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MATHEMATICAL ANALYSIS OF THE GLOBAL COVID-19 SPREAD IN NIGERIA AND SPAIN BASED ON SEIRD MODEL

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Abstract: In this paper, a compartmental model for the transmission dynamics of the new infectious disease referred to as COVID-19 is employed. The model comprises five mutually exclusive compartments (classes) of human population sizes viz: susceptible, exposed, infected, recovered, and death, representing the human dynamics; hence, the name SEIRD model. In the model, the temporal dynamics of the COVID-19 outbreak in Nigeria and Spain are analyzed. The period is between February 15-April 3, 2020 for Spain, and February 27-April 3, 2020, for Nigeria. The analysis of the population data is based on the concerned SEIRD model. Graphical representations of the obtained results are presented. A connection between the contact rate of the infection and the compartmental human population sizes subject to the COVID-19 analysis is revealed. It shows that a decrease in the contact rate of the 'susceptible and the infected' classes is a considerable condition leading to a decline in 'the exposed, infected, and death' cases. This decrease is attributed to the control of the possible infecting contacts. The spread patterns for the

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two considered cases are the same. A lot of measures are needed to be put in place to ensure a corresponding increase in the 'recovered class.' The COVID-19 outbreak would remain global and endemic if the infecting contact rate is not well controlled. Thus, adherence to strict public and government policies such as social distancing and isolation is a plausible requirement. For other aspects of epidemiology with related features, this strategy is highly recommended for implementation.

Keywords: COVID-19; SEIRD model; population modeling; disease spread.

2010 AMS Subject Classification: 93A30, 81T80.

1. LINEAR INTRODUCTION

The Chinese Center for Disease Control and Prevention (CCDC), on December 31, 2019, observed 44 suspected Pneumonia cases in Wuhan, a city located in central China. These were presented with clinical symptoms that include dry cough, fever, dyspnea, pain in the throat as a result of sore throat, shortness of breath, and breathing difficulties [1-3].

The results obtained on January 17, 2020, from the CCDC laboratory, brought about the name of the virus as “Severe Acute Respiratory Syndrome Coronavirus 2” (SARS-CoV-2), see (WHO) [4]. Since the discovery of the COVID-19, there had been a notable rapid spread of the coronavirus within and outside Wuhan city. This pandemic had a total of 282 confirmed cases as at the inception, according to the WHO [2]. It later spread to over 206 countries or territories, given a total of 750, 890 confirmed cases as of March 31, 2020, with Italy as the currently most affected having the highest mortality rate [5].

The reasons for this massive spread have recently been categorized into different cases. These include the presence and increase of asymptomatic infectious cases, as noted by Ebrahim and Memish [6]. The second point is the case of a person to person contact, as Bogoch *et al.*, [7] and Ghinai *et al.* [8] have buttressed this point; also a case of inanimate objects to persons is remarked in [9]. In a like manner, a matter of high travel volume is reported by [10]. The points mentioned above or cases are valid since the COVID-19 can be contacted via contact with respiratory droplets of infected persons, indicating that the entire population is susceptible to COVID-19. Owing to the points mentioned earlier, travellers are always at high risk of contracting infectious diseases such as Ebola and the likes. Hence, in [10], it was suggested that international travel authorities should imbibe restriction and proper health screening once an outbreak is noticed. However, these restrictions cannot be enforced for a long time, as many other issues affecting the global economy would come up. For instance, there is no doubt that China had been known to be Nigeria's most leading commercial partners in the whole world, and as a result, there had been substantial inflows and outflows of traffics between these countries. Unexpectedly, the Nigeria Centre for Disease Control (NCDC) reported that one COVID-19 case, was imported by an Italian, who arrived Nigeria on February 27, 2020, as stated in [11], he further travelled across other states of the country, after which, he was confirmed infected. The latest update by the NCDC shows a rise in the figure of infected persons given as 151 confirmed cases as of April 1, 2020 [12]. Epidemiology is becoming an increasing necessity for the health system of the world today; as such, the situations need good mathematical models to check the spread [13, 14]. The recent health situations (hazards) around the world has made it mandatory for scientists to study and determine the causes and best possible way to control, reduce, or eradicate these hazards [15-18].

Since the beginning of this novel and life-threatening COVID-19, a lot of researches have been conducted across the globe. Many of such are still ongoing, all in a bid to proffer a lasting solution or to control the spread. This paper, therefore, proposed a mathematical model as an extension of the classical SIR model and its modifications for the analysis of the disease spread.

The whole paper is partitioned as follows. In section 1, a detailed introduction is given. Section 2 contains the methodology and the derivation of the model; in section 3, the method of solution is presented, and the model solutions are obtained and discussed. In section 4, the paper is remarkably concluded.

2. METHODOLOGY

Mathematics has been applied in many studies to proffer solutions to epidemic issues [19-26]. In mathematical epidemic modeling, the main objective is to determine how fast the disease spreads, the number of the population that are being be infected, the effects of migration into and out of affected areas, and possible control measures. The first mathematical epidemic model can be traced to the mathematician, Daniel Bernoulli, in 1766. His work was on how inoculation against smallpox affects the life expectancy of the population [27, 28]. Kermack and McKendrick developed the SIR-model, that is, Susceptible-Infectious-Removed (SIR) [29]. They investigated the effects of some factors that aid the spread of an infectious disease right from when an infected person moves to a susceptible population [29]. There have been many extensions of the SIR model, including Susceptible-Infectious-Removed-Susceptible (SIRS), Susceptible-Infectious-Susceptible (SIS) and Susceptible-Exposed-Infectious-Removed (SEIR) [30-33]. These models have been explored for different health hazards, including the current one, coronavirus disease 2019 (COVID-19). So many researchers had published recent results on various issues relating to epidemiology, and the novel COVID-19 [18, 20-26, 34-42]. Zhao *et al.*, [43] considered how inter-city travels affect the spread of the virus using correlation analysis. They employed the Needleman-Wunsch algorithm, an application of dynamic programming to identify changes in the DNA sequence of the coronavirus.

The conventional SIR model or its modified form termed SIRS, claims (by assumption) the disease incubation to be negligible. Such that each susceptible individual (S) becomes infectious once infected and thus move to the infective class (I), who again will move to the recovered class (R) or susceptible class (S), depending on the acquired level of immunity which may be permanent or temporary [44, 45].

Whereas, extensions to these models (SIR and SIRS) have been considered on the ground that susceptible individuals, once infected, need to, first of all, go through a latent stage forming exposed class (E) before they become infectious. This scenario can, therefore, lead to either

SEIR or SEIRS model, depending (still) on the acquired level of immunity [46, 47]. This present work captures the COVID-19 global issue by adding a compartmental class of death individuals, mainly due to the spread of COVID-19. Hence, the SEIRD model.

2.1 Fundamental of the SEIRD Model

In this section, the basic assumptions for the proposed model are presented and the model derivation follows.

2.1.1 Basic assumptions for the SEIRD Model

For the derivation of the model, with $N = N(t)$ as the total population size of the individuals (species), the following assumptions are made:

(i) No natural birth or death is permitted.

(ii) Infection is not due to level of education, so the infective class is not sub-divided [45].

(iii) Exposure to latency period is permitted.

(iv) Observation period (during isolation) is 14 days.

(v) Infected individuals are quarantined.

(vi) The independent variable, t, is measured in days, while the dependent variables, say, $S = S(t)$, count the species (susceptible number of individuals) in each group as a function of time but not as a susceptible fraction of the population, say, $s = S/N$. Though, both sets of dependent variables give the same information regarding the state of the concern epidemic or pandemic.

2.2. COVID-19 Spread Model Formulation

During epidemics (disease outbreak within a community) or pandemic (global disease outbreak) situation, some individuals get infected, while some recover after they have been infected. Meanwhile, some fraction dies due to infectious diseases. It can be captured that some of the susceptible individuals are exposed to the spread before they are infected. Thus, the population at such time can be divided into five compartments resulting in a model herein referred to as SEIRD. Here, for a time parameter, t, $S = S(t)$, denotes the population size of susceptible individuals (those who are neither infected nor immune), $E = E(t)$, denotes the number of individuals who are open to the infection (those who have been infected but are not yet infectious, $I = I(t)$, denotes the population size of infective individuals (those that have been infected and can spread the disease), $R = R(t)$, denotes the population size of recovered individuals (after they have been infected), and $D = D(t)$, denotes the population size of individuals who died due to the infection. In some cases, $(R+D)$, that is, R and D, are referred to as *removed* individuals. This will be denoted as R_m (if need be). Therefore, if $N = N(t)$ is as defined earlier, then:

$$N(t) = S(t) + E(t) + I(t) + R(t) + D(t). \tag{1.1}$$

The detail partition is shown in the compartmental diagram (Fig. 1):

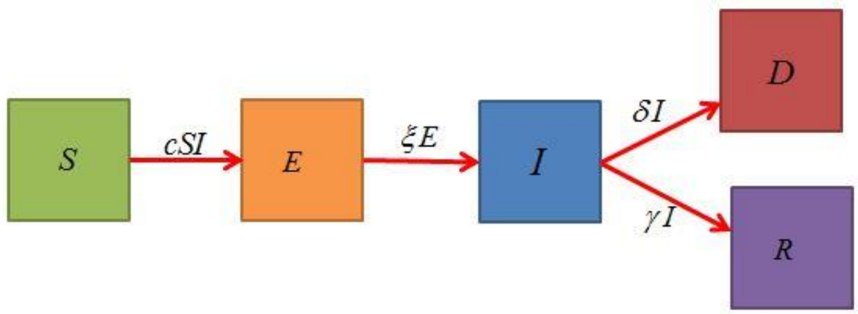

Fig. 1: The COVID-19 Dynamical Pattern

where the parameter c is the rate of infection (probability of S contracting the disease when in contact with I, ξ signifies the latency rate of migration, γ signifies recovery rate and δ is the death rate. By considering Figure 1 via the application of conservation principle, the following dynamics represent a set of a system of differential equations that models the situation:

$$\begin{cases} \frac{dS}{dt} = -cSI \\ \frac{dE}{dt} = cSI - \xi E \\ \frac{dI}{dt} = \xi E - (\sigma + \gamma) I \\ \frac{dR}{dt} = \gamma I \\ \frac{dD}{dt} = \sigma I \end{cases} \tag{1.2}$$

subject to the following initial conditions:

$$\left(S(o), E(o), I(o), R(o), D(o)\right) = \left(S_0, E_0, I_0, R_0, D_0\right). \tag{1.3}$$

The present model (1.2) with its initial data (1.3) extends or complements some vital epidemiological models in literature, such as the researches of [40, 45, 47, 48]. Apart from other parameters considered in [45], the infective class was comprehensively sub-divided into two classes viz: educated and uneducated infected individuals with meaningful results.

Remark 1: The proposed SEIRD model (1.2) deals with human population sizes. Hence, all the corresponding parameters are supposed positive. This leads to the following result(s).

Theorem 2.1: The basic variables in the SEIRD model (1.2) are positive at all time, $t>0$. This implies that the solution set of the system in (1.2) at any time, $t>0$, maintain non-negativity condition(s).

Proof: Let $\bar{t}\in[0,t]$, such that $\bar{t}=\sup\{t>0:0<S,E,I,R,D<\infty\}$. Then, from (1.2), we can write:

$$\frac{dS}{dt}=-cSI$$

as follows:

$$\frac{dS}{S}=-cIdt\,.$$

$$\therefore\ \int_0^{\bar{t}}\frac{dS}{S}=-c\int_0^{\bar{t}}Id\tau$$

$$\Rightarrow\ \ln S(\tau)\Big|_0^{\bar{t}}=-c\int_0^{\bar{t}}Id\tau.$$

Hence, for $S(0)=S_0$, we have:

$$S(t)=S_0\exp\left(-c\int_0^{\bar{t}}I(\tau)d\tau\right)\geq 0$$

since $S(0)=S_0>0$ and $\exp(\cdot)\geq 0$.

The same procedure can be followed to show that $E(t)>0,\ I(t)>0,\ R(t)>0,$ and $D(t)>0,\ \forall t>0.$ Q.E.D.

3. METHOD OF SOLUTION [49-51]

We suppose the projected transform of $S(\cdot),\ E(\cdot),\ I(\cdot),\ R(\cdot),$ and $D(\cdot)$ to be $\bar{S}(\cdot),\ \bar{E}(\cdot),\ \bar{I}(\cdot),\ \bar{R}(\cdot),$ and $\bar{D}(\cdot)$ respectively, then for $j=1,2,\ldots,\ j\phi=1$, at projection, the model dynamics in system (2) is transformed as follows:

$$\overbrace{\begin{aligned}
&\bar{S}(j)=\phi\left\{-c\sum_{n=0}^{j-1}\bar{S}(n)\bar{I}(j-1-n)\right\}\\
&\bar{E}(j)=\phi\left\{c\sum_{n=0}^{j-1}\bar{S}(n)\bar{I}(j-1-n)-\xi\bar{E}(j-1)\right\}\\
&\bar{I}(j)=\phi\left\{\xi\bar{E}(j-1)-(\sigma+\gamma)\bar{I}(j-1)\right\}\\
&\bar{R}(j)=\phi\left\{\gamma\bar{I}(j-1)\right\}\\
&\bar{D}(j)=\phi\left\{\sigma\bar{I}(j-1)\right\}
\end{aligned}} \tag{3.1}$$

such that:

$$\begin{cases}
S(t)=\sum_{i=0}^{\infty}\bar{S}(i)t^{i}\\
E(t)=\sum_{i=0}^{\infty}\bar{E}(i)t^{i}\\
I(t)=\sum_{i=0}^{\infty}\bar{I}(i)t^{i}\\
R(t)=\sum_{i=0}^{\infty}\bar{R}(i)t^{i}\\
D(t)=\sum_{i=0}^{\infty}\bar{D}(i)t^{i}
\end{cases} \tag{3.2}$$

For the sake of simplicity and model analysis, we refer to the following Tables (1 and 2).

Note: **Table 1** is for Spain COVID-19 data between February 15-April 3, 2020. As of April 3, 2020, Spain cases read, *Confirmed:* $C=117,710$, *Death:* $D=10,935$ and *Recovered:* $R=30,513$.

Table 1: Spain-Case Parameters

Initial Data	Value	Scaled Value (SV)	Sources/References
N_0	46,754,778	-	Worldometer [52]
S_0	$0.9(N_0)$	1	Scaled/Assumed
E_0	$0.1(S_0)$	1.0×10^{-3}	Scaled/Assumed
I_0	2	4.76×10^{-8}	Worldometer/scaled [52]
R_0	0	0 (scaled)	WHO/Worldometer [4]
D_0	0	0 (scaled)	WHO/Worldmeter [52]
Model Parameters/Rates			
Parameters	Value	Remark	Sources/References
c	Varied	-	
ξ	0.1	Observation period is $[2,14]$ days	NCNC [11]
γ	0.26	computed	WHO/Worldometer/scaled
σ	0.093	computed	WHO/Worldometer/scaled

Table 2 is for Nigeria COVID-19 data between February 27-April 3, 2020. As of April 3, 2020, Nigeria cases read, *Confirmed:* $C = 210$, *Death:* $D = 4$ and *Recovered:* $R = 25$.

Table 2: Nigeria-Case Parameters

Initial Data	Value	Scaled Value (SV)	Sources/References
N_0	206,139,589	-	Worldmeter [52]
S_0	$0.97(N_0)$	1	Scaled/Assumed
E_0	100	5.0×10^{-7}	Scaled/Assumed
I_0	1	5.0×10^{-9}	Worldmeter/scaled
R_0	0	0	WHO/Worldometer/scaled
D_0	0	0	WHO/Worldometer/scaled
Model Parameters/Rates			
Parameters	Value	Remark	Sources/References
c	Varied	-	
ξ	≈ 0.07	Observation period is $[2,14]$ days	NCNC [11]
γ	0.12	Computed (scaled)	WHO/Worldometer [52]
σ	0.02	Computed (scaled)	WHO/Worldometer [52]

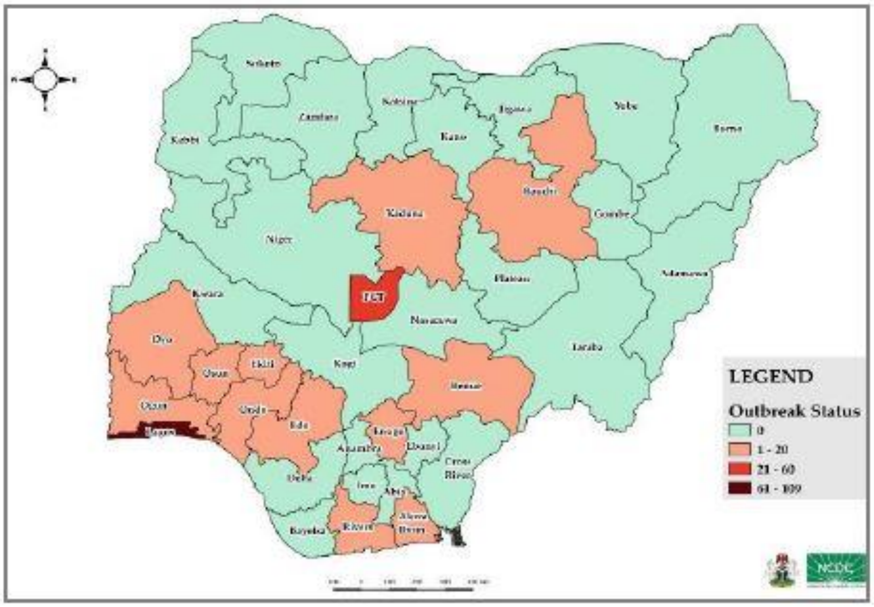

Fig. 1: Nigeria-regions with COVID-19 as at 03/04/2020 (Source: www.ncdc.gov.ng) [11]

3.1 THE ASSOCIATED MODEL SOLUTIONS

This section presents the solution associated with the proposed model via the method of solution earlier presented. The data in Tables 1 and 2 are used accordingly. For clarity of presentation, we denote the obtained solutions for Spain and Nigeria cases with subscripts SPN and NIG, respectively. Thus, the following solutions:

$$
\begin{aligned}
S_{SPN}(t) &= 1 - 4.76\times10^{-8}c + 0.5\times10^{-3}c\left(-\xi + 0.476\times10^{-4}\sigma + 0.476\times10^{-4}\gamma + 2.27\times10^{-12}c\right)t^2 \\
&\quad - 0.167\times10^{-3}c\begin{pmatrix} 0.476\times10^{-4}c\xi - \xi^2 - \sigma\xi + 0.476\times10^{-4}\sigma^2 + 0.952\times10^{-4}\sigma\gamma \\ -\gamma\xi + 0.476\times10^{-4}\gamma^2 + 6.8\times10^{-12}c\sigma + 6.8\times10^{-12}c\gamma \\ +1.08\times10^{-19}c^2 \end{pmatrix}t^3 \\
&\quad + 0.250c\begin{pmatrix} 1.59\times10^{-8}c\sigma\xi + 5.3\times10^{-15}c\sigma\gamma + 1.59\times10^{-8}c\gamma\xi - 1.67\times10^{-4}\xi^3 \\ +8.59\times10^{-31}c^3 + 2.65\times10^{-15}c\sigma^2 + 2.65\times10^{-15}c\gamma^2 + 1.08\times10^{-22}c^2\sigma \\ +1.08\times10^{-22}c^2\gamma + 1.89\times10^{-15}c^2\xi - 1.66\times10^{-4}\ c\xi^2 - 3.33\times10^{-4}\sigma\gamma\xi \\ +2.38\times10^{-8}\sigma\gamma^2 - 1.67\times10^{-4}\gamma\xi^2 - 1.67\times10^{-4}\gamma^2\xi - 1.67\times10^{-4}\sigma\xi^2 \\ -1.67\times10^{-4}\sigma^2\xi + 2.38\times10^{-8}\sigma^2\gamma + 7.93\times10^{-9}\gamma^3 + 7.93\times10^{-9}\sigma^3 \end{pmatrix}t^4 + \cdots
\end{aligned}
$$

$$\begin{aligned}
E_{SPN}(t) = {} & 0.1\times10^{-2} + \left(4.76\times10^{-8}c - 0.1\times10^{-2}\xi\right)t \\
& + \left(0.5\times10^{-3}c\xi - 2.38\times10^{-8}c\sigma - 2.38\times10^{-8}c\gamma - 1.14\times10^{-15}c^2 + 0.5\times10^{-3}\xi^2\right)t^2 \\
& + \begin{pmatrix} 7.93\times10^{-9}c^2\xi - 0.334\times10^{-3}c\xi^2 - 0.167\times10^{-3}c\sigma\xi + 7.93\times10^{-9}c\sigma^2 \\ +1.59\times10^{-9}c\sigma\gamma - 0.167\times10^{-3}c\gamma\xi + 7.93\times10^{-9}c\gamma^2 + 1.13\times10^{-15}c^2\sigma \\ +1.13\times10^{-15}c^2\gamma + 1.8\times10^{-23}c^3 - 0.167\times10^{-3}\xi^3 \end{pmatrix} t^3 \\
& + \begin{pmatrix} 8.32\times10^{-5}c\sigma a\gamma\xi + 8.36\times10^{-5}c\gamma\xi^2 + 4.18\times10^{-5}c\gamma^2\xi + 8.36\times10^{-5}c\sigma\xi^2 \\ +4.18\times10^{-5}c\sigma^2\xi - 5.95\times10^{-9}c\sigma^2\gamma - 3.98\times10^{-9}c^2\sigma\xi - 1.32\times10^{-15}c^2\sigma\gamma \\ -3.98\times10^{-9}c^2\gamma\xi - 5.95\times10^{-9}c\sigma\gamma^2 + 1.25\times10^{-4}\ c\xi^3 - 6.62\times10^{-16}c^2\sigma^2 \\ -6.62\times10^{-16}c^2\gamma^2 - 2.7\times10^{-23}c^3\sigma^2 - 2.7\ 10\times10^{-23}c^3\gamma - 4.72\times10^{-16}c^3\xi \\ +4.15\times10^{-5}c^2\xi^2 - 1.98\times10^{-9}c\gamma^3 - 1.98\times10^{-9}c\sigma^3 - 2.15\times10^{-31}c^4 \\ +4.18\times10^{-5}\xi^4 \end{pmatrix} t^4 + \cdots
\end{aligned}$$

$$\begin{aligned}
I_{SPN}(t) = {} & 4.76\times10^{-8} + \left(0.1\times10^{-2}\xi - 4.76\times10^{-8}\sigma - 4.76\times10^{-8}\gamma\right)t \\
& + \begin{pmatrix} 2.38\times10^{-8}c\xi - 0.5\times10^{-3}\xi^2 - 0.5\times10^{-3}\sigma\xi + 2.38\times10^{-8}\sigma^2 \\ +4.76\times10^{-8}\sigma\gamma - 0.5\times10^{-3}\gamma\xi + 2.38\times10^{-8}\gamma^2 \end{pmatrix} t^2 \\
& + \begin{pmatrix} 0.167\times10^{-3}c\xi^2 - 1.59\times10^{-8}c\sigma\xi - 1.59\times10^{-8}c\gamma\xi - 3.8\times10^{-16}c^2\xi \\ +0.167\times10^{-3}\xi^3 + 0.167\times10^{-3}\sigma\xi^2 + 0.167\times10^{-3}\sigma^2\xi - 7.93\times10^{-9}\sigma^3 \\ -2.38\times10^{-8}\sigma^2\gamma + 0.333\times10^{-3}\sigma\gamma\xi \text{ - } 2.38\times10^{-8}\sigma\gamma^2 \\ +0.167\times10^{-3}\gamma^2\xi^2 + 0.167\times10^{-3}\gamma^2\xi - 7.93\times10^{-9}\gamma^3 \end{pmatrix} t^3 \\
& + \begin{pmatrix} 1.19\times10^{-8}c\sigma\gamma\xi - 1.25\times10^{-4}\sigma^2\gamma\xi - 8.35\times10^{-5}\sigma\gamma\xi^2 - 1.25\times10^{-5}\sigma\gamma^2\xi \\ -8.36\times10^{-5}c\gamma\xi^2 + 5.96\times10^{-9}c\gamma^2\xi - 8.36\times10^{-5}c\sigma\xi^2 + 5.96\times10^{-9}c\sigma^2\xi \\ +3.77\times10^{-16}\ c^2\sigma\xi + 3.77\times10^{-16}c^2\gamma\xi - 8.35\times10^{-5}c\xi^3 + 4.50\times10^{-24}c^3\xi \\ +1.98\times10^{-9}c^2\xi^2 + 1.19\times10^{-8}\sigma^2\gamma^2 + 7.92\times10^{-9}\sigma^3\gamma - 4.18\times10^{-5}\sigma^3\xi^2 \\ -4.18\times10^{-5}\gamma^3\xi - 4.18\times10^{-5}\gamma^2\xi^2 - 4.18\times10^{-5}\gamma\xi^3 + 7.92\times10^{-9}\sigma\gamma^3 \\ +1.98\times10^{-9}\gamma^4 + 1.98\times10^{-9}\sigma^4 - 4.18\times10^{-5}\sigma^2\xi^2 - 4.18\times10^{-5}\sigma\xi^3 \\ -4.18\times10^{-5}\xi^4 \end{pmatrix} t^4 + \cdots
\end{aligned}$$

$$\begin{aligned}
R_{SPN}(t) = {} & \left(4.76\times10^{-8}\gamma\right)t - 0.50\times10^{-3}\gamma\left(-\xi + 0.476\times10^{-4}\sigma + 0.476\times10^{-4}\gamma\right)t^2 \\
& + 0.167\times10^{-3}\gamma \begin{pmatrix} 0.476\times10^{-4}c\xi - \xi^2 - \sigma\xi + 0.476\times10^{-4}\sigma^2 \\ +0.952\times10^{-4}\sigma^2\gamma - \gamma\xi + 0.476\times10^{-4}\gamma^2 \end{pmatrix} t^3 \\
& - 2.5\times10^{-7}\gamma \begin{pmatrix} -167.c\xi^2 + 0.159\times10^{-1}c\sigma\xi + 0.159\times10^{-1}c\gamma\xi \\ +3.8\times10^{-10}c \wedge 2\xi - 167.\xi^3 - 167.\sigma\xi^2 - 167.\sigma^2\xi \\ +0.793\times10^{-2}\sigma^3 + 0.238\times10^{-1}\sigma^2\gamma - 333.\sigma^2\gamma^2\xi \\ +0.238\times10^{-1}\sigma^2\gamma^2 - 167.\gamma\xi^2 - 167.\gamma^2\xi + 0.793\times10^{-2}\gamma^3 \end{pmatrix} t^4 + \cdots
\end{aligned}$$

$$D_{SPN}(t)= 4.76\times10^{-8}\sigma t-0.50\times10^{-3}\sigma\left(-\xi+0.476\times10^{-4}\sigma+0.476\times10^{-4}\gamma\right)t^2$$
$$+0.167\times10^{-3}\sigma\begin{pmatrix}0.476\times10^{-4}c\xi-\xi^2-\sigma xi+0.476\times10^{-4}\sigma^2\\ +0.952\times10^{-4}\sigma^2\gamma-\gamma\xi+0.476\times10^{-4}\gamma^2\end{pmatrix}t^3$$
$$-2.5\times10^{-7}\sigma\begin{pmatrix}-167c\xi^2+0.159\times10^{-1}c\sigma^2\xi+0.159\times10^{-1}c\gamma\xi+3.8\times10^{-10}c^2\xi\\ -167\xi^3-167\sigma\xi^2-167\sigma^2\xi+0.793\times10^{-2}\sigma^3+0.238\times10^{-1}\sigma^2\gamma\\ -333\sigma^2\gamma\xi+0.238\times10^{-1}\sigma\gamma^2-167\gamma\xi^2-167\gamma^2\xi+0.793\times10^{-2}\gamma^3\end{pmatrix}t^4+\cdots$$

$$S_{NIG}(t)= 1-5\times10^{-9}ct+2.50\times10^{-7}c\left(-\xi+0.1\times10^{-1}\sigma+0.1\times10^{-1}\gamma+5\times10^{-11}c\right)t^2$$
$$-8.33\times10^{-8}c\begin{pmatrix}0.1\times10^{-1}c\xi-\xi^2-\sigma\xi+0.1\times10^{-1}\sigma^2+0.2\times10^{-1}\sigma\gamma\\ -\gamma\xi+0.1\times10^{-1}\gamma^2+1.50\times10^{-10}c\sigma+1.5\times10^{-10}c\gamma\\ +2.5\times10^{-19}c^2\end{pmatrix}t^3$$
$$+0.250c\begin{pmatrix}1.67\times10^{-9}c\sigma\xi+5.83\times10^{-17}c\sigma\gamma+1.67\times10^{-17}c\gamma\xi\\ +2.92\times10^{-17}c\sigma^2+2.92\times10^{-17}c\gamma^2+1.25\times10^{-25}c^2\sigma\\ +1.25\times10^{-25}c^2\gamma+2.09\times10^{-17}c^2\xi-8.27\times10^{-8}c\xi^2\\ +8.33\times10^{-10}\gamma^3+8.33\times10^{-10}\sigma^3+2.50\times10^{-9}\sigma^2\gamma\\ +2.50\times10^{-9}\sigma\gamma^2-8.33\times10^{-8}\gamma\xi^2-8.33\times10^{-8}\gamma^2\xi\\ -8.33\times10^{-8}\sigma\xi^2-8.33\times10^{-8}\sigma^2\xi-8.33\times10^{-8}\xi^3\\ +1.04\times10^{-34}c^3-1.67\times10^{-7}\sigma^2\gamma\xi\end{pmatrix}t^4+\cdots$$

$$E_{NIG}(t)= 5.0\times10^{-7}+\left(5.0\times10^{-9}c-5.0\times10^{-7}\xi t\right)$$
$$+\begin{pmatrix}2.48\times10^{-7}c\xi-2.50\times10^{-9}c\sigma-2.5\times10^{-9}c\gamma\\ -1.25\times10^{-17}c^2+2.50\times10^{-7}\xi^2\end{pmatrix}t^2$$
$$+\begin{pmatrix}8.33\times10^{-10}c^2\xi-1.66\times10^{-7}c\xi^2-8.25\times10^{-8}c\sigma^2\xi\\ +8.33\times10^{-10}c\sigma^2+1.67\times10^{-9}c\sigma\gamma\\ -8.25\times10^{-8}c\gamma\xi+8.33\times10^{-10}c\gamma^2+1.25\times10^{-17}c^2\sigma\\ +1.25\times10^{-17}c^2\gamma+2.08\times10^{-26}c^3-8.33\times10^{-8}\xi^3\end{pmatrix}t^3$$
$$+\begin{pmatrix}4.14\times10^{-8}c\sigma\gamma\xi-4.18\times10^{-10}c^2\sigma\xi-1.46\times10^{-17}c^2\sigma\gamma\\ -4.18\times10^{-10}c^2\gamma\xi-6.25\times10^{-10}c\sigma^2\gamma-6.25\times10^{-10}c\sigma\gamma^2\\ +4.14\times10^{-8}c\gamma\xi^2+2.06\times10^{-8}c\gamma^2\xi+4.14\times10^{-8}c\sigma^2\\ +2.06\times10^{-8}c\sigma^2\xi-7.30\times10^{-18}c^2\sigma^2-7.30\times10^{-18}c^2\gamma^2\\ -3.12\times10^{-26}c^3\sigma-3.12\times10^{-26}c^3\gamma-5.22\times10^{-18}c^3\xi\\ +2.05\times10^{-8}c^2\xi^2-2.08\times10^{-10}c\gamma^3-2.08\times10^{-10}c\sigma^3\\ +6.23\times10^{-8}c\xi^3-2.60\times10^{-35}c^4+2.08\times10^{-8}\xi^4\end{pmatrix}t^4+\cdots$$

$$I_{NIG}(t) = 5.00\times10^{-9} + \left(5.0\times10^{-7}\xi - 5.0\times10^{-9}\sigma - 5.0\times10^{-9}\gamma\right)t$$
$$+\begin{pmatrix} 2.5\times10^{-9}c\xi - 2.50\times10^{-7}\xi^2 - 2.50\times10^{-7}\sigma\xi + 2.5\times10^{-9}\sigma^2 \\ +5.00\times10^{-9}\sigma\gamma - 2.50\times10^{-7}\gamma\xi + 2.5\times10^{-9}\gamma^2 \end{pmatrix}t^2$$
$$+\begin{pmatrix} 8.27\times10^{-8}c\xi^2 - 1.67\times10^{-9}c\sigma\xi - 1.67\times10^{-9}c\gamma\xi \\ -4.17\times10^{-18}c^2\xi + 8.33\times10^{-8}\xi^3 + 8.33\times10^{-8}\sigma\xi^2 \\ +8.33\times10^{-8}\sigma^2 xi - 8.33\times10^{-10}\sigma^3 - 2.50\times10^{-9}\sigma^2\gamma \\ +1.67\times10^{-7}\sigma\gamma\xi - 2.50\times10^{-9}\sigma\gamma^2 + 8.33\times10^{-8}\gamma\xi^2 \\ +8.33\times10^{-8}\gamma^2\xi \text{-} 8.33\times10^{-10}\gamma^3 \end{pmatrix}t^3$$
$$+\begin{pmatrix} -2.08\times10^{-8}\sigma^3\xi + 5.20\times10^{-27}c^3\xi + 2.08\times10^{-10}c^2\xi^2 \\ -4.15\times10^{-8}c\xi^3 + 4.16\times10^{-18}c^2\gamma\xi - 4.13\times10^{-8}c\gamma\xi^2 \\ +6.26\times10^{-10}c\gamma^2\xi - 6.25\times10^{-8}\sigma\gamma^2\xi - 4.18\times10^{-8}\sigma\gamma\xi^2 \\ -6.25\times10^{-8}\sigma^2\gamma\xi + 4.16\times10^{-18}c^2\sigma^2\xi \\ +6.26\times10^{-10}c\sigma^2\xi - 4.13\times10^{-8}c\sigma\xi^2 + 8.32\times10^{-10}\sigma\gamma^3 \\ +1.25\times10^{-9}\sigma^2\gamma^2 + 8.32\times10^{-10}\sigma^3\gamma - 2.08\times10^{-8}\gamma^2\xi^3 \\ -2.08\times10^{-8}\gamma^2\xi^2 - 2.08\times10^{-8}\gamma^3\xi - 2.08\times10^{-8}\sigma\xi^3 \\ -2.08\times10^{-8}\sigma^2\xi^2 + 1.25\times10^{-9}c\sigma\gamma\xi + 2.08\times10^{-10}\gamma^4 \\ +2.08\times10^{-10}\sigma^4 - 2.08\times10^{-8}\xi^4 \end{pmatrix}t^4 + \cdots$$

$$R_{NIG}(t) = 5.0\times10^{-9}\gamma t - 2.50\times10^{-7}\gamma\left(-\xi + 0.10\times10^{-1}\sigma + 0.10\times10^{-1}\gamma\right)t^2$$
$$+8.33\times10^{-8}\gamma\begin{pmatrix} 0.10\times10^{-1}c\xi - \xi^2 - \sigma\xi + 0.1\times10^{-1}\sigma^2 \\ +0.20\times10^{-1}\sigma\gamma - \gamma\xi + 0.10\times10^{-1}\gamma^2 \end{pmatrix}t^3$$
$$-0.250\gamma\begin{pmatrix} -8.27\times10^{-8}c\xi^2 + 1.67\times10^{-9}c\sigma\xi + 1.67\times10^{-9}c\gamma\xi \\ +4.17\times10^{-18}c^2\xi - 8.33\times10^{-8}\xi^3 - 8.33\times10^{-8}\sigma\xi^2 \\ -8.33\times10^{-8}\sigma^2\xi + 8.33\times10^{-10}\sigma^3 + 2.50\times10^{-9}\sigma^2\gamma \\ -1.67\times10^{-7}\sigma\gamma\xi + 2.50\times10^{-9}\sigma\gamma^2 - 8.33\times10^{-8}\gamma\xi^2 \\ -8.33\times10^{-8}\gamma^2\xi + 8.33\times10^{-10}\gamma^3 \end{pmatrix}t^4 + \cdots$$

$$D_{NIG}(t) = 5.00\times10^{-9}\sigma t - 2.50\times10^{-7}\sigma\left(-\xi + 0.10\times10^{-1}\sigma + 0.10\times10^{-1}\gamma\right)t^2$$
$$+8.33\times10^{-8}\sigma\begin{pmatrix} 0.10\times10^{-1}c\xi - \xi^2 - \sigma\xi + 0.10\times10^{-1}\sigma^2 \\ +0.20\times10^{-1}\sigma\gamma - \gamma\xi + 0.10\times10^{-1}\gamma^2 \end{pmatrix}t^3$$
$$-0.25\sigma\begin{pmatrix} -8.27\times10^{-8}c\xi^2 + 1.67\times10^{-9}c\sigma\xi + 1.67\times10^{-9}c\gamma\xi \\ +4.17\times10^{-18}c^2\xi - 8.33\times10^{-8}\xi^3 - 8.33\times10^{-8}\sigma\xi^2 \\ -8.33\times10^{-8}\sigma^2\xi + 8.33\times10^{-10}\sigma^3 + 2.50\times10^{-9}\sigma^2\gamma \\ -1.67\times10^{-7}\sigma\gamma\xi + 2.50\times10^{-9}\sigma\gamma^2 - 8.33\times10^{-8}\gamma\xi^2 \\ -8.33\times10^{-8}\gamma^2\xi + 8.33\times10^{-10}\gamma^3 \end{pmatrix}t^4 + \cdots$$

3.2 NUMERICAL AND GRAPHICAL PRESENTATION OF RESULTS

The above solutions are approximate analytical solutions to the proposed SEIRD model. The plots of the resulting solutions are presented in the following figures. Other possible methods of solutions include those of [53-62]. For the Spain model cases, we consider Fig.2, Fig.3, Fig.4, and Fig.5 based the set of parameter values: $(c=1,\ \&\ \xi=0.1)$, and $(c^{-1}=3,\ \&\ \xi=0.1)$.

Similarly, for the Nigeria model cases, we consider Fig.6, Fig.7, Fig.8 and Fig.9, based on the set of parameter values: $(c=1,\ \&\ \xi=0.07)$ and $(c^{-1}=5,\ \&\ \xi=0.07)$.

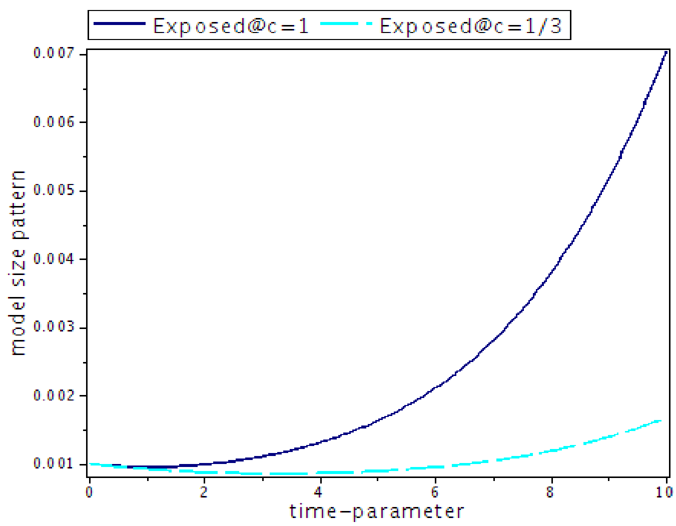

Fig. 2: Spain model exposed cases for $c=1,\ c^{-1}=3,\ \&\ \xi=0.1$

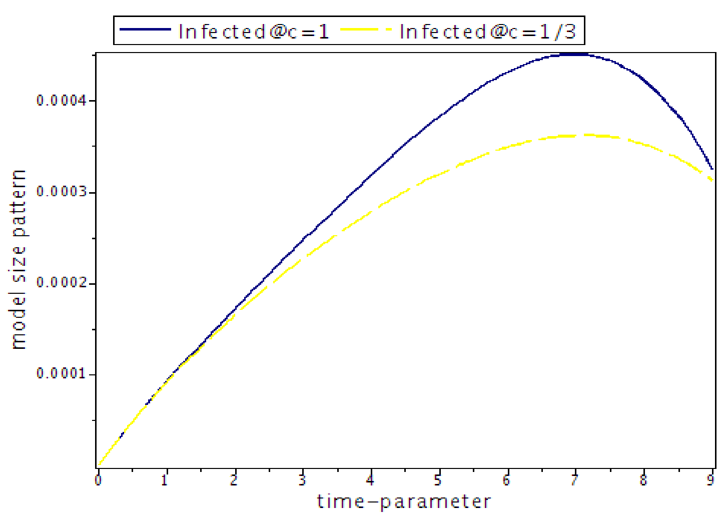

Fig. 3: Spain model infected cases for $c=1,\ c^{-1}=3,\ \&\ \xi=0.1$

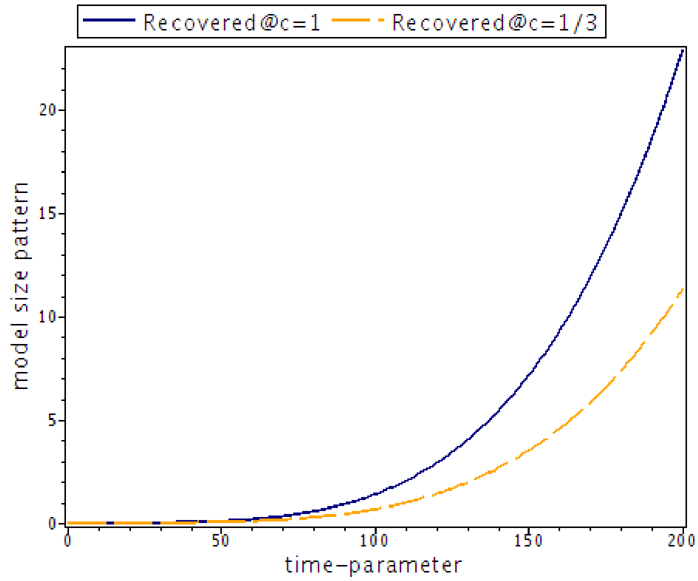

Fig. 4: Spain model recovered cases for $c=1,\ c^{-1}=3,\ \&\ \xi=0.1$

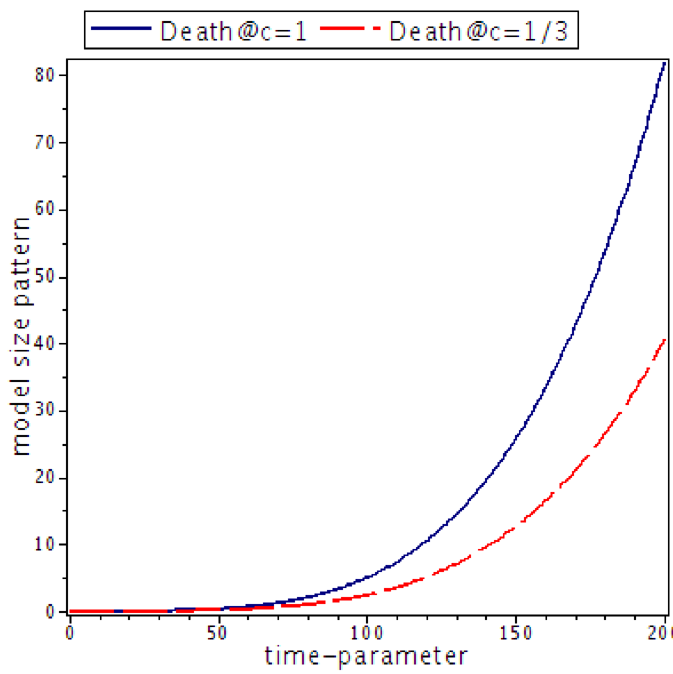

Fig. 5: Spain model death cases for $c=1,\ c^{-1}=3,\ \&\ \xi=0.1$

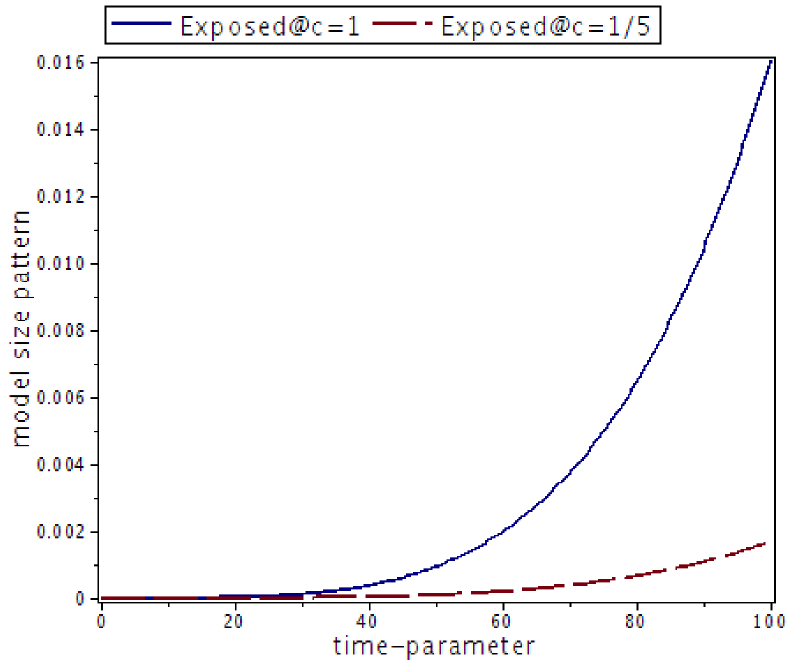

Fig. 6: Nigeria model exposed cases for $c=1,\ c^{-1}=5,\ \&\ \xi \simeq 0.07$

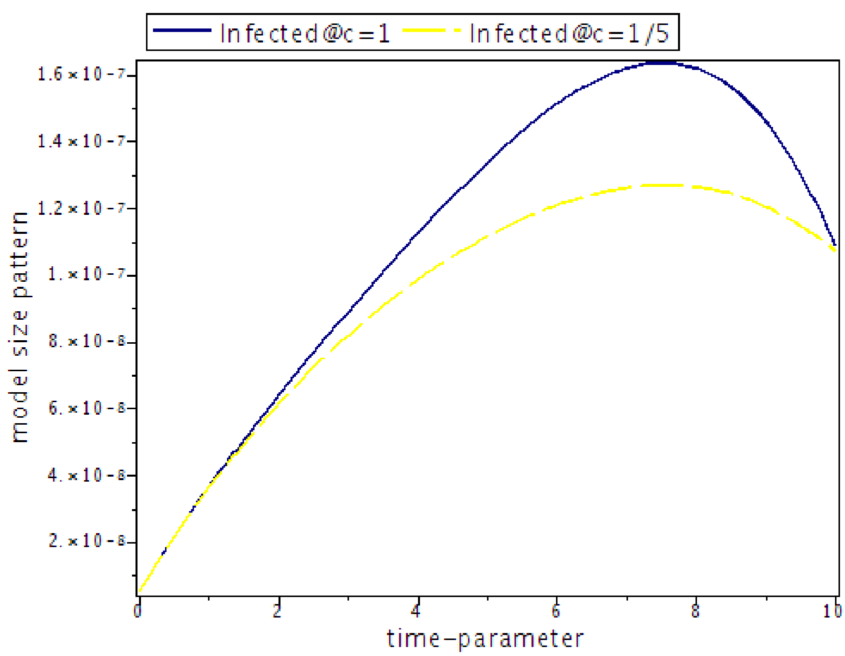

Fig. 7: Nigeria model infected cases for $c=1,\ c^{-1}=5,\ \&\ \xi \simeq 0.07$

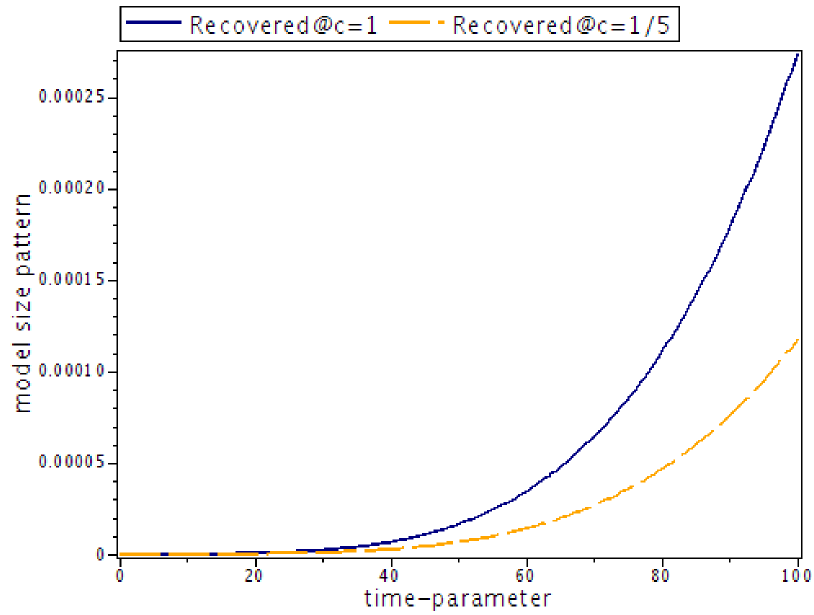

Fig. 8: Nigeria model recovered cases for $c=1,\ c^{-1}=5,\ \&\ \xi\simeq 0.07$

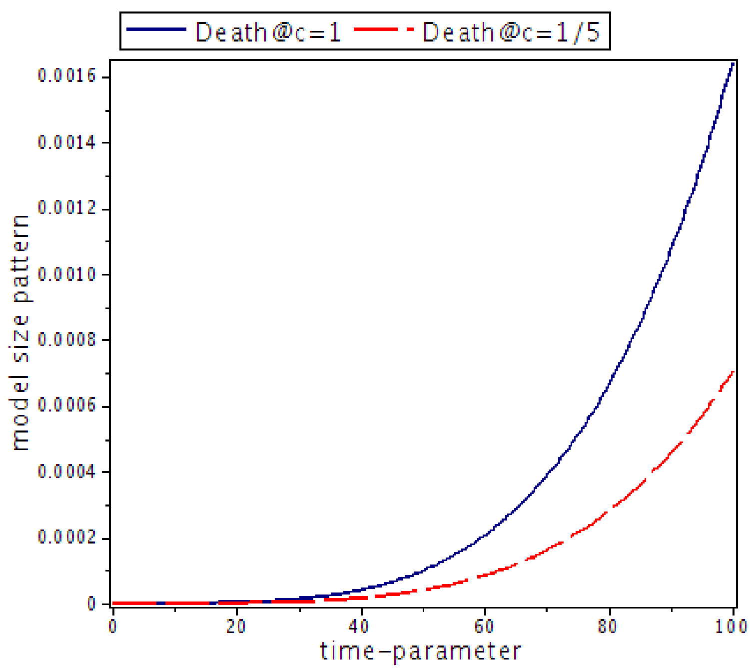

Fig. 9: Nigeria model exposed cases for $c=1,\ c^{-1}=5,\ \&\ \xi\simeq 0.07$

3.1 Parameter values and implications

From the results above, the set values $c=1, \ \& \ \xi=0.1$ imply a situation where each infected person makes one (1) possible infecting contact per day on the average of 10 days of observation period (say latency). This for the Spain case model is depicted in Fig.2, Fig. 3, Fig. 4 and Fig. 5. Similarly, the parameters $c^{-1}=3, \ \& \ \xi=0.1$ were considered to reflect a situation where each infected person makes one (1) possible infecting contact every three (3) days on the average of 10 days of observation period. The results in the two scenarios show a drastic decrease in the 'exposed, infected and death' classes (Fig.2-Fig.5 compared).

For universality and comparison, the Nigeria case is also considered via the parameters, $c=1, \ \& \ \xi=0.07$ to imply a situation where each infected person makes one (1) possible infecting contact per day on the average of 14 days of observation period (see Fig. 6-Fig. 9). Similarly, the parameter values $c^{-1}=5, \ \& \ \xi=0.07$ imply a situation where each infected person makes one (1) possible infecting contact every five (5) days on the average of 14 days of observation period.

4. Concluding Remarks

This paper has successfully considered the implementation of a simple mathematical model for the analysis of the global COVID-19 spread. The model compartments partition the population into Susceptible, Exposed, Infected, Recovered, and Deaths individuals; hence SEIRD model. The pandemic cases analyzed via the SEIRD model were based on data made available by worldometer and WHO between 15/03-03/04/2020 for the case of Spain, and 27/02-03/04/2020 for the case of Nigeria. The reported results of the two countries indicated the same spread patterns for the two considered instances, even though different parameters were used. Due to the considered level of the possible infecting contacts, a reasonable decrease in the 'exposed and infected' likewise the 'infected and death' classes was recorded conditionally, as shown via the graphical representations. Remarkably, more cases would be confirmed at an exponential rate if the possible infecting contact is not properly controlled. Government measures such as social distancing and isolation are complemented, thereby reducing the rate of the infection to a large extent. Though recording an increase in the 'recovered class' is anticipated. Thus, the analyses, approaches, and the proposed method can be extended to other countries for possible adoption during this global and threatening COVID-19 outbreak. For further research, it will be essential to include the age factor in the COVID-19 pandemic consideration; this would lead to a model with two independent variables (age, and time).

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CONFLICT OF INTERESTS

The authors declare that there is no conflict of interests.

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