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A Laplace Decomposition Analysis Of Corona Virus Disease 2019 (Covid 19) Pandemic Model

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Abstract

The deadly corona virus pandemic remained a global threat to human existence. It becomes imperative to develop a Mathematical model to show how this virus spread. This paper provides a Mathematical model that succintly shows the process of transmission of covid 19 and provides measure to control its spreads. The Laplace decomposition method is used to obtain the approximate solutions in the form of infinite series. The obtained result from this paper avail that physical contact with infected persons happens to be the major cause of the spread. Thus, It becomes important to place the infected person in isolation and this will eventually flattened the curve of the spread of the covid 19 virus.

Keywords and Phrases: Covid 19, Pandemic, Laplace decomposition method, Adomian polynomial, Susceptible class, Infected population.
MSC2010:76WXX, 76DXX

1 Introduction

The COVID-19 pandemic constitutes the greatest global public health challenge, with serious health and socio-economic crisis. Mathematical models can be used to show susceptible, exposed infected, isolated and recovered corona virus patients.
Recently, several mathematical, clinical and examination studies have been put forward for modelling, prediction, treatment and control of the disease. There is dare need for further improvement. Wu et al. [1] introduced a SEIR Mathematical model to describe the transmission dynamics of COVID-19 and predicted the national and global spread of the disease. On their part, Yang et al. [2], used mathematical model to investigate the epidemic development of COVID-19 based on a modified susceptible-exposed-infectious-recovered (SEIR) sectoral framework, they predicted the time the disease curve will be flattened under various intervention strategies. Leung et al. [3] quantified the transmission and severity of COVID-19. Sarbaz et al. [4] model the disease as a system of differential equations. Most previous Models for the corona virus were developed with some significant computational simulations and sensitivity analysis included.Fazal et al. [5] introduced

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the use of fractional derivative for childhood infectious diseases. In the paper,the seafood market is considered as the main source of infection. After reducing the model into the seafood market, and proposed a fractional model, parameterized the model using the first month of 2020 data cases. Anwar et al. [6] developed a Mathematical Model for Corona virus Disease 2019 (COVID-19) containing Isolation class.
Laplace Decomposition Method (LADM) was introduced by Khuri [7] based on Adomian techniques. For brevity of the method, see Taiwo et al [8]. This method has been used to solve differential and integral equations of linear and non-linear problems in Mathematics, Physics, Biology and Chemistry. It had been shown that the ADM method is capable of greatly reducing the size of computational work while still maintaining high accuracy of the approximate solution (See [9–12]). The ADM decomposes a solution into an infinite series which converges rapidly to the exact solution whenever it exists. Nhawu [12] worked on the Adomian decomposition method (ADM) as a powerful method which considers the approximate solution of a non-linear equation as an infinite series which usually converges to the exact solution.In the paper, the method was formulated to solve some first-order differential equations.The non-linear problems are solved easily and elegantly without linearising the problem by using ADM

2 Analysis of the Mathematical Models

In this section, the Mathematical model of the covid 19 pandemic is developed. It is divided into five sectors. The susceptible, the exposed, infected, isolated and the recovered from the pandemic.

$$\left.\begin{aligned}
\frac{dS(t)}{dt} &= A - \mu S(t) - \beta(N)S(t)(E(t)+I(t)),\\
\frac{dE(t)}{dt} &= \beta(N)S(t)(E(t)+I(t)) - \pi E(t) - (\mu+\gamma)E(t),\\
\frac{dI(t)}{dt} &= \pi E(t) - \delta I(t) - \mu I(t),\\
\frac{dQ(t)}{dt} &= \gamma E(t) + \delta I(t) - \theta Q(t) - \mu Q(t),\\
\frac{dR(t)}{dt} &= \theta Q(t) - \mu R(t)
\end{aligned}\right\} \tag{2.0.1}$$

with the initial conditions

$$S(0) = S_0 \geq 0, E(0) = E_0 \geq 0, I(0) = I_0 \geq 0, Q(0) = Q_0 \geq 0 \tag{2.0.2}$$

where the parameters are defined as follows S is the susceptible population
E is the exposed population to the pandemic
I is the infected population
Q is the isolated population
R is the recovered population from the pandemic
β is the rate at which susceptible population moves to infected and exposed class
π is the rate exposed population moves to infected one
γ presents the rate at which exposed people take onside as isolated
δ shows the rate at which infected people were added to isolated individual
θ is the rate at which isolated persons recovered
μ is the natural death rate plus disease- related death rate
Based on the initial conditions (2.0.2), all the solutions $S(t).,E(t),I(t),Q(t)$ and $R(t)$ of system (2.0.1) remain non negative for all positive t.

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2.1 Application of Laplace Decomposition Method

The Laplace transformation is used to convert the system of differential equations into a system of algebraic equations. Then, the algebraic equations are used to obtain the required solution in form of infinite series. We will discuss the procedure for solving model (2.0.1) with the given initial conditions (2.0.2). Applying Laplace transform on both sides of model (2.0.1), we obtain the following system:

$$\left.\begin{aligned}
\ell\left\{\frac{dS(t)}{dt}\right\} &= \ell\left\{A-\mu S(t)-\beta(N)S(t)(E(t)+I(t))\right\},\\
\ell\left\{\frac{dE(t)}{dt}\right\} &= \ell\left\{\beta(N)S(t)(E(t)+I(t))-\pi E(t)-(\mu+\gamma)E(t)\right\},\\
\ell\left\{\frac{dI(t)}{dt}\right\} &= \ell\left\{\pi E(t)-\delta I(t)-\mu I(t)\right\},\\
\ell\left\{\frac{dQ(t)}{dt}\right\} &= \ell\left\{\gamma E(t)+\delta I(t)-\theta Q(t)-\mu Q(t)\right\},,\\
\ell\left\{\frac{dR(t)}{dt}\right\} &= \ell\left\{\theta Q(t)-\mu R(t)\right\}
\end{aligned}\right\} \tag{2.1.1}$$

On simplification of (2.1.1) and using the initial conditions (2.0.2) give (2.1.1)

$$\left.\begin{aligned}
\ell\left\{S(t)\right\} &= \frac{S_0}{s}+[\frac{1}{s}\ell\left\{A-\mu S(t)-\beta(N)S(t)(E(t)+I(t))\right\}],\\
\ell\left\{E(t)\right\} &= \frac{E_0}{s}+[\frac{1}{s}\ell\left\{\beta(N)S(t)(E(t)+I(t))-\pi E(t)-(\mu+\gamma)E(t)\right\}],\\
\ell\left\{I(t)\right\} &= \frac{I_0}{s}+[\frac{1}{s}\ell\left\{\pi E(t)-\delta I(t)-\mu I(t)]\right\},\\
\ell\left\{Q(t)\right\} &= \frac{Q_0}{s}+[\frac{1}{s}\ell\left\{\gamma E(t)+\delta I(t)-\theta Q(t)-\mu Q(t)\right\}],\\
\ell\left\{R(t)\right\} &= \frac{R_0}{s}+[\frac{1}{s}\ell\left\{\theta Q(t)-\mu R(t)\right\}]
\end{aligned}\right\} \tag{2.1.2}$$

Now ,assume that the solutions $S(t).,E(t),I(t),Q(t)$ and $R(t)$ are in the form of infinite series given by

$$\left.\begin{aligned}
S(t) &= \sum_{i=0}^{\infty} S_i(t)\\
E(t) &= \sum_{i=0}^{\infty} E_i(t)\\
I(t) &= \sum_{i=0}^{\infty} I_i(t)\\
Q(t) &= \sum_{i=0}^{\infty} Q_i(t)\\
R(t) &= \sum_{i=0}^{\infty} R_i(t)
\end{aligned}\right\} \tag{2.1.3}$$

By decomposing techniques; the solutions $S(t)E(t)$ and $S(t)I(t)$ as

$$\left.\begin{aligned} S(t)E(t) &= \sum_{i=0}^{\infty} Z_i(t) \\ S(t)I(t) &= \sum_{i=0}^{\infty} V_i(t) \end{aligned}\right\} \tag{2.1.4}$$

respectively.
where each Z_i and V_i is the Adomian polynomials defined as

$$\left.\begin{aligned} Z_i &= \frac{1}{i!}\frac{d^i}{d\lambda^i}\left[\sum_{j=0}^{i}\lambda^j S_j(t)\sum_{j=0}^{i}\lambda^j E_j(t)\right]\Bigg|_{\lambda=0}, \\ V_i &= \frac{1}{i!}\frac{d^i}{d\lambda^i}\left[\sum_{j=0}^{i}\lambda^j S_j(t)\sum_{j=0}^{i}\lambda^j I_j(t)\right]\Bigg|_{\lambda=0} \end{aligned}\right\} \tag{2.1.5}$$

simplifying equation (2.1.5) further, the following polynomials are we obtain

$$\left.\begin{aligned} &Z_0 = S_O(t)E_o(t) \\ &Z_1 = \frac{d}{d\lambda}\left[(\lambda^0 S_0(t) + \lambda^1 S_1(t))(\lambda^0 E_0(t) + \lambda^1 E_1(t))\right]\big|_{\lambda=0} \\ &\frac{d}{d\lambda}\left[(S_0(t) + \lambda S_1(t))(E_0(t) + \lambda E_1(t))\right]\big|_{\lambda=0} \end{aligned}\right\} \tag{2.1.6}$$

Simplifying (2.1.6) yield

$$\left.\begin{aligned} &\frac{d}{d\lambda}\left[(S_0(t)E_0(t) + \lambda S_0(t))(E_1(t) + \lambda S_1 E_0(t) + \lambda^2 S_1 E_1(t))\right]\big|_{\lambda=0} \\ &Z_1 = S_0(t)E_1(t) + S_1(t)E_0(t) \end{aligned}\right\} \tag{2.1.7}$$

Similarly,

$$Z_2 = 2S_0(t)E_2(t) + 2S_1(t)E_1(t) + 2S_2(t)E_0(t) \tag{2.1.8}$$

Also,

$$\left.\begin{aligned} &V_0 = S_O(t)I_o(t) \\ &V_1 = \frac{d}{d\lambda}\left[(\lambda^0 S_0(t) + \lambda^1 S_1(t))(\lambda^0 I_0(t) + \lambda^1 I_1(t))\right]\big|_{\lambda=0} \\ &\frac{d}{d\lambda}\left[(S_0(t) + \lambda S_1(t))(I_0(t) + \lambda I_1(t))\right]\big|_{\lambda=0} \end{aligned}\right\} \tag{2.1.9}$$

From (2.1.9), we have

$$\begin{aligned} &\frac{d}{d\lambda}\left[(S_0(t)I_0(t) + \lambda S_0(t))(I_1(t) + \lambda S_1 I_0(t) + \lambda^2 S_1 I_1(t))\right]\big|_{\lambda=0} \\ &V_1 = S_0(t)I_1(t) + S_1(t)I_0(t) \end{aligned}$$

Similarly,

$$V_2 = 2S_0(t)I_2(t) + 2S_1(t)I_1(t) + 2S_2(t)I_0(t) \tag{2.1.10}$$

Substituting (2.1.3) and (2.1.4) into (2.1.1) results in

$$\left.\begin{aligned}
&\ell\left\{\sum_{i=0}^{\infty} S_i(t)\right\} = \frac{S_0}{s} + [\frac{1}{s}\ell\left\{A - \mu\sum_{i=0}^{\infty} S_i(t) - \beta(N)\sum_{i=0}^{\infty} Z_i(t) - \beta(N)\sum_{i=0}^{\infty} V_i(t)\right\}],\\
&\ell\left\{\sum_{i=0}^{\infty} E_i(t)\right\} = \frac{E_0}{s} + [\frac{1}{s}\ell\left\{\beta(N)\sum_{i=0}^{\infty} Z_i(t) + \beta(N)\sum_{i=0}^{\infty} V_i(t) - \pi\sum_{i=0}^{\infty} E_i(t) - (\mu+\gamma)\sum_{i=0}^{\infty} E_i(t)\right\}],\\
&\ell\left\{\sum_{i=0}^{\infty} I_i(t)\right\} = \frac{I_0}{s} + [\frac{1}{s}\ell\left\{\pi\sum_{i=0}^{\infty} E_i(t) - \delta\sum_{i=0}^{\infty} I_i(t) - \mu\sum_{i=0}^{\infty} I_i(t)\right\}],\\
&\ell\left\{\sum_{i=0}^{\infty} Q_i(t)\right\} = \frac{Q_0}{s} + [\frac{1}{s}\ell\left\{\gamma\sum_{i=0}^{\infty} E_i(t) + \delta\sum_{i=0}^{\infty} I_i(t) - \theta\sum_{i=0}^{\infty} Q_i(t) - \mu\sum_{i=0}^{\infty} Q_i(t)\right\}],\\
&\ell\left\{\sum_{i=0}^{\infty} R_i(t)\right\} = \frac{R_0}{s} + [\frac{1}{s}\ell\left\{\theta\sum_{i=0}^{\infty} Q_i(t) - \mu\sum_{i=0}^{\infty} R_i(t)\right\}]
\end{aligned}\right\} \tag{2.1.11}$$

Comparing the two sides of equation (2.1.11) results the following iterative algorithm

$$\left.\begin{aligned}
&\ell\{S_0\} = \frac{N_1}{s}\\
&\ell\{S_1\} = \frac{A}{s^{\varphi}} - \frac{\mu}{s^{\varphi}}\ell\{S_0\} - \frac{\beta(N)}{s^{\varphi}}\ell\{Z_0\} - \frac{\beta(N)}{s^{\varphi}}\ell\{V_0\}\\
&\ell\{S_2\} = \frac{A}{s^{\varphi}} - \frac{\mu}{s^{\varphi}}\ell\{S_1\} - \frac{\beta(N)}{s^{\varphi}}\ell\{Z_1\} - \frac{\beta(N)}{s^{\varphi}}\ell\{V_1\}\\
&\ell\{S_3\} = \frac{A}{s^{\varphi}} - \frac{\mu}{s^{\varphi}}\ell\{S_2\} - \frac{\beta(N)}{s^{\varphi}}\ell\{Z_2\} - \frac{\beta(N)}{s^{\varphi}}\ell\{V_2\}\\
&\vdots\\
&\ell\{S_{k+1}\} = \frac{A}{s^{\varphi}} - \frac{\mu}{s^{\varphi}}\ell\{S_k\} - \frac{\beta(N)}{s^{\varphi}}\ell\{Z_k\} - \frac{\beta(N)}{s^{\varphi}}\ell\{V_k\}
\end{aligned}\right\} \tag{2.1.12}$$

Similarly,

$$\left.\begin{aligned}
&\ell\{E_0\} = \frac{N_2}{s}\\
&\ell\{E_1\} = \frac{\beta(N)}{s^{\varphi}}\ell\{Z_0\} + \frac{\beta(N)}{s^{\varphi}}\ell\{V_0\} - \frac{(\pi+\mu+\gamma)}{s^{\varphi}}\ell\{E_0\}\\
&\ell\{E_2\} = \frac{\beta(N)}{s^{\varphi}}\ell\{Z_1\} + \frac{\beta(N)}{s^{\varphi}}\ell\{V_1\} - \frac{(\pi+\mu+\gamma)}{s^{\varphi}}\ell\{E_1\}\\
&\ell\{E_3\} = \frac{\beta(N)}{s^{\varphi}}\ell\{Z_2\} + \frac{\beta(N)}{s^{\varphi}}\ell\{V_2\} - \frac{(\pi+\mu+\gamma)}{s^{\varphi}}\ell\{E_2\}\\
&\vdots\\
&\ell\{E_{k+1}\} = \frac{\beta(N)}{s^{\varphi}}\ell\{Z_k\} + \frac{\beta(N)}{s^{\varphi}}\ell\{V_k\} - \frac{(\pi+\mu+\gamma)}{s^{\varphi}}\ell\{E_k\}
\end{aligned}\right\} \tag{2.1.13}$$

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with

$$\left.\begin{aligned}
&\ell\{I_0\} = \frac{N_3}{s}\\
&\ell\{I_1\} = \frac{\pi}{s^{\varphi}}\ell\{E_0\} - \frac{(\delta\ +\mu)}{s^{\varphi}}\ell\{I_0\}\\
&\ell\{I_2\} = \frac{\pi}{s^{\varphi}}\ell\{E_1\} - \frac{(\delta\ +\mu)}{s^{\varphi}}\ell\{I_1\}\\
&\ell\{I_3\} = \frac{\pi}{s^{\varphi}}\ell\{E_2\} - \frac{(\delta\ +\mu)}{s^{\varphi}}\ell\{I_2\}\\
&\vdots\\
&\ell\{I_{k+1}\} = \frac{\pi}{s^{\varphi}}\ell\{E_k\} - \frac{(\delta\ +\mu)}{s^{\varphi}}\ell\{I_k\}
\end{aligned}\right\} \tag{2.1.14}$$

also,

$$\left.\begin{aligned}
&\ell\{Q_0\} = \frac{N_4}{s}\\
&\ell\{Q_1\} = \frac{\gamma}{s^{\varphi}}\ell\{E_0\} + \frac{\delta}{s^{\varphi}}\ell\{E_0\} - \frac{(\theta+\mu)}{s^{\varphi}}\ell\{Q_0\}\\
&\ell\{Q_2\} = \frac{\gamma}{s^{\varphi}}\ell\{E_1\} + \frac{\delta}{s^{\varphi}}\ell\{E_1\} - \frac{(\theta+\mu)}{s^{\varphi}}\ell\{Q_1\}\\
&\ell\{Q_3\} = \frac{\gamma}{s^{\varphi}}\ell\{E_2\} + \frac{\delta}{s^{\varphi}}\ell\{E_2\} - \frac{(\theta+\mu)}{s^{\varphi}}\ell\{Q_2\}\\
&\vdots\\
&\ell\{Q_{k+1}\} = \frac{\gamma}{s^{\varphi}}\ell\{E_k\} + \frac{\delta}{s^{\varphi}}\ell\{E_k\} - \frac{(\theta+\mu)}{s^{\varphi}}\ell\{Q_k\}
\end{aligned}\right\} \tag{2.1.15}$$

Finally,

$$\left.\begin{aligned}
&\ell\{R_0\} = \frac{N_5}{s}\\
&\ell\{R_1\} = \frac{\theta}{s^{\varphi}}\ell\{Q_0\} - \frac{\mu}{s^{\varphi}}\ell\{R_0\}\\
&\ell\{R_2\} = \frac{\theta}{s^{\varphi}}\ell\{Q_1\} - \frac{\mu}{s^{\varphi}}\ell\{R_1\}\\
&\ell\{R_3\} = \frac{\theta}{s^{\varphi}}\ell\{Q_2\} - \frac{\mu}{s^{\varphi}}\ell\{R_2\}\\
&\vdots\\
&\ell\{R_{k+1}\} = \frac{\theta}{s^{\varphi}}\ell\{Q_k\} - \frac{\mu}{s^{\varphi}}\ell\{R_k\}
\end{aligned}\right\} \tag{2.1.16}$$

Taking the inverse Laplace transform of (2.1.12), (2.1.13), (2.1.14), (2.1.15) and (2.1.16) and considering the first few terms result

$$\left.\begin{aligned}
&S_0 = N_1\\
&S_1 = \frac{t^n}{n!}(A-\mu S_0) - \frac{t^n}{n!}(\beta(N)Z_0 + \beta(N)V_0)\\
&S_0 = N_1\\
&Z_0 = S_0E_0\\
&V_0 = S_0I_0\\
&E_0 = N_1\\
&I_0 = N_3
\end{aligned}\right\} \tag{2.1.17}$$

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Substituting

$$S_1 = \frac{t^n}{n!}(A - \mu N_1) - \frac{t^n}{n!}(\beta(N)(N_1 N_2) + \beta(N)(N_1 N_2) \tag{2.1.18}$$

$$S_2 = \frac{t^n}{n!}(A - \mu S_1) - \frac{t^n}{n!}(\beta(N) Z_1 + \beta(N) V_1) \tag{2.1.19}$$

Substituting equation (2.1.17) into equation (2.1.19) above yield

$$\left.\begin{aligned} S_2 = \frac{t^n}{n!}A - \frac{t^n \mu [\frac{t^n}{n!}A - \frac{t^n}{n!}\mu N_1 - \frac{t^n}{n!}\beta N_1 N_2 - \frac{t^n}{n!}\beta N_1 N_3] - t^n \beta (\frac{0.1t^n}{n!} - \frac{0.1t^n}{n!}\mu N_1 - \frac{0.1t^n}{n!}\beta N_1 N_2}{n!} \\ \frac{+\frac{0.9t^n}{n!}\beta N_1 N_3 + \frac{0.1t^n}{n!}\beta - \frac{0.1t^n}{n!}\mu N_1 - \frac{0.1t^n}{n!}(\mu + \delta + \pi)}{n!} - \frac{0.1(t^n)^2}{(n)^2!}\beta\pi \end{aligned}\right\} \tag{2.1.20}$$

$$S(t) = 1 + \frac{t^n}{n!}A - \frac{t^n \mu}{n!}S_1 - \frac{t^n \beta}{n!}Z_1 - \frac{t^n \beta}{n!}V_1 \tag{2.1.21}$$

with the following parameters defined as follow

$$\begin{aligned} Z_1 &= S_0 E_1 + S_1 E_0 \\ V_1 &= S_0 I_1 + S_1 I_0 \\ I_1 &= \frac{t^n \pi E_0}{n!} - \frac{t^n \gamma I_0}{n!} - \frac{t^n \mu I_0}{n!} \\ I_1 &= \frac{t^n \pi E_0}{n!} - \frac{t^n \gamma I_0}{n!} - \frac{t^n \mu I_0}{n!} \\ E_1 &= \frac{t^n \beta Z_0}{n!} + \frac{t^n \beta V_0}{n!} - \frac{t^n(\mu + \gamma + \pi)}{n!} \end{aligned}$$

For the exposed class

$$\left.\begin{aligned} E_1 &= \frac{t^n \beta Z_0}{n!} + \frac{t^n \beta V_0}{n!} - \frac{t^n(\mu + \gamma + \pi)E_0}{n!} \\ E_2 &= \frac{t^n \beta Z_1}{n!} + \frac{t^n \beta V_1}{n!} - \frac{t^n(\mu + \gamma + \pi)E_1}{n!} \\ E_3 &= \frac{t^n \beta Z_2}{n!} + \frac{t^n \beta V_2}{n!} - \frac{t^n(\mu + \gamma + \pi)E_2}{n!} \\ &\vdots \\ E_{k+1} &= \frac{t^n \beta Z_k}{n!} + \frac{t^n \beta V_k}{n!} - \frac{t^n(\mu + \gamma + \pi)E_k}{n!} \end{aligned}\right\} \tag{2.1.22}$$

$$E(t) = S(t) = \frac{t^n \beta Z_1}{n!} + \frac{t^n \beta V_1}{n!} - \frac{t^n(\mu + \gamma + \pi)E_1}{n!} \tag{2.1.23}$$

Substituting the values of the parameters into equation (2.1.24)

$$\begin{aligned} E(t) = \frac{1}{n!}\Bigg[t^a \beta \Bigg(N_2 \left(\frac{t^n A}{n!} - \frac{t^n \mu N_1}{n!} - \frac{t^n \beta N_1 N_2}{n!} - \frac{t^n \beta N_1 N_3}{n!}\right) \\ + \left(\frac{t^n \beta N_1 N_2}{n!} + \frac{t^n \beta N_1 N_3}{n!} - \frac{t^n(\mu + \gamma + \pi)N_2}{n!}\right) N_1\Bigg)\Bigg] \\ + \frac{1}{n!}\left[t^n \beta \left(N_3 \left(\frac{t^n A}{n!} - \frac{t^n \mu N_1}{n!} - \frac{t^n \beta N_1 N_2}{n!} - \frac{t^n \beta N_1 N_3}{n!}\right) + \left(\frac{t^n \pi N_2}{n!} - \frac{t^n \gamma N_3}{n!} - \frac{t^{na} \mu N_3}{n!}\right) N_1\right)\right] \\ - \frac{t^n(\mu + \gamma + \pi)\left(\frac{t^n \beta N_1 N_2}{n!} + \frac{t^n \beta N_1 N_3}{n!} - \frac{t^n(\mu + \gamma + \pi)N_2}{n!}\right)}{n!} \end{aligned} \tag{2.1.24}$$

Similarly, for the infected class;

$$\left.\begin{aligned}
I_1 &= \frac{t^n \pi E_0}{n!} - \frac{t^n \gamma I_0}{n!} - \frac{t^n \mu I_0}{n!} \\
I_2 &= \frac{t^n \pi E_1}{n!} - \frac{t^n \gamma I_0}{n!} - \frac{t^n \mu I_1}{n!} \\
I_3 &= \frac{t^n \pi E_2}{n!} - \frac{t^n \gamma I_2}{n!} - \frac{t^n \mu I_2}{n!} \\
&\vdots \\
I_{k+1} &= \frac{t^n \pi E_k}{n!} - \frac{t^n \gamma I_k}{n!} - \frac{t^n \mu I_k}{n!}
\end{aligned}\right\} \tag{2.1.25}$$

$$I(t) = \frac{t^n \pi E_1}{n!} - \frac{t^n \gamma I_k}{n!} - \frac{t^n \mu I_1}{n!} \tag{2.1.26}$$

Substituting the values of the defined parameters into equation (2.1.26), we have

$$I(t) = \frac{\left(\frac{t^n \pi (t^n \beta N_1 N_2 + t^n \beta N_1 N_3 - t^n (\mu+\gamma+\pi) N_2)}{n!}\right)}{n!} - \frac{\left(\frac{t^n \gamma (t^n \pi N_2 - t^n \beta \gamma N_3 - t^n \mu N_3)}{n!}\right)}{n!} \tag{2.1.27}$$

For the isolated population $Q(t)$

$$Q_1 = \frac{t^n \delta E_0}{n!} + \frac{t^n \delta I_0}{n!} - \frac{t^n \theta Q_0}{n!} - \frac{t^n \mu Q_0}{n!} \tag{2.1.28}$$

Substituting the values of the defined parameters into equation (2.1.28) gives

$$Q_1 = \frac{t^n \delta N_2}{n!} + \frac{t^n \delta_3}{n!} - \frac{t^n \theta N_4}{n!} - \frac{t^n \mu N_4}{n!}$$

It follows that

$$\left.\begin{aligned}
Q_2 &= \frac{t^n \delta E_1}{n!} + \frac{t^n \delta I_1}{n!} - \frac{t^n \theta Q_1}{n!} - \frac{t^n \mu Q_1}{n!} \\
Q_3 &= \frac{t^n \delta E_2}{n!} + \frac{t^n \delta I_2}{n!} - \frac{t^n \theta Q_2}{n!} - \frac{t^n \mu Q_2}{n!} \\
&\vdots \\
Q_{k+1} &= \frac{t^n \delta E_k}{n!} + \frac{t^n \delta I_k}{n!} - \frac{t^n \theta Q_k}{n!} - \frac{t^n \mu Q_k}{n!}
\end{aligned}\right\} \tag{2.1.29}$$

So,

$$Q(t) = \frac{t^n \delta E_1}{n!} + \frac{t^n \delta I_1}{n!} - \frac{t^n \theta Q_1}{n!} - \frac{t^n \mu Q_1}{n!}$$

Substituting the value of the given parameters into equation (2.1.29) gives

$$\left.\begin{aligned}
Q(t) = {} & \frac{t^n \gamma \left(\frac{t^n \beta N_1 N_2}{n!} + \left(\frac{t^n \beta N_1 N_3}{n!} - \frac{t^n (\mu+\gamma+\pi) N_2}{n!}\right)\right)}{n!} + \frac{t^n \delta \left(\frac{t^n \beta N_2}{n!} - \frac{t^n \gamma N_3}{a!} - \frac{t^n \mu N_3}{n!}\right)}{n!} \\
& - \frac{t^n \theta \left(\frac{t^n \delta N_2}{n!} + \left(\frac{t^n \gamma N_3}{n!} - \frac{t^n \theta N_4}{n!} - \frac{t^n \mu N_4}{n!}\right)\right)}{n!} - \frac{t^n \mu \left(\frac{t^n \delta N_2}{n!} + \left(\frac{t^n \delta N_2}{n!} + \frac{t^n N_3}{n!} - \frac{t^n \theta N_4}{n!} - \frac{t^n \mu N_4}{n!}\right)\right)}{n!}
\end{aligned}\right\} \tag{2.1.30}$$

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Finally, for the recovered class $R(t)$

$$\left.\begin{aligned}
R_1 &= \frac{t^n\theta Q_0}{n!} - \frac{t^n\mu R_0}{n!}\\
R_2 &= \frac{t^n\theta Q_1}{n!} - \frac{t^n\mu R_1}{n!}\\
R_3 &= \frac{t^n\theta Q_2}{n!} - \frac{t^n\mu R_2}{n!}\\
R_{k+1} &= \frac{t^n\theta Q_k}{n!} - \frac{t^n\mu R_k}{n!}
\end{aligned}\right\} \tag{2.1.31}$$

So,

$$R(t) = N_5 + \frac{t^n\theta Q_1}{n!} - \frac{t^n\mu R_1}{n!} \tag{2.1.32}$$

Substituting the values of the defined parameters into (2.1.32) yields

$$R(t) = \frac{t^n\theta\frac{t^n\delta N_2}{n!} + \frac{t^n\delta_3}{n!} - \frac{t^n\theta N_4}{n!} - \frac{t^n\mu N_4}{n!}}{n!} - \frac{t^n\mu\frac{t^n\theta N_4}{n!} - \frac{t^n\mu N_5}{n!}}{n!} \tag{2.1.33}$$

3 Numerical Method and Results

In this session, the efficiency of the proposed method is demonstrated. Given

$S_0 = N_1 = 1, E_0 = N_2 = 0.1, I_0 = N_3 = 0, Q_0 = N_4 = 0.5, N_5 = 0.4, A = 1000, \pi = 0.4, \beta = 0.8,$
$\gamma = 0.03, \mu = 0.04, \theta = 0.25, \quad \delta = 0.2$

The proposed Laplace Decomposition method for analyzing the Covid 19 Mathematical Model provides solution in the form of an infinite series

$$\begin{aligned}
&S(t) = 1 + \frac{t^n}{n!}A - \frac{t^n\mu}{n!}S_1 - \frac{t^n\beta}{n!}Z_1 - \frac{t^n\beta}{n!}V_1\\
&n = 1,\\
&S(t) = S_r = 1 + 1000t - 120.0440t^2\\
&n = 0.95,\\
&S(t) = S_t = 1 + 1020.532448t^{0.95} - 125.0242027t^{1.90}\\
&n = 0.85,\\
&S(t) = S_u = 1 + 1020.532448t^{0.95} - 125.0242027t^{1.90}\\
&n = 0.75,\\
&S(t) = s_w = 1 + 1088.065252t^{0.75} - 142.1184101t^{1.50}
\end{aligned}$$

The plot of $S(t)$ for $n = 1 = S_r; n = 0.95 = S_t; n = 0.85 = S_u; n = 0.75 = S_w;$

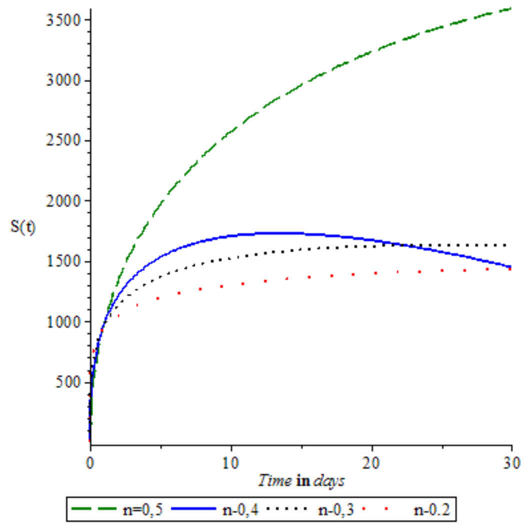

Figure.1: Plot of numerical solution of susceptible class $S(t)$ corresponding to different time in a day

For the exposed population;

$$E(t) = \frac{t^n \beta Z_1}{n!} + \frac{t^n \beta V_1}{n!} - \frac{t^n(\mu+\gamma+\pi)E_1}{n!}$$

$n = 1,$

$$E(t) = E_r = 0.1 + 8.03329t^2$$

$n = 0.95,$

$$E(t) = E_t = 0.1 + 8.214061569t^{1.95} - 0.01615345527t^{1.90}$$

$n = 0.85,$

$$E(t) = E_u = 0.1 + 8..511743729t^{1.85} - 0.01673886547t^{1.80}$$

$n = 0.75,$

$$E(t) = E_w = 0.1 + 8.757619601t^{1.75} - 0.01711139544t^{1.70}$$

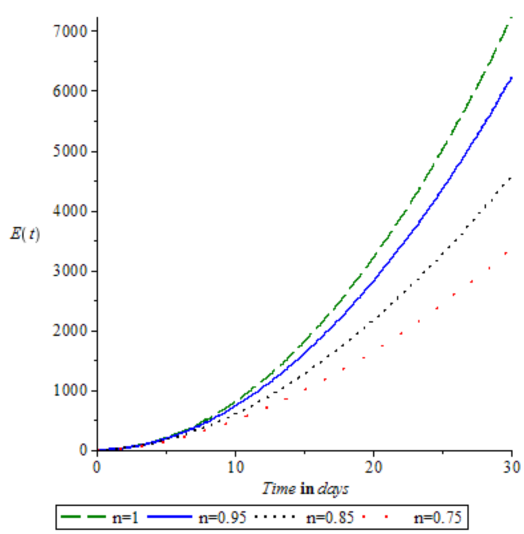

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Figure.2: Plot of numerical solution of Exposed class $E(t)$ corresponding to different time in a day

For the infected population;

$$I(t) = \frac{t^n \pi E_1}{n!} - \frac{t^n \gamma I_1}{n!} - \frac{t^n \pi I_1}{n!}$$

$n = 1,$

$$I(t) = I_r = 0.04352261008t^{0.75}$$

$n = 0.95,$

$$I(t) = I_t = 0.01131587863t^{1.75}$$

$n = 0.85,$

$$I(t) = I_u = 0.01122399749t^{1.85}$$

$n = 0.75,$

$$I(t) = I_w = 0.01154822132t^{1.70}$$

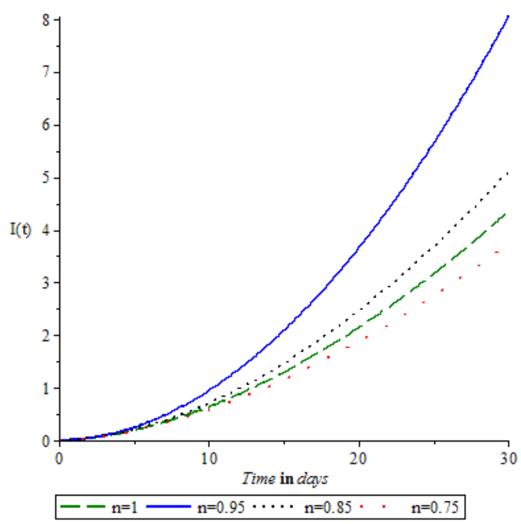

Figure.3: Plot of numerical solution of Infected class $I(t)$ corresponding to different time in a day.

Also, for the isolated population $Q(t)$;

$$Q(t) = 0.5 + \frac{t^n \gamma E_1}{n!} + \frac{t^n \delta I_1}{n!} - \frac{t^n \theta Q_0}{n!} - \frac{t^n \mu Q_1}{n!}$$

$n = 1,$

$$Q(t) = Q_r = 0.5 + 0.04405t^2$$

$n = 0.95,$

$$Q(t) = Q_t = 0.5 + 0.04495445435t^{1.95}$$

$n = 0.85,$

$$Q(t) = Q_u = 0.5 + 0.04658362877t^{1.85}$$

$n = 0.75,$

$$Q(t) = Q_w = 0.5 + 0.04792927435\text{t}^{1.75}$$

The figure below shows the relationship between values of $Q(t)$ corresponding to different time in thirty days.

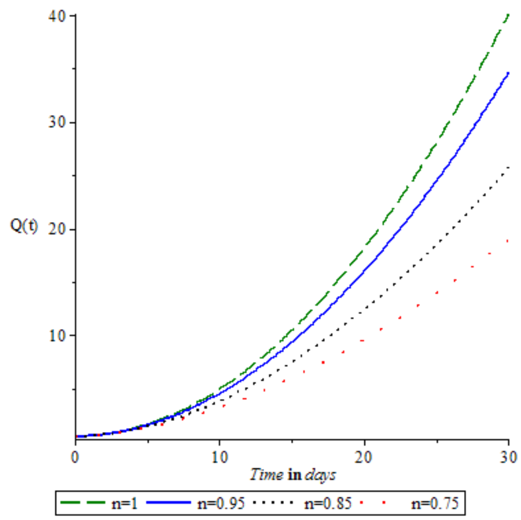

Figure.4: Plot of numerical solution of Isolated class $Q(t)$ corresponding to different time in thirty days.

Finally, the analysis of the recovered class is given below $0.4 + 0.04405t^2$

$$R(t) = 0.4 + \frac{t^n \theta Q_1}{n!} - \frac{t^n \mu R_1}{n!}$$

$$n = 1,$$
$$R(t) = R_r = 0.4 - 0.03561t^2$$
$$n = 0.95,$$
$$R(t) = R_t = 0.4 - 0.03708733347t^{1.90}$$
$$n = 0.85,$$
$$R(t) = R_u = 0.4 - 0.3843139906t^{1.80}$$
$$n = 0.75,$$
$$R(t) = R_w = 0.4 - 0.0394155393\mathrm{t}^{1.70}$$

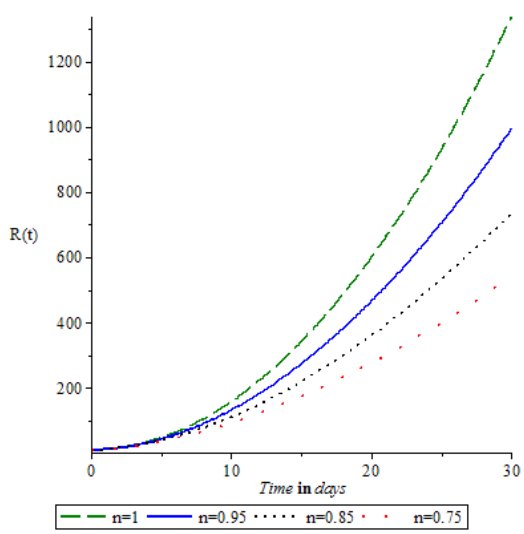

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Figure.5: Plot of numerical solution of Recovered class $R(t)$ corresponding to different time in thirty days.

Figure 6 and figure 7 are graphical plots showing the relationship between the exposed population and infected population and isolated class versus recovered population respectively

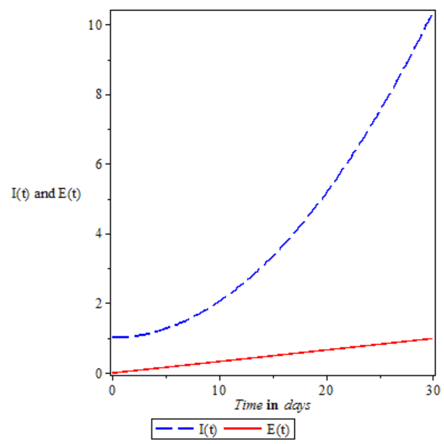

Figure.6: Plot of numerical solution of exposed class and infected class $R(t)$ corresponding to different time in thirty days.

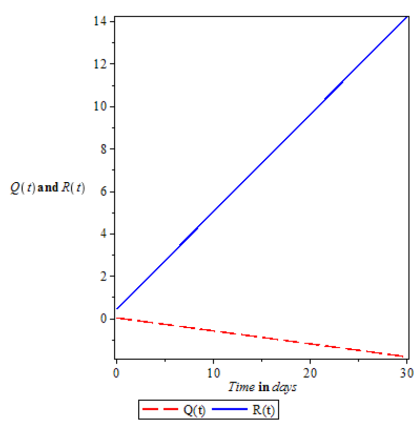

Figure.7: Plot of numerical solution of isolated class and Recovered class $R(t)$ and the corresponding to different time in thirty days.

Conclusion

This paper considered the Mathematical and analysis of COVID 19. The model presented the susceptible class S, exposed population to the pandemic E, the infected population I , the isolated population Q, the recovered population from the pandemic R.
The Laplace Decomposition method which is a very useful algorithm to solve non-linear model is applied. From the study, it is observed that physical contact with the infected person is the major cause of the spread of the pandemic. It becomes imperative that isolation of infected person can flattened the curve of the spread of the virus. From the graphical result, it is also observed that the susceptible class increases as the value of n increases. This is also applicable to the exposed, infected, isolated and recovered population. This confirms that the pandemic increases with physical contact with the infected. To reduce the spread of the disease is to limit the contact with an infected person and also the used of pharmaceutical/non pharmaceutical control measures as a means of reducing the spread of the dreaded covid 19 pandemic.

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Competing financial interests

The author declares no competing financial interests".

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