Can I Trust You?

A comparative study on Covid-19 epidemic models, India

Name: Manu Tom
Reg. No: 20BDA23

Abstract

The COVID-19 pandemic caused by the SARS-CoV-2 virus has by now led to more than a hundred and seventy-eight million cases and nearly three million deaths worldwide. With its high population density, India is under the strike of the second wave, which was unexpected. As hospitals in many cities run out of beds, people are forced to find ways to treat sick people at home. Lack of oxygen and isolation beds within the hospitals make the situation worse. To cope with the health crisis of this magnitude, governments everywhere would require accurate projections of the progress of the pandemic, both in space and time. Many epidemic models are proposed to see the dynamics of the virus and its projection to the future. The government of India has set up a committee that includes statisticians, mathematicians, and health care officials to develop an epidemic model that projects India's situation. This paper compares two such models- the SUTRA model and the IISc-Covid 19 model. Both the models differ by their approach to modelling say, parameters used, factors influencing the spread, and how mutation of the virus with respect to time is treated, etc. The results show that both the models are good, and we cannot conclude that one is better than the other. However, both models have drawbacks. The best thing to do is take only the valuable insights from all the models rather than focussing only on one particular model.

1. Introduction

The novel coronavirus, named Severe Respiratory Syndrome COronaVirus, subsequently named SARS-CoV-2, was first reported in Wuhan, China, in December 2019. The outbreak came into the picture on 30th December when China informed the World Health Organisation about the cluster of cases of pneumonia with an unknown cause. Eventually, the disease started spreading to different provinces of China and later on to different parts of the world. On 30th January 2021, one month after the report from China, the World Health Organisation declared the outbreak a Public Health Emergency of International Concern. World governments were informed about the outbreak and were asked to take necessary measures to bring the situation under control. However, the spread was irresistible. On 11th March 2021, WHO Director-General Dr Tedros Adhanom Ghebreyesus announced SARS-CoV-2 as a pandemic. He said, *"Pandemic is not a word to use lightly or carelessly. It is a word that, if misused, can cause unreasonable fear, or unjustified acceptance that the fight is over, leading to unnecessary suffering and death"* [1]. He also quoted, *"Describing the situation as a pandemic does not change WHO's assessment of the threat posed by this virus. It doesn't change what WHO is doing, and it doesn't change what countries should do"* [1]. He requested the governments to develop comprehensive strategies to prevent infections, save lives and minimise the report. Following these orders, many countries took measures to control the spread. Different strategies were proposed by the advisors and respective health care officials to prevent, minimise and control the existing cases. Complete lockdowns were initiated in almost all the countries, restricting domestic and international flights, asking people to stay in their own homes, providing quarantine to the susceptible people, isolating the infected people, and so on. All these measures were helpful to some extent but could not serve the purpose. So the analysts thought of testing the strategies and ideas in virtually created situations to improve them for better planning. This was when the idea for mathematical modelling and simulation came into the picture.

Mathematical modelling and simulation allow rapid assessment. Simulation is used when the cost of collecting data is comparatively expensive or there are a large number of experimental conditions to test. Over the years, many approaches have been proposed looking at the problem from different perspectives. The very first publication addressing the mathematical modelling of epidemics dates back to 1766. Daniel Bernoulli developed a mathematical model to analyse the mortality due to smallpox in England. He used his model to show that inoculation against the virus would increase the life expectancy at birth by about three years [2]. Later in 1927, Kermack-McKendrik proposed a mathematical model called the SIR model for predicting the infectious category of cholera virus. The idea of the SIR model was to divide the whole population into different compartments, say, Susceptible, Infected, Removed. The models observe the rate at which people in the susceptible state become infected and later removed. The model became widely accepted as it was simple and wholly defined on ordinary differential equations(ODE). One of the essential aspects of epidemics revolves around surveillance, early detection of possible outbreaks, and patterns that may help control a spread. Mathematicians and statisticians use this model to see the projection of infection caused by the pandemic on the population along with these aspects. New compartments are added, or the existing ones are partitioned to incorporate these aspects.

Like all other nations, covid-19 struck very severely on the Indian population. In the beginning, coronavirus cases in India happened due to the abroad connection rather than transmission within the country. The first three cases occurred on 30th January and 3rd February in Kerala as people returned from Wuhan, China. Within a month later, on 3rd March, two more cases were reported where one patient had a travel history from Italy while the other in Hyderabad had visited Dubai. On the very same day, few other cases were observed in Jaipur. To control this spread, the Ministry of Health and Family Welfare (MoHFW) issued travel advisory restrictions which were similar to the previous pandemics such as SARS, Ebola, and bubonic plague, including the imposition of self-quarantine rules for 14 days to all international travellers entering the country [3]. The Indian government took strict measures to stop the spread of the Coronavirus pandemic. Mr Narendra Modi, the Prime Minister of India, declared a complete lockdown in India on 24th March 2020, lasting till 14th April 2020. As of 22nd April 2020, India has reported 18,985 confirmed cases and 603 deaths from COVID-19 in 31 states and union territories since its first case on 30th January. Due to this lockdown, mobility in grocery and pharmacy, recreation and retail, transit to station visits to parks, and workplaces reduced by 64.2%, 70.51%, 65.6%, 46.17and 60.03%, respectively. Due to the growing number of infections from COVID-19, on 14th April, the Indian government declared an extended 2nd phase lockdown till 3rd May, which was further lengthened till 17th May and later imposed until 31st May.

Looking at the current trend in India, from the first confirmed case to a total number of 107 confirmed cases by 15th March, many organisations started to see the projections in the daily confirmed cases. Indian Council of Medical Research (ICMR) projected that India could reduce the cases by 62% if social distancing and proposed quarantine interventions are effectively executed. Many researchers found how important it is to make the projections and started working on them. Mathematical epidemic models started playing a vital role to make these projections. IIT Kanpur, IISc Bangalore, Prof. Vidhyasagar, and other renowned statisticians and mathematicians started working on it. As a result of their hard work, many models came out with projections of the infection. The SUTRA model, IISc-Covid 19 Model, COV-IND-19 are some of the best of them that could predict infection projection.

In this fight against COVID-19, the epidemic models put forward by our mathematicians and statisticians play a prominent role in helping the government take measures to control the situation. In this paper, a comparative study on the existing models is done based on the approach, parameters, factors considered, and dynamics of the virus. We consider two models, the SUTRA model and IISc-Covid 19 Model, put forward by IIT Kanpur and IISc Bangalore. These two models tried to incorporate the dynamics of infection and the virus from the existing epidemic models.

2. Methodology

Epidemic modelling and forecasting became the key to see the projection of a pandemic. Over the past century or so, various epidemic models have been developed. It had gained renewed interest since 2019, when the world was affected by Covid-19. Several computational studies to predict the spread of Covid-19 have been reported. Most of these efforts have been based on compartmental models and stochastic models (including agent-based models). In compartmental modelling (SIR, DELPHI, SAIR), the whole population is divided into compartments and the dynamics of the population are computed using ordinary differential equations. But all of these models were based on the premise that the disease spreads when an infected person comes into contact with a susceptible person. However, a distinctive feature of the COVID-19 disease is the presence of a huge number of asymptomatic people, who are infected and thus capable of infecting others but are not explicitly identified by the health authorities as they do not show any symptoms [7,6].

2.1 SUTRA model

The Government of India formed a national COVID 19 Supermodel Committee on 27th May to make projections about the spread of COVID 19 in India and help in making short and long-term plans to defend the country from the dangerous disease caused due to the virus. The committee was asked to submit the first cut model by 1st July. The committee asked the researchers in India who have completed the modelling for the pandemic to share their findings, go through it, take the valuable information and meld it. After submitting the model, the government asked the committee to work more on it to see the future projections. This led to the discovery of the proper structure and made the projections.

Different from other pandemics, Covid-19 has a more significant number of asymptotic cases. Most of these asymptotic cases are undetected and continue to pass from person to person. Only people in severe states become symptomatic. Questions were raised on how to capture this without detecting it. Even though the SAIR model captures the dynamic well, it does not provide an easy way to estimate parameters and asymptomatic cases. This paved the path for a new mathematical model for pandemics that have asymptomatic patients, called SUTRA. SUTRA stands for Susceptible-Undetected-Tested(positive)-Removed Approach model. Similar to the SAIR model, SUTRA is also a compartmental mathematical model for the spatial and temporal evolution of a pandemic with asymptomatic patients[6] and Susceptible, Undetected, Tested(positive), and Removed are the compartments (fig 2.1.1). This model uses ordinary differential equations to see how people move from one category to another. For predicting the spread of Covid-19, the model considers six parameters. β : Contact rate, governs the speed at which people get infected (measures how many new people an infected person infects per day (R_0)), γ : Removal rate, governs the speed at which infected people get removed, η : Mortality rate, ϵ : Ratio of detected to total infections, c : Constant connecting R_T to R_U *and* ρ : Reach of the pandemic (measures the exposure level of the population to the pandemic). These parameters make up the SUTRA model.

The transition from undictated to tested positive is the fundamentals of the SUTRA model. In most countries, once a person tests positive (i.e., infected) for the SARS-CoV-2 virus, contact tracing begins, whereby family members, and anyone else who might have come into contact with the person who tested positive are themselves tested. Some of these tested persons would be found to be positive, while others would test negative. Those who test negative need not concern us, as they belong to the Susceptible group S. However, among those test positive, which we call T, it is possible to make a further subgrouping into T_A (tested positive and asymptomatic) and T_S (tested positive and symptomatic). In contrast, those in the group U are infected but asymptomatic, and thus are not detected. The point is that, due to contact tracing, some fraction (however small) of asymptomatic patients are also identified [6].

The values of the parameter change in the course of time. The values of γ and η changes with improvement in healthcare, lockdowns and other personal protection measures reduce the β etc. In order to model this with respect to time, the time is divided into different phases identifying when the parameter value change.

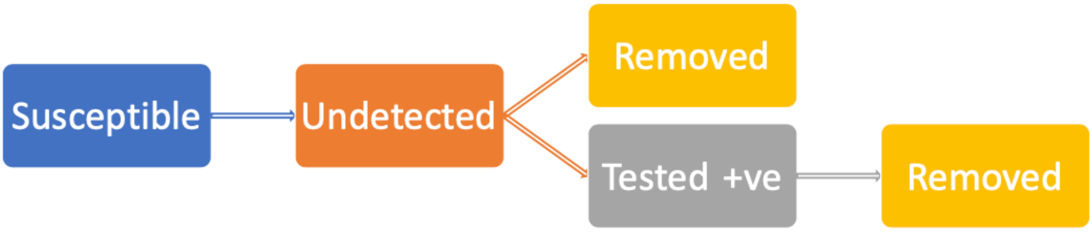

Figure 2.1.1

- Let $S(t)$, $U(t)$, $T(t)$, $R_U(t)$ and $R_T(t)$ represent fraction of population in each of five groups at time t.

$$\boxed{S(t) + U(t) + T(t) + R_U(t) + R_T(t) = 1}$$

- Dynamics:

$$\frac{dS}{dt} = -\beta SU$$

$$\frac{dU}{dt} = \beta SU - N_T - \gamma U$$
$$\frac{dT}{dt} = N_T - \gamma T$$

$$\frac{dR_U}{dt} = \gamma U$$
$$\frac{dR_T}{dt} = \gamma T$$

Figure 2.2.2

2.2 IISc-Covid 19 model

The idea for IISc-Covid 19 came from the question of whether the information from the compartmental models was enough for planning lockdown and strategies, public health policies like quarantine rule, hospital beds, health insurance, vaccination or treatment scheduling etc. So they came up with the idea of a partial differential equation-based spatio-temporal predictive modelling framework for forecasting the spread of infectious disease in heterogeneous populations in open geographies [7]. The roots for this model lie in the population balance equations that are popular in chemical engineering and process studies [8]. In this model, the infected population density is defined as a scalar field on a high-dimensional space. For predicting the spread of Covid-19, a six-dimensional model is presented. The first three dimensions are the space and time, and the other three are the infection severity, duration of the infection (i.e., time since infection), and age of the population. New infections, the impact of quarantine, testing, contact tracing, immunity, intervention policy impact, health infrastructure, recovery, and death are all modelled on this six-dimensional space based on data-driven functions and simple algebraic and integral functions [7].

Certain assumptions about Covid-19 were made for the model. The model assumes that almost 30 lakh people get vaccinated every day with 70% effectiveness. For every reported case, there will be two unreported cases, no interstate transmission of covid or air travel, lockdown restrictions, and once there is an unlock, people follow the social distancing guidelines proposed by the government. All the parameters modelled are influenced by these assumptions.

Based on the six variables, a population balance equation is made. The idea for this equation came from chemical engineering (species interacting with each other). The most important term in the equation is the ‘Nucleation’ term B_{nuc} which controls how many new infections we introduce to the system (fig 2.2.1). The critical modelling lies in deriving this nucleation term. New infections are introduced with a disease age of zero. The internal coordinates are the unique characteristics of the population (time since infection $[l_d]$, age of population $[l_a]$ and severity of infection $[l_v]$). At every time and location, the population has a distribution in the internal coordinates. Based on this distribution, the dependency of quarantine, nucleation, deaths and recovery to the internal coordinates in addition to space and time is modelled. In the nucleation equation, new infections per infected population are basically the R_0 value in the SIR models. But here this term is much richer with information on parameters which are the knobs to control the infection (fig 2.2.2) [9].

Recovery and death are modelled as functions of age and infection levels. A fraction of the infected persons either die or recover. These are treated as two different outcomes of the disease. The partial differential equations in this model are solved using the finite element method [10,11].

$$B_{\mathrm{nuc}}(t,\mathbf{x},\ell_v,\ell_d=0,\ell_a) = \overbrace{R(t,\mathbf{x},\ell_v,\ell_a)}^{\text{New infections per infected population}} \overbrace{\int_{\Omega_\ell} [1-\gamma_Q(t,\mathbf{x},\ell_v,\ell_d,\ell_a)] I(t,\mathbf{x},\ell_a,\ell_d,\ell_v)\,\mathrm{d}\ell_v \mathrm{d}\ell_d \mathrm{d}\ell_a}^{\text{Infected population capable of causing new infections}}$$

Integration over internal coordinates

Quarantine fraction – removes infected population capable of causing new infections

Figure 2.2.1

$$R = R_0\, f_1(t,\sigma)\, f_2(t,H)\, f_3(t,S_D)\, f_4(t,\mathbf{x},\ell_a)\, f_5(\ell_v)$$

Interaction Factor $$f_1(t,\sigma) = \left[\frac{1}{1+\exp\left(-(\sigma(t)-\sigma_c)/b_\sigma\right)}\right]$$

Hygiene Factor $$f_2(t,H) = \left[1 - \frac{1}{1+\exp\left(-(H(t)-H_c)/b_H\right)}\right]$$

Physical Distance Factor $$f_3(t,S_D) = \left[1 - \frac{1}{1+\exp\left(-(S_D(t)-S_{D_c})/b_{S_D}\right)}\right]$$

Age Factor $$f_4(t,\mathbf{x},\ell_a) = a_4 \exp\left(-\frac{(\ell_a-b_4)^2}{c_4^2}\right)$$

Infection Severity Factor $$f_5(\ell_v) = \begin{cases} 3\sqrt{\frac{2}{\pi}}\exp\left(\frac{-(\ell_v-v_{\text{sym}})^2}{2(v_{\text{sym}}/3)^2}\right) & 0 \le v < v_{\text{sym}} \\ 3\sqrt{\frac{2}{\pi}}\exp\left(\frac{-(\ell_v-v_{\text{sym}})^2}{2((1-v_{\text{sym}})/3)^2}\right) & v_{\text{sym}} \le v \le 1. \end{cases}$$

- $\sigma \in [0,1]$ the interactivity index, where $\sigma = 0$ then everything is under perfect lockdown and $R \to 0$
- $H \in [0,1]$ hygiene index,
- $S_D \in [0,1]$ social distancing index, where $S_D = 1$ everyone is following perfect social distancing and $R \to 0$
- integral on the right-hand is the total non-quarantined number density of the infected population at $(t,\mathbf{x})$
- R the rate at which the non-quarantined population infects the susceptible population, R_0 is the basic reproduction rate

Figure 2.2.2

3. Dataset

"The challenge thrown up by the crisis has led us to change our workflow. In this age of social media where authentication of news is a problem, we are keeping the citizens abreast of the latest news in real-time" said H.L. Prabhakar, Project Director at CeG. The authentication of the reports of covid was widely discussed. Many online sites are helping people be informed about practising social distancing and self-isolation, besides providing other updates. The government of India launched an open website covid19india.org [4] which provides daily updates of all the reports of covid-19 all over India and other countries. Data for building these models were collected from the website. Newly added parameters in the models which help were computed from these existing data and were fitted into the models.

Covid19India:

Covid19India.org is an Indian website built to provide detailed information about the Coronavirus-affected areas in the country. The information on the website provides accurate and legit information from credible sources such as *https://www.mohfw.gov.in/* and *Mohfw.gov.in/*, which are official governmental websites. According to the FAQ section of the site, *Covid19India.org* revealed that "*MoH updates the data at a scheduled time and we update them based on State Press Bulletins and Reliable news channels".* In a question asked by a user regarding the data credibility of the site, it responded by saying "*We collect the details from each State Press release, official government links, and reputable news channel as the source. Data is validated by a group of volunteers and pushed into Google sheets*" [5].

4. Analysis

4.1 SUTRA model

The 1st projection of the model was made on 1st July. This was a meld of all models by the researchers who have been working on the pandemic model. Later the government asked the committee to come out with a model that, 1. Predict the spatio-temporal progression of the pandemic across the country, 2. Make predictions about medical inventory, 3. Policy study (lockdowns), 4. Economic optimisation. By the end of July, the committee could achieve the first three of the demands. It was found that the case fatality rate during this period was meagre.

The transition of people from undetected to tested positive with respect to time is fundamental of the SUTRA model (fig.4.1.1). In the equation all the parameters except ϵ are computed. ϵ is chosen because it will be the number of infected people initially and the rest can be estimated. The parameter values for different phases are calculated by keeping the initial ϵ value as 232. The model finds nine different phases with the drift period (time taken by the parameters to stabiles after the change/breakdown) and computes different parameter values (fig 4.1.2). The 1st phase is from 2nd March to 20th March when the number of cases was comparatively low and the government was planning lockdown strategies. The second phase is from 20th March to 24th April when there was strict lockdown initiated by the government.

The β value initially started with .033 in March and went down to 0.15 in the month of August and then went increasing up to 0.33 till March 2021. The η value, which is the mortality rate was 0.002 in the beginning and increased to 0.0063 in the second phase. The mortality rate started to decrease to 0.0008 till February 2021. The second wave began in the month of March and the mortality rate jumped from 0.0008 to 0.0011. The ρ value which is in percentage was initially 0% then raised to 4% by the end of April. This shows that almost 96% of the population was in closed pockets naturally. This happened naturally because there were states where Covid-19 haven't reached yet. Then the rate started increasing very drastically. This is influenced by the movement of migrants from states, lakh of seriousness etc... This rate shot up from 55% to 85% between February 2021 and March 2021. This was the hit time of second wave fig 4.2.

The projection of the second wave stated from February 2021 (fig 4.2.3)[12]. The model could accurately predict the intensity of the second was as the actual data and predicted data approximately coincide with each other. The government seeks insights from this projection to plan for measures to be taken to manage the situation.

$$\boxed{\hat{T} = \frac{1}{\beta(1-\epsilon)(1-c)}\hat{N}_T + \frac{1}{\epsilon\rho(1-c)P_0}(\hat{T}+\hat{R}_T)\hat{T}}$$

$$= b\hat{N}_T + \frac{e}{P_0}(\hat{T}+\hat{R}_T)\hat{T}$$

Fundamental *sutra* of the model

Figure 4.1.1

	Start Date	Drift Period	β	η	1/ϵ	ρ (in %)
Phase 1	02-03-2020	5	0.33 ±0.03	0.002 ±0.0005	37	0 ±0
Phase 2	20-03-2020	0	0.26 ±0.01	0.0063 ±0.0004	37 ±0	0.1 ±0
Phase 3	24-04-2020	5	0.16 ±0	0.0041 ±0.0002	37 ±0	4 ±0.4
Phase 4	21-06-2020	30	0.16 ±0	0.0019 ±0.0001	37 ±0	22.4 ±1.5
Phase 5	22-08-2020	10	0.15 ±0	0.0012 ±0	37 ±0	45.2 ±1.2
Phase 6	02-11-2020	10	0.21 ±0.04	0.0011 ±0	37 ±0	44.3 ±5.9
Phase 7	01-01-2021	10	0.22 ±0.01	0.0009 ±0	37 ±0	44.5 ±1.1
Phase 8	10-02-2021	40	0.39 ±0.01	0.0008 ±0	37 ±0	54.2 ±1.3
Phase 9	29-03-2021	26	0.33 ±0.02	0.0011 ±0	37 ±0	85.3 ±4.9

Figure 4.2.2

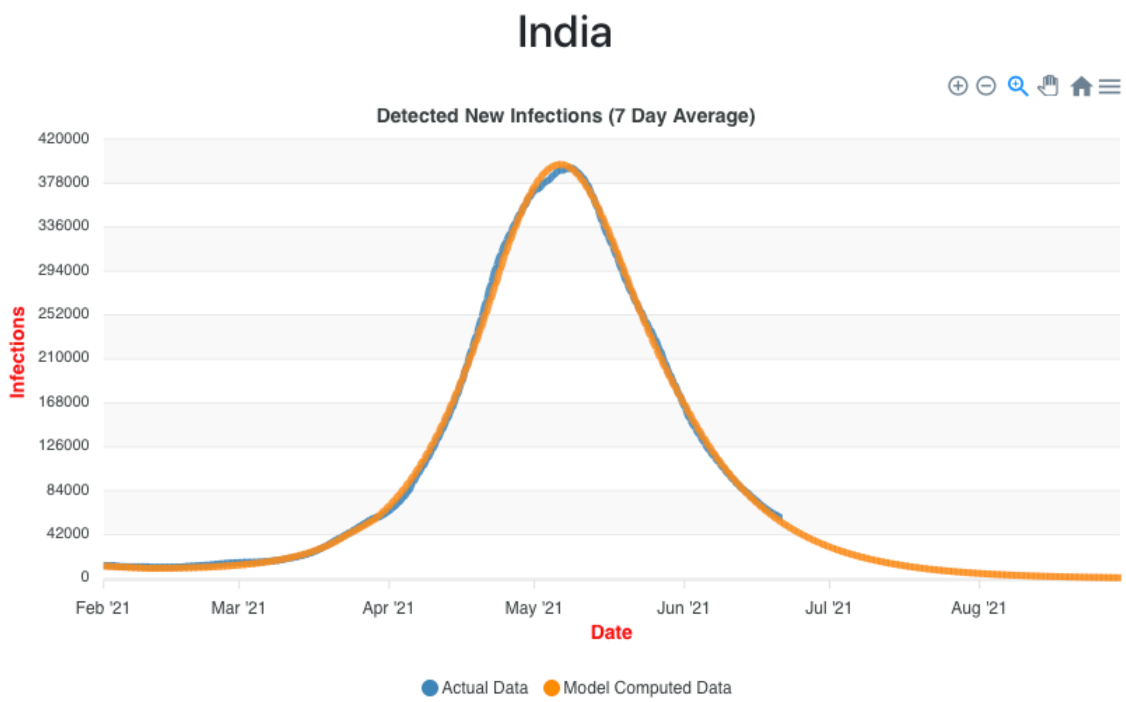

Figure 4.2.3

4.2 IISc-Covid 19 model

IISc team started working on the model in April 2020 when India was shut down due to lockdown. Five projections were made in 2020; 3rd May, 28th May, 18th June, 6th August and 19th September. Coincidence or prophecy or accurate modelling with uncertainty quantifications and ensembles, on 3rd May and 28th May the model forecasted a peak in daily cases during the month of September to December and a worst case scenario of 10 lakh active cases at peak and a total of 90 lakh cases by March 2021. Looking into the real data, the peak of the 1st wave occurred on September 18th with 10 lakh active cases and 1.2 crores by March 2021. One of the early suggestion that they put forward was the weekly lockdown (Saturday-Sunday) which could reduce 10%-20% of the cases.

Scenario analysis based on different compliance of social distancing was done to see the uncertainty band. 4 scenarios were considered for May, August projections. The current scenario spoke about the current situation during that period, a Better scenario where people totally follow all the guidelines from the government and maintain social distancing, the worst scenario in which everyone is left carelessly and an intermittent lockdown scenario. From September onwards as seroprevalence factors started coming up and different vaccines were up, this was taken as a scenario for future projections. Wave 1 with vaccination and seroprevalence, in August September updates, the model predicted a second wave (fig 4.2.1). Even though there was a projection to the second wave, it was not considered. The sero-surveys indicate that for every detected case there were 20 undetected cases. The model also anticipated that there will be 30 lakhs of vaccinated people per day in India. By November the number of daily cases decreased and no more projections were made.

In March when the second wave started, the model was used to see the projection considering the pre-assumptions(fig.4.2.2). Scenario analysis based on the lockdown strategies was considered to see the projection. No lockdown, which is considered as the worst scenario, scenario 1, 21-day lockdown-like restrictions from 27th April and scenario 2, 30-day lockdown-like restrictions from 27th April. In the worst case scenario there was an exponential growth in the daily cases and the death rate was also high. Even though vaccination is a parameter, the effect of the vaccination cannot be seen immediately. It will influence the model later in the future. Projections were made in different states of India especially cities like Bangalore where population density is very high. Projections on ICU and oxygenated beds requirement were made. It was seen that a 60% to 70% reduction in ICU and oxygenated beds can be made if lockdowns are initiated.

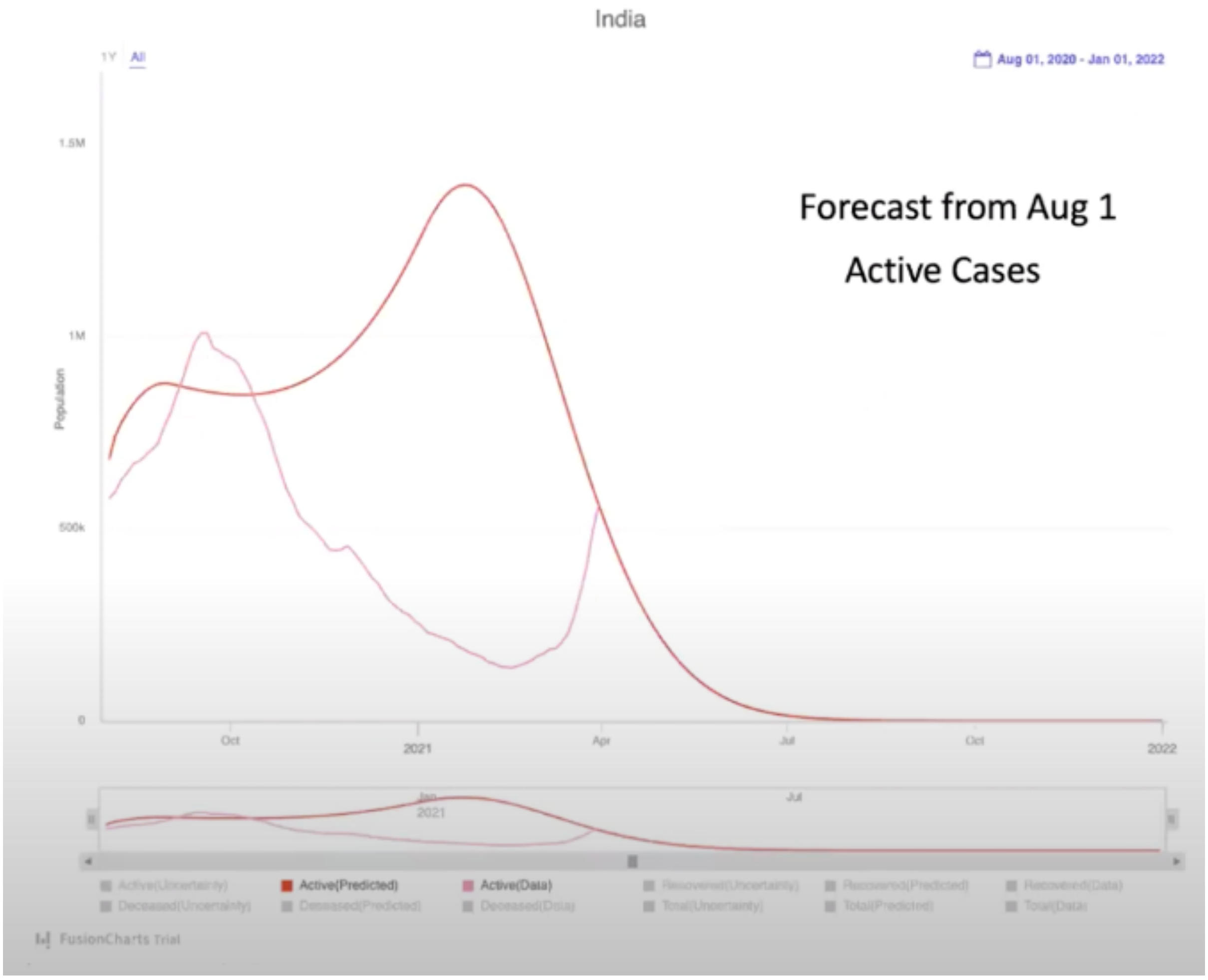

Figure 4.2.1

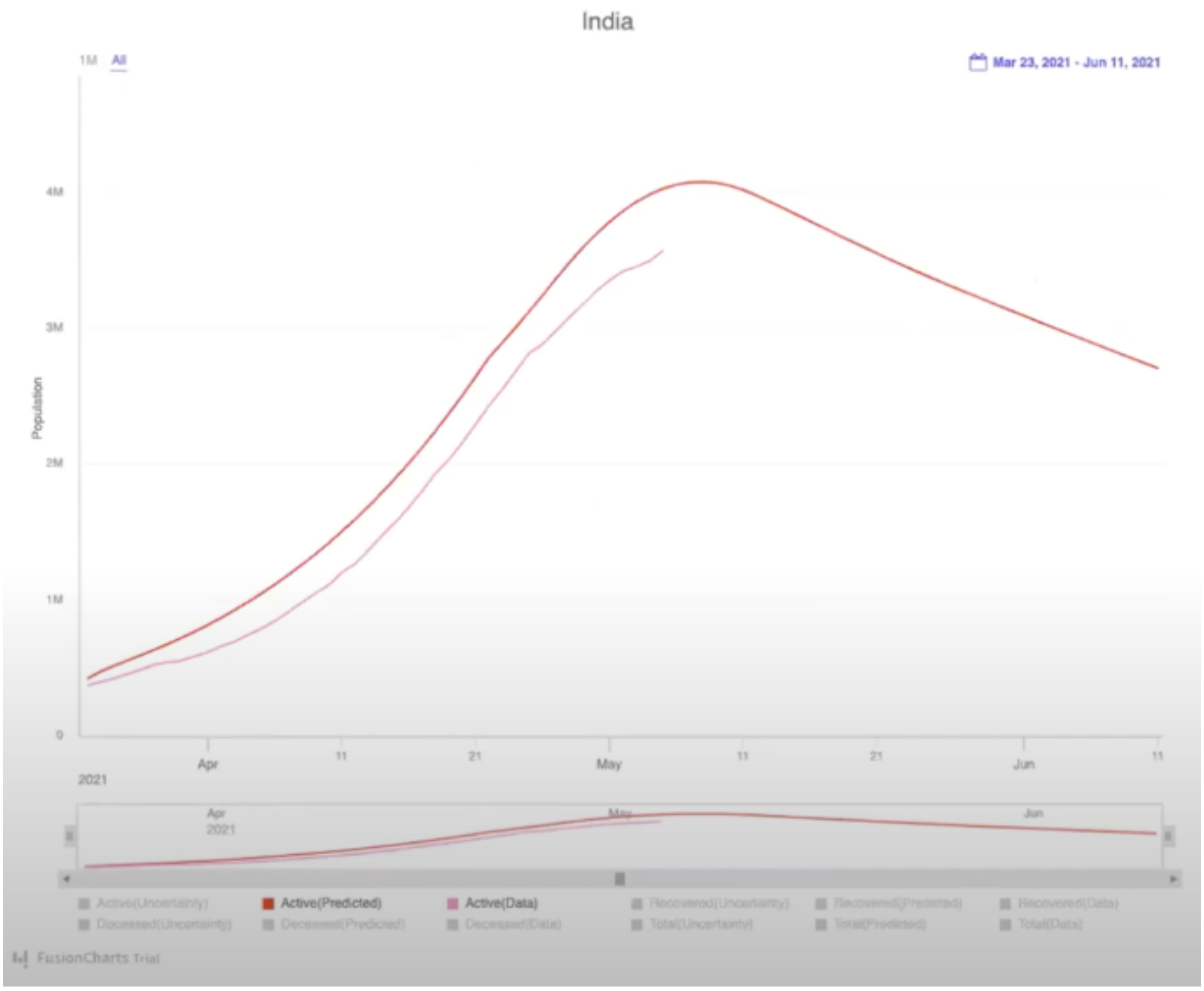

Figure 4.2.2

5. Results

"All models are wrong, but some are useful" – George E P Box

The supermodel committee or team SUTRA is a government-backed model. The model came into public attention when one of its expert members announced in October that India was "past its peak" [14]. The authentication of this model is widely discussed from the day it came into the picture. In the early days of the model, it projected that if we take necessary measures and actions to control the outbreak of covid, the rate of infection, as well as the death rate, will shoot up. People didn't take this into the deal and criticised that this is another strategy by the government to control people. But when the second wave hit us, and we were unplanned, we are clueless to believe that the earlier findings of the model were true. The SUTRA model predicted the daily infections correctly. The projected model and the actual data are almost overlapping. The accuracy of the projection within is given by ± 10%.

The major criticism that the SUTRA model faced was its prediction did not signal the catastrophic second wave. This may be due to an inaccurate parameter or calibration errors.

An official connected with the Covid-19 management exercise said that, on condition of anonymity, that the SUTRA model input was "an important one, but not unique or determining [14]." In a session with the CMI students on January 8th 2021, Dr. Manindra Agrawal said that there won't be a chance for a second wave [13]. A high number of parameters will cause computational errors. The age of the population or the mutation happening to the virus over time are not considered in the model. Another key factor is the vaccinated category, the SUTRA model does not consider that population. This brings an inconsistency in the model. The question arises, without considering all this, how the model could be so accurate. Is it the government controlling the model or the model controls the policies of the government.

The IISc-Covid 19 model took a partial differential equation based spatio-temporal predictive modelling framework. This brought a new method to mathematical epidemiological modelling. The concept of deriving the balanced equation for modelling came from chemical engineering. The model took six dimensional parameters which include the age of the disease and population age. Considering these parameters was necessary as there was mutation happening to the virus as well as even though the 1st wave hit more severely on the 60+ age of the population, we observed that during the second wave that was not the case. The time take by the virus to infect the person completely also change from time to time. The IISc model could consider all these changes. Even though the predicted number of daily cases and actual cases are not the same, considering all these parameters, IISc brought out a good model.

As George E P Box said, we cannot say one model is the best, but we can take insights from these models and take necessary measures. The key feature of SUTRA model is that it could correctly model the asymptotic population. It looks into the undetected population, which is high in the case of covid. It also provides us with the value of R_0 which is the rate at which one infected person can infect susceptible people the next day. The IISc model could create a projection by incorporating the age of the population, the age of the virus and even the vaccinated population. It assumes that nearly 30 lakh of the population get vaccinated daily. The IISc model was the 1st model to see a chance for a second wave. But the researchers didn't consider this as serious it should be and hence didn't make any further developments.

The second wave was an unpredicted event for the Indian population. The SUTRA model told that there won't be a second wave. It assumed that almost 65% of the population had the immune to the virus by the end of December. The researchers think that the second wave occurred maybe because that the immune that people had was short-term and the virus also get mutated.

Corona Virus have been around for centuries

Coronaviruses are found in a diverse array of bat and bird species, which are believed to act as natural hosts. Molecular clock dating analyses of coronaviruses suggest that the most recent common ancestor of these viruses existed around 10,000 years ago. This relatively young age is in sharp contrast to the ancient evolutionary history of their putative natural hosts, which began diversifying tens of millions of years ago [15].

6. Conclusion

Creating mathematical models for projecting infectious diseases started years back. A lot of evolution had taken place in this field. Many mathematicians and statisticians tried to make new models which could give more accurate predictions. Modelling Covid 19 was one such great task. Unlike other pandemics, the parameters that have to be considered are high in number. So the need for an efficient model for the government as well as the people was necessary. The SUTRA model and the IISc Covid-19 model are some among many models that came into picture. While SUTRA is a government backed model, IISc model is built by the professors of IISc. When there are lot of models in existence, which one to use or which is the correct one, is a major question. Only after studying this model, one could make conclusions about them. This study shows that both the models are good in its own way. When the SUTRA model gives preference to the asymptomatic population, the IISc model tries to look into the internal features if the virus. To analyse the situation, it is better to consider both of these models as they have their own merits. However both of these models could not predict about the future consistently. Since the parameter values are changing with respect to time, and one cannot predict this change, prediction about the future remains untouched. According to the study there will be a third wave coming in the next few weeks, but the magnitude of the impact still remains unknown. Thus, considering only one model is not a great choice. Always remember "*All models are wrong, but some are useful" – George E P Box.*

Acknowledgement

Mathematical epidemic modelling consists of a lot of equations and derivations. Understanding them and make a study based on that requires a lot of time. The interviews given by Dr Manindra Agrawal and professors of IISc laid the foundation during study.

A work without proper guidance may not produce good outputs. Dr Srenivas Bholge, Dr Jaythi Bhadhra and Dr Anntreessa Benny helped to complete the study.

References

1. *https://www.who.int/director-general/speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefing-on-covid-19---11-march-2020*
2. *https://doi.org/10.4161/viru.24041*
3. *https://doi.org/10.1016/j.sintl.2020.100021*
4. *https://www.covid19india.org*
5. *https://www.republicworld.com/technology-news/apps/what-is-covid19india-org-website-shows-live-data-of-coronavirus-cases.html*
6. *arXiv:2101.09158*
7. *https://doi.org/10.1038/s41598-021-86084-7*
8. *10.1146/annurev-chembioeng-060713-040241*
9. *https://youtu.be/lGCPc_TLur8*
10. *https://doi.org/10.1051/m2an/2012012*
11. *https://doi.org/10.1016/j.amc.2012.12.027*
12. *https://www.sutra-india.in*
13. *https://www.youtube.com/watch?v=LVzT4UsICRM&t=2550s*
14. *https://www.thehindu.com/news/national/government-backed-model-to-predict-pandemic-rise-and-ebb-lacks-foresight-scientists/article34479503.ece*
15. *https://dx.doi.org/10.1128%2FJVI.03273-12*