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Mathematical Modelling Of Covid-19 Disease Epidemics And Pandemics Of Sokoto State 2019/2020

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ABSTRACT
In this research work we introduce a mathematical model to study the behaviour of the Covid-19disease. Studies show that this disease can kill in a few days of infection and about 30% of the infected population die. The objectives of this work is to describe a mathematical model that can model the transmission of COVID-19 using Euler method and shows that the disease dies out if the basic reproductive number Ro<1 while the diseases may become epidemic if Ro >1. At end we run some numerical simulation to elaborate the result. Here, we modelled the COVID-19 epidemics and pandemics using Euler techniques and we used SEIQRD model. The model consists of a set of ordinary different equations. We apply Euler method to analysis quantitative data. A quantitative result was be presented.
Keywords:

INTRODUCTION

Nigeria whose health care system does not provide the basic and regular health services adequately for its citizens even in normal situations. Nigeria, the most populous country in sub-Sahara Africa, hit by the double burden from Covid-19 and other infectious and non-infectious disease. Some basic measures prior to the first case detection in 27 February 2020 and still modifying them according to WHO recommendation (Musa et al., 2021).

The first truly globally pandemic and endemics of the twenty – first century is the COVID -19 in recorded history. At least the word has witness nine influenza-type of out breaks. The 1918 influenza pandemics (H1N1 virus), and the 1957-1958 pandemics and the Asian flu a new influenza A (H2N2 virus), and the 1968 pandemics H3N2-[VIRUS].(Akam et al., 2021).181 million has directly affected by COVID-19pandemics and almost 5milion deaths as of (July/13/ 2021). As it spreads more easily than the common flu and cause serious illness in many people the coronavirus is the tenth and pandemics and ultimately may takes its place among the deadliest one(Akam et al.,2021).

Corona virus Disease 2019 (Covid-19) the coronavirus diseases 2019 (Covid -19) is a communicable respiratory disease caused by a new strain of corona virus that causes illness in human. Coronavirus are a family of viruses that cause respiratory illness in human “Corona” as they are called because of crown like spikes on the surface of the virus. SARs normally refers to severe acute respiratory syndrome, mild east respiratory syndrome (MERS) and the common cold are examples of Coronavirus that cause illness in human. SARs-COV-2 was the new strain of Corona virus and was reported in Wuhan China in December 2019.Coronavirus has since spread to every country around the world.SARs-COV-2 simply

known as COVID-19 is caused by SARs-COV-2 virus. COVID-19 can cause mild to severe respiratory illness including death, vaccination, wearing of masks during times of high transmission, staging 6 (six) feet apart washing hands often and avoiding sick people (Health essential., 2022). Coronavirus are commonly found in cats, bats, and camels. Animals are usually reservoir of the viruses but don't infect the animals. Sometimes these viruses then spread to different animals species. The virus mutates (change) as they transfer to other species. Eventually the viruses spread to animal to species and begin to infect human. The first people infected in the case of SARs-COV-19 are thought to have contracted the viruses at a foot marketing that sold meat fish and live animals. Contacting COVID-19, COVID-19 normally known as SARs-COV-2 the viruses that causes Covid-19 enter your nose or eyes (directly from the airborne droplet or from the transfer of the virus from your hands to your face). Then the virus travels to the back of your nasal passage and mucous membrane in the back of your throat. The virus attached to cells there, begins to multiply and moves into lung tissues. From there, the virus can spread to other body tissue (Health essential, 2022).

Method of Transmission from Person to Person

-The virus travel in respiratory droplets released into the air when an infected person coughs or sneezes, talk, sings or breath near you, you may be infected if you inhale these droplets.

-You can also contacted with Corona virus from close contact (touching, shaking hands) with an infected person and then touching your face. (Health Essential, 2022)

Average Time Taken to Develop Symptoms of Covid-19

For a person with Covid-19, it can take several days to develop symptoms but you are contagious during this time, you are no longer contagious 10 days after your symptoms began, the best way to avoid spreading covid-19 to others is to:

-Stay 6 (six) feet away from other whenever possible

-Wear a cloth mask that covers your mouth and nose when around other

-Wash your hands often if soap isn't available, use a hand sanitizer that contains at least 60% alcohol.

-If you are feeling ill with symptoms of Covid-19 stay self-isolated at home or have test for Covid-19

-Clean and disinfect frequently touched surfaces

Incubation Periods

The average incubation period or latent period can be range between or from two to 14 days. The average time before experiencing symptoms is five days. Symptoms can vary from very mild to severe in about 80% of people, covid-19 caused only mild symptoms although this may changes as variant emerges (Health essential, 2022).

Symptoms and Causes

Covid-19 symptoms change from person to person in fact some infected people don't develop any symptoms (asymptomatic) in general people with covid-19 report some of the following symptoms:-

- Fever or chills
- Cough
- Shortness of breath or difficulty in breathing
- Tiredness
- Muscle or body aches
- Headaches
- loss of taste or smell
- Sore throat
- Congestion or runny nose
- Nausea or vomiting
- Diarrhoea

Between 2 to 14 day symptoms may appear after exposures to the virus children, usually have similar symptoms but milder than adults symptoms, older adult and people who have severe underlying medical condition are at higher risk of more serious complication from Covid-19.

Problem Statement/Justification

Viral airways diseases as a result of Covid-19 pose extreme health problems to humans, basically affecting pupil of any age particularly those with hidden therapeutic conditions. Pandemics and regular infections are public health danger with significant morbidity and mortality worldwide. Furthermore, research has shown that elderly were most affected by Covid-19. Rate of sickness are noteworthy among elderly, and Covid-19 are viruses that are responsible for significant health and economic burden. Especially in elderly people, hospitalization from in Covid-19 and its complication are similar to those seen among the elderly population. Hence Covid-19 vaccination is widely recommended by international health organization, with increase in communicable diseases around the world and other pathogenic disease like COVID-19, flu, such as A/ H1N1, SARS, Swine flu, Ebola virus etc. It became necessary, to come out with a way to control the spread of the disease among the populated communities. So as to avoid further spread and higher mortality. COVID-19 as one of the latest pandemic in 2019/20 which cover a larger geographical area around the World, with about 98,794,942confirmpeaple including 2,124,193 deaths according to WHO (https://covid19.who.int/WHO,2029a, 2020b). This lead to introduction of different modelling technique to help in reducing the effect and even eradicating of the disease among the affected communities.

Objective(s) of the study

i) To collect the data from hospitals and published journal articles of COVID-19 outbreak online and run simulation by applying Euler method.

ii)To describe a mathematical model that can model the transmission of COVID-19 disease using Euler method and shows that the disease dies out if the basic reproductive number Ro<1 while the diseases may be come epidemic if Ro >1. At end we run some numerical simulation to elaborate the result.

iii) To analyse and interpret the result and see how accurate the method applied compare to other method.

iv) Make remark on accuracy, similarities or differences where possible between the method and techniques if exist.

LITERATURE REVIEW

COVID-19 is of great concern of researchers, governments and all people, because of the higher rate of infection spread and the significant number of deaths that occurred in December 2019 coronavirus first reported in Wuhan, China is an infectious caused by newly discovered coronavirus, covid-19 is cause by the virus mainly transmitted through droplets of generated when an infected person cough, sneezes or exhale. These droplets quickly fall on the surface or floors because they are too heavy to hang on the air (Zeb et al., 2020; Musa et al., 21). Nearly four million in 187 countries of confirmed coronavirus cases and approximately 295,000 people have lost their live due to coronavirus. The largest cases occurred at US and more than 77,000 deaths happened, it also has the world's highest death toll according to figure collected by Johns Hopkins University.COVID-19 known as coronavirus are usually transmitted from person to person through droplet of respiratory and close contact and the coronavirus can easily be transmitted from person to person in densely populated place, the measures taken to reduce the spread among the people include the social distancing or low contact rate to increase the physical space between people to slow down the spread of the virus(Zeb et al., 2020). Since March 2020the epidemic has largely been controlled in China and some countries, but still remains serious public health and social-economic problem in other regions or countries for example Europe, America, middle east ,and Africa causing hundred thousand fatalities (Musa et al., 2021). As of January 25, 2021 the coronavirus outbreak affected 98,794,942 people consisting 2,124,193 associated deaths worldwide, see https://covid19.who.int/(2020a,2020b). According to the world health organisation WHO (Musa et al., 2021). Some of the symptoms of coronavirus are similar to other two coronavirus as follows :(MERS-coV and SARS-coV), which may consist of pneumonia in severe cases and common cold, other symptom include coughing, fever, and difficulty in breathing (Musa et al., 2021).

COVID-19 pandemic already caused over 21 million confirm cases and 758,000 deaths the economic impact is already in trillions of dollars and is the significant pandemic since 1918 influenza. As in other pandemics researchers and public health policy makers are interested in question such as (i) How did it

star? (ii) How is it likely to progress and how can we control it? (iii) How can we intervene while balancing public health and economic impact? (iv) Why did some countries do better than other countries thus far into the pandemics? In particular, model and their projection/ have received unprecedented attention (Adiga et al., 2020). With underlying assumptions, and different modelling frameworks, available datasets and region/ time frame being modelled, these forecasts have varied widely, causing confusion among end users and consumers. We believed an over view of the current modelling land scape will benefit the readers and also serve as a historical record for future efforts.

To minimize the spread of infectious disease, it is absolutely essential and worthy to quarantine each individual who is likely been expose for a sufficient time for either transmission to occur or until it can be guarantee that there is no probability of transmission. Stated by the centre for Disease Control and Prevention (Haas. 2014).In a situation where somebody has been exposed to an infectious disease and he or she is not yet known whether they have been caught the disease in this case quarantine or separation from others who have not been exposed to the disease is necessary. To avoid further possible spread of the diseases People who are exposed may be ask to stay or remain in their respective residences. A special care and attention for early symptoms of the disease should be granted (Haas 2014).

METHODOLOGY

This chapter explained in details the next step in the research process, which is the development of methodology. The methodology involves what you will actually do so as to address the specific objectives and research question you have develop (Newing et al., 2011).Research is a careful and systematic investigation towards increasing the sum of knowledge (Newing et al., 2011).

In this research work data was collected from different relevant published journals that adopted different mathematical modelling of COVID-19 disease outbreak. Various author used different modelling techniques to analyses the COVID-19 disease. But in this research work Euler method has been used to make an analysis with different methods adopt. In this research work, a quantitative analysis has been applied, because it involved numerical data to carry out the analysis.

Method

The transmission of COVID-19 follows SEIQDR model (susceptible-Expose- Infectious - Recovered) dynamics and can be described by the set of five ordinary differential equations (ODEs) (Anwar Zeb et al., 2020). In this research work we develop a transmission models for COVID-19 infection to investigate how well simple compartmental models are able to qualitatively capture the patterns of disease observed in the COVID-19. Although we aim to keep the models as simple as possible (ignoring for example the spatial heterogeneity in disease incidence that is known to exist), several key features must be incorporated to adequately represent the dynamics of COVID-19 infection. Where there is uncertainty in the most appropriate model structures and assumptions we have examined a range of options.

$$\frac{dS}{dt} = -\beta(t)SI/N$$

$$\frac{dI}{dt} = \sigma E - \gamma I$$

$$\frac{dI}{dt} = \sigma E - \gamma I$$

$$\frac{dR}{dt} = \gamma I - f\gamma I$$

$$\frac{dD}{dt} = f\gamma I$$

The above ODEs, has been used to developed a black box or compartmental boxes which indicate the movement of individual from one states of infection to another and also the rate of transmission and recovery during the infectious period. The compartmental boxes below are representing the proportion of individuals at a particular period of time during the infectious period.
Black boxes representing SEQIRD Model.

Mathematical Epidemics Model (SEQIRD)

Mathematical model are a simplified representation of how an infection spread across a population over time and generally come in two forms: Stochastic and deterministic models. The first ones employ randomness, with variable being described by probability distribution (Louzet al., 2010). Here the main focus will be a deterministic model which splits the population in to subclasses, and an ODEs (Ordinary differential Equations) with respect to time is formulated for each. The stated variables are determined using parameters and initial conditions. In the SEQIRD model, the transmission process occurs with initial inoculation with a very small number of pathogens. Then, during a period of time the pathogen reproduces rapidly within the host, relatively unchallenged by the immune system. During this stage pathogen abundance is too low for active transmission to other susceptible host, and yet pathogen is present. The time in this stage is very difficult to quantify, since there is no symptomatic features of the disease. It is refers to latent period.

The transmission of COVID-19 follows SEIR (susceptible-expose- infectious- recovered) dynamics and can be described by the following set of ordinary differential equations ODEs (Musa et al., 2021). Given the above ODEs, we use them to developed a black box or compartmental boxes which indicate the movement of individual from one states of infection to another and also the rate of transmission and recovery during the infectious period. The compartmental boxes above are representing the proportion of individuals at a particular period of time during the infectious period.

After transmission of the virus, susceptible individuals S move to the exposed class E before they become infectious individuals, that both recover and survive R or die D.

$1/\sigma$ and $1/\gamma$ are average durations of incubation and infectiousness respectively. The case fatality rate is given by f. The transmission rate in absence of control measures is constant, i.e., $\beta(t) = \beta$. The measures are introduced at a time $\tau \leq t$, the transmission rate was assumed to decay exponentially at rate K i.e.

$$\beta(t) = \beta e^{-k(t-\tau)}$$

The Euler method gives the following sequence of approximation of the above ODEs.

$$t_{n+1} = t_{n+h} \Rightarrow A5 + \$C\$2$$

$$S_{n+1} = S_{n+h}\,(-\beta S_n I_n) \Rightarrow B5 - \$C\$2 * (\$E\$1 * B5 * D5)$$

$$E_{n+1} = E_{n+h}\,(\beta S_n I_n - \sigma E_n) \Rightarrow C5 - \$C\$2 * (\$E\$1 * B5 * D5 - \$G\$1 * C5)$$

$$I_{n+1} = I_{n+h}(\sigma E_n - \gamma I_n) \Rightarrow \text{" } = D5 + \$C\$2 * (\$G\$1 * C5 - \$I\$1 * D5)\text{"}$$

$$R_{n+1} = R_{n+h}\,(\gamma I_n - F\gamma I_n)$$

$$\Rightarrow " = E5 + \$C\$2 * (\$I\$1 * D5 - \$S\$1 * \$I\$1 * D5)"$$

$$D_{n+1} = D_{n+h}\,(F\gamma I_n) \qquad \Rightarrow " = F5 + \$C\$2 * (\$S\$1 * \$I\$1 * D5)"$$

Basic Assumptions

Let the total population be size $N = S + E + I + D + R$ where;

The susceptible individual exist whom are free of the diseases before exposure S Individual get expose, and fall in to expose class i.e E

Individual become infected after having contact with the infectious person, will be Quarantine and isolated, QI or I.

Patient dies after infection, D or Individual recovered after infection, R.

Assumptions

Assumption: 1, every susceptible individual (S) in the community is free of the disease before becoming expose to the disease and inter a latent period. Here birth is very important we can use SEIR model with demography. So here the birth rate inters in to the susceptible correspond with new-borns while the corresponding going out of the E, I and R compartments is the death rate i.e. represent both birth and death rate.

Assumption: 2, we assumed an individual who is carrier or expose can be represented by (c or E)

Assumption: 3, we assume individual become infected (I) after being expose or passing through a latent period can be quarantine and isolated is

represented by QI OR I.

Assumption: 4, we assumed that every infected individual recovers or die from the infection and returns to the susceptible class.(R or D)

Assumption: 5, is the average duration of the latent period

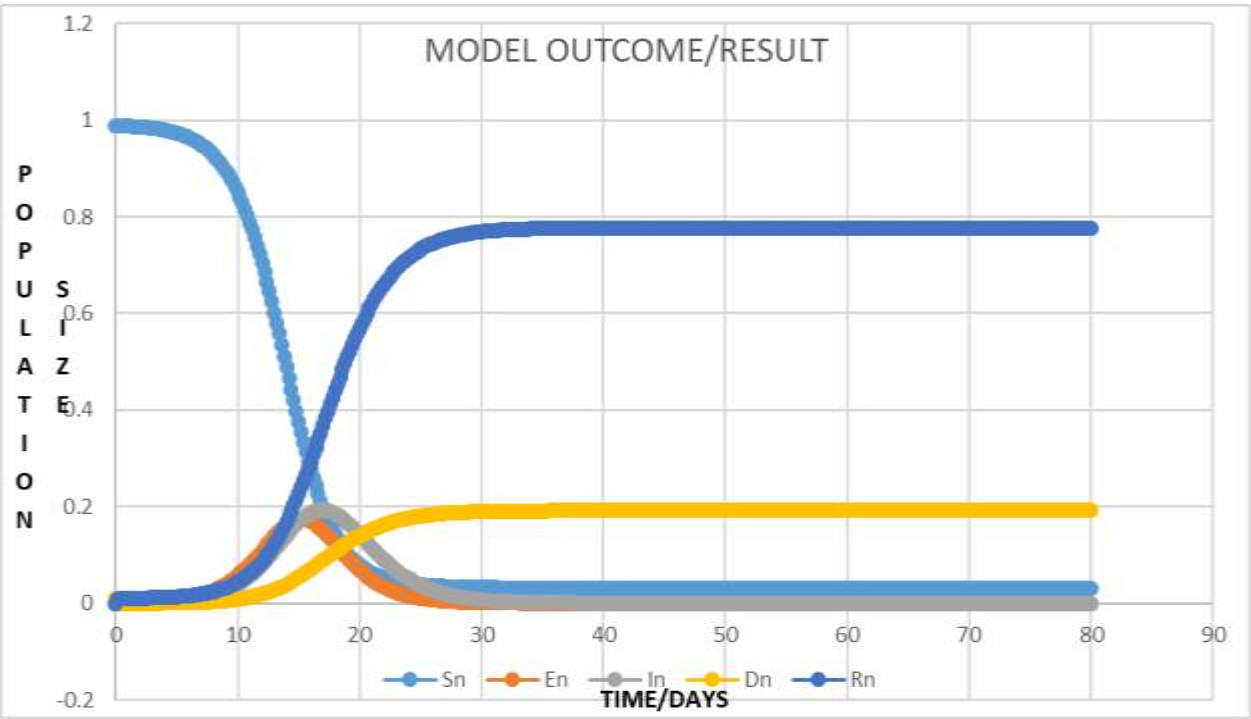
Other Assumption: Are β is the product of the contact rate and the transmission probability and the ϒ is the recovery rate while $\sigma$is the incubation or latent period.

Table 1. Parameters used in simple modelling Covid-19.

Parameter	symbol	values	Sources
Transmission rate	β	0.5990-1.68	Musa *et al.*, 2021
Recovery rate (day^{-1})	γ	0.9654	NCDC COVID-19Situation Report 2022
Latent period(incubation period $)(day^{-1})$	σ	O.6/0.0714	Musa*et al.*, 2021
Number of Susceptible	S	0.999	
Number of people expose	E	0.0	
Number of people infected	I	0.001	
Numberofpeople recovered	R	0.0	
Number of people Death	D	0.0341	NCDC COVID-19 Situation Report 2022

The parameters in the table 1 above used in simple SEQIR Model.

Model Outcome Or The Result



CONCLUSION

We modelled Covid-19virus using Euler method /techniques which follows SEIR Model and the model corresponds to the world problem which was adopted by different researchers in modelling and this research we found out the reproductive number reached up to thirteen Ro >13. The result shows clear similarities with the techniques or method adopted in the modelling of Covid-19 virus by other researchers. We found out that Pandemic of the 21st century is considerably less lethal than was feared in advance case of fatality rate. Fatality has differed by age in a similar pattern of the previous pandemics. The research, shows that covid-19can be modelled by SEIR model using Euler techniques, because in this piece of work, we found out that infectious cases reach it final peak of 20% within one hundred days before the disease disappeared or eradicated after hundreds days which is resemblance of the world scenarios. Similarly, the pandemics started with a single case as it can be seeing in the graph of model outcome estimated incident of pandemics Covid-19in Figure 2 above, which is an evidence that Euler techniques can be adopted to contained the pandemics of Covid-19 virus with initial infectious case as one and more than 70% of the infected recovered as it was clearly seeing in the figure 2 above.

Strength And Weakness

This work has a limitation to the use of SEIR model in modelling Covid-19 virus using Euler techniques only; it fails to address any other model and techniques or disease. The feature work should focus on extension of this research work to the model that includes vaccination that is to model covid-19 virus with vaccine. However, other method like Runge-Kutta fourth order method can also be used in modelling the Covid-19 virus.

RECOMMENDATIONS

To model the Covid-19 virus disease we recommend that bigger model should be introduced which will cover larger population size, should in case of emergence of an outbreak in a very densely populated area or big cities.i.e.The models which consider different structure to the population than one homogeneous assumption because of the vast area of Sokoto, more especially the Covid-19 virus pandemic areas

constitute disperse and highly densely populated town and villages. For further future work method like Runge-Kutta can be applied to carry out the analysis.

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