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Investigating the Relation between Meteorological Parameters and the Number of Patients and Clinical Symptoms of Outpatients with COVID-19: A Case Study in Abarkouh, Iran

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ABSTRACT

Introduction: SARS CoV-2 pandemic has caused illness and death in millions of people worldwide. Extensive studies are being conducted on the effect of meteorological parameters on the number of patients and clinical symptoms of COVID-19.

Materials and Methods: This cross-sectional descriptive study was conducted in Abarkouh city with a population of 51199 people during 215 days (from April 20, 2020 to November 20, 2020). The present study aimed to investigate the effect of meteorological parameters, such as temperature, humidity, sunshine hours, evaporation, and maximum wind speed on the number of cases with definite diagnosis of COVID-19. Moreover, symptoms in the infected patients were assessed using Pearson correlation coefficient and regression coefficient.

Results: During the 215 days of the study, a total of 2526 symptoms were diagnosed in 1298 outpatients. Among which, fever and body aches were the most common symptoms in the subjects. The results of examining the relationship between meteorological parameters and the prevalence of symptoms showed that there was a negative correlation between the minimum and maximum temperature, sunshine hours, evaporation, and wind speed with the number of cases and the prevalence of symptoms. The results of regression coefficient also showed that among the meteorological parameters, the minimum temperature variable had the most negative effect on the prevalence of symptoms as well as the number of cases.

Conclusion: The results showed that changing the meteorological parameters in cold weather can increase both the number of patients and clinical symptoms of outpatients with COVID-19.

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Introduction

In December 2019, a new subtype of coronavirus called SARS-CoV-2 was first identified in Wuhan, China, and then spread around the world. This is the third time that the world has suffered from another coronavirus pandemic after SARS-CoV and MERS-CoV pandemic over the past two decades [1]. SARS-CoV-2 is a positive-sense single-stranded RNA virus with a diameter of 60 to 140 nm [2]. Viral replication mechanism of COVID-19 is slightly more than MERS-CoV and SARS-CoV-1 [3]. COVID-19 can be transmitted from person to person through close contact and its major symptoms (based on clinical laboratory, and radiological features) include fever, dry cough, fatigue, shortness of breath, anorexia, sore throat, nasal congestion, and headache [4]. Various factors, such as weather conditions, air pollution, population density, quality of healthcare services, and quantity of face mask use can affect the prevalence of COVID-19 [5]. Factors, such as temperature and humidity are important seasonal factors changing viral infections [6]. Epidemiological studies have confirmed that climatic conditions are among the factors affecting the life and transmission of coronaviruses [7, 8]. For instance, it has been proven that some climatic parameters, such as temperature and humidity affect the survival of SARS virus [9], so that SARS outbreak in 2003 in Guangdong stopped by increasing temperature [10]. The epidemiological studies of SARS and the flu have shown that cold and dry environments (low absolute humidity) facilitate the survival of viruses, and viruses can spread further through droplets in these environments. However, hot and humid environments (high absolute humidity) reduce the transmission of viruses [11]. Extensive studies have been conducted on the effect of meteorological parameters on the spread of COVID-19 [12- 14]. Lin et al. in their study reported that decreasing relative humidity and increasing temperature, air pressure, and wind speed reduce the spread of COVID-19 [15]. Survival and transmission of the coronavirus generally occur by droplets and is facilitated in dry and cold climates [16]. The results of most studies have confirmed that in hot and humid climates the prevalence of COVID-19 has decreased [14, 17]. However, the World Health Organization (WHO) has stated that more studies are required to predict meteorological models and their impact on public health in terms of the prevalence of COVID-19 [18] and the effect of meteorological parameters on the spread of COVID-19 has not yet been definitively confirmed [19, 20].

Since the emergence of the coronavirus pandemic in the world, the first case of coronavirus in Iran was officially reported on February 19, 2020, and so far (April 22, 2021) 2311813 people have been infected and 67913 people have died (Worldometer).

The present study aims to investigate the relationship between changes in meteorological parameters on the number of cases and also the symptoms of the disease in patients with COVID-19. Moreover, this study investigated the relationship between meteorological parameters with the number of cases and symptoms in patients with definite diagnosis of COVID-19. Meteorological parameters included minimum temperature (˚C), maximum temperature (˚C), minimum humidity (%), maximum humidity (%), sunshine hours (hr), evaporation (mm), and maximum wind speed (m/sec). The symptoms included fever, shortness of breath, cough, sore throat, loss of taste and smell, body aches, fatigue, headache, gastrointestinal symptoms, low oxygen saturation, and asymptomatic cases from April 20, 2020 to November 20, 2020.

Materials and Methods

The present cross-sectional descriptive study was carried out in Abarkouh city with a hot and dry desert climate and population of 51199 people during 215 days (from April 20, 2020 to November 20, 2020). This study aims to investigate the relationship between the number of cases and symptoms and meteorological parameters during the study period. Figure 1 shows the geographical position of the studied region.

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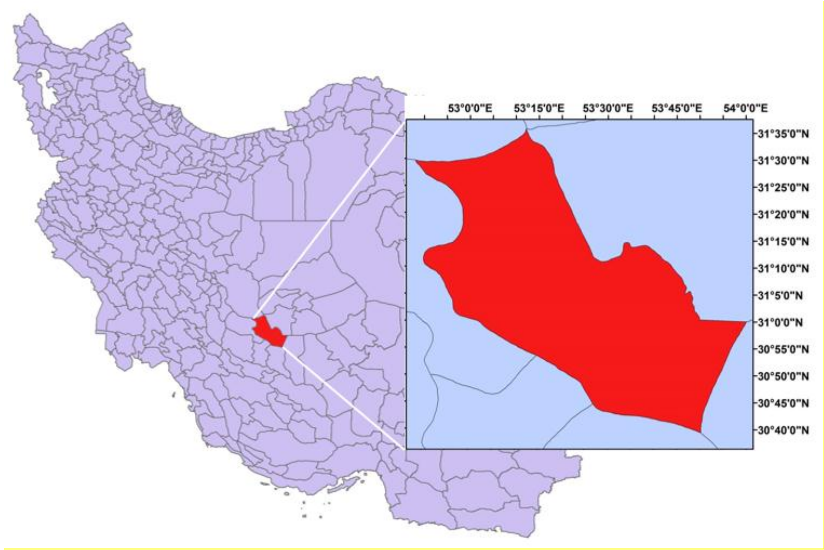

Figure 1: The geographical position of the studied region

In this study, the cases referring to the only clinic (Shahid Motahari) designated for outpatient with COVID-19. The participants included 1298 people with definite diagnosis of COVID-19 by PCR test. Moreover, this study examined symptoms occurred in 1298 outpatients, including fever, shortness of breath, cough, sore throat, loss of smell, loss of taste, body aches, fatigue, headache, gastrointestinal symptoms, low oxygen saturation, and asymptomatic cases. These symptoms were evaluated by the physician at the beginning of the patient's admission to the clinic and were recorded after confirmation. Furthermore, meteorological information were determined during the study period for each day at a meteorological synoptic station located in 31˚07'12"N, 53˚13'48.0"E. After data collection, the relationship between the mentioned variables was analyzed by SPSS 16 software using regression model, and Pearson correlation coefficient.

Ethical issue

The current study was conducted after receiving approval from the ethics committee of Shahid Sadoughi University of Medical Sciences [IR.SSU.SPH.REC.1400.173].

Results

Meteorological parameters

The results of examining meteorological parameters during the 215-day study period showed that the minimum and maximum air temperatures were 1.1 °C and 42.3 °C, respectively. The minimum and maximum humidity during this period were 7% and 100%, the minimum and maximum of sunshine hours were 0 h and 13 h, respectively. The minimum and maximum evaporation during the same period were 0 mm and 22.1 mm, respectively. The minimum and maximum wind speeds during the study period were 4.20 m/s and 30.3 m/s, respectively. Table 1 reveals the information of meteorological parameters during the study period. Figure 2 shows the changes in meteorological parameters and the number of cases during the study period.

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Table 1: Descriptive statistics of the meteorological parameters during the study period (April 20, 2020 to November 20, 2020)

Meteorological parameters	Maximum	Minimum	Mean	Std. Deviation
Maximum temperature (˚C)	42.30	13.10	32.58	6.82
Minimum temperature (˚C)	28.70	1.10	17.31	6.61
Maximum humidity (%)	100.00	10.00	32.35	18.07
Minimum humidity (%)	71.00	7.00	12.06	9.16
Sunshine hours (hr)	13.10	0.00	10.38	2.31
Evaporation (mm)	22.10	0.00	12.09	4.62
Wind speed (m/sec)	30.30	4.20	11.14	4.33

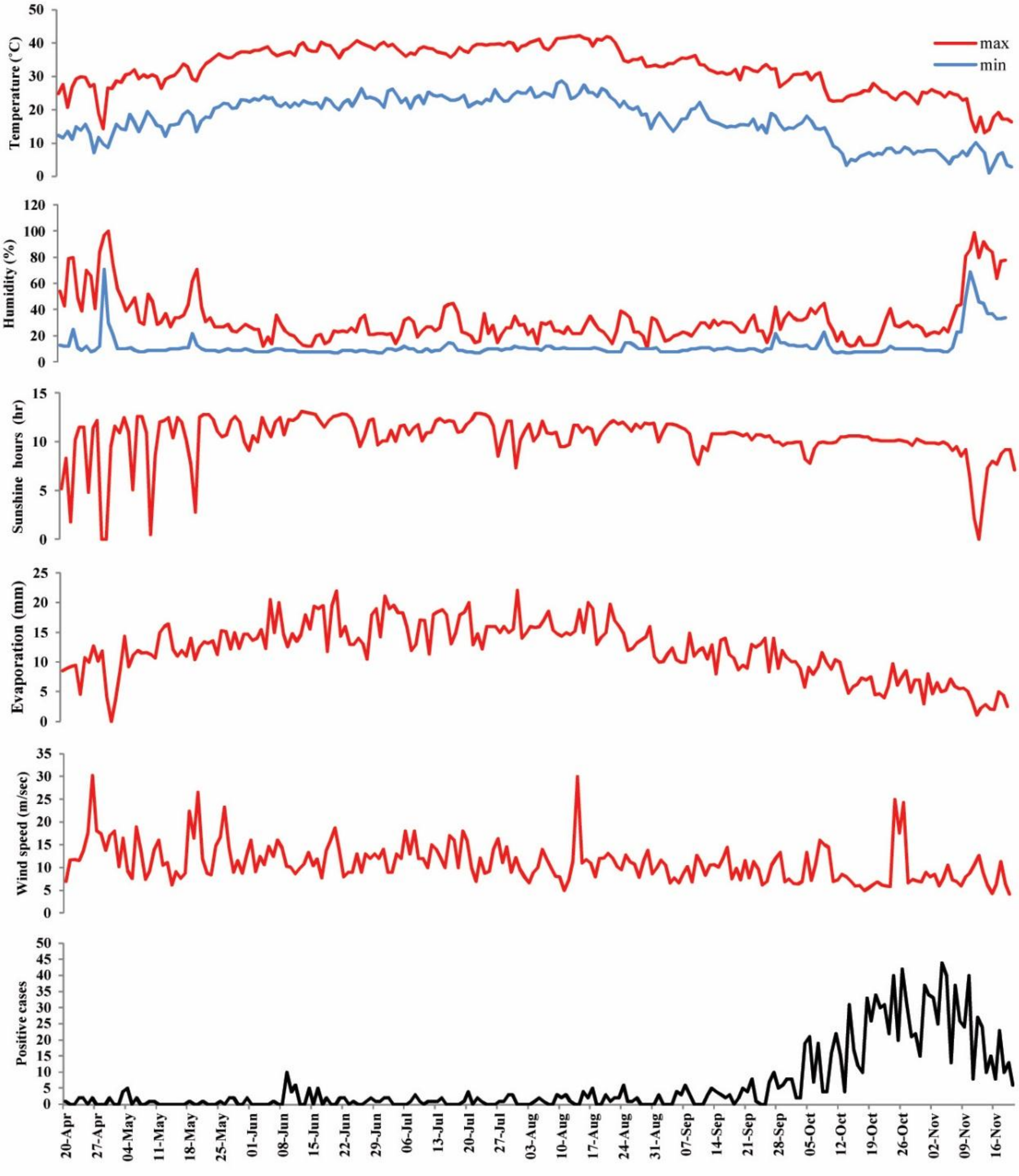

Figure 2: Changes in meteorological parameters and the number of cases during the study period

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Number and symptoms of COVID-19

During the study period (215 days), 1298 outpatients with definite diagnosis of COVID-19 were identified using PCR test. Fever, shortness of breath, cough, throat sore, loss of taste and smell, feeling pain in the body, fatigue, headache, and gastrointestinal disorders were the main symptoms among diagnosed cases. Table 2 reveals the frequency and percentage of symptoms in the study population. According to the findings, the most common symptoms among the patients included body aches and fevers with a frequency of 457 and 447 cases, respectively, and the lowest symptoms included low oxygen saturation with a frequency of 21 cases. Also, 46 patients were asymptomatic. Figure 3 shows the frequency of symptoms in people with COVID-19 during the study period. Based on Figure 3, the prevalence of symptoms increased over time, and the highest prevalence was between September 22 and November 20.

Table 2: Information of symptoms in the patients with COVID-19

Symptoms	Abundance	Percent
Fever	447	17.70
Shortness of breath	112	4.44
Cough	406	16.07
Sore throat	177	7.00
Loss of taste	86	3.40
Loss of smell	224	8.87
Body aches	457	18.09
Fatigue	77	3.05
Headache	398	15.76
Gastrointestinal symptoms	121	4.79
Low oxygen saturation	21	0.83
Sum	2526	100
Asymptomatic	46	1.82

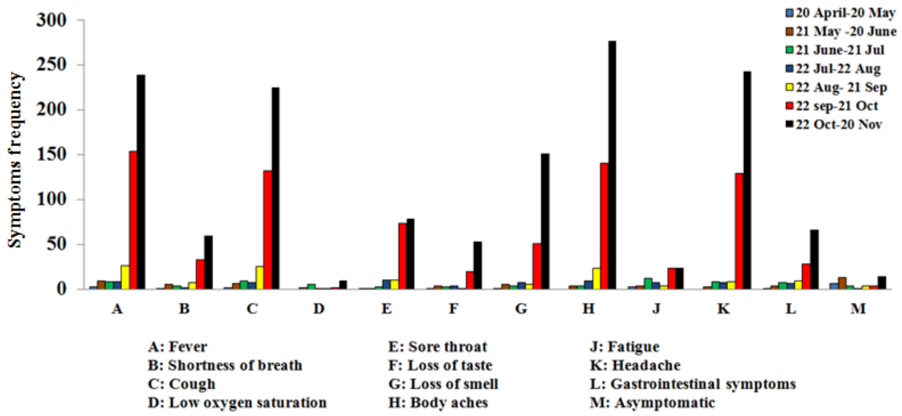

Figure 3: Frequency of symptoms in the patients with COVID-19 during the study period

The relationship between meteorological parameters and the number and symptoms of the patients with COVID-19

The correlation between meteorological parameters and the number of cases and symptoms in people was examined by Pearson formula. Table 3 shows the degree of correlation and significance level. The relationship and dependency of each meteorological parameter with the number of cases and symptoms in the patients with COVID- 19 was examined as follows.

Table 3: Correlation coefficient and significance level between meteorological parameters and the number and symptoms of COVID-19

Symptoms	Maximum temperature		Minimum temperature		Maximum humidity		Minimum humidity		Sunshine hours		Evaporation		Wind speed	
	*r	**p	r	p	r	p	r	p	r	p	r	p	r	p
Positive cases	- 0.575	< 0.001	- 0.676	< 0.001	0.022	0.753	0.168	0.013	- 0.231	0.001	- 0.608	< 0.001	- 0.268	< 0.001
Fever	- 0.510	< 0.001	- 0.606	< 0.001	- 0.053	0.438	0.093	0.174	- 0.202	0.003	- 0.540	< 0.001	- 0.271	< 0.001
Shortness of breath	- 0.493	< 0.001	- 0.542	< 0.001	0.124	0.069	0.298	< 0.001	- 0.281	< 0.001	- 0.523	< 0.001	- 0.208	0.002
Cough	- 0.543	< 0.001	- 0.639	< 0.001	0.004	0.952	0.128	0.062	- 0.182	0.007	- 0.575	< 0.001	- 0.271	< 0.001
Sore throat	- 0.431	< 0.001	- 0.546	< 0.001	- 0.068	0.320	0.045	0.508	- 0.128	0.060	- 0.445	< 0.001	- 0.227	0.001
Loss of taste	- 0.388	< 0.001	- 0.515	< 0.001	- 0.033	0.631	0.055	0.422	- 0.127	0.062	- 0.458	< 0.001	- 0.281	< 0.001
Loss of smell	- 0.502	< 0.001	- 0.574	< 0.001	0.015	0.831	0.126	0.064	- 0.151	0.027	- 0.505	< 0.001	- 0.223	0.001
body aches	- 0.541	< 0.001	- 0.626	< 0.001	0.012	0.863	0.149	0.029	- 0.219	0.001	- 0.578	< 0.001	- 0.249	< 0.001
Fatigue	- 0.158	0.020	- 0.246	< 0.001	- 0.108	0.114	- 0.072	0.293	- 0.002	0.975	- 0.217	0.001	- 0.139	0.042
Headache	- 0.536	< 0.001	- 0.649	< 0.001	- 0.018	0.795	0.120	0.078	- 0.191	0.005	- 0.571	< 0.001	- 0.256	< 0.001
Gastrointestinal symptoms	- 0.373	< 0.001	- 0.455	< 0.001	0.022	0.753	0.113	0.100	- 0.135	0.048	- 0.417	< 0.001	- 0.148	0.030
Low oxygen saturation	- 0.106	0.120	- 0.126	0.064	0.000	0.996	0.091	0.185	- 0.049	0.478	- 0.076	0.267	- 0.121	0.076
Asymptomatic	- 0.112	0.101	- 0.126	0.065	0.071	0.300	0.105	0.125	- 0.034	0.622	- 0.081	0.234	- 0.028	0.685

* Pearson correlation,** Significance

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Discussion

Temperature

Pearson correlation coefficient between the maximum temperature variable and the number of patients with COVID-19 and the number of patients with fever, shortness of breath, cough, and sore throat, loss of taste, loss of smell, body aches, fatigue, headache, and gastrointestinal symptoms was significant. The correlation coefficient between these variables was negative, indicating the inverse relationship between these variables. In other words, the higher the temperature increases/decreases, the more these variables decrease/increase. Pearson correlation coefficient between the maximum temperature variable and the variables of the number asymptomatic cases and patients with low oxygen saturation was not significant. The findings of the present study showed that increasing the temperature reduces the number of cases and also causes major symptoms.

Both laboratory and epidemiological studies have confirmed that ambient temperature is a critical factor in the transmission and survival of coronaviruses, such as MERS-CoV and SARS-CoV-1 [7, 16]. The results of a study showed that temperature has a negative linear relationship with the number of positive cases of COVID-19 [21].

The results of Pearson correlation coefficient showed that there was a significant negative correlation between the minimum temperature variable with the variables of the number of patients with COVID-19 and the number of patients with symptoms of fever, shortness of breath, cough, sore throat, loss of taste, loss of smell, body aches, fatigue, headache, and gastrointestinal symptoms. However, no significant correlation was observed between the minimum temperature variable and the variables of the number of patients with asymptomatic cases and the patients with low oxygen saturation.

Furthermore, the results obtained from the regression model of the effect of the minimum temperature component on the number of patients with COVID- 19, showed that the minimum temperature had the most effect on the number of patients with symptoms of shortness of breath (with regression coefficient of -0.61), sore throat (-0.66), loss of taste (-0.82), fatigue (-0.34), headache (-0.64), gastrointestinal (-0.55), and low oxygen saturation (-0.32). It also has the greatest effect on increasing the number of cases with COVID-19 with a regression coefficient of -0.623.

The data from China and South Korea also confirmed that there is a non-linear relationship between air temperature and the number of cases [19], so that at temperatures below 3 °C, its prevalence increases by 4.86% (95% CI = 3.21–6.51). Hoang et al., in their study, set this temperature at 8 °C and showed that when the temperature drops below 8 °C, the prevalence of COVID-19 increases by 19.9% [22]. In another study, the temperature threshold was set at 20 °C, so that when the temperature drops below 20 °C, the number of cases increases significantly [23]. Increased virus transmission by decreasing temperature is probably due to the fact that low temperatures can increase the survival of the virus, as well as the negative effect of low temperatures on the immune system [24]. According to a study conducted on 31 Mexican states, temperature has a significant negative relationship with the prevalence of COVID-19 [12]. Other studies have also reported an inverse association of temperature with the spread of COVID-19 in Barcelona [25], China [26], Iran [27, 28], Turkey [14], and Indonesia [29].

Humidity

The results of Pearson correlation coefficient indicated that there was no significant correlation (p- values greater than 0.05) between the maximum relative humidity variable with the number of patients with COVID-19 and the number of patients with symptoms of fever, shortness of breath, cough, sore throat, loss of taste, loss of smell, body aches, fatigue, headache, gastrointestinal symptoms, low oxygen saturation, and the number of asymptomatic cases.

The results obtained from the regression model of the effect of maximum humidity component on patients with COVID-19, showed that maximum humidity had the most effect on increasing the number of patients with symptoms of fever (with regression coefficient of - 0.59), cough (- 0.49), loss of smell (- 0.47), and body aches (- 0.53).

Previous studies have confirmed an increase in the number of cases by decreasing humidity [30]. Reducing the relative humidity by affecting the survival of the aerosol increases the transmission and also reduces the ability of airways to remove virus particles. The results of previous studies showed that when the relative humidity is less than 70%, it has a significant negative relationship with the spread of COVID-19. However, this relationship was not confirmed at humidity levels above 70% (24). In a study, a nonlinear relationship was observed between relative humidity and precipitation with the number of cases [21]. Shantanu et al. reported that humidity had no significant but positive correlation with the number of positive cases [31]. However, in other studies in Germany [32], the United States [30], and China [33], a significant negative relationship was reported. Studies have also shown that absolute humidity has a stronger relationship than relative humidity with the spread of COVID-19 [33, 34].

A positive and significant Pearson correlation coefficient was observed between the minimum relative humidity variable with the number of patients with COVID-19 and the number of patients with symptoms of shortness of breath and body aches. In other words, by increasing/ decreasing the minimum relative humidity, these variables increase/decrease. Pearson correlation coefficient was not significant between the minimum relative humidity variable with the number of patients with symptoms of fever, cough, sore throat, loss of taste, loss of smell, fatigue, gastrointestinal symptoms, low oxygen saturation, and the number of asymptomatic cases.

The results obtained from the regression model of the effect of the minimum humidity component on the patients with COVID-19, showed that the minimum humidity has the least effect on patients with symptoms of loss of taste with a regression coefficient of 0.07.

Sunshine hours

Pearson correlation coefficient was negative and significant between the sunshine hour's variable with the number of patients with COVID- 19 and the number of patients with fever, shortness of breath, cough, and loss of smell, body aches, headache, and gastrointestinal symptoms. However, no significant correlation was observed between the sunshine hour's variable and the number of asymptomatic cases and the number of patients with sore throat, loss of taste, fatigue, and low oxygen level.

The results obtained from the regression model of the effect of the sunshine hours variable on the patients with COVID-19, showed that the sunshine hours variable has the least effect on the number of patients with symptoms of loss of smell (with regression coefficient of 0.02) and low oxygen level (- 0.05).

Studies have shown that increasing sunshine hours inactivates MERS- CoV faster and reduces its spread [35]. Similar results have been also observed in the study by Gupta et al. [36].

Evaporation

A negative and significant Pearson correlation coefficient was observed between the evaporation variable with the variables of the number of patients with COVID-19 and the patients with symptoms of fever, shortness of breath, cough, sore throat, loss of taste, loss of smell, body aches, fatigue, headache, and gastrointestinal symptoms. However, the Pearson correlation coefficient was not significant between the evaporation variable and the variables of the number of asymptomatic cases and the patients with low oxygen saturation.

Wind speed

There was a negative and significant Pearson correlation coefficient (p-value less than 0.05) between the maximum wind speed variable with the variables of the number of patients with COVID-19 and the number of patients with fever, shortness of breath, cough, sore throat, loss of taste, loss of smell, body aches, fatigue, headache, and gastrointestinal symptoms. However, no significant Pearson correlation coefficient was observed between the maximum wind speed variable and the variables of the number of asymptomatic cases and the number of patients with low oxygen saturation.

The results obtained from the regression model showed that the maximum wind speed had the least effect on the number of patients with symptoms of fever (with regression coefficient of -0.007), shortness of breath (-0.002), cough (- 0.006), sore throat (0.014), body (0.013), fatigue (-0.019), headache (0.02), and gastrointestinal symptoms (0.04). Moreover, the maximum wind speed had the least effect on increasing the number of cases with COVID-19 with regression coefficient of -.009.

Wind is one of the important factors in the spread of viral infections [37]. Previous studies have shown that wind speed has a significant inverse relationship with the spread of COVID-19 [38]. In a study, the wind speed threshold of 7 m/sec was set, so that if the wind speed increases from this value, the number of cases decreases significantly [23]. Morawska et al. also reported that the mean wind speed and air pressure affect the spread of COVID-19, so that higher wind speeds cause shorter suspension of droplet in outdoor air and better indoor ventilation and reduce the spread of COVID-19 [39]. A significant negative relationship has been reported between wind speed and disease spread in other studies in Iran [27].

Conclusion

This study investigated the relationship between the number of cases with the disease and symptoms in outpatients with meteorological parameters based on statistical relationships. The results of this study showed that the variables of maximum temperature, minimum temperature, sunshine hours, evaporation, and wind speed had a significant negative relationship with the number of cases. Among the meteorological parameters, maximum and minimum humidity had the least significant relationship with symptoms in cases with COVID-19. None of the studied parameters had a significant relationship with low oxygen saturation in patients with COVID-19. No significant relationship was observed between asymptomatic cases and meteorological parameters. Maximum and minimum temperature, evaporation, and wind speed were significantly associated with all symptoms except low oxygen saturation. Among the studied meteorological parameters, the minimum temperature had the most effect on the number of patients and the prevalence of symptoms, including shortness of breath, sore throat, loss of taste, fatigue, headache, gastrointestinal symptoms, and low oxygen saturation. Although the maximum humidity was not significantly associated with the studied symptoms, the results of regression coefficient showed that it had the greatest effect on the symptoms of fever, cough, loss of smell, and body aches. Wind speed had a significant relationship with all symptoms except low oxygen saturation. However, it had the least effect on the symptoms of fever, shortness of breath, cough, sore throat, body aches, fatigue, headache, gastrointestinal symptoms, and the number of patients with COVID-19. According to the findings of this study, the prevalence of symptoms increases in cold weather. This study showed that increasing temperature, sunshine hours, evaporation, and wind speed reduce the number of cases and symptoms.

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Conflict of interest

The authors declare that there is no conflict of interest regarding the publication of this article.

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