ORIGINAL ARTICLE

The nexus between meteorological parameters and COVID-19 pandemic: case of Islamabad, Pakistan

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Abstract
The study aimed to investigate the correlation between meteorological parameters and the spread of the COVID-19 pandemic in Islamabad, Pakistan. The meteorological parameters include temperature minimum (°C), temperature maximum (°C), temperature average (°C), humidity minimum (%), humidity maximum (%), humidity average (%), and rainfall (mm). The data of COVID-19, such as the number of new confirmed cases and deaths was obtained from the Ministry of Health, Pakistan. The correlations of various types, i.e., Pearson, Spearman, and Kendall correlations between meteorological parameters and COVID-19, were employed for data analyses. The results exhibited a highly significant relationship between COVID-19 and temperature minimum and temperature average among all meteorological parameters. The study findings may help competitive authorities to combat this disease in Pakistan.

Keywords Islamabad · COVID-19 · Meteorological parameters · Correlation analysis

Introduction

The COVID-19 is a renowned disease code worldwide for coronavirus disease 2019, which is caused by novel coronavirus also known as severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2). It primarily emerged from Wuhan city of China in late December 2019 and spread all over the world, then was declared as global pandemic approximately after three months. This pandemic is the third outbreak of coronavirus family in two decades after Severe Acute Respiratory Syndrome (SARS) and Middle East Respiratory Syndrome (MERS) (Gorbalenya et al. 2020). Now, it's like a plague of the twenty-first century, which has affected almost all the countries of the world with more than eight million confirmed cases and 0.44 million deaths as of June 15, 2020 (WHO 2020a). The rapid spread of this contagious disease includes pneumonia-like symptomatic or asymptomatic manifestations (80% infections) (WHO 2020b). The incubation period of this novel coronavirus is

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1–14 days after infection; most commonly, the symptoms start to appear within 5–8 days (Linton et al. 2020; Shakoor et al. 2020). The infected person could experience mild to severe symptoms mainly including fever (most frequent), cough, shortness of breath. The most ruthless form of this novel disease can cause pneumonia, kidney failure, sore throat, fatigue, severe damages to the respiratory system and even death (Cheng et al. 2020; Michelen et al. 2020). The dangerous aspect is its fast-human to human transmission rate. Epidemiology of this novel disease is mainly affected by three factors, i.e., the host, transmission media, and the environment (Bilal et al. 2020; Sobral et al. 2020).

In Pakistan, the first two cases were reported in Karachi, Sindh province, on February 26, 2020 (Dawn News, 2020). The total number of confirmed cases were 148,921 and 2839 deaths as of June 15, 2020 in Pakistan. Sindh reported highest confirmed cases (75,168) among all the provinces while Punjab was second with 71,987 confirmed cases, and Islamabad had 11,981 confirmed number of cases. A rapid rise in the number of daily confirmed cases and deaths was seen from May 7, 2020, onwards. As of June 15, 2020, Pakistan ranked 14th on the globe. The situation of COVID-19 in Pakistan can be checked through official national and international websites like covid.gov.pk, covid19.who.int, and worldometers.info.

Several studies have shown the impacts of environmental and weather conditions on spread of viral diseases. For instance, certain weather and climatic conditions possibly play a vital role in restricting the spread of contagious diseases (Wang et al. 2010; D'Amato et al. 2014). A recent study in Norway, Oslo concluded that temperature was positively and precipitation negatively correlated with the COVID-19 disease (Menebo 2020). Similar kinds of results have been found in another study conducted in New York City, USA (Bashir et al. 2020). A global study also showed the association between COVID-19 cases and the climatic indicators (Sobral et al. 2020). By taking all the above mentioned scenarios into account, this study is aimed to investigate the association between meteorological parameters like temperature, precipitation, and humidity with COVID-19 cases and deaths.

Materials and methods

Pakistan is situated in South Asia and bordered with India, Afghanistan, China, and Iran. It is ranked fifth as the world's most populous country with a total population of about 212.2 million, with an area of about 770,880 km^2. Islamabad, the capital of Pakistan, having a total population of 1.095 million, covers an area of 906.5 km^2. Pakistan, as a developing country, has limited resources to combat COVID-19 disease. The data set of COVID-19 regarding

confirmed cases and deaths in Islamabad (on a daily basis) was taken from the official website of Pakistan (covid.gov. pk). While the data set of meteorological parameters such as temperature and humidity (on a daily basis) was taken from a USA based website of National Oceanic and Atmospheric Administration (NOAA) (noaa.gov). However, the dataset of rainfall was also tallied from the Pakistan Meteorological Department's website (pmd.gov.pk). The datasets of both meteorological parameters and COVID-19 daily new cases and deaths were taken within the time era of May 1, 2020, to June 15, 2020. The correlation tests were used to determine the association between the COVID-19 pandemic and the meteorological parameters. The pictorial graphs were made of the meteorological COVID-19 data by using OriginPro software, and SPSS was used for correlation and data analysis. Figure 1 shows the total number of cases and deaths of COVID-19 on August 10, 2020, in Pakistan.

Results and discussion

The daily confirmed COVID-19 patients of Islamabad city were within the hundred numbers until mid of May, 2020. After then, the daily new cases escalated very swiftly (Fig. S1). In June the daily new cases have touched the mark of 700 for the capital of the country. The total number of confirmed cases in Islamabad were 8857 as of June 15, 2020. In the span of May 1, 2020, to June 15, 2020, minimum cases as 21 and maximum cases as 771 were reported on May 5, and June 13, 2020, respectively. However, the average of daily new confirmed cases was 185. The deaths started to report from May 9, with the total number of fatalities as 83 until June 15, 2020 (Fig. S2). The weather data of Islamabad showed temperature ranges from 26 °C (highest minimum temperature) to 40 °C (highest maximum temperature) with an average of 32 °C (highest average temperature) (Fig. S3); likewise, humidity ranged from 57% (highest minimum humidity) to 100% (highest maximum humidity) with an average of 89% (highest average humidity) (Fig. S4). The rainfall data showed 11 days of rainfall recorded with a maximum of 160 mm within the period taken for this study (Fig. S5).

Table 1 illustrates the Pearson, Spearman, and Kendall's correlations between COVID-19 new cases, deaths and the weather parameters (minimum temperature, maximum temperature, average temperature, minimum humidity, maximum humidity, average humidity and minimum rainfall, maximum rainfall, average rainfall). While, Fig. 2 shows correlations between COVID-19 new cases, deaths and the weather parameters. All three types of correlations results showed that new COVID-19 cases and deaths were significantly correlated with temperature minimum at $p < 0.01$ with a high level as the correlation coefficients were greater than
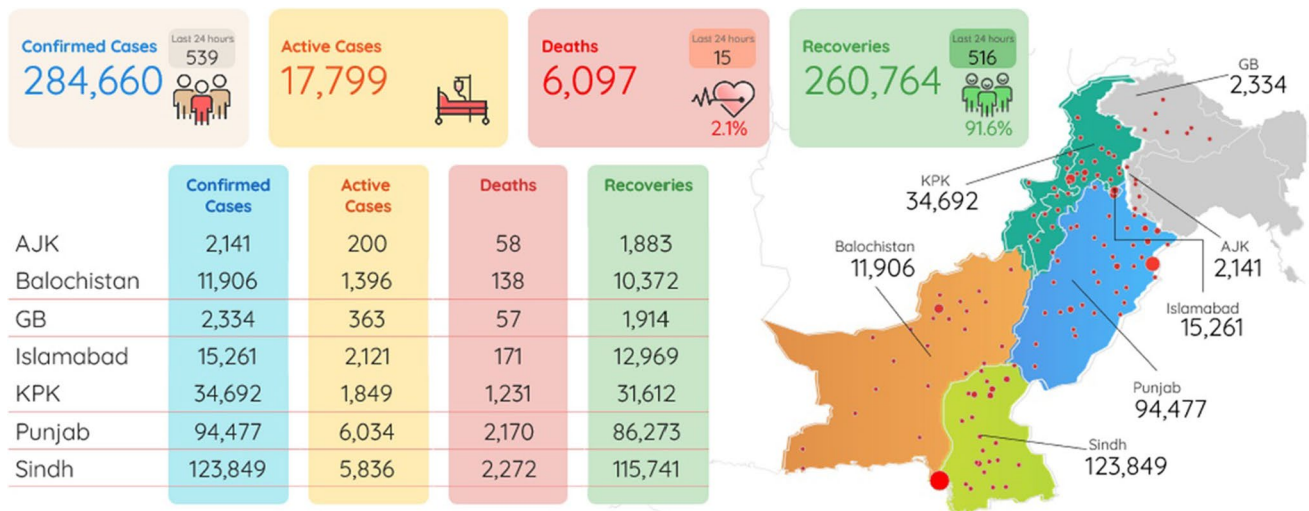
Fig. 1 Total number of cases and deaths of COVID-19 in Pakistan (10-Aug-2020). Source: covid.gov.pk

Table 1 Correlation between new COVID-19 cases, deaths and metrological parameters

	Min. temp	Max. temp	Avr. temp	Min. humidity	Max. humidity	Avr. humidity	Rainfall
Pearson's correlation							
New cases	0.62[b]	0.15	0.31[a]	0.22	−0.13	0.04	−0.18
Deaths	0.54[b]	0.12	0.27	0.17	−0.14	0.01	−0.19
Spearman's correlation							
New cases	0.67[b]	0.21	0.35[a]	0.23	−0.19	0.01	0.09
Deaths	0.58[b]	0.19	0.30[a]	0.15	−0.17	−0.04	0.18
Kendall's correlation							
New cases	0.50[b]	0.16	0.23[a]	0.12	−0.15	−0.03	0.06
Deaths	0.46[b]	0.14	0.21	0.11	−0.14	−0.04	0.12

[a]Correlation is significant at the 0.05 level

[b]Correlation is significant at the 0.01 level

0.5. Also, new cases were mediumly correlated with temperature average at $p < 0.05$. However, temperature maximum, humidity minimum, humidity maximum, humidity average, and rainfall were not significantly correlated with new COVID-19 cases and deaths (Table 1).

The current study provides information in support of the spread of COVID-19 and fatalities in Islamabad with relation to various metrological parameters. While the findings showed that the spread of COVID-19 has an association with temperature minimum with the lowest minimum temperature of 15 °C and the highest minimum temperature of 26 °C; also, with the temperature average having the lowest average temperature 20 °C and highest average temperature 32 °C. An argument on positive relationship between COVID-19 and temperature around 15–25 with pleasant sunny days could be the breaking of lock-down rules resulting in the spread of COVID-19. In contrast, people are less prone to go outside in high temperature and rainfall days. Several studies argued that COVID-19 is a cold virus having high stability at lower temperatures, while sensitive to high temperature (Shi et al. 2020). However, the spread of contagious diseases like COVID-19 and its relation to weather transmission and other meteorological parameters like temperature, humidity, wind speed, precipitation etc. was reported previously with the severe acute respiratory syndrome (SARS), Respiratory Syncytial Virus (RSV), and West Nile virus infection (Tan et al. 2005; Wang et al. 2010; Vandini et al. 2013).

In the early days of the emergence of this disease in Wuhan, a study indicated the correlation between weather temperature and the spread of COVID-19. It concluded that the disease conquers with the rise in environmental temperature (Guo et al. 2020). Nonetheless, the temperature in Islamabad is going further up in the ongoing summer, while the number of cases daily reports is also increasing. This study also showed no association with temperature maximum. However, the spread of this virus might be influenced by other factors like population density, people's attitude towards taking precautionary measures, lockdown

Fig. 2 Correlation between new COVID-19 cases, deaths and metrological parameters
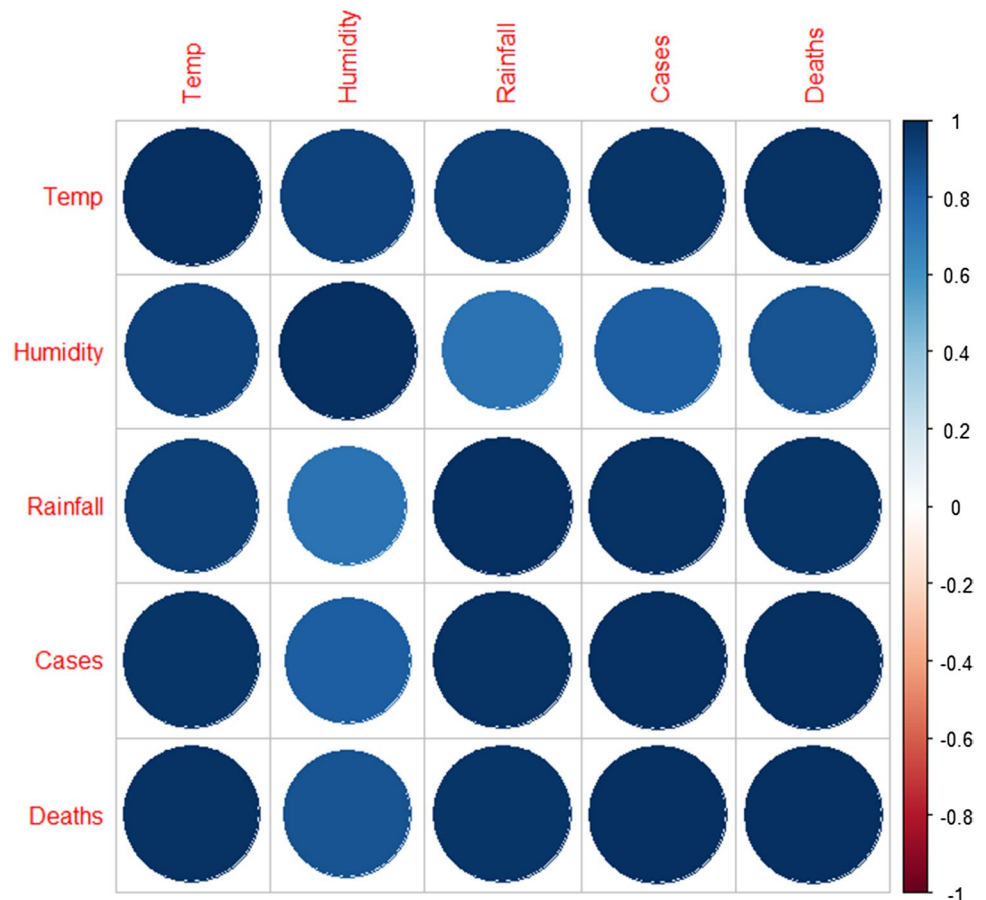
implementation, population mobility, testing facilities and capacity, and development of herd immunity.

This study can assist the cognitive policymakers regarding COVID-19 spread and its association with meteorological parameters. Despite this, the study may have some limitations. First, the date of test conduction and the time of result intimation may not imply the infection date, and the incubation of this virus is yet another factor to influence. Secondly, the limited daily testing capacity may also influence the number of confirmed new cases. Thirdly, this study is based on the dataset of one and a half months (May 1 to June 15), the solid conclusions require more time because the spread of this disease is not as yet over in Pakistan.

Conclusion

Previous literature on similar global pandemics proved the association between meteorological parameters and the spread of contagious diseases. This study concluded that temperature minimum and temperature average were significantly correlated with COVID-19, nevertheless humidity and rainfall do not have any relation with COVID-19 proliferation in Islamabad, Pakistan. However, various other factors like population density and social distancing etc. may also affect the spread of this disease. Hence, there is still a need to imply the "stay home stay safe" policy with strict implementation of Standard Operating Procedures (SOPs) suggested by the World Health Organization (WHO) in Pakistan.

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