INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY: APPLIED BUSINESS AND EDUCATION RESEARCH
2025, Vol. 6, No. 5, 2658 – 2670
http://dx.doi.org/10.11594/ijmaber.06.05.39

Research Article

A Compartmental Mathematical Model for Examining Transmission data of COVID-19 Pandemic in India

Chandan Kumar Sahoo[1]*, Kailash Chandra Paul[2], Nilamadhba Mishra[3]

[1]Dept. of Mathematics, GIET, Ghangapatna, Odisha-752054, India
[2]Dept. of Mathematics, IGIT SARANGA, Odisha-759146, India
[3]Dept. of Computer Science, G. H Raisoni College of Engineering, India

Article history:
Submission 06 February 2025
Revised 30 April 2025
Accepted 23 May 2025

**Corresponding author:*
E-mail:
sahoock2012@gmail.com

ABSTRACT

IT is public knowledge that the World Health Organization declared the COVID-19 outbreak a Public Health Emergency of International Concern on 30th January 2020 and a pandemic on 11th March of the same year. Its origination was traced to Wuhan in China. Till date, it has spread to around 222 countries in the world, including India. One of the major causes of the snowballing increase in COVID-19 cases has been the scarcity of knowledge on the behavior of the new virus and the awareness regarding the basic preventive practices to be adopted by people during the preliminary days of the spread of the infection. The very 1st case in India was logged on 15th February 2020, and since then, the caseload of infected persons has snowballed to over 2.67cr only in India and 159.8 million cases worldwide, as recorded by the Worldometer. The spreading rate of COVID-19 version 2.0 has been phenomenal as compared to the version1.0. Countrywide complete and or partial lockdowns, followed by immediate isolation of infected persons, were the measures initiated by the authorities in order to contain the spread of the disease. The aim of the study is to suggest means to reduce the active cases and control the transmission risk and mortality rates. The research thus helps to calculate and predict the threshold value of the disease. In addition, the Environmental Impact Assessment Tool (EIAT) was used to perform the sensitivity analysis to determine the robustness of the assessment by examining the extent of the evolution and impacts of the pandemic in the country. The constructed control model introduced five control variables as the backbone of the adopted control strategies. The simulated results and analysis carried there upon give strong indication that quarantine and provision of timely and appropriate medical attention to the infected individuals

How to cite:
Sahoo, C. K., Paul, K. C., & Mishra, N. (2025). A Compartmental Mathematical Model for Examining Transmission data of COVID-19 Pandemic in India. *International Journal of Multidisciplinary: Applied Business and Education Research*. *6*(5), 2658 – 2670. doi: 10.11594/ijmaber.06.05.39

will help reduce the number of critically infected cases to a considerably low level, which will further arrest transmission rate, mortality and active ceases in India.

Keywords: *COVID-19, Dynamic Transmission, EIAT, EIA model*

Introduction

The novel corona virus disease (known as named as COVID-19) was first detected in the Wuhan city of the Hubei province of China in the month of December, 2019 and since then it has spread like wildfire over 222 countries including India. Being a novel virus of Corona type, there was absolute dearth of knowledge about its characteristics and behaviors during the preliminary periods of its onset, and obvious lack of its remedy led to fast spreading of the infection. So much so that 155.6 millions of people worldwide got affected in a span of a year and half, out of which almost 26.7 million belonged to India. In India first positive case has been detected on 15th February, 2020. The outbreak has taken the form of pandemic with more than 155.6 million positive cases and has taken toll of more than 3.25 million. In India 2.67 crore individuals has been reported positive with 303,751 deaths and 23,720,919 recoveries. Immediate measures have been taken by both central as well as respective state Governments in India to contain the COVID-19; spreading the awareness on the need for social distancing, testing in massive scale, identification and containment of infected clusters, lockdown, shut down and massive vaccination drive post availability of vaccines, are such measures. Such various steps have not excluded mathematical perspectives [1, 2]. Mathematical model to predict and analyze the progression of an affliction has been adopted by the SIR model which is one of the variant of SIQR [3].This modeling technique for COVID-19has emphasized the isolation of infectious cases. Analysis of this model includes a couple of the initially most contrived countries, like Brazil [4] and Italy [5]. As per the power-law growth [6], the lock down and shut down effect on arresting the proliferation of the infection [7] have been significant in India. In the month of December 2019, the outbreak of COVID-19 spiraled out not only within China but also spread over worldwide [8, 21]. Scientists and Medical experts trialed with the existing drugs to treat COVID-19, which however did not yield the expected result. In February 2020, the WHO declared COVID-19 as a pandemic and pressed upon the urgent need to control the viral transmission from amongst humans [9]. In spite of the very stringent measures adopted by China the spiral progression of the disease could not be contained, moreover it spread rapidly to many countries and territories throughout the world in a very short span of time [10, 11]. The most significant cause for rapid proliferation of novel corona virus has been dearth of knowledge and awareness regarding the virus of during its initial stages of growth. This virus causes high mortality, spread rapidly. It does not show any symptoms in its early infection stage and it affects any age of peoples [12]. Records showed that mortality rate of old age humans are more because they are not only affected by Covid-19 but also by other diseases like diabetics, blood pressure, heart disease etc.

In India, the outbreak of COVID-19 spiked very rapidly, mostly because of the migration of people in large scale from their place of work to their respective hometowns on the aftermath of nationwide lockdown, largely negating the expected positive effect of such a stringent action. Besides, as figured out by experts the visible symptoms of the disease in an infected person was supposed to take 5 to 6 days from the day of contamination, however it was ascertained that it could also last up to 14 days, which makes it tougher to isolate infected individuals during the preliminary stages of infection [13]. The symptoms of COVID-19 include fever with high body temperature, dry coughing, fatigue, body ache, sore throat, diarrhea, conjunctivitis, headache, loss of taste and/or smell, skin rashes, discoloration of fingers and/or toes, shortness of breath, chest pain, loss of speech or movement etc. [14]. Current evidences suggest that the virus proliferates amongst people spending time in close contact with each other, typically when the distance between two individuals is less than 1 meter (short-range). Also, the said virus being airborne in nature, persons can be infected through eye, nose, or mouth by inhaling or coming in direct contact with the virus containing aerosols or droplets [15]. The possibility of spread also becomes more stronger in poorly ventilated, crowded indoors [16], as aerosols tend to remain suspended in the air and travel more than 1 meter (long-range). Infection can also spread by touching contaminated surfaces and passing on the same to the body by eyes, nose or mouth, thus requiring proper sanitization of public places and frequent cleaning of hands with soap [14, 17]. The risk factor of getting contaminated by COVID-19 is very high as the virus remains in active state in the environment for several days [18]. Aged persons and children are more vulnerable to COVID-19 as they possess low immunity, and they tend to get seriously affected by it [19]. As the a lack of any definitive treatment or vaccines to fight this virus, keeping isolated the infected persons in quarantine facilities has been the primary and the only means of containing the disease as adopted by most of the affected countries. Also, lockdown and shutdown steps are taken in the highly affected regions [20]. Despite of all these preventive strategies, Indians are still at high risk as the transmission is still at large and mortality continues as the virus is changing its form through genetic mutation, the delta strain followed by currently concerning omicron being the dark realities of the affair.

To ameliorate this situation, study of EIAT and EIA mathematical model play very vital roles to identify, recognize value and predict the pandemic behavior of the infectious disease and minimize the active cases. A gamut of studies has already been carried out to analyze the dynamics of COVID-19 proliferation. Based on these databases, our studies of COVID-19 outbreak employed data from 31st December2019 to 23rd May2021 to analyze the evolution of COVID-19 in India with the EIAT and EIA model. The parameters and indicators that can determine the growth, spread of disease and minimize the infected and positive active cases in India are considered.

Assumptions

- Lockdown reduces the infection rate.
- Social distancing minimizes the spread of disease.
- Use of masks and gloves minimizes social contact.
- Use of sanitizer kills the virus of COVID-19.
- Spreading rate should be minimized by home isolation and quarantine.
- Vaccination reduces the rate of spreading of virus of COVID-19.

Notations

- E (t): Individuals exposed to infected person(s) but not infected yet
- I(t) : Persons infected by COVID-19
- C(t) : COVID-19 infected persons in critical condition
- H(t) : Persons hospitalized
- D(t) : Persons succumbed to COVID-19
- B : Exposed individual's birth rate. (0.01)
- γ_1 : Test positive Rate (0.11 to 0.13)
- γ_2 : Rate of recovery of infected persons with strong immunity and getting exposed again (0.25-0.34)
- γ_3 :Hospitalized rate of infected individuals. (0.26-0.35)
- γ_4 : Rate of infected individuals who passed away. (0.015 – 0.033)
- γ_5 : Rate of infected individuals into critical condition. (0.36-0.45)
- γ_6 :Rate of recovery of hospitalized persons and getting exposed again. (0.87-0.97)
- γ_7 : Rate of critically infected individuals to hospitalized (0.65-0.80 assumed)
- γ_8 : The rate of hospitalized individuals goes into critical condition. (0.4calculated)
- γ_9 :Rate of critically infected individuals to pass away (0.09)
- γ_{10} :Rate of infected corpse spreading infection (0.011 assumed)
- μ : Natural death rate. (0.01)

Mathematical Model Formulation

This study analyzes the dynamicity of COVID-19 by a compartmental constructed model. The model encompasses all feasible means of transmission of the virus in the human populace. The contagious nature of COVID-19 and caseload of infection has been quite severe in most of the countries around the world. The susceptible population is ignored in this model, and the total population is divided into five parts. The dynamicity of the proliferation of COVID-19 from human to human has been represented graphically.

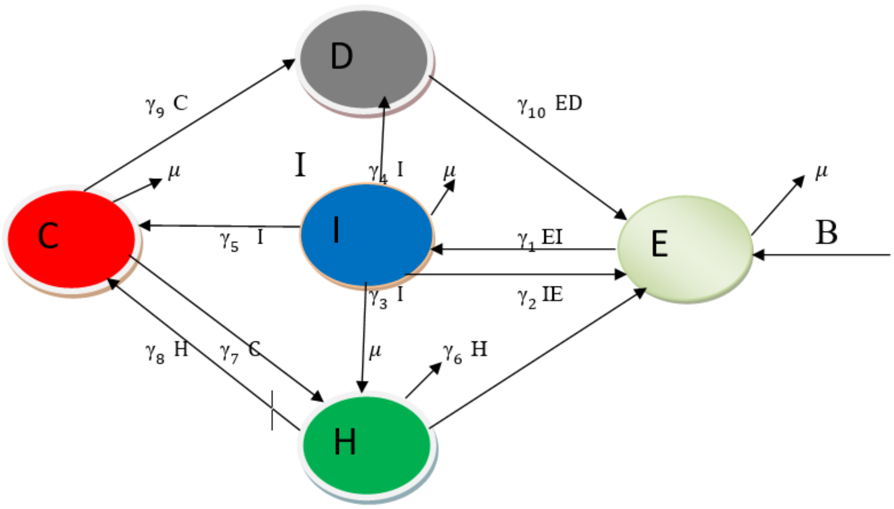


Figure 1. Dynamical Transmission of COVID-19

Using the above figure 1, the system of a set of nonlinear differential equations for the model is represented as below:

$$\frac{dE}{dt} = B + \gamma_2 IE - \gamma_1 EI + \gamma_6 H + \gamma_{10} ED - \mu E$$

$$\Rightarrow \frac{dE}{dt} + \mu E = B + \gamma_2 IE - \gamma_1 EI + \gamma_6 H + \gamma_{10} ED \quad (1)$$

$$\frac{dI}{dt} = \gamma_1 EI - \gamma_2 IE - (\gamma_3 + \gamma_4 + \gamma_5 + \mu)I$$

$$\Rightarrow \frac{dI}{dt} + (\gamma_3 + \gamma_4 + \gamma_5 + \mu)I = \gamma_1 EI - \gamma_2 IE \quad (2)$$

$$\frac{dC}{dt} = \gamma_5 I + \gamma_8 H - (\gamma_7 + \gamma_9 + \mu)C$$

$$\Rightarrow \frac{dC}{dt} + (\gamma_7 + \gamma_9 + \mu)C = \gamma_5 I + \gamma_8 H \quad (3)$$

$$\frac{dH}{dt} = \gamma_3 I + \gamma_7 C - (\gamma_6 + \gamma_8 + \mu)H$$

$$\Rightarrow \frac{dH}{dt} + (\gamma_6 + \gamma_8 + \mu)H = \gamma_3 I + \gamma_7 C \quad (4)$$

$$\frac{dD}{dt} = \gamma_4 I + \gamma_9 C - \gamma_{10} ED \quad (5)$$

(Here, all the parametric values used in this proposed model are positive)

From eqn (2)

$I.F = e^{(\gamma_3+\gamma_4+\gamma_5+\mu)t}$

And $$I(t) = \frac{\gamma_1 \mathbf{EI} - \gamma_2 IE}{(\gamma_3+\gamma_4+\gamma_5+\mu)} + Ke^{-(\gamma_3+\gamma_4+\gamma_5+\mu)t} \quad (6)$$

At t=0, $\gamma_1 = \gamma_2 = \gamma_3 = \gamma_4 = \gamma_5 = 0$

$$I(t) = I_0 e^{-(\gamma_3+\gamma_4+\gamma_5+\mu)t} + \frac{\gamma_{1.EI} - \gamma_{2.}IE}{(\gamma_3+\gamma_4+\gamma_5+\mu)} \quad (7)$$

A_0 is the number of infected individuals in the country at the start of the disease. In this model I_0 = 222704, considered as the initial value.

Confirmed positive Active cases $A^* = [C_0$ +I+C+H] in the country at the time (t).

$$A^*(t) = C_0 + I(t) + C(t) + H(t) \quad (8)$$

From eqn (3)

$$I.F = e^{(\gamma_7+\gamma_9+\mu)t}$$

$$C(t) = \frac{\gamma_5 I+\gamma_8 H}{\gamma_7+\gamma_9+\mu} + K_1 e^{-(\gamma_7+\gamma_9+\mu)t} \quad (9)$$

At t=0, $\gamma_5 = \gamma_7 = \gamma_8 = \gamma_9 = 0$ and $C(t_0) = C_0$, then we get

$$C(t) = C_0 e^{-(\gamma_7+\gamma_9+\mu)t} + \frac{\gamma_5 I+\gamma_8 H}{\gamma_7+\gamma_9+\mu} \quad (10)$$

From eqn (4)

$$\frac{dH}{dt} + (\gamma_6 + \gamma_8 + \mu)H = \gamma_3 I + \gamma_7 C$$

$$I.F = e^{(\gamma_6+\gamma_8+\mu)t}$$

$$H(t) = \frac{\gamma_3 I+\gamma_7 C}{\gamma_6+\gamma_8+\mu} + K_2 e^{-(\gamma_6+\gamma_8+\mu)t} \quad (11)$$

At t=0,$\gamma_3 = \gamma_6 = \gamma_7 = \gamma_8 = 0$ and $H(t_0) = H_0$

$$H(t) = H_0 e^{-(\gamma_6+\gamma_8+\mu)t} + \frac{\gamma_3 I+\gamma_7 C}{\gamma_6+\gamma_8+\mu} \quad (12)$$

Substituting eqn (7), eqn (10), and eqn (12) in eqn (8), we get

$$A(t) = \begin{Bmatrix} C_0 + I_0 e^{-(\gamma_3+\gamma_4+\gamma_5+\mu)t} + C_0 e^{-(\gamma_7+\gamma_9+\mu)t} + H_0 e^{-(\gamma_6+\gamma_8+\mu)t} \\ + \frac{\gamma_{1.EI} - \gamma_{2.}IE}{(\gamma_3+\gamma_4+\gamma_5+\mu)} + \frac{\gamma_5 I+\gamma_8 H}{\gamma_7+\gamma_9+\mu} + \frac{\gamma_3 I+\gamma_7 C}{\gamma_6+\gamma_8+\mu} \end{Bmatrix} \quad (13)$$

From (5) we get

$$\frac{dD}{dt} = \gamma_4 I + \gamma_9 C - \gamma_{10} ED$$

$$\Rightarrow D(t) = (\gamma_4 I + \gamma_9 C - \gamma_{10} ED)t + K_3$$

At t=0, $D(t = 0) = D_o$ then we get

$$D(t) = D_o + (\gamma_4 I + \gamma_9 C - \gamma_{10} ED)t$$

The total confirmed positive cases $T_{cP} = C_0 + I(t) + C(t) + H(t) + D(t)$

i.e. $$T_{cP} = \begin{Bmatrix} C_0 + I_0 e^{-(\gamma_3+\gamma_4+\gamma_5+\mu)t} + C_0 e^{-(\gamma_7+\gamma_9+\mu)t} + H_0 e^{-(\gamma_6+\gamma_8+\mu)t} + D_o \\ + \frac{\gamma_{1.EI} - \gamma_{2.}IE}{(\gamma_3+\gamma_4+\gamma_5+\mu)} + \frac{\gamma_5 I+\gamma_8 H}{\gamma_7+\gamma_9+\mu} + \frac{\gamma_3 I+\gamma_7 C}{\gamma_6+\gamma_8+\mu} + (\gamma_4 I + \gamma_9 C - \gamma_{10} ED)t \end{Bmatrix} \quad (14)$$

Now we want to minimize the Active cases to control the COVID-19 issues in India

$$\frac{dA}{dt} = 0 \; and \; \frac{d^2A}{dt^2} > 0$$

$$\frac{dA(t)}{dt} = \begin{Bmatrix} -(\gamma_3+\gamma_4+\gamma_5+\mu)I_0e^{-(\gamma_3+\gamma_4+\gamma_5+\mu)t} \\ -(\gamma_7+\gamma_9+\mu)C_0e^{-(\gamma_7+\gamma_9+\mu)t} \\ -(\gamma_6+\gamma_8+\mu)H_0e^{-(\gamma_6+\gamma_8+\mu)t} \end{Bmatrix} = 0$$

And

$$\frac{d^2A}{dt^2} = \begin{Bmatrix} (\gamma_3+\gamma_4+\gamma_5+\mu)^2I_0e^{-(\gamma_3+\gamma_4+\gamma_5+\mu)t} \\ +(\gamma_7+\gamma_9+\mu)^2C_0e^{-(\gamma_7+\gamma_9+\mu)t} \\ +(\gamma_6+\gamma_8+\mu)^2H_0e^{-(\gamma_6+\gamma_8+\mu)t} \end{Bmatrix} > 0$$

Numerical Example

In this section, it has been provided a numerical data to understand the model. Considering the following parameter value in proper percentage and the output of the Numerical model implemented by MATHEMATICA software version 12.0. A_0 = 2805399, C_0 = 1081460, H_0 = 402154 , EI=2123782, IE= I_0 = 222704, μ =0.01,γ_1 = 0.11 ,γ_2=0.25, γ_3=0.35, γ_4= 0.01, γ_5 = 0.45 , γ_6 =0.87, γ_7 =0.65, γ_8 = 0.40, γ_9 = 0.09, γ_{10} = 0.0112. According to the programming, it is found that minimizing the infection cases (I*) as well as reducing the confirmed positive cases (A*).

Table-1: variation of I with γ_1 and γ_2*

γ_2	$\gamma_1 = 0.13$	$\gamma_1 = 0.12$	$\gamma_1 = 0.11$
0.25	268800	242900	217000
0.28	260651	234752	208852
0.31	252504	226604	200705
0.34	244356	218456	192557

- when test positive rate(γ_1) decreases and recovery rate of infected persons with strong immunity (γ_2) remains unchanged, then the current infection (I*) decreases.
- When Testpositiverate(γ_1) becomes unchanged and recovery rate of infected persons with strong immunity (γ_2) increases, then the current infection (I *) decreases.

Table-2: variation of I with γ_1 and γ_3*

γ_3	$\gamma_1 = 0.13$, $\gamma_2 = 0.25$	$\gamma_1 = 0.12$, $\gamma_2 = 0.25$	$\gamma_1 = 0.11$, $\gamma_2 = 0.25$
0.32	279007	252124	225241
0.29	290021	262076	234132
0.26	301939	272846	243753

- when Test positive Rate(γ_1) increases and recovery rate of infected persons with strong immunity (γ_2) remains unchanged & Hospitalization rate of infected individuals (γ_3) decreases, then the current infection (I *) increases.
- When the recovery rate of infected persons with strong immunity (γ_2) and the Hospitalization rate of infected individuals (γ_3) remains unchanged &Test positive Rate(γ_1) decreases, then the current infection (I *) decreases.

Table-3: variation of I with* γ_1 *,* γ_2 *and* γ_5

γ_5	$\gamma_1 = 0.11$ $\gamma_2 = 0.28$	$\gamma_1 = 0.11$ $\gamma_2 = 0.31$	$\gamma_1 = 0.11$ $\gamma_2 = 0.34$
0.42	216783	208326	202688
0.39	225341	216550	210689
0.36	234601	225449	219348

- when Test positive Rate (γ_1) and rate of infected individuals into critical condition (γ_5) are unchanged & recovered rate of infected persons with strong immunity (γ_2) increase, then current infection(I*) decreases.
- when Test positive Rate (γ_1) & recovery rate of infected persons with strong immunity (γ_2) remains unchanged & rate of infected individuals in critical condition (γ_5) decreases, then the current infection (I *) increases.

Table-4: variation of I and C* with* γ_1

parameters	%values	I*	C*
γ_1	0.11	217000	855527
	0.12	242900	871067
	0.13	268800	886607
γ_2	0.28	208852	850638
	0.31	200705	845750
	0.34	192557	840861
γ_5	0.42	225241	851462
	0.39	234132	847075
	0.36	243753	842328

- When the recovery rate of infected individuals themselves due to strong immunity (γ_2) remains unchanged and Test positive Rate(γ_1) increases, then current infection (I*) and current critical cases(C*) increases.
- When Test positive Rate(γ_1) remains unchanged, and the recovery rate of infected individuals themselves due to strong immunity (γ_2)increases, then current infection (I*) and current critical cases (C*) decrease.
- When the rate of infected individuals into critical condition (γ_5) decreases and remaining γ values remain unchanged, then current infection(I*) increases and current critical cases (C*) decreases.

Table-5: variation of H with I* and C**

I*	C*	H*
217000	855527	605597
242900	871067	620570
268800	886607	635544

- When current infection (I*) and current critical cases (C*) increase, then current Hospitalization (H*) increases.

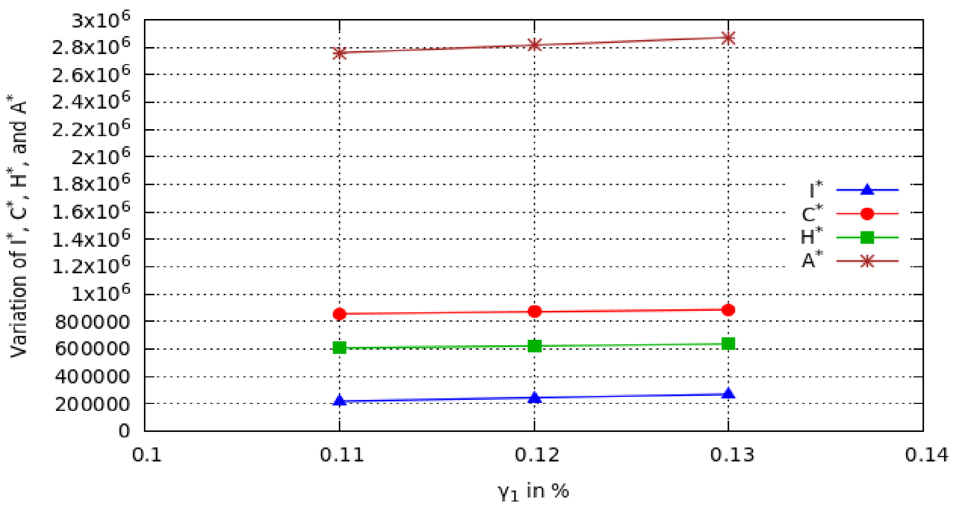
Table-6: variation of H with γ_6*

γ_6	I*	C*	H*
0.90	217000	855527	590983
0.93	242900	871067	576975
0.97	268800	886607	559175

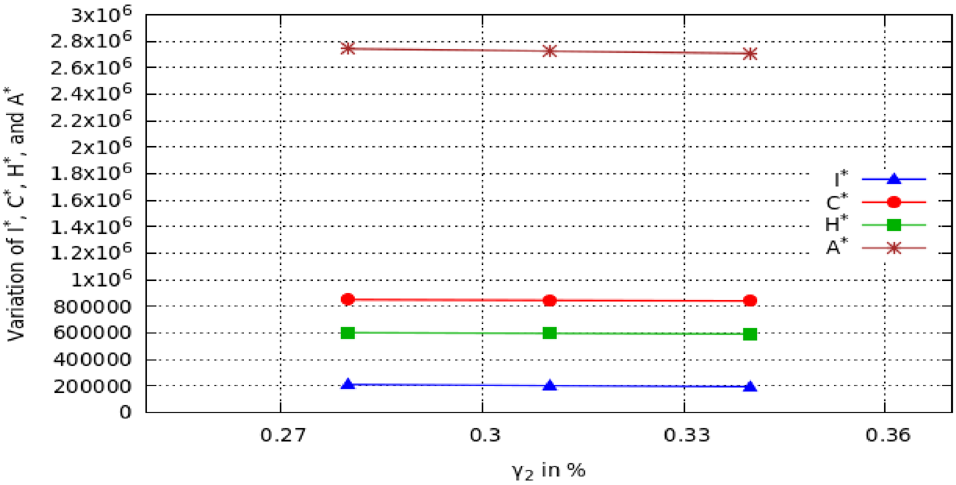
- When the rate of hospitalized individuals getting recovered (γ_6) increases, then current Hospitalization (H*) decreases.

Table-7: Summary of all cases considered (with predicted values)

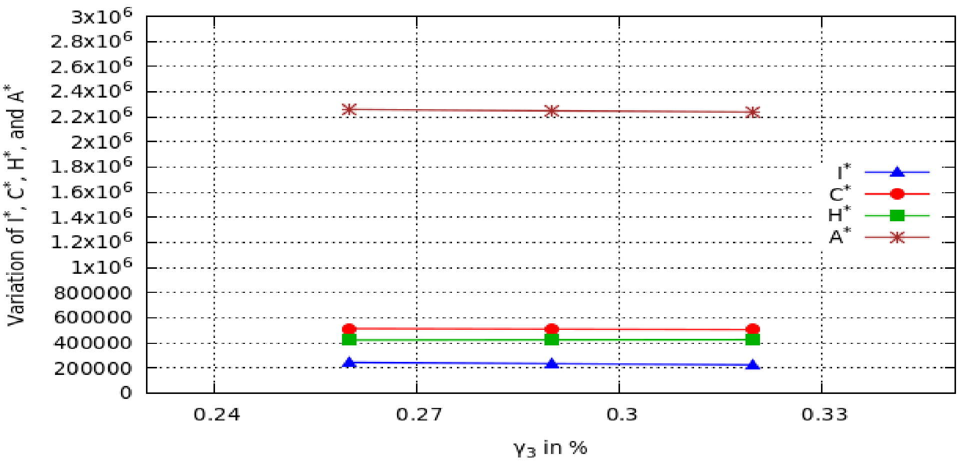
parameters	% value	I*	C*	H*	A*
γ_1	0.11	217000	855527	605597	2,759,585
	0.12	242900	871067	620570	2,815,997
	0.13	268800	886607	635544	2,872,411
γ_2	0.28	208852	850638	600886	2,741,836
	0.31	200705	845705	596176	2,724,091
	0.34	192557	840861	591466	2,706,344
γ_3	0.32	225241	505545	424846	2,237,092
	0.29	234132	508671	423169	2,247,432
	0.26	243753	512053	421353	2,258,619
γ_5	0.42	225241	851462	605786	2,763,949
	0.39	234132	847075	605990	2,768,657
	0.36	243753	842328	606210	2,773,751
γ_6	0.90	217000	855527	590984	2,744,971
	0.93	217000	855527	576975	2,730,962
	0.97	217000	855527	559175	2,713,162
γ_7	0.70	217000	589298	481378	2,369,136
	0.75	217000	561877	488171	2,348,508
	0.80	217000	536134	493896	2,328,490



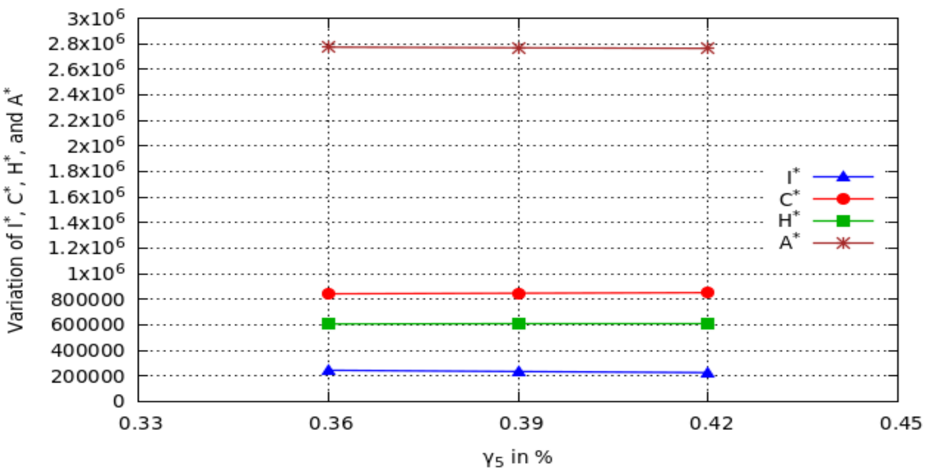
Variation of Infected cases (I*), Critical cases (C*), Hospitalized cases (H*), and Active cases (A*) with respect to TPR (Υ_1) growth per day in India as of 23rd May 2021.



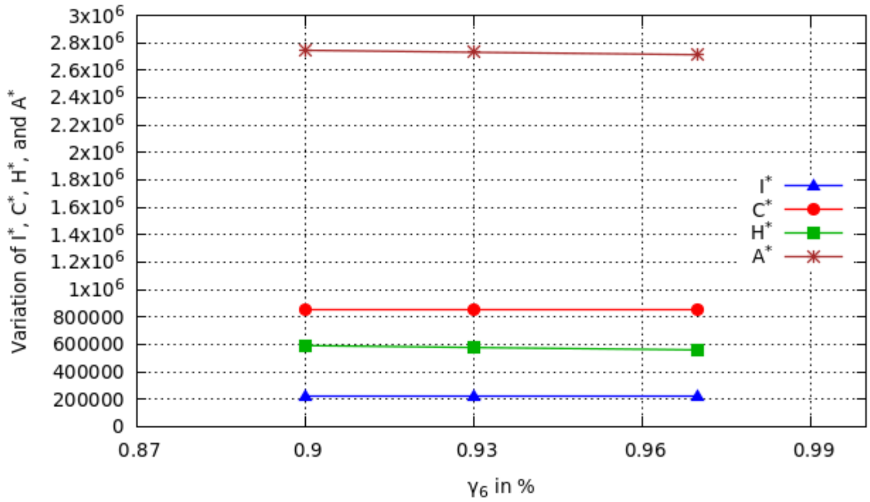
Variation of Infected cases (I*), Critical cases (C*), Hospitalized cases (H*), and Active cases (A*) with respect to TPR (Υ_2) growth per day in India as of 23rd May 2021.



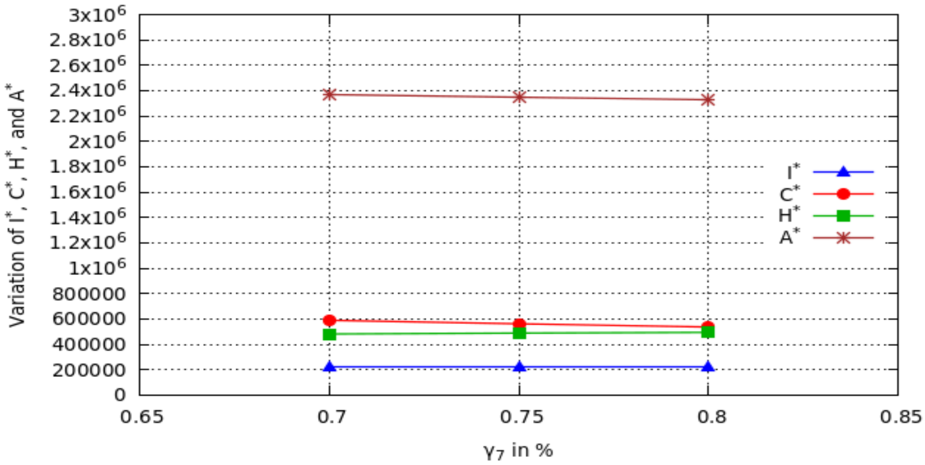
Variation of Infected cases (I*), Critical cases (C*), hospitalized cases (H*), and Active cases (A*) concerning TPR (Υ_3) growth per day in India as of 23rd May 2021



Variation of Infected cases (I*), Critical cases (C*), Hospitalized cases (H*), and Active cases (A*) with respect to TPR (Υ_5) growth per day in India as of 23rd May 2021.



Variation of Infected cases (I*), Critical cases (C*), Hospitalized cases (H*), and Active cases (A*) with respect to TPR (Υ_6) growth per day in India as of 23rd May 2021



Variation of Infected cases (I*), Critical cases (C*), Hospitalized cases (H*), and Active cases (A*) with respect to TPR (Υ_7) growth per day in India as of 23rd May 2021

Sensitivity Analysis

- When the test positive rate ($\boldsymbol{\gamma_1}$) increases, then simultaneously the current value of infection (**I***), current critical cases(**C***), current hospitalized cases(**H***), and current active cases(**A***) increases.
- When the recovered rate of infected individuals themselves due to strong immunity (γ_2) increases, then simultaneously the current value of infection (**I***), current critical cases(**C***), current hospitalized cases(**H***), and current active cases(**A***) decrease.
- When hospitalized rate of infected individuals (γ_3) decreases gradually, then current Hospitalized cases (**H***) decreases but current value of infection (**I***), current critical cases (**C***) and current active cases (**A***) increases.
- When the rate of infected individuals into critical condition (γ_5) gradually decreases, then current critical cases (**C***) decreases but current value of infection (**I***), current Hospitalized cases (**H***) and current active cases (**A***) increases.
- When the rate of hospitalized individuals get recovered (γ_6) gradually increases, then current hospitalized cases (**H***) and current active cases (**A***) decrease.

- When the rate of critically infected individuals to hospitalized (γ_7) gradually increases, then current critical cases (**C***) decrease, current hospitalized cases (**H***) increase, but current active cases (**A***) decrease.

Conclusion

The study proposes a compartmental model designed to examine the proliferation of the COVID-19 outbreak in the human populace. The objective of this work is to reduce active cases and control the transmission risk and demises. The research has helped to calculate and predict the threshold value of the disease using India as a case study. To develop strategies in order to prevent the pandemic of COVID-19, a successful control model has been invented and applied to minimize the active cases and risk of transmission. Based on the literature reviewed, the study also discovered that there is need to speedily accelerated the vaccination process, maintain social distance, wear masks, washing of hands using soap, sanitized hands and the surroundings by using sanitizer, increasing SARS-CoV-2 antibody and antigen tests and increases hospital facility for both infected and critical individuals; particularly in places where the government has restricted gathering during the lockdown and shutdown period. The above-mentioned sorts of measures have to be firmly undertaken to slow down the social transmission of disease to the uninfected class of the population. However, using our control model, the research introduced five control variables as the form of control strategies. These strategies include self-imposed quarantine by the persons exposed to COVID-19-affected individuals, home or institutional isolation of infected persons, optimum care of infected persons in order to keep the case load of critically ill at a minimal level, and capacity expansion of hospital and related health facilities specifically meant for COVID-19 infected patients. The simulated results and analysis carried there upon give strong indication that quarantine and provision of timely and appropriate medical attention to the infected individuals will help reduce the number of critically infected cases to a considerably low level, which will further arrest transmission rate, mortality and active ceases in India. Since the onset of the COVID-19 virus, it has been evolving by presenting newer variants with the progress of time, ushering in waves of the spread. The proposed model can very well be verified for its efficacy against these surges as a future scope of research.

Declaration of Competing Interest

We declare that there was no known competing financial interest and/or relationship with the respondents, any financial body, or governmental or non-governmental agency that might have influenced the data collection process or the dataset.

Supplementary Materials

The survey questionnaire and the MATHEMATICA Software version 12.0 programming for Solving Numerical Examples.

Acknowledgments

The authors appreciate all the participants who took part in this online survey.

Funding

We declare that this survey was not funded by any research agency. The authors did not receive any funds from any governmental or non-governmental organization.

References

Ana Catarina Pêgo, Illyane Sofia Lima and Raffaella Gozzelino, covid 2024 ,4(2),170-190; https://doi.org/10.3390/covid4020014

Chen, Y., Cheng, J., Jiang, Y., & Liu, K. (2020). A time delay dynamic system with an external source for the local Outbreak of 2019-nCoV. Applicable Analysis, 1-12. https://doi.org/10.1080/00036811.2020.1732357

Cheng, Z. J., & Shan, J. (2020). 2019 Novel coronavirus: where we are and what we know. *Infection*, 1-9. DOI: 10.1007/s15010-020-01401-y

Crokidakis, N. (2020), Data analysis and modeling of the evolution of COVID-19 in Brazil, arXiv:2003.12150 (2020).

https://www.researchgate.net/publication/340270886

Diekmann, O., Heesterbeek, J. A. P., & Metz, J. A. (1990). On the definition and the computation of the basic Reproduction ratio R0 in models for infectious diseases in heterogeneous populations. Journal of Mathematical Biology, 28 (4), 365-382. https://link.springer.com/article/10.1007/BF00178324

Driessche, P.; Watmough, J.; Reproduction numbers and sub-threshold endemic equilibria for compartmental models of disease transmission, Mathematical Biosciences.180(1) (2002), 29-48. https://doi.org/10.1016/S0025-5564(02)00108-6

https://www.worldometers.info/coronavirus/country/india// [Last accessed on 23.05.2021].

https://www.mohfw.gov.in/[Last accessed on 23.05.2021]

Janet O. Agbaje, Oluwatosin Babasola,Kabiru Michael Adeyemo,Abraham Baba Zhiri,Aanuoluwapo Joshua Adigun,Samuel Adefisoye Lawal,Oluwole Adegoke Nuga,Roseline Toyin Abah,Umar Muhammad Adam and Kayode Oshinubi COVID 2024, 4(2), 289-316; https://doi.org/10.3390/covid4020020

Khot, W. Y., & Nadkar, M. Y. (2020). The 2019 Novel Corona virus Outbreak–A Global Threat. J Assoc Physicians India, *68*(3), 67-71. https://pubmed.ncbi.nlm.nih.gov/32138488/

Li Q., Guan X., Wu P., Wang X, Zhou L., Tong Y. (2020) Early transmission Dynamics in Wuhan, China, of Novel Corona Virus-Infected Pneumonia. N Engl J Med. DOI: 10.1056/NEJMoa2001316

OluwatobiBanjo, Kazeem A. Adeleke, Peter I. Ogunyinka, Dawud Adebayo Agunbiade (2021) "Survey data on the knowledge, attitudes and practices of Nigerians towards the prevention and spread of COVID-19 during the lockdown period in Nigeria." Africa Journal of Sustainable Development (AJSD). doi: 10.1016/j.dib.2021.107074

Pedersen, M.G. and Meneghini, M., (2020) Quantifying undetected COVID-19 cases and effects of Containment measures in Italy, preprint 2020, available online at https://www.researchgate.net/publication/339915690.

Q. Li, X. Guan, P. Wu, et al.Early transmission dynamics in Wuhan, China, of novel coronavirus-infected pneumoniaN Engl J Med, 29 (2020), 10.1056/NEJMoa2001316

Singh, R. and Adhikari, R. (2020). Age-structured impact of social distancing on the COVID-19 epidemic in India (2020). arXiv:2003.12055v1

Tang, B., Wang, X., Li, Q., Bragazzi, N. L., Tang, S., Xiao, Y., & Wu, J. (2020). Estimation of the transmission risk of the 2019-nCoV and its implication for public health interventions. Journal of Clinical Medicine, *9*(2), 462. Doi: 10.3390/jcm9020462

Thevarajan, I., Nguyen, T. H., Koutsakos, M., Druce, J., Caly, L., van de Sandt, C. E.& Tong, S. Y. (2020). Breadth of concomitant immune responses before patient recovery: a case report of non-severe COVID-19. Nature Medicine, 1-3. https://www.nature.com/articles/s41591-020-0819-2

Tiwari Alok "Modelling and analysis of COVID-19 epidemic in India"https://doi.org/10.1101/2020.04.12.20062794,(2020)

Verma, M.K., Asad, A. and Chatterjee, S. (2020) COVID-19 epidemic: Power law spread and flattening of the curve, preprint 2020, https://doi.org/10.1101/2020.04.02.20051680

World Health Organization. Corona virus disease 2019 (COVID-19): Situation report, 51, (2020) https://apps.who.int/iris/handle/10665/331475

Wu, J. T., Leung, K., & Leung, G. M. (2020) Now casting and forecasting the potential domestic and international spread of the 2019-nCoV outbreak originating in Wuhan, (2020). China: a modeling study. *The Lancet*, *395*(10225), 689-697. https://doi.org/10.1016/S0140-6736(20)30260-9

Yang, C., & Wang, J. (2020). A mathematical model for the novel corona virus epidemic in Wuhan China. Mathematical Biosciences and Engineering, *17*(3), 2708-2724. DOI: 10.3934/mbe.2020148

Zhao, Z., Zhu, Y. Z., Xu, J. W., Hu, Q. Q., Lei, Z., Rui, J., Liu, X., Wang, Y., Luo, L. Yu, S.S. & Li, J. (2020). A mathematical model for estimating the age-specific transmissibility of a novel coronavirus. *MedRxiv*. Doi: https://doi.org/10.1101/2020.03.05.20031849

Zhong, L., Mu, L., Li, J., Wang, J., Yin, Z., & Liu, D. (2020). Early Prediction of the 2019 Novel Corona virus Outbreak in Mainland China based on Simple Mathematical Model. IEEE Access, 51761 - 51769. DOI: 10.1109/ACCESS.2020.2979599