Original Article

Impact of temperature and sunshine duration on daily new cases and death due to COVID-19

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Abstract

Context: Control of COVID-19 has now become a critical issue for public health. Many ecological factors are proven to influence the transmission and survival of the virus. However, the association between different climatic factors and spread and mortality due to COVID-19 is unknown. **Aim:** To determine the association of different climatic factors with the spread and mortality due to COVID-19 during January 2020 to May 2020. **Methods and Material:** The climatic indicators included in the study were duration of sunshine, average minimum temperature, and average maximum temperature, with cumulative confirmed cases, deceased, and recovered cases. The data was performed for 138 different countries of the world, from January 2020 to May 2020. **Statistical analysis used:** Spearman's correlation analysis was used to assess the correlation between temperature and the spread and mortality of COVID-19 cases. Both univariate and multivariate analysis was performed for cumulative and month-wise analysis, using SPSS software. **Results:** Average maximum temperature and sunshine duration were significantly associated with COVID-19 confirmed cases, deceased, and recovered. For every 1° increase in average temperature, the confirmed, deceased, and recovered cases decreased by 2047 (P = 0.03), 157 (P = 0.016), and 743 (P = 0.005) individuals. The association remained significant even after adjusting for environmental as well as non-environmental variables. Average sunshine duration was inversely correlated with an increase in daily new cases (r = -2261) and deaths (r = -0.2985). **Conclusion:** Higher average temperature and longer sunshine duration are strongly associated with COVID-19 cases and deaths in 138 countries.

Keywords: COVID-19, incidence, mortality, sunshine duration, temperature

Introduction

A novel virus with pneumonia-like illness was reported as a cluster of cases in Wuhan, China towards the end of the previous year.[1] In few days, the cluster of cases resulted in a public health emergency and later transformed into a pandemic by March 13, 2020, infecting ~4.5 million individuals across all the countries and territories in the world.[2,3] The disease is speedily spreading and has resulted in rapid deaths of affected individuals depending on their comorbidities, socio-demographic profile, the capacity of the country's health system, and population density.[4]

In addition, existing statistics indicate that the spread and mortality associated with the disease potentially vary with temperature and other climatic conditions such as humidity, wind speed, and solar radiation exposure. The previous studies on the influenza virus indicated significant correlations with absolute humidity, survival, and transmission rate of the virus.[5] Moreover,

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an outbreak caused by severe acute respiratory syndrome (SARS), an older member of the coronavirus family, depicted a gradual decrease in the number of cases with increasing warm weather.[6] These studies have indicated a potential association between respiratory viruses and climatic factors, especially temperature, highlighting the fact that the survival time of the virus on the surface depends on variation in temperature.

Recent studies on SARS-CoV-2 have shown some association between temperature and rate of infection as the SARS-CoV-2 virus showcased better stability at lower temperatures and lower humidity.[7] However, many other contradictory studies are reporting no association between the meteorological conditions and the spread of COVID-19.[8,9] Thus, there is uncertainty in the association between the environmental factors and transmission susceptibility of the virus. Till date, no study has studied the association between the sunshine duration and temperature from such a large cohort of the population, as a proof of concept. Hence, the present study aimed to assess the effect of temperature, sunshine duration on confirmed, recovered, and deceased cases from January 2020 to May 2020. There is an urgent need for better planning, regulation for preventive measures to combat the COVID-19 pandemic and our study will pave way for better understanding and may help the government and primary care providers in formulating better preventive measures based on climatic conditions of the region. Moreover, this information can also be used by primary care providers in providing warnings to the individuals living in regions with more risk of SARS-CoV-2 and can advise stricter preventive measures. In addition to this, these regions can prepare their primary care providers in the management of COVID-19 for better outcomes.

Methods

Data collection

In silico, we collected the data of confirmed, recovered, and death cases of COVID-19 from an open-source compiled by the Johns Hopkins University Centre for Systems Science and Engineering (JHU CCSE) https://data.humdata.org/dataset from January 22, 2020 till May 17, 2020[10] from all the countries, considering the range of countries with maximum-minimum average daily new cases and death in COVID-19. The data related to the maximum and minimum temperature for all the countries were retrieved from Accuweather online for 5 months from January 2020 to May 2020.[11] However, it was difficult to gather information on all the locations in a particular country, we restricted ourselves to the capital cities of each country under consideration. Hence, we collected the data on maximum and minimum temperature and sunshine duration information only for the capital city and assumed it to be representative of the entire country for simplification. The various variables that can be the potential confounders in the association between temperature and transmission of COVID-19 like population, the median age of the country, Global Health Security (GHS) Rank, were also considered in the analysis. The data related to population and the median age was downloaded from https://ourworldindata.org/grapher.[12] GHS score and GHS rank from Global Health Security Index- 2019 was studied as a proxy for the healthcare preparedness of each country.[13] Since the main aim of our study was to assess the association between transmission and cause of COVID-19 death and temperature or sunshine duration, we assumed that countries having less than 300 confirmed cases majorly consist of imported cases and no transmission has been initiated by these imported cases in the country. Hence, we only included countries which have more than 300 confirmed cases in the analysis and excluded countries with less than 300 cases. We only included countries in our analysis and hence, we also excluded Diamond Princess from the analysis as it was a cruise ship and not a country as a whole.

Data analysis

All the data were analyzed using the SPSS software version 22 (IBM SPSS). Spearman's correlation analysis was used to assess the association between temperatures and confirmed, recovered, and death cases of COVID-19. Followed by correlation analysis, we performed univariate and multivariate analyses. We assumed that the exposure and the outcome variable are following normal distribution and are having a linear relationship for simplicity. We checked the other assumptions for linear regression and failing to fulfill them, we used a robust option for further analysis.

We prepared various multivariate models for the analysis to understand the association better. The first model consists of an environmental variable – sunshine duration. In the second model, we included other non-environmental variables, which potentially can affect the association like GHS score, the median age of the population, and total population per 1,00,000 individuals.

Results

The data retrieved from January 22, 2020 to May 17, 2020, reported a total of 45,25,497 confirmed positive cases of COVID-19 infection spread over 213 countries in the world. Table 1 represents the global burden of confirmed, recovered, and death due to COVID-19 in various WHO-Regions till May 17, 2020[14] showing maximum deaths in Region of America (AMRO) and minimum deaths in the African region (AFRO). However, Figure 1 shows the global cumulative trend in cases of COVID-19 from January 2020 to May 2020, clearly showing the larger exponential growth of the number of cases than recovered cases globally.

Though the Wuhan, China was the origin of the infection, at present, the ten countries – United States of America (USA), Russian Federation, United Kingdom, Spain, Italy, Brazil, Germany, Turkey, France, and Iran account for more than 70% of the burden of the confirmed cases. Moreover, the majority of COVID-19 related deaths are majorly contributed by the USA, Italy, France, The United Kingdom, and Spain whereas the maximum recovery has been observed in countries like the USA, Germany, Spain, Italy, and Turkey. These statistics indicate countries that are highly under the impact of COVID-19 cases and mortality are also showing a speedy recovery. Further,

these could be an influence due to environmental factors like temperature and sunshine duration.

Correlational Analysis between Mean Maximum Temperature and Cumulative Confirmed Cases, Death, and Recovered Cases

We performed the analysis with 138 countries, having more than 300 confirmed cases of SARS-COV-2. The overall Spearman's rank correlation analysis between average temperature (maximum and minimum) for 5 months and confirmed positive cases, dead and recovered cases of COVID-19 showed a weak and negative (-0.34) but significant association, indicating the severity of COVID-19 increases at low temperature. Further, a strong correlation (~0.87) was observed between confirmed, recovered cases, and deaths for 5 months [Table 2]. We also performed a similar correlation analysis for the 5 months separately [Supplementary 1: Supplementary Table 1a-1e]. The number of confirmed cases represented a significant association with recovered and deceased cases each month separately, however, the correlation became stronger with an increased number of confirmed cases, i.e., from January 2020 to May 2020 [Figure 2].

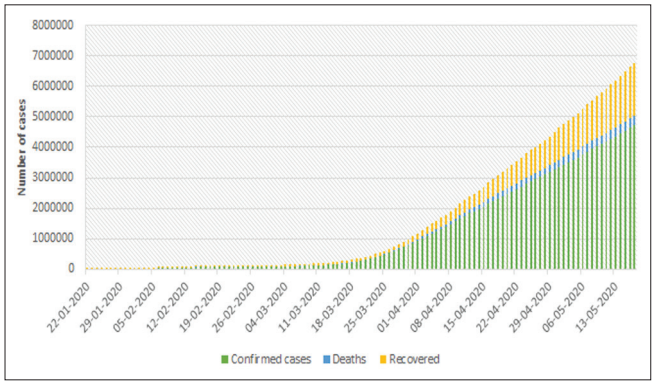

Figure 1: Global cumulative increase in the number of new cases, death due to SARS-CoV-2 from all the countries affected from January 2020 to May 2020

Table 1: Global burden of COVID-19 across WHO-regions*

WHO-Regions	Confirmed cases	Deaths	Recovered Cases
African Region (AFRO)	58663	1710	23480
Region of the Americas (AMRO)	1966932	118799	512810
Eastern Mediterranean Region (EMRO)	335088	9916	165594
European Region (EURO)	1870545	165951	855847
South-East Asia Region (SEARO)	135036	4411	48911
Western Pacific Region (WPRO)	167755	6737	145523

WHO=World Health Organization. *The data is extracted as on May 17, 2020

Univariate Analysis between Mean Maximum Temperature and Cumulative Confirmed Cases, Death, and Recovered Cases

Significant results were obtained on performing univariate analysis with temperature and confirmed cases, recovered cases, and death due to COVID-19 separately [Table 3]. We also performed the same analysis for each month separately. The univariate analysis was not found to be significant for January and February, whereas significant association (<0.05) with March and April. However, for May data is marginally significant in recovered and death cases but not with confirmed cases [Supplementary 1: Supplementary Table 2a-2e]. A clear trend was visible, the increase in temperature, there is a decline in the number of cases and deaths [Figure 3].

Multivariate Regression Analysis between Mean Maximum Temperature and Cumulative Confirmed Cases, Death, and Recovered Cases

Further analysis with another environmental variable like sunshine duration showed a significant association between confirmed cases, recovered cases, death, and temperature [Table 4a]. Table 4b suggests the association between temperature and confirmed cases, recovered cases and deaths remain significant (<0.05) even after adjusting for non-environmental factors like GHS score, GHS rank, the median age of the country, and population per 1,00,000 individuals. Month wise adjusted analysis is available in Supplementary 1: Supplementary Table 3a-3e. However, more factors can be added to make the model better.

Discussion

The spread and transmission of the COVID-19 pandemic is a global emergency issue that is challenging for everyone. Our finding suggests the significant association between the temperature and sunshine duration with daily new cases and deaths of COVID-19. We analyzed the data from January 22, 2020 to May 17, 2020, from 138 countries. Wuhan Province in China being the epicenter

Table 2: Results of Spearman's rank correlation

	Confirmed cases	Deaths	Recovered	Avg Max Temp	Avg Min Temp	Avg Sunshine duration
Confirmed cases	1.00					
Deaths	0.8731*	1.00				
Recovered	0.8826*	0.7728*	1.00			
Avg Max Temp	-0.3406*	-0.3876*	-0.3544*	1.00		
Avg Min Temp	-0.3374*	-0.4129*	-0.3675*	0.9432*	1.00	
Avg Sunshine duration	-0.2261*	-0.2985*	-0.2286*	0.6891*	0.6510*	1.00

Avg=Average.*Indicates significance <0.05

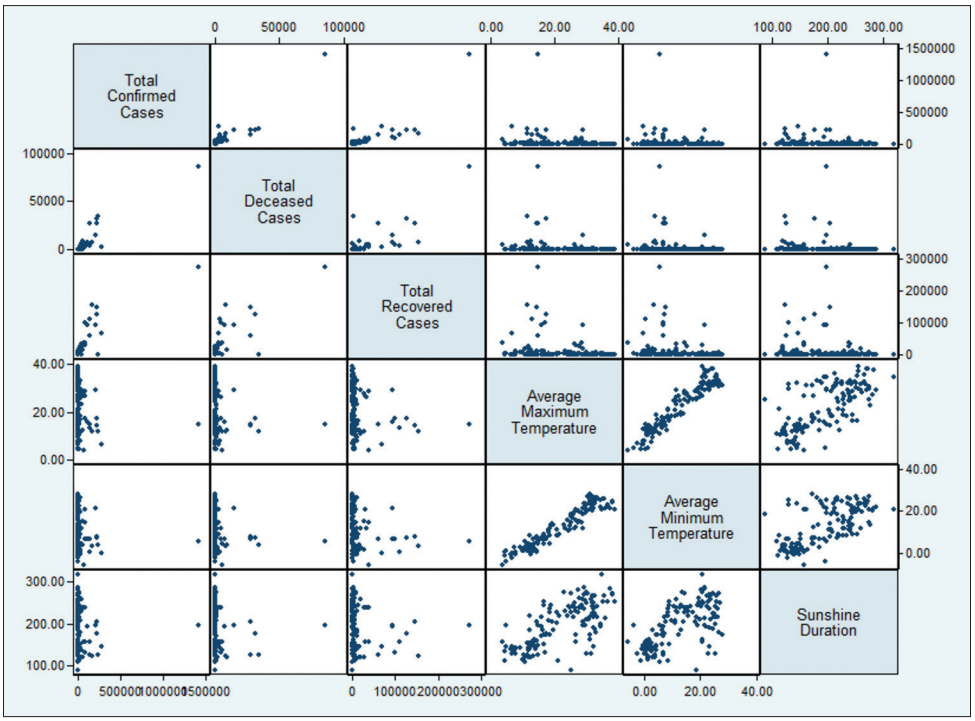

Figure 2: Scatter plots for each variable of minimum, maximum average temperature, and duration of sunshine to determine the correlation between total confirmed cases, total deaths, and total recovered cases

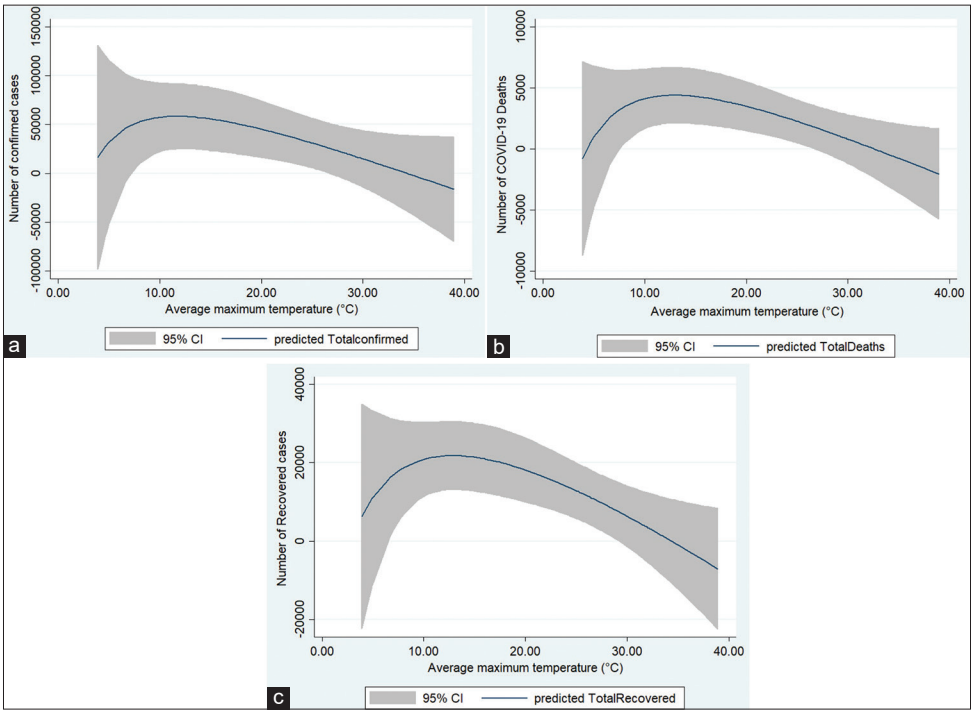

Figure 3: Association between temperature and COVID-19 cases: (a) Association between temperature and confirmed cases. (b) Association between temperature and deceased cases. (c) Association between temperature and recovered cases

of the outbreak occupies eighth place whereas American and European countries are at the top of the list. Most of the Asian countries are not available on the list of WHO highly affected countries by a novel coronavirus. This unexpected distribution of data can be due to many reasons such as the genetics of the host, the immunization against different viral strains, mode of transmission of the virus, and climate conditions.[15]

This is a unique study which is addressing the association of temperature and sunshine duration with COVID-19 transmission

after adjusting for non-environmental factors. The study also performed the cumulative as well as month-wise analysis.

In the correlation analysis confirmed cases, death, and recovered cases were found to be significantly correlated with the average minimum, maximum temperature, and sunshine duration (<0.05).

Table 3: Univariate analysis of temperature with a confirmed case, recovered cases, and death

Variables	β-coefficient (95% CI)	*P*
Maximum average temperature		
Confirmed cases	-2047.12 (-3897.42-196.82)	0.03
Deaths	-157.49 (-284.75-30.24)	0.016
Recovered cases	-742.93 (-1261.89-223.97)	0.005
Minimum average temperature		
Confirmed cases	-1990.38 (-3837.26-143.51)	0.035
Deaths	-148.36 (-272.03-24.69)	0.019
Recovered cases	-760.77 (-1279.32-242.21)	0.004

Our study suggested a weak and negative correlation of temperature with the cumulative confirmed cases, cumulative deaths, and cumulative recoveries. Moreover, the average sunshine duration was also found to be significantly correlated with cumulative confirmed cases, cumulative deaths, and cumulative recoveries. Our results were found to be not coinciding with a similar study[16] as the Yales study has taken data until March whereas the present study has taken data till May 2020.

The univariate analysis suggested that the cumulative confirmed cases, recovered cases, and deaths due to COVID-19 were found to be significantly associated with mean maximum temperature and mean minimum temperature (<0.05). For every 1° increase in average temperature, the confirmed cases, deaths, recovered cases decreased by 2047, 157, 743 individuals, respectively. Though the results seem to be obvious, the decline in recovered cases can be attributable to the other factors such as an increasing burden on the healthcare system which we have not yet addressed in our study.

Table 4a: Adjusted analysis for association of COVID-19 and temperature

Variables	β-coefficient Estimate (95% CI)	Standard Error	R^2	*F*-statistics	Model *P*
Confirmed COVID-19 cases					
Maximum average temperature	-2565.40 (-5983.24-852.43)	1728.19	0.0240	4.03	0.019
Sunshine duration	134.9689 (-324.46-594.40)	232.31			
Deaths due to COVID-19					
Maximum average temperature	-158.98 (-374.68-56.72)	109.07	0.0275	3.70	0.027
Sunshine duration	0.39 (-32.32- 33.09)	16.53			
Recovered COVID-19 cases					
Maximum average temperature	-776.79 (-1587.60-34.02)	409.97	0.0397	4.25	0.016
Sunshine duration	8.82 (-117.81-135.44)	64.03			

Table 4b: Adjusted Analysis for the association of COVID-19 and temperature and other environmental and non-environmental variables

Variables	β-coefficient Estimate (95% CI)	Standard Error	R^2	*F*-statistics	*P*
Confirmed COVID-19 cases					
Maximum average temperature	-1030.83 (-2709.16-647.50)	848.39	0.1138	3.00	0.0089
Sunshine duration	228.31 (-371.98-828.59)	303.44			
Population per 1,00,000	14.92 (-5.99-35.83)	10.57			
Median age of the country	-918.34 (-3832.84-1996.17)	1473.28			
GHS Rank	-437.83 (-930.19-54.53)	248.88			
GHS Score	729.26 (-1268.52-2727.03)	1009.87			
Deaths due to COVID-19					
Maximum average temperature	-32.29 (-152.18-87.59)	60.60	0.1069	2.20	0.0465
Sunshine duration	6.80 (-33.49-47.05)	20.35			
Population per 1,00,000	0.75 (-0.52-2.02)	0.64			
Median age of the country	-61.81 (-261.55-137.92)	100.97			
GHS Rank	-37.79 (-71.32-4.26)	16.95			
GHS Score	47.89 (-75.86-171.64)	62.56			
Recovered COVID-19 cases					
Maximum average temperature	-378.47 (-915.52-158.57)	271.47	0.1957	3.60	0.0024
Sunshine duration	34.37 (-102.18-170.92)	69.03			
Population per 1,00,000	6.56 (1.53-11.59)	2.54			
Median age of the country	283.81 (-414.69-982.32)	353.09			
GHS Rank	-111.75 (-222.57-0.93)	56.02			
GHS Score	109.16 (-283.86-502.18)	198.67			

GHS Rank=Global Health Security Rank; GHS Score=Global Health Security Score

After adjusting for environmental factors like sunshine duration, the association was found to be significant between mean maximum temperature and cumulative confirmed cases, death, and recovered cases. However, the model had a weak R^2 ranging from 2.40% to 3.97%. The association was still found to be significant with a *P* value <0.05. After adjusting for non-environmental factors like GHS score, the median age of the population, total population per 1,00,000 individuals, the R^2 also improved and now ranges from 11.38% to 19.57%. A reduction of 1031 confirmed cases, 32 deaths, and 378 recovered cases were observed after adjusting for environmental and non-environmental factors. The decline in recovered cases can be attributable to other factors such as an increasing burden on the healthcare system.

Though our study is unique there are several limitations to our study. The lacune of this study is that we assumed normal distribution of the outcome variable and linear relationship between exposure and outcome variable. However, the study was not able to address some kind of nonlinearity in the analysis. Moreover, the data collected for the temperature and sunshine duration was only retrieved for the capital city and was assumed to be representative of the entire country and in reality, it may not be the actual scenario. Since this study was retrospective, data for various variables were not available like humidity, airspeed, and most importantly the lockdown of human movement which is adopted by many countries. The total number of cases across the globe is difficult to predict due to the uncertainty of data collected by different countries. Hence, further evaluations are needed for a better understanding of the role of environmental and non-environmental factors influencing the transmission of this pandemic. In conclusion, our study showed a possible association between environmental conditions and COVID-19 infection.

Key points

1. There is a correlation of climatic factors like temperature and sunshine duration with the cumulative confirmed cases, cumulative deaths, and cumulative recoveries associated with COVID-19.
2. The association was found to be significant between mean maximum temperature and cumulative confirmed cases, death, and recovered cases. For every 1° increase in average temperature, the confirmed cases, deaths, recovered cases decreased by 2047, 157, 743 individuals, respectively.
3. The association remained significant between mean maximum temperature and cumulative confirmed cases, death, and recovered cases after adjusting for non-environmental factors like GHS score, GHS rank, the median age of the country, and population per 1,00,000 individuals.

Key Messages

Higher average temperature and longer sunshine duration are strongly associated with COVID-19 cases and deaths across the world indicating temperature as an important factor in the survival of SARS CoV-2. This study will help in formulating better preventive measures to combat COVID-19 based on their climatic conditions.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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Supplementary 1

Supplementary Table 1a: Results of Spearman's rank correlation for the month of January, 2020

	Confirmed cases	Deaths	Recovered	Avg Max Temp	Avg Min Temp	Avg Sunshine duration
Confirmed cases	1.00					
Deaths	0.2306*	1.00				
Recovered	0.4527*	0.5055*	1.00			
Avg Max Temp	-0.0426	-0.0676	0.0740	1.00		
Avg Min Temp	-0.0282	-0.0740	0.0254	0.9252*	1.00	
Avg Sunshine duration	-0.1074	-0.0568	0.1032	0.7809*	0.7054*	1.00

*Indicates significant <0.05, Avg :Average

Supplementary Table 1b: Results of Spearman's rank correlation for the month of February, 2020

	Confirmed cases	Deaths	Recovered	Avg Max Temp	Avg Min Temp	Avg Sunshine duration
Confirmed cases	1.00					
Deaths	0.4075*	1.00				
Recovered	0.6437*	0.5293*	1.00			
Avg Max Temp	-0.2939*	-0.1050	-0.1101	1.00		
Avg Min Temp	-0.2586*	-0.0996	-0.0585	0.9264*	1.00	
Avg Sunshine duration	-0.2397*	-0.0985	-0.0915	0.7822*	0.7153*	1.00

* Indicates significant <0.05, Avg :Average

Supplementary Table 1c: Results of Spearman's rank correlation for the month of March, 2020

	Confirmed cases	Deaths	Recovered	Avg Max Temp	Avg Min Temp	Avg Sunshine duration
Confirmed cases	1.00					
Deaths	0.8551*	1.00				
Recovered	0.8184*	0.6955*	1.00			
Avg Max Temp	-0.5234*	-0.3818*	-0.3306*	1.00		
Avg Min Temp	-0.5219*	-0.4010*	-0.3304*	0.9482*	1.00	
Avg Sunshine duration	-0.3854*	-0.3085*	-0.2207	0.6983*	0.6636*	1.00

*Indicates significant <0.05, Avg :Average

Supplementary Table 1d: Results of Spearman's rank correlation for the month of April, 2020

	Confirmed cases	Deaths	Recovered	Avg Max Temp	Avg Min Temp	Avg Sunshine duration
Confirmed cases	1.00					
Deaths	0.8760*	1.00				
Recovered	0.8347*	0.7696*	1.00			
Avg Max Temp	-0.3133*	-0.3992*	-0.3459*	1.00		
Avg Min Temp	-0.3662*	-0.4737*	-0.4095*	0.9212*	1.00	
Avg Sunshine duration	-0.1506	-0.2431*	-0.1717*	0.5192*	0.5136*	1.00

*Indicates significant <0.05, Avg :Average

Supplementary Table 1e: Results of Spearman's rank correlation for the month of May#, 2020

	Confirmed cases	Deaths	Recovered	Avg Max Temp	Avg Min Temp	Avg Sunshine duration
Confirmed cases	1.00					
Deaths	0.8301*	1.00				
Recovered	0.7515*	0.7041*	1.00			
Avg Max Temp	-0.0170	-0.2470*	-0.1841*	1.00		
Avg Min Temp	-0.0723	-0.3016*	-0.2437*	0.9306*	1.00	
Avg Sunshine duration	0.0409	-0.0364	0.0038	0.1771*	0.1092	1.00

#Considered the data till 17th May 2020, * Indicates significant <0.05, Avg :Average

Supplementary Table 2a: Univariate analysis of temperature with a confirmed case, recovered cases and death for the month of January 2020

Variables	βcoefficient (95% CI)	*P*
Maximum average temperature		
Confirmed cases	-5.72 (-17.09 - 5.65)	0.322
Deaths	-0.13 (-0.37 - 0.12)	0.321
Recovered cases	-0.12 (-0.37 - 0.13)	0.342
Minimum average temperature		
Confirmed cases	-6.07 (-18.16 - 6.01)	0.322
Deaths	- 0.13 (-0.39 - 0.13)	0.321
Recovered cases	-0.13 (-0.39 - 0.14)	0.340

Supplementary Table 2b: Univariate analysis of temperature with confirmed case, recovered cases and death for the month of February, 2020

Variables	β-coefficient (95% CI)	*P*
Maximum average temperature		
Confirmed cases	-32.63 (-91.29 - 26.02)	0.273
Deaths	-1.15 (-3.35 - 1.05)	0.305
Recovered cases	-16.40 (-49.19 - 16.39)	0.325
Minimum average temperature		
Confirmed cases	-45.15 (-127.52 - 37.21)	0.280
Deaths	-1.61 (-4.71 - 1.48)	0.306
Recovered cases	-23.22 (-69.37 - 22.94)	0.322

Supplementary Table 2c: Univariate analysis of temperature with confirmed case, recovered cases and death for the month of March, 2020

Variables	βcoefficient (95% CI)	*P*
Maximum average temperature		
Confirmed cases	-341.32 (-556.12 - -126.53)	0.002
Deaths	-16.92676 (-31.44 - -2.42)	0.023
Recovered cases	-65.29 (-113.24- -17.34)	0.008
Minimum average temperature		
Confirmed cases	-338.60 (-549.43 - -127.77)	0.002
Deaths	-15.79 (-29.45 - -2.13)	0.024
Recovered cases	-65.69 (-113.26 - -18.13)	0.007

Supplementary Table 2d: Univariate analysis of temperature with confirmed case, recovered cases and death for the month of April, 2020

Variables	β-coefficient (95% CI)	*P*
Maximum average temperature		
Confirmed cases	-1327.32 (-2573.13 - -81.50)	0.037
Deaths	-108.28 (-195.88 - -20.69)	0.016
Recovered cases	-444.88 (-763.20 - -126.57)	0.007
Minimum average temperature		
Confirmed cases	-1176.16 (-2220.22 - -132.09)	0.028
Deaths	-96.91 (-170.74 - -23.08)	0.010
Recovered cases	-418.07 (-697.82 - -138.32)	0.004

Supplementary Table 2e: Univariate analysis of temperature with confirmed case, recovered cases and death for the month of May[#], 2020

Variables	βcoefficient (95% CI)	*P*
Maximum average temperature		
Confirmed cases	-499.97 (-1225.56 - 225.62)	0.175
Deaths	-51 (-103.28 - 1.27)	0.056
Recovered cases	-199.03 (-444.92 - 46.86)	0.112
Minimum average temperature		
Confirmed cases	-491.52 (-1107.38 - 124.34)	0.117
Deaths	-46.35 (-91.74 - -0.96)	0.045
Recovered cases	-244.63 (-469.98 - -19.27)	0.034

[#]considered the data till 17th May 2020

Supplementary Table 3a: For the month of January

Variables	β-coefficient Estimate (95% CI)	Standard Error	R^2	*F*-statistics	*P*
Confirmed COVID-19 cases					
Maximum average temperature	1.11 (-4.74-6.99)	2.96	0.4832	0.58	0.7454
Sun-shine duration	-0.68 (-1.65 -0.29)	0.49			
Population per 1,00,000	0.33 (-0.12-0.77)	0.23			
Median Age of the country	9.20 (-2.29-20.69)	5.81			
GHS Rank	1.57 (-0.28-3.42)	0.93			
GHS Score	2.60 (-2.57-7.76)	2.61			
Deaths due to COVID-19					
Maximum average temperature	0.02 (-0.11-0.15)	0.064	0.4828	0.57	0.7499
Sun-shine duration	-0.02 (-0.04-0.01)	0.01			
Population per 1,00,000	0.01 (-0.002-0.02)	0.005			
Median Age of the country	0.20 (-0.05-0.45)	0.127			
GHS Rank	0.04 (-0.01-0.08)	0.02			
GHS Score	0.06 (-0.06-0.17)	0.057			
Recovered COVID-19 cases					
Maximum average temperature	0.03 (-0.01-0.16)	0.066	0.4824	0.59	0.7353
Sun-shine duration	-0.01 (-0.04-0.01)	0.011			
Population per 1,00,000	0.01 (-0.002-0.02)	0.005			
Median Age of the country	0.21 (-0.05-0.46)	0.128			
GHS Rank	0.03 (-0.01-0.07)	0.021			
GHS Score	0.06 (-0.05-0.17)	0.058			

GHS Rank : Global Health Security Rank ; GHS Score: Global Health Security Score

Supplementary Table 3b: For the month of February

Variables	β-coefficient Estimate (95% CI)	Standard Error	R^2	*F*-statistics	*P*
Confirmed COVID-19 cases					
Maximum average temperature	19.45 (-46.43-85.32)	33.30	0.4855	0.65	0.6910
Sun-shine duration	-7.99 (-20.38-4.41)	6.26			
Population per 1,00,000	2.33 (-0.85-5.51)	1.61			
Median Age of the country	69.90 (-13.43 -153.22)	42.12			
GHS Rank	11.11 (-2.08-24.31)	6.67			
GHS Score	20.46 (-14.13 -55.05)	17.49			
Deaths due to COVID-19					
Maximum average temperature	0.82 (-1.65-3.29)	1.25	0.4859	0.60	0.7311
Sun-shine duration	-0.33 (-0.80-0.13)	0.24			
Population per 1,00,000	0.08 (-0.03-0.21)	0.06			
Median Age of the country	2.56 (-0.57-5.71)	1.58			
GHS Rank	0.43 (-0.07-0.93)	0.25			
GHS Score	0.68 (-0.61-1.97)	0.65			
Recovered COVID-19 cases					
Maximum average temperature	13.45 (-23.44-50.33)	18.65	0.4853	0.59	0.7407
Sun-shine duration	-5.03 (-11.98-1.90)	3.51			
Population per 1,00,000	1.31 (-0.47-3.09)	0.90			
Median Age of the country	37.19 (-9.65-84.02)	23.68			
GHS Rank	6.32 (-1.11-13.75)	3.76			
GHS Score	10.11 (-9.17-29.40)	9.75			

GHS Rank : Global Health Security Rank ; GHS Score: Global Health Security Score

Supplementary Table 3c: For the month of March

Variables	β-coefficient Estimate (95% CI)	Standard Error	R^2	*F*-statistics	*P*
Confirmed COVID-19 cases					
Maximum average temperature	-121.21 (-370.93 -128.52)	126.24	0.1055	2.01	0.0681
Sun-shine duration	31.04 (-35.04-97.13)	33.41			
Population per 1,00,000	0.78 (-1.27-2.84)	1.04			
Median Age of the country	57.64 (-322.30 -437.59)	192.06			
GHS Rank	-58.68 (-115.32 - -2.04)	28.63			
GHS Score	147.62 (-72.18 -367.42)	111.11			
Deaths due to COVID-19					
Maximum average temperature	-6.85 (-23.38-9.69)	8.36		1.27	0.2773
Sun-shine duration	1.38 (-2.14-4.91)	1.78	0.0453		
Population per 1,00,000	0.02 (-0.03-0.08)	0.03			
Median Age of the country	14.20 (-9.67-38.08)	12.07			
GHS Rank	-2.11 (-4.54 -0.33)	1.23			
GHS Score	5.60 (-1.47-12.67)	3.57			
Recovered COVID-19 cases					
Maximum average temperature	-21.63 (-81.78-38.51)	30.40	0.3326	2.11	0.0567
Sun-shine duration	-2.36 (-14.63-9.92)	6.20			
Population per 1,00,000	1.28 (-0.36-2.92)	0.83			
Median Age of the country	78.47 (5.06 -151.89)	37.11			
GHS Rank	0.91 (-9.09-10.92)	5.06			
GHS Score	21.96 (-0.49-44.42)	11.35			

GHS Rank : Global Health Security Rank ; GHS Score: Global Health Security Score

Supplementary Table 3d: For the month of April

Variables	β-coefficient Estimate (95% CI)	Standard Error	R^2	*F*-statistics	*P*
Confirmed COVID-19 cases					
Maximum average temperature	-591.94 (-1445.57-261.70)	431.51	0.0940	2.51	0.0246
Sun-shine duration	148.57 (-172.74 -469.88)	162.43			
Population per 1,00,000	6.39 (-6.50 -19.28)	6.52			
Median Age of the country	-685.90 (-2515.25-1143.44)	924.73			
GHS Rank	-241.99 (-517.98-33.99)	139.51			
GHS Score	477.01 (-572.07 -1526.09)	530.31			
Deaths due to COVID-19					
Maximum average temperature	-16.46 (-93.10 -60.18)	38.74	0.1048	1.89	0.0865
Sun-shine duration	3.62 (-17.58-24.82)	10.72			
Population per 1,00,000	0.35 (-0.39-1.09)	0.38			
Median Age of the country	-47.47 (-170.20-75.25)	62.04			
GHS Rank	-23.08 (-42.92 - -3.24)	10.03			
GHS Score	33.59 (-27.89-95.07)	31.08			
Recovered COVID-19 cases					
Maximum average temperature	-170.49 (-459.54-118.64)	146.13	0.1077	2.16	0.0511
Sun-shine duration	19.20 (-55.23 -93.63)	37.63			
Population per 1,00,000	1.64 (-0.82-4.09)	1.24			
Median Age of the country	118.28 (-298.72 -535.29)	210.80			
GHS Rank	-65.14 (-127.10 - -3.18)	31.32			
GHS Score	76.81 (-110.02-263.65)	94.45			

GHS Rank : Global Health Security Rank ; GHS Score: Global Health Security Score

Supplementary Table 3d: For the month of April

Variables	β-coefficient Estimate (95% CI)	Standard Error	R^2	*F*-statistics	*P*
Confirmed COVID-19 cases					
Maximum average temperature	-591.94 (-1445.57-261.70)	431.51	0.0940	2.51	0.0246
Sun-shine duration	148.57 (-172.74 -469.88)	162.43			
Population per 1,00,000	6.39 (-6.50 -19.28)	6.52			
Median Age of the country	-685.90 (-2515.25-1143.44)	924.73			
GHS Rank	-241.99 (-517.98-33.99)	139.51			
GHS Score	477.01 (-572.07 -1526.09)	530.31			
Deaths due to COVID-19					
Maximum average temperature	-16.46 (-93.10 -60.18)	38.74	0.1048	1.89	0.0865
Sun-shine duration	3.62 (-17.58-24.82)	10.72			
Population per 1,00,000	0.35 (-0.39-1.09)	0.38			
Median Age of the country	-47.47 (-170.20-75.25)	62.04			
GHS Rank	-23.08 (-42.92 - -3.24)	10.03			
GHS Score	33.59 (-27.89-95.07)	31.08			
Recovered COVID-19 cases					
Maximum average temperature	-170.49 (-459.54-118.64)	146.13	0.1077	2.16	0.0511
Sun-shine duration	19.20 (-55.23 -93.63)	37.63			
Population per 1,00,000	1.64 (-0.82-4.09)	1.24			
Median Age of the country	118.28 (-298.72 -535.29)	210.80			
GHS Rank	-65.14 (-127.10 - -3.18)	31.32			
GHS Score	76.81 (-110.02-263.65)	94.45			

GHS Rank : Global Health Security Rank ; GHS Score: Global Health Security Score

Supplementary Table 3e: For the month of May

Variables	β-coefficient Estimate (95% CI)	Standard Error	R^2	*F*-statistics	*P*
Confirmed COVID-19 cases					
Maximum average temperature	-335.61 (-986.41 -315.17)	328.98	0.0953	1.59	0.1552
Sun-shine duration	36.07 (-33.19-105.33)	35.01			
Population per 1,00,000	5.55 (-2.08-13.18)	3.86			
Median Age of the country	-394.51 (-1391.25 -602.22)	503.85			
GHS Rank	-132.62 (-270.89 -5.64)	69.89			
GHS Score	2.00 (-482.27-486.28)	244.80			
Deaths due to COVID-19					
Maximum average temperature	-23.69 (-52.56-5.17)	14.59	0.0853	1.73	0.1179
Sun-shine duration	0.87 (-3.32-5.06)	2.12			
Population per 1,00,000	0.31 (-0.23-0.86)	0.28			
Median Age of the country	-35.15 (-114.84 -44.54)	40.28			
GHS Rank	-11.73 (-22.75- -0.69)	5.57			
GHS Score	4.59 (-34.40-43.59)	19.71			
Recovered COVID-19 cases					
Maximum average temperature	-60.93 (-307.80-185.94)	124.79	0.1496	2.72	0.0160
Sun-shine duration	19.03 (-6.86-44.91)	13.09			
Population per 1,00,000	2.38 (0.01-4.76)	1.20			
Median Age of the country	79.17 (-242.48 -400.82)	162.59			
GHS Rank	-57.69 (-104.61 - -10.76)	23.72			
GHS Score	-1.97 (-154.85-150.90)	77.28			

GHS Rank : Global Health Security Rank ; GHS Score: Global Health Security Score