The Association between Weather Conditions (Ambient Air Temperature and Relative Humidity) with Coronavirus Disease (COVID-19) Risk in Bandar Abbas, Iran

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Research Article

Keywords: SARS-CoV-2, Weather, COVID-19, Temperature, Humidity

Posted Date: September 7th, 2021

DOI: <https://doi.org/10.21203/rs.3.rs-864631/v1>

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Abstract

Background: This study was devoted to evaluate the association between COVID-19 infection and weather conditions in Bandar Abbas, Iran.

Methods: The positive cases data was retrieved from the Ministry of Health and Medical Education of Iran (MOHME) and weather conditions from the Iran meteorological organization (IMO) from the 01, October 2020 to 27, November 2020. The components of weather consist of average of the ambient air temperature (°C) and relative humidity (%). The Spearman correlation test was used to determine the association between weather conditions (temperature and relative humidity) with COVID-19 infection.

Results: Spearman analysis showed that air temperature (Coefficient = -0.303 and P-value = 0.001) were negatively associated with COVID-19 infection. However, no significant association was observed between relative humidity (Coefficient = 0.088 and P-value = 0.340) and COVID-19 infection. Hence, the ambient air temperature can be considered as a considerable variable in the COVID-19 infection in Bandar Abbas.

Conclusions: The results of this study can be used for prevention and control of COVID-19 infection in areas with similar meteorological conditions in world.

1. Background

The severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) was observed in Wuhan, China on 31 December 2019 [1–3]. The 2019 novel coronavirus disease (COVID-19) declared as a pandemic by World Health Organization (WHO) on March 11, 2020 [4, 5]. As of 1 May, 2020, more than 3,292,489 positive cases and about 233,144 death cases have been reported [6].

The studies shows that COVID-19 can be less risk than severe acute respiratory syndrome (SARS) and middle east respiratory syndrome (MERS) [1, 2]. However, COVID-19 is more contagious than both SARS and MERS [5, 7].

The clinical symptoms of COVID-19 consist of coughing, shortness of breath, and fever [8]. The period from the onset of COVID-19 signs and symptoms to the outcome (death or recovery) can be from 6 to 41 days with an average of 14 days [9, 10]. This period is dependent on the immune system and age of the patients [10]. In severe cases of the disease, COVID-19 infection can cause kidney failure, pneumonia, and even death [11]. The clinical signs of severe cases are like to the symptoms of MERS and SARS [12].

The first confirmed cases of COVID-19 were observed in Qom on 19 February, 2020 [13]. Then COVID-19 infection spread other areas of Iran consists of Tehran, Markazi, Isfahan, and Semnan [14]. In Hormozgan province, the first confirmed case of COVID-19 was observed in Qeshm on February 23, 2020 and following other confirmed cases were observed in the other areas of the Hormozgan province.

The long-term climate change could affect the emission of the Nile virus in Europe and US [15]. Also, the weather conditions can be one of the main effective variables on respiratory diseases such as MERS and SARS [16]. Optimal wind speed, relative humidity, and air temperature are weather components that can affect the survival of the SARS-Coronavirus [17, 18].

Although several studies have shown the association between weather conditions and respiratory disease [15–17, 19, 20] but due to the uncertain behavior of SARS-CoV-2[21], more research is needed. The aim of this study was to evaluate the association between COVID-19 infection and weather conditions (air temperature and relative humidity) in Bandar Abbas, Iran.

2. Material And Method

2.1. Study area

The coastal city of Bandar Abbas is the capital of Hormozgan province in the south of Iran with geographical coordinates of 27°.1837 N latitude and 56°.2774 E longitude [22]. The area of Bandar Abbas city consists of 45 Km² with the height of 10 m above open sea [23]. The population of this city was 526,648 inhabitants based on the latest population census in 2017 [24]. In addition, the average air temperature of Bandar Abbas city is 26.9°C with 64.8% relative humidity and 182.1 mm/year precipitation [25].

2.2. Data collection

COVID-19 infection was diagnosed based on the World Health Organization (WHO) protocols [26] using RT-PCR assay of pharyngeal swab and nasal samples [5, 27]. Collected samples were transferred to the COVID-19 laboratory in the Ministry of Health and Medical Education (MOHME) in Tehran. The results of COVID-19 diagnostic tests were transmitted to HUMS center through an integrated health information system (IHIS, <http://bi.hums.ac.ir/reports/powerbi/MCMC>), continuously. The number of positive cases per day was recorded from 01, October 2020 to 27, November 2020. In addition, the weather data were retrieved from 01, October 2020 to 27, November 2020 from the meteorological organization in Bandar Abbas. The weather data consist of average of air temperature (°C) and relative humidity (%) [28].

2.3. Data analysis

Kolmogorov–Smirnov test shows that data were not normal distribution. As distribution of our data was not normal, therefore spearman correlation analysis was used to determine the association between daily positive cases of COVID-19 and the weather conditions. Statistical analysis was conducted using IBM SPSS software version 20.0 (Chicago, IL, USA). The P-value < 0.05 was considered as statistical significant.

3. Results And Discussion

This study investigated the association between weather conditions including air temperature, and relative humidity with the confirmed cases of COVID-19 infection (Table 1s). The trend of changes in the positive cases of COVID-19 infections, ambient air temperature and relative humidity was presented in Fig. 1. Two major peaks of COVID-19 cases were observed in 15th October (n = 22 cases) and 8th November (n = 20 cases). The overall trend of confirmed cases is increasing over study period. However as expected small fluctuations can be observed. In case of Temperature, the overall trend is decreasing from the peak at 37.3°C (5th August) to the lowest values around 21.2°C (25th November). In case of RH, some large fluctuations were detected, namely in 30th August – 5th September, 9th September – 26th September, and 10th October – 1st November. The total number of positive cases COVID-19 infection was 1041 in Bandar Abbas during the study period. In addition, the averages of air temperature, and relative humidity were $30.04 \pm 4.34^{\circ}\text{C}$ and $53.18 \pm 17.93\%$, respectively (Table 1). These results show that Bandar Abbas has a warm and humid climate.

Table 1
Spearman coefficients between positive cases of Covid-19 infection with weather variables.

Weather variables	Mean $\pm$ SD	Coefficient	P value
Ambient air temperature ($^{\circ}\text{C}$)	30.04 ± 4.34	-0.303	0.001
Relative humidity (%)	53.18 ± 17.93	0.088	0.340

The Spearman correlation analysis shows that there was a significant association between the daily number of confirmed cases of COVID-19 and ambient air temperature (Coefficient = -0.303 and P-value = 0.001) (Table 1 **and** Fig. 2A). In case of relative humidity, no significant correlation with daily number of COVID-19 cases was observed (Coefficient = 0.088 and P-value = 0.340) (Table 1 **and** Fig. 2B). These results show that ambient air temperature can negatively affect the spread of COVID-19, i.e. with increasing air temperature, a decrease in number of COVID-19 cases could be expected. While, increasing relative humidity can increase the daily confirmed cases of the disease.

Our findings are consistent with some other studies. In a study conducted on 31 provincial-level regions in China, using a distributed lag non-linear model (DLNM), the authors found that although higher temperatures directly affected the number of COVID-19 cases in some regions, the association in most of the areas and also in the whole country was negative, indicating a reduction in positive cases of COVID-19 after the incidence of high temperatures (RR: 0.96, 95% CI: 0.93–0.99). In the same study, a significant negative association was found between temperature and relative risk of COVID-19 infection in mainland China (Coefficient = - 0.0100, 95% CI: -0.0125, - 0.0074) [29]. In another study on 11 cities of China, temperature and humidity negatively associated with the transmissibility of COVID-19 (P-value < 0.001) [30]. In a study of 430 cities around the world for 52 days, a meteorological model was able to predict the global outbreak with a high association ($R^2 > 0.6$) [31]. Despite our study, a study in Indonesia showed that the average air temperature has a positive significant association with the daily positive cases of COVID-19, indicating an increase in the number of positive cases with the increase in temperature. The

association was also positive for other weather variables including minimum and maximum temperature, relative humidity, and rainfall [32]. In a study of Wuhan, the mortality of COVID-19 was associated with temperature positively ($R = 0.44$) and with relative humidity negatively ($R = -0.32$) [33].

The contradiction between the results of studies may be due to the range of temperature and RH observed in each place. An analysis of 122 Chinese cities shows that the association between COVID-19 and ambient air temperature was approximately linear in the range of $< 3^{\circ}\text{C}$. When ambient air was less than 3°C , each 1°C rise temperature was associated with a 4.86% (95% CI: 3.21–6.51) increase in positive cases of COVID-19 [18]. In another study, the spread of the virus showed a strong association within the $4\text{--}12^{\circ}\text{C}$ mean daily air temperature [34]. Shi et al. (2020) considering 31 provincial-level regions in China reported that the association between daily cases of COVID-19 and air temperature is biphasic (with a peak at 10°C). For temperatures higher than 10°C , a decrease in the number of positive cases was observed; while, with increasing temperature up to 10°C , positive cases increased [29].

There are many other factors that can potentially affect the spread of COVID-19 infection, and interfere with the effect of weather [32]. This is probably why the results of relevant studies contradict. First, the mobility of the population i.e. entry and exit into the city can change the daily number of positive cases. Second, the change in individual health parameters consist of use of hand sanitizers and hand washing habits due to education could alter the trends. Third, there are other weather variables such as visibility and atmospheric variables such as ultra-violet (UV) radiation that are included in other studies [31, 34], but these data were not accessible. And last but not the least, socio-economic development, urbanization, population immunity, and level can all be other affecting factors [35].

To draw a conclusion whether meteorological parameters such as temperature and humidity can affect the spread of SARS-CoV-2, more comprehensive studies with longer study periods and broader study areas are required. Since the SARS-CoV-2 is novel, current evidence stands only on data recorded during a few months and from some limited areas. Therefore, the results of this study and similar ones should be used conservatively. In addition, the association between weather conditions and the number of positive cases of COVID-19 could be non-linear. Therefore, investigating a limited range of temperatures and also other variables could lead to different results.

Conclusions

In this study, the association between COVID-19 infection and weather (temperature and humidity) was investigated in Bandar Abbas, Iran. Air temperature, but not relative humidity, was significantly associated with daily number of COVID-19 confirmed cases. Therefore, weather conditions can be considered as an important variable in COVID-19 spread in Bandar Abbas and areas with similar meteorological conditions. Findings of this study can be used for the prevention and control of COVID-19 infection in the world.

Declarations

Ethics approval

Ethical approval was approved from the Hormozgan University of medical sciences Ethics Committee (IR.HUMS.REC.1398.471).

Consent to participate

Not applicable.

Consent to Publish

Not applicable.

Authors Contributions

Study design was conducted by Yadolah Fakhri and Ali Mouseli; Analysis of data by Mostafa Hadei and Ali Rostami;; Prepare manuscript by Yadolah Fakhri, Mostafa Hadei and Ali Mouseli.

Acknowledgements

The Authors extend their thanks to Infectious and Tropical Diseases Research Center, Hormozgan Health Institute, Hormozgan University of Medical Sciences for the financial grants of this study (IR.HUMS.REC.1398.471).

Funding

Infectious and Tropical Diseases Research Center, Hormozgan Health Institute, Hormozgan University of Medical Sciences for the financial grants of this study (IR.HUMS.REC.1398.471).

Availability of data and materials

Data openly available in a public repository

Conflict of interest

The authors declare that there is no conflict of interests.

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Figures

Figure 1

The positive cases of Covid-19 infection, air temperature (°C), and relative humidity (%) between 01, October 2020 to 27, November 2020.

Figure 2

Association between positive case of SARS-CO-2 with ambient air temperature (A) and relative humidity

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