Comparing with other countries the spread of COVID-19 within the first 120 days of its outbreak in Nigeria

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Abstract

Background: COVID-19 is an emerging global public health crisis. The increase in the daily COVID-19 confirmed cases in Nigeria is worrisome vis-a-vis its large and dense population. This study aims at assessing the first 120 days of COVID-19 case confirmation in Nigeria.

Methods: Data extracted from the World Bank’s website were used for the descriptive assessment and modelling of COVID-19 disease using the first 120 days of the index case in Nigeria and seven other countries. Linear, quadratic, cubic and exponential methods of regression model were used to fit the data ($\alpha=0.05$).

Results: The COVID-19 growth pattern in Nigeria was similar to that of Egypt, Ghana and Cameroun; Nigeria COVID-19’s daily death distribution was comparable to six of the other seven countries considered. There was an increasing trend in the daily COVID-19 confirmed cases in Nigeria. During the lockdown, the growth rate of COVID-19 in Nigeria was 5.85 ($R^2=0.728$, $p<0.001$); however, it was 8.42 ($R^2=0.625$, $p<0.001$) after the lockdown’s relaxation. Across all the countries investigated, the cubic polynomial model (CPM) provided the best fit for predicting COVID-19 cumulative cases and there was a clear deviation from the exponential growth model. Using the CPM, all things being equal, a 3-month (30 September 2020) prediction of COVID-19 cases in Nigeria was 155,467 (95% CI:151,111-159,824, $p<0.001$).

Conclusions: An improvement in COVID-19 control measures and strict compliance with the COVID-19 recommended protocols are essential. A contingency plan is needed to provide care for the active cases in case the predicted target is realised.

Background

The novel Coronavirus disease (COVID-19) is one of the diseases that have constituted a global threat in human history. The daily increase in the global sum of cases and deaths associated with COVID-19 is enormous [1–3]. The infection rate of the disease is high and, unfortunately, no known vaccine for the cure of the disease. The COVID-19 cases have been confirmed in different parts of the world, Africa including Nigeria [3]. The first case of COVID-19 was confirmed in Nigeria on 27 February 2020 [2] and by the first 120 days (25 June 2020) after the index case confirmation, the total cumulative case has risen to 22,614 [2]. There is an apprehension that the total confirmed case does not reflect the true situation in Nigeria due to low testing.

Comparing the rate of COVID-19 tests in Nigeria with other countries in Africa and others with comparable population size, the Nigeria testing rate is low. Although there was a challenge to testing apparatus and kits in terms of demand and supply at the early stage of COVID-19 pandemic in Nigeria, the Nigeria Centre for Disease Control (NCDC) has claimed that strict adherence to their protocol and guideline for testing might be responsible for the low testing [2]. However, in recent times, there has been an increase in the number of testing centres and improvement in COVID-19 testing capacities across the country.
The daily reported COVID-19 infected individuals in Nigeria is a major concern despite the control strategies instituted by the government to curb its spread. Nigeria, a low-income country with large and dense population, makes it a centre of attraction for COVID-19 issues by the epidemiologists and disease control experts. Going by the experience of some other affected countries, we attempted to monitor and assess the disease situation in Nigeria using the data for the first 120-day COVID-19 case confirmation and projected for a three-month COVID-19 cumulative case to inform policy. In addition, in the current study, we compared the disease's spread, death, and the fitted model with seven other countries.

Methods

The study was conducted in Nigeria, a country with a population size of over 200 million. The country has many international land borders and a few international airports. As at the time of writing this report, situation assessment shows that the compliance with the government directive on precautionary measures against COVID-19 is still very low in Nigeria [2].

Data for this report were from eight countries (Bangladesh, Egypt, Cameroun, Nigeria, South Africa, Mexico, Ghana and Indonesia) extracted from the World Bank data on COVID-19 [1]. The countries were selected from sub-Saharan Africa, Asia and South America. The extracted data were restricted to the first 120 days of the outbreak of COVID-19 in these countries. The population figure, population density [4] and number of confirmed cases of COVID-19 as at the 120th day of the outbreak of the disease in the selected countries are represented in Table 1.

| Country      | Population figure | Population Density (person/km²) | Total COVID-19 CC |
|--------------|-------------------|--------------------------------|-------------------|
| Bangladesh   | 164,689,353       | 1,116                          | 149,258           |
| Egypt        | 102,334,903       | 102.2                          | 41,304            |
| Cameroun     | 26,545,868        | 55.84                          | 12,192            |
| Nigeria      | 206,139,587       | 223.2                          | 22,614            |
| South Africa | 59,308,689        | 48.65                          | 159,333           |
| Mexico       | 128,932,753       | 65.63                          | 231,770           |
| Ghana        | 31,072,970        | 130.26                         | 18,134            |
| Indonesia    | 273,523,620       | 143.14                         | 54,010            |

*as at the 120th day of the outbreak in the respective counties*

Sources: United Nations, Department of Economic and Social Affairs, Population Division. World Population Prospects: The 2019 Revision; https://www.ecdc.europa.eu/en/publications-data
Data were presented with charts and line graphs. Four classes of regression model were used to fit the cumulative data on COVID-19. These are: linear, quadratic, cubic and exponential models. The equations representing each model are presented in Table 2.

Table 2 The four predictive models

| Model             | Equation                                      | df |
|-------------------|-----------------------------------------------|----|
| Linear            | \( N_x = a+bx+\varepsilon \)                 | 1  |
| Quadratic         | \( N_x = c+dx+ex^2+\varepsilon \)            | 2  |
| Cube polynomial   | \( N_x = f+gx+hx^2+jx^3+\varepsilon \)       | 3  |
| Exponential       | \( N_x = kexp(mx)+\varepsilon \)             | 1  |

where \( a, c, f \) and \( k \) are intercept; \( b, d, e, g, h, j \) and \( m \) are slope respectively which are estimated by least square estimation, \( x \) is the time-point and \( \varepsilon \)'s are mutually uncorrelated random errors with mean (0) and common variance \( (\sigma^2) \).

Further, the model of best fit was used to predict a 3-month (30 September 2020) COVID-19 cumulative confirmed case in Nigeria.

Results

The data as presented in Fig. 1 show an increasing trend in the daily confirmed cases of COVID-19 in Nigeria, from the 1st day through the 120th day of the COVID-19 confirmation. More number of cases and consistent increasingly pattern of COVID-19 were found after the relaxation of lockdown in Nigeria. During the lockdown, the growth rate of COVID-19 in Nigeria was 5.85 \( (R^2 = 0.728; p < 0.001) \) and this increased to 8.42 \( (R^2 = 0.625; p < 0.001) \) after the relaxation of the lockdown.

Figure 1

Daily COVID-19 confirmed cases as at the first 120 days of the outbreak in Nigeria

Figure 2 shows the cumulative daily confirmed cases of COVID-19 in the first 120 days after the outbreak in eight countries. The findings showed that the pattern of Nigeria's cumulative daily confirmed cases aligned with three (Ghana, Egypt and Cameroun) of the seven other countries, particularly within the first 97 days. The trajectory of the spread of COVID-19 in Nigeria aligned perfectly with Ghana's pattern and slightly differs from the pattern exhibited by Cameroun after the 97th day. There was a clear difference in the pattern observed between Nigeria and Mexico, Bangladesh, South Africa and Indonesia respectively.

Figure 2
COVID-19 cumulative confirmed cases in some countries as at the first 120-day of the outbreak

The distribution of deaths associated with COVID-19 within the first 120 days after its outbreak shows that the observed pattern for Nigeria was nearly the same to six of the seven countries compared. In particular, the Nigeria pattern was identical to the countries from the West-Africa (Cameroun and Ghana). The apparent higher number of cumulative confirmed cases found in Mexico may be the reason for striking disparity in its death distribution compared to other countries (Fig. 3).

Figure 3

COVID-19 cumulative daily deaths for the first 120 days in some countries

The summary of the model and estimated parameters are shown in the Table 3 below. Across all the eight countries included in the analysis, the cubic polynomial model was identified as the best fit for model COVID-19 data and this model perfectly fits the Mexico data with R-square being 100%. The R-square for Nigeria was 99.9%, an indication that 99.9% of the variation in the cumulative daily confirmed cases of COVID-19 in Nigeria can be explained by time. The predictive models for Nigeria are as follows: Linear: \( N_x = -4937.222 + 164.210x \), Quadratic: \( N_x = 1748.194 - 164.581x + 2717x^2 \), Cubic: \( N_x = 151.233 - 9415x - 0.475x^2 + 0.018x^3 \), Exponential: \( N_x = 2.245 \exp(0.090x) \) (Table 3).
Table 3  
Model Summary and Parameter Estimates

| Summary | Parameter Estimates |
|---------|---------------------|
| **Country** | **R Square** | **Constant** | **β₁** | **β₂** | **β₃** |
| **Bangladesh** | | | | | |
| Linear | 0.767* | -33018.645 | 1122.635 |
| Quadratic | 0.987* | 13105.539 | -1222.663 | 20.045 |
| Cubic | 0.999* | -313.915 | 124.858 | -8.625 | 0.163 |
| Exponential | 0.915* | 9.628 | 0.098 |
| **Egypt** | | | | | |
| Linear | 0.699* | -8039.316 | 256.061 |
| Quadratic | 0.956* | 4274.644 | -349.544 | 5.005 |
| Cubic | 0.995* | -1566.637 | 218.015 | -6.673 | 0.064 |
| Exponential | 0.893* | 2.352 | 0.094 |
| **Cameroun** | | | | | |
| Linear | 0.860* | -2845.963 | 112.376 |
| Quadratic | 0.992* | 591.439 | -59.494 | 1.444 |
| Cubic | 0.993* | 146.269 | -15.528 | .525 | 0.005 |
| Exponential | 0.820* | 15.465 | 0.069 |
| **Ghana** | | | | | |
| Linear | 0.894* | -3633.083 | 156.014 |
| Quadratic | 0.995* | 268.922 | -49.354 | 1.817 |
| Cubic | 0.995* | 183.709 | -40.501 | 1.622 | 0.001 |
| Exponential | 0.853* | 29.047 | 0.068 |
| **Indonesia** | | | | | |
| Linear | 0.887* | -10357.170 | 422.333 |
| Quadratic | 0.997* | 1439.768 | -157.844 | 4.795 |
| Cubic | 0.999* | -550.761 | 35.562 | .815 | 0.022 |

*Significant at 0.1%*
| Summary      | Parameter Estimates |
|--------------|---------------------|
| Exponential  | 0.782*              |
|              | 56.394              |
|              | 0.069               |

**Mexico**

| Linear       | 0.823*              |
|--------------|---------------------|
|              | -50669.386          |
|              | 1832.606            |
| Quadratic    | 0.995*              |
|              | 14390.013           |
|              | -1447.700           |
|              | 27.799              |
| Cubic        | 1.000*              |
|              | 1958.116            |
|              | -209.705            |
|              | 1.682               |
|              | 0.148               |
| Exponential  | 0.868*              |
|              | 97.206              |
|              | 0.079               |

**Nigeria**

| Linear       | 0.785*              |
|--------------|---------------------|
|              | -4937.222           |
|              | 164.210             |
| Quadratic    | 0.991*              |
|              | 1748.194            |
|              | -164.581            |
|              | 2.717               |
| Cubic        | 0.999*              |
|              | 151.233             |
|              | -9.415              |
|              | -0.475              |
|              | 0.018               |
| Exponential  | 0.911*              |
|              | 2.245               |
|              | 0.090               |

**South Africa**

| Linear       | 0.667*              |
|--------------|---------------------|
|              | -29085.662          |
|              | 929.637             |
| Quadratic    | 0.941*              |
|              | 17807.574           |
|              | -1395.647           |
|              | 19.377              |
| Cubic        | 0.995*              |
|              | -7413.468           |
|              | 1074.917            |
|              | -31.878             |
|              | 0.285               |
| Exponential  | 0.865*              |
|              | 50.331              |
|              | 0.075               |

*Significant at 0.1%

The data as presented in Fig. 4 depict the observed and predicted cumulative cases of COVID-19 in the selected countries as at the first 120 days after the outbreak confirmation. The trajectory of observed COVID-19 cumulative cases in Nigeria deviates from the exponential and linear models but perfectly fits the quadratic and cubic regression models. The exponential model fits the data for South Africa and to some extent Egypt in the first 70 days of the outbreak confirmation in those countries. The simple linear regression model does not in any way fit the data for any of the studied countries.

**Figure 5**

Predictive model of cumulative cases of COVID-19 in Nigeria

The observed and estimated values of cumulative cases of COVID-19 in Nigeria using both quadratic and cubic polynomial models are presented in Fig. 5 as shown below. The predicted COVID-19 cumulative case, for 30 September 2020, was: Quadratic − 93,988 (95% CI: 91,209 – 96,767) and cubic − 155,467 (95% CI:151,111–159,824) with the assumption that the present testing
**Discussion**

The coronavirus SARS-CoV-2, otherwise known as COVID-19, is a worldwide pandemic of respiratory illness which has caused thousands of deaths across the globe [1]. The morbidity rate has put huge pressure on the health sector of many nations where cases have been confirmed. The negative economic impact of the disease is enormous and unmatched in the history of disease outbreak worldwide [5]. This contagious disease has no cure and its spread is sporadic. The first confirmed case of COVID-19 in sub-Saharan Africa was in Nigeria (27 February 2020) [2]. Since the outbreak of the disease in Nigeria, the government has put in place preventive measures and policies including lockdown to mitigate the spread of the disease. Despite these instituted mechanisms and structures, the cumulative COVID-19 confirmed case continues to grow; as at the first 120 days of its outbreak confirmation it had risen to 22,614 [2]. The figure attracts criticisms and divergence opinion from the experts in the field of epidemiology. Some opined that, drawing from the experience of countries like USA, Brazil, Russia, and Italy, the figure is low due to low testing capacity in Nigeria, while others likened the disease spread’s pattern to what is obtainable in some Africa countries. The Nigeria Centre for Disease Control (NCDC), however, argued that the number may be underreported due to community spread but was of the view that the differential in protocol and guideline for testing could be responsible for the current disease trend in Nigeria compared to other countries [2]. The huge population size of Nigeria, its population density and poor compliance with preventive measures are other possible reasons for the disagreement with the total reported cases of COVID-19 as at the 120th day of its outbreak in Nigeria. Unfortunately, little is known about the evidence to either support or refute these claims.

In this study, the COVID-19 data in Nigeria show an increasing trend. The curve for Nigeria is unlike a typical propagated epidemic curve that would have been expected in the case of COVID-19 being an infectious disease. The transmissibility interval of COVID-19, that is its reproductive number which signifies the number of people a single case can infect with the virus, was estimated to be from 1.4 to 2.5, 3.6 to 4.0, and 2.24 to 3.58 by earlier studies [3, 6–8]. An indication that the disease will continue to be on the increase. Therefore, the observed pattern found in our study agrees with the known pattern of spread of the disease. We also found a higher number of cases were reported after the relaxation of lockdown than during the lockdown period. There is no doubt that the spread of the disease will be more after the relaxation of lockdown due to poor adherence to the standard precautionary measures in Nigeria. However, an increase in capacity for testing may be the possible explanation for this finding.

We found a similarity possibly due to about the same capacity for testing in the trajectory pattern of cumulative confirmed cases of COVID-19 in Nigeria, Ghana and Cameroon in the first 120 days after the first outbreak in these countries. Conversely, a difference was observed in the pattern exhibited by Nigeria compared to four of the seven countries investigated (Mexico, Bangladesh, South Africa and Indonesia).
As at the 120th day after first case confirmation in these four countries, the total COVID-19 test conducted and test per 1 million population were strikingly higher than that of Nigeria over the same period [1]. Except Indonesia, which has comparable population size with Nigeria, the population figure for each of the other seven countries was extraordinarily lower. One would have expected the pattern of the disease spread in Nigeria to be similar to that of Mexico, Bangladesh, South Africa and Indonesia, all things being equal. Thus, it is tempting to conclude that low testing capacity in Nigeria is responsible for variability in the observed pattern of COVID-19 cases compared to the four countries. The implication is that community testing has not commenced fully in Nigeria as it is done in South Africa; the disease is presently having a sporadic cluster of local transmission in Nigeria.

We further found that the distribution of COVID-19 associated deaths in the course of the study period demonstrates that except Mexico, the pattern observed for Nigeria was comparable to 7 of the 8 countries investigated but aligns perfectly with the Cameroun and Ghana pattern. The prominent difference in COVID-19 related death trajectory found in Mexico compared to other countries may be explained by the higher number of observed COVID-19 cases within the study period. The compactness in the similarity in COVID-19 deaths between Nigeria, Ghana and Cameroon, countries from west Africa may be attributed to other factors aside the COVID-19 testing capacity and case management capabilities.

The cubic polynomial (CPM) was identified as the model of best fit among the four models used in this study. Next to the CPM is the quadratic model (QM). The CPM and QM have been identified in the previous studies as predictive models for some infectious diseases including COVID-19 [9, 10]. None of the data for the countries follow the exponential model except South Africa which aligns with the data within the first 70 days of the outbreak confirmation. A similar remark has been made in the past on the suitability of exponential model for fitting the spread curve of infectious disease [11]. In our study, the predicted COVID-19 cumulative cases for 30 September 2020 using QM and CPM was 93,988 and 155,467 respectively, provided the present testing capacity for COVID-19 and the level of compliance with the preventive measures to mitigate the disease spread is sustained throughout the period.

**Limitations**

The Nigeria data was based on testing suspected cases who either reported at the testing centres or symptomatic individuals at homes who call the NCDC response team lines for help. Differential in the scope of testing and atmospheric conditions in different countries should not be overruled while interpreting our findings. Inaccessibility to data on socio-demographic profile and health history of the COVID-19 patients and survivors limits the opportunity to do some statistical and mathematical modelling.

**Conclusions**

The spread of COVID-19 is increasing daily and the projection provides insight into what the situation could be in days ahead in Nigeria. Thus, emergency preparedness and contingency plans to mitigate the
COVID-19 spread are urgently required. An improvement in COVID-19 control measures and strict compliance with the COVID-19 recommended protocols are strongly recommended. Preparation should be made for the case management of COVID-19 cases in Nigeria in case the figure predicted is realised by the 30 October 2020.

Declarations

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Authors’ Contributions

ASA, AAF, JOA, OKO, RFA and SOO conceptualised and designed the study. ASA analysed the data while ASA, AAF, JOA and OKO interpreted the analysed data. ASA, AAF and RFA drafted the original manuscript. ASA, AAF, JOA, OKO, EJA, RFA, SOO and SAA reviewed and edited the manuscript. All authors have read and agreed to the published version of the manuscript.

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Availability of data and materials

Data sharing is not applicable to this article as no new data were created or analysed in this study. The data is accessible at https://www.ecdc.europa.eu/en/publications-data

Ethics approval and consent to participate

Not applicable

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests

Abbreviations
SARS-CoV-2: severe acute respiratory syndrome coronavirus 2; WHO: world health organization; NCDC: Nigeria centre for disease and control; ECDC: European centre for disease prevention and control; R$^2$: coefficient of determination; FCT: Federal capital territory; CPM: cubic polynomial model

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Figures
Figure 1

Daily COVID-19 confirmed cases as at the first 120 days of the outbreak in Nigeria
Figure 2

COVID-19 cumulative confirmed cases in some countries as at the first 120-day of the outbreak

Figure 3

COVID-19 cumulative daily deaths for the first 120 days in some countries
Figure 4

Predictive model of cumulative cases of COVID-19 in Nigeria
Figure 5

Observed and projected COVID-19 cumulative cases in Nigeria