the values between 0-1.0 show a decreasing pattern”^{2,11}.

Ethical Statement

For this study the data on the global daily new cases and deaths due to COVID-2019 and other related information were obtained from the “World Health Organization”, and “climate web Time and Date” from the publically available data; hence, ethical approval was not required.

Statistical Analysis

In this study, all the six GCC countries in the Middle East with confirmed new cases and new deaths of COVID-19 were included. The data were recorded and analyzed; Mean and Standard Error of Mean (SEM) were calculated. A descriptive analysis was performed, with numerical variables described using means, SEM and distributions. A correlation coefficient was calculated between meteorological factors, temperature and relative humidity, and daily new cases and daily new deaths of COVID-19. The growth factor, by which quantity multiplies itself over time (daily cases divided by cases on the previous day), was calculated.

Results

We analyzed the impact of temperature and humidity on the daily new cases and deaths due to COVID-19 in all six GCC countries. The daily basis mean temperature and humidity were recorded from the date of appearance of first patient of COVID-19 in the GCC region, from Jan 29, 2020 to May 15, 2020 (Table I, Figure 1-2). The number of daily cases, daily deaths and cumulative cases due to COVID-19 infection are presented in Table I. The impact of temperature and humidity on the epidemiological trends on number of cases and deaths were presented and correlation coefficient values are given in Table II, Figures 3-4. The mean temperature and humidity in Oman was 29.89 ± 0.48 , 51.32 ± 2.21 ; United Arab Emirates 29.03 ± 0.55 , 39.45 ± 1.58 ; Kuwait 28.85 ± 0.52 , 31.16 ± 1.68 ; Bahrain 27.99 ± 0.49 , 44.87 ± 1.78 ; Saudi Arabia 29.75 ± 0.55 , 20.59 ± 1.12 and Qatar 29.67 ± 0.55 , 40.29 ± 2.04 . The overall mean temperature in all these six GCC countries was $29.20 \pm 0.30^\circ\text{C}$ and humidity was $37.95 \pm 4.40\%$ (Table I, Figures 1-2).

Temperature and Daily Cases and Daily Deaths

The results revealed that in GCC countries an increase in temperature was associated with an in-

Table 1. COVID-19: mean temperature, humidity, number of daily cases, cumulative cases, daily deaths, cumulative deaths in GCC countries.

Country with data collection dates	Temperature °C (Mean ± SEM)	Humidity % (Mean ± SEM)	Daily cases (Mean ± SEM)	Cumulative cases (Mean ± SEM)	Daily deaths (Mean ± SEM)	Cumulative deaths (Mean ± SEM)
Oman 24/2/2020-15/5/2020	29.89 ± 0.48	51.32 ± 2.21	56.40 ± 7.72	1008.07 ± 140.42	0.24 ± 0.06	4.65 ± 0.65
United Arab Emirates 29/1/2020-15/5/2020	29.03 ± 0.55	39.45 ± 1.58	202.14 ± 34.82	3969.54 ± 589.98	1.94 ± 0.43	33.83 ± 5.71
Kuwait 24/2/2020-15/5/2020	28.85 ± 0.52	31.16 ± 1.68	151.77 ± 27.06	2099.54 ± 340.85	1.15 ± 0.24	12.91 ± 2.51
Bahrain 24/2/2020-15/5/2020	27.99 ± 0.49	44.87 ± 1.78	76.43 ± 10.93	1506.00 ± 186.81	0.12 ± 0.04	4.33 ± 0.37
Saudi Arabia 2/ 3/2020-15/5/2020	29.75 ± 0.55	20.59 ± 1.12	655.68 ± 81.17	10823.01 ± 1641.99	3.89 ± 0.40	79.40 ± 10.39
Qatar 1/3/2020-15/5/2020	29.67 ± 0.55	40.29 ± 2.04	387.16 ± 50.95	6279.67 ± 943.27	0.18 ± 0.05	5.34 ± 0.60

Data presented from the date of appearance of first case of SARS-COV-2 patient in the GCC region, Jan 29, 2020 to May 15, 2020. Values are presented in Mean and SEM. (Temperature °C: Humidity %).



Figure 1. GCC countries with mean temperature and humidity from the date of appearance of first case of SARS-COV-2 in the region Jan 29, 2020 to May 15, 2020.

crease in the number of daily cases of COVID-19. The correlation coefficient between temperature and daily cases in Oman was (0.637), United Arab Emirates (0.493), Kuwait (0.664), Bahrain (0.575), Saudi Arabia (0.526) and Qatar (0.664) (Table II, Figure 3). Similarly, the increase in the temperature was also associated with an increase in number of daily deaths due to COVID 19. The correlation coefficient between temperature and daily deaths in Oman was (0.3442), United Arab

Emirates (0.459), Kuwait (0.603), Bahrain (0.051), Saudi Arabia (0.536) and Qatar (0.186) (Table II, Figure 4).

Humidity and Daily Cases and Daily Deaths

While analyzing the correlation coefficient between humidity with daily cases in GCC countries, it was identified that there was a negative

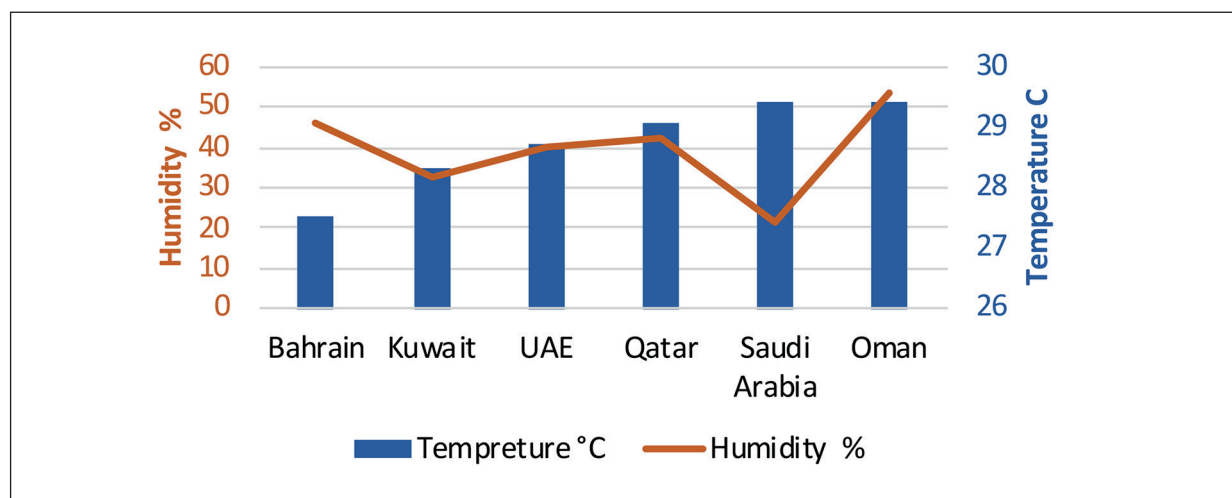


Figure 2. Mean temperature and humidity trends in GCC countries from the date of appearance of first case of SARS-COV-2 patient in the region Jan 29, 2020 to May 15, 2020.

Table II. COVID-19: correlation coefficient between temperature and humidity with daily cases and daily deaths, and growth factor in GCC countries.

Country with data collection dates	Temperature °C and daily cases	Temperature °C and daily deaths	Humidity and daily cases %	Humidity and daily deaths %	Daily cases growth factor (Mean ± SEM)	Daily death growth factor (Mean ± SEM)
Oman 24/2/2020-15/5/2020	0.637 (<i>p</i> 0.001)	0.3442 (<i>p</i> 0.002)	-0.360 (<i>p</i> 0.001)	-0.213 (<i>p</i> 0.054)	1.11 ± 0.02	1.08 ± 0.03
United Arab Emirates 29/1/2020-15/5/2020	0.493 (<i>p</i> 0.001)	0.459 (<i>p</i> 0.001)	-0.254 (<i>p</i> 0.008)	-0.254 (<i>p</i> 0.008)	1.09 ± 0.01	1.10 ± 0.03
Kuwait 24/2/2020-15/5/2020	0.664 (<i>p</i> 0.001)	0.603 (<i>p</i> 0.001)	-0.346 (<i>p</i> 0.001)	-0.322 (<i>p</i> 0.003)	1.12 ± 0.03	1.13 ± 0.03
Bahrain 24/2/2020-15/5/2020	0.575 (<i>p</i> 0.001)	0.051 (<i>p</i> 0.647)	-0.271 (<i>p</i> 0.014)	-0.041 (<i>p</i> 0.714)	1.18 ± 0.09	1.05 ± 0.02
Saudi Arabia 2/ 3/2020-15/5/2020	0.526 (<i>p</i> 0.001)	0.536 (<i>p</i> 0.001)	-0.111 (<i>p</i> 0.341)	-0.126 (<i>p</i> 0.280)	1.20 ± 0.06	1.13 ± 0.03
Qatar 1/3/2020-15/5/2020	0.664 (<i>p</i> 0.001)	0.186 (<i>p</i> 0.108)	-0.324 (<i>p</i> 0.005)	-0.033 (<i>p</i> 0.776)	1.28 ± 0.18	1.07 ± 0.03

Data presented from the date of appearance of first case of SARS-COV-2 patient in the GCC region Jan 29, 2020 to May 15, 2020. Values are presented in Mean and SEM. (Temperature °C: Humidity %).

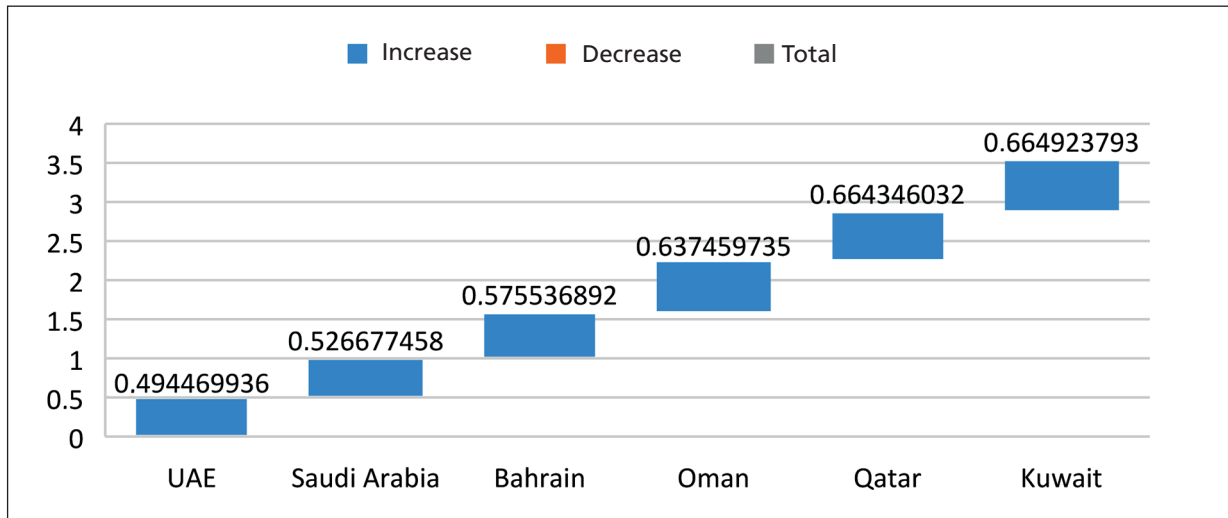


Figure 3. The correlation between temperature with daily cases in GCC countries.

correlation, and an increase in humidity was associated with decrease in number of daily cases of COVID-19 in Oman (-0.360), Kuwait (-0.346), Qatar (-0.324), Bahrain (-0.271), United Arab Emirates (-0.254), and Saudi Arabia (-0.111) (Table II, Figure 5).

Furthermore, there was also a negative correlation between humidity and daily deaths. An increase in humidity showed a decrease in the number of daily deaths due to COVID 19 in Kuwait (-0.322), United Arab Emirates (-0.254), Oman (-0.213), Saudi Arabia (-0.126), Bahrain (-0.041), and Qatar (-0.033) (Table II, Figure 6). The associations between temperature and humidity and COVID-19 were not consistent throughout the six countries of GCC region.

Growth Factor for Daily Cases and Daily Deaths

We also analyzed the growth factor for mean daily cases and growth factor for mean daily deaths.

The growth factor results for daily cases of COVID-19 show declining trends in all the GCC countries (Figure 7). Similarly, the growth factor for mean daily deaths showed declining trends in GCC countries (Figure 8).

Discussion

The COVID-19 pandemic is an evolving global health concern and has infected a significant

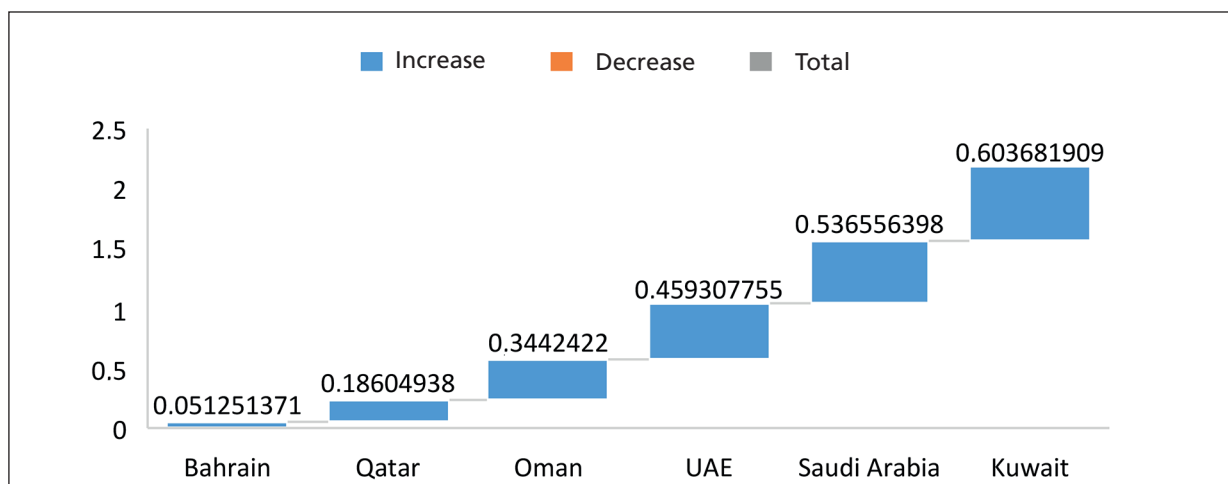


Figure 4. The correlation between temperature with daily deaths in GCC countries.

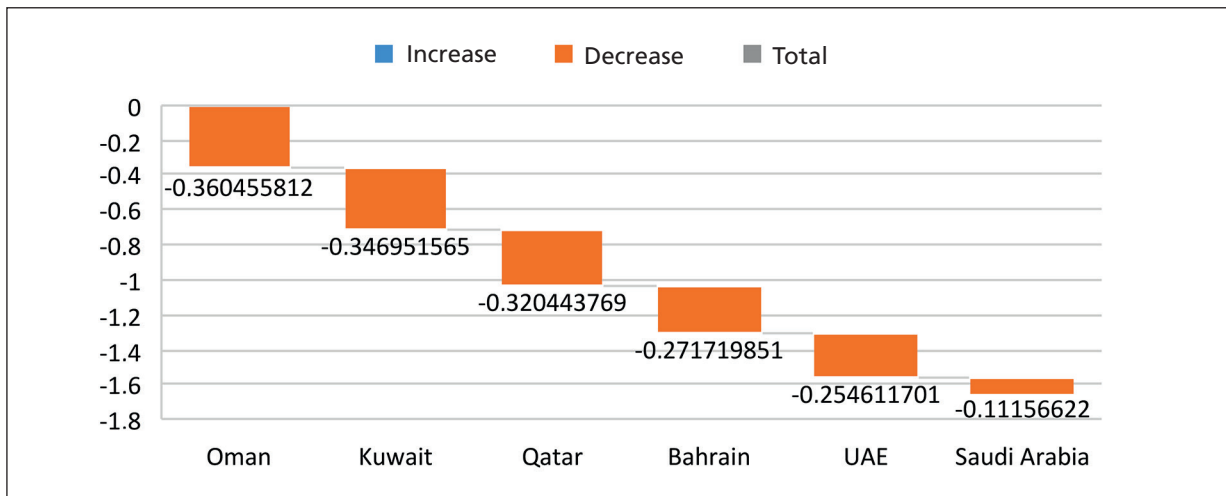


Figure 5. The correlation between humidity with daily cases in GCC countries.

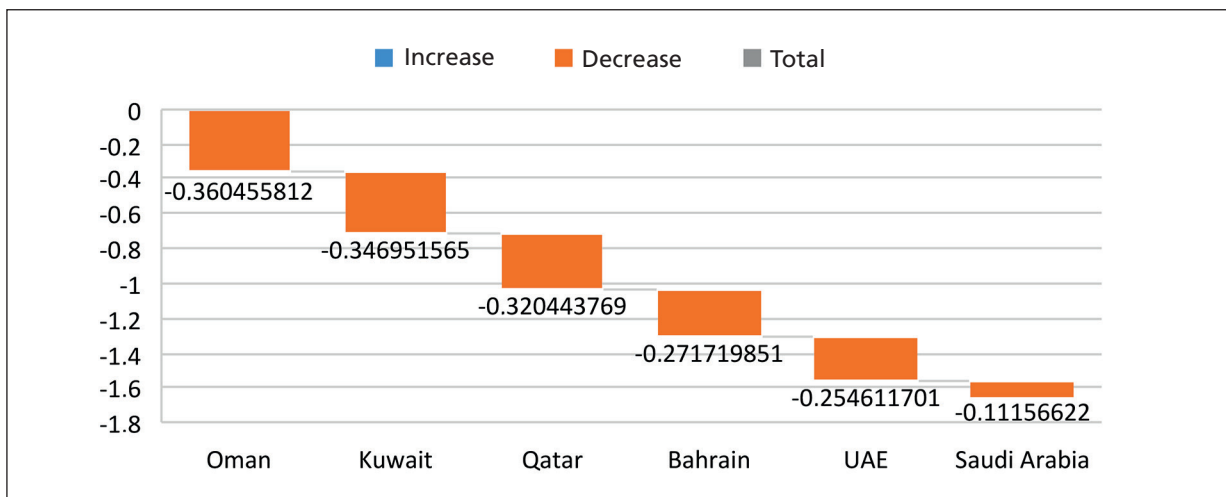


Figure 6. The correlation between humidity with daily deaths in GCC countries.

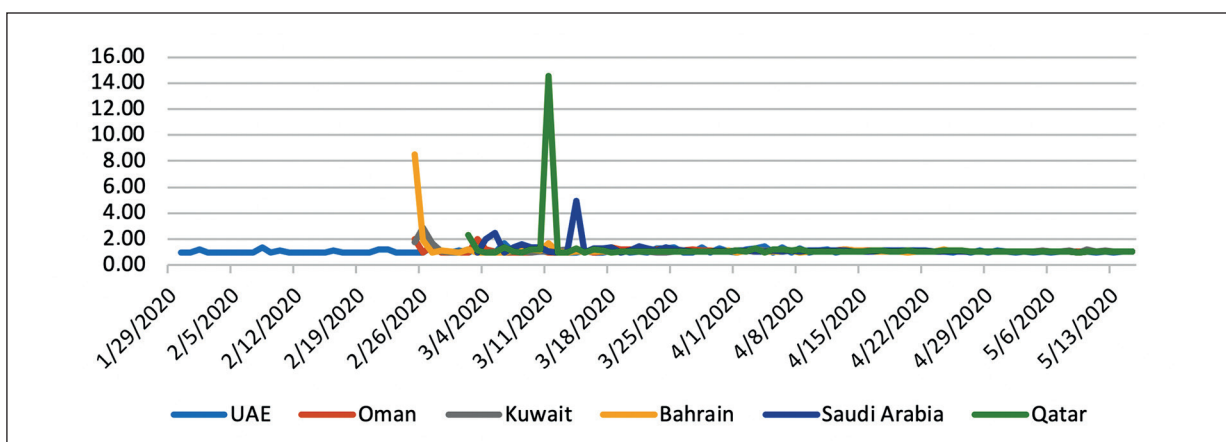


Figure 7. The growth factor of daily cases in GCC countries (log base 10).

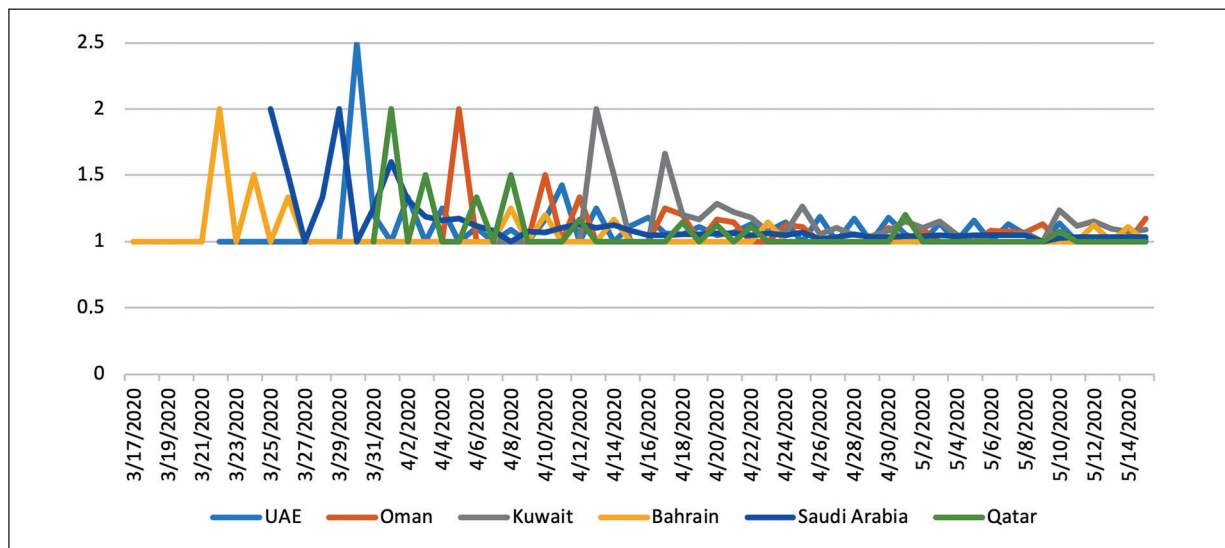


Figure 8. The growth factor of daily deaths in GCC countries.

number of people worldwide^{1,2}. The virus does not replicate outside living cells but it may persist on contaminated environmental surfaces and the duration of persistence is affected by temperature and humidity¹². In the earlier five months since its circulation from Dec 2019, the variations in COVID-19 cases over time have been unclear. This study investigated the impact of temperature and humidity on the daily new cases and deaths due to COVID-19 in GCC countries. There was a negative correlation and a decrease in the number of daily cases and daily deaths of COVID-19 with increase in humidity in the GCC region. However, this association was not established with temperature.

Wu et al¹³ assessed the impact of temperature and relative humidity on daily new cases and daily new deaths of COVID-19. The authors identified that temperature and relative humidity have negative association to daily new cases and deaths. Qi et al¹⁴ found that temperature and humidity showed significant negative relationship with COVID-19. Their study findings suggest that daily temperature and relative humidity influenced the occurrence of COVID-19. However, the association between COVID-19, temperature, and humidity was not consistent throughout Mainland China.

The present results revealed that in GCC countries an increase in temperature was associated with an increase in the number of daily cases and deaths due to COVID-19. However, there was a negative correlation and decrease in number of

daily cases and daily deaths due to COVID-19 with an increase in humidity in the GCC countries. Hence, humidity plays a more important role in minimizing the daily incidence and mortality in the GCC region. However, as a note, the weather in the GCC region still has not seen peak temperature and humidity.

More recently, Xie and Zhu¹⁵ examined the correlation between COVID-19 and temperature in China, and their results showed a positive linear association between the number of COVID-19 cases and the mean temperature. They did not find any evidence that COVID-19 cases decline when the weather becomes warm. Wang et al¹⁶ investigated the association of temperature on the spread of COVID-19 and claimed that temperature significantly affects the transmission of COVID-19. Bannister-Tyrrell et al¹⁷ demonstrated that an average temperature increase was negatively correlated with the number of cases.

More recently, Ma et al¹⁸ reported that an increase in diurnal temperature was associated with increase in COVID-19 deaths whereas increase in humidity was related to a decrease in COVID-19 deaths. The present study results are inconsistent with the findings reported by Ma et al¹⁸. In the present study, we identified that increase in humidity decreases the number of daily cases and daily deaths due to COVID-19 in GCC countries. In the present study, we also analyzed the growth factor for mean daily cases and growth factor for mean daily deaths. The growth factor results for daily cases and daily deaths due to COVID-19

show declining trends in the GCC countries (Figure 7-8]. We believe that meteorological parameters are important factors influencing infectious diseases, including the COVID-19 infection.

Study Strengths and Limitations

This is the first study added in literature, to our knowledge, that has investigated the impact of temperature and humidity on epidemiological trends of incidence and mortality of COVID-19, and findings are based on six countries from the Middle East. Second strength is that the study data were collected using reliable sources, including “World Health Organization”.

Thirdly, this study included variables that reflected same ethnicity, geographical, socioeconomic level, standardized health care system and diagnostic criteria to reduce confounding bias. Fourth, the study period is long starting from Jan 29 till May 15, 2020, hence it can be anticipated that many covariates would differ considerably during such a long time period. The longer the study period, the more stable the findings. We also analyzed the growth factor, a very vital component to determine the epidemiological trends. One limitation of our study is that we examined data from the six Gulf countries of the Middle East, so it is not appropriate to generalize the results globally.

Conclusions

In GCC countries, an increase in humidity was associated with a decrease in the number of daily cases and deaths from COVID-19. However, an increase in temperature was associated with an increase in the number of daily cases and daily deaths due to COVID-19. As a consequence, the association between COVID-19, temperature and humidity were not consistent throughout the GCC region. The findings have convenient inferences for policymakers and the community about the impact of climatological factor, such as temperature and humidity on trends of incidence and mortality of COVID-19. We strongly believe that required essential measures must be taken to control the source of infection and transmission to prevent the further spread of COVID-19.

Conflict of Interest

The Authors declare that they have no conflict of interests.

Acknowledgements

We thank the “Researchers supporting project number (RSP-2019/47), King Saud University, Riyadh, Saudi Arabia”.

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