A Study of The Potential Relationship between COVID-19 (Corona Virus) Daily Outbreak and Temperature Changes in Iran During March 2020

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ABSTRACT
Climate is one of the most important structural factors on planet Earth and it is undoubtedly natural and all manifestations are at a wide range of levels. To recognize, control and adapt it, scientists have tried to improve life and well-being under various climatic conditions. Decreasing ambient temperatures can be common or annihilated by various diseases. The aim of this study is to investigate the possible relationship between covid-19 (Corona virus) disease and temperature fluctuations in Iran during March 2020. This is, of course, a preliminary study, and further research may explore other aspects of the subject.

The methodology applied was the chi-square statistic to evaluate the test of independence between the studied variables and linear regression analysis to find the possibility of the influence of temperature as an independent climatic factor in the increase or decrease of the number of patients. In case of failure of linear regression analysis, the quadratic fit estimation was used.

Results of this study proved the slight significant correlation between the occurrence of Corona and the temperature changes in the study area during March 2020. Although the temperature element is considered to be an influential climatic factor in Corona-like diseases such as influenza or SARS, this study could not profoundly prove such a relationship. The prevalence of Corona in Iran can be affected by several other factors such as deficiency of medical equipment, the behavior of the Iranian people towards the epidemic and the spread of this virus, socio-political and cultural gatherings.

Keywords: Corona Virus, Climate, Temperature, Chi Square Test, Quadratic Fit Estimation, Iran

INTRODUCTION
Fever, cold, sneezes and coughs play major role in the Corona disease. The common cold is of course, a separate disease from Corona. As winter is mostly cold and flu season, one can only hope that in the spring and summer the Corona epidemic will be slightly reduced. The problem is not just where the Corona is most likely to breed and spread. It is also important to note that in which season its peak would occur. At present, the most vital solution to Corona is probably home quarantine. For example, it is assumed that colder air causes more Corona emissions, but if people home quarantine themselves and make less appearance in the public environment, then such weather may reduce the number of infected people. Another example is that in the tropics, the flu season is increasing. Not because of the change in the climate component of humidity, but because people in the area gather in cafes when it rains. In southern Iran, people stay at home in the heat, but many use water cooler that provides a suitable environment for the Corona propagation due to cold humidity. Consequently with the assumption that there is the possibility of a kind of linkage between Corona cases and seasonal temperature, we established this research basis. We addressed the important question of: *Can Corona be a seasonal phenomenon?* However, it is not certain that when Corona is coming and when it is going. In the meantime, there are some points that can be hoped that Corona will be a winter phenomenon and that as the weather warms it will cease its epidemic and spread. Scientists claim that heat and sun are basically the enemies of Corona [1]. The type of SARS that was born in 2002 was also related to the Corona family because a great deal of SARS DNA resembles Corona. Incidentally, both came from China. SARS also came in early winter and peaked in April. At that time with the warmer weather subsiding, and in August, almost no new cases of SARS were reported. Can Corona keep up with the warmer weather like SARS? Of course there is no scientific certainty yet.

Corona seems to be a cold item. The optimum temperature for it is 4°C. It turns off at 37 degrees but lasts up to three days. It perishes at 70 degrees after 15 minutes. At 60 degrees Celsius it can survive for many years (it means any Corona virus that now gets trapped in a freezing cold glacier can re-emerge years later and infect others [2]. Experts are not completely sure how this virus will behave when the weather gets even warmer [3]. Limited number of studies have been carried out to investigate the relationship between Middle East respiratory syndrome Corona virus (MERS-CoV), severe acute respiratory syndrome (SARS), severe acute respiratory syndrome Corona virus 2 (SARS-CoV-2) and climate factors.

Tan *et al.* realized the relationship between the outbreak of SARS and the temperature of the environment and the basis was given for control measures and prevention against this disease in the Hong Kong, Guangzhou, Beijing, and Taiyuan [4]. In studies of similar type, Cai *et al*. investigated the relationship between the SARS outbreak and meteorological variables and the air pollution [5], and Bi *et al.* assessed the impact of weather on SARS in Beijing and Hong Kong [6]. Another research by Alghamdi *et al.* explained the epidemiology of Middle East respiratory syndrome Corona virus (MERS-CoV) in Saudi Arabia while taking into account the humidity and temperature of the infected regions [7]. Lin *et al.* attempted to classify factors that contribute towards the incidence, prevention and removal of SARS in Hong Kong. The possible impacts of weather, time and interaction effect of hospital infection were estimated [8].

Recently some more studies have been carried out in this context. A study by Altamimi *et al.* aimed to estimate the monthly occurrence of MERS-CoV cases and analyzed their association with the climate factors. Their findings manifested that the MERS-CoV is affected by climatic conditions between April and August, with rising incidence. High ultraviolet index, low wind velocity, high temperature and low relative humidity contributed to maximum cases [9]. Gardner *et al.* reported a link between climate factors and virus presence in primary MERS-CoV cases. According to their findings, primary human MERS cases more likely appeared in Saudi Arabia when the conditions were fairly cold and dry [10]. Sajadi *et al.* reported that most of the infectious diseases exhibit seasonal trends in their occurrence, including human Corona viruses. MERS-CoV and SARS being Beta-Corona viruses are not known to be seasonal. According to this study, weather modeling can help in the prediction of areas at higher risk of major COVID-19 community spread [11]. Araujo *et al.* developed a wide range of ecological niche models which predicted monthly alterations in the climate suitability for SARS-CoV-2 Corona virus over a typical climate year. Their findings showed that a degree of climate determination with Corona virus presenting preference for dry and cold environments is indicated by the current spread. Their predictions reduced uncertainty about SARS-CoV-2 spread [12]. In this context, another study was conducted by Xie and Zhu which aimed to know whether the temperature is an important variable in the infection resulted by the novel Corona virus. The results indicated that there was a positive linear relationship between the number of COVID-19 cases and mean temperature with 3^{o}C threshold. It was concluded that there was no proof which support that case counts of the disease could decrease when the weather gets warmer [13]. A study by Bashir *et al.* examined the climate factors and COVID-19 relation in New York City, USA. They found that there was a notable association between COVID-19 pandemic and average temperature and minimum temperature and air quality. Their study also discussed that there was scientifically no confirmation of COVID-19 that warm weather would suppress its spread [14]. Sahin found the relationship between weather and Corona virus disease in nine cities of Turkey. The significant relationships were noticed between Corona virus disease and population, wind speed 14 days earlier, and temperature on the day, respectively [15]. Qi *et al.* assessed the relationship of daily counts of COVID-19 cases with the average temperature (AT) and relative humidity (ARH) in 30 provinces of China. According to their results, humidity and temperature exhibited negative association with the daily counts of COVID-19 cases [16]. Ahmadi *et al.* investigated the role of statistical and climatological variables in the spread of Corona virus in Iran. Direct relationship was noticed between the COVID-19 outbreak and the population density as well as intra-provincial movement. Regions having low wind speed, solar radiation and humidity were highly exposed to the disease. As compared to the Southern provinces of the country, the provinces in northern parts were vulnerable because of their maximum population, high rates of humidity and intra-provincial movements [17]. Similar type of research was conducted by Prata *et al.* in Brazil for determining the relationship of COVID-19 infection and the temperature. Results showed that there was an inverse linear relationship between temperature and the number of cases that were confirmed [18]. Ma *et al.* explored the impacts of meteorological variables on COVID-19 mortality rate. Daily death counts of COVID-19 and diurnal temperature range were positively correlated with each other while absolute humidity was negatively correlated [19].

Some other studies were also carried out in this regard [20, 21, 22]. The existing literature confirmed that the relationship between climate factors and COVID-19 was uncertain and further research is needed in this regard**.**

MATERIALS AND METHODS

The present study is applied and its data were taken from the official reports of the Iranian Meteorological Organization and the Ministry of Health and Medical

Education. Hourly temperature data were obtained in 8 time periods at 0, 3, 6, 9, 12, 15, 18, 21 (a.m. and p.m.) from March 1 to March 20, 2020 in 31 provinces of the country and then Corona disease statistics were divided into 31 provinces. SPSS 22 and S-plus software were used to analyze the statistical data. Then the mean daily temperatures were calculated and the daily chart of the centers was drawn. The data of all provinces were taken and a new column was established for Iran's mean daily temperature in Minitab Software. The Corona statistics of the number of people who were recognized and hospitalized in 31 provinces of the country were received from March 1 to March 29, when each province had its own figures.

The Chi square statistic

This estimation is commonly used for testing the relationship between categorical variables. The formula for Chi square statistic is:

$$\chi^2 = \sum_{i=1}^{n} \frac{(Oi-Ei)2}{Ei} \qquad (1)$$

where O represents the observed frequency and E represents the expected frequency [23].

In this research, the null hypothesis for the Chi-Square test was that no relationship exists between the categorical variables in the population and they are independent. We raised the question of whether there is a significant relationship between the Corona cases and temperature changes during the time period of study. Our aim in this regard was to evaluate the test of independence between the studied variables.

Linear regression analysis

We carried out a linear regression analysis to find the possibility of the influence of temperature as an independent climatic factor in Corona disease increase or decrease of the number of patients during the study period. In the regression model, the following equation was adapted:

$$Y = \beta_{\circ} + \beta_1 x \qquad (2)$$

Where x is the independent variable or predictor variable and Y is the dependent variable or response variable. β_1 is the slope of the line and β_o is the line intercept [24].

The Quadratic model

Then we used a quadratic fitted equation for the same purpose using matrix notation as:

$$Y\hat{}(x) = b_0 + b'x + x' Bx \qquad (3)$$

Where $b' = (b_1, b_2, \dots b_k)$ denotes a vector of the first-order parameter estimates,

$$\begin{pmatrix} b11 & \frac{b12/2}{b22} \dots & bik/2 \\ & \ddots & \vdots \\ Symmetric & & bkk \end{pmatrix} \qquad (4)$$

B is a matrix of the second-order parameter estimates and $x' = (x_1, x_2, \dots, x_k)$ is the vector of controllable factors. Note that the off-diagonal elements of B are equal to half of the two-factor interaction coefficients. Equating the partial derivatives of Y^ with respect to x to zeroes and solving the resulting system of equations, the coordinates of the stationary point of the response are given by:

$$x^* = -1/2B^{-1}b \qquad (5)$$

RESULTS

Through Chi-square test, we firstly assessed the association between the two variables of cases and temperature by comparing the observed pattern of responses in the cells to the pattern that would be expected if the variables were truly independent of each other (Fig. 1).

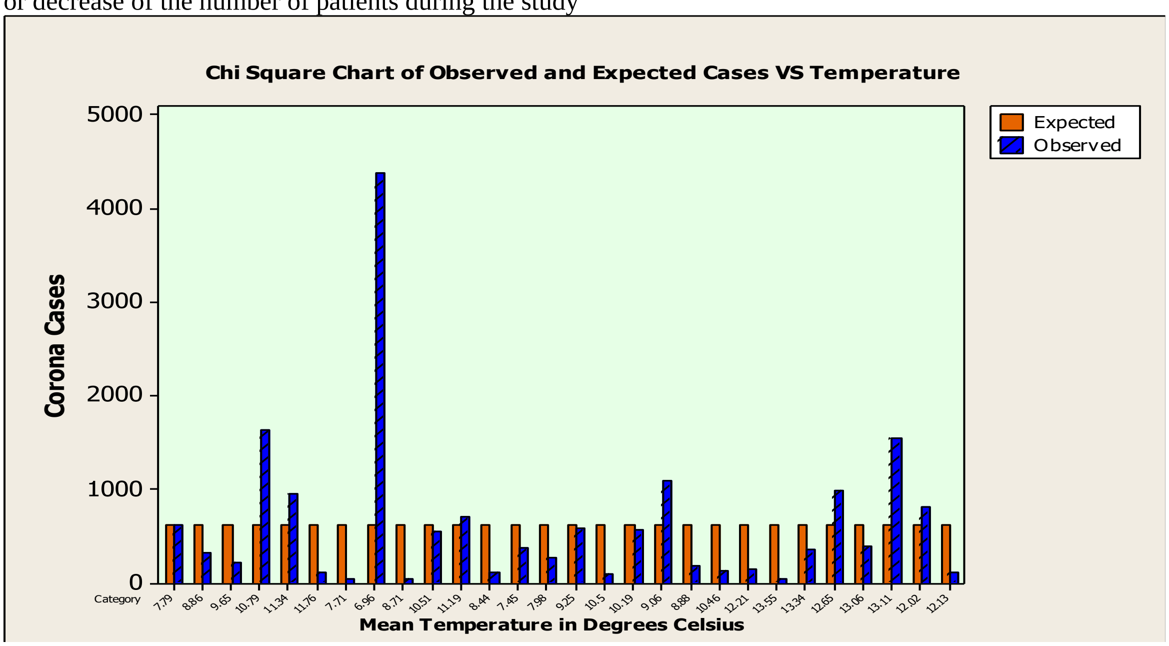

Fig. 1: Chi-square chart of observed and expected Corona cases vs temperature in degrees Celsius

The X^2 test showed that the magnitude of the difference between the observed and expected values compared to its corresponding expected value is large for categories such as Corona cases and mean temperature in degrees Celsius. If we choose an alpha-level of 0.05, the p-value (0.000) is less than alpha therefore; we could reject the null hypothesis and conclude that the No. of occurrence of Corona cases is not directly related to the mean temperature and generally the temperature fluctuations. We should take into the consideration that the chi-square test is an approximate test and its result may not be valid when the expected value for a category is less than 5. We knew that if the categories have expected values less than 5, we could combine them with adjacent categories to achieve the minimum required expected value.

The results of linear regression analysis could not prove the H_1 hypothesis whereby there was a significant difference between temperature fluctuations and the incidence of Covid-19 disease. The calculated P-value figures, which indicate a significant level of 0.05, failed to quantify this difference. The models summary results are presented in Table 1, 2 and 3.

Table 1: Summary of linear regression analysis model

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.182[a]	.033	-.003	848.22528

a. Predictors: (Constant), Temperature

b. Dependent Variable: Corona cases

Table 2: Analysis of variance (ANOVAb) of the linear regression model

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	667172.335	1	667172.335	.927	.344[a]
	Residual	1.943E7	27	719486.131		
	Total	2.009E7	28			

a. Predictors: (Constant), Temperature

b. Dependent Variable: Corona cases

Table 3: The coefficients of computed model parameters

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	1430.902	866.838		1.651	.110
	Temperature	-79.333	82.385	-.182	-.963	.344

a. Dependent Variable: Corona cases

Compared to the linear regression model which was initially run in this study but did not provide suitable results, the quadratic model had a larger p-value for the lack of fit test, higher adjusted R^2, and a lower press statistic; thus it could be almost reliable model (Fig. 2). The fitted quadratic equation, in the specified units was calculated as:

$$\text{Corona cases} = 10399 - 1873 \text{ Mean Temp} + 86.62 \text{ Mean Temp}^{**}2 \quad (6)$$

The quadratic model (p-value= 0.000, or actually p-value< 0.05) appears to provide a relative fit to the data. The R indicates that temperature accounts for 9.3% of the variation in log10 of the Corona cases occurred. A visual inspection of the plot reveals that the data are randomly spread about the regression line, implying incomplete fit.

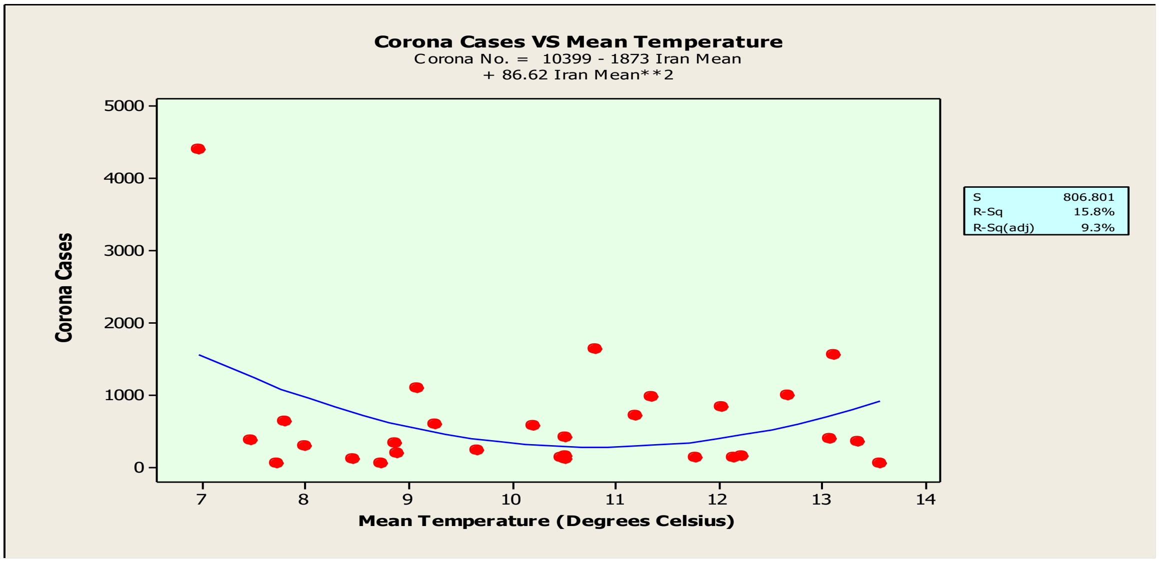

Fig. 2: Corona cases vs mean temperature in degrees Celsius

DISCUSSIONS

Results of this study explored a slight potential relationship between COVID-19 daily outbreak and temperature changes by using the Chi-square test, linear regression analysis and quadratic model. Not very strong relationship was observed between the temperature changes and the prevalence of Corona disease. The importance of temperature and its effect on the spread of COVID-19 have been examined and emphasized in other studies too which observed different relationships for different regions around the world and are discussed here. Ye *et al.* found no significant association between cumulative incidence rate of COVID-19 and maximum temperature, minimum temperature and relative humidity and their results are in agreement with our study [25]. Xie and Zhu noticed positive linear relationship between average temperature and the daily number of COVID-19 cases with 3ºC threshold. They mentioned that the evidence for supporting this statement that the number of confirmed cases could decrease with the warm weather is not available [13]. Similarly Prata *et al.* found negative linear relationship between temperature and daily COVID-19 confirmed cases and in the same way their is no evidence that the increase in temperature will decline the number of cases [18]. Menebo found significant positive correlations between maximum and normal temperature and negative with the precipitation level which means that as the temperature increases, the number of daily confirmed cases increases and vice versa but when the precipitation increases the number of confirmed cases decreases and vice versa [26]. Meraj *et al.* discussed that the increase in temperature is favorable to COVID-19 spread in India and that the temperature alone does not explain the spread of the disease and other climatic factors, socioeconomic conditions and epidemiology related factors are most likely involved in the spread which is also mentioned by our study. Further they mentioned that only temperature should not be considered for making planning strategies to control the pandemic [27]. Ma *et al.* found positive relationship of daily death counts of COVID-19 with the diurnal temperature range in Wuhan China while negative with the absolute humidity [19]. Auler *et al.* in their research noticed that the higher average relative humidity and mean temperatures favored the transmission of COVID-19 [20]. Taking all these findings into consideration with the aim of comparing their main outcomes with our findings in Iran, we should firstly mention that the number of studies are so far limited in Iran and the results of one study carried out by Ahmadi *et al.* are in agreement with our study which investigated the impact of climatology parameters (average temperature, average precipitation, wind speed, humidity and average solar radiation) and geographical indicators (intra-provincial movements, population density and days of infection) on the COVID-19 outbreak in Iran. This study concluded that the main variables that play significant role in this outbreak are intra-provincial movements; population density, humidity and wind speed whereas the other variables such as air temperature and precipitation are not significantly correlated with the outbreak [17]. In brief, on the basis of different results of studies, one can understand that the relationship of temperature and the spread of COVID-19 are not clear. Our study could not observe a strong and vivid significant association of temperature and COVID-19 infection. A possible reason may be that the period of study was limited in spring. There is need of further laboratory studies to determine the underlying mechanism. Preliminary studies on other similar diseases and common types of colds in the UK show a seasonal pattern that is often seen at the peak of the outbreak of viruses during the winter and disappears in spring and summer. However, talking about Iran (Fig. 3) may indicate many issues.

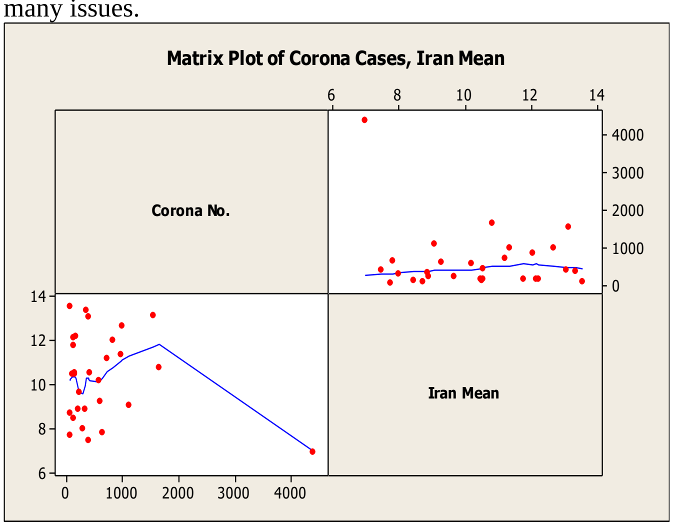

Fig. 3: Matrix diagram of Corona cases and temperature conditions

Finding a strong scientific link between the incidence of Corona virus disease and the average temperature or temperature fluctuations in Iran is an acute task. In addition, difficult economic conditions of the people may be another factor, because the people have been forced to reopen public places and shops, even in the difficult days of the Corona, due to their living conditions. The development of retail jobs and the like also have irreparable consequences.

CONCLUSION

The results of this study showed that there is not strong correlation between temperature changes and the prevalence of Corona disease in the study period. Despite the relatively low correlation between these two variables, the findings indicate that the prevalence of Corona in Iran can be affected by several different factors. Deficiency of medical equipment such as masks and disinfectants are among these factors. The behavior of the Iranian people towards the epidemic and the spread of this virus can be also considered. The prevalence of this disease in Iran coincides with various social occasions, which are a significant factor in themselves. Socio-political and cultural gatherings are noteworthy on specific days. Especially the coincidence of the ancient Iranian Nowruz and the traditional views and visits of the people and the thirteenth day of New Year can be a reason for the spread of the Corona in Iran during the period of study. Like many countries, restrictions had to be imposed on the movement of people regarding the measures taken by the Ministry of Health to prevent the spread of the Corona virus.

Finally, it should be noted that although the temperature element is considered to be an influential climatic factor in Corona-like diseases such as influenza or SARS, this study cannot profoundly prove such a relationship. In the last days of the study, which has been accompanied by an increase in the temperature of the whole country, the amount and number of viruses has decreased to some extent which is like other countries that are located in the northern hemisphere and are approaching the summer, but the trend more or less has been wavelike. Altogether, scientists consider that the Corona virus is expected to weaken as the temperature rises and the season warms, and that governments are expected to have more and better opportunities to deal with it.

ETHICAL ISSUES

All paper work is unique and is not plagiarized.

CONFLICT OF INTEREST

Authors have no conflict of interests.

Authors Contributions

All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by Ali Mohammad Khorshiddoust, and Mozaffar Faraji. Xiao Yan conceived of the presented idea. Mozaffar Faraji developed the theory and performed the computations. Ali Mohammad Khorshiddoust also performed the analytic calculations and performed the numerical simulations. The first draft of the manuscript was written by Ali Mohammad Khorshiddoust and Sapna Tajbar and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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