# MATHEMATICAL MODEL AND DYNAMIC ANALYSIS OF COVID-19: A SYSTEMATIC REVIEW

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*Abstract*—**Coronavirus (covid-19) is an infectious respiratory disease caused by the newly discovered virus. Affecting 219 countries and territories, a total of 101,561,219 confirmed cases and 2,196,944 deaths worldwide as per 30th January 2021 reported by World Health Organisation (WHO). In this study, the main emphasis is given to the effects of the active and sensitive parameters such as basic reproduction number and transmission rate to analyze the spread of coronavirus. The basic goal of this systematic review paper is to make a comprehensive clear understanding of the mathematical model on the covid-19 of previous research work by collating all the necessary and useful information of different countries to utilize the available covid related data for the welfare of every single country across the world. A comprehensive study of the mathematical model will also give an insight to the readers to understand better this virus to predict the target accurately or at least near the target. In the conclusion, the current art-of-state methods and their optimum analysis are enumerated.**

*Keywords*—**Coronavirus, Basic reproduction number, Transmission rate, Stability analysis, Sensitivity analysis, Mathematical Model**

## I. INTRODUCTION

SARS-COVID-2 or Covid-19 or Coronavirus is an infectious respiratory syndrome which origin is zoonotic [1] [2]. It was first spotted in the Wuhan Province of China in December 2019. Initially, it was declared as an outbreak and later declared as a pandemic on 12th March 2020 by the WHO. In India, this virus came from a student, who returned home on 30th January 2020, was studying at Wuhan University in China [3]. Initially, it was known as the novel coronavirus (nCov). Considering its recovery point, covid-19 is not that disastrous. However, the recovery in extreme cases would be 4 to 6 weeks [4].

To understand the behavior of coronavirus in a better way, researchers across the globe have devoted their time to develop the mathematical model. The mathematical model does not only help to understand the nature of this virus but also helps the government to collate the information for an effective strategy regarding the covid solution. Different mathematical models have been developed taking various parameters. For the analysis point of view of coronavirus (covid-19) spread, active and sensitive parameters are taken into account.

## II. COMPARABLE CASE STUDY OF NIGERIA AND ETHIOPIA

In this section, readers would be able to compare the mathematical model and dynamics analysis of two countries i.e. Nigeria and Ethiopia. The transmission dynamics of the Mathematical model of coronavirus has been developed in Ethiopia and Nigeria in the African continent [5] [6], [7]. In this study, the data of covid-19 infected persons in Ethiopia and Nigeria have been carefully analyzed, and observing the dynamics of transmission and then made inference on the available data. 'Model Fitting' method has been used taking into consideration both symptomatic and asymptotic patient data. In this research work, more emphasis on the two equilibrium points is given namely:

- Disease-free equilibrium point and
- Endemic equilibrium point

A parameter estimation result tells about the analysis of stability and sensitivity in terms of locally and globally asymptotic patients. Analyzing these results, an inference can be drawn that disease-free equilibrium point [8] [9] and endemic equilibrium points [9], [10] are very much dependent on the basic reproduction no. ($R_0$) i.e. locally asymptotically stable for $R_0 < 1$ (and for $R_0 > 1$ unstable) and globally asymptotically stable for $R_0 > 1$ which indicates that the disease may remain in society [6]. For the stability [11] of locally asymptotical, the lower the basic reproduction number, the more the stability in the locally asymptotic class. The

Basic reproduction number determines the spread of the disease.

Basic reproduction number is the number of secondary infections from infected persons. If the value of $R_0$ to be found out with the help of the Jacobian approach then many times it does not work well with the higher complex systems.

The sensitivity analysis [12] of the parameters shows the spreaders of the disease. Contact rate is one of the most sensitive parameters in basic reproduction number which further depends on the susceptible person and rate of transmission ($\alpha$) between exposure to the symptomatically infected person. Reducing the transmission rate is desirable as it tells the transfer rate of infection of disease from one to another. Lower the value of $\alpha$, the higher the suppression of coronavirus.

Analysis of optimum condition has been done by assessing the health education of the public, effects on the measurement of personal protective types of equipment, effects of treatment of hospitalized and isolated cases [7]. It infers that applying personal protective equipment can further suppress the spread of the disease. A comparison of two countries (Nigeria and Ethiopia) has been made in the below table as shown in Table.1 between basic reproduction number and transmission rate of the covid-19 infected person data.

Table -1 Experiment Result

| Parameters | Nigeria | Ethiopia |
|---|---|---|
| $R_0$ | 1.7031 | 1.5085 |
| $\alpha$ | 1 | 0.47 |

### III. ANALYSIS OF A MATHEMATICAL MODEL FROM STARTING TO THE CURRENT ART-OF-STATE MODEL BY TAKING SENSITIVE PARAMETERS

Initially, the basic reproduction number ($R_0$) (for the duration of 21st to 28th January 2020) [13] was very high approximately 2.4829 when the model was at the early developmental stage. As the research across the globe has been continued in this direction, the readers have a clear understanding of the behavior of the coronavirus. The research work provides the targeted value of the $R_0$ and $\alpha$ for a better understanding of the suppression of the coronavirus. Gradually, the research work, to better understand the behavior of covid-19, has started in varying degrees and dimensions of performance.

Many mathematical models, based on the particular country's covid-19 infected data along with the records of having pre-disease and no such information, have been developed to understand the coronavirus behavior. A comprehensive relative comparison of the mathematical model helps to provide a better understanding of the behavior of the coronavirus [13]. A unique method named Sobol's method has been implemented on the existing previous mathematical model of covid-19 [13]. The main motto of this method is to study the combined effects as well as the individual effects of the involved parameter in the model. Another aim is the identification of the controlling parameters which can play a crucial role in the various policy developments.

One of the models was from taking the data sets of covid infected of Spain [14]. In Spain covid infected person data, a model has been developed by the deterministic method and it is further extended by the stochastic method to keep track of the variation or uncertainty. In the stochastic method, by using the Lyapunov functional method [15], it proved that infected persons of the stochastic method are zero exponentially as the $R_0 < 1$.

Another research on the mathematical model of covid-19 when the immunity waning [16] The effective strategies are, to eliminate the covid virus or at least to reduce the effect of the spread of the virus, to provide isolation, vaccination (once or twice depending on the severity of the disease).

The mathematical model provides effective strategies regarding the issues and it develops an insight to think on the direction to understand the behavior of the problem towards a solution. It is a closer step towards achieving the target. In the current covid-19 pandemic case, it is an important scientific tool to develop the desirable targets. To better understand the behavior of the SARS-COVID-2, mathematical models based on the different parameters which are necessary for the model must be developed [6], [7],[13], [17],[18] ,[19], [20] and be analyzed.

### IV. CONCLUSION

In this paper, the mathematical models are discussed which may vary country by country due to the varying nature of the virus and its different effects. This study gives a better understanding to readers of the basic reproduction number and transmission rate for the accurate and precise targets in the developmental stage. For the optimum analysis, data at a granular level is essential for effective regulatory strategy. Local-level contact tracing is needed for better covid prevention. It gives crucial information on several parameters such as the period of incubation, basic reproductive number, transmission rate, etc.

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