Correlation between weather conditions and COVID-19 pandemic in the southeast area of Iran

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Research Article

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Abstract

The Coronavirus disease 2019 (COVID-19) has influenced the live of all people around the world. This study analyzed the relationship between the weather elements (daily temperature, wind speed and humidity) and daily active, recovered and dead cases of covid-19 in Rafsanjan, in the southeast area of Iran. Covid-19 data and meteorological variables were obtained from 29 February 2020 to 20 March 2021 (386 days) from Rafsanjan University of Medical Sciences and Meteorological Organization of Iran, respectively. The results showed that there is a significant inverse association between daily average temperature with the number of daily active cases (r: -0.293, p<0.01), recovered cases (r: -0.301, p<0.01) and dead cases (r: -0.198, p<0.01). With decreasing the average wind speed, the number of daily active cases (r: -0.224, p<0.01), recovered cases (r: -0.232, p<0.01) and dead cases has been increased. A nonsignificant positive correlation between daily humidity average and daily active cases (r:0.033, p=0.518) and recovered cases (r:0.044, p=0.390), and significant positive correlation with the number of daily dead cases (r: 0.254, p<0.01) was observed. Therefore, temperature and wind speed can be considered as affective factors in COVID-19 as an auxiliary solution.

Introduction

COVID-19 is an infectious illness caused by severe acute respiratory disease coronavirus 2 (SARS-CoV-2) (Rosario et al. 2020). SARS-CoV-2 belongs to the Coronaviridae family and contains a single-stranded RNA as its genetic material (Ouassou et al. 2020). Fever, cough, and breathlessness are reported as common clinical symptoms of the disease (Shahzad et al. 2020); however, this virus, similar to other coronaviruses, has the potential to cause severe Acute Respiratory Syndrome (SARS) (Rosario et al. 2020). SARS-CoV-2 is transmitted from human to human through respiratory droplets or aerosol (Shahzad et al. 2020). People with pre-existing ailments, including diabetes mellitus, asthma, hypertension, and cardiovascular disease, as well as the elderly and males, are more susceptible to COVID-19 disease or have more severe symptoms (Alqahtani et al. 2020; Wu and McGoogan 2020; Zhou et al. 2020). Due to the fast outbreak of the disease globally, it has become a serious public health threat, and the World Health Organization (WHO) has announced this disease as a pandemic (Bashir et al. 2020). More than 192,284,207 million confirmed cases and 4,136,518 million deaths around the world have been reported until 23 July 2021 (WHO. Coronavirus disease (COVID-19) pandemic.).

Multiple different factors, including demographic and environmental, can play important roles in the course of a pandemic; thus, it is essential to find out the effect of these factors (Anderson et al. 2020). Weather conditions (e.g., temperature and humidity) are important in the transmission of viruses (Ahmadi et al. 2020). High temperature and humidity decrease the stability of the virus, while low temperature and humidity can increase the half-life of SARS-CoV-2 (Chin et al. 2020). Laboratory studies have suggested that the viability of SARS-CoV-2 has been reduced by increasing temperature (4°C, 22°C, and 37°C) (Liu et al. 2021; Matson et al. 2020).

Weather factors impact the transmission of COVID-19; however, their influences are different among different regions. Recently, studies have shown a strong relationship between humidity, temperature, and COVID-19 outbreak in different countries worldwide (Yang et al. 2021).

A positive correlation between temperature and COVID-19 spread in Singapore, Brazil, Indonesia, Japan, and Norway (Auler et al. 2020; Azuma et al. 2020; Menebo 2020; Pani et al. 2020; Tosepu et al. 2020) and a significant negative correlation in New York City, Iran, Bangladesh, and China have been reported (Ahmadi et al. 2020; Bashir et al. 2020; Haque and Rahman 2020; Shi et al. 2020). The high wind speed has increased the prevalence of COVID-19 in Turkey (Şahin 2020) but did not impact the outbreak in Singapore (Pani et al. 2020). A positive correlation between relative air humidity in Brazil and Singapore has been reported (Auler et al. 2020; Azuma et al. 2020).

Regarding the effect of weather indicators, such as humidity, temperature, and wind speed, on the spread of COVID-19 disease in different countries, the investigation of the impact of climatology factors can be helpful to limit and control the spread of SARS-CoV-2. The effect of climate factors on the spread of COVID-19 has not been explored in Rafsanjan city; therefore, the main goal of the current study is to investigate the correlation between the numbers of new positive daily cases of this disease and three environmental factors, including temperature, humidity, and wind speed, in this city.

Material And Methods

Study area

This study was conducted in Rafsanjan city which is located in the north of Kerman province, Iran. This city is situated at a longitude of 55° 59' 30" E and latitude of 31° 13" N (Hosseinifard and Aminiyan 2015). The maximum and minimum annual temperature and humidity in Rafsanjan are -8 and 43 ˚C, and 7 and 94 %, respectively. The total population of the city is 311,214 people (Eslami et al. 2021).

Data collection

In the present study the relationship between weather variables and daily COVID-19 cases (confirmed, recovered and dead cases) were investigated. Data from 29 February 2020 to 20 March 2021 (386 days) in Rafsanjan were collected, including daily number of COVID-19 confirmed positive cases (through real-time reverse-transcriptase–polymerase-chain-reaction (RT-PCR)), improved cases, dead cases and meteorological data. COVID-19 data were obtained from Rafsanjan University of Medical Sciences, in the southeast of Iran. while weather variables including daily average temperature, daily average wind speed, daily average humidity, daily maximum temperature and daily minimum temperature were obtained from Meteorological Organization of Iran.

Data analysis

In order to find the associations between weather and daily COVID-19 cases Statistical Package for the Social Sciences (SPSS) software was used to calculate Spearman's correlation coefficient. A p-value of

<0.05 considered a statistically significant relationship.

Results

During the study period (29 February 2020 to 20 March 2021), 11436 active cases have been reported, among these cases 11104 cases were recovered and 332 cases were dead in Rafsanjan. The spearman's correlation analysis between whether variables and the daily active cases, recovered cases and dead cases of COVID-19 are presented in Table 1.

Table 1
Spearman correlation between COVID-19 and weather parameters

Climate variable	New cases	Recovered cases	Dead cases
Temperature Maximum	-0.235**	-0.245**	-0.184**
Temperature Minimum	-0.330**	-0.338**	-0.182**
Temperature Average	-0.293**	-0.301**	-0.198**
Humidity Average	0.033	0.044	0.254**
Wind speed Average	-0.224**	-0.232**	-0.169**
**. Correlation is significant at the 0.01 level (2-tailed).			

COVID-19 and temperature

The trend of COVID-19 daily new, recovered and dead cases and temperature changes during the study period were shows in Figure 1. According to Figure 1a and b, and Table 1, there is a significant inverse correlation between daily temperature average with the number of daily active cases (r: -0.293, p<0.01), recovered cases (r: -0.301, p<0.01) and dead cases (r: -0.198, p<0.01), which means by decreasing daily temperature average, the total daily numbers of COVID-19 cases are increased.

COVID-19 and humidity

In figure 2 the trend of COVID-19 daily new, recovered and dead cases, and humidity changes during the study period are showed. According to Figure 2 and Table 1, there is a positive correlation between the number of COVID-19 cases and daily humidity average, indeed by increasing daily humidity average, the number of daily active cases (r:0.033, p=0.518), recovered cases (r:0.044, p=0.390) and dead cases (r:0.254, p<0.01) with a slight slope are increased. It can be seen from the data in Table.1 that only the association between daily humidity average with daily mortality is significant.

COVID-19 and wind speed

The trend of COVID-19 daily new, recovered and dead cases and wind speed changes during the study period were shows in Figure 3. According to Figure 3, there has been a slight decline in the number of

daily active cases (r:-0.224, p<0.01), recovered cases (r: -0.232, p<0.01) and dead cases (r: -0.169, p<0.01) as average wind speed has been increased. A significant reverse correlation between the number of COVID-19 cases and daily wind speed average is shown in Table1.

Discussion

The COVID-19 disease is a global pandemic since the onset of which the world has altered. This pandemic has negatively affected economic activities and human health (Lin et al. 2020). In the present study, the correlation of five main weather variables, including daily average temperature, wind speed, humidity, maximum temperature, and minimum temperature, with the number of daily active, recovered, and death cases of COVID-19 is investigated. Among weather elements, the effect of temperature has been the most studied (Liu et al. 2020; Tosepu et al. 2020). A significant negative correlation between COVID-19 cases and temperature is found in this study. This result seems to be consistent with other researches. Adekunle et al. indicated temperature average to be related inversely to COVID-19 growth in Africa (Adekunle et al. 2020). A moderate negative correlation between average temperature, maximum temperature, and the number of COVID-19 infections in the State of Rio de Janeiro, Brazil, was reported by Rosario et al. (Rosario et al. 2020). According to the study by Alkhowailed et al., as the average and maximum temperature increased, the number of COVID-19 positive cases decreased in Saudi Arabia (Alkhowailed et al. 2020). In a study from eight South American locations, Zhu et al. observed a negative association between average temperature and COVID-19 confirmed cases (Zhu et al. 2020). In a comprehensive study in 166 countries, the authors reported the number of daily positive cases and new deaths of COVID-19 to be reduced for every1°C rise in temperature (Wu et al. 2020). In another study in Brazil, Prata et al. reported that when the temperature was below 25.8°C, every 1°C increase in temperature led to a 4.9% decrease in COVID-19 cases (Prata et al. 2020). According to Wu et al., with increasing 1°C temperature, the daily new cases and dead were decreased by 3.08% and 1.19% (Wu et al. 2020). Other studies have reported conflicting results. Bashir et al. pointed out a positive correlation between minimum and average temperature with COVID-19 cases in New York City (Bashir et al. 2020). In another study from Wuhan, Ma et al. suggested diurnal temperature ranges be significantly associated with the number of COVID-19 daily deaths (Ma et al. 2020). Xie and Zhu illustrated that when the average temperature was below 3°C, the number of daily confirmed cases of COVID-19 was increased for every 1°C increase in temperature in 122 cities in China (Xie and Zhu 2020). A significant positive correlation for both minimum temperature and mean temperature with daily new COVID-19 cases was reported in Singapore by Pani et al. (Pani et al. 2020). The possible explanation for our results might be that an elevated temperature has the potential to damage the virus lipid membrane and consequently diminishes the stability and transmission rate of viruses (de Ángel Solá et al. 2020; Moriyama et al. 2020). Also, in hot weather, viral load in the air and surfaces can be decreased due to exposure of pathogens to ultraviolet (UV-A) and infrared (IR) rays of the sun; as a result, they are damaged, inactived, or degraded, thus decreasing the transmission (Eslami and Jalili 2020). Cold weather in winter can reduce blood supply, thus decreasing immune cells in the nasal mucosa and innate human immunity (Sun et al. 2020). However, differences in minimum and maximum temperatures, characteristics of the participants in

different area, and other factors such as overcrowding and non-compliance with hygiene tips, recommended by WHO, can also cause differences in study results (Tosepu et al. 2020).

The wind is considered a crucial climatic factor in transmitting infectious respiratory ailments since it may modulate the dynamics of various vectors and pathogens (Ellwanger and Chies 2018). The data of the present study demonstrated that the number of COVID-19 positive, recovered, and dead cases elevated due to the decrease of wind speed; studies on this element are scarce. Pani et al. founded that wind speed decrease was associated with an elevated incidence of COVID-19 (Pani et al. 2020). Alkhowailed et al. also reported a significant reverse correlation between daily confirmed cases and wind speed (Alkhowailed et al. 2020). Moreover, another study from Iran indicated that in provinces such as Golestan, Mazandaran, Gilan, and Tehran, where the wind speed was low, the outbreak rate of COVID-19 disease was much higher (Ahmadi et al. 2020). Research by Rendana revealed that wind speed was negatively correlated with the number of total cases of COVID-19 (new and dead cases) (Rendana 2020). A significant negative correlation between confirmed cases and wind speed was reported when its speed was below 7m/s in 127 countries (Yuan et al. 2021). These results are in line with those of the present research. However, the current study does not support the earlier researches reporting a significant positive association between wind speed and COVID-19 cases (Adekunle et al. 2020; de Paula Correa et al. 2021). One of the main factors to explain the negative correlation between daily confirmed cases and wind speed is that the wind speed has the potential to spread suspended particles in the air, and higher wind speed results in less particle density and contamination (Afiq et al. 2012; Sun et al. 2019). Due to the small size of SARS-COV-2 (50-200 nm), it is transmitted via droplets and aerosols; Therefore, higher and stronger wind speed reduces the concentration of the SARS-COV-2 virus in the air, thus reducing the transmission potential of the virus (Lai et al. 2020).

In this study, daily average humidity was found to be positively but insignificantly related to daily new confirmed cases and daily recovered cases, while it was positively and significantly associated with daily dead cases. These results are in line with those of other studies, which reported no significant association between humidity and COVID-19 (Adekunle et al. 2020; Bashir et al. 2020; Meyer et al. 2020; Tosepu et al. 2020). A significant positive correlation between the number of COVID-19 cases and relative humidity was reported in the US (Chien and Chen 2020), China (Pirouz et al. 2020), and Saudi Arabia (Alkhowailed et al. 2020). Experimental studies showed that viral inactivation could occur due to viral capsids accumulation at the air-water surface, leading to viral cell structural damage (Alkhowailed et al. 2020). However, the studies from China (Qi et al. 2020; Wu and McGoogan 2020) and Spain (Paez et al. 2020) found a significant negative relationship between humidity and COVID-19 incidence. Currently, the COVID-19 pandemic shows a non-stable trend in different areas of the world, and it is expanding rapidly; thus, the effect of meteorological factors, such as temperature, wind speared, and humidity, on COVID-19 is not enough to control it (Leung et al. 2020).

This study had few limitations: firstly, the number of daily confirmed cases was based on the results of PCR test, and also, patients infected by the SARS-COV-2 virus but did not go to health-care centers or hospitals were not reported. Secondly, the effect of important factors, including medical resources and

government interventions, on the COVID-19 mortality were ignored; thus, future studies should focus on their effect. Finally, due to the effect of multiple factors such as medical resources and demographic variations on the spread of the virus, they should be analyzed in future researches. Also, this study data and results related to ambient air and therefore, indoor air needs to future studies for this relation.

Conclusion

This project was undertaken to determine the association between weather elements and the number of COVID-19 cases in Rafsnjan, Iran. It indicated temperature and wind speed to be important factors affecting the COVID-19 infectivity. As the temperature and wind speed increased, the number of COVID-19 cases was decreased. Moreover, no significant association between humidity and COVID-19 incidence was found. Taken together, these results suggested that weather might be an important factor in determining the incidence rate of COVID-19.

Declarations

Ethics approval

This work is the result of a research project (99254) with an ethics code IR.RUMS.REC.1399.264 approved by Rafsanjan University of Medical Sciences.

Consent to participate

Not applicable

Consent for publication

Not applicable

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Competing interests

The authors have no conflicts of interest to declare that are relevant to the content of this article.

Availability of data and material

Not applicable

Authors' contributions

Najmeh Parvaz: Conceptualization, Methodology, Formal analysis and investigation, Writing - original draft preparation, Writing - review and editing, Supervision

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Hadi Eslami: Conceptualization, Methodology, Formal analysis and investigation, Writing - original draft preparation, Writing - review and editing, Supervision

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Figures

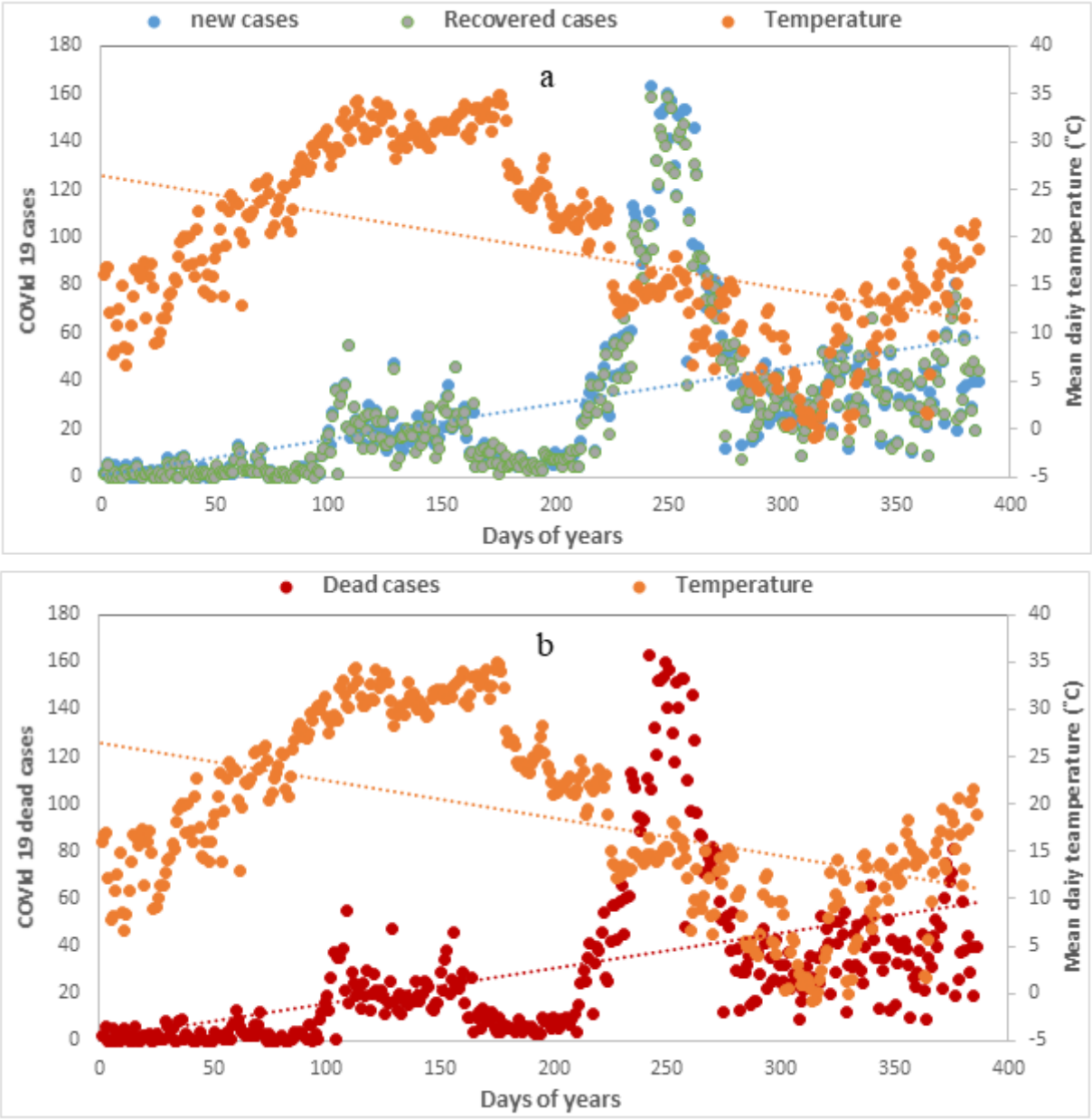

Figure 1

Trend of COVID-19 daily new, recovered (a) and dead cases (b), and temperature changes during the study period

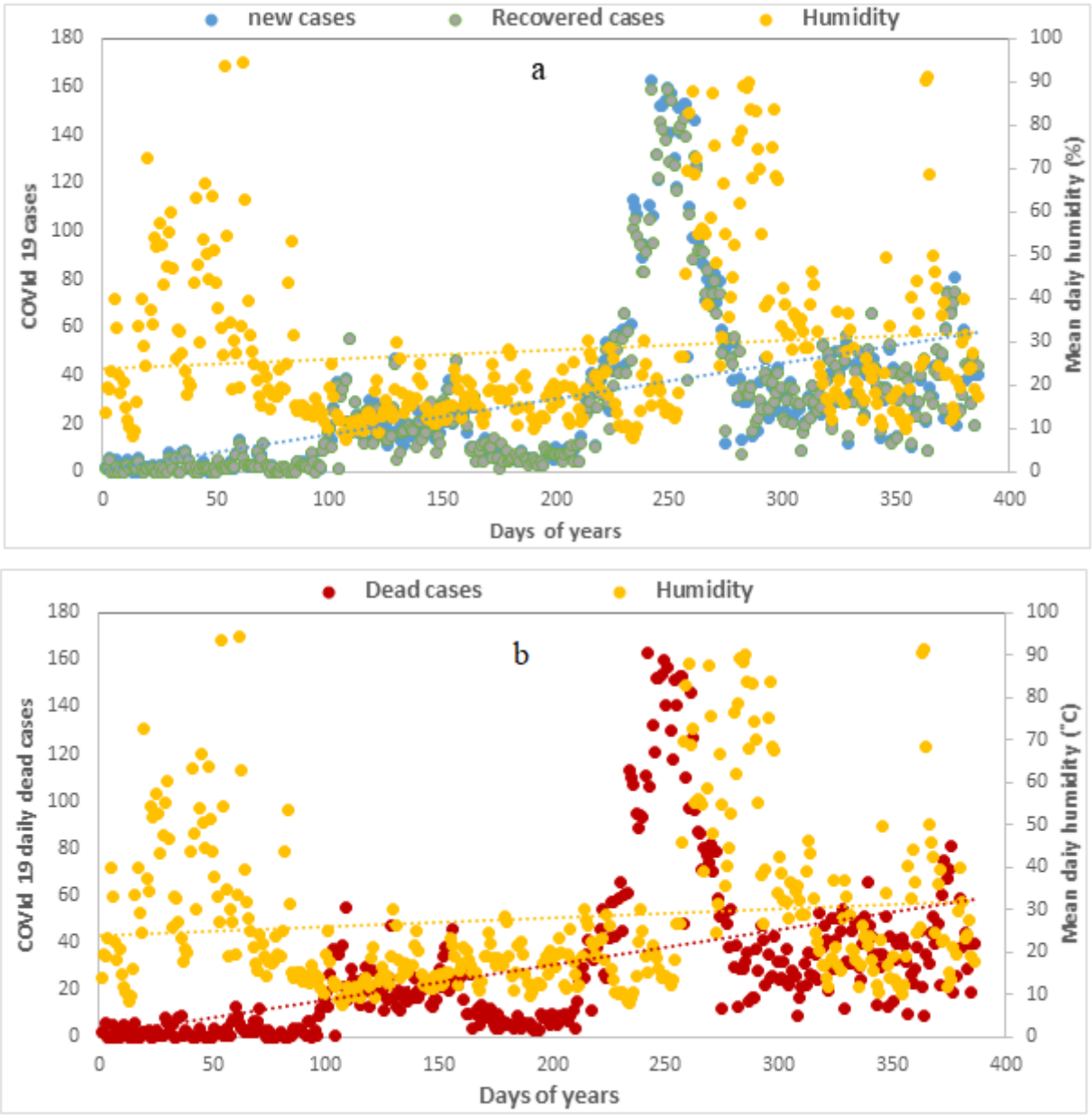

Figure 2

Trend of COVID-19 daily new, recovered (a) and dead cases (b), and humidity changes during the study period

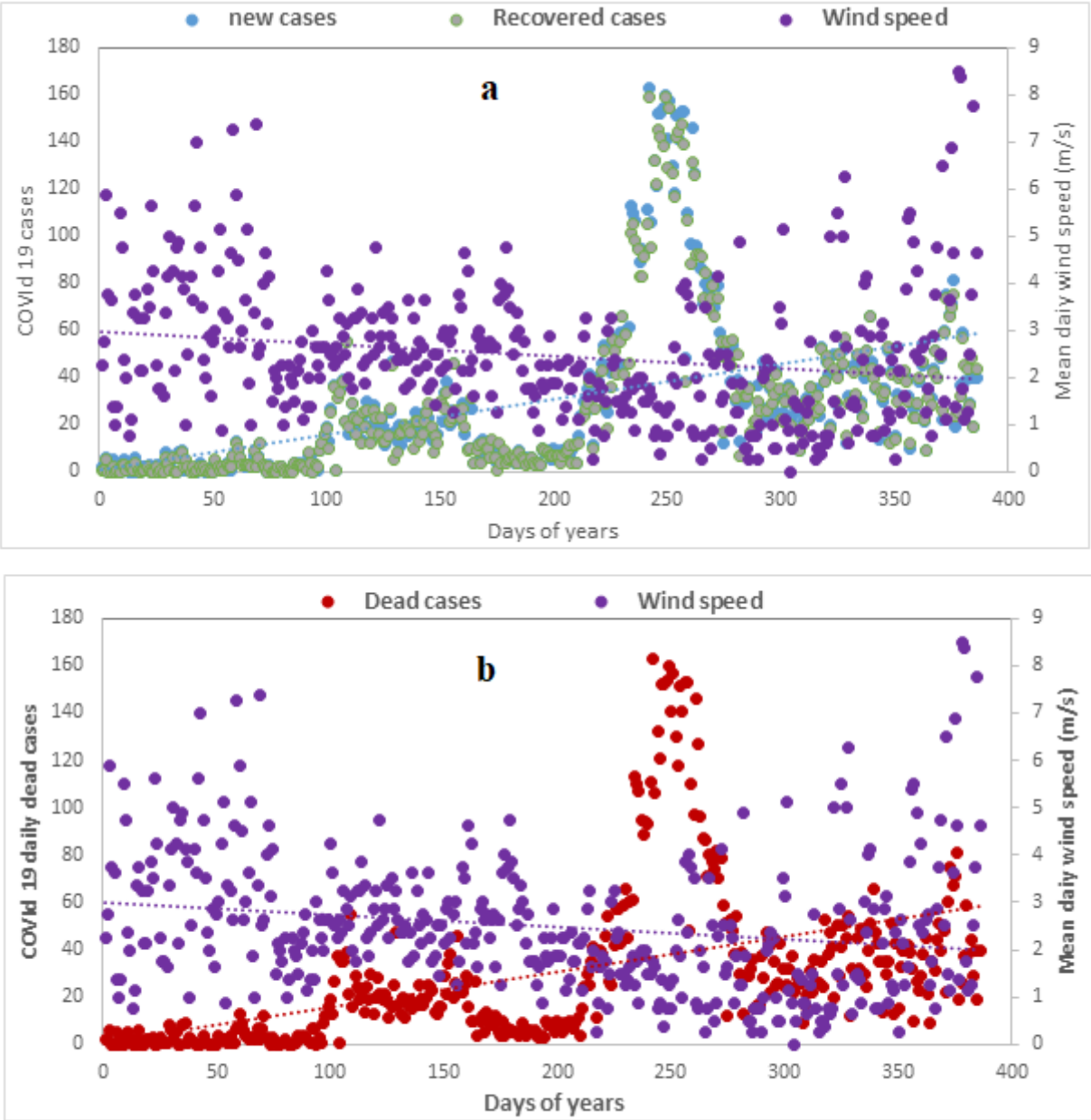

Figure 3

Trend of COVID-19 daily new, recovered (a) and dead cases (b), and wind speed changes during the study period