



Estimation of the Final Size of COVID-19 Epidemic in Balochistan

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Significance:

SIR model is used in this study to predict the magnitude of the disease in Balochistan from May 2020 on wards when lock down and other social distancing measures were loosened up by the government of Balochistan. Our Prediction model shows that about 30,00000 individuals in Balochistan will be infected by 5th of July 2020. Over all 25% of the total population of Balochistan will be affected by this disease with 98% (2940,000) recovery rate by the end of 15th July 2020.

ABSTRACT

COVID-19 is a new disease that is spreading very fast in Pakistan. Cases have been reported from all of the provinces including Balochistan. The first two confirmed cases in Pakistan had travel history by road from Iran to Balochistan, hence SIR model used to predict the magnitude of the disease in Balochistan from May 2020 on wards when lock down and other social distancing measures were loosen up by the government of Balochistan. Our Prediction model shows that about 30,00000 individuals in Balochistan will be infected by 5th of July 2020. Over all 25% of the total population of Balochistan will be affected by this disease with 98% (2940,000) recovery rate by the end of 15th July 2020.

Introduction

The first case of COVID 19 appeared in Pakistan in the month of Feb 2020, since than the infection has spread all over the country. Cases have been reported from all the four provinces including Balochistan. Since it is a new disease it is highly expected to become endemic in Pakistan very soon. The first case of COVID 19 in Pakistan had travel history by road from Iran to Pakistan, and it had to travel from Balochistan which is situated at the crossroad of trade route between Pakistan and Iran.

Since the government of Balochistan has relaxed the lock down measures from May 2020 it will have huge impact on the spread of the disease. Considering this situation, the SIR Mathematical modeling can play a key role in predicting the overall impact of COVID-19 in Balochistan.

SIR mathematical model is a compartmental model, it assumes the whole population of Balochistan into three compartments i.e. Susceptible (S), Infected (I) and recovered (R). Every individual in Balochistan will have to pass through all of these compartments.

SIR model operates under the assumption that the total population of Balochistan remains constant and no new births, deaths, in migrants and out migrants are included in the modeling. The model predicts the overall epi-curve by not taking into consideration several factors like age, gender, lock-down, quarantine and social distancing. The Recovery (R) compartment assumes a permanent immunity for the infected individuals and also consider the number of individuals that died due to COVID-19 into consideration. COVID-19 is a novel infection and not much is known about it. It may become endemic in Pakistan in near future. So far, no published study has surveyed the impact of COVID 19 in Balochistan.

Every infection follows a triangle of agent, host and environment. Every infection can classify society in to three categories i.e., susceptible, infected and recovered. Various factors come into play while considering such classification e.g., β : how often a susceptible and infected contact results in a new infection; γ : rate of an infected recovers and moves into recovery phase. (1)

Estimating the true picture of COVID-19 is essential. It could help us in decision making and policy guidelines, more over it would tell us the rate of spread and its potential of transfer from human to human. (2,4) In Wuhan the COVID-19 transmission started from the veterinary market. It is actually believed that this virus jumped from the bats to humans. Remission rate got severe day by day mostly affecting elderly showing symptoms while the young population remain asymptomatic. (3)

The R_0 for COVID-19 has been estimated between 2 and 4, with such rapid progression this infection was able to become pandemic. The disease is also deadly with almost 2% mortality rate. (5,9) Various phase adjusted estimates like sub-clinical, pre-clinical and clinical could possible explain the natural history of this disease but since most of the cases are asymptomatic hence it is very hard to classify and identify each and every carrier in a huge population, making it difficult to identify the cases. Event based surveillance system came up with a suspected case definition; every individual with fever, cough, and shortness of breath from experienced during the last 14 days, vaguely. (6)

The COVID-19 has shown little to no effect to various antibiotics used for the treatment; other clinical trials with controlled and blinded studies could potentially be able to produce a drug for this study. Hence, no effective treatment could be suggested to the critically ill individuals. (7) The Novel corona virus is a new disease; we can't surely state its symptoms and signs particularly when most of the individuals are asymptomatic. Major lessons learned are to use masks, protective gown, goggles, social distancing, hand washing etc. Because this virus is able to sustain

on surfaces for a longer period of time probably 12 days. (8,10)

Materials and Methods

A Mathematical Prediction Modeling conducted at District Quetta. The whole population of Balochistan (i.e., 12,344,408) was included in the study. Data was collected from daily situation report and analyzed through Vensim Software. SIR-Model Assumptions was used on this data. The model is built on the following set of assumptions, based on the methodology described by Ronald Ross and William Hammer 1, is expressed as the following differential equations:

$$\begin{aligned} \frac{dS}{dt} &= -\beta IS/N \\ \frac{dI}{dt} &= \beta IS/N - \gamma I \\ \frac{dR}{dt} &= \gamma I \end{aligned}$$

Where S: Susceptible, I: Infected, R: Recovered, dt: Rate of particular disease and others as described above.

The basic assumption of the SIR model is that the total number of susceptible infected and recovered cases at any given time is equivalent to the test population, so the equations can be represented as:

$$S(t) + I(t) + R(t) = N$$

The basic reproduction number (R_0) is a ratio between the fraction of individuals susceptible per day (β) and the fraction of recoveries (γ); represented as:

$$R_0 = \beta/\gamma$$

The value of R_0 plays a significant role in determining the infectiousness of a certain disease-causing organism. Therefore, the rate of change in infected individuals is directly dependent on the R_0 , given by:

$$\frac{dI}{dT} = (R_0 \frac{S}{N} - 1) I$$

Further assumptions of the SIR model assume that if the R_0 is greater than the ratio of total population and the susceptible cases at time zero then it would imply that the outbreak will turn into a full-fledged epidemic.

$$\begin{aligned} R_0 &> N/(0) \\ \frac{dI}{dt} (0) &> N/(0) \end{aligned}$$

Similarly, if the R_0 is less than $N/S(0)$, then it would imply that the outbreak will not cause an epidemic. Therefore, the R_0 plays a crucial role in determining the fate of an epidemic.

$$\begin{aligned} R_0 &< N/(0) \\ \frac{dI}{dt} (0) &< N/(0) \end{aligned}$$

Model Parameters: In the case of COVID-19, the value of R_0 is highly variable and varies from country to country. Several sources report a range of R_0 values between 1.4–3.9, therefore, we took an average value of 2.65 for our current analysis. The value of R_0 will continue to evolve as the epidemic progresses throughout the globe. The value of γ was considered based on the average infectious period for COVID-19, so $\gamma=0.14$. The value of β was calculated to be 0.378 from equation

$$R_0 = \beta/\gamma$$

The so was assumed to be 12,344,408 since the entire population of Balochistan is susceptible to COVID-19, as the disease is new and is spreading across all regions.

Results

The SIR model for the spread of COVID-19 in Balochistan, under the assumptions mentioned in Model Parameters, indicate that the number of infections will peak on Day 45 (5th July 2020), where 3,000,000 individuals could be potentially infected. Over all 25% of the total population of Balochistan will be affected by this disease with 98% (i.e 2940,000) recovery rate by the end of 15th July 2020.

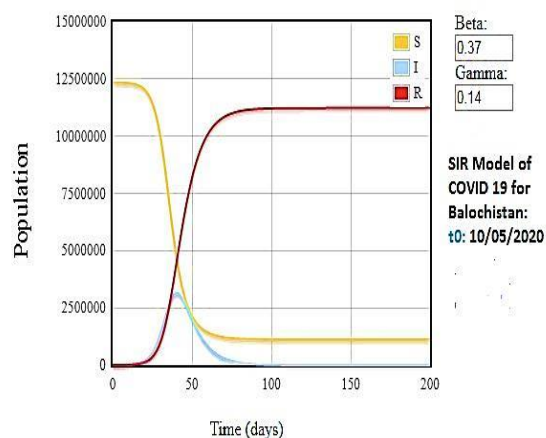


Figure 1; The SIR Model of the COVID-19 Epidemic in Balochistan. The simulations suggest that peak infection day will fall on $T=45$, where $I_{(45)}=3000000$. The epidemic should have resolved by $T=100$ where the value of $R_{(120)}=2940,000$. Susceptible cases (S) shown in orange, Infected cases (I) shown in light blue and Recovered cases (R) shown in Green. The x-axis represents the number of days, whereas the y-axis represents the number of cases.

Discussion

Our study was focused on modeling the COVID-19 epidemic in Balochistan in order to estimate the number of infections, the peak infection day, the rate of increase of infections per day and the resolution of the end-point of the epidemic. (1)

The simulation parameters were adjusted according to the population of Balochistan. Our model simulated the conditions where COVID-19 is spreading in a closed population of 12,344,408 people, without the effect of any extraneous variables such as social distancing, hand washing or travel restrictions. The values of $R_0=2.65$, $\beta=0.378$ and $\gamma=0.14$ were used.

According to the simulations the peak infection day will occur on 5th July 2020, where 30,00000 persons could get infected with the virus. Previous reports from China (8) have indicated that COVID-19 initially follows an exponential growth pattern (9)

coupled with asymptomatic carriers (10), leads to a rapid increase in the number of infections.

The study starts from the 10th May 2020 using the situation report and prior to 200 days the peak is predicted to have reached with 30,00000 individuals infected that is almost 25% of the population will be infected till 5th of July 2020 (11).

However, the major concern for Balochistan would be the healthcare system which would not be able to cope with the overwhelming number of patients if the trajectory remains the same. Studies place the mortality rate of COVID-19 at 2.3%, severe cases at 14% and critical cases at 5% (8, 12), which would imply that potentially 60,000 could die; 420,000 cases could become severe and 150,000 could become critical during the aftermath of epidemic in Balochistan. Therefore, there is an urgent need to implement effective measures to curb the rise in COVID-19 infections in Balochistan, otherwise it could lead to drastic consequences.

Conclusion

Estimating the true picture of COVID-19 is essential. It could help the Government of Balochistan in decision making and policy guidelines. Moreover, it would tell us the rate of spread and its potential of transfer from human to human. COVID-19 is a new disease not much is known about it and it is expected become endemic in Pakistan soon as a result, annual morbidity and mortality is expected. As the diseases can spread quickly in a population, due to its R_0 ranging in between 2 and 4 and with almost 2% mortality rate.

Conflict of interest: Authors do not have any conflict of interest to declare.

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Human/Animal Rights: No human or animal rights are violated during this study.

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