A Mathematical Algorithms of Covid-19 and intervention programme in India

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# A Mathematical Algorithms of Covid-19 and intervention programme in India

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**Abstract**

*Covid-19 intervention strategies consists of lockdown, quarantine, hospitalization, vaccination and SOP procedure. In India, such intervention strategies or programmes implemented in India has brought tremendous results with reduction in the spread. These strategies have optimised the three phases peak level of the pandemic to converge confirming the decline in the country. Some of the coronavirus research studies reviewed shows the nuances of Covid-19 non-pharmaceutical interventions, pharmaceutical interventions and other measures. Mask-based intervention and maintaining social-distancing plays an important role in curbing the Covid-19. The amount spent on combating Covid-19 varies from the highest of 967 percent of GDP in India followed by 187 percent of GDP in Turkey, 11.8 percent of GDP in UK and fiscal Support via Loans and Loan Guarantees is more with 15.9 percent of GDP in Czech, 10.9 percent in UK etc. The Covid-19 has impacted all the sectors and its efficacy with reduced growth rate is seen in the major industries like electricity, coal, finished steel, cement, crude petroleum, petroleum refinery products, natural gas and fertilizers. In the epistemological studies, mathematical tools have been used to analyse the impact of virus. Mathematical algorithm is devised to lists out the parameters involving Covid-19 intervention strategies have been attempted in this study.*

**Keywords:** Covid-19, epistemological studies, mathematical tools, WHO standards, India.

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## Introduction

The epistemological studies use mathematical tools as it simplifies complex parameters like control measures, projecting its potential impact, and addressing the ongoing transmission in an easily understandable manner. In this study, an attempt is made to analyse the ongoing Covid-19 intervention strategies like lockdown, quarantine, hospitalization, vaccination and SOP procedure are imperative to save people from devastating public health and socio-economic burden. These intervention strategies or programmes implemented in India has brought tremendous results with reduction in the spread of this killer disease. The effectiveness of intervention strategies on transmission dynamics is ubiquitous in health economics as it has brought reduction in Covid-19 cases and death over a period of time. The algorithm design guzzles transmission dynamics from human to human which includes using non-pharmaceutical interventions like social distancing, time window, personal protection levels, and the SOP procedures of the Government as per the WHO standards. These strategies have optimised the three phases peak level of the pandemic to converge confirming the decline in the country. It is a clear example of achievement in health care arrangements as well as control the spread of Covid-19 provided in India.

The mathematical algorithms attempted here deals with the Covid-19 intervention strategies incorporating the estimation of parameters that predicts the near future scenario of the disease. The dynamics of the pandemic disease has different situations of lockdown viz., complete lockdown, partial lockdown, and no lockdown with SOP. The high transmission rate found in the peak level of cases and death rates during the different phases of the pandemic Covid-19 shows the higher level of endemicity. It is noted that by reducing the contacts with intervention strategies and by increasing the efficacy of lockdown the pandemic may be controlled with the detection and containment of infection and stopping it before the community transmission in order to mitigate its effect on human health.

## Review of literature

Some of the coronavirus research studies are: Studies conducted before 2003 mostly related to murine coronavirus. After 2003 studies were on molecular virology like viral genome, spike protein, and RNA virus. After the current COVID-19 studies deals with clinical characteristics, testing approaches; vaccine development, treating, emotional distress and psychiatric symptoms and preventing COVID-19. Data required for mathematical algorithm in the pandemic is by collating real-time public-health data, including confirmed cases, deaths and testing figures, to keep the public informed and support policymakers in refining interventions, time-series charts and geographic maps, ranging from region-level statistics.

Jon C Emery and others have opined that some key gaps in the understanding of SARS-CoV-2 infection remain unattended with regard to the transmission from individuals experiencing asymptomatic infections. They have used a transmission model of COVID-19 with asymptomatic and pre-symptomatic states calibrated to outbreak data from the Diamond Princess, to quantify the contribution of asymptomatic infections to transmission. It is found that the asymptomatic SARS-CoV-2 infections may contribute substantially to transmission and it is essential to consider when assessing the potential effectiveness of ongoing control measures to contain COVID-19 (Jon C

Emery, et.al., 2019). Ngonghala and others (2020) have applied mathematical model to study the non-pharmaceutical interventions using in USA. They found that the mask-based intervention combined with social-distancing plays an important role in curbing the Covid-19.

J. Haushofer and C. J. E. Metcalf (2020) noticed different strategies are used in complex combinations, disorganized, built-in evolution it cannot attribute to a particular policy in controlling the transmission of the pandemic. The interventions are different from each other in terms of psychological and economic cost, ranging from very low-cost to expensive. Therefore, they have suggested that it is important to recognize the interventions that reduce the transmission at the lowest psychological and economic cost.

Vijay Pal Bajiya, Sarita Bugalia, and Jai Prakash Tripathi (2020) have suggested non-pharmaceutical interventions. They used method of least squares and the best fit curve and estimated the model parameters to calibrate the model with daily new confirmed cases. They found that implementation of perfect isolation has brought 33.33 percent increment in contact-tracing on June 26, 2020 may reduce the number of cumulative confirmed cases of Covid-19 in India by around 53.8 percent at the end of July 2020. Authors have suggested a nationwide lockdown combined with non-pharmaceutical interventions to reduce the spreading of COVID-19 in India.

S. Khajanchi, K. Sarkar, J. Mondal, and M. Perc, (2020) have used deterministic model to study the dynamics of Covid-19 transmission with social distancing, media effect, contact-tracing, and hospitalization in India. They found that Covid-19 has demonstrated oscillatory dynamics which can be controllable by maintaining social distances and the effectiveness of isolation or hospitalization. Nadim and Chattopadhyay (2020) have discussed with mathematical model on COVID-19 transmission which 'demonstrates the backward bifurcation phenomenon in the case of imperfect lockdown, and there is no possibility of having the backward bifurcation phenomenon in the perfect lockdown scenario and found that effective lockdown is very necessary to decrease the prevalence of COVID-19 and reduce the risk of the disease burden'.

A. Senapati and J. Chattopadhyay (2020) proposed a mathematical model to describe the COVID-19 transmission that is fitted to the daily cumulative new confirmed cases during the period of March 2–24, 2020. The authors considered two intervention scenarios that are dependent on the flexibility of the intervention intensity throughout implementation. Their results suggested that higher intervention effort is needed to control the Covid-19 outbreak or eradicate the disease from India.

**Intervention programmes in India**

COVID-19 is a deadly virus has attacked the human beings. The WHO has declared Covid-19 as a Public Health Emergency of International Concern and declared this disease as pandemic on March 11, 2020. The WHO has given guidelines to be followed to combat its spread. Some of the policy measures implemented worldwide during 2020 are given below.

**Table 1: Some policy measures during the 2020 to combat Covid-19 worldwide**

| Type | Fast policy response adopted by policy makers | Countries |
|---|---|---|

| | | | |
|---|---|---|---|
| 1 | Monetary policy measures | Granting regulatory forbearance to banks, and principal or interest moratorium to debtors affected by COVID-19 | Ireland, China, Nigeria and Italy |
| Central banks' provision of liquidity to financial (bond and equity) markets | | China and US | |
| Central banks' purchase of bonds and securities that were plunging in value rapidly | | Australia, EU and Canada | |
| Lowering interest rates by Central banks | | Turkey, US, New Zealand, Japan and UK, Nigeria, South Korea and Canada | |
| Sustained flow of credit to banks, SMSEs, public health sector, individuals and essential businesses | | Australia, Nigeria, US and UK | |
| 2 | Fiscal measures | Governments approving a large federal stimulus package for sectors and industries most affected by the COVID-19 pandemic | UK, US, Australia and Nigeria |
| Provision of income support for individuals | | Australia, US, UK and India | |
| Social welfare payments to support each household | | Australia, US | |
| 3 | Public health measures | Public quarantine | India, US, UK and almost every country |
| Border quarantine | | Poland, Vietnam, India, UK, US, Pakistan, Australia and Colombia | |
| Issuing a stay-at-home policy | | Italy, Iran, Nigeria and UK | |
| Social distancing policy | | South Africa, US, UK, UAE, Singapore, Nigeria, Japan, China, India, Germany, Pakistan, Australia, South Korea and Israel | |
| 4 | Human control measures | Temporary release of prisoners from overcrowded prisons | Iran and US |
| Shut-down of air, land and sea borders | | Taiwan, India, Mexico, US., Germany, Serbia and Nigeria | |
| Shutdown of schools | | UK, Spain, Italy, South Africa, Nigeria and US | |
| Using the military to enforce a coronavirus stay-at-home lockdown | | Malaysia, Italy, US, Israel, South Africa and Spain | |
| Travel ban | | EU, US, Argentina, Austria, Australia, Bolivia, Cambodia, Canada, China, Cape Verde, Cambodia, Colombia, Croatia, Denmark, Egypt, Germany, Greece and Haiti | |
| Visa denial and suspension | | South Africa, Canada, Singapore, China, Nigeria, Ghana, Kenya, Bolivia and Brazil | |

Source: Media reports and Central Banks' press release

Table 1 shows some policy measures taken during 2020 to combat Covid-19 worldwide which included monetary policy measures, fiscal measures, public health measures, human control measures and travel ban by many countries. These measures have achieved desired results across the countries and they could control the menace of virus spread drastically from its three phases.

Table 2: Fiscal Policy Measures to Combat Spread of Coronavirus worldwide

| Countries | Total Increase in Direct Spending | % of GDP | Fiscal Support via Loans and Loan Guarantees | % of GDP | Remarks |
|---|---|---|---|---|---|
| US | USD $484bn | 2.4 | USD2.3tn | 9.3 | Measures announced |
| UK | GBP 350bn | 11.8 | GBP330bn | 10.7 | Measures announced |
| Canada | C$ 107bn | 6.2 | - | - | Measures announced |
| Czech | CZK 100bn | 1.8 | CZK900bn | 15.9 | Measures announced |
| Poland | ZL 212bn | 9 | ZL700mn | 0.1 | - |
| Romania | RON 9bn | 0.9 | EUR 400mn | 0.2 | - |
| Russia | RUB 1.4tn | 0.3 | - | - | Measures announced |
| Egypt | EGP 50bn | 0.8 | EGP50bn | 0.8 | - |
| Israel | ILS 2.8bn | 0.4 | - | - | - |
| Saudi Arabia | SR 120 billion | 3.9 | - | - | - |
| Turkey | 100 billion LIRA | 185 | - | - | Increased credit, lower taxes and deferred payments |
| Nigeria | NGN3.5tn | 2.3 | $6.9bn | 7.5 | Measured announced |
| India | ₹1.7 lakh crore | 967 | $1 billion | 0.04 | World bank loan |

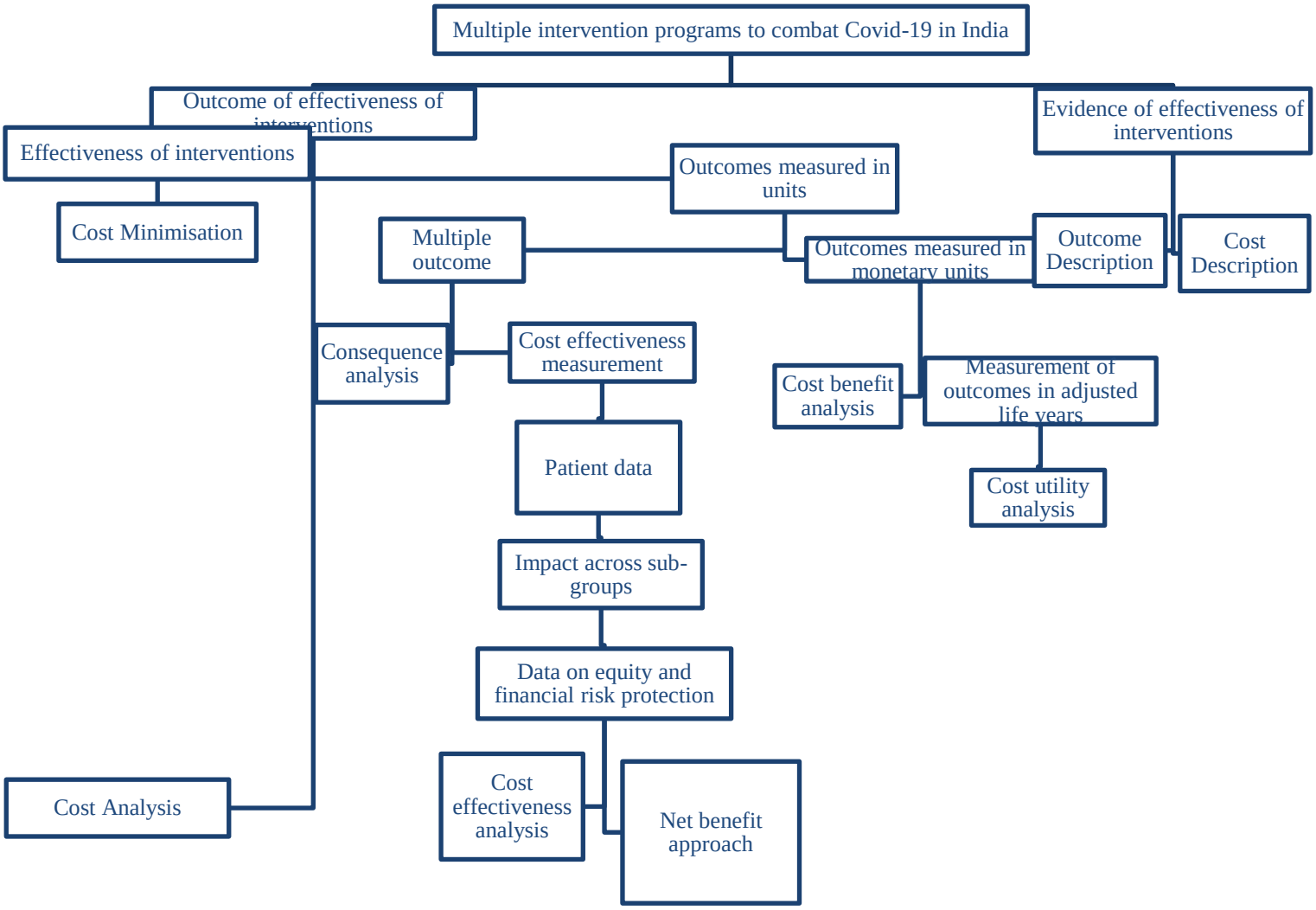
Source: Media reports and Central Banks' press release

Table 2 provides the fiscal policy measures to control the spread of coronavirus in many countries. The amount spent varies from the highest of 967 percent of GDP in India followed by 187 percent of GDP in Turkey, 11.8 percent of GDP in UK etc. Fiscal Support via Loans and Loan Guarantees is more with 15.9 percent of GDP in Czech, 10.9 percent in UK etc. Such measures taken by these countries despite their financial burden has proved with positive indicators in the Covid-19 impact reduction in its three phases.

**Algorithm of Covid-19 Intervention program**

Algorithm of Covid-19 intervention program in India given below provides a base for mathematical model application to measure its impact with various tools.

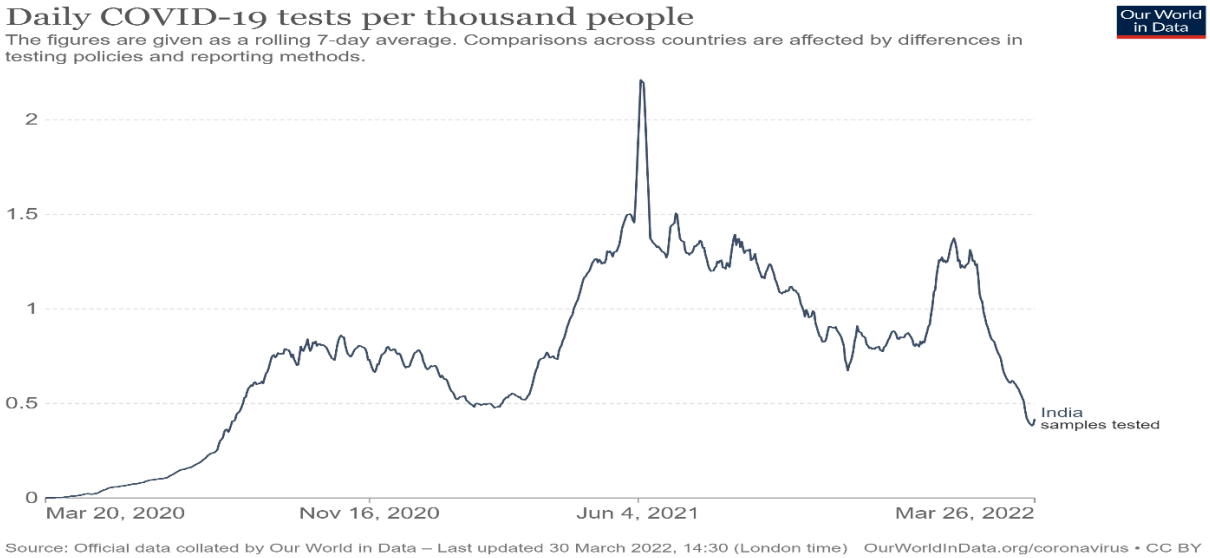
Algorithm of Covid-19 Intervention program in India




**Impact of multiple intervention programs to combat Covid-19 in India**

The impact of multiple intervention programmes to combat Covid-19 in India is depicted in the following charts on various parameters.

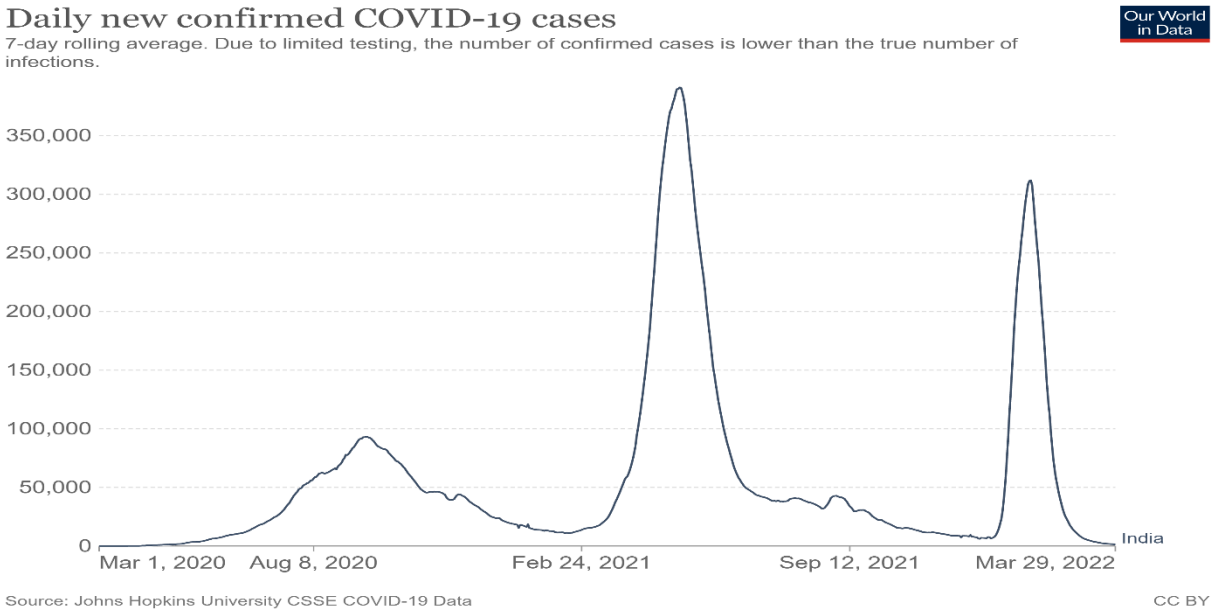
Chart 1: Covid-19 test per 1000 people




Source: https://ourworldindata.org/coronavirus/country/india

Chart 1 portrays the Covid-19 test per 1000 people from 20.03.2020 to 26.03.2022 which explains the drastic decline in the tests due to control of the virus in India.

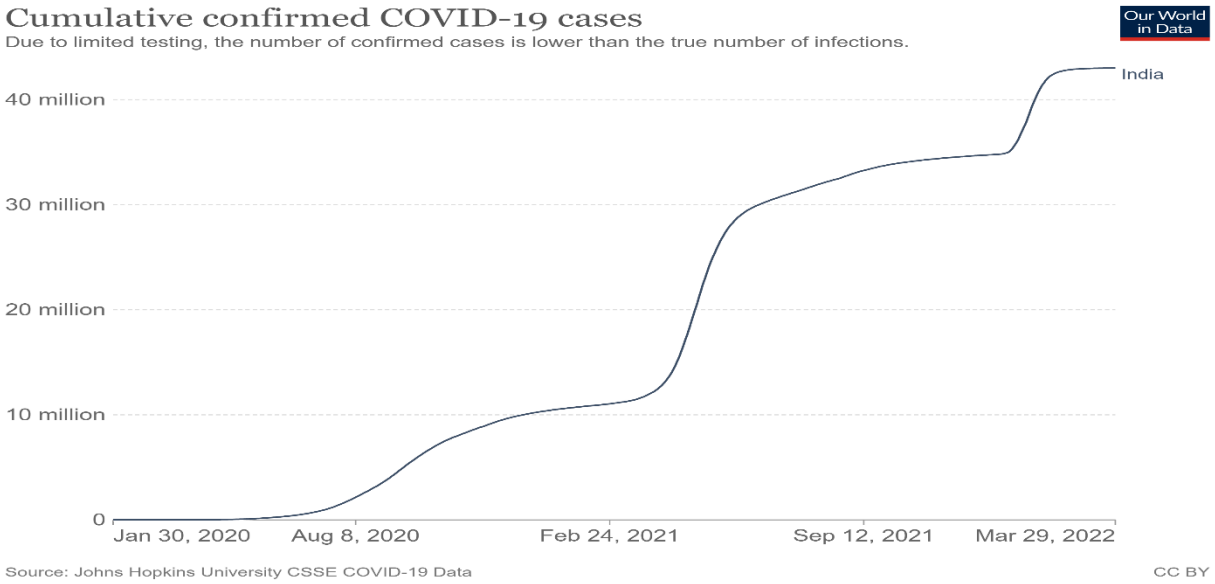
Chart 2: Daily new confirmed Covid-19 cases in India




Source: https://ourworldindata.org/coronavirus/country/india

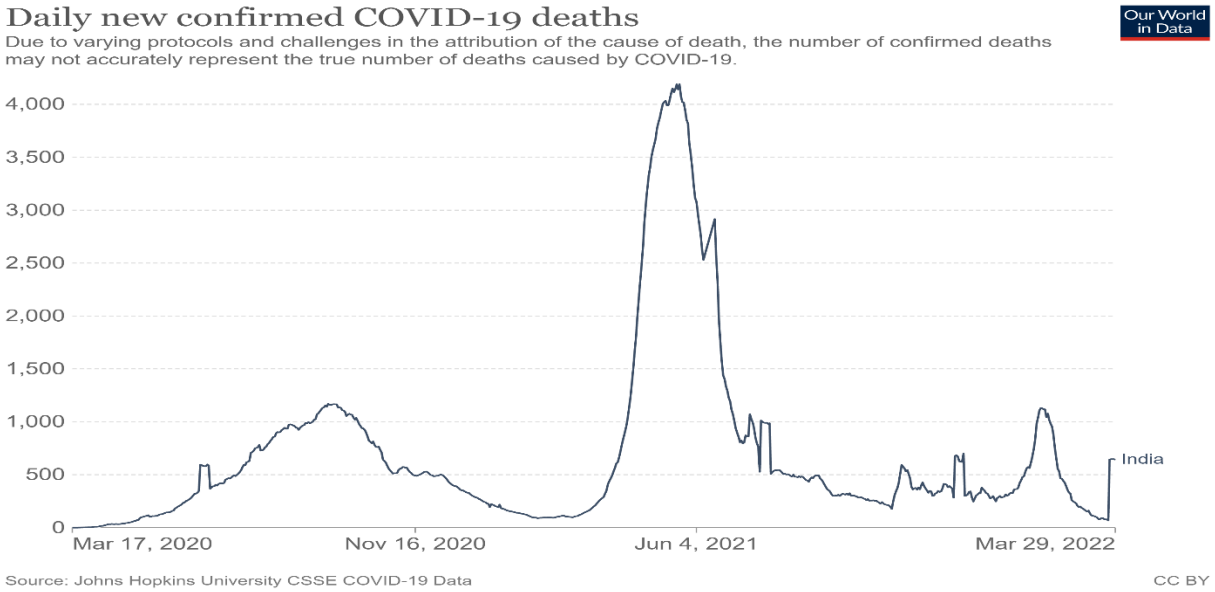
Chart 2 shows that the decline in the new confirmed Covid-19 cases as on 29.03.2022 in India which is in contrast of cumulative cases given in Chart 3.

Chart 3: Cumulative confirmed Covid-19 cases in India




Source: https://ourworldindata.org/coronavirus/country/india

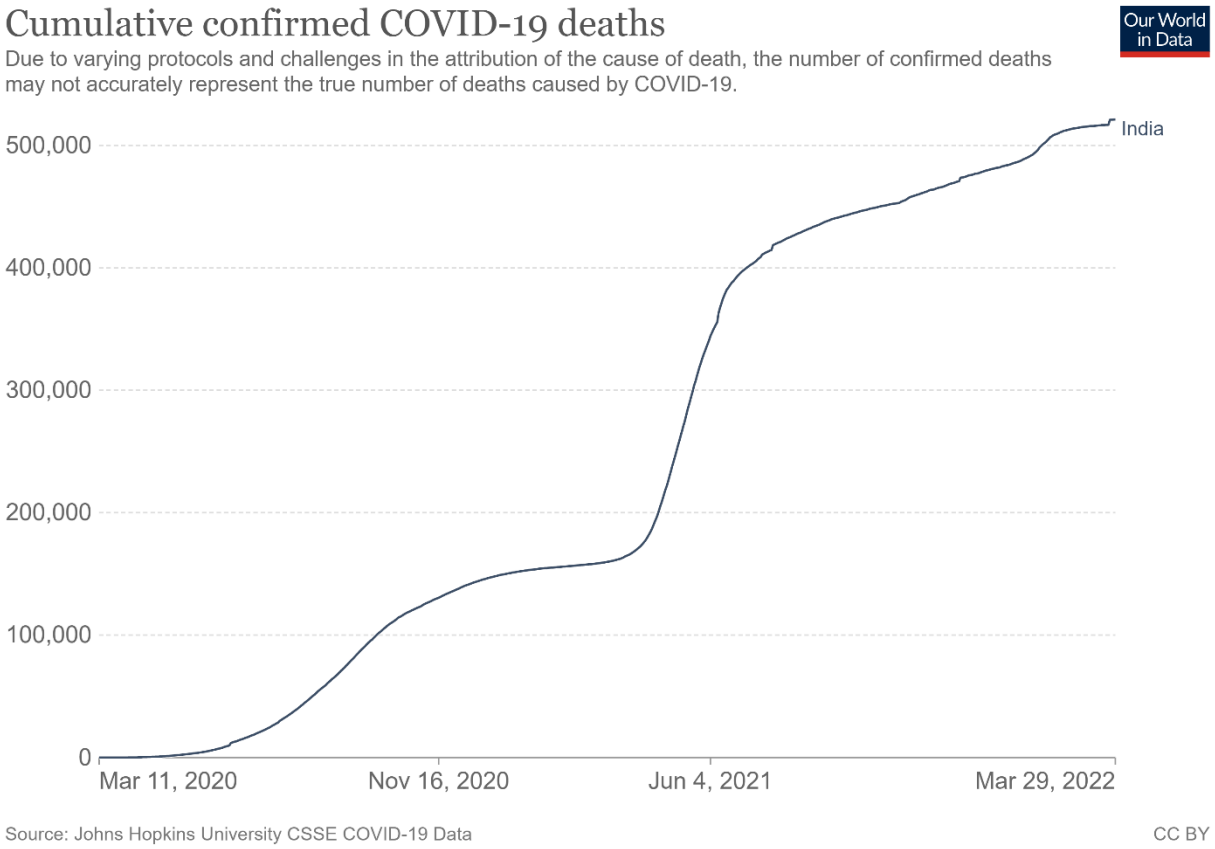
Chart 4: Daily new confirmed Covid-19 deaths in India




Source: https://ourworldindata.org/coronavirus/country/india

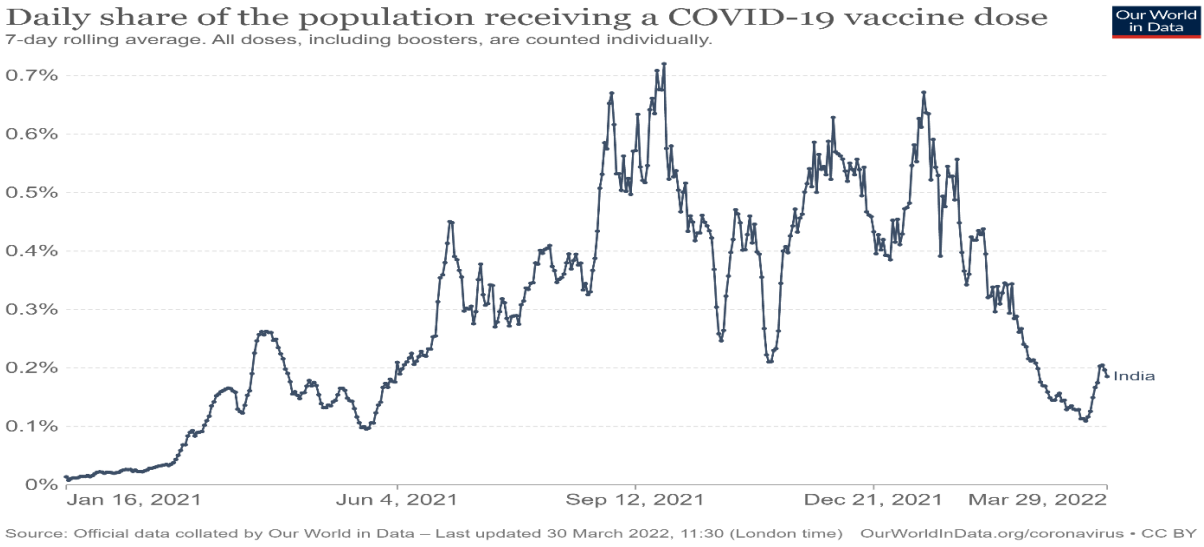
As given in Chart 4 the daily new confirmed Covid-19 deaths in India from 17.03.2020 to 29.03.2022. The cumulative confirmed Covid-19 death cases data is alarming as given in Chart 5. It is a remarkable achievement to our country with a huge population.

Chart 5; Cumulative confirmed Covid-19 deaths in India




Source: https://ourworldindata.org/coronavirus/country/india

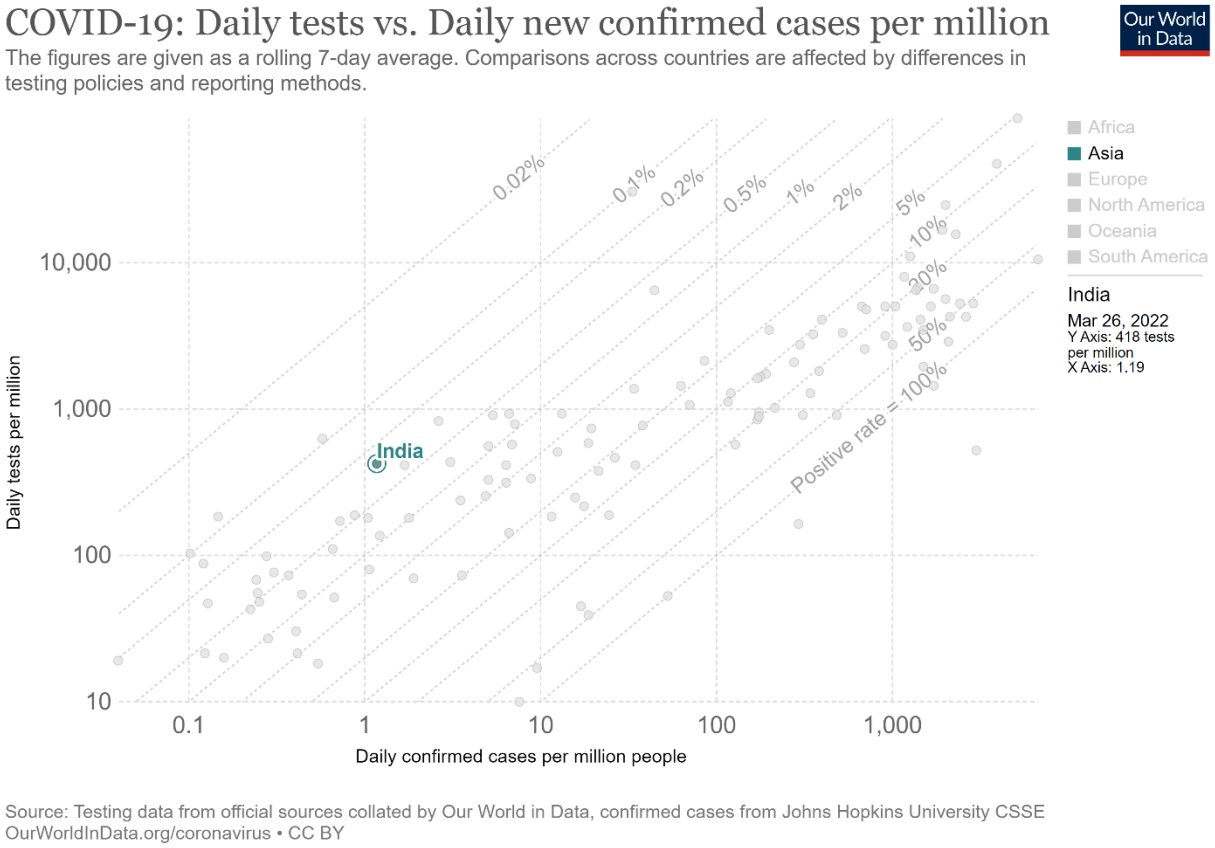
Chart 6: Daily share of the population receiving a Covid-19 vaccine dose in India




Source: https://ourworldindata.org/coronavirus/country/india

Chart 6 shows the daily share of the population receiving a Covid-19 vaccine dose in India from 16.06.2021 to 29.03.2022 which has gone up to 0.7 percent of the population which is a remarkable record achievement of the Governments.

Chart 7: Daily tests Vs. Daily new Covid-19 confirmed cases per million in India




Source: https://ourworldindata.org/coronavirus/country/india

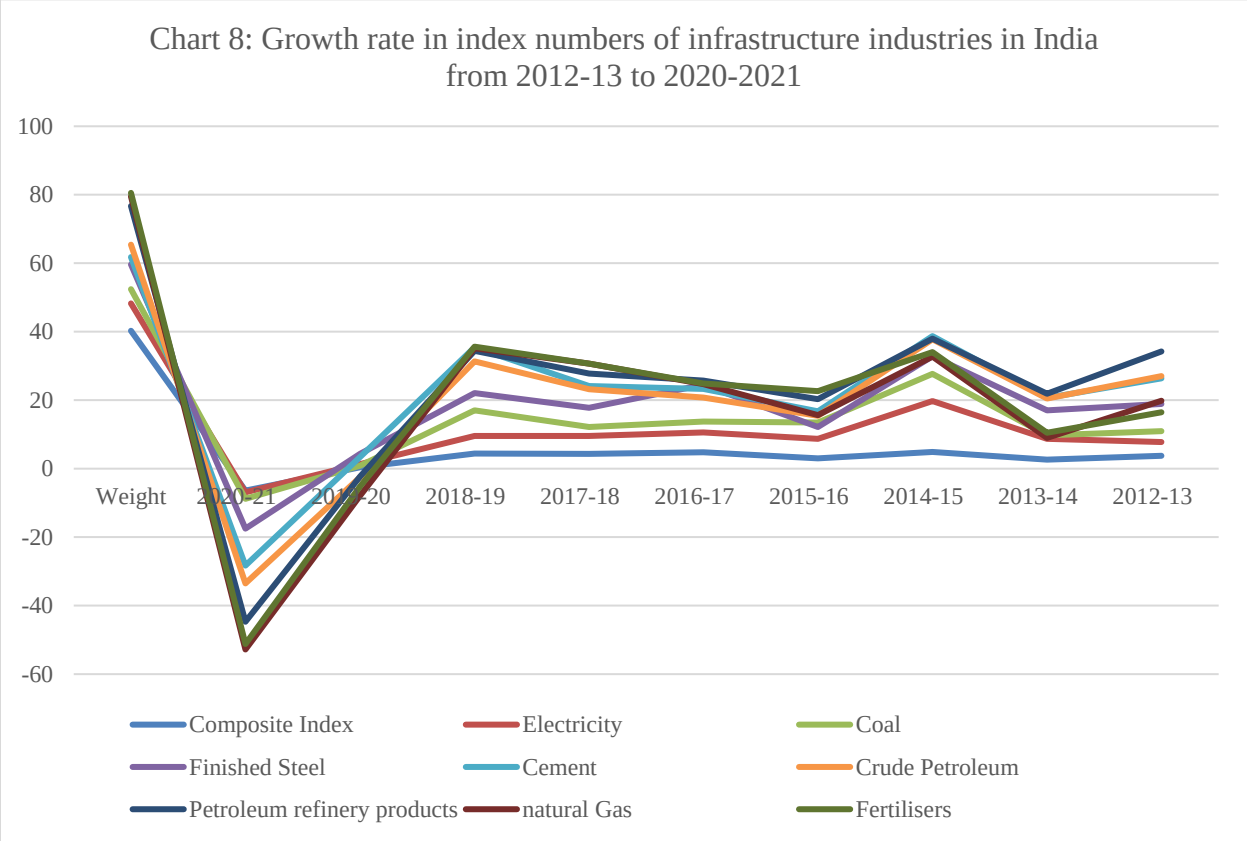
Chart 7 presents the daily test vs. daily new Covid-19 confirmed cases per million as a 7-day average in India shows that it is affirmative in reporting the differences between both the parameters as on 26.03.2022.

The virus has brought standstill to all the countries in general and India in particular. The impact is experienced in employment, income, savings etc., due to several lockdowns and SOP procedures during its three phases. It is inevitable to the Government as the pandemic has to be controlled to save people. The Covid-19 has impacted all the sectors and Table 3 shows its efficacy with reduced growth rate in the major industries like electricity, coal, finished steel, cement, crude petroleum, petroleum refinery products, natural gas and fertiliers. Chart 8 shows the decline in the growth rate during the peak periods of the Covid-19, that is during 2019-20 and 2020-21.

Table 3: Growth rate in index numbers of infrastructure industries in India from 2012-13 to 2020-2021 with Base year 2011-12 =100

| Year | Composite Index | Electricity | Coal | Finished Steel | Cement | Crude Petroleum | Petroleum Refinery Products | Natural Gas | Fertilisers |
|---|---|---|---|---|---|---|---|---|---|
| Weight | 40.27 | 7.99 | 4.16 | 7.22 | 2.16 | 3.62 | 11.29 | 2.77 | 1.06 |
| 2020-21 | -6.4 | -0.5 | -1.9 | -8.7 | -10.8 | -5.2 | -11.2 | -8.1 | 1.6 |
| 2019-20 | 0.4 | 0.9 | -0.4 | 3.4 | -0.9 | -5.9 | 0.2 | -5.6 | 2.7 |
| 2018-19 | 4.4 | 5.2 | 7.4 | 5.1 | 13.3 | -4.1 | 3.1 | 0.8 | 0.4 |
| 2017-18 | 4.3 | 5.3 | 2.6 | 5.6 | 6.3 | -0.9 | 4.6 | 2.9 | 0.0 |
| 2016-17 | 4.8 | 5.8 | 3.2 | 10.7 | -1.2 | -2.5 | 4.9 | -1.0 | 0.2 |
| 2015-16 | 3.0 | 5.7 | 4.8 | -1.3 | 4.6 | -1.4 | 4.9 | -4.7 | 7.0 |
| 2014-15 | 4.9 | 14.8 | 8.0 | 5.1 | 5.9 | -0.9 | 0.2 | -5.3 | 1.3 |
| 2013-14 | 2.6 | 6.1 | 1.0 | 7.3 | 3.7 | -0.2 | 1.4 | -12.9 | 1.5 |
| 2012-13 | 3.8 | 4.0 | 3.2 | 7.9 | 7.5 | 0.6 | 7.2 | -14.4 | -3.3 |

Source: Reserve Bank of India, 2022.




## Conclusion:

The legacies of stunted education, job loss, widening inequalities, gender gap, increase in the cost of raw materials, decline in GDP, fall in the income, and the effects is the biggest since the Great Depression. The World Bank warned in its of "a decade of global growth disappointments" and the global output will be 5 percent lower by 2025 when compared to pre-pandemic trend. Therefore, in India as well as across the countries several crores of rupees were spent to arrest the negative impact of Covid-19. Varieties of vaccines have been developed with huge investment and it is made available to the people as regular and booster doses. All these have resulted in better recovery rate of 98.76 percent in India. No doubt the Covid-19 infection rate has declined in India, but the spread of the next wave is observed in South Korea, China, UK etc., and hence continuation of SOP is important to prevent the virus.

## References

1. McCall, B. (2020). COVID-19 and artificial intelligence: protecting health-care workers and curbing the spread. Lancet Digit Health 2, e166–e167.

2. Vijay Pal Bajiya, Sarita Bugalia, and Jai Prakash Tripathi (2020). Mathematical modelling of COVID-19: Impact of non-pharmaceutical interventions in India, Chaos 30, 113143 (2020); https://doi.org/10.1063/5.0021353, 24.11.2020.

3. J. Haushofer and C. J. E. Metcalf, (2020). "Which interventions work best in a pandemic?" Science, 368(6495), pp 1063–1065.

4. S. K. S. Nadim and J. Chattopadhyay, (2020). "Occurrence of backward bifurcation and prediction of disease transmission with imperfect lockdown: A case study on COVID-19," Chaos Solitons Fractals 140, 110163.

5. Senapati and J. Chattopadhyay, (2020). "Impact of intervention on the spread of COVID-19 in India: A model-based study," arXiv:2004.04950.

6. S. Khajanchi, K. Sarkar, J. Mondal, and M. Perc, (2020). "Dynamics of the COVID-19 pandemic in India," arXiv:2005.06286 (2020).

7. C. N. Ngonghala, E. Iboi, S. Eikenberry, M. Scotch, C. R. MacIntyre, M. H. Bonds, and A. B. Gumel, (2020). "Mathematical assessment of the impact of nonpharmaceutical interventions on curtailing the 2019 novel coronavirus," Math. Biosci. 325, 108364.

8. Russel, T. W. et al. (2020). Using a delay-adjusted case fatality ratio to estimate under-reporting. Centre for Mathematical Modelling of Infectious Diseases Repository https://cmmid.github.io/topics/covid19/global_cfr_estimates.html (accessed 26 April 2020).

9. Edelstein, M., Lee, L. M., Herten-Crabb, A., Heymann, D. L. & Harper, D. R. (2018). Strengthening global public health surveillance through data and benefit sharing. Emerg. Infect. Dis. 24, pp 1324–1330.

10. Smith, G. E. et al. (2017). Novel public health risk assessment process developed to support syndromic surveillance for the 2012 Olympic and Paralympic Games. J. Public Health (Bangk.) 39, e111–e117.

11. Crichton, G., Guo, Y., Pyysalo, S., and Korhonen, A. (2018). Neural networks for link prediction in realistic biomedical graphs: a multi-dimensional evaluation of graph embedding-based approaches. BMC Bioinformatics 19:176. doi: 10.1186/s12859-018-2163-9.

12. Timothy W Russell, Joel Hellewell, Sam Abbott, Nick Golding, Hamish Gibbs, Christopher I Jarvis, Kevin van Zandvoort, (2020). CMMID COVID-19 working group, Stefan Flasche, Rosalind M Eggo, W John Edmunds & Adam J Kucharski. (2020). Using a delay-adjusted case fatality ratio to estimate under-reporting, Centre for Mathematical Modelling of Infectious Diseases, 25-08-2020.

13. Jon C Emery, Timothy W Russel, Yang Liu, Joel Hellewel, Carl AB Pearson, (2019). CMMID 2019-nCoV working group , Gwenan M Knight , Rosalind M Eggo , Adam J Kucharski, Sebastian Funk, Stefan Flasche, Rein M G J Houben, (2020). The contribution of asymptomatic SARS-CoV-2 infections to transmission - a model-based analysis of the Diamond Princess outbreak, Centre for Mathematical Modelling of infectious diseases,

Department of Infectious Disease Epidemiology, Faculty of Epidemiology and Population Health, London School of Hygiene and Tropical Medicine, London, UK, 24.08.2020.

14. Anastassopoulou, C., Russo, L., Tsakris, A., & Siettos, C. Data-based analysis, modelling and forecasting of the COVID-19 outbreak. PLoS ONE 15, e0230405 (2020).

15. Lee, J. K., & Jeong, H. W. (2020). Wearing facemasks regardless of symptoms is crucial for preventing spread of COVID-19 in hospitals. Infect. Control Hosp. Epidemiol. https://doi.org/10.1017/ice.2020.202.

16. Kiesha Prem, Yang Liu, Timothy W Russell, Adam J Kucharski, Rosalind M Eggo, Mark Jit, and Petra Klepac, (2020). The effect of control strategies to reduce social mixing on outcomes of the COVID-19 epidemic in Wuhan, China: a modelling study. Lancet 5, e261–e270, DOI:https://doi.org/10.1016/S2468-2667(20)30073-6.

17. Kwok, K. O., Lai, F., Wi, W., Wong, S. Y. S., & Tang, J. W. T. (2020). Herd immunity—estimating the level required to halt the COVID-19 epidemics in affected countries. J. Infect. https://doi.org/10.1016/j.jinf.2020.03.027.

18. Osmar Pinto Neto, Deanna M. Kennedy, José Clark Reis, Yiyu Wang, Ana Carolina Brisola Brizzi, Gustavo José Zambrano, Joabe Marcos de Souza, Wellington Pedroso, Rodrigo Cunha de Mello Pedreiro, Bruno de Matos Brizzi, Ellysson Oliveira Abinader & Renato Amaro Zângaro. (2021). Mathematical model of COVID-19 intervention scenarios for São Paulo—Brazil, Nature Communications volume 12, Article number: 418 (2021).

19. Subhas Khajanchi, Kankan Sarkar, Jayanta Mondal, Kottakkaran SooppyNisar, (2021). Mathematical modelling of the COVID-19 pandemic with intervention strategies, Elsaviour, Volume 25, June 2021, 104285.

20. Samui P., Mondal J., Khajanchi S. (2020). A mathematical model for COVID-19 transmission dynamics with a case study of India, Chaos Solitons Fractals, 140 (2020), Article 110173.

21. Das A., Dhar A., Kundu A., Goyal S. (2020). Covid-19: analysis of a modified SEIR model, a comparison of different intervention strategies and projections for India, (2020), 10.1101/2020.06.04.20122580.

22. Abba B.Gumel, Enahoro A.Iboi, Calistus N.Ngonghala, andElamin H.Elbash (2021).A primer on using mathematics to understand COVID-19 dynamics: Modeling, analysis and simulations, Science Direct, Volume 6, 2021, Pp 148-168.

23. Pakwan Riyapan, Sherif Eneye Shuaib, and Arthit Intarasit, (2021).A Mathematical Model of COVID-19 Pandemic: A Case Study of Bangkok, Thailand, Volume 2021,Article ID 6664483, https://doi.org/10.1155/2021/6664483.

24. Sarita Bugalia , Vijay Pal Bajiya , Jai Prakash Tripathi, Ming-Tao Li, Gui-Quan Sun (2020). Mathematical modeling of COVID-19 transmission: the roles of intervention strategies and lockdown, Mathematical Biosciences and Engineering, 2020, Volume 17, Issue 5: 5944-5960. doi: 10.3934/mbe.2020317.

25. Abhyudai Singh, Roger M. Nisbet (2008). Variation in risk in single-species discrete-time models. Mathematical Biosciences and Engineering, 2008, 5(4): 859-875. doi: 10.3934/mbe.2008.5.859.

26. Salihu Sabiu Musa, Sania Qureshi, Shi Zhao, Abdullahi Yusuf, Umar Tasiu Mustapha, and Daihai He, (2021). Mathematical modeling of COVID-19 epidemic with effect of awareness programs, Infect Dis Model. 2021; 6: 448–460.18.2.2021.

27. Enahoro Iboi, Oluwaseun O. Sharomi, Calistus Ngonghala, Abba B. Gumel, (2020). Mathematical Modeling and Analysis of COVID-19 pandemic in Nigeria, Mathematical Biosciences and Engineering doi: 10.3934/mbe.2020369, 31.06.2020.

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