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Original Article

The Exponentially Increasing Rate of Patients Infected with COVID-19 in Iran

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Abstract

Background: Coronavirus, the cause of severe acute respiratory syndrome (COVID-19), is rapidly spreading around the world. Since the number of corona positive patients is increasing sharply in Iran, this study aimed to forecast the number of newly infected patients in the coming days in Iran.

Methods: The data used in this study were obtained from daily reports of the Iranian Ministry of Health and the datasets provided by the Johns Hopkins University including the number of new infected cases from February 19, 2020 to March 21, 2020. The autoregressive integrated moving average (ARIMA) model was applied to predict the number of patients during the next thirty days.

Results: The ARIMA model forecasted an exponential increase in the number of newly detected patients. The result of this study also show that if the spreading pattern continues the same as before, the number of daily new cases would be 3574 by April 20.

Conclusion: Since this disease is highly contagious, health politicians need to make decisions to prevent its spread; otherwise, even the most advanced and capable health care systems would face problems for treating all infected patients and a substantial number of deaths will become inevitable.

Keywords: COVID19, Forecast, Iran

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Introduction

Coronaviruses are a large family of enveloped viruses with single-stranded RNA and a crown on their surface.[1,2] These viruses are severely pathogenic for humans, causing respiratory infection, liver disease, and gastrointestinal and neurological diseases.[3] Two outbreaks of coronaviruses, SARS-CoV-1 and MERS-CoV, occurred in 2003 and 2012, respectively.[3]

The novel coronavirus was reported in December 2019 with the emergence of several cases of pneumonia of unknown etiology that caused severe acute respiratory syndrome in Wuhan city, China.[4-8] Some of these cases were seen in people who used seafood in Wuhan.[3,9]

The novel coronavirus was introduced as coronavirus disease 2019 (COVID-19) by the World Health Organization, that probably originated from bats.[4] However, its origin has not been confirmed yet.[10,11] COVID-19 is an infectious disease caused by SARS-CoV-2.[6] Symptoms include fever, cough and shortness of breath[10] The disease is transmitted through inhalation of respiratory droplets, close contact with the infected person, and contact with contaminated surfaces or objects.[3] The incubation period of COVID-19 is over 14 days and during this period, the virus can be transferred to other people.[3]

COVID-19 spread rapidly in China[6,12] and around the world,[7] and was introduced as a pandemic by the WHO on March 11, 2020.[13] By March 22, the number of infected countries was more than 180 and the number of confirmed patients and deaths were 314 135 and 13 560 people in in the world, respectively.[14] Although the disease is controlled in China, it is increasing in other countries of the world including Iran.[15] Iran experienced the first case of COVID-19 in Qom on February 19, 2020. Then, the disease spread rapidly throughout the country.[16] As of March 22, 2020, the total number of confirmed patients has been 21 638.[14]

Some of the most important questions are when the spread of COVID-19 will end, what the trend of this outbreak looks like, and how many people would be infected with COVID19 daily. These are the main concerns of people and health policy makers. These questions could be answered through predictive models.[2,6] Therefore, due to the increasing rate of coronavirus positive patients in Iran, this study was conducted to forecast daily new infected cases for next days in this country.

Materials and Methods

This time-series study was undertaken to forecast the number of new cases of COVID-19 in Iran, until April 20, 2020. The data used in this study included the number of new cases from February 19 to March 21, 2020 in

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Iran. New cases are all cases that have been approved by laboratory tests. Data were extracted from two sources. First: the daily reports of the Iranian Ministry of Health and Medical Education, which included the number of new cases, new remissions and new deaths. Second: open datasets provided by the Johns Hopkins University, which provides information cumulatively for the general public.

Statistical Model Building

The autoregressive integrated moving average (ARIMA) model was used for forecasting time-series data in order to forecast the number of newly infected patients. ARIMA (p, d, q) is actually simultaneous fit of other two models including Auto Regressive (p) and Moving Average (q)[17] The plot of residuals was used in addition to Autocorrelation and Partial Autocorrelation Functions (ACF & PACF) to assess the model's goodness of fit. Residuals were also tested to be stationary using Box-Ljung.

Box-cox is another popular transformation to provide stationary time-series.[18] It should be noted that Box-Cox transformation was applied to prepare data for fitting ARIMA(0,1,0), by use of 'forecast' package in R software. Statistical significance was set at 0.05 and the model goodness of fit was assessed through inspection of residuals.

Results

The observed trend of new cases from February 18 to March 21, 2020 is displayed in Figure 1. This Figure also shows the forecasted number for thirty days ahead, by ARIMA model (Table 1). Obviously, an exponential increase is clear in the daily number of newly detected patients. According to this prediction, if the spreading pattern continues similarly to the observed pattern, the number of daily new cases would be 3574 by April 20.

The plot of residuals versus observations' order showed no pattern. It seems that they were randomly scattered around zero (Figure 2a). Autocorrelation and Partial Autocorrelation Functions showed no spike and this implied that there was no remaining auto coloration regarding the residuals (Figure 2). The Shapiro-Wilk test was used to check the normality of residuals (*P*value = 0.60), in addition to Normal Probability Plot and Histogram of residuals which did not show any substantial deviation from normality (Figure 3). All residual assessment confirmed goodness of fit for the fitted ARIMA model, as depicted in Figure 1.

Discussion

This study was conducted to forecast the number of the daily new cases infected with COVID-19 until April 20, 2020 in Iran using the ARIMA predicting model. The total number of confirmed patients and deaths in Iran was 21 638 and 1685, respectively, until March 22, 2020. The results of our study indicate that if the spreading pattern continues as before, there will be a sharp increase in the number of new cases in the next days. Based on our predictions, the number of new cases would be 3574 on April 20, 2020 according to ARIMA.

Of course, the accuracy of this prediction depends on the accuracy of applied data and the adequacy of the applied statistical model. Even if the forecast is overestimated and only a fraction of this prediction is realized, Iran's health care system would face an extremely difficult problem. Given that the disease is transmitted through respiratory droplets and is spreading rapidly, this forecast is important for health planning.

Finally, we must say that we do not have additional evidence that can estimate the exact number of patients, but we hope that our results could help timely decisions by health policy makers in Iran in providing adequate hospital equipment, medical and nursing staff and essentials needs, in order to prevent a more serious crisis.

Limitations

Two major limitations should be considered in this study. First, due to the lack of data at the individual level, including patients' demographic information, their social networks

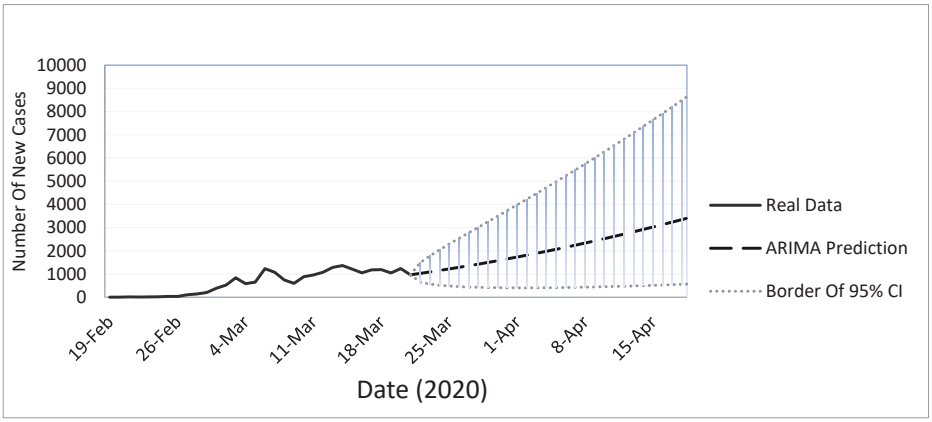

Figure 1. Forecasted and 95% Confidence Interval of New Cases with Covid19 in Iran; until April 20, 2020.

Table 1. Forecasted Number of Daily New Cases with 95% Confidence Intervals

Days (of 2020)	Prediction		
	ARIMA	95% CI for ARIMA	
		Lower	Upper
22-Mar	1026.402612	653.1516367	1483.652205
23-Mar	1088.63684	567.8413155	1777.429597
24-Mar	1152.702682	516.4981522	2040.903061
25-Mar	1218.600139	481.6742792	2291.520464
26-Mar	1286.329211	456.8553398	2535.796164
27-Mar	1355.889898	438.8200933	2776.951401
28-Mar	1427.2822	425.7248814	3016.829833
29-Mar	1500.506117	416.4136128	3256.587551
30-Mar	1575.561648	410.1144707	3496.996372
31-Mar	1652.448795	406.2881487	3738.595604
1-Apr	1731.167556	404.5445755	3981.775316
2-Apr	1811.717933	404.5939391	4226.825321
3-Apr	1894.099924	406.2162804	4473.965578
4-Apr	1978.31353	409.2417741	4723.365913
5-Apr	2064.358751	413.5374742	4975.159271
6-Apr	2152.235587	418.9981334	5229.4509
7-Apr	2241.944038	425.5396791	5486.324872
8-Apr	2333.484103	433.0944766	5745.848822
9-Apr	2426.855784	441.6078204	6008.077456
10-Apr	2522.059079	451.0352951	6273.055188
11-Apr	2619.09399	461.3407578	6540.818162
12-Apr	2717.960515	472.4947767	6811.39581
13-Apr	2818.658655	484.4734088	7084.812075
14-Apr	2921.18841	497.2572311	7361.086379
15-Apr	3025.54978	510.8305679	7640.234398
16-Apr	3131.742765	525.1808665	7922.268685
17-Apr	3239.767364	540.2981911	8207.199176
18-Apr	3349.623579	556.1748077	8495.033605
19-Apr	3461.311409	572.804843	8785.777845
20-Apr	3574.830853	590.1840004	9079.436192

and travels, no risk factor for this disease was assessed and studied. Second, the small number of observations for this type of time-series algorithms is another major limitation of this study as models might not be trained very well. However, the prediction of this study may be useful for health decision makers; therefore, it was not reasonable to waste time for data provision.

Conclusion

In conclusion, the result of this study is an alarm for health policy planners and decision makers to make timely decisions regarding the supply of essential equipment for hospitals.

Authors' Contribution

ML searched and provided data, wrote, edited and critically reviewed manuscript. SM designed the study, performed statistical analysis and wrote the manuscript. The final version of the manuscript was approved by all authors.

Conflict of Interest Disclosures

None.

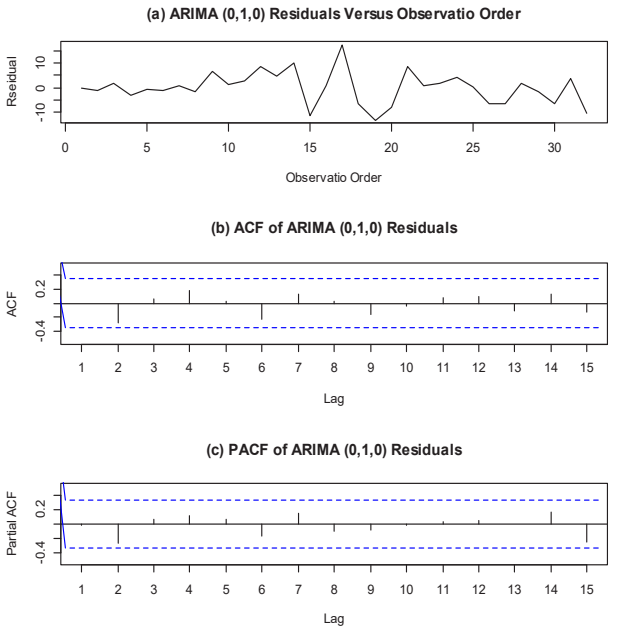

Figure 2. Residual Assessment of ARIMA Model Including (a) Plot of Residuals Versus Observation Order, (b) Auto Corrolation Function of Residuals, and (c) Partial Auto Corrolation Function of Residuals.

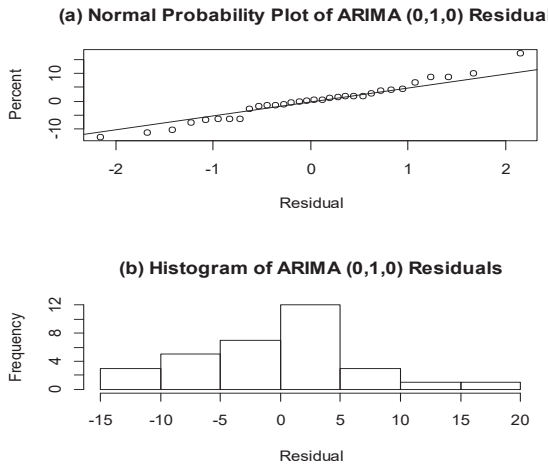

Figure 3. Residual Assessment of ARIMA Model Including (a) Normal Probability of Plot and (b) Histogram of Residuals.

Ethical Statement

In this study we applied the information about the number of new cases with Covid19 in Iran. The data was provided by Johns Hopkins University and Iranian Ministry of Health. Therefore it seems that ethical approval is not required.

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