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SPREAD OF COVID-19 IN INDIA-A MATHEMATICAL APPROACH

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ABSTRACT: Introduction: The country needs to plan its present as well as future activities for the safety measure of coronavirus.Materials and Methods: A mathematical model is divided into four compartments as susceptible, infected, recovered, and dead peoples and used to study the stability of coronavirus in India.Results: The study shows the growth of the coronavirus on available data. During the infection period, the stability condition will not hold well if the number of patients increases concerning time.Conclusion: Different investigations, assessment of the relative of different sorts of planning can be investigated. The outcomes of the study show that the given model for the epidemic disease is unstable.

KEYWORDS— Pandemic corona-virus; mathematical models; differential equations models, covid-19**.**

I. INTRODUCTION:

World Health Organization (WHO) declared a deadly virus that has been reported by health workers in China in the last week of December with an origin at Wuhan. It has been reported that in the province of Hubei, a clan of pneumonia patients all of sudden come into the picture with the severity of problems in their lungs due to which difficulty in breathing arose and some of them lead to death which was investigated in the first month of 2020. After formal examination and based on the consequences, it has been found that these early cases caught the virus from the seafood wholesale market and the reason for the outbreak of the deadly virus was considerable [3, 4]. The virus that caused the outbreak of the pandemic is named as SARS-CoV-2. Some studies mentioned that the virus is very similar to bat coronaviruses, pangolin coronaviruses, SARS-CoV, etc.

COVID-19 is a novice infection and the details of spreading with valid reasons are still under investigation. It unfurls between well beings very nimbly not like in influenza and measles. It expands when the distance between people is less than 2 meters or 6 feet. It often spreads through tiny droplets during coughing or sneezing or talking without protection. COVID-19 is the most recent infectious disease caused by Coronavirus discovered. This new virus and disease were unknown before the outbreak, in December 2019, in Wuhan, China.

One can catch COVID-19 from an already infected person. Illness can spread by small droplets from person to person. The nose or mouth that is stretched when a COVID-19 person coughs or outbursts. Those droplets fall on surfaces and objects around that person. At that point, others get COVID-19 by contacting these items or surfaces at that point contact their eyes, their nose, or their mouth. Individuals can likewise get COVID-19 if the beads are inhaled from a COVID-19 man who coughs out or breathes out drops. The virus enters into the lungs which causes severity in breathing which causes death. The virus can be transmitted to the next person who is prone to have the disease without showing any symptoms immediately after inhaling the virus. The life span of the virus is about two weeks starting from the day when a person shows symptoms like fever, whooping cough, and consistent sneezing resulting to get more persons infected in the vicinity of infection. The only solution to have not come into the infected category is to remain more than 1 meter (3 feet) from a sick person [5,8]
The importance of face masks in today's scenario where COVID-19 spreads primarily through droplets generated when an infected person coughs or sneezes. It emphasizes the fact that the use of homemade masks by individuals gives some degree of barrier protection from the respiratory droplets that are coughed or sneezed around by infected individuals and also their use by infected people prevents the further spread of the virus. To date, there is no vaccine available to prevent the deadly virus, the only solution to fight with the virus is self-isolation at home or quarantine the person who is infectious just to further spread of the disease[7,10].

Spreads of the virus in India
The outbreak of the disease was declared in India when the first case was confirmed in January which was originated from China. To date, more than 3.5 lacs cases are confirmed in India with 52% recovery rate. In Asia,

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India has the biggest number of infected individuals. Arogya-setu app was launched by the Government of India just to create awareness about the containment zone and carrier of the deadly disease. The goal of the work is to create a mathematical model of the epidemiological disease and future scenarios consideration [9].

II. MATHEMATICAL MODELS

Mathematical modeling is the framework of translating real-life problems in terms of mathematical language that can be solved using numerical methods and theoretical methods depending upon the type of model and that describes the model correctly.

Let the current cases of coronavirus (I), the number of future cases (F), the window period in days (t) and the rate of growth (r). Thus the formula for calculation

$$r = \left(\frac{F}{I}\right)^{1/t} - 1$$

$$r + 1 = \left(\frac{F}{I}\right)^{1/t}$$

$$\log(r+1) = \frac{1}{t}\log\left(\frac{F}{I}\right)$$

$$\log\left(\frac{F}{I}\right) = t\log(r+1)$$

$$\log(F) = t\log(r+1) - \log(I)$$

In the simple deterministic model, we consider the total population say N at any time' t ' is taken to be constant. If a small set of infected persons is introduced into a big population, the fundamental problem is to explain the spread of the infection within the population, and this depends on a variety of conditions, which includes the particular disease concerned. This work consider a disease in which removal is also included like recovery after taking any drug or death or loss of interest. Consider the disease is such that the population can be divided into three different classes: the susceptible, S, who are prone to disease; the invectives, I , who are having the disease and able to transmit it; and the removed class, R, namely, those who are removed from the population by recovery, death, hospitalization or by any other means. The structure of the above model is represented by

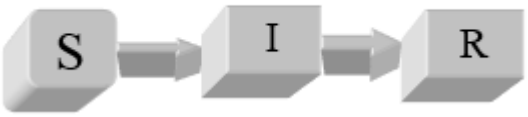

FIGURE 1. A Presentation of SIR Model

Such type of models is called SIR models. Let n be the initial number of susceptible persons in the total population in which there is only one infected person has been introduced. As a result of which the number of susceptible started decreasing and at the same time, the number of infective increases. Also, the number of recovered persons is increasing. This work consider the different classes when mixed uniformly with the condition that every individual has the same probability of coming in contact with each other [1, 2].

Basic assumptions for the mathematical model:

- The total number of the population is fixed.
- The infection is transmitted by direct individual contact.
- The recovery from an infectious disease will vary.

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$$\frac{dS}{dt} = -\beta SI$$
$$\frac{dI}{dt} = \beta SI - \alpha I - \mu R$$
$$\frac{dR}{dt} = \alpha I$$

Adding above equations, we get $\frac{dS}{dt} + \frac{dI}{dt} + \frac{dR}{dt} = 0$ which implies$S + I + R = N$, at time's' with the initial conditions that $S(0) > 0, I(0) > 0$ and$R(0) = 0$.

SIR is the simple deterministic model

Where S = Susceptible Class, I= Infective Class, R = Recovered Class, β = Transmission Rate, α = Recovery Rate and μ = Death Rate. The standard epidemic model was firstly invented in 1927 by Kermack et al. [5] and has played a significant role in mathematical epidemiology.

Stability Analysis for the system of differential equations (SIR) model

Jacobian matrix of the governing equation (SIR Model) is given as:

$$J = \begin{bmatrix} -\beta I & -\beta S & 0 \\ \beta I & \beta S - \alpha - \mu & 0 \\ 0 & \alpha & 0 \end{bmatrix} \begin{bmatrix} S \\ I \\ R \end{bmatrix}$$

$$Det(J - \lambda I) = \begin{bmatrix} -\beta I - \lambda & -\beta S & 0 \\ \beta I & \beta S - \alpha - \mu - \lambda & 0 \\ 0 & \alpha & -\lambda \end{bmatrix} \begin{bmatrix} S \\ I \\ R \end{bmatrix} = 0$$

$$i.e., \lambda_1 < 0, \lambda_2 < 0, and\ \lambda_3 < 0; if\ -(\beta I - \beta S + \alpha) > \sqrt{(\beta I - \beta S + \alpha)^2 - 4\alpha\beta I}$$

Since all the Eigen values are negative, then the given model is steady (stable), otherwise non-steady (unstable).

III. NUMERICAL SOLUTIONS

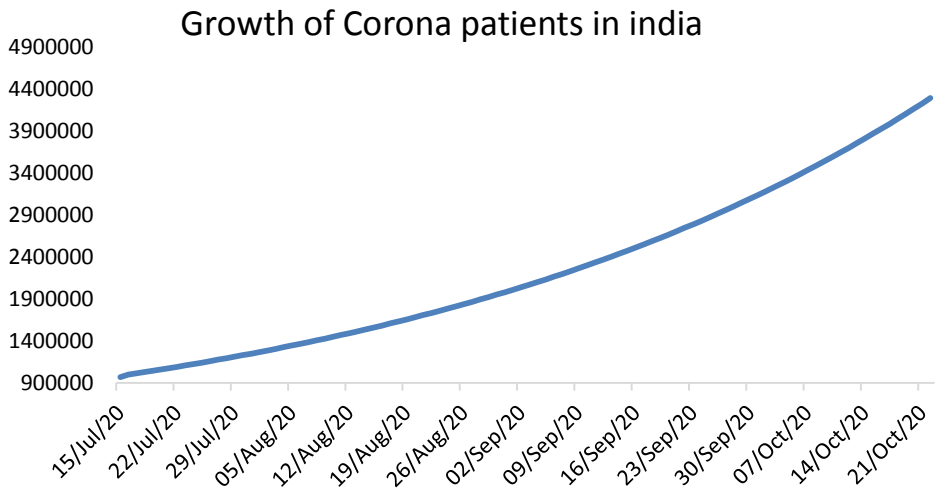

FIGURE 2. Growth of Corona patients in India

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The graph shows that the number of infected people is getting increased day by day which can be seen by the unbounded exponential nature of the graph. The complex data has been converted to simple data using graph to analyze easily. The condition shows that the rate of infection is very high.

Table 1: Parameters estimations for corona virus spreading in India on 15 July 20

Parameters	Values
β	0.20 per day
α	0.012 per day
μ	0.002 per day
S(0)	10000×10^4
I(0)	90.0000×10^4
R(0)	55.6543×10^4

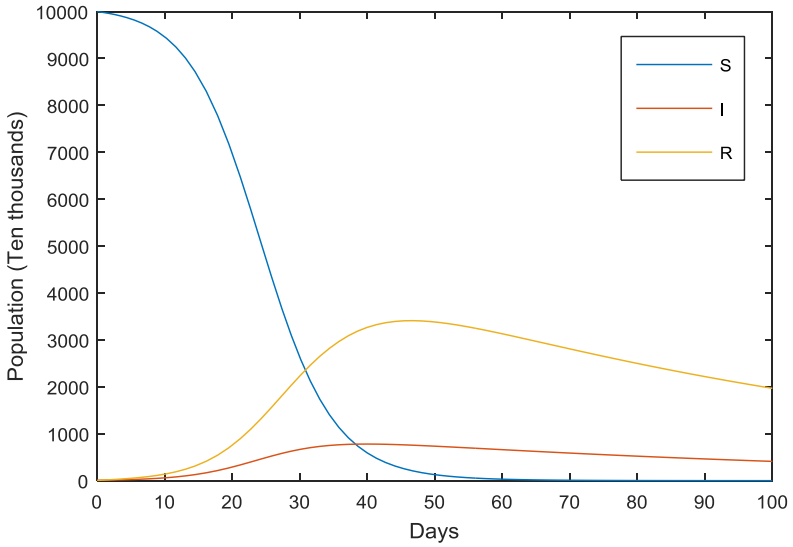

FIGURE 3: SIR Model representation of Corona patients in India

In the graph, S in blue color represents the compartment of susceptible inhabitants, I in red color represents the compartment of infectious inhabitants, and R in yellow color represents the compartment of recovered (which include death cases) inhabitants. The graph above shows that the susceptible inhabitants are decreasing which is increasing the infected inhabitants concerning time with a very high flying rate. The scale of the graph.

IV. CONCLUSION:

In this work, an approach for analyzing data of the coronavirus has been presented and the behavior of the coronavirus in India has been studied with the help of the epidemiological SIR model. The model considered is of the type- "continuous infection" as per which infected inhabitants continued in the same compartment until getting recovered by treatment or death. Prediction is based on collected secondary data for a particular period from the online resources. SIR model has been applied to the data and after analyzing the stability of the differential equations, the condition seems unstable and observed that the deadly virus can only be controlled with safety measures but is not be eradicated soon.

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