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

Leila Moftakhar, MSc1; Mozhgan Seif, PhD2*

1Student Research Committee, Shiraz University of Medical Sciences, Shiraz, Iran
2Department of Epidemiology, School of Health, Shiraz University of Medical Sciences, Shiraz, Iran

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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*Corresponding Author: Mozhgan Seif, PhD; Department of Epidemiology, School of Health, Shiraz University of Medical Sciences, Shiraz, Iran. Tel: 98 9374322827; Email: m.seif@sums.ac.ir
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)\textsuperscript{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.\textsuperscript{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

![Image](image-url)

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

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

| Days (of 2020) | ARIMA Prediction | 95% CI for ARIMA       |
|---------------|------------------|------------------------|
|               |                 | Lower                  |
| 22-Mar        | 1026.402612      | 653.1516367            |
| 23-Mar        | 1088.63684       | 567.8413155            |
| 24-Mar        | 1152.702662      | 516.4901522            |
| 25-Mar        | 1218.600139      | 481.6742792            |
| 26-Mar        | 1286.329211      | 456.8553398            |
| 27-Mar        | 1355.889898      | 438.8200933            |
| 28-Mar        | 1427.2822        | 425.7248814            |
| 29-Mar        | 1500.506117      | 416.4136128            |
| 30-Mar        | 1575.561648      | 410.1144707            |
| 31-Mar        | 1652.448790      | 406.2417741            |
| 1-Apr         | 1731.167556      | 406.5445755            |
| 2-Apr         | 1811.717933      | 404.5939391            |
| 3-Apr         | 1894.099924      | 426.825321             |
| 4-Apr         | 1978.31353       | 409.2417741            |
| 5-Apr         | 2064.358751      | 413.574742             |
| 6-Apr         | 2152.235587      | 418.9981334            |
| 7-Apr         | 2241.944038      | 425.5396791            |
| 8-Apr         | 2333.484103      | 406.5126804            |
| 9-Apr         | 2426.855384      | 411.0728024            |
| 10-Apr        | 2522.059079      | 416.032951             |
| 11-Apr        | 2619.09399       | 461.3405758            |
| 12-Apr        | 2717.960515      | 418.9981334            |
| 13-Apr        | 2818.658655      | 406.5445755            |
| 14-Apr        | 2921.18841       | 425.5396791            |
| 15-Apr        | 3025.54978       | 406.5126804            |
| 16-Apr        | 3131.742765      | 411.0728024            |
| 17-Apr        | 3239.767364      | 416.032951             |
| 18-Apr        | 3349.623579      | 462.825321             |
| 19-Apr        | 3461.311409      | 572.804843             |
| 20-Apr        | 3574.830853      | 590.1840004            |

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