Title: Study of Epidemiological Characteristics and In-silico Analysis of the Effect of Interventions in the SARS-CoV-2 Epidemic in India

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Article Summary Line: The 21 day lockdown in India to slow the COVID 19 epidemic in the country has still not shown significant results, but the earlier interventions done are showing their effect now.

Running title: In-silico analysis of SARS-CoV-2 epidemic in India

Keywords: SARS-CoV-2; COVID 19; Coronavirus; Epidemiological parameters; Interventions; Mathematical analysis

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Abstract :

After SARS-CoV-2 set foot in India, the Indian Government took a number of steps to limit the spread of the disease in the country. This study involves assessing how the disease affected the population in the initial days of the epidemic. Data was collected from government controlled and crowdsourced websites and then put through analysis and calculations. With a study on age and sex parameters of 413 patients, the median age of the affected individuals was found out to be 36 years (IQR 25-54 years) with 20-39 years males being the most affected group. The number of affected males (66.34%) was more than that of the females(33.66%).Using SIR model, the range of contact rate(β) of India was calculated and the role of public health

interventions was assessed which proved that the interventions were effective for a little while but the effect reduced due to violations.

INTRODUCTION:

In December 2019, a cluster of patients with pneumonia of unknown origin was encountered in Wuhan, China *(1)*. The causative agent was determined to be a novel virus of the *Coronaviridae* family of RNA viruses and was claimed to be of zoonotic origin *(1)*. Due to its close relationship with the SARS-CoV, this novel coronavirus was named SARS-CoV-2 *(2)*. Since then, SARS-CoV-2 has caused a widespread outbreak of the disease now known as COVID-19 and was declared to be a pandemic by WHO on March 11 2020 *(3)*. Human to human transmission occurs primarily through close-contact with the infected person, through fomites in the immediate surroundings of the infected person and via droplets of respiratory secretions *(4, 5)*, although there is some evidence pointing to a possibility of airborne and faeco-oral transmission as well *(6, 7)*. According to few case studies, transmission may also occur via viral shedding in "pre-symptomatic" individuals during the incubation period *(8, 9)*.

The incubation period for COVID-19 is thought to be within 14 days of exposure, with a median incubation period of 4-5 days *(4, 10, and 11)*. The median age of patients affected by COVID-19 is 47 years with the most common clinical findings being fever and cough *(4, 12)*. Other symptoms include expectoration, headache, myalgia fatigue, and diarrhoea and haemoptysis in rare cases. About 18% of patients develop shortness of breath (4). Severe disease has been shown to occur in 14% of patients with older age and pre-existing chronic disease being risk factors for severe disease *(4, 13)*. Critical disease requiring intensive care unit admission has been reported in 5 percent, and overall case-fatality rate as 2.3% *(13)*. Currently, there are no approved treatments for COVID-19 and clinical trials such as the WHO SOLIDARITY trial are

underway to evaluate the effectiveness of drugs like lopinavir-ritonavir, remedisvir, hydroxychloroquine and azithromycin *(3, 14)*.

India reported its first case of COVID-19 on 30 January, 2020; a medical student who had travelled from Wuhan, China, the then epicenter of COVID-19 *(15)*. While there were only a few reported imported cases in the month of February, the number began to increase rapidly in March *(14)*. On 15th March 2020, India sealed its borders and stopped all international flights, meaning all the initial imported cases which seeded COVID-19 in India arrived in the Indian subcontinent before 15 March 2020 *(16)*. According to the data available in the public domain, India had approximately 3726 cases (both imported cases and due to person-to-person transmission) as of 5 April 2020 *(17)*. According to the Indian Council of Medical Research, as of 31st March 2020, community transmission has not yet started and India is in category 2 of WHO classification for transmission patterns, i.e., sporadic cases without evidence of community transmission *(18)*.

The most important question in the current scenario concerns the mathematical parameters of the initial spread of COVID-19 in India, and what are the epidemiological aspects that can predict this spread. We acknowledge there are certain difficulties in making precise calculations due to the rapidly changing dynamic of the epidemic in the early stages, limited availability of data in the public domain, absence of robust line listing of cases and limited testing capacity. Nonetheless, mathematical models with reasonable assumptions based on available information can help in analysis of the currently available data to provide important insights for guiding public health interventions. For a predictive model to be relevant to the reality, the model itself should represent what is happening in the real world. The most basic of these models is the SIR

(susceptible-infected-removed) model *(19,20)*, which we've used in the current Indian scenario to determine the range in which contact rate β lies and also calculate the range of the current reproduction number, R_t.

In the first part of our paper, we outline the several public health measures taken by India in response to the COVID-19 outbreak. We then study and analyze the epidemiological parameters of COVID-19 in India using publicly available data till 28 March 2020. Finally, we use the SIR model, and run simulations to determine the effective contact rate β, and derive from that the reproduction number R_t ,and comment on the result of the nationwide public health measures implemented from mid-March 2020 and the lockdown implemented from 25 March 2020.

INDIA'S OUTBREAK RESPONSE:

Since the beginning of the outbreak in India, there have been a number of interventions done at various levels by the state governments and by the Central Government agencies. The number of cases started increasing in March *(21)*, prompting a number of interventions to control the outbreak. The first interventions were mostly related to travel advisories and bans. Gradually there were more social distancing measures in March which were then followed by lockdowns, ultimately culminating in a nation-wide 21 day lockdown from 25 March, 2020 (Table 1)

METHODS:

Epidemiological analysis:

Data Source- The raw data was collected from the patient database of covid19india.org which is a crowdsourced patient database for positive cases of SARS-CoV-2 which have been confirmed by laboratory testing, including data from state government and central government agencies (https://www.covid19india.org/). The data was taken for cases confirmed on 28 March, 2020 or earlier. Only those patient data were analyzed which had both age and sex data of the patient

mentioned. For convenience of analysis, patients whose age data was given as a range were excluded.

Study population - The above method yielded a sample of size n=413. Of these patients, the status of the patient as of 28th March 2020 was not known for 13 patients.

Study Design - For the epidemiological analysis part of the study, we used a descriptive design. After collecting the data analysis was done in regard to the age distribution, status of patients and sex distribution using Microsoft Office Excel 2007. Fatality ratio in any category was found out by dividing the number of deaths in the category by the number of affected individuals of that category. Central tendencies for age of patients of various categories were also calculated.

Mathematical analysis:

Study Design- The transmission rate β is used to describe the flow of individuals in a population going from a susceptible state to an infected state, and it is important to obtain a realistic estimate of the transmission rates in order to create useful and realistic simulation models for decision support. Accurate estimation of this rate is important because it can have a major influence on disease predictions and conclusions**.**

We have used the data available till 4th April to estimate the two parameters, β and R_t (time varying reproductive number) used in the SIR model (www.statista.com). We assumed that the recovery rate γ would remain constant for the population. We plotted the γ distribution curve till 3rd April and took the mean value of γ. Since the effect of interventions would reflect in the contact rate β, we then took the value of γ to be constant equal to the mean and ran the SIR model multiple times by varying the value of β, and comparing the trends with the real data. We plotted the trendline for the real data using Microsoft Office Excel 2007, and used the equation

of the curve to find out the trend of β in India in the present day scenario by comparing it to equation 4.

The spread of a disease in the population is studied by the SIR model *(19,20)* which divides the (fixed) population of N individuals into three "compartments" which vary as a function of time (For purposes of this study, we have not included vital dynamics like birth and death rate.) -

- S(t) - S(t) are those susceptible but not yet infected with the disease (in a novel disease like nCOV-19,the entire population is assumed to be susceptible as there is no pre-existing immunity);
- I(t) - I(t) is the number of infectious individuals;
- R(t) - R(t) are those individuals who have been removed from the infected population(includes those who have recovered from the disease and also the deaths)

The SIR model describes the change in the population of each of these compartments in terms of two parameters, β and γ.

B - β describes the effective *contact rate* of the disease: a susceptible individual comes into contact with an infectious individual and acquires the disease. This parameter takes into account both the number of people contacted per unit time, and the effectiveness of transmission in each contact.

γ - γ is the mean *removal rate*: In our model, it is calculated using the removed cases as against the new cases on a daily basis.

β and γ are useful in the SIR model using the following differential equations-

$$dS/dt = -\beta SI/N \quad \text{.....[1]}$$

$$dI/dt = \beta SI/N - \gamma I \quad \text{.....[2]}$$

$$dR/dt = \gamma I \quad \text{.....[3]}$$

Assuming the present scenario in India where I<<N and R<<N, S is almost equal to N. So S/N=1.

Putting this in equation 2 and integrating, we get

$$I(t) = Ae^{(\beta-\gamma)t} \text{.....[4]}$$

Where A is determined the number of cases at t=0.

Study setting- β, the effective *contact rate* reflects the force of infection of the disease. It is time-varying, and helps us understand at what rate the epidemic is progressing. We have analyzed the data from the initial period of the COVID epidemic in India, till 4 April 2020 and calculated the β and the R_t for the same.

Data variables, Sources and Analysis- γ was calculated to be 0.103(the removal rate followed a normal distribution, and the mean was calculated with the data available from 01 March to April 04 2020) *(22)*.

RESULTS:

Epidemiological parameters:

The patients affected in India had a median age of 36 years with IQR of 25-54 years. Largest percentage of affected patients was in the age group of 20-39 years. There were 66.34% male patients and 33.66% female patients. The median age for affected males was 35 years (IQR 25-50) and for females was 40 years (IQR 24.5-59). Both in male patients and female patients the largest number of affected patients was in the 20-39 years age group accounting for 54.38% of

males and 41.01% of females. This was followed by the age group 40-59 years accounting for 25.91% of males and 26.62% of females. According to the data, 16 patients out of 413 had died accounting for 3.8 % cases, with 68.75% of all the deaths among 60-79 years, accounting for 11 deaths. The median age of deceased patients was 65 years with IQR 59.25-69. The mortality rate in male patients was 4.38% and for female patients was 2.88%.

For recovered patients, most were in the 20-39 age group followed by the 40-59 years age group. Median 36 years with IQR 21.75-56.25. As per the data as on 28 March, 2020, 14 of these 413 patients had recovered.

The number of hospitalized patients accounted for 370 of the 413 patients. However, status of 13 of the 413 patients was not available.

Table 3 gives the current status of patients across age and sex, and Table 2 gives the age and gender distribution with normalized values with respect to percentage in Indian population.

Mathematical analysis:

After running multiple simulations, all assuming different values of β, we found that the value of β in the current India scenario calculated from the trendline of real data lies around 0.258. , which is also visible in the graph of real-time active cases lying between 0.24 and 0.29 (Figure 3).

Also visible in the graph, is the real data line shifting from 0.24 to 0.28 from day 8. Also, as $R_t = \beta/\gamma$, the value of the Reproduction number is found to be varying between 2.4-2.9 in the Indian scenario until 4thApril 2020.

Considering the present trend of β, India can have more than 9700 active cases by the end of the 21 day lockdown.

DISCUSSION:

The median age of affected patients in our study sample of 413 was 36 years(IQR 25-54)with the median age for female patients (40 years, IQR 24.5-59) was more than that of male patients (Median age 35 years, IQR 25-50). In study cohorts of Wuhan, the median age of affected patients range from 49-56 years *(4, 23, 24)*. Thus, there are more people affected at a lower age in India when compared to China. This observation can be explained by the population distribution of India. In previous studies on COVID 19, it has been established that the risk increases with age and comorbidities *(13, 23, 24)*. However, according to the population demographics in India for 2020 *(36)*, the broad based nature of India's population pyramid means there are more people in the younger age group category and very few people in the above 80 years age group category.This is reflected in the number of cases which are more in the younger age groups. On normalizing the percentage of patients in each age group with the corresponding percentage representation of the population, we observed that the highest number of male patients is in the 20-39 years age group category. Interestingly, according to this analysis, males in the 20-39 years age group are more affected than even the 60-79 years age group males or above 80 years age group males. This is something that has not been reported until now and it has to be seen whether this changes as the number of cases in India grows. Similarly finding the normalized ratio of affected patients by age group shows that for females, above 80 years age group is more affected. On the same lines the mortality rate due to the disease was found to be lower as compared to other countries.

As of 30 March, 2020, India has still not officially reported community spread *(25)*. So the cases now are people who were affected in foreign countries or their direct contacts. In 2018, Indian residents between 35 and 49 years of age took the most holidays outside the nation *(26)*. So, it is

also possible that the number of young patients is more in India than other countries because they constitute the majority of outbound tourists. If community spread begins, this can get altered. Another consideration in this regard are the comorbidities in the Indian population because hypertension, COPD, neoplasms have been related to higher risk of infection by SARS-Cov 2. In a 2016 Global Burden of Disease Study in the Indian population *(27)*, it was found that diseases like cardiovascular diseases, chronic respiratory diseases, and neoplasms were as prevalent in the 40-69 yrs age group as older age groups. Hence, this can be another reason for the lower median patient age in India.

The present data gives a case fatality rate of 4.38% for males and 2.88% for females. In China, the case fatality rate was found as 2.3% with 1023 deaths of 44672 confirmed cases, 14.8% in the above 80 years population, and 8.0% in the 70-79 years population *(13)*. Our estimate gives a higher value which may be due a smaller sample size or can also be because mild cases of COVID 19 have so far been missed due to limited testing capacities in India. In our study, there is a 16.18% mortality rate in 60-79 years age group and 20.0% in above 80% age group. These may be an underestimation or overestimation of the actual mortality rate as the total number of deaths is still small and many are still hospitalized. The mean age of the deceased males and females implies male patients of younger age have higher risk of death than females of similar age. The mean age for recovered patients is lower than the mean ages for the deceased implying younger patients have a higher chance of recovery. These are in accordance with findings from other countries *(13, 28)*. If we consider all the patients, males account for 66.34% of patients, implying more males are generally affected. 75.0% of the deceased were also males which show that males are more vulnerable agreeing with previous studies *(29, 30)*.The explanation for a

lower mortality rate due to CoVID infection than that of other countries [worldometer.org], could also be the universal immunisation policy against BCG *(31)*.

The value of the β being 0.258 (range between 2.4-2.9) and the trend for R_t being about 2.50, shows that the interventions which were put in place by the Indian government (assuming a lag period of 11 days) during the mid-March period were partially effective, preventing the scenario where Rt can reach even more than 4 *(32)*, and further data would tell how effective the lockdown is. The increase in β from day 8 is probably due to the identification of the Tablighi cluster and the cases it added to the Indian data *(33)*.

According to a study *(32)* in the early days of the epidemic, Wuhan city and Hubei province showed Rt between 1.85 and 4.46 which matches our study. All over China, the Rt varied from 1.23 to 5.77. South Korea which has high population density like India had a decreasing trend of Rt from 9.72 on 20 February to 1.50 on 7 March. This indicates that the interventions have been helpful in preventing the worst case scenario in India but is unable to prevent the spike in number of cases *(33,34)*.The situation can still be controlled if Rt can be brought down close to 1.This indicates the need for severe interventions required and ensuring optimum testing to avoid underestimation of danger.

The impact of the COVID-19 response (overall quarantine regulations , social distancing, and isolation of infections) in China in this context is encouraging for the many other countries *(35)* where the Rt gradually stabilized for most provinces ranging between 0.96 to 1.57 where there were more than 100 cases *(32)*, and India should try and replicate this when community transmission starts by strict enforcement of lockdown measures to get the Rt closer to 1,so that COVID would not overwhelm the Indian healthcare system. The Indian government will not be

able to minimise both deaths from coronavirus disease 2019 (COVID-19) and the economic impact of viral spread. Keeping mortality as low as possible will be the highest priority for individuals; hence the Indian government must put in place measures to ameliorate the inevitable economic downturn *(36)*. However the Indian government's timely decision to put a country wide lockdown into place when the number of cases was documented to be only 415,and effective contact tracing definitely helped to reduce the Rt and prevent an Italy/US like situation (however in the context of violations of the lockdown, more data awaited).

LIMITATIONS

The lack of enough kits for testing at the beginning of the outbreak among other logistic and political reasons was one of the major issues. The Indian government tried to correct these issues by altering the criteria for testing on 21 March 2020. However, it undermines the quality of data collected in the early phase of the epidemic. We have used crowd sourced data from covid19india.org due to lack of availability of official data. Even though the number of cases in India till 28 March was more, we could not include all the cases due to unavailability of the demographic details of all the patients. If these details along with the clinical details as well are released, further studies can help in better assessment of the disease course. Also, it could help the government with better interventions to control the spread of the disease.

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Biographical Sketch: Mehak Arora, Archisman Mazumder, Vishwesh Bharadiya and Parul Berry are all 2nd year medical students (MBBS) at All India Institute of Medical Sciences, New Delhi. Their research interests include public health and clinical investigations.

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433 **Table 1: Interventions done at the central government or state level in India to control the**

434 **COVID 19 outbreak till 27 March, 2020 (Source : MoHFW)***

Date	Intervention	Category
17-01-2020	First travel advisory to people visiting China to observe specific guidelines	Movement Restriction
24-01-2020	Guidance for sample Collection, Packaging and Transportation for Novel Coronavirus released	Public Health Measures
25-01-2020	Guidance on Surveillance for human infection with 2019-nCoV released	Public Health Measures
	Second travel advisory issued	Movement Restriction
01-02-2020	324 people evacuated from Wuhan by India	Evacuation
02-02-2020	323 Indians evacuated from Wuhan by India	Evacuation
05-02-2020	Travel advisory to China with quarantine warning for 15 Jan onwards, E-visas to China suspended	Movement Restriction
18-02-2020	Thermal screening starts at major international airports in India	Public Health Measures
26-02-2020	Travel advisory that travellers from China have to be quarantined	Movement Restriction

27-02-2020	Third evacuation from Wuhan by India	Evacuation
03-03-2020	Central government suspended the issuing of new visas and visas already issued for nationals of Italy, Iran, South Korea, and Japan	Movement Restriction
04-03-2020	The Minister of Health and Family Welfare, Dr. Harsh Vardhan, announced compulsory screening of all international passengers arriving in India. Universal surveillance of international passengers started.	Public Health Measures
05-03-2020	Primary school shut in Delhi; Government advisory on avoiding mass gatherings	Social Distancing
06-03-2020	Government advisory for Exemption to mark biometric attendance in AEBAS released	Public Health Measures
07-03-2020	Primary schools in Jammu and Kashmir shut after two cases with 'suspected high viral load	Social Distancing
09-03-2020	Manipur, Mizoram close international borders; Qatar bans travel to India	Movement Restriction
	Karnataka, Kerala declare holidays for educational institutions	Social Distancing
	ICMR testing strategy released to test symptomatic people with travel history or contact history	Public Health Measures
10-03-2020	Travel advisory regarding home quarantine on return from affected	Movement Related

	countries	
	SOP for international cruise ships at major ports released	Public Health Measures
11-03-2020	Cabinet Secretary of India announced that all states and Union Territories should invoke provisions of Section 2 of the Epidemic Diseases Act, 1897	Public Health Measures
	The Indian government suspended all visas to India effective from 12:00 GMT on 13 March 2020 except diplomatic, official, United Nations/International organisations, employment and project visas till 15 April 2020. suspended visa free travel for OCI card holders and Indians coming from COVID hit nations quarantined for 14 days	Movement Restriction
	Guidelines for home quarantine by citizens released	Social Distancing
	Guidelines on use of mask by public	Public Health Measures
12-03-2020	Schools shut in Delhi	Social Distancing
	Public places to be disinfected in Delhi	Public Health Measures
13-03-2020	The Government of India suspended all international passenger	Movement

	traffic in and out of Indo-Bangladesh, Indo-Nepal, Indo-Bhutan and Indo-Myanmar border check posts.	Restriction
	Gazette Notification - Essential Commodities Order, 2020 - with regards to Masks and Hand Sanitizers released	Public Health Measures
14-03-2020	Central government declared the pandemic as a "notified disaster" under the Disaster Management Act, 2005, enabling states to spend a larger part of funds from the State Disaster Response Fund (SDRF) to fight the virus	Public Health Measures
15-03-2020	Guidelines on dead body management released	Public Health Measures
16-03-2020	Advisory on social distancing released	Social Distancing
	Indo-Pakistan checkposts closed; the entry of travelers from the European Union, United Kingdom and Turkey banned	Movement Restriction
17-03-2020	Indian states with high footfall of international tourists like Sikkim start banning entry of tourists and ask existing tourists to leave(other states like Himachal Pradesh,Uttarakhand follow suit);quarantine of passengers from United Arab Emirates, Qatar, Oman, Kuwait	Movement Restriction
	Monuments like Taj Mahal closed by Archaeological Survey of	Social Distancing

	India	
	Guidelines for Clinical Management and Discharge released; lopiravir-ritonavir allowed on case-to-case basis for vulnerable population;ICMR testing guidelines revised	Public Health Measures
18-03-2020	Some states ban public transport; SOP for quarantine released;	Movement Restriction
	OM released regarding preventive measures to be taken to contain the spread of COVID19; Directives to educational institutions and education boards regarding precautionary measures; Govn order for Monitoring of quality standards for hand sanitizers	Public Health Measures
19-03-2020	Himachal Pradesh bans entry of all tourists, other states followed;	Movement Restriction
	OM for preventive measures for spread in training institutes; sports events, competitions suspended, strict measures for Olympic trainees	Social Distancing
20-03-2020	Maharashtra declares lockdown in Mumbai, Nagpur, Pune	Lockdown
	Instruction to all ports to deal with COVID 19	Movement Related
	Digital/e-learning platforms promoted by the Government	Public Health Measures

21-03-2020	Punjab bans public transport	Movement Restriction
	Rajasthan lockdown till march 31	Lockdown
	Maharashtra allows private labs to conduct tests; ICMR testing policy revised to include all hospitalized SARI patients, asymptomatic contacts	Public Health Measures
22-03-2020	Janta curfew,voluntary self isolation at home issued by Prime Minister to the entire county; 12 states including Telangana and Delhi announce lockdown till March 31	Curfew/Lockdown
	Railways suspended till March 31;	Movement Restriction
	Mock drill for hospital preparedness; ICMR guidelines for private lab testing of COVID 19	Public Health Measures
23-03-2020	All commercial international flights suspended for 1 week;	Movement Restriction
	union and state governments announce the lockdown of 75 districts where cases were reported;	Lockdown
	Advisory for prophylactic use of hydroxychloroquine;	Public Health Measures

	Restrictions on non-essential services	Social Distancing
24-03-2020	Suspension of domestic flight operations ;	Movement Restriction
	Guideline on rational use of PPE; Model micro-plan for containment of local transmission released ; Release of plans to make temporary medical camps in Jawahar Navodaya Vidyalayas	Public Health Measures
25-03-2020	Nationwide Lockdown begins till 14th April, legal action for violation;	Lockdown
	Telemedicine practice guidelines released	Public Health Measures
26-03-2020	Hydroxychloroquine now a schedule H1 drug, can be sold on prescription only; Doorstep Delivery of Drugs to consumers	Public health Measures
27-03-2020	SOP for allocation of residents and nursing students as part of hospital management	Public Health Measure

COVID 19-Coronavirus Disease 19; MoHFW-Ministry of Health and Family Welfare, Government of India; 2019-nCoV-2019 novel Coronavirus; AEBAS-Aadhar Enabled Biometric Attendance System;ICMR-Indian Council of Medical Research;SOP-Standard Operating Procedure; OM-Office Memorandum; OCI-Overseas Citizenship of India; PPE-Personal Protective Equipment; SARI-Severe Acute Respiratory Illness

**Colour coding used: Movement Restriction-Green; Public Health Measure-Yellow; Lockdown-Red; Social Distancing-Blue; Evacuation-Purple*

Table 2: Distribution of COVID 19 patients in India confirmed till 28th March 2020 across different age groups and sex (n=413)

Age group	Male	Percentage of patients accounted (normalized value)*	Female	Percentage of patients accounted (normalized value)*
<20years	14	3.39%(0.18)	12	2.91%(0.17)
20-39 years	149	36.08%(2.07)	57	13.80%(0.88)
40-59 years	71	17.19%(1.53)	37	8.96%(0.85)
60-79 years	38	9.20%(2.04)	30	7.26%(1.54)
>=80 years	2	0.48%(1.20)	3	0.73%(1.82)
Total	274		139	

**Normalized values have been calculated by dividing the percentage of patients in each category by the percentage of Indian population in that category.*

Table 3: Distribution of COVID 19 patients of India with age, sex and status of disease updated till 28 March, 2020 (n=413)

Variables	Deceased	Recovered	Hospitalized*	Status not known
AGE				
<20years	0	2	22	2

20-39 years	2	5	195	4
40-59 years	2	4	98	4
60-79 years	11	2	52	3
>=80 years	1	1	3	0
GENDER				
Male	12	11	243	
Female	4	3	127	
TOTAL	**16**	**14**	**370**	**13**

**Hospitalized include patients in facility isolation, in ICU or under medical care in hospital*

Figure 1 This graph depicts the number of people found infected with CoVID-19(both daily and cumulative) beginning from 1st March, 2020 until 27th March, 2020 and the major interventions done by the government to control the spread of the disease. Data Source: ICMR-NIE and MOHFW

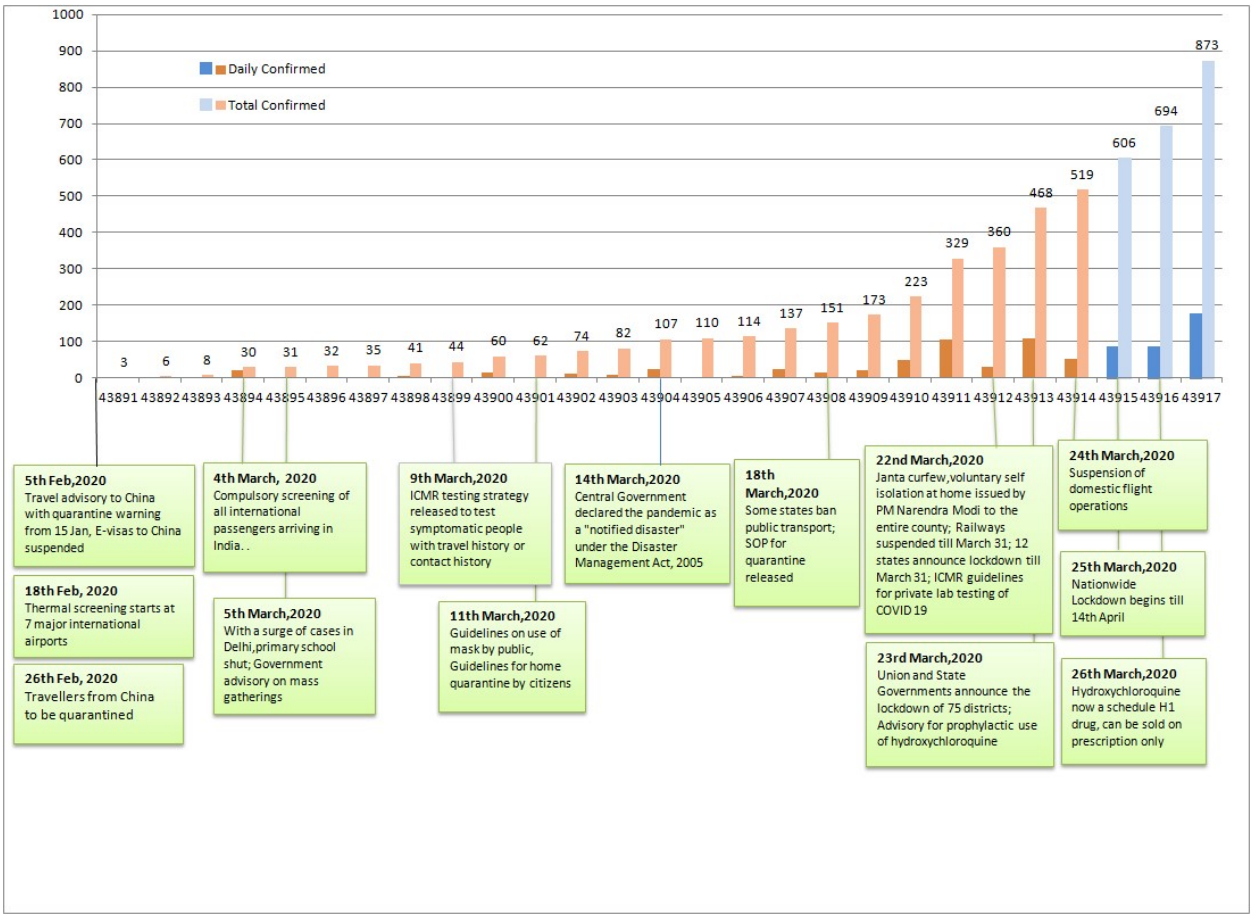
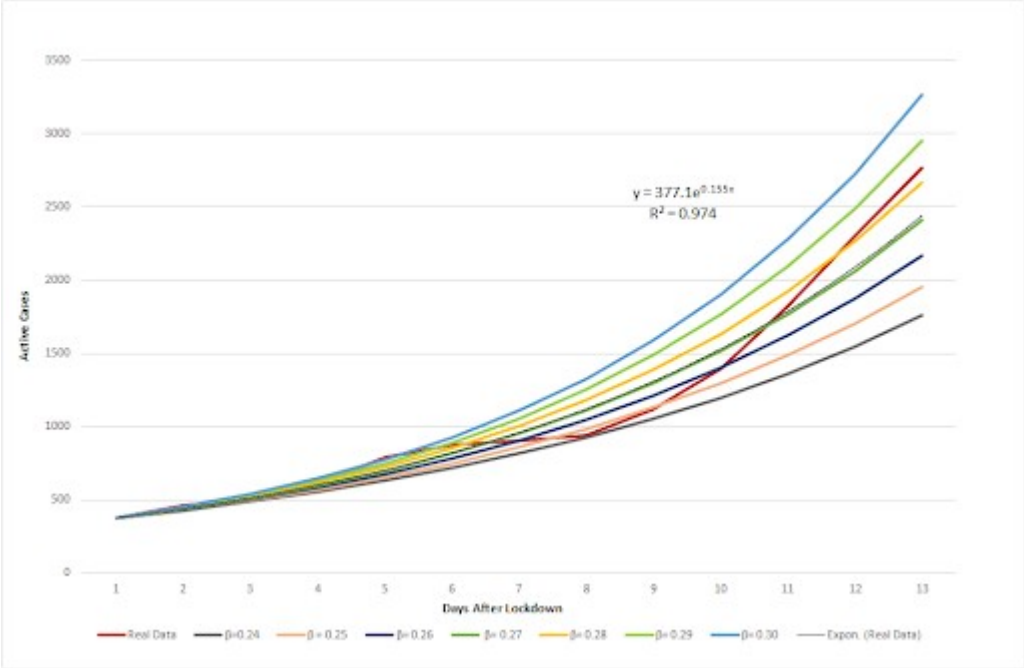


Figure 2 Flow rates in SIR Model.

458 **Figure 3** Figure 3.This graph compares real data with varying values of β, thus helps in

459 estimating the range β lies in**.** Datasource:https://www.statista.com/statistics/1104054/india-

460 coronavirus-covid-19-daily-confirmed-recovered-death-cases/



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462 **Appendix Table:** Output of the model run by varying β

days after lockdown	β= 0.28	real data	β= 0.29	β= 0.30	β= 0.27	β= 0.26	β = 0.25	β=0.24
0	378	378	378	378	378	378	378	378
1	444.8304	461	448.6104	452.3904	441.0504	437.2704	433.4904	429.7104
2	523.4764147	507	532.4108227	541.4208307	514.6176067	505.8343987	497.1267907	488.4947827
3	616.0270	615	631.8651	647.9724	600.4558	585.1492	570.1050	555.3208

	448		644	502	235	324	036	69
4	724.9406 264	794	749.8975 771	775.4934 284	700.6118 549	676.9006 321	653.7964 181	631.2887 639
5	853.1101 291	879	889.9784 445	928.1105 351	817.4739 123	783.0386 512	749.7737 323	717.6490 668
6	1003.94	902	1056.226 418	1110.762 688	953.8285 608	905.8191 117	859.8405 162	815.8234 591
7	1181.436 592	942	1253.529 513	1329.360 786	1112.927 165	1047.851 548	986.0651 04	927.4281 083
8	1390.314 581	1117	1487.688 826	1590.978 988	1298.563 416	1212.154 671	1130.819 461	1054.300 274
9	1636.122 199	1397	1765.589 098	1904.083 653	1515.163 794	1402.220 524	1296.823 758	1198.528 551
10	1925.388 604	1826	2095.401 142	2278.807 316	1767.893 114	1622.088 702	1487.197 486	1362.487 257
11	2265.797 309	2303	2486.822 075	2727.276 596	2062.777 686	1876.432 21	1705.518 077	1548.875 513
12	2666.390 274	2767	2951.360 439	3264.004 63	2406.849 004	2170.656 781	1955.888 13	1760.761 684

13	3137.808074		3502.674569	3906.360741	2808.311418	2511.015764	2243.012508	2001.633882
14	3692.572542		4156.974179	4675.132535	3276.737762	2904.743036	2572.286744	2275.457397
15	4345.419367		4933.496955	5595.198617	3823.297621	3360.206744	2949.898438	2586.739969
16	5113.689511		5855.074186	6696.333705	4461.023664	3887.087161	3382.943529	2940.605997
17	6017.789817		6948.802045	8014.172178	5205.122411	4496.582428	3879.559639	3342.880897
18	7081.735056		8246.838266	9591.361263	6073.33683	5201.646553	4449.078994	3800.187004
19	8333.785814		9787.347655	11478.94116	7086.369413	6017.264732	5102.20379	4320.052586
20	9807.199146		11615.6242	13737.99678	8268.375831	6960.771842	5851.207307	4911.03578
21	11541.11196		13785.4228	16441.63455	9647.540919	8052.220867	6710.164539	5582.865474

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