Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Elsevier hereby grants permission to make all its COVID-19-related research that is available on the COVID-19 resource centre - including this research content - immediately available in PubMed Central and other publicly funded repositories, such as the WHO COVID database with rights for unrestricted research re-use and analyses in any form or by any means with acknowledgement of the original source. These permissions are granted for free by Elsevier for as long as the COVID-19 resource centre remains active.
Analysis of the Adomian decomposition method to estimate the COVID-19 pandemic

Garima Agarwal\textsuperscript{a}, Man Mohan\textsuperscript{a}, Athira M. Menon\textsuperscript{b}, Amit Sharma\textsuperscript{c}, Tikam Chand Dakal\textsuperscript{b}, and Sunil Dutt Purohit\textsuperscript{d}

\textsuperscript{a}DEPARTMENT OF MATHEMATICS AND STATISTICS, MANIPAL UNIVERSITY JAIPUR, RAJASTHAN, INDIA \textsuperscript{b}GENOME AND COMPUTATIONAL BIOLOGY LAB, DEPARTMENT OF BIOTECHNOLOGY, MOHANLAL SUKHADIA UNIVERSITY, UDAIPUR, RAJASTHAN, INDIA \textsuperscript{c}DEPARTMENT OF OPHTHALMOLOGY, UNIVERSITY CLINIC BONN, BONN, GERMANY \textsuperscript{d}DEPARTMENT OF HEAS (MATHEMATICS), RAJASTHAN TECHNICAL UNIVERSITY, KOTA, RAJASTHAN, INDIA

1 Introduction

The recent emergence of 2019-nCoV in Wuhan city of China and its subsequent transmission in almost every part of the world has not only led to a serious health crisis, but also impacted our socioeconomic development. The genetic feature of the novel coronavirus (2019-nCoV), which may have been transmitted by bats, according to the WHO\cite{1,2}, has recently been discussed. Besides, some clinical findings leading from a mild-to-severe phenotype of respiratory infection have also been reported by Casella\cite{3}. In the midst of this global pandemic solution, we even do not have any potent therapy available in any form to treat COVID-19 patients. New drugs, medicines, therapies, or vaccines for COVID-19 are either in the development stage or in clinical trials\cite{4}. The infected symptomatic patients display a number of symptoms such as hyperthermia, dry cough, and labored breathing\cite{5}. In the Indian context so far, we have registered approximately 40,000 cases with a death toll of more than 1000 as per the latest records of Government of India\cite{6}. We have also adopted preventive measures such as social distancing during this lockdown period. The Indian Government announced a 54-day lockdown (like in the Moroccan Case\cite{7}) in three stages from March 24 to May 17. Nevertheless, how much more time would be required in order to completely achieve a state of control over this virus and COVID-19 in India is certainly not known yet.

Given the high transmission rate of this virus, more than 200,000 deaths have been reported worldwide and the outbreak of coronavirus has been declared a pandemic. Compared to the very high mortality rate in countries such as Italy, Spain, the United Kingdom, and the United States, India registered around 67,000 infected cases with 2200 deaths\cite{8}.
Importantly, preventive measures such as social distancing and lockdown in populated areas have proven to be highly effective in this pandemic. As there is no potential therapy (drugs, vaccines), several scientific approaches have either been tested or are in development. Several mathematical models using the epidemiological data were also tested to estimate the transmission rate of the virus and to monitor the predominant factors contributing to this pandemic [9].

Herein we have collected the epidemiological, pathophysiological, and relevant data related to COVID-19 and employed a rational approach to forecast the time required to effectively control COVID-19 in India considering the ideal situation of social distancing and lockdown being followed adequately and appropriately in different location in India [10]. We combined a stochastic transmission model with data on cases of coronavirus disease 2019 (COVID-19) in India to estimate how transmission had varied over time from March 14, 2020 to March 26, 2020. To estimate the early dynamics of transmission in India, we fitted a stochastic transmission dynamic model to multiple publicly available datasets on cases in India. The four datasets we fitted were: (1) infected patients, (2) exposed individuals, (3) asymptomatic patients, and (4) patients recovered. Based on these estimates, we calculated the probability that newly introduced cases (suspected people) might generate outbreaks in other areas. Hence, we used an additional dataset for comparison with model outputs, i.e., (5) suspected individuals and (6) reservoir individuals.

In the current study, we have evaluated the epidemiological, pathophysiological, and other publicly available COVID-19 associated data from the Indian population. Besides infected patients, exposed persons, and convalesced patients, we have exclusively analyzed the suspected persons to accurately assess the early dynamics of transmission in India.

2 Methodology

2.1 Integral transform

It is a mathematical operator which produces a new function \( f(t) \) by integrating the multiple of a function \( F(t) \) and another function \( K(\zeta, t) \), which is called the Kernel between the suitable limits. This process of transform of that function into another is called integral transform, which is written as

\[
f(\zeta) = \int K(\zeta, t)F(t)dt.
\]

There are so many integral transforms generally named after the mathematicians who developed them such as Laplace Transform, Mellin Transform, Hankel Transform, Fourier Transform, etc.

The main aim of integral transform is that it gives powerful working methods for solving initial value problems and the initial-boundary value problems for the linear differential and integral equations. It has many mathematical and physical applications.
The choice of taking a suitable integral transform for a particular differential equation is very important because it decides to convert not only the derivative into an appropriate differential equation but also the terms of boundary values into algebraic structures.

Also, Harinder Singh noted the advanced numerical methods for differential equations [11] and fractional differential equations [12], which may also be helpful in analysis for this. He also studied on fractional dynamics on ebola virus [13], computational study [14], Jacobi collocation method [15], numerical simulation for stability analysis [16], fractional delay differential equation [17], simulation for fractional Bloch equation [18], and treatment for HIV infection [19].

For the complete solution of the problem, it is also necessary to convert the equation into its original form by applying inverse integral transform.

Hence, inverse integral transform is the contrapositive part of the integral transform so that the solution may be obtained in a more simple way.

In this subsection of this chapter, we have studied Laplace integral transform, Adomian Laplace transform, iterative Laplace transform.

2.2 Laplace transform

The Laplace Transform of the function $F(t)$, $t > 0$ is given by

$$f(\xi) = LF(t) = \frac{1}{\xi} e^{-\xi t} F(t) dt.$$ 

And the inverse Laplace transform is given by

$$F(t) = L^{-1}f(\xi).$$

There are some functions with their Laplace transforms that are given in the list.

| S. No. | Functions $F(t)$ | Laplace transforms $f(\xi) = LF(t)$ |
|--------|------------------|-------------------------------------|
| 1      | 1                | $\frac{1}{\xi}$                     |
| 2      | $e^{\alpha t}$   | $\frac{1}{\xi - \alpha}$           |
| 3      | $t^n, n = 1,2,3,4...$ | $\frac{n!}{\xi^{n+1}}$               |
| 4      | $t^p, p > -1$    | $\frac{\Gamma(p+1)}{\xi^{p+1}}$    |
| 5      | $\sin(\alpha t)$ | $\frac{\alpha}{\xi^2 + \alpha^2}$ |
| 6      | $\cos(\alpha t)$ | $\frac{\xi}{\xi^2 + \alpha^2}$    |
| 7      | $\sinh(\alpha t)$ | $\frac{\alpha}{\xi^2 - \alpha^2}$ |
| S. No. | Functions $F(t)$ | Laplace transforms $f(\zeta) = LF(t)$ |
|-------|------------------|----------------------------------|
| 8     | $\cosh(at)$     | $\dfrac{\zeta}{\zeta^2 - a^2}$  |
| 9     | $t \sin(at)$    | $\dfrac{2a\zeta}{(\zeta^2 + a^2)^2}$ |
| 10    | $t \cos(at)$    | $\dfrac{\zeta^2 - a^2}{(\zeta^2 + a^2)^2}$ |
| 11    | $e^{at} \sin(bt)$ | $\dfrac{b}{(\zeta - a)^2 + b^2}$ |
| 12    | $e^{at} \cos(bt)$ | $\dfrac{\zeta - a}{(\zeta - a)^2 + b^2}$ |
| 13    | $e^{at} \sinh(bt)$ | $\dfrac{b}{(\zeta - a)^2 - b^2}$ |
| 14    | $e^{at} \cosh(bt)$ | $\dfrac{\zeta - a}{(\zeta - a)^2 - b^2}$ |
| 15    | $F(ct)$         | $\dfrac{1}{c} f\left(\dfrac{\zeta}{c}\right)$ |
| 16    | Heaviside function $u(t - c)$ | $e^{-\zeta c}$ |
| 17    | Dirac Delta function $\delta(t - c)$ | $e^{-\zeta c}$ |
| 18    | $t^n F(t)$      | $(-1)^n f^n(\zeta)$ |
| 19    | $\dfrac{1}{t} F(t)$ | $\int_{\zeta}^{\infty} f(x) \, dx$ |
| 20    | $\int_{0}^{t} F(v) \, dv$ | $\dfrac{f(\zeta)}{\zeta}$ |
| 21    | Convolution function $\int_{0}^{t} F(t - \tau) G(\tau) \, d\tau$ | $f(\zeta) g(\zeta)$ |
| 22    | $F'(t)$         | $\zeta f(\zeta) - F(0)$ |
| 23    | $F''(t)$        | $\zeta^2 - \zeta F(0) - F'(0)$ |
| 24    | $F^{(n)}(t)$    | $\zeta^{(n)} f(\zeta) - \zeta^{(n-1)} F(0) - \ldots$ |

Source: https://en.wikipedia.org/wiki/List_of_Laplace_transforms

### 2.3 Initial approach to design the input equation

Recently, a few independent studies by Chen [20] and Zhang [21] successfully applied mathematical models on the coronavirus disease (COVID-19). Herein we have used and adapted the mathematical equation proposed by Khan and colleagues [22], which is presented as

\[
D_t S(t) = \theta - \lambda S - \frac{\alpha S(I + \beta A)}{N} - \gamma S Q
\]

\[
D_t E(t) = \frac{\alpha S(I + \beta A)}{N} + \gamma S Q - (1 - \Phi) \delta E - \Phi \mu E - \lambda E
\]

\[
D_t I(t) = (1 - \Phi) \delta E - (\rho + \lambda) I
\]
\[ D_t A(t) = \Phi \mu E - (\sigma + \lambda)A \]
\[ D_t R(t) = \rho I + \sigma A - \lambda R \]
\[ D_t Q(t) = k I + \nu A - \eta Q \]  
(1)

with the initial conditions

\[ S(0) = S_0; \ E(0) = E_0; \ I(0) = I_0; \ A(0) = A_0; \ R(0) = R_0; \ Q(0) = Q_0 \]

In this equation, \( N \) represents the total population which is segregated into five subclasses, namely, susceptible people \( S(t) \), exposed people \( E(t) \), infected people \( I(t) \), asymptotically infected people \( A(t) \), and recovered people \( R(t) \). The detailed parameters relevant to this equation are defined in Table 1.

### 3 Theory and calculations

#### 3.1 Adomian decomposition method (ADM)

George Adomian [23] established the Adomian decomposition method (ADM) in the 1980s. The ADM has received much attention in recent years in applied mathematics and in the field of infinite series solution. It is an effective method to solve many types of linear, nonlinear, ordinary, or partial differential equations and integral transforms (such as the Volterra and Fredholm integral transforms). After that, he extended the modified Adomian decomposition method for solving the nonlinear Emden-Fowler system of differential Eqs. Alderremy, Elzaki, and Chamekh [24] also wrote a research article on the solution of the Emden-Fowler system using MADM (modified Adomian decomposition method). It may be relevant to point out that by ADM we can solve the Mathematical Model of coronavirus for people.
ADM can be explained by the linear differential equation as follows:

\[ f'(x) = f(x); \quad f(0) = 1 \]

Using the Adomian decomposition method, the differential term is first written as an operator \( L[\frac{d}{dx}()] \)

Similarly, the \( L^{-1} \) operator is defined by \( \int_0^x f(x) \, dx \).

In general form, \( L \) is used for the highest differential operator used in the equation and similarly \( L^{-1} \) for that times the integral operator.

Using \( L \), the given equation can be written as

\[ L(f) = f \]

Now taking the inverse operator \( L^{-1} \) on both sides, we get

\[ L^{-1}(f) = L^{-1}(f) \]

\[ f(x) = 1 + L^{-1}(f) \] [as given by \( f(0) = 1 \)]

Now, the Adomian decomposition suggests that \( f(x) \) can be written as the summation of continue infinite series \( f_0 + f_1 + f_2 + f_3 + \ldots \) and so on. i.e., \( f(x) = \sum_{n=0}^{\infty} f_n \)

\[ \left( \sum_{n=0}^{\infty} f_n \right) = 1 + L^{-1} \left( \sum_{n=0}^{\infty} f_n \right) \]

\( f_0 + f_1 + f_2 + f_3 + \ldots = 1 + L^{-1}(f_0 + f_1 + f_2 + f_3 + \ldots) \). Comparing both sides, we get \( f_0 = 1 \)

\[ f_1 = L^{-1}(f_0) = L^{-1}(1) = \int_0^x 1 \, dx = x \]

Similarly,

\[ f_2 = L^{-1}(f_1) = L^{-1}(x) = \int_0^x x \, dx = \frac{x^2}{2} = \frac{x^2}{2!} \]

\[ f_3 = L^{-1}(f_2) = L^{-1} \left( \frac{x^2}{2} \right) = \int_0^x \frac{x^2}{2} \, dx = \frac{x^3}{6} = \frac{x^3}{3!} \]

\[ f_4 = L^{-1}(f_3) = L^{-1} \left( \frac{x^3}{6} \right) = \int_0^x \frac{x^3}{6} \, dx = \frac{x^4}{24} = \frac{x^4}{4!} \] and so on.

Using these in the above equation \( x = 1 + x + \frac{x^2}{2!} + \frac{x^3}{3!} + \frac{x^4}{4!} + \ldots \), i.e., \( f(x) = e^x \)

### 3.2 Analysis with the Adomian decomposition method

The Adomian Decomposition method (ADM) is a semianalytical method for solving ordinary and partial nonlinear differential equations. The method was developed from the 1970s to the 1990s by George Adomian. Considering the Adomian decomposition method (ADM) [23] can effectively solve several types of linear, nonlinear, ordinary, or partial
differential equations and integral transforms (such as the Volterra and Fredholm integral transforms) and the method has lately been modified in several studies [24]. We used Eq. (1) as input for the ADM to perform numerical simulation, data fitting, and the estimation of different values. Hence, using the \( L \) operator for the first-order differential equation, we wrote Eq. (1) as

\[
LS(t) = \theta - \lambda S - \frac{\alpha S(I + \beta A)}{N} - \gamma SQ
\]

\[
LE(t) = \frac{\alpha S(I + \beta A)}{N} + \gamma SQ - (1 - \Phi)\delta E - \Phi \mu E - \lambda E L I(t) = (1 - \Phi)\delta E - (\rho + \lambda) I
\]

\[
LA(t) = \Phi \mu E - (\sigma + \lambda) A
\]

\[
LR(t) = \rho I + \sigma A - \lambda R
\]

\[
LQ(t) = kl + \nu A - \eta Q
\]

Using \( L^{-1} \) on both sides, we obtained

\[
S(t) = S_0 + c - \lambda L^{-1} S(t) - L^{-1} \left[ \frac{\alpha N}{\alpha} (SI + \beta SA) + \gamma SQ \right]
\]

\[
E(t) = E_0 + L^{-1} \left[ \frac{\alpha N}{\alpha} (SI + \beta SA) + \gamma SQ \right] - (1 - \Phi)\delta L^{-1} E(t) - (\rho + \lambda) L^{-1} I(t)
\]

\[
I(t) = I_0 + (1 - \Phi)\delta L^{-1} E(t) - (\rho + \lambda) L^{-1} I(t)
\]

\[
A(t) = A_0 + \Phi \mu L^{-1} E(t) - (\sigma + \lambda) L^{-1} A(t)
\]

\[
R(t) = R_0 + \rho L^{-1} I(t) + \sigma L^{-1} A(t) - \lambda L^{-1} R(t)
\]

\[
Q(t) = Q_0 + \kappa L^{-1} I(t) + \nu L^{-1} A(t) - \eta L^{-1} Q(t)
\]

Using \( L^{-1} \) on both sides, we obtained

\[
S(t) = S_0 + c - \lambda L^{-1} S(t) - L^{-1} \left[ \frac{\alpha N}{\alpha} (SI + \beta SA) + \gamma SQ \right]
\]

System (3) is the solution for the given model. Now, using decomposition \( S(t) = \sum_{n=0}^{\infty} S_n \), we obtain

\[
\sum_{n=0}^{\infty} S_n = S_0 + c - \lambda L^{-1} \left( \sum_{n=0}^{\infty} S_n \right) - L^{-1} \left[ \frac{\alpha N}{\alpha} (SI + \beta SA) + \gamma SQ \right]
\]

Solving in the recurrence manner and writing the \((n+1)^{th}\) term, the nonlinearity terms \( SI, SA, and SQ \) can also be written as

\[
SI = \sum_{n=0}^{\infty} U_n; \ SA = \sum_{n=0}^{\infty} V_n; \ SQ = \sum_{n=0}^{\infty} W_n; \ U_n, V_n, W_n \ are \ further \ decomposed \ as \ follows:
\]

\[
U_n = \sum_{k=0}^{n} \sum_{k=0}^{n} I_k - \sum_{k=0}^{n-1} \sum_{k=0}^{n-1} I_k
\]

\[
V_n = \sum_{k=0}^{n} \sum_{k=0}^{n} A_k - \sum_{k=0}^{n-1} \sum_{k=0}^{n-1} A_k
\]

\[
W_n = \sum_{k=0}^{n} \sum_{k=0}^{n} Q_k - \sum_{k=0}^{n-1} \sum_{k=0}^{n-1} Q_k
\]
Using these notations, the last equation can be written as

\[ S_{n+1}(t) = S_n(0) + c - \lambda L^{-1} S_n(t) - L^{-1} \left( \frac{\alpha}{N} \left( \sum_{n=0}^{\infty} U_n \right) + \beta \left( \sum_{n=0}^{\infty} V_n \right) \right) + \gamma \left( \sum_{n=0}^{\infty} W_n \right) \]  

(4)

Similarly, solving in the same manner all the other five equations of the system of differential Eq. (1) gives the solutions as

\[ E_{n+1}(t) = E_n(0) + L^{-1} \left[ \frac{\mu}{N} \left( \sum_{n=0}^{\infty} U_n \right) + \beta \left( \sum_{n=0}^{\infty} V_n \right) \right] + \gamma \left( \sum_{n=0}^{\infty} W_n \right) - [(1 - \Phi) \delta - \Phi \mu - \lambda] L^{-1} E_n(t) \]

\[ I_{n+1}(t) = I_n(0) + (1 - \Phi) \delta L^{-1} E_n(t) - (\rho + \lambda) L^{-1} I_n(t) \]

\[ A_{n+1}(t) = A_n(0) + \Phi \mu L^{-1} E_n(t) - (\sigma + \lambda) L^{-1} A_n(t) \]

\[ R_{n+1}(t) = R_n(0) + \rho L^{-1} I_n(t) + \sigma L^{-1} A_n(t) - \lambda L^{-1} R_n(t) \]

\[ Q_{n+1}(t) = Q_n(0) + \kappa L^{-1} I_n(t) + \nu L^{-1} A_n(t) - \eta L^{-1} Q_n(t) \]  

(5)

Eqs. (4) and (5) are the recurrence solution for the given mathematical model of the system.

We also considered finding a numerical solution (approximation) of the iterative values of using the parametric values (particularly estimated or fitted) from Table 1. Notably, as described by the World Health Organization (WHO) [1], 35% of the Indian population live in cities or urban areas of India [10]; we therefore considered a parameter for the total population \( N = 481747192 \) that corresponds to 35% of India’s population.

Hence, the formulated equation can be written as:

\[ N = S(0) + E(0) + I(0) + A(0) + R(0) + Q(0), \quad S(0) = 480021700, \quad E(0) = 1724266, \quad I(0) = 745, \quad A(0) = 413, \quad R(0) = 66, \quad Q(0) = 1000000. \]

Based on the parameters given in Table 1, the initial conditions are given below. By using these inputs to system (3) and solving, we obtained the following equation in the end:

\[ S(t) = S_0 + c - \lambda L^{-1} S(t) - L^{-1} \left[ \frac{\alpha}{N} (SI + \beta SA) + \gamma SQ \right] \]

\[ E(t) = E_0 + L^{-1} \left[ \frac{\alpha (SI + \beta SA)}{N} + \gamma SQ \right] - [(1 - \Phi) \delta + \Phi \mu + \lambda] L^{-1} E(t) \]

\[ I(t) = I_0 + (1 - \Phi) \delta L^{-1} E(t) - (\rho + \lambda) L^{-1} I(t) \]

\[ A(t) = A_0 + \Phi \mu L^{-1} E(t) - (\sigma + \lambda) L^{-1} A(t) \]

\[ R(t) = R_0 + \rho L^{-1} I(t) + \sigma L^{-1} A(t) - \lambda L^{-1} R(t) \]

\[ Q(t) = Q_0 + \kappa L^{-1} I(t) + \nu L^{-1} A(t) - \eta L^{-1} Q(t) \]  

(6)

The complete solution is given by the following series form:

\[ S(t) = S_0 + S_1 + S_2 + S_3 \]

\[ E(t) = E_0 + E_1 + E_2 + E_3 \]
\[ I(t) = I_0 + I_1 + I_2 + I_3 \]
\[ A(t) = A_0 + A_1 + A_2 + A_3 \]
\[ R(t) = R_0 + R_1 + R_2 + R_3 \]
\[ Q(t) = Q_0 + Q_1 + Q_2 + Q_3 \ldots \]  

These systems of solution are obtained by solving these separate partitions simultaneously.

For this we know all the values of the system with \( t = 0 \) which are as follows:

\[ S_0 = 480021700 \]
\[ E_0 = 1724266 \]
\[ I_0 = 745 \]
\[ A_0 = 413 \]
\[ R_0 = 66 \]
\[ Q_0 = 1000000 \]  

Now, for \( S_1 \), we have

\[ S_1 = c - \lambda S_0 t - L^{-1} \left[ \frac{a}{N} (S_0 I_0 + \beta S_0 A_0 + \gamma S_0 Q_0) \right] \]

Putting the corresponding values, we get

\[ S_1 = 6931614 \]
\[ E_1 = 5.18 \times 10^{-10} (474583054139 + 5870907.63) t \]
\[ I_1 = 0.0043 (1724266) - 0.1127 (745) t \]
\[ A_1 = 0.00062 (1724266) - 0.8683 (413) t \]
\[ R_1 = 0.09871 (745) + 0.8543 (413) - 0.014 (66) t \]
\[ Q_1 = 9999.29 \]  

These are the first set solution of all equations with \( t = t_1 \).

Now, the simultaneous solution set for \( t = t_2 \) is given by using these above data

\[ S_2 = -S_1 \left[ 0.014 + 43956.44 \times 10^{-10} - 1229.91 \times 10^{-7} \right] t^2 \]
\[ E_2 = S_1 \left[ 43956.44 \times 10^{-10} - 1229.91 \times 10^{-7} \right] - (0.019347) E_1 \]
\[ I_2 = [(0.004727) E_1 - (0.1127) I_1] t^2 \]
\[ A_2 = [(0.00062) E_1 - (0.8683) A_1] t^2 \]
\[ R_2 = [(0.09871) I_1 + (0.8543) A_1 - (0.014) R_1] t^2 \]
\[ Q_2 = [(0.000398) I_1 + (0.0001) A_1 - (0.01) Q_1] t^2 \]  

Chapter 10 • Analysis of COVID-19 mathematical model 181
and solution set with $t^3$ is as follows:

$$S_3 = -S_2\left[0.014 + 5.18 \times 10^{-10}(I_2 + (0.5944)A_2) + 0.123 \times 10^{-7}Q_2\right] \frac{t^3}{6}$$

$$E_3 = \left[ S_2\left\{5.18 \times 10^{-10}(I_2 + (0.5944)A_2 + 0.123 \times 10^{-7}Q_2\right) - \{(0.019347)E_2\}\right] \frac{t^3}{6}$$

$$I_3 = [(0.004727)E_2 - (0.1127)I_2] \frac{t^3}{3}$$

$$A_3 = [(0.00062)E_2 - (0.8683)A_2] \frac{t^3}{3}$$

$$R_3 = [(0.09871)I_2 + (0.8543)A_2 - (0.014)R_2] \frac{t^3}{3}$$

$$Q_3 = [(0.000398)I_2 + (0.001)A_2 - (0.01)Q_2] \frac{t^3}{3}$$

(11)

Arranging these values and after solving, we put these in system

$$S(t) = S_0 + S_1 + S_2 + S_3$$

$$E(t) = E_0 + E_1 + E_2 + E_3$$

$$I(t) = I_0 + I_1 + I_2 + I_3$$

$$A(t) = A_0 + A_1 + A_2 + A_3$$

$$R(t) = R_0 + R_1 + R_2 + R_3$$

$$Q(t) = Q_0 + Q_1 + Q_2 + Q_3$$

Finally, we get the results as:

$$S(t) = (480021700) - (5693202.83517)t + (39514.82584)\frac{t^2}{2} - (625.63184.50875)\frac{t^3}{6} + ...$$

$$E(t) = (1724266) + (5871153.461256)t - (56457.0089)\frac{t^2}{2} + (548.5999)\frac{t^3}{6} + ...$$

$$I(t) = (745) + (8066.64213)t + (13421.911)\frac{t^2}{2} + 2(111346)\frac{t^3}{6} + ...$$

$$A(t) = (413) + (710.4421)t + (1511.621)\frac{t^2}{2} - (449.1832)\frac{t^3}{6} + ...$$

$$R(t) = (66) + (425.44325)t + (698.6157)\frac{t^2}{2} + (868.8243)\frac{t^3}{6} + ...$$

$$Q(t) = (1000000) - (9999.2911)t + (51.95567)\frac{t^2}{2} + (2.111346)\frac{t^3}{6} + ...$$

(12)

4 Results and discussion

On the basis of the results obtained, we found that under the ideal situation of an appropriate and efficient implementation of social distancing, it was possible to curb COVID-19 within 22–25 days of strict lockdown (Fig. 1A). As a downstream effect, the number of exposed individuals would be expected to increase very slowly by up to 4 months from onset of disease (Fig. 1B). It is noteworthy that this graph (Fig. 1C) also depends on the
FIG. 1 Analysis of the Adomian decomposition method to estimate the COVID-19 pandemic in the Indian population. (A) Dynamical behavior of suspected people $S(t)$ with respect to time (days); (B) Dynamical behavior of exposed people $E(t)$ with respect to time (days); (C) Dynamical behavior of infected people $I(t)$ with respect to time (days); (D) Dynamical behavior of asymptotic people $A(t)$ with respect to time (days); (E) Dynamical behavior of recovered people $R(t)$ with respect to time (days); (F) Dynamical behavior of reservoir people $Q(t)$ with respect to time (days).
number of newly infected persons. As the numbers of exposed individuals were insigni-
cificant up to the first 50 days, i.e., only after 150 days (approximately 5 months), the drastic
increase in the number of exposed persons would be accounted for. Even if the number
of suspects at the outbreak of the disease would be 50 crore within 4–5 months, the
numbers could still be reduced to zero (Fig. 1D). Furthermore, the number of suspected
recovered individuals followed the same trend (Fig. 1E), thus indicating that if social
distance had been adequate and effective, stable disease control would have been
achieved.

Overall, the parameters defined by our mathematical model may help to refine the
future strategies to control similar pandemic situations. In the context of limitations, con-
sideration of the additional factors (gender stratification, age-related death risk, epidemi-
ological factor, smoking behavior, etc.) can further improve this model.

5 Conclusion
The main aim of this study was to determine an eventual numerical reality (month-wise),
such as when under an ideal situation of social distancing in the lockdown period we
could expect a significant reduction in the number of COVID-19 cases, and when we could
consider the situation to be under control. The time duration of clinical progression, such
as pathogen entry and its life cycle in the human body, and recovering duration is also
discussed, which can help in epidemic analysis and its control (Fig. 2). During the early
stages of cell attachment, the pathogen attaches to the cell surface in 5 min postinfection
and hijacks the cell’s function within 30 min [27]. The virus infects the lung cells and
reaches a peak stage within 10–13 days [28]. By this time, the immune cells of the body
get activated and produce a cytokine microenvironment to destruct the virus [29]. The
virus has a mean incubation period of 5.1 days and the patient recovers within 2–3 weeks
postinfection [30,31]. Therefore, such model projections are highly beneficial to forecast
health-care facility (including the number of critical/intensive care units, ventilators,
safety kits, medicines, etc.) and would be needed for successful treatment and manage-
ment of COVID-19. By applying the Adomian decomposition method on the Indian
population impacted by COVID-19, we could show that the strict initial isolation for
22–25 days would have a significant positive impact on the whole pandemic situation.
Finally, the presented mathematical model would also consider other necessary interven-
tions and initiatives that our government may need to take in order to curb the disease
burden.

Acknowledgments
The authors are grateful to the editor and reviewers for their thorough review and comments, which con-
tributed to improving this article.
Funding
No funding was received for this work.

Conflicts of interests
The authors declare no conflict of interests.

References
[1] WHO novel coronavirus (2019-nCoV) situation reports, <http://www.who.int/emergencies/disease/novel-coronavirus-2019/situation-reports> 2019 [accessed 20.12.19].

[2] World Health Organization, Clinical care for severe acute respiratory infection: toolkit: COVID-19 adaptation (No. WHO/2019-nCoV/SARI toolkit/2020-21).

[3] M. Cascella, M. Rajnik, A. Cuomo, S.C. Dulebohn, R. Napoli, Features, evaluation and treatment coronavirus (COVID-19), StatPearls 123 (5) (2020) 543–549.
[4] S.G.V. Rosa, W.C. Santos, Clinical trials on drug repositioning for COVID-19 treatment, Rev. Panam. Salud Publica 44 (2020) 3–9.

[5] C.J. Rhodes, R.M. Anderson, Contact rate calculation for a basic epidemic model, Math. Biosci. 216 (1) (2008) 56–62.

[6] Coronavirus Outbreak in India, covid19.org, <http://www.covid19india.org/> >2019 [accessed 19.12.19].

[7] R. Yafia, Modeling and dynamics in epidemiology, COVID19 with lockdown and isolation effect, application to Moroccan case, MedRxiv 234 (2020) 256–268.

[8] WHO-China joint report on coronavirus, <http://www.who.int/emergencies/disease/novel-coronavirus-2019/situation-reports> >2019 [accessed 20.12.19].

[9] A. Arenas, W. Cota, J. Gómez, A mathematical model for the spatiotemporal epidemic spreading of COVID19, medRxiv 12 (2020) 342–352.

[10] S. Raj, S.K. Paul, A. Chakraborty, J. Kuttipurath, Anthropogenic forcing exacerbating the urban heat islands in India, J. Environ. Manag. 257 (2019) 102–109.

[11] H. Singh, J. Singh, S.D. Purohit, D. Kumar, Advanced Numerical Methods for Differential Equations: Applications in Science and Engineering, CRC Press Taylor and Francis, 2021, pp. 112–145.

[12] H. Singh, D. Kumar, D. Baleanu, Methods of Mathematical Modelling: Fractional Differential Equations, CRC Press Taylor and Francis, 2019, pp. 78–128.

[13] H. Singh, Analysis for fractional dynamics of Ebola virus model, Chaos, Solitons Fractals 138 (2020) 24–35.

[14] H. Singh, D. Baleanu, J. Singh, H. Dutta, Computational study of fractional order smoking model, Chaos, Solitons Fractals 142 (3) (2020) 110–440.

[15] H. Singh, Jacobi collocation method for the fractional advection-dispersion equation arising in porous media, Numer. Methods Partial Differ. Eq. 10 (2) (2020) 235–239.

[16] H. Singh, H.M. Srivastava, Z. Hammouch, K.S. Nisar, Numerical simulation and stability analysis for the fractional-order dynamics of COVID-19, Results Phy. 20 (2021) 103–722.

[17] H. Singh, Numerical simulation for fractional delay differential equations, Int. J. Dyn. Control 207 (9) (2020) 463–474.

[18] H. Singh, A.K. Singh, Numerical simulation for fractional Bloch equation arising in nuclear magnetic resonance, Nonlinear Stud. 28 (2) (2020) 531–548.

[19] H. Singh, Analysis of drug treatment of the fractional HIV infection model of CD4+ T-cells, Chaos, Solitons Fractals 146 (2020) 3–7.

[20] T. Chen, J. Rui, Q. Wang, Z. Zhao, J. Cui, L. Yin, A mathematical model for simulating the phase-based transmissibility of a novel coronavirus, Infect. Dis. Poverty 24 (2) (2020) 11–16.

[21] W. Zhang, Estimating the pre symptomatic transmission of COVID19 using incubation period and serial interval data, MedRxiv 215 (1) (2020) 35–39.

[22] M.A. Khan, A. Atangana, Modeling the dynamics of novel coronavirus (2019-nCoV) with fractional derivative, Alexandria Engineering Journal 59 (4) (2020) 2379–2389.

[23] G. Adomian, A review of the decomposition method in applied mathematics, J. Math. Anal. Appl. 135 (3) (1988) 501–544.

[24] A.A. Alderremy, T.M. Elzaki, M. Chamekh, Modified Adomian decomposition method to solve generalized Emden-fowler system for singular IVP, Math. Probl. Eng. 15 (4) (2019) 135–138.

[25] J. Karkazis, T. Markopoulos, Deterministic and simulation models forecasting new and total cases of COVID19 in Italy, GEOPOL Reports (University of the Aegean) 13140 (2) (2020) 155–163.

[26] SRS Bulletin, Sample registration system, 52 (1) (2019) 15–18.
[27] M.L. Ng, S.H. Tan, E.E. See, E.E. Ooi, A.E. Ling, Early events of SARS coronavirus infection in vero cells, J. Med. Virol. 71 (3) (2003) 323–331.

[28] F. Pan, T. Ye, P. Sun, S. Gui, B. Liang, L. Li, C. Zheng, Time course of lung changes on chest CT during recovery from 2019 novel coronavirus (COVID-19) pneumonia, Radiology 295 (3) (2020) 200–370.

[29] E. Prompetchara, C. Ketloy, T. Palaga, Immune responses in COVID-19 and potential vaccines: lessons learned from SARS and MERS epidemic, Asian Pac. J. Allergy Immunol. 38 (1) (2020) 1–9.

[30] S.A. Lauer, K.H. Grantz, Q. Bi, F.K. Jones, Q. Zheng, H.R. Meredith, J. Lessler, The incubation period of coronavirus disease 2019 (COVID-19) from publicly reported confirmed cases: estimation and application, Ann. Intern. Med. 20 (5) (2020) 324–331.

[31] Q. Li, X. Guan, P. Wu, X. Wang, L. Zhou, Y. Tong, X. Xing, Early transmission dynamics in Wuhan, China, of novel coronavirus–infected pneumonia, N. Engl. J. Med. 382 (2020) 1199–1207.