

Analysis and Simulation of COVID-19

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Abstract: India is facing a severe second wave of COVID-19 which is much worse than the first wave. It is spreading much faster. India has now surpassed U.S. in terms of daily COVID-19 cases. This paper aims to analyze the trend of COVID 19 and examine why second wave happened and why it is so bad by simulating a simple SEIR model. Which is a compartmental model based on 4 compartments Susceptible, Exposed, Infectious, Recovered.

Keywords: Covid-19, SIR model, SEIR Model, Compartmental Models, Data Analytics, Data Visualization.

I. INTRODUCTION

COVID-19 outbreak was first reported in Wuhan, China at the end of Dec, 2019 and the first case traces back to Nov 17, 2019 while first case in India was reported on Jan 27, 2020. On March 11, 2020 WHO declared the Covid-19 outbreak a global pandemic. Since then, Covid-19 has spread rapidly across the world causing heavy life losses and severe socio-economic impacts. It has been more than one year and India is facing worse of pandemic right now we tried to explain the sudden rise by simulating SEIR model.

II. RELATED WORK

Ever since the covid-19 outbreak hit numerous compartmental models have been suggested to further understand the spread of this novel disease in order to identify best measures to control its transmission. In fact, the very first epidemiological model was published in 1766 by a prominent mathematician and physicist named Daniel Bernoulli [1]. That time small pox was spreading rapidly. Small pox is one of the deadliest diseases in human history as back then the healthcare was also not that advanced as it is today. His main objective was to find the effectiveness of inoculation against smallpox. He developed a static model in which the population was divided into susceptibles and immunes expressed as a ratio of expected time spent in the susceptible state to the expectation of life at birth.

Sir Ronald Ross gave us the concept of Basic Reproduction rate [2] which is used in all the epidemiological models we have now by developing a simple compartmental

model for mosquitoes and humans showing that limiting mosquito's population below a critical level would be sufficient to eliminate malaria which earlier was believed that malaria couldn't be eliminated as long as there are mosquitoes present in the population.

Then there is the SIR model the simplest model, base of all other epidemiological models proposed by biochemist William Ogilvy Kermack and physician Anderson Gray McKendrick in 1927. [3]. The idea was to use three compartments for the population susceptible, infectious or recovered/removed. They found out that there's certain threshold of population density depending upon infectivity rate, recovery rate and death rate if the population density is lower than the threshold then epidemic won't happen. But a small increase in infectivity rate can have large effect on the spread of the disease and epidemic generally ends before there's no more susceptible population left.

Several variations have been proposed over time like the SIRD model, SEIR model, SIQR model.

In the paper "Early Transmission Dynamics in Wuhan, China, of Novel Coronavirus-Infected Pneumonia" the authors analyzed the very first 425 confirmed cases in Wuhan and found that human-to-human transmission has occurred from the middle of December 2019.

In the paper "Estimating the parameters of susceptible-infected-recovered model of COVID-19 cases in India during lockdown periods" [5] the author analyzed the lockdown period in India using sir model and found out the basic reproduction number decreased which means it did help in flattening down the curve.

In the paper "SEIR modeling of the COVID-19 and its dynamics" [6] the author used the SEIR model to investigate the dynamics of the system with the parameters estimated by PSO algorithm.

In the paper "Characterization of the Second Wave of COVID-19 in India" the author finds that although infection rate of second wave is much higher than the first wave the case fatality rate is lower.

Howard Weiss in his paper "The SIR model and the Foundations of Public Health" talked about the herd immunity by vaccinating only a fraction of the susceptible class to prevent epidemic and found out that if reproduction rate is 1.3 then only 23% of population is needed to be vaccinated in order to prevent epidemic [8]. For small pox this value is 5 so 80% vaccination is needed. Similarly, for covid-19 reproduction rate is around 3 and around 60-70% vaccination is estimated [9]. however achieving herd immunity only through vaccination seems unlikely to achieve now as the vaccine roll out is uneven and the virus is mutating the new strains are more dangerous than the previous ones,

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we don't know how much vaccine is effective to them and even immunity is not permanent whether it's by taking vaccination or recovering they could catch covid-19 again.

In the paper "Early transmissibility assessment of the N501Y mutant strains of SARS-CoV-2 in the United Kingdom, October to November 2020." [10] the author finds out that covid 501Y variant 2 is 75% more infectious compared to 501N.

III. METHODOLOGY

Big data analytics machines and algorithms can produce very persuasive data trends, analysis and visualization reports. Pharmaceutical data is extensively used in investigations conducted to constrain COVID-19, within which it is plausible to ascertain the features of the virus that assist in its analysis as well as forecast the happening. Further data on COVID-19 is also employed, which supports knowing the extent, situation of crises, and the results of the PCR COVID-19 test. An extra type of data relies on sampling and the application of algorithms to recognize virus incubators and contaminated spots. Also, analytical reports are used for supply administration and risk prediction designs, such as extensive utilization of ICU availability, to devise proactive answers. Conclusively, the environmental data, which a few researchers have remained interested in, assess the uncertainties of the extent of the pandemic and discover the regions in which the community will be exceedingly exposed to virus.

The data in the time series form is taken from covidindia.org then checked for any null values or redundant rows and unnecessary columns are removed. Then analysis is done using NumPy and pandas and visualized using matplotlib, seaborn and plotly. Then SEIR model is used with variation in social distancing to simulate second wave of COVID-19.

IV. DATA ANALYSIS

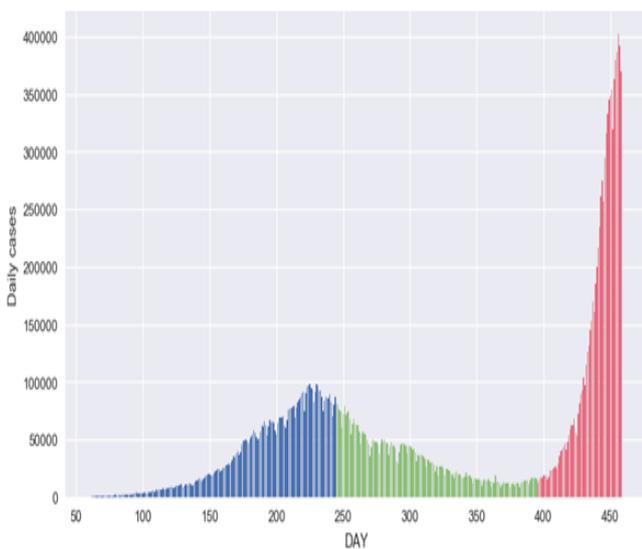


Fig. 1. Daily Cases

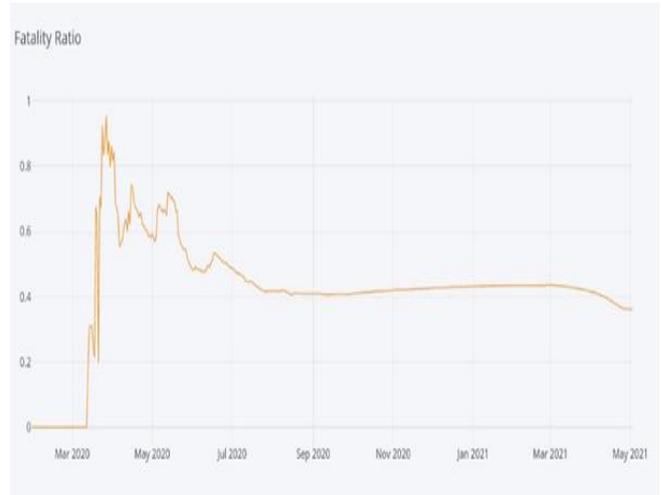


Fig. 2. Fatality Ratio

V. SIR MODEL

It is a compartmental model with four compartments Susceptible, Exposed, Infectious, Recovered assigned to the population.

- S: The number of susceptible people
- E: The number of incubated people
- I: The number of infectious people
- R: The number of recovered/removed people

$$dS/dt = -\rho \cdot \beta \cdot S \cdot I$$

$$dE/dt = \rho \cdot \beta \cdot S \cdot I - \alpha \cdot E$$

$$dI/dt = \alpha \cdot E - \gamma \cdot I$$

$$dR/dt = \gamma \cdot I$$

where,

α is the inverse of the virus incubation period

β is the average contact rate in the population

γ is the inverse of the mean infectious period

ρ is the social mixing factor.

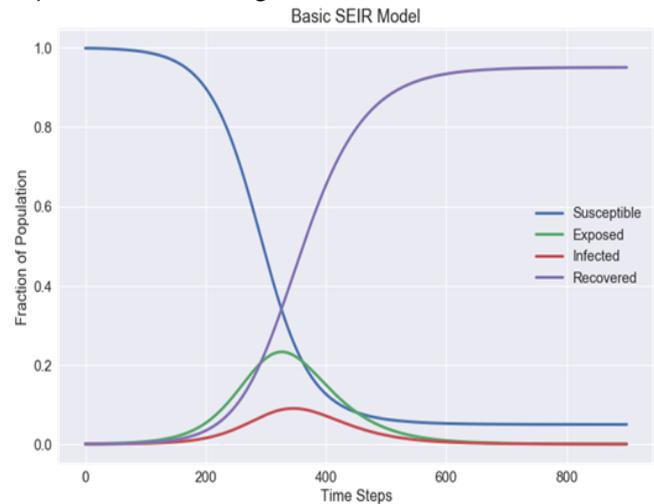


Fig. 3. Basic SEIR Model

This is the normal trend of the covid-19, number of susceptible people decreases as number of recovered people increases and the infected people first increases and then decreases

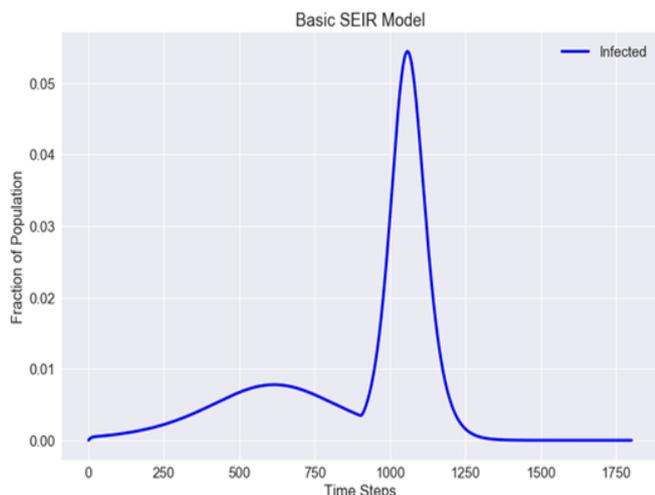


Fig. 4. Severe Second Wave

This is the trend when lockdown is lifted and people stopped social distancing. Second wave is much higher than the first one as what we are seeing now in India.

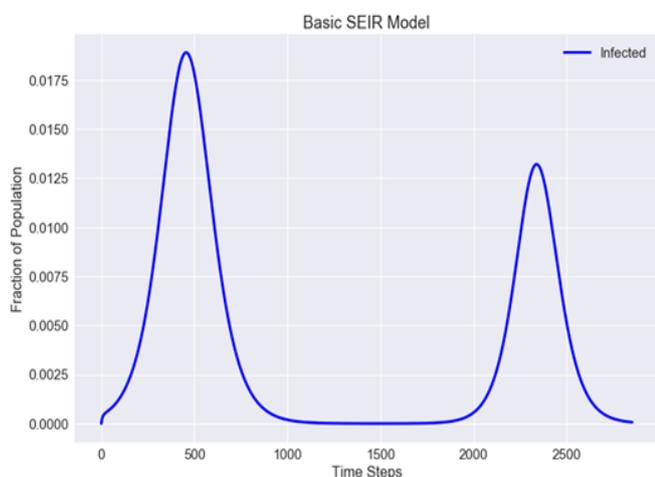


Fig. 5. Controlled Second Wave

This is the trend of infected people when lockdown is long enough to build some herd immunity and people takes some precautions.

VI. CONCLUSION

The Second wave is severe because lockdown was lifted and people stopped social distancing. Also, the mutation made the virus more infectious. Although the cases are high but the fatality ratio is less compared to earlier. We need to take precautions get the most of population vaccinated in order to fight this virus. Many difficulties may prevent the advantageous result of the implementation of big data analytics mechanisms in the medical area are faced when devising algorithms to approach the COVID-19 pandemic, which are thrown light on in this paper. Interpreting big data aids in building proactive supply administration, like the health sector staff allocation algorithm and predicting the demand for ICUs, as this will be decided based on the predicted demands of sufferers also the cases in every single city. Big data models such as machine learning aid to recognize distinct disease models, indications, and condition progression, and recognize spread agents affiliated amidst the

pandemic. Aforementioned benefits in generating policies and proactive steps as well as obtaining conclusions associated to the allocation of medicinal supplies.

Furthermore, most utmost wearable gadgets can map many of the important symptoms and support to collect, also interpreting such data is of great uses to us, including the following:

1. Big data analytics of the global population and cases will support in cataloging recent health trends amongst the society and aid in this forecast of crises and pandemics.
2. Individual tracking and daily monitoring of the basic symptoms of the global society does speak plenty regarding their wellness and support in the steep incline of anxiety levels furthermore the complete health administration.
3. This shall assist in the verification of fitness initiatives and hospitals cultivating recognition of the proper circumstances amongst those people.
4. Interpreting respiratory movement and oxygen reading data would back the classification of respiration-related difficulties among the people, amongst several centers, seniority combinations, and gender.

VII. FUTURE SCOPE

This model built is very simple one to understand how second wave got so severe it can't be used to accurately predict the cases as it doesn't take account of a lot of parameters like age, vaccination, migration, healthcare and real-life scenario is much more complex there has already been mutation going on in the virus and other things to take account for which lots of research is going on by epidemiologists. That could be the next step for this project to try to model accurately the real world. The COVID-19 pestilence has caused countless human misfortunes and destruction in the monetary, social, cultural, and wellbeing frameworks all throughout the planet. Controlling such pestilence requires understanding its qualities and conduct, which can be distinguished by gathering and dissecting the connected enormous information. Data analytics tools assume an imperative part in building information needed in settling on choices and prudent steps. Nonetheless, because of the immense measure of data accessible on COVID-19 from different sources, there is a need to audit the parts of big data in controlling the spread of COVID-19, introducing the primary difficulties and headings of COVID-19 information investigation, just as giving a structure on the connected existing applications and studies to work with future exploration on COVID-19 analysis. Along these lines, in this paper, we direct a report to feature the commitments of a few examinations in the area of COVID-19-based large information investigation. The investigation presents as a scientific categorization a few applications used to oversee and control the pandemic. In addition, this review talks about a few difficulties experienced while operating COVID-19 data. The discoveries of this paper propose important future bearings to be considered for additional exploration and applications.

REFERENCES

1. Klaus Dietz, J.A.P. Heesterbeek (2002) "Daniel Bernoulli's epidemiological model revisited," *Mathematical Biosciences*, 180 (June):1-21
2. Fred Brauer (2017) "Mathematical epidemiology: Past, present, and future," *Infectious Disease Modelling*, 2(2) (May): 113-127
3. William Ogilvy Kermack, A. G. McKendrick (1927) "A contribution to the mathematical theory of epidemics," *Proceedings of the Royal Society A*, 115 (772) (Aug): 700-721
4. Li Q, Guan X, Wu P, Wang X, Zhou L, Tong Y, Ren R, Leung KSM, Lau EHY, Wong JY, Xing X, Xiang N, Wu Y, Li C, Chen Q, Li D, Liu T, Zhao J, Liu M, Tu W, Chen C, Jin L, Yang R, Wang Q, Zhou S, Wang R, Liu H, Luo Y, Liu Y, Shao G, Li H, Tao Z, Yang Y, Deng Z, Liu B, Ma Z, Zhang Y, Shi G, Lam TTY, Wu JT, Gao GF, Cowling BJ, Yang B, Leung GM, Feng Z. (2020) "Early Transmission Dynamics in Wuhan, China, of Novel Coronavirus-Infected Pneumonia," *N Engl J Med*. 26;382(13) (Mar):1199-1207.
5. Dilip Kumar Bagal, Arati Rath, Abhishek Barua, Dulu Patnaik (2020) "Estimating the parameters of susceptible-infected-recovered model of COVID-19 cases in India during lockdown periods," *Chaos, Solitons & Fractals*, Volume 140 (Nov)
6. He, S., Peng, Y. & Sun K. (2020) "SEIR modeling of the COVID-19 and its dynamics." *Nonlinear Dyn* 101 (Jun), 1667-1680
7. Rajesh Ranjan, Aryan Sharma, Mahendra K. Verma (2021) "Characterization of the Second Wave of COVID-19 in India," *medRxiv* (April)
8. Howard (Howie) Weiss (2013) "The SIR model and the Foundations of Public Health," *MATerials MATematics*: 1-17
9. Ashwanden C. (2021) "Five reasons why COVID herd immunity is probably impossible." *Nature*.591(7851) (Mar):520-522
10. Leung Kathy, Shum Marcus HH, Leung Gabriel M, Lam Tommy TY, Wu Joseph T. (2021) "Early transmissibility assessment of the N501Y mutant strains of SARS-CoV-2 in the United Kingdom, October to November 2020," *Euro Surveill* 26(1) (Jan)
11. David Smith and Lang Moore (2004) "The SIR Model for Spread of Disease," *JOMA* (Dec)

AUTHORS PROFILE



Ritika Singh, is currently working as an Assistant Professor. She possesses prior experience of serving on multiple application security projects in Deloitte USI. She was earlier associated with the strategic research unit at the Reserve Bank of India and the election planning unit at the Election Commission of India for research and development positions. When not absorbed in the latest gripping page-turner, Ritika loves photography, paints rather unsuccessfully, enjoys riding her bike around town, and otherwise spends far too much time at the computer. She enjoys cake, as should all right-thinking people. She is trying her worth as a blogger, you can find her by @singhritika on Medium.



Nilansh Panchani, is completing his Bachelor's of Technology (B.TECH.) in Computer Science and Engineering. He is good at programming and is interested in theoretical computer science as well. He is good at C, CPP and Python. He is also interested in Machine Learning and cyber security. He loves to read about the growing technologies and how it affects our daily life. He loves facing challenges and then solving them with full enthusiasm. He loves listening to music. When not with his computer he loves to spend time in nature. He loves reading about new things going around the world and simultaneously wants to implement new things in his life too.



Aastha Bhatnagar, is completing her Bachelor's of technology (B.TECH.) in Computer Science and Engineering. She is good at different programming languages like Python, C, CPP. She is currently working as an intern at Cognizant Technology Solutions India Private Limited ("Cognizant"). She is currently working on the "SAP ABAP" technology. She is a person full of enthusiasm, creativeness and emotions. She is good at problem solving and loves to give her best at every aspect possible. Aastha loves poetry, cooking and singing. She loves to pen down her thoughts and trying her best to be a good writer. She is trying her worth as a writer, you can find her by "adhuree_panne" on instagram.

