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SEIR Model on the Review Impact of Social Distancing for COVID-19 Transmission Dynamics

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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Abstract

The COVID-19 pandemic has had a huge influence on world health, with many countries enacting lockdowns and social distancing measures to help reduce transmission. However, the efficiency of these efforts is questionable, particularly in locations like as North East Nigeria, where specific socioeconomic and demographic characteristics can alter virus transmission dynamics. In this paper, we assess the pandemic in North East Nigeria by modifying the SIR to SEIR compartmental model, which incorporates data from the National Centre for Disease Control. We exposed that social distancing techniques like face masks, hand washing, and avoiding big gatherings are more successful than lockdowns in slowing the spread of COVID-19 in the region. Our findings suggest that future pandemic response plans should concentrate on social distancing measures that are both effective and feasible while avoiding the economic and social disruptions caused by lockdowns. Our work emphasizes the significance of specialized approaches to pandemic control in varied situations, including North East Nigeria.

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Keywords: Covid-19; SEIR model; social distancing measures; mathematical model; reproduction number.

1 Introduction

"COVID-19, a novel coronavirus outbreak, is a recent pandemic that emerged in Wuhan, China" [1,2]. "The virus spreads when an infected person coughs or sneezes, and it can also spread through any contaminated object. The disease induces a moderate to serious respiratory illness with symptoms (such as cough) and breathing difficulties, ultimately leading to the death of the patient. The deadly virus's current presence has had and continues to have a huge impact on global economic activities and growth. The worst-affected continent (in terms of economic activities) is Africa, which includes Nigeria. According to data available on the Nigeria Centre for Disease Control (NCDC) website, the outbreak has taken the lives of 1,907 people and resulted in 155,657 confirmed cases in Nigeria as of February 28" [1,2].

"The COVID-19 pandemic in Nigeria was a part of the worldwide pandemic of coronavirus disease 2019 (COVID-19) caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). The first confirmed case in Nigeria was announced on 27 February 2020, when an Italian national in Lagos tested positive for the virus" [3]. "On 27th February, a 44-year-old Italian citizen was diagnosed with COVID-19 in Lagos State. The case is the first to be reported in Nigeria since the first confirmed case was reported from China in January 2020. The case arrived at the Murtala Muhammed International Airport, Lagos at 10 pm on 24th February 2020 aboard Turkish Airline from Milan, Italy. He traveled to his company site in Ogun state on 25th February. On 26th February, he presented at the staff clinic in Ogun and there was a high index of suspicion by the managing physician. He was referred to IDH Lagos and COVID-19 was confirmed on 27th February. Contacts of the index case were identified as follows: 19 contacts identified in Lagos state; and 39 contacts identified in Ogun state" [3].

"As of 29th February 2020, a total of 85,403 confirmed cases were reported (95.5% cases in China); 2, 924 deaths; 49 countries affected; and three countries affected in Africa: Egypt, Algeria, and Nigeria. On March 11, 2020, the World Health Organization (WHO) declared SARS-CoV-2 (Severe Acute Respiratory Syndrome), COVID-19, a pandemic" [4]. Several countries as well as Nigeria, have applied social distancing to reduce the spread of covid-19 diseases. This lockdown move was commended globally and particularly by the World Health Organization (WHO), tagging it as "unprecedented in public health history" [5].

"Social distancing is a strategy aimed at reducing physical contact between people, to reduce the risk and spread of COVID-19 in a community. This measure meant that, at least, two meters in physical distance must be maintained between two individuals. Moreso, physical greetings-hugs and handshakes were to be avoided" [6]. "However, on the heels of the persistent increase and spread of the COVID-19 virus in the Nigerian case, the federal government eventually announced a nationwide lockdown on March 30, 2020, taking immediate effect in three states of the federation: Lagos, Ogun, and Abuja" [3,4,7,8]. "Subsequently, there were widespread declarations of lockdown in over 100 countries between April and June 2020. This lockdown moves became an inevitable option owing to both the anticipated and unanticipated macroeconomic shocks that could be triggered by the evolving virus. Conceptually speaking, lockdown has been referred to as an emergency response imposed by the government, mandating people to stay indoors in the event of an outbreak. In the case of COVID-19, the ultimate goal of a lockdown measure is to flatten the curve of the novel virus. The exercise entails the closure of all activities-based centers such as schools, hotels, clubs, and religious houses that could make a sizable number of people come together. This apart, directives such as social distancing, banning of congregations of more than 20 people, and compulsory usage of face masks, particularly, in public places were all forcefully enforced" [3,4,7].

"The first confirmed case of COVID-19 infection in North East of Nigeria was reported on the 24th of March 2020 in Bauchi State. Since then, there has been a steady rise in the number of cases in states of the region. According to the Nigerian Centers for Disease Control (NCDC) as of 18th October 2020, a total of 2782 COVID-19 infections had been reported with 2540 recoveries or immune and 108 deaths from 49,270 samples tested and 134 still active cases.

On April 27th the Federal Government of Nigeria announced the gradual easing of the five-week lockdown, the lockdown was eased to a nationwide night curfew (8 pm to 6 a.m.) from May 4th to May 17th. The curfew was later amended by many state governments. The first phase of the lockdown was extended by two weeks and elapsed at midnight on June 1. The second phase which elapsed on June 29th was extended by 4 weeks. The additional 4 weeks elapsed at midnight on July 29 but was extended by one week due to the Sallah celebration it then elapsed at midnight on August 6. It was further extended by four weeks and elapsed on September 3” [3,9]. “This lockdown exercise, however, could not be sustained in the face of mounting public agitation caused by the severe socioeconomic implications of the exercise, prompting the lockdown to be lifted” (this day, May 4, 2020). “This one action has resulted in an increase in viral cases across the states. According to official data, the reported daily case on the first day of easing, May 4, 2020, saw the pandemic rise to 245, the highest since the country’s first index case was reported” [10]. “s a result, assessing the impact of social separation remains a vital task. Modeling has been used to solve knowledge gaps and inform health policy for the prevention and control of COVID-19. Currently, researchers have developed different types of modeling approaches to estimate the relationship between COVID-19 and various risk factors in different socio-demographic and geospatial settings” (6]. “There has been much recent theoretical work revisiting, expanding, and studying dynamical and control properties of classical epidemic models to understand the spread of COVID-19 during quarantine and social distancing” [11,12,13,14,15] including studies of (integral) input to state stability, network stability of epidemic spread [16,17], and optimal control strategies for meta-population models. “These models have been used to predict the potential number of infected individuals and virus-related deaths, as well as to aid government agencies in decision-making” [18].

In addition, modeling studies also explore the impact of different intervention strategies to identify the most effective ones. In this study, we carry out a literature review on COVID-19 and infectious disease modeling strategies to develop a robust research framework for North East Nigeria. We believe the impact of social distance may help improve the control strategy for epidemics at the regional level, and the prospective modeling outcomes will be helpful to decision-makers.

Social distancing has been publicized as one of the best forms of response in managing a swift increase in the number of infected cases during a pandemic, in this paper we present a deterministic model that will review the impact of social distancing on the transmission dynamics of covid-19 in north-east Nigeria.

2 Literature Reviews

“The literature on the influence of social distancing measures in controlling the COVID-19 pandemic is also rapidly expanding. Employing the data on confirmed COVID-19 cases from different countries, A comprehensive data-driven analysis of the SIR Model on the Review Impact of Social Distancing for COVID-19, in North East Nigeria was carried out in” (A. A. Madaki and A. Sambo) A system of nonlinear differential equations was formulated and solved numerically using Excel. The reproductive numbers were estimated by fitting the curves between the actual daily data and the numerical solution. For the analysis, data were taken for a duration of 165 days, from March 24th, when the first case was announced in the region.

In the context of the outbreak in India, [19] focused on “the estimation of three epidemiological aspects, namely, the estimation of parameters, the effectiveness of the lockdown imposed in March 2020, and strategies of relaxation in the lockdown. The data from the lockdown period was analyzed to determine the basic, as well as the time-varying reproduction number. An adaptation of the SEIR model was incorporated into the study setup to include a mandated quarantine (but not preemptive social distancing) and the key model parameters were estimated using the incidence data”. Moosa, [20] advocates that “social distancing measures, in general, are beneficial in controlling the spread of the virus. The author reports an Insignificant level and slope of the stochastic trend for countries such as Australia and China, highlighting that they have successfully contained the infection’s spread over the sampled timeframe by imposing social distancing measures when the reported cases were lower”. The importance of social distancing interventions can be traced back to previous pandemics, [21] highlight that “targeted social distancing measures, including keeping children at home and school closures, can reduce the attack rate of the influenza pandemic by approximately 90%”. F. Nyabadza et al., [22] present “a deterministic model to describe the impact of social distancing on the transmission dynamics of COVID-19 in South Africa. Their model is fitted to data from March 5 to April 13, 2020, on the cumulative number of infected cases, and a scenario analysis on different levels of social distancing is presented. The model shows that with the levels of social distancing under the initial lockdown level between March 26 and April 13, 2020, there would be a projected continued rise in the number of infected cases. The model also looks at the impact of relaxing the social distancing measures after the initial announcement of the lockdown”. K.B. Ajide et al., [23], studied “the extent to which lockdown measures impact COVID-19-confirmed cases in Nigeria. Six indicators of lockdown entailing retail and recreation, grocery and pharmacy, parks, transit stations, workplaces, and residential, are considered. The empirical evidence is anchored on the negative binomial regression estimator, due to the count nature of the dataset on the daily cases of the virus". S. Sampath, et al. [24] modified "the SEIR model equations to model the effect of lockdowns and other influencers, and fit the model on data of the daily COVID-19 infections in India using limit, a python library for least squares minimization for curve fitting". T. Sardar, S.S. Nadim and S. Rana et al., [25] study "the effect of social distancing measures; they considered a new mathematical model on COVID-19 that incorporates the lockdown effect. By validating their model to the data on notified cases from five different states and overall India, Combining the mechanistic mathematical model with different statistical forecast models, they projected notified cases in the six locations for the period May 17, 2020, to May 31, 2020".

Lyra W et al., [26], assessed "the feasibility of covid-19 scenario as an exit strategy for the current lockdown in terms of its ability to keep the number of cases under the healthcare system capacity. They developed a modified SEIR model, including confinement, asymptomatic transmission, quarantine, and hospitalization. The population is subdivided into 9 age groups, resulting in a system of 72 coupled nonlinear differential equations. The rate of transmission is dynamic and derived from the observed delayed fatality rate; the parameters of the epidemics are derived with a Markov chain Monte Carlo algorithm". Mwalili et al., [27], applied "a modified susceptible-exposed-infectious-recovered (SEIR) compartmental mathematical model for the prediction of COVID-19 epidemic dynamics incorporating pathogens in the environment and interventions. They used a next-generation matrix approach to determine the basic reproduction number R0. The model equations are solved numerically using fourth and fifth-order Runge–Kutta methods. Veronika G. et al., [28], they propose an extension of the epidemiological SEIR model to enable a detailed analysis of commonly discussed tailored measures of epidemic control—among them group-specific protection and the use of tracing apps. They introduced groups into the SEIR model that may differ both in their underlying parameters as well as in their behavioral response to public health interventions. Moreover, they allow for different infectiousness parameters within and across groups, different asymptomatic, hospitalization, and lethality rates, as well as different take-up rates of tracing apps".

3 Methodology and Data

3.1 Data

We used data from daily COVID-19 situation reports from the Nigerian Center for Disease Control (NCDC) for the North Eastern Nigerian states, the state, in alphabetic Adamawa, Bauchi, Borno, Gombe, Taraba, Yobe States as well as the World Health Organization (W.H.O) website from March 24, 2020, when the first case was confirmed in North East Nigeria, to January 12, 2022 [3,4].

3.2 Model formulation

Individuals in the susceptible class (t) are individuals who do not yet have the disease but could get infected if they come in contact with the individuals in the infected class. Individuals in the infected class(t) are those with the symptoms of the virus disease. Individuals in the exposed class are those who are confirmed to have the virus and can transmit the disease/virus but are under quarantine. Individuals in the recovered class R(t) are those who have tested negative for the virus and or have died.

This work modifies the compartmental epidemiological Susceptible-Infectious Removed (SIR) model used by A. Madaki & A.Sambo, [29] to the Susceptible-Exposed-Infectious-Removed (SEIR) model that describes the spread of COVID-19 in North East Nigeria. The population under study is divided into Susceptible, S, Exposed, E, Infected, I, and Recovered, R, respectively, through a dynamical system. The name of these compartments represents the state variables or the number of people in each compartment at time t. Thus, S(t), E(t), I(t), and R(t) denote the susceptible, exposed, infectious, and recovered population at time t. The four compartments make up the entire population of the region.

The following equation model will describe the transmission dynamics of the coronavirus epidemic using

$$S \rightarrow E \rightarrow I \rightarrow R$$

S + E + I + R = N

We build a mathematical model of COVID-19 transmission based on the SEIR model, in the model, the total population size, N is considered as constant. The total population is divided into susceptible (S), exposed E, infected (I), and removed individuals. Susceptible individuals might acquire the infection at a given rate when they come in contact with an infectious person and enter the exposed disease state before they become infectious and later either recover or die. We assumed Northeast Nigeria to be a closed system with a constant population size of 26 million, around 12% of the total population of Nigeria (N = S + E + I + R=26 million) throughout this pandemic.

$$N = S + E + I + R$$

From the above, we assume that $N\ (t)$ = S(t) + $E(t)$ + $I\ (t)$ + $R(t)$ is constant and denotes the total number of populations in the system. We look at the population new people come in and out of the population. We assume there is a constant influx of people in and out, we assume there is a bilinear incident (mass interaction) everyone has the same chance to interact with each other homogeneously.

"That is, the population is closed in the sense that the immigration, new births, and deaths of people are not considered. The quantity S(t) denotes the number of individuals who are susceptible to the disease but not infected at time t. The quantity E(t) denotes the number of individuals who are exposed to the virus or infected but not yet infectious. The quantity I(t) denotes the number of infected individuals who can spread the disease through contact with susceptible, and $R(t)$ denotes the number of individuals who have successfully gained immunity from the disease and or removed it by death. After transmission of the virus, susceptible individuals S(t) enter the exposed class $E(t)$ before they become infectious individuals and later either recover or die. The parameter β is the transmission rate of disease from susceptible to exposed. Similarly, $1/\sigma$ and $1/\gamma$ are the average durations of incubation and infectiousness respectively" [30,31,32,33]

Table 1. List of variables and their descriptions

Variable	Description
S(t)	Number of individuals those are susceptible to the disease but not infected at time at time t.
E(t)	Number of individuals those are exposed to the virus or infected but not yet infectious at time t. INFECTED BUT NOT INFECTOUS
I(t)	Number of infected individuals who can spread the disease through contact with susceptible at time t.
R(t)	Number of individuals those have successfully gained immunity from the disease and /or removed by death at time t.
N(t)	Total number of humans at time t

Table 2. Parameter description

Parameter		Description
beta	$\boldsymbol{\beta}$	Transmission rate
sigma	$\boldsymbol{\sigma}$	Infection rate
gamma	γ	Average durations of infection
delta	$\boldsymbol{\delta}$	death rate
Omega	$\boldsymbol{\omega}$	Recovery rate
Alpha	$\boldsymbol{\alpha}$	Constant date rate
Mu	$\boldsymbol{\mu}$	Birth rate
Epsilon =	ε	Average latency period
Lamda-	λ	Constant influx of susceptible
PI	π	fraction of contact between infection and non-infection
K		number of contacts

We now look at the differential equation

$$\frac{dS}{dt} = \lambda - \beta SI - \delta S \qquad \text{(i)}$$
$$S(0) = S_0$$

$\frac{dE}{dt} = \beta SI - \varepsilon E - \delta E$ (ii)
$E(0) = E_0$

$\frac{dI}{dt} = \varepsilon E - \delta I - \gamma I$ (iii)
$I(0) = I_0$

$\frac{dR}{dt} = \gamma I - \delta R$ (iv)
$R(0) = R_0$
$(S, E, I, R) \in R_0^4 S_0$

We look at the feasible region ∑ ⬚
We want the derivative n of the total population to be increasing

$$\frac{dN}{dt} \geq 0$$
$$\frac{dN}{dt} = \frac{d}{dt}(S + E + I + R)$$

a solution to this ode system is a at 4 function S(t), E(t), I(t), and R(t) satisfying the equation.
By linear transformation we split the sum

$$\frac{dS}{dt} + \frac{dE}{dt} + \frac{dI}{dt} + \frac{dR}{dt}$$
$$\frac{dN}{dt} = \frac{dS}{dt} + \frac{dE}{dt} + \frac{dI}{dt} + \frac{dR}{dt} = 0$$
$$= (\lambda - \beta SI - \delta S) + (\beta SI - \varepsilon E - SE) + (\varepsilon E - \delta I - \gamma I) + (\gamma I - \delta R)$$

after cancellations we have

$$\frac{dN}{dt} = \lambda - \delta S - \delta E - \delta I - \delta R = \lambda - \delta(S + E + I + R)$$

$$\sum \left\{ (S, E, I, R) \in R^4 / S + E + I + R \leq \frac{\lambda}{\delta} \right\}$$

Find equilibra in the fiseable region ∑ ⬚

From III

$$\frac{dI}{dt} = \varepsilon E - \delta I - \gamma I = 0$$
$$\varepsilon E = \delta I + \gamma I$$
$$= (\delta + \gamma) I \text{ iv}$$

$$I = \left(\frac{\varepsilon}{\delta + \gamma}\right) E \quad \text{(v)}$$

from IV

$$\frac{dR}{dt} = \gamma I - \delta R = 0$$
$$\gamma I = \delta R$$
$$R = \gamma I + \delta$$

$$R = \frac{\gamma}{\delta} I \quad \text{(vi)}$$

FROM V = $I = \left(\frac{\varepsilon}{\delta + \gamma}\right) E$

$$R = \frac{\gamma}{\delta}\left(\frac{\varepsilon}{\delta+\gamma}\right)E$$

From III and IV we can see that I and R depends on E, so we can focus on E to have two cases, if E is zero I and R will be zero and if E, I, R, are zero that means no infection.

CASE I. E = 0, I = 0, R = 0

∴ FROM (i) we say that, $\lambda - \beta SI - \delta S$

$$= \lambda - \delta S$$
$$S = \frac{\lambda}{\delta}$$
$$(S^*, E^*, I^*, R^*)$$
$$P_0 = (\frac{\lambda}{\delta}, 0, 0, 0)$$

CASE II

$$E^* \neq 0$$
$$I^* \neq 0$$
$$R^* \neq 0$$

We can see here that all are non-zero

From II and III

$$(\beta SI - \varepsilon E - \delta E + \varepsilon E - \delta E - \gamma I)$$
$$\beta SI - \delta I - \gamma I - \delta E = 0$$
$$\beta SI - (\delta - \gamma)I - \delta E = 0$$
$$\beta SI - (\delta - \gamma)\left(\frac{\varepsilon}{\delta+\gamma}\right)E - \delta E = 0$$
$$\beta SI - (\varepsilon + \delta)E = 0$$
$$E \neq 0$$
$$\beta S\left(\frac{\varepsilon}{\delta+\gamma}\right)t - (\varepsilon + \gamma)E = 0$$
$$\beta S\left(\frac{\varepsilon}{\delta+\gamma}\right) - \varepsilon + \delta)E = 0$$
$$\left(\frac{\varepsilon}{\delta+\gamma}\right)S - \varepsilon + \delta = 0$$
$$S = \frac{(\varepsilon+\gamma)(\delta+\gamma)}{\beta E}$$

3.3 General reproduction number R_0

The basic reproduction number, usually denoted as defines the average number of secondary infections caused by an individual in an entirely susceptible population. This number indicates whether the infection will spread through the population or not.

$$S^* \geq \frac{\lambda}{\delta}$$
$$S^* = \frac{(\varepsilon+\gamma)(\delta+\gamma)}{\beta E}$$

NON -NEGETIVE

$$S^* = \frac{(\varepsilon+\gamma)(\delta+\gamma)}{\beta E}$$

$$1 \geq \frac{\lambda\beta E}{\delta(\varepsilon+\gamma)(\delta+\gamma)} = R_0$$

3.4 Analysis

According to NCDC, subjects within the 31 – 40 years age category were more susceptible to contracting the disease in Nigeria which accounted for 24%. For this study, we took the susceptible (S) stage as the adult population aged greater or equal to 15 years, which accounts for about 57.81% (15, 030,600), of the region's approximately 26 million people around 12% of the total population of the country (National Population commission). The exposed E is the number of people screened as of January (49,270 people) minus the number of people screened as of March 24th, 2020. The infected (I) stage is the number of confirmed cases from March 24th, 2020 to August 18th, while the removed R stage is several individuals who have successfully gained immunity from the disease and/or removed by death from March 24, until January 9, 2022.

Table 3. National population commission analysis

Susceptible (S)	S = 15,030,600 S rate = $\frac{15030600}{26000000}$ = 0.5781	National population commission
Exposed (E)	E = 49627 E rate = $\frac{49267}{15030600}$ = 0.00327778	NCDC
Infected (I)	I = 2782 I rate = $\frac{2782}{26000000}$ = 0.000107	NCDC
Recovered/died (R)	R = 2648 R rate = $\frac{2648}{26000000}$ 0.00010	NCDC

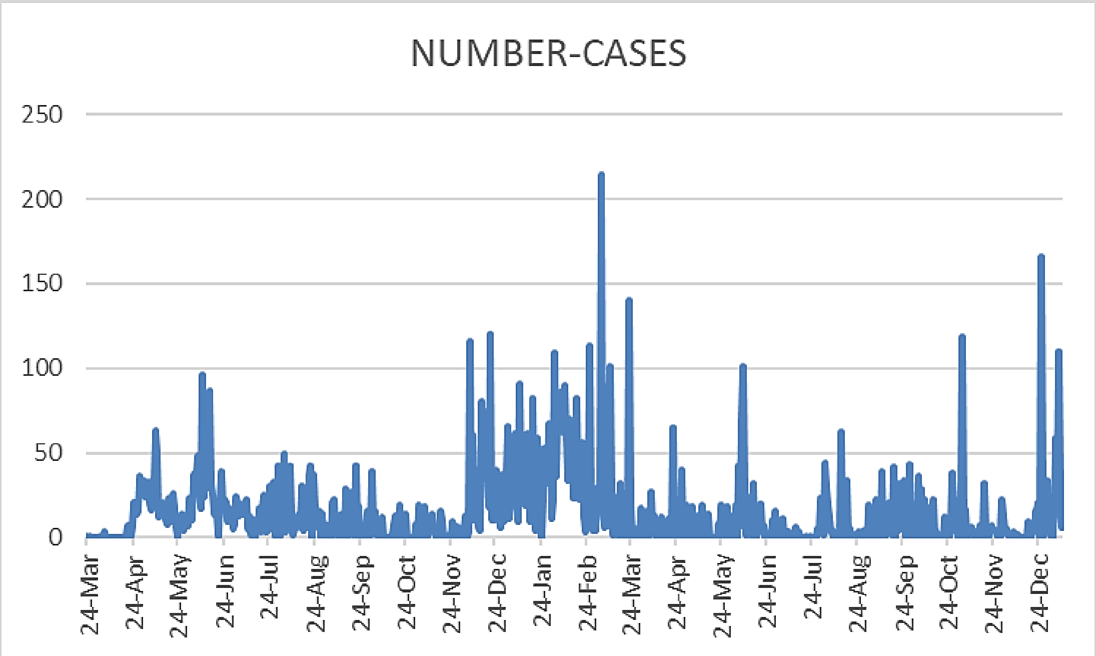

Fig. 1. Bar graph showing number cases

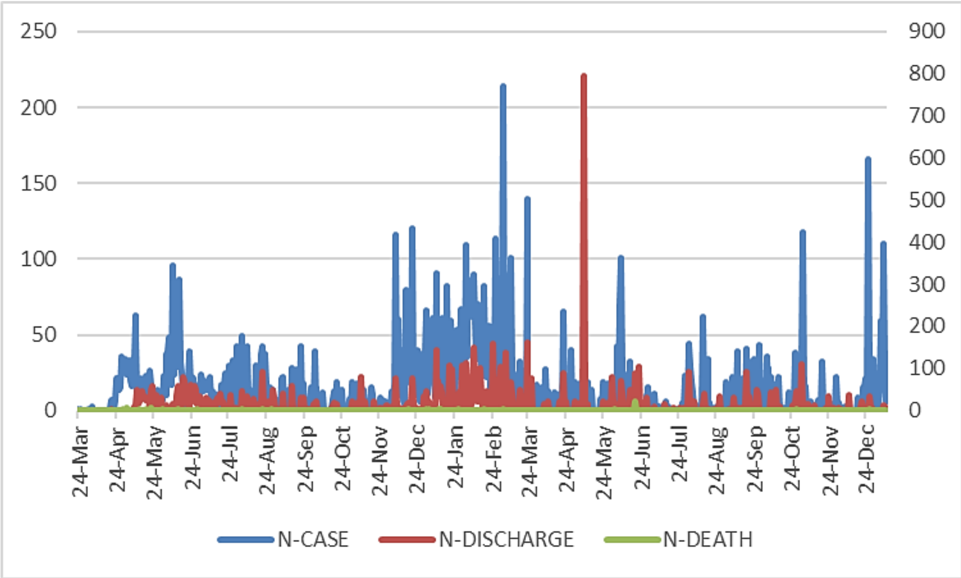

Fig. 2. Bar graph showing Number of confirmed cases (NCDC)
https://covid19.ncdc.gov.ng
https://www.who.int/emergencies/diseases/novel-coronavirus-2019/situation-reports/

Using the cumulative "death cases" data provided by NCDC from 27/02/2020 to 17/05/2020, Enahoro et al. [34],[35] estimated the basic reproduction number for COVID-19 dynamics in Nigeria as $2.05 \leq R0 \leq 2.301$. Using the "active cases" data provided by NCDC from 16/03/2020 to 02/05/2020, Okuonghae and Omame [36], estimated the basic reproduction number for COVID-19 dynamics in Lagos (the epicenter of COVID-19 in Nigeria) as $2.006 \leq R0 \leq 2.1074$.

It shows that the number of confirmed cases, discharge cases, and number of deaths fluctuates, it increases and decreases on a daily basis. But cumulatively, the number of confirmed cases increases likewise the fatality cases.

4 Results

In our previous paper, we discussed the SIR MODEL, which categorizes every individual into one of three groups – Susceptible, Infected, or Recovered. In this study, we have modified the SIR model to a more advanced model, known as the SEIR model. We have categorized the population into four compartments – Susceptible, Exposed, Infected, and Recovered. We have applied this model to determine the prevalence of COVID-19 in North-East Nigeria.

There is a birth rate MU we assume in a given day the number of birth mu*N we talk the number of people could go down through death but we assumed it's fixed. Then a fraction of people MU people dies each day from non-disease causes, which will keep the population stable, we assume MU = 0. Now beta = pi*k, pi = fraction of time contacts between infection and non-infection which results in somebody being sick. k is the number of contacts. Beta x infection x the fraction of people who are susceptible but will move to the exposed group. Beta*/(s/no move to E not I, and they will stay exposed on average 1/sigma days, we assume sigma = 1/7, so basically, one stay in exposed stage for 1/7 days, infectious people who do not die spend 1/gamma day infected, now recovered people loose immunity in the average of 1/omega days and can become re-infected, I/omega days = 365.25 days we assume people can stay immune.

People die at the rate alpha, assuming death rate = 0.4% infected people die even though hundreds of thousands of people got infected in Nigeria and the North East than what is recorded by the NCDC. death rate per day for infected people is 0.004/14.

Now let's modify the SIR, the result from the numerical simulation showed that R_0 is 0.0019 < 1 which implies that there is a 99.99% chance of secondary infection when infected individuals and exposed individuals interact with susceptible through contact.

The equation for the Susceptible Exposed Infected and Recovered at day t+1

Susceptible: $S(t+1) = S(t) + \mu - N - \left(\beta * I(t) * \frac{S(t)}{N}\right) + \omega * R(t) - \mu * S(t)$
Exposed: $E(t+1) = E(t)\beta * I(t) * S(t)/N) - \sigma * E(t) - \mu * E(t)$

Infected: $I(t+1) = I(t) + \sigma * E(t) - \gamma * I(t) - (\mu + \alpha) * I(t)$

Recovered: $R(t+1) = R(t) + \gamma * I(t) - \omega * R(t) - \mu * R(t)$

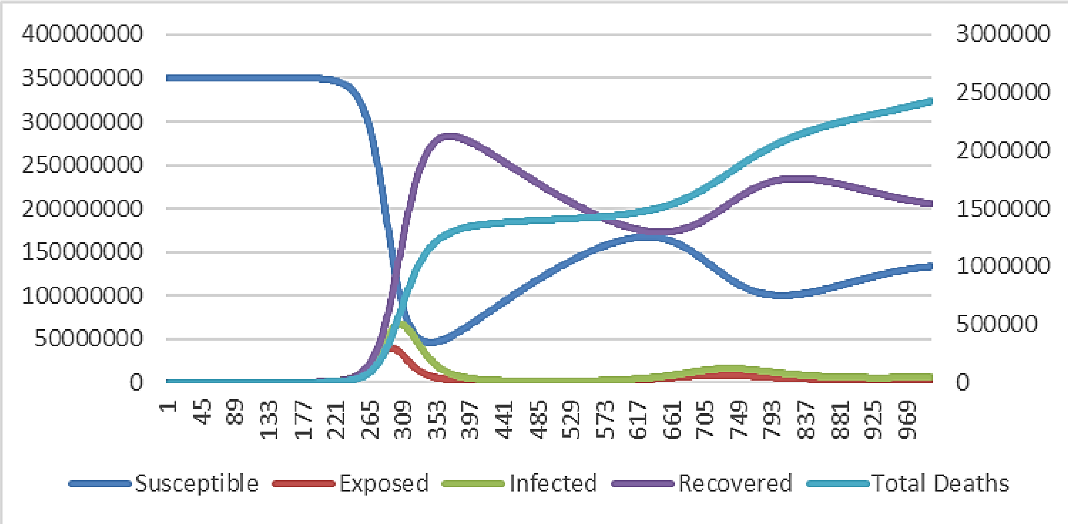

Fig. 3. Seir model

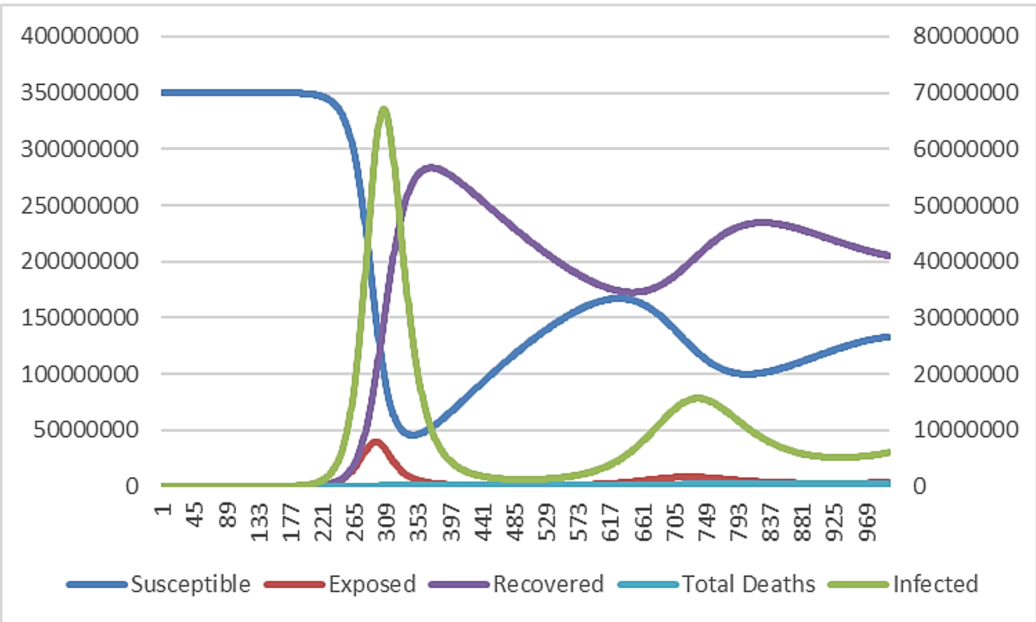

Fig. 4. Seir model-infections

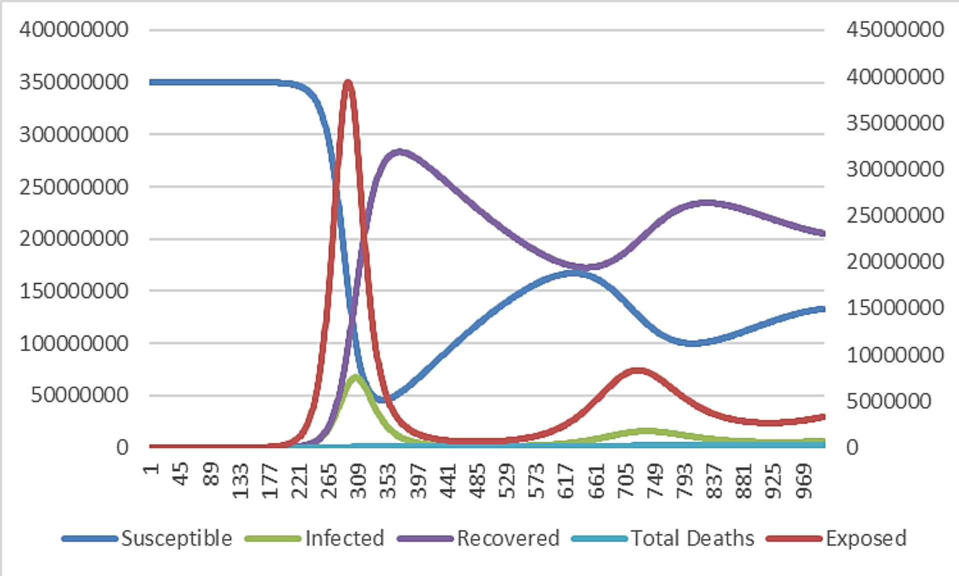

Fig. 5. Seir- model- exposed

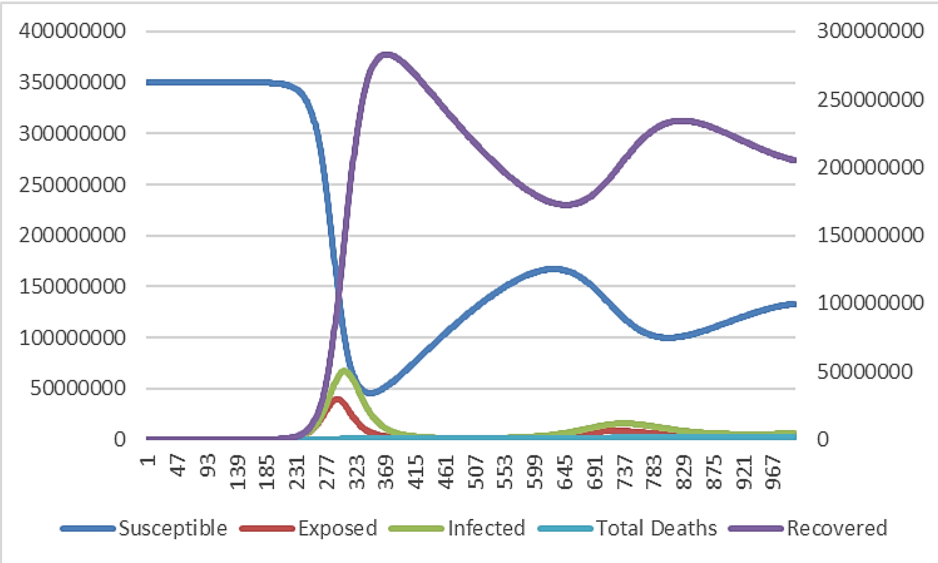

Fig. 6. Seir - model-recovered

Fig. 3 show the epidemic curve of Susceptible, exposed, infected, recovered and number of death of people, if we run the model for almost 1000 days we can see that the number of death will have reached 2.5 million, with is high, the susceptible drops after about 300 days plus, the susceptible come up and down again as people lose their immunity, that’s why we have second waves and third waves. cases from march 24, 2020, to January 9, 2020. Figs. 4-5 shows that the rate of infection and exposed people sharply raised and suddenly dropped as R_0 decreases, then continued to fluctuate as people lose immunity or get back to susceptible, there is a continual need for social distancing, and constant use of face masks to reduce the infection curve. So, we can control R_0 by our behaviors by social distancing, wearing masks, going out less etc.

5 Discussion

The first case of COVID-19 in Nigeria was reported on February 27, 2020. However, non-pharmaceutical interventions were not implemented in Nigeria until 20 days after the initial case. This study focused on estimating the COVID-19 impact in North-East Nigeria and modified the SIR model to forecast the aftermath of the disease in the region. Data from the NCDC in Nigeria served as the basis for numerical modeling in this research. The techniques employed for collecting coronavirus data in Nigeria need refinement to ensure accurate data that can inform appropriate policies and actions. The containment measures, including physical distancing, hand hygiene, and mask-wearing, are deemed sufficient and should be upheld. Implementing a lockdown would be excessive and could significantly harm the economy, impacting the socio-economic well-being of the population. Increased testing and treatment facilities are necessary to expand testing capacity due to the novelty of the disease.

6 Conclusion

The coronavirus pandemic has ravaged the whole world. This research work, with the prediction made, shows that with the stipulated time days from the time of this work, the COVID-19 curve will flatten if the government can enforce all the guidelines given by the Nigeria Centre for Disease Control (NCDC), in future pandemics, and the government should not relent in their efforts to contain diseases, especially in the non-availability of vaccine. However, there are various problems in Nigeria’s reaction to the first wave of COVID-19 that need to be addressed. These include the lack of electronic contact tracing and geo-mapping capabilities, a priority COVID-19 testing policy due to a lack of adequate testing resources and effective laboratory networks, early relaxation of social distancing measures during a period when virus transmission is increasing, the absence or unavailability of models or epidemiological data available to the general public that influence response plans and decision-making, a political intervention that hampered the NCDC from carrying out its required public health tasks, insufficient execution of the national response plans, particularly in local and community settings, and a lack of socioeconomic aid for homes and firms.

To optimize Nigeria’s potential to respond to such pandemics in the future, we must address these challenges and put forth solutions. We have seen that have shown that 2019-nCoV poses a dangerous risk to humans. In this study, we developed a SEIR model that incorporates social distancing as a preventive measure for disease spread. Our analyses show that social distancing directly affects the basic reproduction number, and hence the stability of the disease-free equilibrium.

7 Recommendations

The coronavirus containment measure of physical distancing, hand washing/sanitization, and face or nose coverings are enough and should be sustained. Lockdown will be highly unnecessary and will negatively impact the already ailing economy with consequences on the socioeconomic livelihood of the people. Additional testing and treatment facilities are required to ensure that more persons are tested since the disease is still a novel disease. The Basic Reproduction Number (R_0) remains the appropriate index for measuring the rate of infection rather than the nominal figures.

8 Limitations

It is easier to develop models and measures on the effectiveness of social distancing interventions, but more complicated to determine when to lift such measures. Some proceedings found that countries that deployed multiple interventions at early stages of the pandemic had significantly lower deaths rates. Lack of early implementations and stick compliance of the social distancing measure have significantly become a an issue in getting an accurate result.

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Competing Interests

Authors have declared that no competing interests exist.

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