European Review for Medical and Pharmacological Sciences 2020; 24: 9216-9225

Effect of heat and humidity on the incidence and mortality due to COVID-19 pandemic in European countries

S.A. MEO[1], A.A. ABUKHALAF[2], A.A. ALOMAR[3], O.Y. SUMAYA[4], W. SAMI[5], K.M. SHAFI[6], A.S. MEO[7], A.M. USMANI[8], J. AKRAM[9]

[1-4]Department of Physiology, College of Medicine, King Saud University, Riyadh, Saudi Arabia
[5]Department of Public Health, University of Health Sciences, Lahore, Pakistan
[6]National Defense University, Islamabad, Pakistan
[7]Army Medical College, National University of Medical Sciences, Rawalpindi, Pakistan
[8]Strategic Centre for Diabetes Research, College of Medicine, King Saud University, Riyadh, Saudi Arabia
[9]Department of Medicine, University of Health Sciences, Lahore, Pakistan

Abstract. – OBJECTIVE: The weather allied conditions have an impact on air, water, soil, food, ecosystem, feelings, behaviors, and pattern of health and disease. The present study aims to investigate the impact of heat and humidity on the daily basis incidence and mortality due to COVID-19 pandemic in European countries.

MATERIALS AND METHODS: We selected 10 European countries, Russia, United Kingdom, Spain, Italy, Germany, Turkey, France, Belgium, Netherlands and Belarus. This region has a relatively low temperature and high humidity, and has homogenous European ethnicity with almost similar socioeconomic culture and health care system. The data on COVID-19 pandemic including daily new cases and new deaths were recorded from World Health Organization (WHO). The information on daily temperature and humidity was obtained from world climate web "Time and Date". The daily cases, deaths, temperature and humidity were recorded from the date of appearance of first case of "Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2)" in the European region, from Jan 27, 2020 to July 17, 2020.

RESULTS: In 10 European countries, (Russia, United Kingdom, Spain, Italy, Germany, Turkey, France, Belgium, Netherlands and Belarus), the daily basis mean temperature from Jan 27, 2020 to July 17, 2020 was 17.07±0.18°C, and humidity was 54.78±0.47%. The overall results revealed a significant inverse correlation between humidity and the number of cases (r= -0.134, $p<0.001$) and deaths (r= -0.126, $p<0.001$). Moreover, an increase in temperature was linked with an increase in the number of cases (r=0.062, $p=0.013$) and deaths (r=0.118, $p<0.001$). The regression analysis results further revealed that with an increase of 1% humidity the number of cases (β = -15.90, $p<0.001$) and deaths (β=-1.56, $p<0.001$) reduced significantly. Whereas, with an increase of 1°C in temperature the number of cases (β = 20.65, $p<0.001$) and deaths (β = 3.71, $p<0.001$) increased significantly.

CONCLUSIONS: Increase in relative humidity was associated with a decrease in the number of daily cases and deaths, however, a rise in temperature was allied with an upsurge in the number of daily cases and daily deaths due to COVID-19 pandemic in European countries. The study findings on weather events and COVID-19 pandemic have an impact at European regional levels to project the incidence and mortality trends with regional weather events to enhance public health readiness and assist in planning to fight against this pandemic situation.

Key Words:
COVID-19, Climate, Temperature, Humidity, Prevalence, Mortality, Europe.

Introduction

The current COVID-19 pandemic situation caused by "Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) infection" has speedily spread across the entire globe, causing a lot of havoc and resulting in many devastating consequences on human health, lives, and economies[1]. The COVID-19 pandemic is highly hostile, and relatively more prevalent than other similar pandemics which have occurred before, such as

Corresponding Author: Sultan Ayoub Meo, MBBS, Ph.D; e-mail: sultanmeo@hotmail.com/ smeo@ksu.edu.sa

Severe Acute Respiratory Syndrome Coronavirus (SARS-CoV-1), and Middle East Respiratory Syndrome Coronavirus (MERS-CoV)[2]. On July 29, 2020, this pandemic has spread to 216 countries, and has infected 16523815 people with a mortality rate of 655112 (3.96%)[3].

The science community, researchers, policymakers, as well as public, all are highly anxious about the contagious nature of the disease and pandemic calamities, which has first time developed an extraordinary instable and threatened situation in the world. The transmission of this pandemic and its subsequent incidence and mortalities have continued worldwide. There is great debate on the climate connected conditions, impact of heat and humidity, and incidence and mortality due to COVID-19 pandemic. There are some meteorological factors in relation to transmission and magnitude of spread of viruses[4]. More recently, a few published studies demonstrated that warm weather and humidity may change the epidemiological trends of COVID-19 pandemic[4,5], which has already infected over 16 million people worldwide[3].

The weather conditions have an impact on air, water, soil, agriculture, food, ecosystem[6], feelings behaviors, and pattern of health and disease[2,4]. The present study aimed to investigate the impact of heat and humidity on the daily basis incidence and mortality due to COVID-19 pandemic in European countries, including Russia, The United Kingdom, Spain, Italy, Germany, Turkey, France, Belgium, Netherlands and Belarus.

Materials and Methods

Europe is the sixth largest continent, situated in the Northern hemisphere and mostly in the Eastern hemisphere. There are 50 states in Europe, with a 747 million people, about 11% of the world population[7,8]. In this study, from 50 European states, we selected 10 European countries, including, Russia, The United Kingdom, Spain, Italy, Germany, Turkey, France, Belgium, Netherlands and Belarus.

This region has relatively homogenous weather conditions, ethnicity, socioeconomic culture and health care system. The data on COVID-19 pandemic, daily new cases and daily new deaths were collected from the World Health Organization[3]. The daily information on meteorological conditions, temperature and humidity was recorded from climate web "Time and Date"[9], and mean values were calculated. The daily new cases and new deaths due to COVID-19, daily information on meteorological conditions, temperature and humidity were recorded from the date of appearance of first case of SARS-COV-2 in the region, Jan 27, 2020 to July 17, 2020. The daily mean temperature during this period was 17.07±0.18°C and humidity was 54.78±0.47%.

Statistical Analysis

In this study, 10 European countries were selected with confirmed new cases and new deaths of COVID-19. The data was analyzed using R-Core Team 2020, a language and environment for statistical computing, R Foundation for Statistical Computing, Vienna, Austria. Mean ± SEM has been reported for quantitative meteorological factors. Normality of data was checked through one-sample Kolmogorov-Smirnov test. Pearson correlation was applied to assess the relationship between humidity, temperature with no of cases and deaths at 1% level of significance, whereas, Linear Regression Analysis was performed to predict the number of cases and deaths with humidity and temperature after fulfilling the assumptions, i.e., normality, linearity, homoscedasticity, and independence. There was slight deviation from normality regarding one of the dependent variables in for which Box-Cox transformation was used, which was later back transformed for interpretation. An $\alpha=0.05$ was considered as statistically significant.

Results

The impact of heat and humidity on the daily new cases and deaths due to COVID-19 pandemic in 10 European countries was analyzed. The daily basis mean temperature and humidity were recorded from the date of appearance of first case of SARC-COV-2 in the European region, from Jan 27, 2020 to July 17, 2020 (Table I, Figure 1). The mean values of number of daily cases, daily deaths and cumulative cases due to SARS-COV-2 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, and regression analysis results are presented in Table III, IV, Figures 2-5. The mean temperature and humidity in Russia was 11.58±0.73, 59.79±1.55; The United Kingdom 16.56±0.44, 55.97±1.41;

Table I. Temperature, humidity, number of daily cases, cumulative cases, daily deaths and cumulative deaths due to COVID-19 pandemic in European countries.

Countries	Temperature °C (mean ± SEM)	Humidity % (mean ± SEM)	Daily Cases (mean ± SEM)	Cumulative Cases (mean ± SEM)	Daily Deaths (mean ± SEM)	Cumulative Deaths (mean ± SEM)
Russia	11.58 ± 0.73	59.79 ± 1.55	4492.33 ± 316.73	221994.73 ± 20133.13	71.73 ± 5.61	2910.13 ± 292.70
United Kingdom	16.56 ± 0.44	55.97 ± 1.41	1737.31 ± 239.34	141853.67 ± 9701.21	266.97 ± 32.60	20242.77 ± 1421.50
Spain	22.73 ± 0.59	47.32 ± 1.52	1535.30 ± 172.25	144515.35 ± 8162.83	195.56 ± 23.80	16076.84 ± 947.54
Italy	21.69 ± 0.46	50.35 ± 1.17	1425.35 ± 134.00	140949.22 ± 7634.66	204.77 ± 19.11	19454.39 ± 1114.02
Germany	15.77 ± 0.50	52.94 ± 1.49	1167.69 ± 125.26	107958.17 ± 6239.47	52.80 ± 5.89	4435.39 ± 298.82
Turkey	20.85 ± 0.59	46.08 ± 1.55	1668.25 ± 107.41	120192.20 ± 6380.17	41.84 ± 3.14	3151.66 ± 171.75
France	16.56 ± 0.43	58.57 ± 1.32	938.80 ± 103.17	84509.58 ± 5039.22	170.63 ± 22.95	15398.05 ± 995.18
Belgium	15.84 ± 0.44	57.18 ± 1.43	381.13 ± 38.99	33812.28 ± 2032.35	59.02 ± 7.56	5190.72 ± 336.21
Netherlands	16.07 ± 0.42	59.45 ± 1.33	361.23 ± 31.78	32203.95 ± 1590.58	43.15 ± 4.61	3892.99 ± 206.07
Belarus	13.00 ± 0.63	59.59 ± 1.66	465.41 ± 40.48	26236.71 ± 2102.62	3.44 ± 0.24	161.52 ± 13.27
Mean ± SEM	17.07 ± 0.18	54.78 ± 0.47	14445.61 ± 59.34	107814.61 ± 3192.75	116.09 ± 5.87	9520.72 ± 309.06

Data presented from the date of appearance of first case of SARS-COV-2 in European countries, Jan 27, 2020 to July 17, 2020.Values are presented in Mean and SEM. Temperature °C: Humidity %.

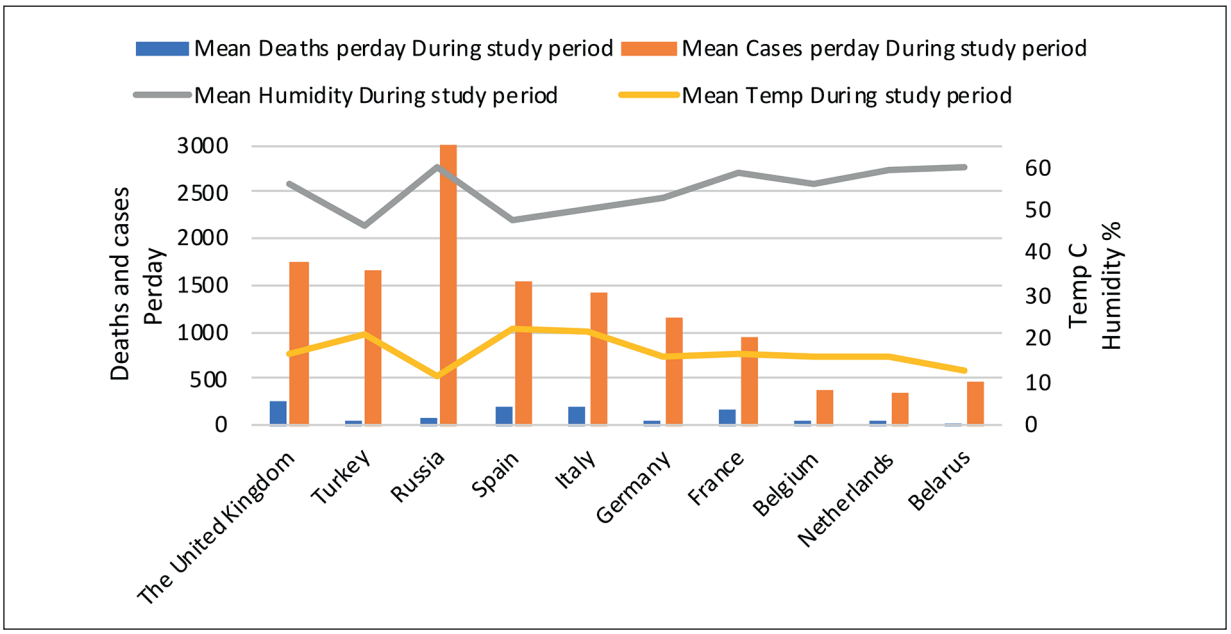

Figure 1. Mean temperature, humidity, number of daily cases, daily deaths due to COVID-19 pandemic in European countries.

Spain 22.73±0.59, 47.32±1.52; Italy 21.69±0.46, 50.35±1.17; Germany 15.77±0.50, 52.94±1.49; Turkey 20.85±0.59, 46.08±1.55; France 16.56±0.43, 58.57±1.32; Belgium 15.84±0.44, 57.18±1.43; Netherlands 16.07±0.42, 59.45±1.33 and Belarus 13.00±0.63, 59.59±1.66. The overall mean temperature in all these 10 European countries was 17.07±0.18°C, and humidity was 54.78±0.47% (Table I).

While analyzing the overall correlation coefficient the results showed that an increase in temperature was linked with an increase in the number of cases (r=0.062, p=0.013) and deaths (r=0.118, p<0.001). Moreover, the correlation coefficient between temperature and cumulative cases was (r=0.576, p<0.001) and temperature and cumulative deaths (r=0.573, p<0.001) (Table II). In-addition, for humidity, the overall correlation coefficient results showed that an increase in humidity was associated with a decrease in the number of cases (r=-0.127, p<0.001) and deaths (r=-0.125, p<0.001). Moreover, an increase in humidity was associated with a significant decreased in cumulative cases (r=-0.188, p<0.001) and cumulative deaths (r=-0.229, p<0.001) in the European countries (Table II).

Regression Analysis Between Humidity, Daily Cases and Daily Deaths

The overall regression analysis results further revealed that with an increase of 1% relative humidity, the number of cases and deaths reduced

Table II. Overall correlation coefficient between daily cases, cumulative cases, daily deaths and cumulative deaths due to COVID-19 pandemic in European countries.

Comparable parameters	Correlation coefficient	Significance level
Temperature and Daily Cases	0.062	$p = 0.013$
Temperature-Cumulative Cases	0.576	$p < 0.001$
Temperature-Daily Deaths	0.118	$p < 0.001$
Temperature-Cumulative Deaths	0.573	$p < 0.001$
Humidity-Daily Cases	-0.127	$p < 0.001$
Humidity-Cumulative Cases	-0.188	$p < 0.001$
Humidity-Daily Deaths	-0.125	$p < 0.001$
Humidity-Cumulative Deaths	-0.229	$p < 0.001$

Temperature, humidity, and correlation coefficient analysis is based on data recoded from the date of appearance of first case of SARS-COV-2 in European countries, Jan 27 to July 17, 2020. Temperature °C: Humidity %.

Table III. Regression analysis between humidity and daily cases and deaths due to CIVID-19 pandemic in European countries.

Countries	Humidity and Daily Cases	Significance level	Humidity and Daily deaths	Significance level
Russia	β = -47.37	$p < 0.001$	β = -0.41	$p = 0.142$
United Kingdom	β = -50.74	$p < 0.001$	β = -5.06	$p < 0.001$
Germany	β = -33.18	$p < 0.001$	β = -1.68	$p < 0.001$
France	β = -39.39	$p < 0.001$	β = -7.30	$p < 0.001$
Belgium	β = -11.97	$p < 0.001$	β = -2.06	$p < 0.001$
Netherlands	β = -11.16	$p < 0.001$	β = -1.52	$p < 0.001$
Belarus	β = -2.57	$p = 0.210$	β = -0.10	$p = 0.417$
Italy	β = 7.08	$p = 0.372$	β = 0.69	$p = 0.579$
Turkey	β = -9.120	$p = 0.133$	β = -0.52	$p = 0.003$
Spain	β = 34.27	$p < 0.001$	β = 3.998	$p < 0.001$

Data presented from the date of appearance of first case of SARS-COV-2 in European countries, Jan 27, 2020 to July 17, 2020. Temperature °C: Humidity %.

by (β= -15.90, $p<0.001$) and (β = -1.56, $p<0.001$) respectively.

The country-wise regression results showed that with an increase of 1% humidity the number of cases reduced in Belgium were (β = -11.97, $p<0.001$), France (β = -39.39, $p<0.001$), Germany (β = -33.18, $p<0.001$), Netherlands (β = -11.16, $p<0.001$), Russian Federation (β = -47.37, $p<0.001$) and UK (β = -50.74, $p<0.001$). Humidity has no significant effect on number of cases in Belarus (β = -2.57, $p=0.210$), Italy (β = 7.08, $p=0.372$) and Turkey (β = -9.120, $p=0.133$). Whereas Spain was the only country where the number of cases increased with 1% increase in humidity (β = 34.27, $p<0.001$) (Table III, Figure 2).

Regarding the country-wise relation between deaths and humidity, the results showed that with an increase of 1% humidity the number of deaths reduced in Belgium were (β = -2.06, $p<0.001$), France (β = -7.30, $p<0.001$), Germany (β = -1.68, $p<0.001$), Netherlands (β = -1.52, $p<0.001$), UK (β = -5.06, $p<0.001$) and Turkey (β= -0.52, $p=0.003$). Humidity had no significant effect on number of deaths in Belarus (β = -0.10, $p=0.417$), Italy (β = 0.69, $p=0.579$) and Russian Federation (β = -0.41, $p=0.142$). Again, Spain was the only country where the number of deaths increased with 1% increase in humidity (β = 3.998, $p<0.001$) (Table III, Figure 3).

Regression Analysis Between Temperature, Daily Cases and Daily Deaths

The overall regression analysis results showed that with an increase of 1° of the temperature the number of cases and deaths increased were (β=20.65, $p<0.001$) and (β = 3.71, $p<0.001$) respectively. Country-wise regression results

Table IV. Regression analysis between temperature and daily cases and deaths due to COVID-19 pandemic in European countries.

Countries	Temperature and Daily Cases	Significance level	Temperature and Daily deaths	Significance level
Russia	β = 300.02	$p < 0.001$	β = 6.19	$p < 0.001$
United Kingdom	β = 102.8	$p < 0.001$	β = 13.18	$p = 0.014$
Germany	β = -17.30	$p = 0.365$	β = 1.61	$p = 0.071$
France	β = 24.98	$p = 0.163$	β = 13.02	$p < 0.001$
Belgium	β = 12.09	$p = 0.08$	β = 4.05	$p < 0.001$
Netherlands	β = -10.0	$p = 0.113$	β = -0.46	$p = 0.061$
Belarus	β = 23.94	$p < 0.001$	β = 0.24	$p < 0.001$
Italy	β = -90.82	$p < 0.001$	β = 10.1	$p < 0.001$
Turkey	β = -37.5	$p = 0.018$	β = -1.22	$p = 0.008$
Spain	β = -104.9	$p < 0.001$	β = 3.998	$p < 0.001$

Data presented from the date of appearance of first case of SARS-COV-2 in European countries, Jan 27 to July 17, 2020. Temperature °C: Humidity %.

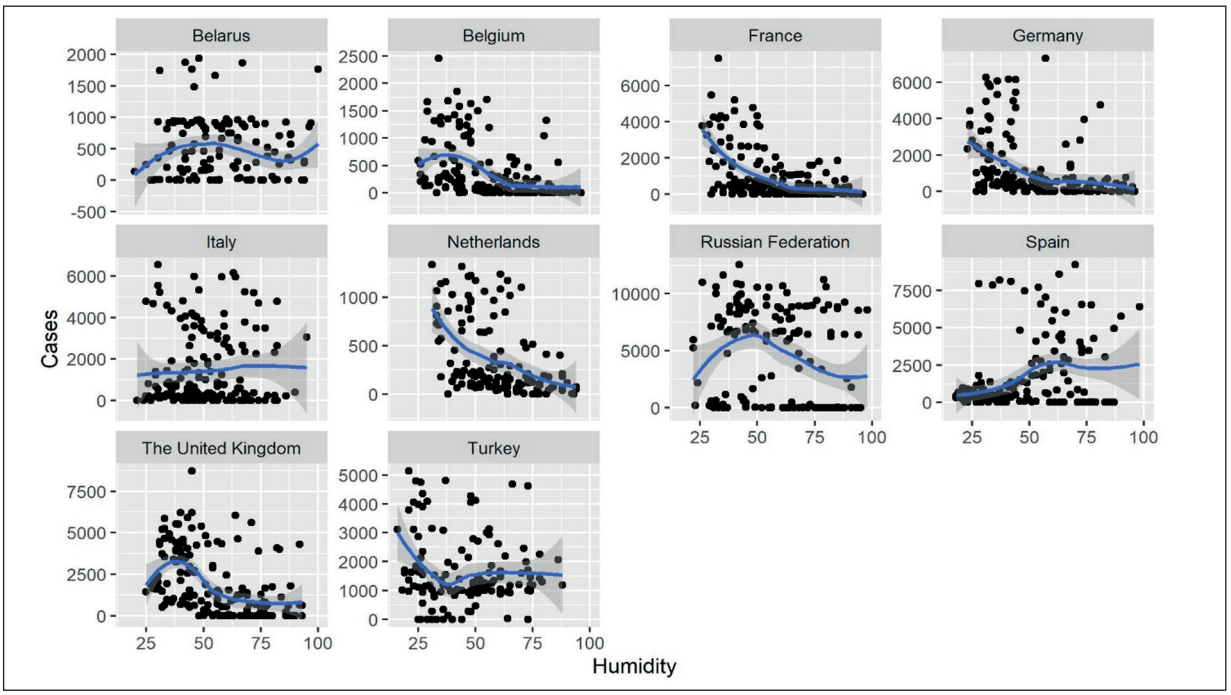

Figure 2. Trend of humidity and daily cases due to COVID-19 pandemic in European countries.

showed that with an increase of 1° temperature the number of cases increased in Belarus were (β = 23.94, p<0.001), Russian Federation (β = 300.02, p<0.001) and UK (β = 102.8, p<0.001). However, the number of cases decreased significantly in Italy (β = -90.82, p<0.001), Spain (β =

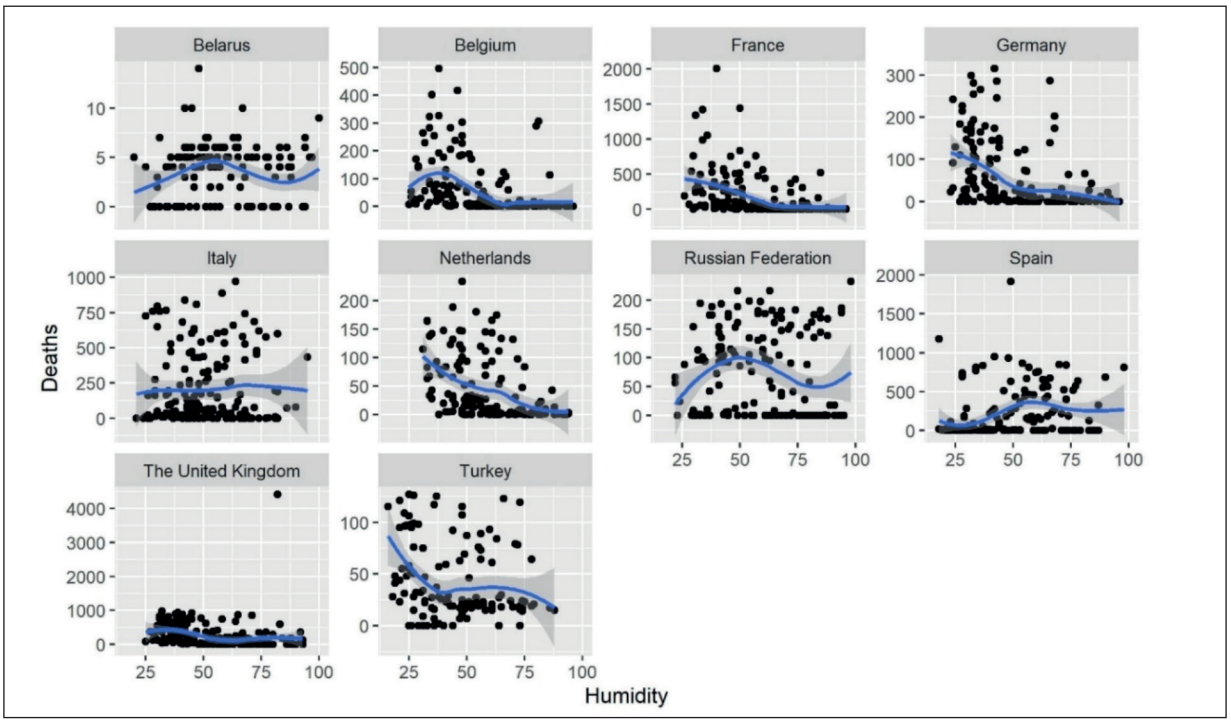

Figure 3. Trend of humidity and daily deaths due to COVID-19 pandemic in European countries.

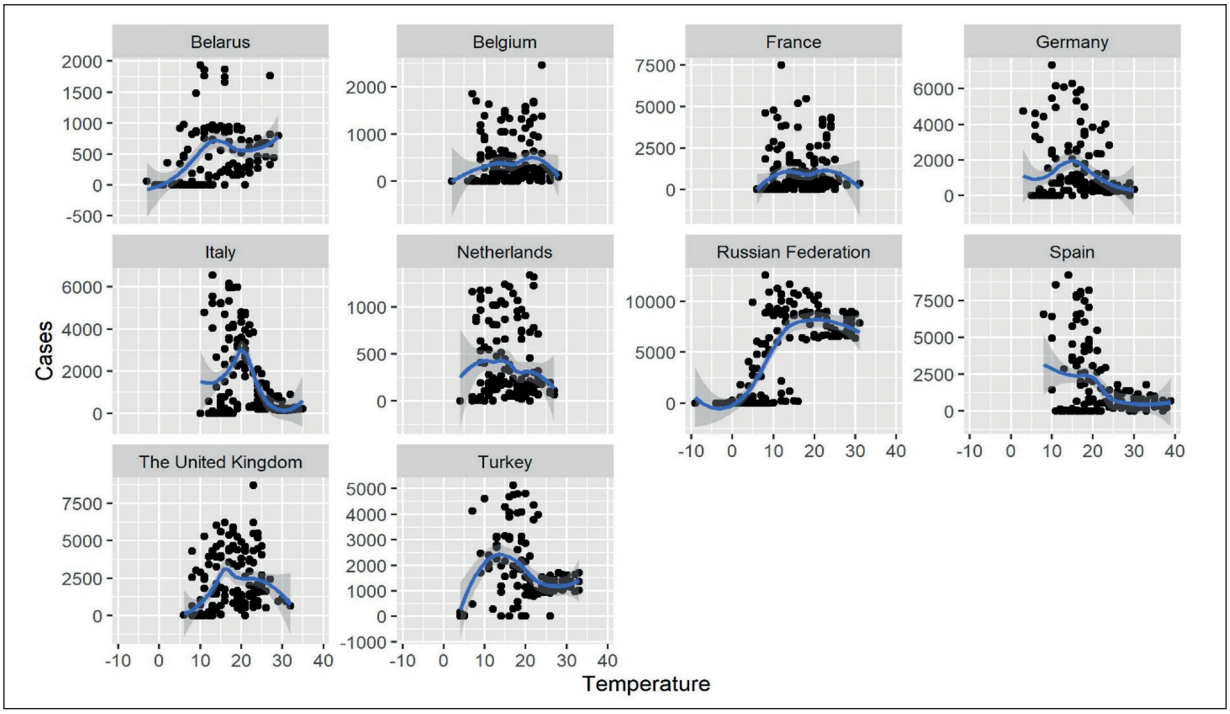

Figure 4. Trend of temperature and number of daily cases due to COVID-19 pandemic in European countries.

-104.9, $p<0.001$) and Turkey (β = -37.5, $p=0.018$) with 1° increase in temperature. Temperature had no significant effect on number of cases in Belgium (β = 12.09, $p=0.08$), France (β = 24.98, $p=0.163$), Germany (β = -17.30, $p=0.365$) and Netherlands (β = -10.0, $p=0.113$) (Table IV, Figure 5).

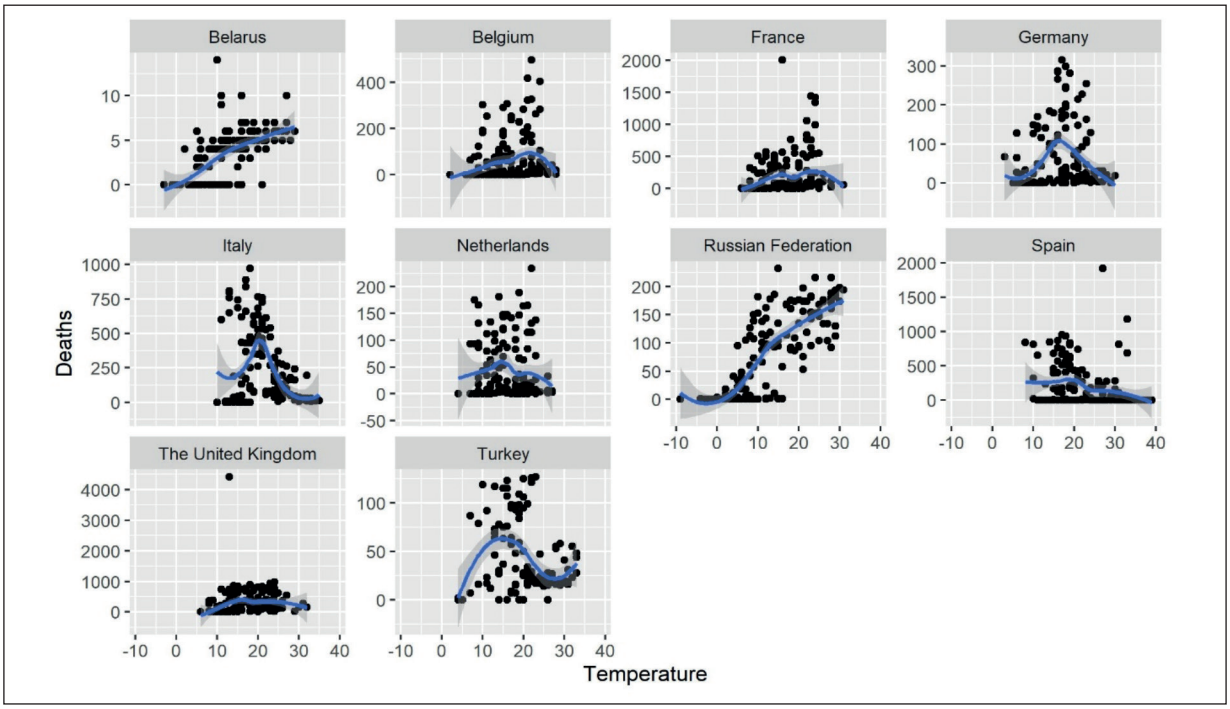

Figure 5. Trend of temperature and daily deaths due to COVID-19 pandemic in European countries.

Regarding the country-wise relation between deaths and temperature, results showed that with an increase of 1° temperature the number of deaths increased in Belarus were (β = 0.24, $p<0.001$), Belgium (β = 4.05, $p<0.001$), France (β = 13.02, $p<0.001$), Russian Federation (β = 6.19, $p<0.001$) and UK (β = 13.8, $p=0.014$). Whereas the number of deaths reduced in Italy were (β = -10.1, $p<0.001$) and Turkey (β = -1.22, $p=0.008$). Temperature had no significant effect on number of deaths in Germany (β = 1.61, $p=0.071$) and Netherlands (β = -0.46, $p=0.614$) (Table V, Figure 5).

Discussion

The present study explored the impact of heat and humidity on the incidence and mortality due to COVID-19 pandemic in 10 European countries to understand the dispersal pattern of COVID-19 pandemic. The epidemiologic and public health facts considering the periodic variation in weather conditions are essential factors in defining the seasonal behavior of some forms of diseases and health phenomena[10]. The change in weather conditions is believed to alter the ecosystem pattern at wide regional levels. The impact of extreme weather events are traumatic in nature, leading to injuries, lethal diseases, and deaths. Extreme weather events include heat waves, cold waves, heavy rain, and snowfalls etc. These weather conditions have a great influence on the pattern of health and disease[4].

The environmental conditions required for the persistence and spread of SARS-COV-2 are rather clear, but there is limited knowledge about the climate associated causes of SARS-COV-2 transmission[11,12]. However, few studies on SARS-CoV-2 have shown that humidity and temperature possibly affect the activity and transmissibility of the SARS-COV-2.

Harmooshi et al[5] reported that environmental conditions are necessary for the survival and spread of SARS-COV-2 infection. The virus may tolerate for about 9 days at 25°C, but life span may reduce if temperature rises to 30°C. The SARS-COV-2 is sensitive to humidity, lifespan at 50% humidity is longer than at 30%. The authors further reported that low temperature, dry and unventilated environment may affect the stability and spread the virus.

Sajadi et al[13] conducted a study on COVID-19 pandemic and temperature and humidity, they did not find an association between weather changes and spread of SARS-CoV-2. Similarly, Huang et al[14] study result demonstrates an optimal climatic zone in which SARS-CoV-2 increases in ambient environment. Their findings demonstrate that COVID-19 pandemic may episodically appear and outbreak may recur in metropolitan areas in autumn season.

Wu et al[15] assessed the impact of "temperature and humidity on new cases and deaths of COVID-19". The authors identified that "temperature and relative humidity have negative association to daily new cases and deaths". Qi et al[16] identified 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 relationship between COVID-19, temperature, and humidity was not constant throughout Mainland China.

The results of the present study revealed that in 10 European countries, an increase in temperature was allied with an increase in the number of daily cases and deaths due to COVID-19. However, there was a negative correlation, decrease in number of daily cases, and daily deaths due to COVID-19 with an increase in humidity in the European countries. The results reflect that humidity plays a more important role in minimizing the daily incidence and mortality in the European countries. However, as a note, the weather in the European countries is still changing.

More recently, Xie and Zhu[17] 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 could see a decline when the weather becomes warm. Wang et al[18] investigated the association of temperature on the spread of COVID-19 and claimed that temperature affects the transmission of COVID-19. Bannister-Tyrrell et al[19] demonstrated that an average temperature increase was negatively correlated with the number of cases.

More recently, Meo et al[4] investigated the impact of whether events, temperature and humidity on the daily basis new cases and new deaths due to COVID-19 pandemic in Gulf Cooperation Council (GCC) countries in the Middle East region. They found out that 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. In another study,

Meo et al[20] reported a decrease trends in the incidence of daily cases and deaths in world's top ten warmest countries compared to world's top ten coldest countries.

Ma et al[21] reported that an increase in diurnal temperature was associated with increase in COVID-19 deaths whereas an increase in humidity was related to a decrease in COVID-19 deaths. The present study results are inconsistent with the findings reported by Meo et al[4] and Ma et al[21]. In the present study, we identified that increase in humidity decreases the number of daily cases and daily deaths due to COVID-19 in European countries. We believe that meteorological parameters are important elements influencing infectious diseases, including the SARS-COV-2 infection.

Study Strengths and Limitations

This is the first article 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 ten countries from European region. Second strength is that the study data were collected using reliable sources, including "World Health Organization". Thirdly, this study included variables that reflected almost 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 27 till July 17, 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. One limitation of our study is that we examined the impact of temperature and humidity on COVID-19 pandemic from the ten European countries, therefore, it is not appropriate to generalize the results globally.

Conclusions

In European countries an increase in relative humidity was allied with a decrease in the number of daily cases and deaths, however, an increase in temperature was associated with an increase in the number of daily cases and daily deaths due to COVID-19 pandemic. The findings have outcomes for policymakers and health officials about the impact of heat and humidity on the epidemiological trends of daily new cases and deaths due to COVID-19 pandemic in the European region. The studies regarding the impact of weather events on COVID-19 pandemic epidemiological trends at regional levels may be focused to project the trends in regional weather events which as a result can improve public health readiness and mitigation. The similar epidemiological studies may also provide more accurate measures and assist in future planning to fight such pandemic situations. We also strongly believe that the required essential measures must be taken to control the source of infection and transmission to prevent the further spread of COVID-19 pandemic both at regional and international levels.

Conflict of Interest

The Authors declare that they have no conflict of interests.

Acknowledgements

Thankful to the "Researchers Supporting Project Number (RSP-2019/47), King Saud University, Riyadh, Saudi Arabia".

Ethical Statement

For this study the data on the daily new cases and deaths due to COVID-2019 pandemic and other related information were obtained from the "World Health Organization", and "Climate Web Time and Date" from the publicly available data, hence ethical approval was not required.

References

1) Meo SA, Al-Khlaiwi T, Usmani AM, Meo AS, Klonoff DC, Hoang TD. Biological and epidemiological trends in the prevalence and mortality due to outbreaks of Novel Coronavirus COVID-19. J King Saud Univ Sci 2020; 32: 2495-2499
2) Meo SA, Alhowikan AM, Al-Khlaiwi T, Meo IM, Halepoto DM, Iqbal M, Usmani AM, Hajjar W, Ahmed N. Novel coronavirus 2019-nCoV: prevalence, biological and clinical characteristics comparison with SARS-CoV and MERS-CoV. Eur Rev Med Pharmacol Sci 2020; 24: 2012-2019.
3) World Health Organization: Coronavirus. Available at: https://www.who.int/health-topics/coronavirus, cited date July 29, 2020.
4) Meo SA, Abukhalaf AA, Alomar AA, Alsalame NM, Al-Khlaiwi T, Usmani AM. 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. Eur Rev Med Pharmacol Sci 2020; 24: 7524-7533.
5) Harmooshi NN, Shirbandi K, Rahim F. Environmental concern regarding the effect of humidity and temperature on 2019-nCoV survival: fact or fiction. Environ Sci Pollut Res Int 2020; 26: 110.

6) World Health Organization. Climate change, Available at: https://www.afro.who.int/health-topics/climate-change. Cited date July, 12, 2020.

7) World Population Prospects: The 2019 Revision population.un.org. United Nations Department of Economic and Social Affairs, Population Division. Cited date, June, 24, 2020.

8) Worldometer. Available at : https://www.worldometers.info/demographics/demographics-of-europe/ Cited date July 12, 2002.

9) Time and Date, weather: Available at https://www.timeanddate.com/weather/uk, cited date July 18, 2020.

10) Ballester F, Michelozzi P, Iñiguez C. Weather, climate, and public health. J Epidemiol Community Health 2003; 57: 759-760.

11) Boulos MNK, Geraghty EM. Geographical tracking and mapping of coronavirus disease COVID-19/severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) epidemic and associated events around the world: how 21st century GIS technologies are supporting the global fight against outbreaks and epidemics. Int J Health Geogr 2020; 19: 8.

12) Khafaie MA, Rahim F. Cross-Country Comparison of Case Fatality Rates of COVID-19/SARS-COV-2. Osong Public Health Res Perspect 2020; 11: 74-80.

13) Sajadi MM, Habibzadeh P, Vintzileos A, Shokouhi S, Miralles-Wilhelm F, Amoroso A (2020b) Temperature and latitude analysis to predict potential spread and seasonality for COVID-19. JAMA Net Open 2020; 3: e2011834.

14) Huang Z, Huang J, Qianqing Gu, Pengyue Du, Liang H, Dong Q. Optimal temperature zone for the dispersal of COVID-19. Sci Total Environ 2020; 736: 139487.

15) Wu Y, Jing W, Liu J, Ma Q, Yuan J, Wang Y, Du M, Liu M. Effects of temperature and humidity on the daily new cases and new deaths of COVID-19 in 166 countries. Sci Total Environ 2020; 729: 139051.

16) Qi H, Xiao S, Shi R, Ward MP, Chen Y, Tu W. COVID-19 transmission in Mainland China is associated with temperature and humidity: a time-series analysis. Sci Total Environ. 2020; 728: 138778.

17) Xie J, Zhu Y. Association between ambient temperature and COVID-19 infection in 122 cities from China. Sci Total Environ 2020; 724: 138201.

18) Wang M, Jiang A, Gong L, Luo L, Guo W, Li C, Zheng J, Li C, Yang B, Zeng J, Chen Y, Zheng K, Li H. Temperature significant change COVID-19 transmission in 429 cities. medRxiv, 2020; doi: 10.1101/2020.02.22.20025791.

19) Bannister-Tyrrell M, Meyer A, Faverjon C, Cameron A. Preliminary evidence that higher temperatures are associated with lower incidence of COVID-19, for cases reported globally up to 29th February 2020. MedRxiv, 2020. doi: 10.1101/2020.03.18.20036731.

20) Meo SA, Abukhalaf AA, Alomar AA, Al-beeshi IZ, Alhowikan A, Shafi KM, Meo AS, Uumani AM8, Akram J. Climate and COVID-19 pandemic: effect of heat and humidity on the incidence and mortality in world's top ten hottest and top ten coldest countries. Eur Rev Med Pharmacol Sci 2020; 24: 8232-8238.

21) Ma Y, Zhao Y, Liu J, He X, Wang B, Fu S. Effects of temperature variation and humidity on the death of COVID-19 in Wuhan, China. Sci Total Environ 2020; 724: 138226.