Epidemiology model report on SARS-CoV-2

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Region: Rhode Island (U.S.A)

Model Implemented: S-I-R

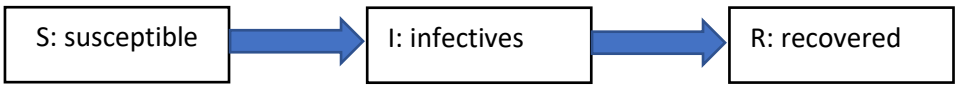
Abstract:

SARS-CoV-2 in short COVID-19 is a virus which originated in China and in a very short span of time took over the world. It has also proven to be deadly and hence WHO declared Pandemic. We use various epidemiological models which helps us to predict the maximum infected no., duration of the epidemic, no. of deaths to expect all backed by mathematics. The accuracy of the model depends on its complexity. The maximum no. of parameters ensures more accurate model but there is guarantee that it will be exact. As George E. P. Box quotes

"All models are wrong, but some are useful"

So here we implement the S-I-R model which is the most basic one in the realm of epidemiology on the given region.

S-I-R model:



It is the most basic compartmental model consisting the above mentioned 3 compartments.

It is based on the most general consideration that a Susceptible gets Infected and later either gets recovered or die.

Fitting the model:

Variables Used: -

N: - Total population

S(t): - Number of people susceptible on day t

I(t): - Number of people infected on day t

R(t): - Number of people recovered on day t

β: - Expected amount of people an infected person infects per day

D: - Number of days an infected person has and can spread the disease

γ: - The proportion of infected recovering per day (γ = 1/D)

R_o: - The total number of people an infected person infects (R_o = β / γ)

L: - Days after the start of outbreak, lockdown was imposed

Equations Used:

- ➢ β= R_o γ
- ➢ $dSdt = -\beta * I * SN$
- ➢ $dIdt = \beta * I * SN - \gamma * I$
- ➢ $dRdt = \gamma * I$

Initial Conditions:

N= 10,60,000 (Total Population)

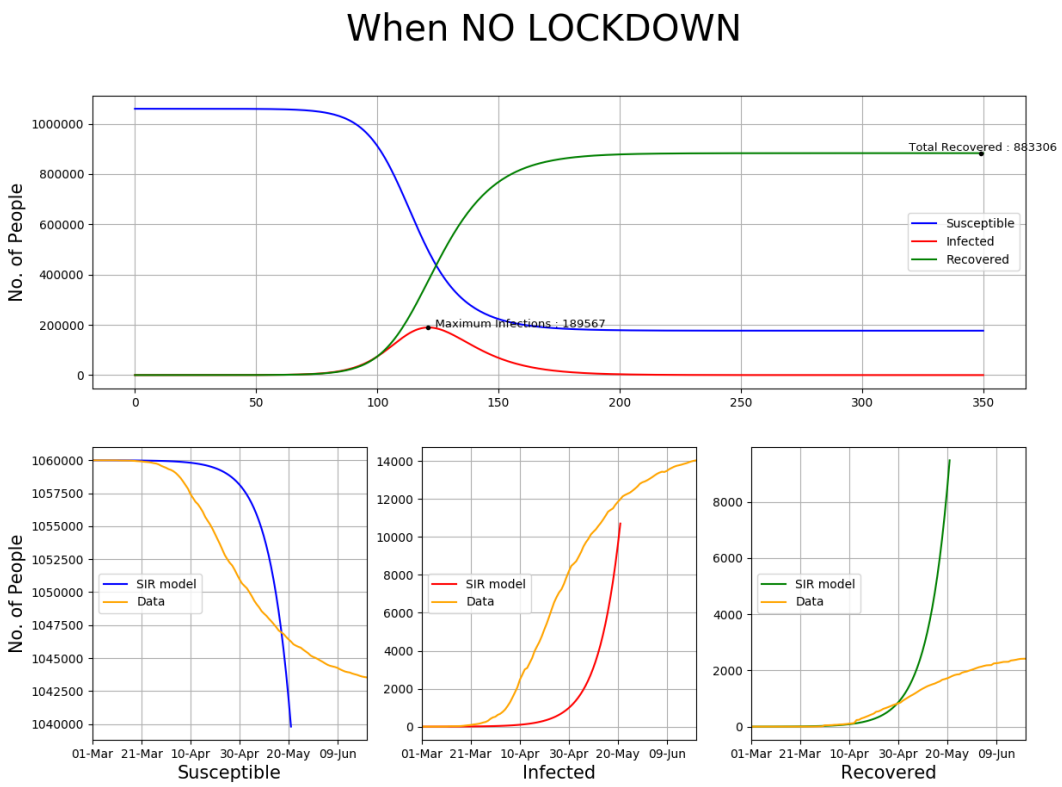
γ= 0.1 (Gamma)

I (0) = 1

R (0) = 0

- Data for number of Susceptible(S), Infectives(I) and Recovered(R) on each day starting from 01/03/2020 in real time has been collected. (source :https://ri-department-of-health-covid-19-data-rihealth.hub.arcgis.com/)
- Median values of R_o for each day in real time has also been collected. (source :https://rt.live/)
- We will plot the respective graphs for our model and compare the values obtained, with the values from real time data.
- We continuously make changes in the parameters to fit our model to the real time data. Here we try to optimize that value of R_o(Basic Reproduction Rate) for which our model best fit the real data.
- We use R_o= 2.15, The reason being as it is the mean value for R_o in the initial period of epidemic in the region in and around USA.
- Once our approximation of the model fits the real data, then we can use it to predict future data and can plan accordingly to deal with the epidemic.

Results:



Predictions in accordance with our S-I-R Model (refer subplot1): -

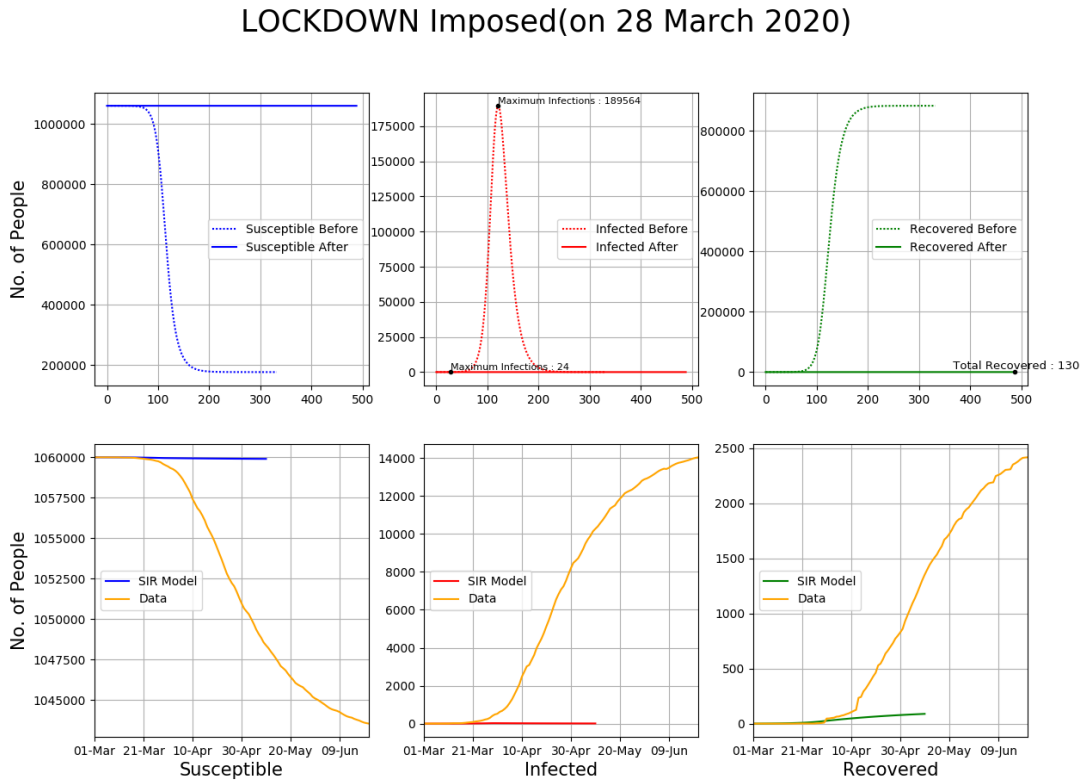
- Highest Number of Infected that may be Observed = 1,89,567 on 121th day from the start of Epidemic.
- Total Number of Recovered that may be Observed = 8,83,306 at the end of the Epidemic
- Duration of Epidemic = between 250 to 300 days

Conclusions from the subplot2: -

- It compares the data of our S-I-R model with the one collected in real time. We can observe there is an inaccuracy in the data after 10-Apr it is attributed to decreasing value of R_o.
- As initially for our model we have taken, R_o= 2.15(reason mentioned above) but the changing values of R_o each day which become lesser with time brings inaccuracy to our model after 10-Apr.
- The reason for this decreasing trend in value of R_o is because of LOCKDOWN Imposed on 28-MAR. (this point is discussed in detail further with supporting results)

Precautionary measures:

Since there is no vaccine available for COVID-19, we have to rely on precautionary measures in the initial stages. Among them all, imposing LOCKDOWN is the most effective one to maintain social distancing on a large scale. It significantly reduces the effective contact rate and hence we can observe a decrease in R_o.



Conclusions after imposing lockdown: -

- In the subplot1 we can see that there is a drastic change in the Maximum Infections before and after lockdown. This is because of decreased effective contact rate(β) which attributes to decrease in value of R_o.
- Before lockdown R_o lied between 1.80-2.50 but after imposing lockdown R_o lied between 1.10-1.60 (with reference to data collected)
- Maximum number of infections: 24 on the 28th day of epidemic.
- Duration of epidemic: between 75 to 100 days.

Limitations of the model:

- Over-simplified model.
- Assumes that immune power is same throughout the population.
- Assumes the transmission rate of virus constant throughout the epidemic.
- Assumes recovered individual has developed immunity towards the virus.
- Uses a constant average value for some parameters whose value actually changes daily in real time. For example, R_o.

**NOTE: In the data,

No. of recovered = no. of hospital discharge (includes both no. of recovered + no. of death)

The above fact has been stated by RI Department of health on 28-APR 2020.(source : https://en.wikipedia.org/wiki/COVID-19_pandemic_in_Rhode_Island)