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Analysis and Projections of the Efficacy of Non-Phamaceutical Measures against Covid-19 in Nigeria

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Abstract
This study shows the efficacy of the various non-pharmaceutical control measures in line with the international protocol against COVID-19 in Nigeria as well as offers a year's projection of the likely effects of the disease in Nigeria. The study adopts a cutting edge variant of the SEIR epidemiological model and made use of a mathematical software Geogebrato estimate the model. The findings of the study indicates that the virus is not much a problem in Nigeria as it does not have the capacity of causing more death than usual and the adoption of more non-pharmaceutical control measures in the country for a year will not significantly improve the welfare of Nigerians.

Keywords: SEIR, COVID-19, Non-pharmaceutical, Measures
JEL Classification: I11, I18

1. Introduction

The spread of Covid-19 diseases and the low death rate of the diseases in many Sub-Saharan African economies compared to their counterpart in Europe and America is a source of suspicion and doubt with regards to the narrative of the risk of the virus in Nigeria and other countries in the sub-region. Unlike other parts of the world, after ten months (March 1st – January, 2021) of the disease, the fatality rate is less than 3 per cent of the infected in Nigeria. This is an indication that the disease is not really a matter to worry about, because it is yet to be responsible for large number of death in Nigeria like malaria. For example the official figures indicate that death by malaria in Nigeria accounts for a quarter of global death from malaria (Nigeria Center for Diseases Control (NCDC), 2016) but the death rate from the novel virus is less than 3 per cent for ten months now.

Although neither the infection mode nor the epidemiology of the two(malaria and Covid-19) diseases are same, the attention Covid-19 is receiving in terms of technical and financial interventions is displacing those of other diseases that are deadlier in Nigeria(World Health Organisation, 2020). The extent to which the amount of attention given the novel disease impacts on the accumulation of confirmed cases, death, exposed and infectious individuals in Nigeria is not clear. While many countries especially in Europe and America recorded thousands of

death from the virus in few months, Nigeria being the most populous country in Africa is yet to have up to two thousand death from the novel disease after ten months of the index case. Yet the Nigerian authority massively implements the protocol of COVID-19 by World Health Organization (WHO) but it is not clear whether the intervention by the country's authority is yielding any good result.

Therefore, the objective of this study is to analyze the effects of the intervention by the Nigerian authority on the spread of the disease and the proportion of death arising from the disease. For the purpose of this study in particular, recovery rate and hospitalization rate (isolation center) of the infectious were used as proxy for the interventions of the Nigerian health authority against COVID-19. Most of the interventions in Nigeria are in line with global best practices and the official advice of the WHO. This study is particularly informed by the fact that several studies argued that the protocol against the virus by WHO could be effective if adequately implemented, yet the case of Nigeria is such that the protocol is officially implemented but the effective implementation in the country's large informal economy may not be assured.

2. Literature Review

So far the literature of COVID-19 is multifaceted; some are particular about the biology or biochemistry of the virus and many others are interested in the epidemiology of the virus (Mason , 2020; Harrison, 2020; Susan & Sonia, 2005; Hussin & Siddappa, 2020; Yuanji, Tamires, Laureane, Sherry, Renata , & Sandro, 2020). While some of them are mainly global in scope many others focused on some countries or group of countries (Fatimah, Phillip, Gibril, Micheal, William, & James, 2020, Nishant , Preeti, Ratho, & Shailendra , 2020).Meanwhile, there have been several concerns about the likely consequences of the pandemic in developing economies in Africa with weak health system (Matthew, et al., 2020). Nigeria is the largest economy in Africa and at the same time the most populated and its health sector has not witnessed a challenging period like this period (pandemic) in recent history. Some scholars have attempted at profiling the socio-economic situation of life in Nigeria following the pandemic (Amzat, Aminu, Kolo, Akinyele, Ogundairo, & Danjibo, 2020). The consensus in the first three months of the pandemic and the lock down policy was so that community level infection is on the rise and will continue for a long time should the social distancing among other non-pharmaceutical control measure of curbing the menace of the disease increase.

Many studies made attempt at predicting the trend of the accumulation of cases, infections and death from the disease in Nigeria. Ayinde, Lukman, Rauf, Alabi, Okon, & Ayinde (2020) used econometrics models at identifying the best estimator and the models for predicting the spread and death caused by the virus in Nigeria. The results of their findings suggest that the Least Absolute Deviation (LAD) estimator offers precision in the forecast of the spread of the virus than nine other estimators indicated in their work. However, unlike econometrics or statistical models, the classic epidemiology model i.e. the SIR first suggested by Kermack and McKendrick in 1927 is a deterministic mathematical model with clear theoretical underpinnings about the compartment of epidemics. Several other variants of the SIR model have been used to model COVID-19 and the SIR model

has also been expanded to as much as it reflects realities. Giordano et.al(2020) for example modeled the transition phases of the disease as Susceptible (S), Infected (I), Diagnosed (D), Ailing (A), Recognized (R), Threatened (T), Healed (H) and Extinct (E), otherwise termed SIDARTH. Similarly, Iboi *et.al*. (2020) modeled the compartment and spread of the virus as susceptible (S(t)), exposed (E(t)), symptomatically-infectious (Is(t), asymptomatically-infectious (Ia(t)), hospitalized (Ih(t)) and recovered (R(t)) individuals. Theirs focused on the impact of the non-pharmaceutical control of the disease like the use and efficacy of face mask, social distancing, the lock down policy among several others in Nigeria. It should be noted that the present work adopts Iboi's model of COVID-19.

Several other works adopted the Susceptible Infections and Recovery (SIR) model as espoused byKermack and McKendrickto they explain the infectious and recovery accumulation cases of the COVID-19 Lockdown, social distancing and other non-Pharmaceutical control measures are suggested as ways of mitigating the risk of contracting the virus. Social network model has also been used to analyze and explain the spread of infectious disease through the use of a SIR model (Saif, 2019). The research actually aimed at identifying the threshold of infection rate i.e the divide between infection persistence and infections extinction. Its conclusion is that if an infection rate is high enough to infect neighbors, the infection rate will persist but if the rate is not high enough to infect its neighbors the disease will go into extinction.

3. Methodology

The study made use of a more suited type of the popular epidemiology model advanced by (Iboi, Sharomiz, Ngonghala, & Gumel, 2020) to model important variables of COVID-19 in Nigeria through the use of a dynamic mathematical model.

In particular, the present study adopts the model formulated in Iboi's *et.al.* (2020) work. Similarly, the baseline parameters of the study are adaptation of same study. Theirs is among the few that reflected on the reality in Nigeria. It accounts for different categories of the infectious population as it exists in Nigeria because of the low level of medical infrastructures and institutions in the country.

The model assumed that the total population in the country at any time (Nt) consist of those Susceptible to the disease (St), Exposed(Et), asymptotically infectious(Iα(t)), symptotically infectious(Is(t)), hospitalized (Ih(t)), recovered (Rt) and dead (Dt). This compartment of the total population is assumed to be mutually exclusive. Included in the hospitalized (Ih(t)) are those who are observing self-isolation in their respective homes. The following differential equations are the deterministic representation of the model:

$$\frac{dS}{dt} = -\beta_s(1-\varepsilon m\xi m)I_S\frac{S}{N} - \beta_\alpha(1-\varepsilon m\xi m)I_\alpha\frac{S}{N} \quad \ldots\ldots\ldots\ldots 1$$

$$\frac{dE}{dt} = \beta_s(1-\varepsilon m\xi m)I_S\frac{S}{N} + \beta_\alpha(1-\varepsilon m\xi m)I_\alpha\frac{S}{N} - \sigma E - \quad \ldots\ldots\ldots\ldots 2$$

$$\frac{dIs}{dt} = (1-\lambda)\sigma E-(\phi_s+\gamma_s+\delta_s)I_s \quad \ldots\ldots\ldots\ldots 3$$

$\frac{dI\alpha}{dt} = \lambda\sigma E - \gamma_\alpha I_\alpha$ …… 4

$\frac{dh}{dt} = \phi I_s - (\gamma_h + \delta_h) I_h$ …… 5

$\frac{dR}{dt} = \gamma_s I_s + \gamma_\alpha I_\alpha + \gamma_h I_h$ …… 6

$\frac{dD}{dt} = \delta_s I_s + \delta_s I_h$ …… 7

where S(t) is susceptible to the disease E(t), Exposed, Iα(t), asymptotically infectious, Is(t), symptotically infectious, Ih(t), hospitalized, R(t) recovered and D(t)death. β, λ, ϕ, σ, ξ, and γ are coefficients of the respective state parameters associated with them in the model. Table 1 shows the description of each.

The study use empirical values of the proportion of the infectious, susceptible individuals, recovered, hospitalized and death whens the first positive case of covid-19 was discovered in Nigeria on February 29th as the initial values of the state variables. Similarly, the range of values of the parameters of the model for Nigeria obtained through using Nigeria data on Covid-19 obtained through the simulation in Iboi's (2020) work, are used as parameters for the baseline scenario. We use dynamic mathematical software *Geogeba* to solve equation 1-7 simultaneously for the numerical values of S(t), E(t), asymptotically infectious (Iα(t)), symptotically infectious(Is(t)), hospitalized (Ih(t)), recovered (Rt) and dead (Dt). The software automatically graphs the solution path.

The first scenario (Scenario I) is concerned with hospitalization and recovery rate. Hospitalizations (isolation) parameters were adjusted well below the 14 days in the WHO protocol to take note of the effect on the state variables susceptible, exposed, recover, and death. Also, the recovery rate was also changed below and above the baseline to take note of the effect on the state variables.

4. Results

Baseline Scenario

When all the parameters of the model are within the range indicated to be the normal range of each of the parameters for the case of Nigeria from the simulation in Iboi's (2020) work, the numerical estimation indicates that the proportion of population of the death(D), hospitalized (Ih) and the susceptible (S) are low and only marginally steadily rising (0.004%) from inception of the pandemic to the end of the first year of the pandemic i.e. February 28th 2020 to February 28th 2021.Meanwhile,as the proportion of those who recovered increased astronomically, so does the proportion of the exposed (D) increased. The proportions of those who are susceptible to the virus are more than 99.9 per cent of the population in the first one year of the outbreak of the disease in Nigeria.

The following are the parameter of the baseline: the recovery rate for individuals who are infectious are within theoretical range of 14 days for those hospitalized ($1/14days^{-1}$) while symptomatically and asymptomatically infectious individual recover in 7 days ($1/7days^{-1}$). Also, it is assumed that 10 per cent of the population makes use of face mask and that the quality of the face mask is 50 per cent.

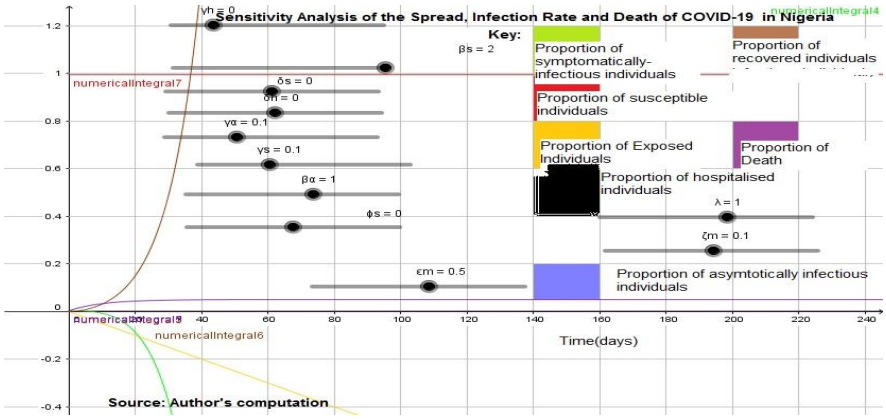

Figure 1: Source: Author's draft

Table 1: State Parameters of the Epidemiology Model

Parameter	Description	Baseline	Nigeria(fitted values)
Bs	Effective community contact rate (a measure of social-distancing effectiveness)	0.4	0.401-1.11
Bα		0.2	0.38-0.56
Φs	Hospitalization rate for infectious individuals	0.0	0.003-0.2
Em	Efficacy of face-masks to prevent acquisition of infection by susceptible individuals		0.5
Ξm	Proportion of members of public who wear masks in public (i.e., masks compliance)		0.1
γ_α	Recovery rate for individuals in the		1/7days
γ_s	Is(Ia)(Ih) compartment		1/7days
γ_h			1/14days
Σ	Rate of progression from the exposed compartment to the infectious compartment (1/ σ)isthe incubation period)		5.1
1-λ	Fraction of exposed individuals who show clinical symptoms at the end of the incubation Period		0.5
δ_s	Disease-induced mortality rate for	0.043	0.011- 0.3
δ_h	infectious(δ_s) (hospitalized, δ_h) individuals	0.103	0.01- 0.295

Source: Iboi's (2020)

The Scenario of Changes in Hospitalization and Recovery Rate

Any increase in the recovery rate of asymptotical infectious individuals from the usual 7 days indicated in Iboi's (2020) work followed by a 10 per cent increase in hospitalization rate, results in a steady increase in the proportion of the asymptotical infectious individual in the first year of the pandemic in Nigeria while a negative proportion indicated (in figure 2) for the exposed (E) following the increase in the recovery rate is an indication that the proportion of those exposed (E) but immune to the virus also increase following an increase in the recovery rate of infectious. It should be noted that the rate of change of the asymptotical and exposed is same but in opposite direction. Meanwhile, the proportion of death (D), hospitalized, symptotical (Is) and recovered (R) are very low(less than 0.005%) and remain low throughout the first year of the pandemic in Nigeria. Similar to the proportion of the infectious, recovered and death, the proportion of the susceptible remain stable in the first year of the pandemic. As indicated above, while the proportion of the infectious, recovered, and death are low throughout the first year of the pandemic, the proportion of the susceptible are high (above 99%) throughout the first year of the pandemic in Nigeria.

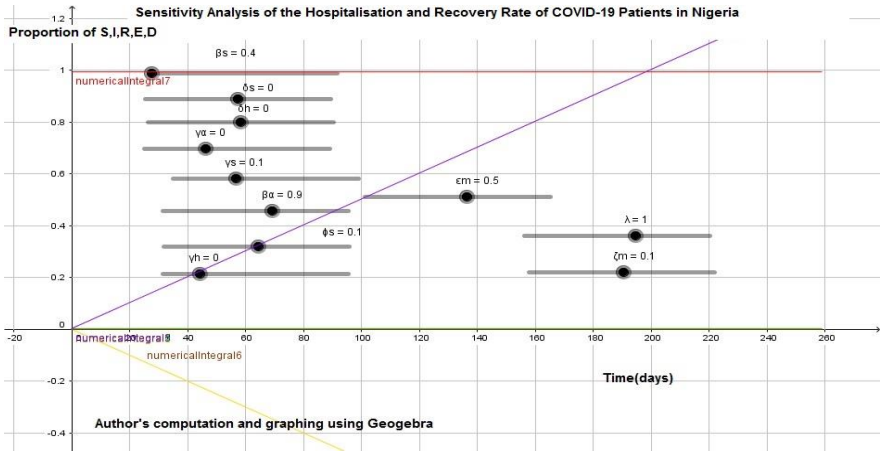

Figure 2: Sensitivity Analysis of the Hospitalisation and Recovery Rate of COVID-19 patients in Nigeria
Source: Author's draft

Similarly, if the hospitalization rate(ϕs)is increased by 10 per cent but the recovery rate of the infectious (asymptotically and symptotically) remains same(7days), the proportion of the dead will remain very low (less than 0.004 per cent of the population) for the first year of the pandemic in Nigeria but the proportion of the infectious and those that recovered surged astronomically after the first ten days of the pandemic in Nigeria. The proportion of the exposed (E) and the symptotitical infectious (Is) surged in an opposite direction which indicates majority of them are immune to the virus.

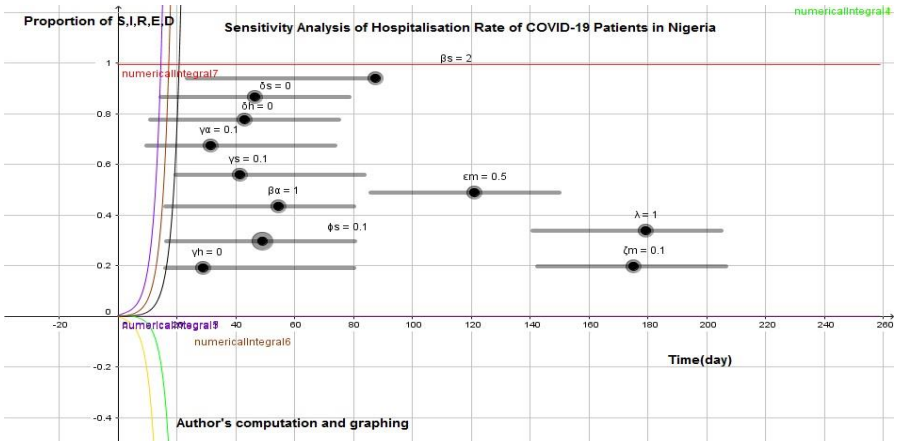

Figure 3: Sensitivity Analysis of the Hospitalisation Rate of COVID-19 patient in Nigeria
Source: Author's draft

5. Conclusions and Recommendation

Using a variant of the SEIR model amenable to condition of live and COVID-19 in Nigeria by Iboi's (2020) work, this study make a year's projection of the likely event as the health authorities put in place several non-pharmaceutical controls in Nigeria like other parts of the world.

So far the non-pharmaceutical controls against the disease does not improve the situation beyond the normal trajectory for months and the projections show that the disease is not much of a threat as it is portrayed in Nigeria. Increase in hospitalization rate for example does not bring about reduction in infections rate neither does it bring about stoppage of death due to the virus.

The study therefore recommends that lockdown policy and other restrictive movement policy against the disease be relaxed and not to be re-introduced in the next twelve months as they are not effective against recovery and rate of spread of the diseases.

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