Title: Modeling the Corona Virus Outbreak in IRAN

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Abstract

Background: As the outbreak of Coronavirus disease 2019 (COVID-19) is a worldwide pandemic, and it is rapidly expanding in Iran, real-time analyses of epidemiological data are needed to increase situational awareness and inform interventions. In this study, we built a predictive model based on the cumulative trend of new cases and deaths for the top five provinces. We will also look at modeling the trends for confirmed cases, deaths and recovered for the whole country.

Method: In this study, we have chosen to apply the exponential smoothing model to iteratively forecast future values of a regular time series from weighted averages of past daily values. This method is exponential because the value of each level is influenced by every preceding actual value to an exponentially decreasing degree – more recent values are given greater weight. The available data is too small to identify seasonal patterns and make a predictable variation in value, such as annual fluctuation in temperature related to the season. The trend is a tendency of the data to increase or decrease over time.

Results: If no control is applied, it is expected that over 40,000 people will be infected in Tehran by mid-June. However, if the control measures are successfully implemented, the COV-19 virus outbreak is expected to decline in early April by the end of May (70 days). In the scenario, that no further actions are implemented, the spread of COVID-19 is expected to continue slowly, reaching 21,000 by mid-June. The same process has been applied to review the confirmed cases, deaths and recovered dataset. The forecast has been carried out for the next 30 days; a shorter timeframe has been selected as there is a high probability that the Iranian New Year's celebration, Farvardin, first month of spring (30th March in Western calendar) will have an impact on the infection rate following the event. The best predictive model predicts the number of reported deaths of COVDI-19 to be between 3,000–5,000 and the number of recovered cases between 5,000 – 30,000 from the total confirmed cases in the range of 35,000-70,000 infected cases.

Conclusions: The Modeling of Covid-19 outbreak shows that the number of patients and deaths is still increasing. Contagious diseases follow an exponential model and the same be Haves this one. This is because the virus can spread to others and finally each person turns into a carrier of the virus and transmit it to another person. Disease control depends on disconnection and social distancing. In addition, many factors are effective in stopping the disease. These include citizens' participation in the prevention process, health education, the effectiveness of instructive traditions, environmental conditions, and so on.

Introduction:

On 31 December 2019, the World Health Organization (WHO) office located in China was informed of pneumonia of unknown etiology cases (unknown cause) detected in Wuhan City, Hubei Province of China. WHO reported that a novel coronavirus (2019-nCoV), named as severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) and chosen by International Committee on Taxonomy of Viruses on 11 February 2020, was identified as the causative virus by Chinese authorities on 7 January.(1)

During the 2019–20 coronavirus pandemic, Iran reported its first confirmed cases of SARS-CoV-2 infections on 19 February 2020 in Qom(2). As of 17 March 2020, according to Iranian health authorities, there had been 988 COVID-19 deaths in Iran with more than 16,000 confirmed infections(3,4,5) This respiratory disease caused by a coronavirus is one of the leading causes for serious illnesses in people all over the world. According to the global statistics of fatalities caused by coronavirus, and its spread in Iran, it is vital and essential to forecast its outbreak by a model.
As the outbreak of coronavirus disease, 2019 (COVID-19), is a worldwide pandemic, it is rapidly expanding in Iran, real-time analyses of epidemiological data are needed to increase situational awareness and inform interventions. Previously, real-time analyses have shed light on the transmissibility, severity, and natural history of an emerging pathogen in the first few weeks of an outbreak, such as with severe acute respiratory syndrome (SARS), the 2009 influenza pandemic, and Ebola. Analyses of detailed line lists of patients are particularly useful to infer key epidemiological parameters, such as the incubation and infectious periods, and delays between infection and detection, isolation, and reporting of cases. However, official individual patient data rarely become publicly available, when the information is most needed. This is an analysis of the COVID-19 out-break in Iran. In this population-level observational study, I used the Iranian Ministry of Health reports downloaded from GitHub, an online data-sharing platform. This dataset is updated on a daily basis with a 24 hour delay. The dataset includes time-stamped counts of the daily cases and deaths within each province in Iran.

In this study, we will build a predictive model based on the cumulative trend of new cases and deaths for the top five provinces. I will also look at modeling the trends for confirmed cases, deaths and recovered for the whole country.

Method

In this study, I have chosen to apply the exponential smoothing model to iteratively forecast future values of a regular time seires from weighted averages of past daily values of the series. This method is exponential because the value of each level is influenced by every preceeding actual value to an exponentially decreasing degree – more recent values are given a greater weight.

Due to the lack of historical data, seasonality analysis has been removed from the modeling and the trends are analyzed based on the daily timeframe. The available data is too small to identify seasonal patterns and make predictable variation in value, such as annual fluctuation in temperature relative to the season. The trend is a tendency in the data to increase or decrease over time.

The predictive model will be tested against four regression model evaluations for robustness. They are as follow:

- MAE – mean absolute error, this gives less weight to the outliers
- MAPE – similar to MSE, but normalized by true observation. The downside is when the true observation is zero, this metric could be problematic.
- MSE – mean squared error, it is like a combination measurement of bias ad variance of the prediction. For example, bias squared add variance.
- RMSE – root MSE, this takes the root of MSE to bring the unit back to the actual value. It is the standard deviation of residuals (prediction errors). Residuals are a measure of how far from the regression line data points.

Both MAE & RMSE can range from 0 to infinity. They are negatively-oriented scores: lower values are better.

The Akaike Information Criterion, AIC test will be applied to the predictive model. The purpose of this test is to see how well the model fits the dataset without over-fitting it. The AIC score rewards models that achieve a high goodness-of-fit score ad penalizes them if they become over complex. A low AIC score indicates a better fit.

Statistical analysis

Since the outbreak has begun in early February 2020, the rate of infection and number of deaths has been increased significantly as seen in the illustration below. On the 19th February, the first 2 deaths were reported, on the 23rd February, 4 other provinces reported COVID-19 deaths, and within the space 28 days the virus has spreaded across the whole country (see illustration 2), by 20th March 2020, Tehran, the capital city of Iran reported approximately to 4000 confirmed cases of COVID-19.

<u>Illiustration 1</u>

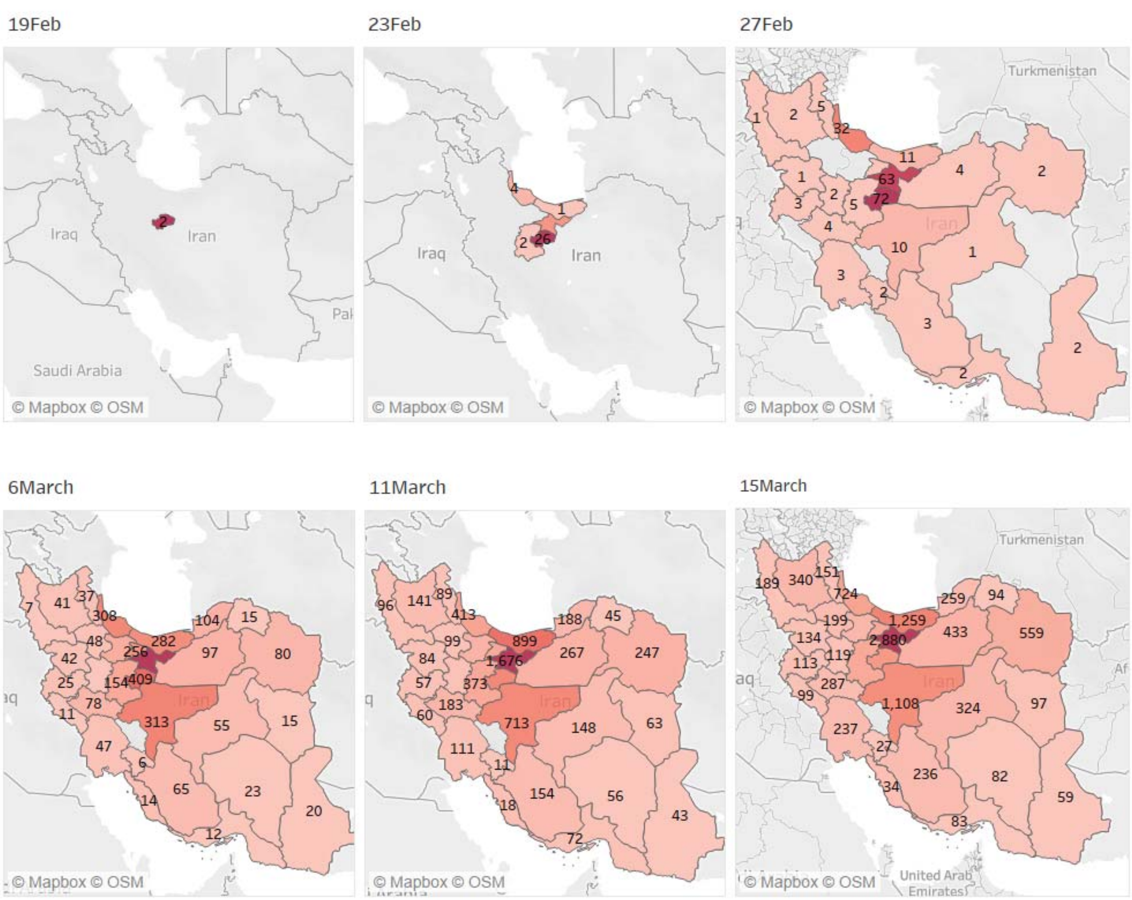
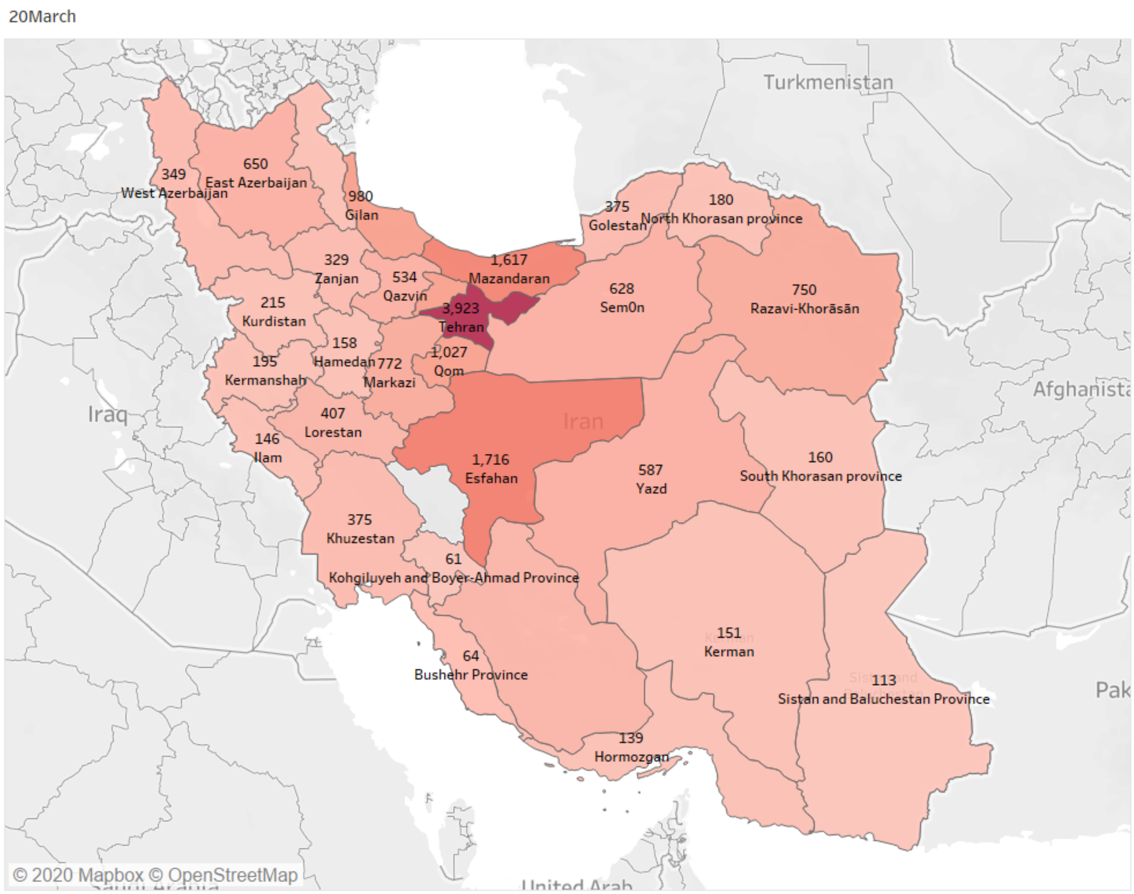
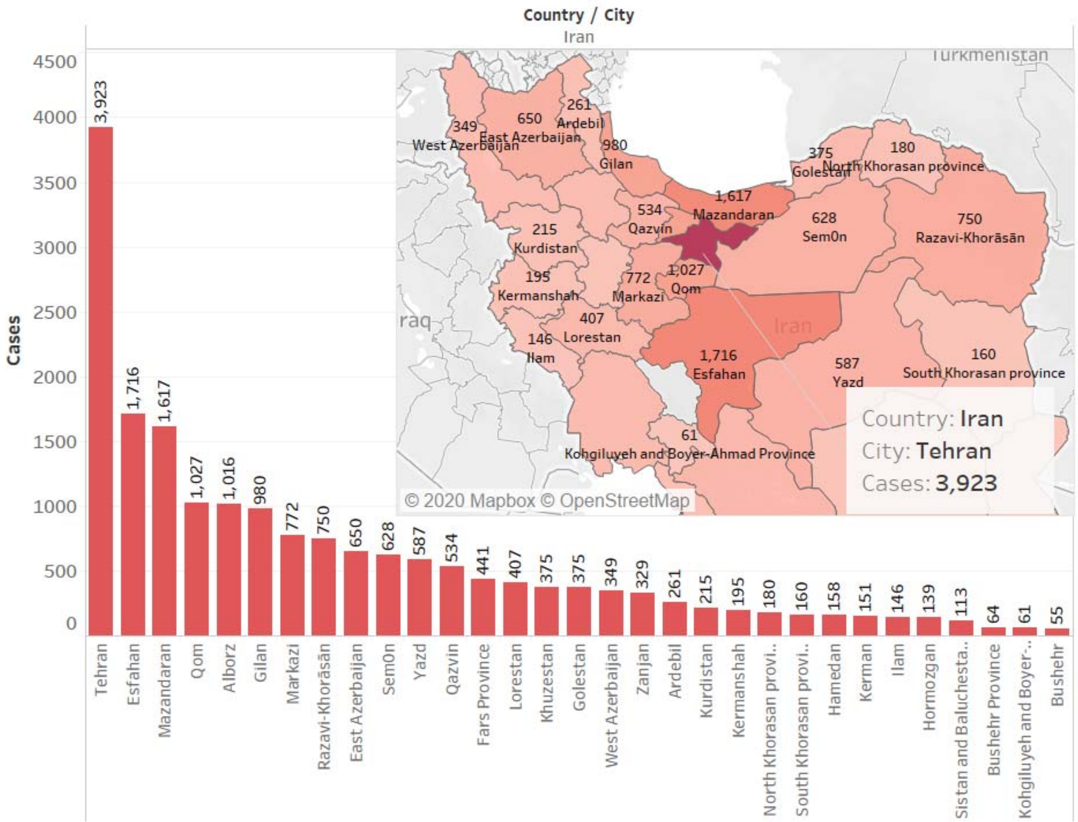


Illustration 2



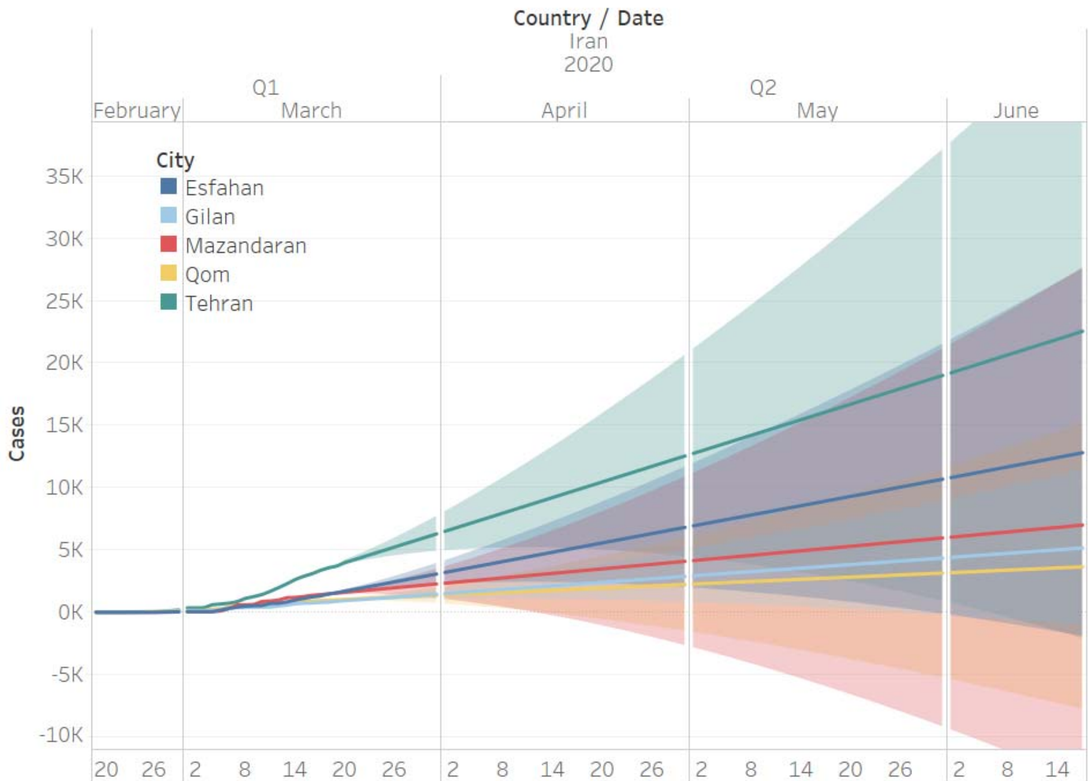
The total number of confirmed cases of infected patients on the 20th March 2020 is 19,661, with 1,411 deaths and 6,226 recovered. The top 10 most affected provinces are Tehran, Esfahan, Mazandaran, Qom, Alborz, Gilan, Markazi, Razavi-Khorasan, East Azerbaijan and Semon, which can be reviewed in illustration 3, province ranked by confirmed cases from the highest number to the least.

Illustrattion 3



Based on the exponential smoothing model, the projection for the next 90 days across the top 5 with the most reported confirmed cases are shown in illustration 4. If no control measures are put in place, it is expected that over 40,000 would be infected in Tehran around the middle of June. However, if control measures were implemented with a high degree of success, one would expect the spread of the COV-19 virus would peak at the start of April with a downward trend dropping off by the end of May (70 days). In the scenario, that no further measures are implemented, one would expect the spread of COVID-19 to continue on a gentle incline, reaching 21,000 by mid-June.

Illustration 4



Two models have been tested with varying degrees of accuracy. The base model shown in Illustration 5 is the simple forecast model, without trend or seasonality built-in. It has the highest AIC out of the three models across the 5 sampled provinces, although it has a low MAPE, when compared to the other three statistical metrics like RMSE, MAE, MASE it yields the highest margin of error in the group.

The quality of the predictive model for Tehran is acceptable because the dataset is more robust compared to one integrated with seasonality. The Mean Absolute Scaled Error, MASE is less than 1 for the projected 90 days period which is a positive score for the model. The RMSE, unbiased forecast score is slightly higher than the MAE, which gives a median future distribution of 84. The MAPE is over 100% which means the errors are “much greater” then the actual values.

Table 1 & 2

Options Used to Create Forecasts

Time series: Day of Date
Measures: Sum of Cases
Forecast forward: 30 days (20 Mar 2020 – 18 Apr 2020)
Forecast based on: 19 Feb 2020 – 19 Mar 2020
Ignore last: 1 day (20 Mar 2020)
Seasonal pattern: None

Sum of Cases

Column	Color	Detail	Initial	Change From Initial	Seasonal Effect		Contribution		
Country	City	City	20 Mar 2020	20 Mar 2020 – 18 Apr 2020	High	Low	Trend	Season	Quality
Iran	Tehran	Tehran	3,989 ± 4.9%	151.5%	None		100.0%	0.0%	Ok
Iran	Qom	Qom	1,028 ± 8.8%	82.8%	None		100.0%	0.0%	Poor
Iran	Mazandaran	Mazandaran	1,603 ± 10.2%	109.5%	None		100.0%	0.0%	Poor
Iran	Gilan	Gilan	926 ± 9.2%	148.8%	None		100.0%	0.0%	Poor
Iran	Esfahan	Esfahan	1,697 ± 6.9%	213.0%	None		100.0%	0.0%	Poor

All forecasts were computed using exponential smoothing.

Sum of Cases

Column	Color	Detail	Model			Quality Metrics					Smoothing Coefficients		
Country	City	City	Level	Trend	Season	RMSE	MAE	MASE	MAPE	AIC	Alpha	Beta	Gamma
Iran	Tehran	Tehran	Additive	Additive	None	100	84	0.66	188.7%	286	0.500	0.500	0.000
Iran	Qom	Qom	Additive	Additive	None	46	33	0.96	123.8%	240	0.500	0.500	0.000
Iran	Mazandaran	Mazandaran	Additive	Additive	None	83	51	0.97	102.7%	275	0.500	0.500	0.000
Iran	Gilan	Gilan	Additive	Additive	None	44	35	1.15	171.1%	236	0.500	0.281	0.000
Iran	Esfahan	Esfahan	Additive	Additive	None	59	44	0.81	42.2%	255	0.500	0.500	0.000

%Illustration 5

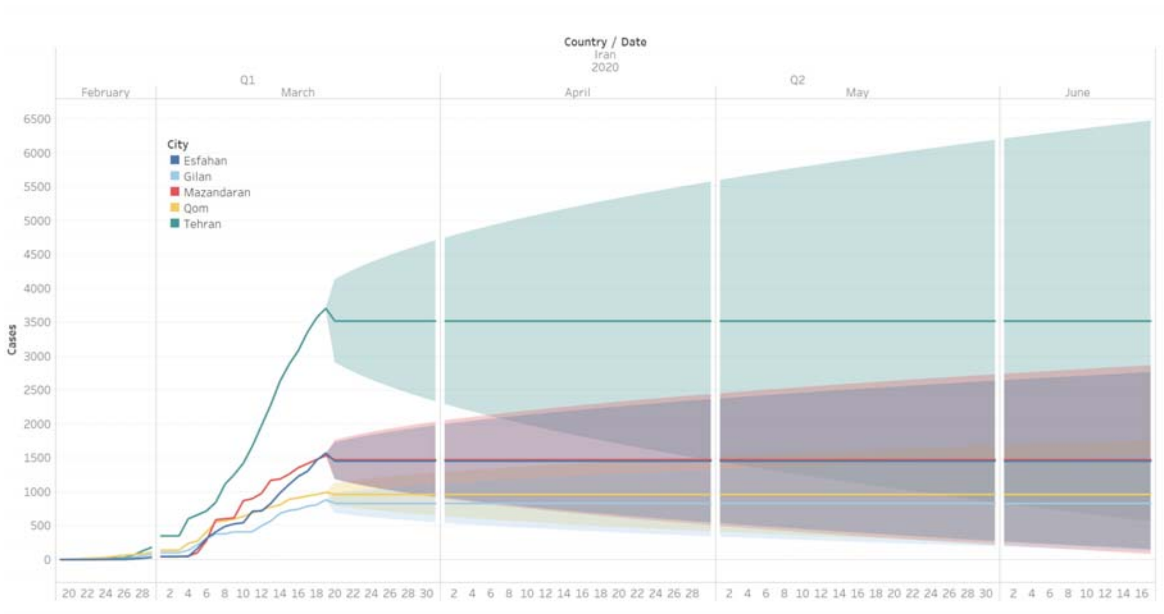


Table 3 & 4

Options Used to Create Forecasts

Time series: Day of Date
Measures: Sum of Cases
Forecast forward: 90 days (20 Mar 2020 – 17 Jun 2020)
Forecast based on: 19 Feb 2020 – 19 Mar 2020
Ignore last: 1 day (20 Mar 2020)
Seasonal pattern: None

Sum of Cases

Column	Color	Detail	Initial	Change From Initial	Seasonal Effect		Contribution		
Country	City	City	20 Mar 2020	20 Mar 2020 – 17 Jun 2020	High	Low	Trend	Season	Quality
Iran	Tehran	Tehran	3,517 ± 17.4%	0.0%	None		0.0%	0.0%	Poor
Iran	Qom	Qom	961 ± 17.1%	0.0%	None		0.0%	0.0%	Poor
Iran	Mazandaran	Mazandaran	1,471 ± 19.6%	0.0%	None		0.0%	0.0%	Poor
Iran	Gilan	Gilan	828 ± 17.6%	0.0%	None		0.0%	0.0%	Poor
Iran	Esfahan	Esfahan	1,452 ± 18.7%	0.0%	None		0.0%	0.0%	Poor

All forecasts were computed using exponential smoothing.

Sum of Cases

Column	Color	Detail	Model			Quality Metrics					Smoothing Coefficients		
Country	City	City	Level	Trend	Season	RMSE	MAE	MASE	MAPE	AIC	Alpha	Beta	Gamma
Iran	Tehran	Tehran	Additive	None	None	313	235	1.84	33.8%	351	0.500	0.000	0.000
Iran	Qom	Qom	Additive	None	None	84	64	1.88	37.7%	272	0.500	0.000	0.000
Iran	Mazandaran	Mazandaran	Additive	None	None	147	98	1.85	33.2%	306	0.500	0.000	0.000
Iran	Gilan	Gilan	Additive	None	None	75	55	1.82	30.7%	265	0.500	0.000	0.000
Iran	Esfahan	Esfahan	Additive	None	None	138	97	1.79	30.8%	302	0.500	0.000	0.000

The same process has been applied to review the confirmed, deaths and recovered dataset. The forecast has been carried out for the next 30 days; a shorter timeframe has been selected as there is a high probability that the Iranian New Year's celebration, Farvardin, first month of spring (30th March in Western calendar) will have an impact on the infection rate following the event.

The best predictive model as seen in Illustration 7 predicts the confirmed cases to be in the range of 35,000-70,000, with the number of reported COVDI-19 deaths to be between 3,000 – 5,000 and 5,000 – 30,000 of recovered cases.

Iluustration 7

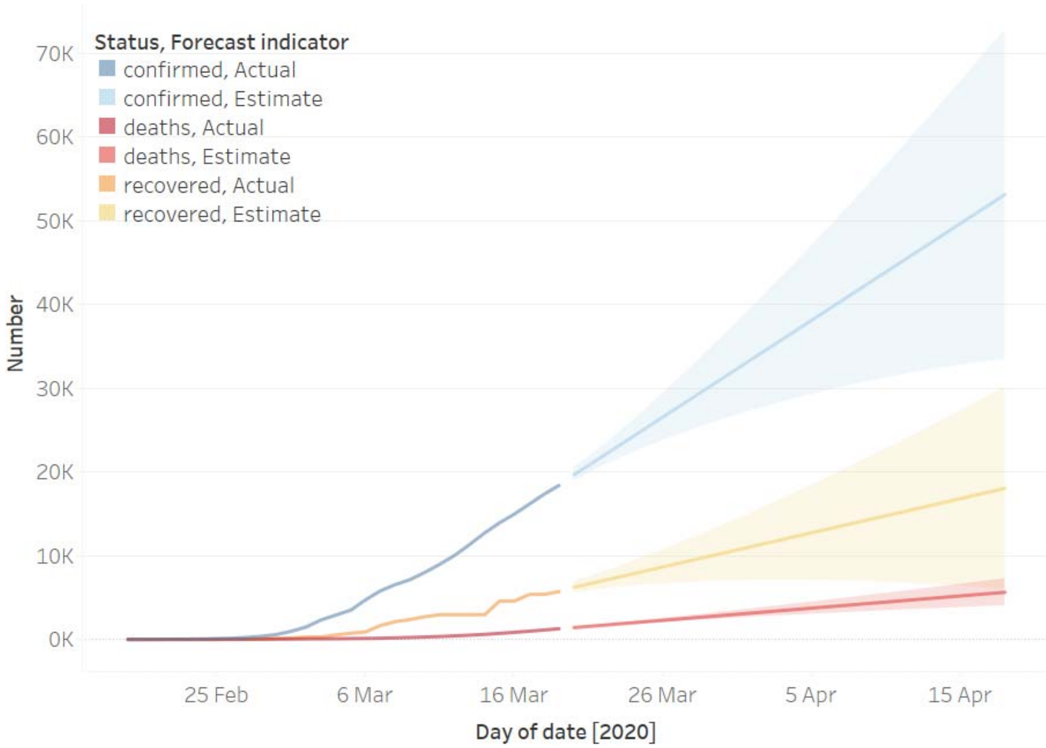

Status, Forecast indicator
confirmed, Actual
confirmed, Estimate
deaths, Actual
deaths, Estimate
recovered, Actual
recovered, Estimate
70K
60K
50K
40K
30K
20K
10K
0K
Number
25 Feb
6 Mar
16 Mar
26 Mar
5 Apr
15 Apr
Day of date [2020]

Table 5 & 6

Options Used to Create Forecasts

Time series: Day of date
Measures: Sum of Number
Forecast forward: 30 days (20 Mar 2020 – 18 Apr 2020)
Forecast based on: 19 Feb 2020 – 19 Mar 2020
Ignore last: 1 day (20 Mar 2020)
Seasonal pattern: None (Searched for a seasonal pattern recurring every 7 Days)

Sum of Number

Color Status	Initial 20 Mar 2020	Change From Initial 20 Mar 2020 – 18 Apr 2020	Seasonal Effect High	Seasonal Effect Low	Contribution Trend	Contribution Season	Quality
recovered	6,226 ± 11.5%	189.9%	None		100.0%	0.0%	Poor
deaths	1,411 ± 4.5%	299.5%	None		100.0%	0.0%	Ok
confirmed	19,661 ± 3.9%	170.4%	None		100.0%	0.0%	Ok

All forecasts were computed using exponential smoothing.

Sum of Number

Color Status	Model Level	Model Trend	Model Season	Quality Metrics RMSE	MAE	MASE	MAPE	AIC	Smoothing Coefficients Alpha	Beta	Gamma
recovered	Additive	Additive	None	364	257	1.31	15.9%	364	0.500	0.314	0.000
deaths	Additive	Additive	None	32	26	0.59	240.7%	218	0.500	0.500	0.000
confirmed	Additive	Additive	None	393	319	0.50	1,812.2%	368	0.500	0.500	0.000

Conclusion

The modeling outbreak of Covid-19 shows that the number of patients and deaths is still increasing. Contagious diseases follow an exponential model and the same be Haves this one. This is because, the virus can spread to others and finally each person turns into a carrier of the virus and transmit it to another person. Disease control depends on disconnection and social distancing. In addition, many factors are effective in stopping the disease.

These include citizens' participation in the prevention process, health education, the effectiveness of instructive traditions, environmental conditions, and so on. This article strived to analyze the growth trend of the number of patients, deaths and patients recovered in some provinces of Iran. The knowledge gained can help health planners and planners. Combining the findings of this study with other countries' studies can help to extract a global pattern for the virus outbreak process analysis. We believe that there are still many factors that can be included in the study. Adding these factors helps to validate and consolidate the findings. We hope that our study as part of an effort to better understand the disease and prevent the spread of the disease will help a global achievement

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