Monitoring Bangladesh COVID-19 spread by an adaptive SEIRD model

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Abstract- Due to the pandemic situation for COVID-19, many of our research communities giving effort in analyzing models for understanding the present situation and predicting future scenarios. In this paper we proposed SEIRD model accounting for the spread of infection during the latent period in which we also incorporate effects of varying proportion of containment taken by the government. Based on the data of CMED health ltd bd from 4th Mar, 2020 to 5th June, 2020, we obtained key epidemic parameters and make prediction on infection rate as well as total infected as a time dependent function. As the mitigation strategy of the government varying time to time. Our model can cope with that for better prediction. Also, can suggest substantial reduction in both Infected and deaths by showing the efficacy of drastic social distancing interventions.

Keywords – Machine learning, SEIRD Model, Pandemic disease, COVID-19

INTRODUCTION

COVID-19 Corona-virus has renewed the interest of the scientific in the mathematical models for the epidemic. Many researchers are working hard for proposing new refined models to analyze the present situation and predict possible future scenarios. With this paper, we hope to contribute to the ongoing research on this topic and to give a prediction regarding total number infected during latent period, duration of the epidemic.
The modelling of infectious diseases is currently performed by Ordinary Differential Equations (ODEs) deterministic compartmental models or by stochastic procedures. The tuning of the parameters of the equations allows better modelling of environmental features, such as social restrictions or changes of political strategies in the outbreak containment specially in Bangladesh those parameters varies often. As the mitigation strategy taken by the government is being relaxed in different scale so in our research, we have tried to influence the average contact rate by adding social distancing parameter. In this paper we will find the key epidemic parameter values from the real data. Using those parameters, we will predict future scenarios. We will take 5 sets of parameters and for the initial value we will take the most recent data. Here we will try to show the possibly latent period as well as predict day wise cumulative infected, recovered and deaths.

OUR DATASET

We have collected the data set from CMED health ltd bd. There we have the data available from 4th may, 2021 to 20th may, 2021. There are 3 attributes named confirmed, recovered and deaths.

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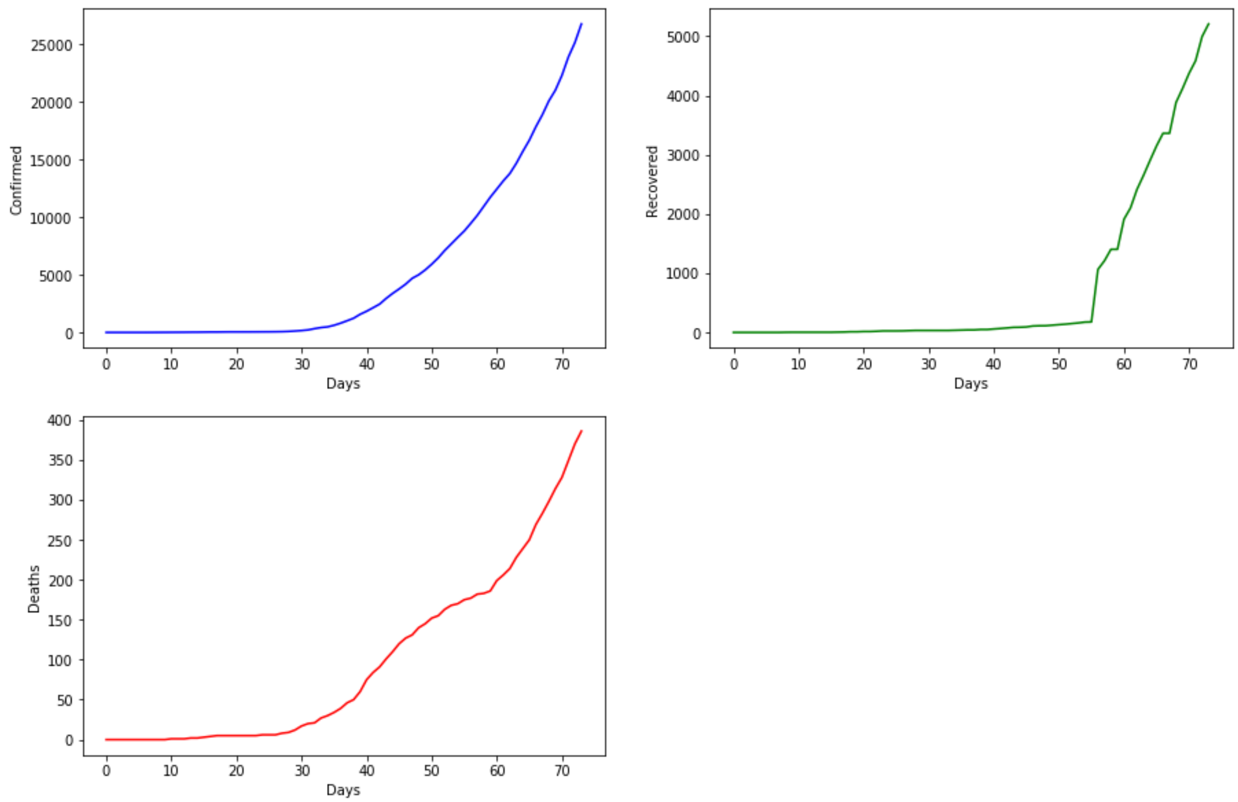

Figure 1. Data Visualization

MATERIALS AND METHODS

The Proposed SEIRD model –

The epidemiological compartmental model divides the population into groups, where the changes in those groups in time is described by continuous functions, and model the relations between the groups with ODEs involving the relative functions. The first step to begin the simulation is to determine the differential equations regarding the model. We have divided the total population in five groups. They are susceptible, exposed, infected, recovered and deaths. Susceptible people $S(t)$ are those who are in the epidemic area but not exposed, Exposed people $E(t)$ contacts with infected people but not yet infected, infected people who already show symptoms $I(t)$, and recovered people $R(t)$ who are recovered from the disease and acquired immunity and the ones who sadly died from the disease $D(t)$.

Their sum, at each time t, is the total number N of individuals in the examined population, i.e. N = S + E + I + R + D.

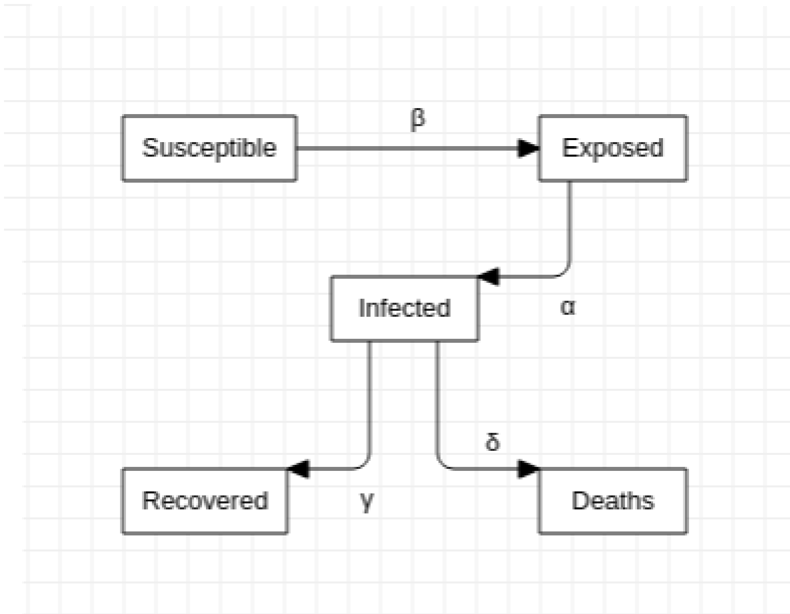

Figure 1. SEIRD Diagram.

The system of the equation in the SEIRD model is given by:

$$dS/dt = -\beta S(t)I(t)/\mathrm{N}$$

$$dE/dt = \beta S(t)I(t)/N - \alpha E(t)$$

$$dI/dt = \alpha E(t) - \gamma I(t) - \delta I(t)$$

$$dR/dt = \gamma I(t)$$

$$dD/dt = \delta I(t)$$

Where α is the inverse of Incubation period, β is the average contact rate in the population, γ is the inverse of the mean infection period and δ is the average death period.

In the first equation we get a number of people who are being exposed in β rate and the number of total susceptible people will get decreased by that amount in a certain time. In the second equation we can find the exposed people by subtracting the number of recovered people from the number of exposed people on that day. In the third equation we can find the number of infected people on that day by subtracting the number of recovered people and deaths and In 4th and 5th equation we can find the number of recovered people and deaths. We will sum the results with the previous observations to get the cumulative numbers of people in a group up to that time.

Parameter estimation–

After Solving the derivatives, we found the key epidemic parameters as follows:

$$\beta(t) = ((dS + dI + dR + dD)\ \mathrm{N})/S(t)I(t)$$

$$\alpha(t) = (dI + dR + dD)\ /E(t)$$

$$\gamma(t) = dR/\ I(t)$$

$$\delta(t) = dD/\ I(t)$$

Using those equations, we have obtained the parameter values from the available data. To do so we had to estimate the initial exposed people and also the susceptible people. We assumed initial exposed as the next 10 days confirmed people eliminating the infected people of current date. The initial susceptible people found as follow as:

$$S\_0 = \mathrm{N} - E - I - R - D$$

Running the model with several interactions we saved five set of parameters based on the very recent data. We made predictions for each set of kay epidemic parameters.

α	β	γ	δ
0.002364681376862381	**1.832158299420991**	**0.014793830657853321**	**0.0010072395341517155**
0.0030209809578816	**1.8489007782172215**	**0.015455204056991065**	**0.0008452064718666989**
0.0035548350512816657	**1.862636567048207**	**0.012068082199578755**	**0.0011954232367507257**
0.002597181278169799	**1.8381994639070731**	**0.021546261089987327**	**0.001108998732572877**
0.0031390548557097358	**1.8523748532598479**	**0.010831055774876**	**0.0008097985626075514**

Table-1 Values of key epidemic parameters

RESULTS AND DISCUSSION

As a part of monitoring we have applied SEIRD model for 5 different sets of parameters and observed 5 different predictions, each of them is very close to the real data. Our predictions came up with minimal error rate. In this research we also have tried to find the latent period where we found the pick value of total number of infected people around 17.5 million.

Date	Infected	Recovered	Deaths
2020-05-21	**20535**	**5123**	**356**
2020-05-22	**21784**	**5472**	**391**
2020-05-23	**22916**	**5951**	**419**
2020-05-24	**25176**	**6349**	**444**
2020-05-25	**26023**	**6783**	**487**

Table-2 Real data of 5 days from 21^{st} may to 25^{th} may, 2021

Date	Infected	Recovered	Deaths
2020-05-21	**20835**	**5459**	**405**
2020-05-22	**21881**	**5767**	**426**
2020-05-23	**22996**	**6091**	**448**
2020-05-24	**24186**	**6431**	**471**
2020-05-25	**25452**	**6789**	**495**

Table-3 Prediction of 5 days from 21st may to 25th may, 2021 Using 1st set of parameters

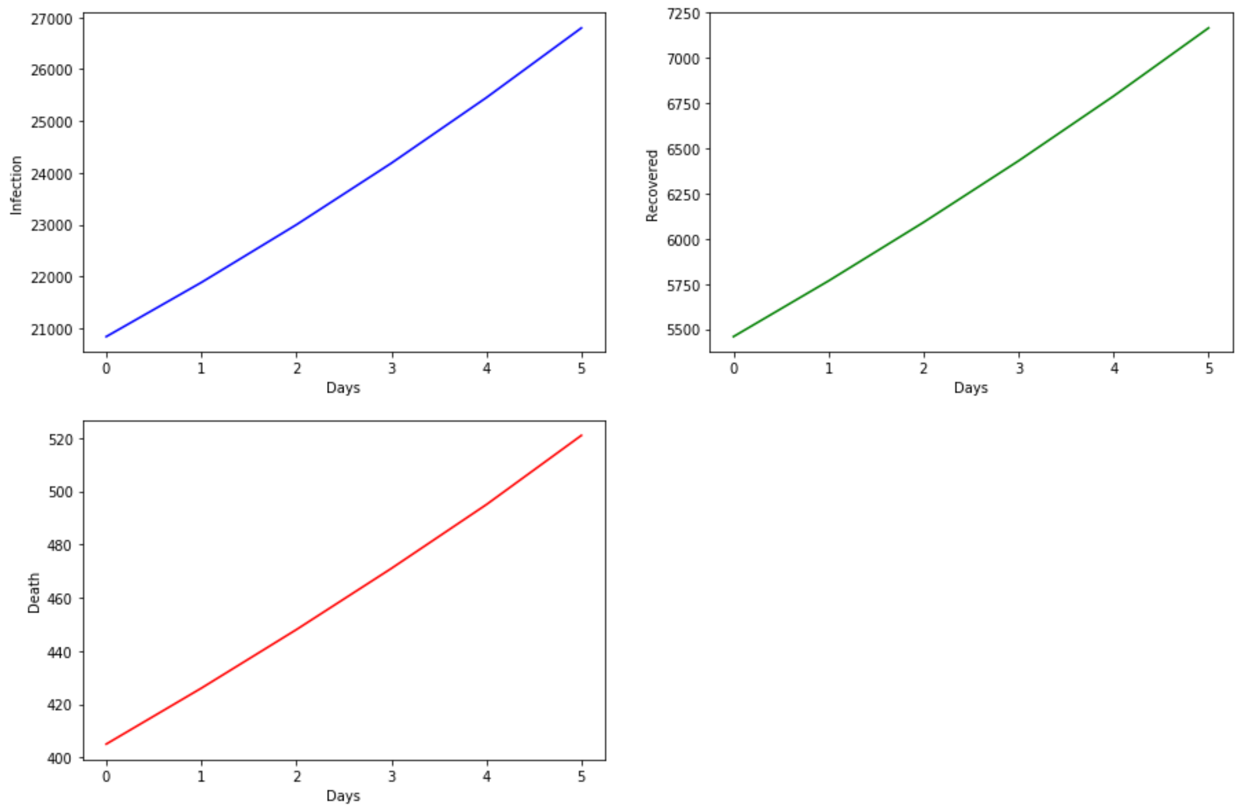

Figure 3. Infection, Recovered and Death curve without containment for next 5 days.

After observing the curve and the related data found by predictions shows that the change rate is almost linear. And the model sometimes causing over prediction for the time distance taken as one day which is a long period. We have got almost similar predictions for other key epidemic parameter sets.

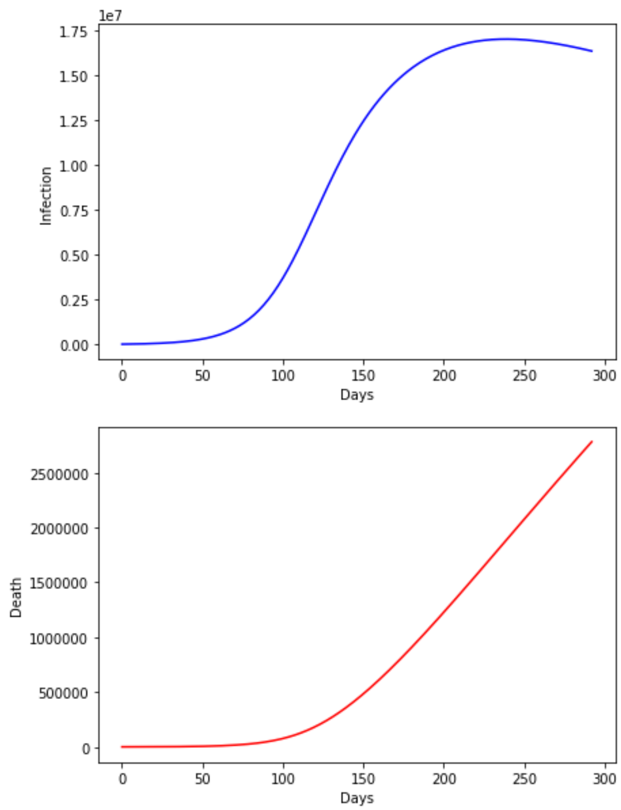

Figure 2. Infection, Recovered and Death curve without containment for next 300 days.

According to our prediction, this will take almost 7 months to see the maximum number of infected people. After that the curve will be flatten gradually. If no mitigation strategy is followed then the prediction shows that at the end of December,2021, we might observe around 17.5 million people infected and 1.45 million deaths. In the above figure we can see the infection curve is flattening after 245 days.

Also tried to impose social distancing measure with reducing the average contact rate by four fifth and found the curve below.

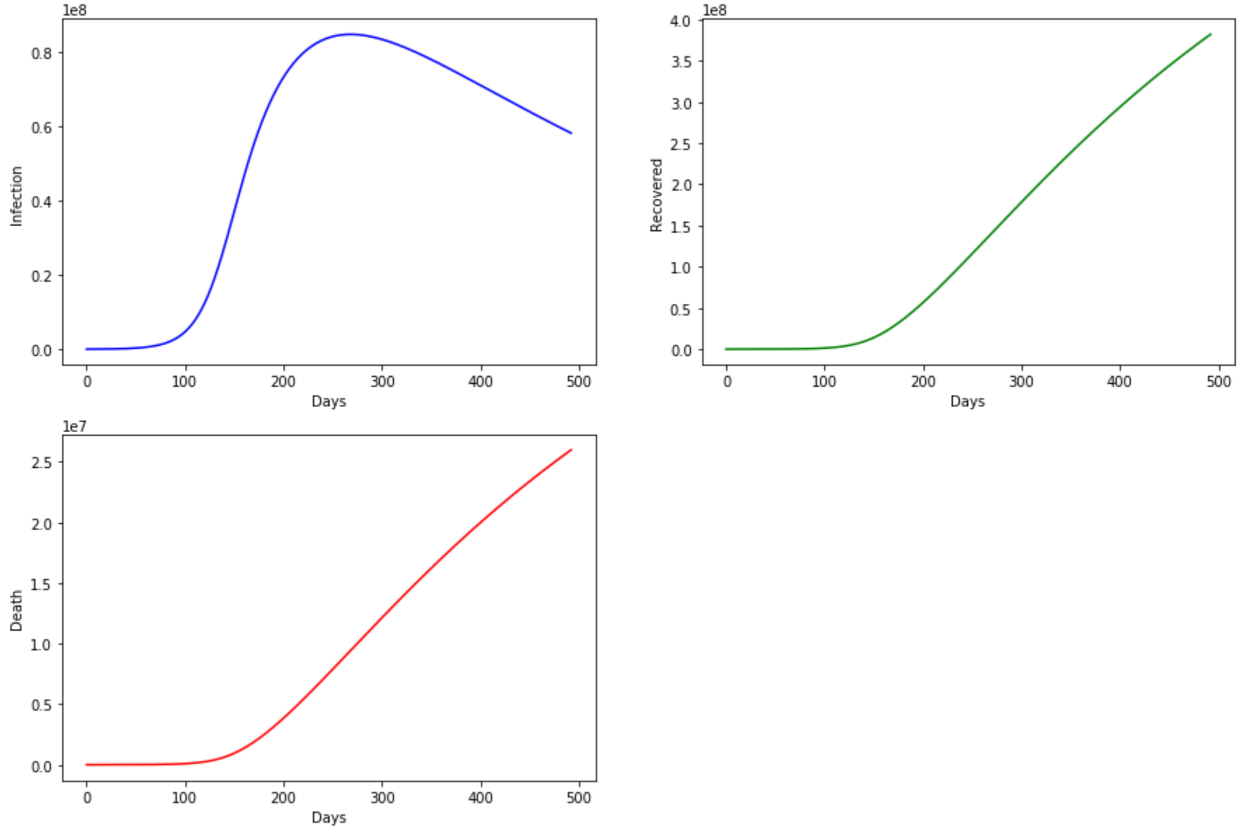

Figure 3. Infection, Recovered and Death curve for next 500 days

CONCLUSION

In this study we propose a adaptive SEIRD model to analyze the COVID-19 outbreak diffusion in Bangladesh. Here we tried to incorporate another stage named deaths with the existing SEIR model to make the model predicting death scenario as well. In our new formulation, we have found the parameter values solving the derivatives, where the key epidemic parameters have been adaptively learned by the real data. This model flexibly takes account of the successive mitigation strategies imposed by the Bangladesh Government to contain the outbreak. The results obtained by fitting the data of Bangladesh, available since February 4th mar, 2020, show a very good fit to the data, with very small errors.

We have then used the model to forecast the epidemic spread for future times especially we tried to find the latent period. We have considered five different key epidemic parameter sets obtained from the data to describe the infection rate coefficient and shown the simulation results obtained with each of them.

We highlight that only a few days passed since restrictions started in Bangladesh and, maybe in the next few days, the effects of such measures will be more evident, hopefully causing a further decrease in the infection trend.

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