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 study gives the epidemiological characteristics of the SARS-CoV-2 epidemic in India, where unlike other countries, the 20-39 years males are most affected, and the SIR model predicts the probable number of cases of COVID-19 by the end of

the 21 days lockdown in the country, which will help to develop appropriate public health interventions to control the COVID-19 epidemic.

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

Keywords: SARS-CoV-2; COVID-19; Coronavirus; Epidemiological parameters; Interventions; SIR Model

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Abstract (142 words)

After SARS-CoV-2 set foot in India, the 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 analyzed. Studying age and sex parameters of 413 Indian COVID-19 patients, the median age of the affected individuals was found to be 36 years (IQR, 25-54) 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 Susceptible-Infected- Removed (SIR) model, the range of contact rate (β) of India was calculated and the role of public health

interventions was assessed. If current contact rate continues, India may have 5583 to 13785 active cases at the end of 21 days lockdown.

Text (3212 words):

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 limited 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, 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 reported to occur in 14% of patients with older age and pre-existing chronic disease being risk factors *(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, remdesivir, 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 Susceptible-Infected-Removed (SIR) 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 days 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:

The spread of the 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.

β- 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. It reflects the force of infection of the disease and helps us understand at what rate the epidemic is progressing

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.

We have used the data available till 4th April to estimate the two parameters, β and R_t (time varying reproductive number) with the help of SIR model (www.statista.com). We assumed that the recovery rate **γ** would remain constant for the population. The removal rate followed a normal distribution, and the mean was calculated with the data available from 01 March to April 04, 2020 *(22)*. 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 (0.103) 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.

RESULTS

Among the 413 patients, there were 274 (66.34%) male and 319 (33.66%) female. The patients affected in India had a median age of 36 years (IQR, 25-54). The median age of females was higher (40 years; IQR, 24.5-59) than males (35 years; IQR, 25-50). Nearly half of the patients (49.88%) of affected patients were in the age group of 20-39 years. (refer Table 2). There were sixteen deaths (3.8%). Majority of them (68.75%) were in the 60-79 years age group. The median age of deceased patients was 65 years (IQR, 59.25-69). The mortality rate in male patients was 4.38% and for female patients was 2.88%. Overall case fatality rate was 3.87%. There is a 16.18% mortality rate in the 60-79 years age group and 20.0% in the equal to or above 80 years age group. (refer Table 3)

For recovered patients, most were in the 20-39 years age group followed by the 40-59 years age group. Median age was 36 years (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.

After running multiple simulations using the SIR model, all assuming different values of β (Appendix Table), we found that the value of β in the current Indian 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 β=0.24 and β=0.29 curves (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 reproductive number is found to be varying between 2.4-2.9 in the Indian scenario until 4th April 2020. Considering the present trend of β, India can have nearly 7765 active cases by the end of the 21 days lockdown. Considering the range in which contact

rate varies, number of active cases after 21 days lockdown period may vary from 5583 to 13785. (Figure3)

DISCUSSION:

After the disease set foot in India on 30th January, 2020, the government started taking precautionary measures to control the outbreak of the disease. These interventions included restricting the inflow of international passengers, self quarantine measures, directives on testing and management strategies in-country travel restrictions.

The median age of affected patients in our study sample of 413 was 36 years (IQR, 25-54) and higher in females (40 years) compared to males (35 years). In study cohorts of Wuhan, the median age of affected patients ranges 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 *(25)*, the broad based nature of India's population pyramid means there are more people in the younger age group and very few people in the equal to or above 80 years age group . 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 affected more than the 60-79 years age group males and equal to 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. This is new to the literature of COVID-19 and needs to be studied further. Similarly

finding the normalized ratio of affected patients by age group shows that for females, equal to or above 80 years age group is most affected.

As of 30 March, 2020, India has still not officially reported community spread *(26)*. 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 *(27)*. 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.

In our study, we found a case fatality rate of 3.87% which is lower than countries like Italy *(28)*. The explanation for a lower mortality rate due to COVID-19 infection could be the universal immunisation policy against BCG *(29)*. Case fatality rate was higher for males (4.38%) than females (2.88%). In China, the case fatality rate was found as 2.3%, 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, the mortality rates for 60-79 years age group (16.18%) and equal to or above 80 years age group (20%) 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 median age for recovered patients (36 years) is lower than the median ages for the deceased (65 years) implying younger patients have a higher chance of recovery. This is in accordance with findings from other countries *(13, 30)*. 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 *(31, 32)*.

In the SIR model, the value of β being 0.258 (the range being between 0.24-0.29) 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 *(33)*, 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 *(34)*.

According to a study *(33)* in the early days of the epidemic, Wuhan city and Hubei province reported Rt between 1.85 and 4.46 which aligns with our study findings. 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 *(34,35)*.The situation can still be controlled if Rt can be brought down close to 1.This indicates the need for more effective strategies 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 *(36)* where the Rt gradually stabilized for most provinces ranging between 0.96 to 1.57 where there were more than 100 cases *(33)*, 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 *(37)*. 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). Since at the end of the 21 days lockdown, India is likely to have significant number of active cases (5583 to 13785), it may enter the exponential growth phase and it would become very difficult to contain it. Hence, appropriate public health interventions like strict social distancing measures are necessary immediately to decrease the R_t in India.

The increase in β can be attributed to two possibilities: the Nizamuddin super cluster and change in the testing strategy. As on 4th April,2020, 1023 COVID-19 positive cases across 17 states in India can be traced to the Tablighi Jamaat congregation in Nizamuddin *(38).* Additionally, ICMR recently updated the testing strategy which might have increased the detection of the positive cases significantly *(39)*. For now the epidemic is being reported either in clusters or super-clusters and community transmission is still in its infancy. If the disease leaks into the rural areas or urban slums, it will provide a big challenge to the health care delivery system which is not yet ready to combat the epidemic. India might as well enter the exponential phase of growth of the epidemic curve if stringent measures are not in place. Hence, strict social distancing, optimum testing and acceptance and awareness in Indian community are vital elements to control the COVID-19 epidemic in India.

LIMITATIONS:

We have used crowd sourced data from covid19india.org due to lack of availability of official data. We could not include all the cases of COVID-19 till 28th March due to unavailability of the demographic details of few patients.

CONCLUSION:

COVID-19 epidemic in India is affecting younger age groups more as compared to other countries.. Although the contact rate decreased initially after the Indian government's stringent measures, the recent increase may be attributed to factors such as increase in testing or the occurrence of superclusters. Our mathematical model predicts that India will have adequate number of active cases after the 21 days lockdown. Hence, there is a need to develop appropriate public health interventions to control the COVID-19 epidemic in India.

ABBREVIATIONS

IQR: Interquartile Range

SIR: Susceptible-Infected-Removed

COMPETING INTERESTS: None

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ETHICS APPROVAL AND CONSENT TO PARTICIPATE:

Mathematical modelling was done and available data in the public domain was used for analysis. Ethical approval was not required.

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

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Table 1[a]: Interventions done at the central government or state level in India to control the 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

[a] Abbreviations used: 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 Day wise COVID-19 (new and cumulative) cases during 1st-27th March, 2020 and the major interventions taken by the government to control the spread of the CoVID-19.

Data Source: ICMR-NIE and MoHFW

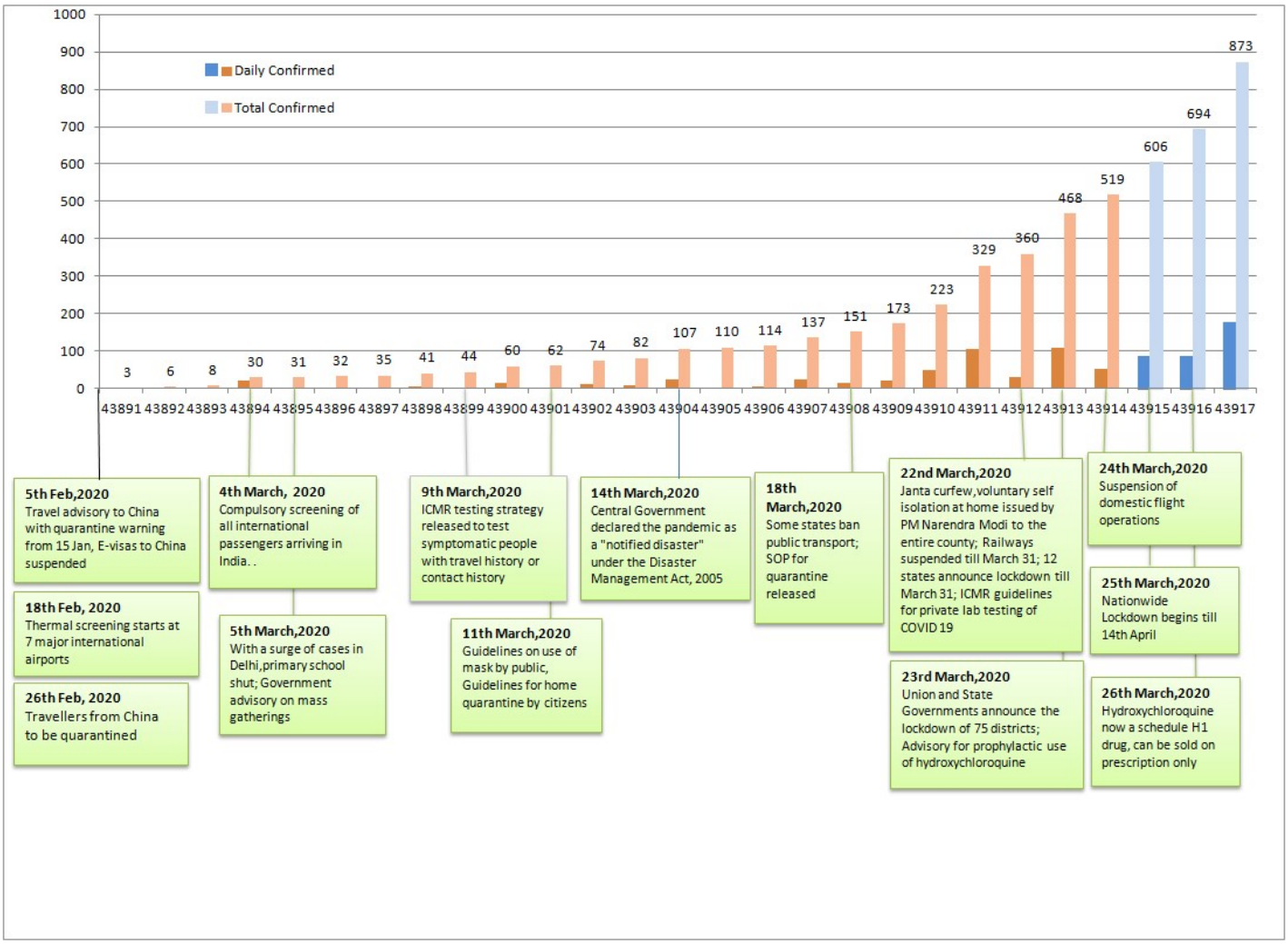
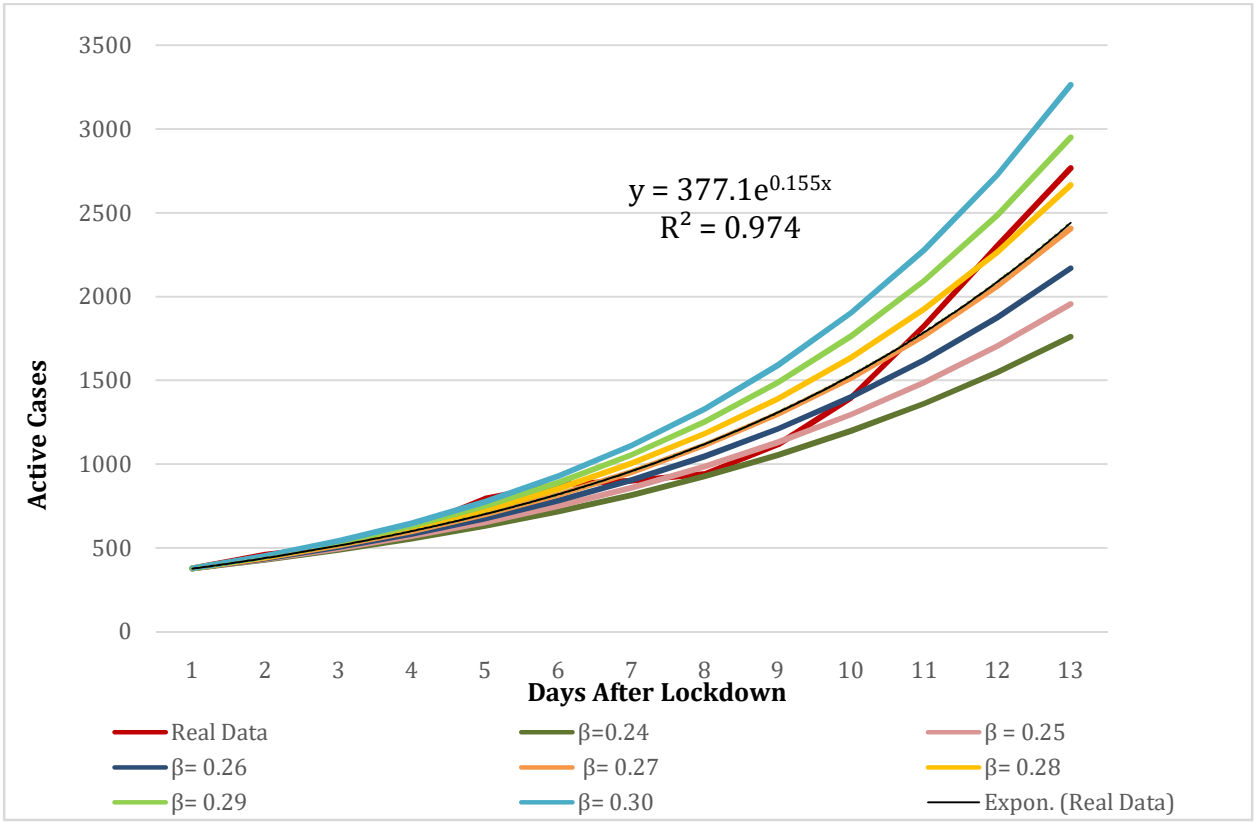


Figure 2 Flow diagram of transitions in SIR Model.

Figure 3 Figure 3.This graph compares real data with varying values of β, thus helps in estimating the range β lies in**.** Datasource:https://www.statista.com/statistics/1104054/india-coronavirus-covid-19-daily-confirmed-recovered-death-cases/



Appendix Table: Output of the SIR 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	616.0270448	615	631.8651644	647.9724502	600.4558235	585.1492324	570.1050036	555.320869
4	724.9406264	794	749.8975771	775.4934284	700.6118549	676.9006321	653.7964181	631.2887639
5	853.1101291	879	889.9784445	928.1105351	817.4739123	783.0386512	749.7737323	717.6490668
6	1003.94	902	1056.226418	1110.762688	953.8285608	905.8191117	859.8405162	815.8234591
7	1181.436592	942	1253.529513	1329.360786	1112.927165	1047.851548	986.065104	927.4281083
8	1390.314581	1117	1487.688826	1590.978988	1298.563416	1212.154671	1130.819461	1054.300274

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	3137.808 074		3502.674 569	3906.360 741	2808.311 418	2511.015 764	2243.012 508	2001.633 882
14	3692.572 542		4156.974 179	4675.132 535	3276.737 762	2904.743 036	2572.286 744	2275.457 397
15	4345.419 367		4933.496 955	5595.198 617	3823.297 621	3360.206 744	2949.898 438	2586.739 969
16	5113.689 511		5855.074 186	6696.333 705	4461.023 664	3887.087 161	3382.943 529	2940.605 997
17	6017.789 817		6948.802 045	8014.172 178	5205.122 411	4496.582 428	3879.559 639	3342.880 897
18	7081.735		8246.838	9591.361	6073.336	5201.646	4449.078	3800.187

	056		266	263	83	553	994	004
19	8333.785 814		9787.347 655	11478.94 116	7086.369 413	6017.264 732	5102.203 79	4320.052 586
20	9807.199 146		11615.62 42	13737.99 678	8268.375 831	6960.771 842	5851.207 307	4911.035 78
21	11541.11 196		13785.42 28	16441.63 455	9647.540 919	8052.220 867	6710.164 539	5582.865 474