Journal of Scientific Research & Reports

26(6): 110-119, 2020; Article no.JSRR.59393
ISSN: 2320-0227

The Impact of the Lockdown Measure on the Confirmed Cases of the Novel Coronavirus (COVID-19) in Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. Author COA designed the study, and performed the statistical analysis. Author NUO wrote the introduction. Authors JCE and PNO managed the literature searches. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/JSRR/2020/v26i630276
Editor(s):
(1) Dr. Tzasna Hernandez Delgado, National Autonomous University of Mexico, Mexico.
(2) Dr. Karl Kingsley, University of Nevada, United States of America.
Reviewers:
(1) S. Prasath, Nandha Arts and Science College, India.
(2) Gabriele Galli, University of Michigan, United States of America.
Complete Peer review History: http://www.sdiarticle4.com/review-history/59393

Original Research Article

Received 10 July 2020
Accepted 23 July 2020
Published 05 August 2020

ABSTRACT

Aims: This study examined the impact of the lockdown measure on the confirmed cases of the Novel Coronavirus (COVID-19) in Nigeria. The objectives of the study include to identifying an appropriate autoregressive integrated moving average (ARIMA) model that is adequate for estimating the reported cases of COVID-19 in Nigeria and to ascertain whether the ease of lockdown has a significant impact on the reported cases of COVID-19 in Nigeria.

Place and Duration of Study: The source of the data used for this study was the secondary data obtained from the daily report of the United Nations Office for the Coordination of Humanitarian Affairs (OCHA) from 1st February 2020 to 30th June 2020.

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Methodology: The statistical tools used for data analysis are the ARIMA time series model and the Chow test analysis.
Results: Nigeria ranked 1st in West Africa sub-region with a total of 25, 133 confirmed COVID-19 cases, followed by Ghana with 17, 351 confirmed cases while Gambia recorded the least number of confirmed cases with 47 cases of COVID19. The ARIMA (0, 1, 1) was identified as the best model for forecasting the confirmed COVID-19 cases in Nigeria within the observed period. It was found that there exists a significant difference in the number of confirmed cases of COVID-19 during the lockdown period and the post lockdown period.
Conclusion: The study revealed that Nigeria has the most confirmed cases of COVID-19 in West Africa region. Also, the ease of the lockdown was found to increase the number of confirmed virus cases in Nigeria.

Keywords: ARIMA; COVID-19; lockdown; forecasting; time series.

1. INTRODUCTION

Due to the increasing rate of the spread of coronavirus disease (COVID-19) which is caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) authorities around the world have resorted to the lockdown strategy to curb the spread of the virus. The pandemic has affected over 200 countries across the globe in a matter of months. Even though there are containment measures adopted by some countries, the number of reported cases keeps increasing especially as human activities cannot be eradicated. As was predicted there is serious concern regarding the national health systems' carrying capacity around the world with a special focus on Africa. It was identified that the population of people most affected by the pandemic across the world is older people and those with pre-existing medical conditions.

On 31 January 2020, the World Health Organization following the trend of COVID-19 pandemic across the world listed Nigeria among other 13 African countries identified as high-risk for the spread of the virus. The federal government of Nigeria on that note set up a Coronavirus, Preparedness Group to mitigate the impact of the virus on the country.

Just like most countries of the world, Nigerian government resorted to the lockdown strategy with the hope of preventing the spread of the virus especially when it was established that the major means for transmitting the COVID-19 comprises of droplet transmission, contact transmission and aerosol transmission. The transmission through droplets occurs when someone infected with the virus coughs or sneezes and a non-infected person in close environment inhales it. Also, the COVID-19 may be contacted when an infected person touches a surface or comes in contact with a non-infected person who ends up touching their mouth or nose. Thus, it may be contacted when respiratory droplets mix with air and inhaled into the lungs in a closed environment. However, the transmission method has necessitated the restriction of gatherings and close contact, these gatherings which usually occur in places of worship, banks, parties, beach, malls, offices, schools, and airport e.t.c. These activities contribute to the economic activities of countries therefore; their restrictions will impact on the country's economic growth. The lockdown is necessitated due to the wild spread of the virus and the fact that no certified medication has been approved for the treatment. Apart from the preventive measures such as the use of face mask, avoiding contact with infected individuals, using disinfectants, coughing or sneezing into a tissue or a flexed elbow, avoid touching the face or nose. The best way of preventing the virus is to avoid coming in contact with it and this can only be achieved when people are restricted from coming in contact, thus, the lockdown even though the decision of lockdown has economic implications [1]. It can be said that the lockdown strategy is due to the need to ensure that people do not come into close contact with each other. Social distancing is an effort made to reduce the level of COVID-19 transmission in a country by minimizing the number of contacts between infected and healthy individuals. The inevitable effect of such social distancing measures is a lockdown of all activities in the country to ensure that COVID-19 transmission is drastically reduced. Hence, the present study seeks to determine the impact of the lockdown measure in Nigeria on the number of reported cases of the novel Coronavirus (COVID-19). The objectives of the study include to identifying an appropriate autoregressive integrated moving average (ARIMA) model that is adequate for estimating the reported cases of COVID-19 in Nigeria and to ascertain whether the ease of lockdown has a significant impact on the reported cases of COVID-19 in Nigeria.

2. LITERATURE REVIEW

The federal government of Nigeria on the 19th of March 2020 announced an entry restriction in Nigeria for travellers from the following high-impact countries: China, United States of America, UK, Italy, Spain, Japan, France, Germany, Iran, Norway, South Korea, the Netherlands and Switzerland, effective from 21st of March 2020 for an initial period of four weeks. At the time, countries listed recorded over 1,000 cases of the COVID-19. Also, on the 29th of March 2020, the surcease of the movement in the Federal Capital Territory Abuja, Lagos and Ogun State was announced to reduce the spread of COVID-19. The Lockdown was effective at 11 pm on the 30th of March 2020 and remained in effect for an initial period of fourteen days, but was however extended for another fourteen days due to increasing confirmed cases of the virus. Shortly before the end of the extended lockdown of the federal government, the Nigeria Governors Forum (NGF) decided to ban the interstate movement for two weeks as part of efforts to control the spread of COVID-19, which was necessitated by the increasing evidence of transmission of the virus across the states. During this time, businesses and offices have remained closed and people should stay home. The lockdown has some exemptions, including hospitals and healthcare facilities and some businesses in the food, energy, oil and security sectors.

There is currently no safe and effective vaccine or antiviral for use against the pandemic in humans. As a result, control and mitigation efforts against the pandemic focus on the implementation of non-pharmaceutical interventions (NPI), such as social (physical) distancing, community lockdown, contact tracing, quarantine of suspected cases, isolation of confirmed cases and the use of face masks in public [2]. Social distancing (also known as physical distancing) implies maintaining a physical distance of 2 meters (or 6 feet) from other humans in public meetings. Community lockdown implies the implementation of the strategy of staying at home or refuge (so that people stay at home and work from home), the closure of schools and non-essential activities and services, avoiding large public or private gatherings etc.

Also, Inyang [3] reported that the Nigerian government is considering another total blockade that could be effective by July 22, 2020. The reason for this decision is the growing COVID-19 case rate in the country, particularly among authorities and health professionals. However, on 15/06/2020 doctors from state hospitals in Nigeria went on strike for welfare reasons and inadequate protective equipment.

A study by Ngonghala et al. [4] developed a detailed mathematical model to assess the community-wide impact of non-pharmaceutical interventions on the fight and mitigation of COVID-19 burden. Their study showed that while the relaxation or early lifting of measures of social distancing and community lockdown measures is likely to lead to the second wave, it has prolonged the duration of the social-distancing and lockdown measures can significantly reduce COVID-induced mortality in the United States in general and New York state in particular.

3. MATERIALS AND METHODOLOGY

3.1 Data Collection

The source of the data used for this study was the secondary data obtained from the daily publication/report of the United Nations Office for the Coordination of Humanitarian Affairs (OCHA) from 1st February 2020 to 30th June 2020.

3.2 Method of Data Analysis

The autoregressive integrated moving average (ARIMA) approach has been identified as a useful tool to estimate and predict the epidemic trend of diseases such as the COVID-19 pandemic. A few months after COVID-19 was declared a pandemic, several publications contributed to the body of knowledge in an attempt to determine the trend of the COVID-2019 pandemic using different approaches [5-9]. However, none of the studies reviewed considered the impact of lockdown on the trend of reported/confirmed cases of COVID19.

One of the forecasting approaches used in some literature was the Autoregressive Integrated Moving Average (ARIMA) model [8-9]. The ARIMA model is considered as one of the most used forecasting models for epidemic time series. It is often used with non-stationary time series to capture the linear trend of an epidemic or disease. In particular, it allows the prediction of a specific time series considering its lags; this is done by considering the previous values of the time series and the expected errors. Since most of the reviewed publications have used the ARIMA model for their related study, it is important that this study follows the trend.

ARIMA models are also known as Box-Jenkins models which require historical chronological data of the underlying variables. The time-series approach involves three phases, namely the process of identifying the model, estimating the parameters and checking the model. In the model identification phase, the data set is determined whether the series is stationary before the development of the Box-Jenkins model or the ARIMA model. A stationary series in the Box-Jenkins model will have a constant mean, a constant variance and a constant autocorrelation. For a non-stationary series, differentiation will be made on the non-stationary series one or more times to obtain stationary.

3.2.1 Model identification

The order (the p and q) of the autoregressive and moving average terms can be identified when the series has been tested for stationarity. The tools employed for determining the order of the model are the autocorrelation function (ACF) and the partial autocorrelation function (PACF).

In the present study, the Auto ARIMA approach was used to determine the appropriate ARIMA model for the study. The auto ARIMA function uses the generated AIC and BIC to determine the best combination of parameters for the model. The AIC (Akaike Information Criterion) and BIC (Bayesian Information Criterion) values are estimators for comparing the models. The lower these values, the better the model.

Suppose we consider the following ARIMA model written as

$$Y_t = \alpha_1 Y_{t-1} + \alpha_2 Y_{t-2} + \cdots + \alpha_p Y_{t-p} + \varepsilon + \beta_1 \varepsilon_{t-1} + \beta_2 \varepsilon_{t-2} + \cdots + \beta_q \varepsilon_{t-q} \tag{1}$$

Equation (1) can also be expressed as:

$$\alpha(L)Y_t = \beta(L)\varepsilon_t \tag{2}$$

where,

L is the Log operator, $LY_t = Y_{t-1}$ and $L^2 Y_t = Y_{t-2}$

$$\alpha(L) = 1 - \alpha_1 L - \alpha_2 L^2 - \cdots - \alpha_p L^p \tag{3}$$

$$\beta(L) = 1 - \beta_1 L - \beta_2 L^2 - \cdots - \beta_q L^q \tag{4}$$

The degree of homogeneity d is determined in the identification process while is the response variable representing the stationary series. However, the model parameters are estimated using the least-squares method.

3.2.2 The chow test

The Chow test is often used to determine if there are different subgroups in a population of interest. The goal of the Chow test is to verify whether the coefficients in two linear regressions on different data set is equal [10]. In econometrics, it is most commonly used in the analysis of time series to verify the presence of a structural break in a period that can be presumed to be known a priori.

To test for presence of structural break in a given set of data, a special and useful application of the F test procedure is found in the Chow test statistic. Note that a structural break is when the coefficients of the model change with respect to a time parameter for the Chow test.

$$F = \frac{(\mathrm{RSS_T} - (RSS_1 + RSS_2))/k}{(RSS_1 + RSS_2)/(n_1 + n_2 - 2k)} \approx F(k, n_1 + n_2 - 2k) \tag{5}$$

where,

RSS_T represents the residual sum of squares for the full model

RSS_1 represents the residual sum of squares for the first sub sample or first reduced model

RSS_2 represents the residual of the second sub sample or second reduced model,

k is the number of parameters,

n_1 and n_2 represents the length of the two subsamples.

In the present study, the number of confirmed cases of COVID19 in Nigeria from 30th of March 2020 which is the effective date of the lockdown in Nigeria to 3rd of May 2020 when the lockdown was eases were considered as the lockdown period while 4th of May 2020 to 30th of June 2020 was considered as the ease of lockdown period. Hence, we will want to verify whether there exists significant variation for the coefficients in the linear regression on the number of confirmed cases of COVID19 during the lockdown period and during the ease of lockdown.

4. DATA ANALYSIS AND RESULT

4.1 Descriptive Analysis of Total Confirmed COVID-19 Cases for the Observed Period

Table 1 shows the ranking by total confirmed cases for 16 selected West Africa countries as at the 30th of June 2020.

Table 1. Table showing the ranking by total number of confirmed COVID-19 cases for 16 selected West Africa countries as at 30th June 2020

Country	Total case	Rank
Nigeria	25133	1
Ghana	17351	2
Côte D'Ivoire	9101	3
Senegal	6698	4
Guinea	5351	5
Mauritania	4149	6
Mali	2173	7
Guinea-Bissau	1654	8
Sierra Leone	1450	9
Benin	1187	10
Cape Verde	1165	11
Niger	1075	12
Burkina Faso	959	13
Liberia	770	14
Togo	642	15
Gambia	47	16

Source: Compiled by Authors

The result obtained in Table 1 revealed that Nigeria ranked 1st amongst the 16 selected West Africa countries with a total confirmed 25, 133 COVID-19 cases, followed by Ghana with 17, 351 confirmed cases of COVID-19 while Gambia recorded the least number of confirmed cases with 47 cases of COVID19.

The result obtained in Table 2 found the distribution of the confirmed COVID19 cases (CCOVID19C) to have a mean of 166.4, media of 19.0, Standard deviation of 224.6, Skewness of 1.23, Kurtosis of 0.51 and coefficient of variation of 134.97.

4.2 Testing the CCOVID19C for Stationarity

A test of stationarity was carried out as required for the ARIMA model using the Augmented Dickey-Fuller (ADF) test.

H_{00}: Series has a unit root (Non-Stationarity) Versus

H_{01}: Series has no unit root (Stationarity)

The result of the unit root test on the variable using the Augmented Dickey-Fuller test statistic obtained in Table 3 found that the series has no unit root and stationary overtime at first order of integration I(1) since the test statistic value has a more negative value than the critical values and *P*-value falling on the rejection region assuming a 95% confidence level. This result implies that the series has no unit root and can be used to make a forecast for future behavior of the process.

4.3 Result of the Auto Arima Function for for the confirmed COVID-19 Cases in Nigeria

The auto ARIMA function was used as discussed in the methodology to identify the appropriate ARIMA model for forecasting the confirmed COVID-19 cases in Nigeria using data from 1st February to 31st May 2020 while data the observed data from 1st June to 3o June was used to test the adequacy of the model for estimating confirmed COVID-19 cases. Fig. 1. shows the distribution of confirmed cases from 1st February to 31st May 2020 has random increasing cases of COVID19 since 28th of February that Nigeria recorded the first case of COVID-19.

The result of the auto ARIMA function was obtained as:

Series: CCOVID19C

ARIMA(0,1,1) with drift

The auto ARIMA function result presented in Table 4 found that ARIMA (0, 1, 1) will be best for forecasting the confirmed COVID-19 cases in Nigeria within the observed period. The model found a log-likelihood value of -685.73, AIC value of 1377.46, AICc value of 1377.66, and BIC value of 1385.82. Also, the graph of the autocorrelation function (ACF) and the partial autocorrelation function (PACF) are presented as Figs. 2 and 3 in the Appendix.

The result obtained from Fig. 4 showed that there is very little variation between the forecasted and observed cases of COVID19 for June 2020. This result implies that the obtained model is adequate for estimating number of confirmed cases of COVID19 in Nigeria (see Table 5 in the Appendix for the summary result of 30 days forecast).

Table 2. Table showing the descriptive statistics of daily confirmed cases of COVID-19 Nigeria from 1st February 2020 to 30th June 2020

	Mean	Median	Std. dev.	Skewness	Kurtosis	Coefficient of variation
CCOVID19C	166.4	19.0	224.6	1.23	0.51	134.97

Source: Authors Analysis

Table 3. Result of augmented dickey-fuller unit root test for the confirmed COVID-19 cases in Nigeria

Series	Level		First difference		Order of integration
	No trend	With trend	No trend	With trend	
CCOVID19C	-0.502956	-1.813372	-12.11406	-12.25728	I(1)
			Critical values		
1%	-3.475500	-4.022135	-3.475500	-4.022135	
5%	-2.881260	-3.440894	-2.881260	-3.440894	
Prob.*	.9863	.6934	.0000*	.0000*	

Source: Results computed by authors

Note: The critical values are taken from Mackinnon (1996) one-sided p-values. The null hypothesis is based on the series having unit root. Asterisks (*) denote statistical significance at a 5% level and the variable have a constant and linear trend.

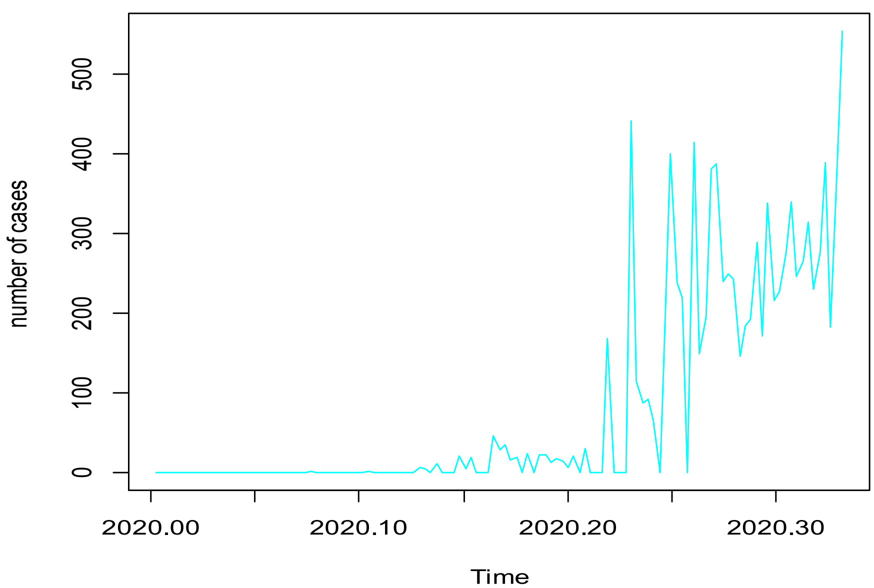

Fig. 1. Time series plot showing the distribution of confirmed cases from 1st February to 31st May 2020

Table 4. Model coefficients for the ARIMA (0, 1, 1) Model

	ma1	drift
Coefficients	-0.8128	3.0482
s.e.	0.0473	1.2992

sigma^2 estimated as 5425: log-likelihood=-685.73, AIC=1377.46, AICc=1377.66, BIC=1385.82

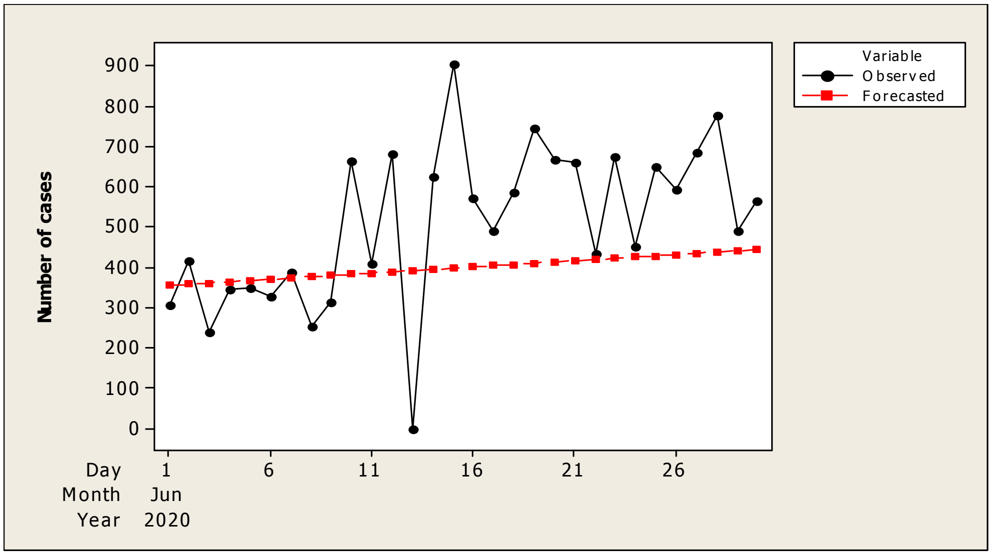

Fig. 4. Plot showing forecast from ARIMA (0, 1, 1) model and the observed confirmed COVID-19 cases for the month of June 2020

Table 6. Table showing the result of chow test analysis

Chow Breakpoint Test: 5/04/2020			
Null Hypothesis: No breaks at specified breakpoints			
Equation Sample: 3/30/2020 6/30/2020			
F-statistic	42.38604	Prob. F(2,89)	0.0000
Log likelihood ratio	62.22706	Prob. Chi-Square(2)	0.0000
Wald Statistic	84.77207	Prob. Chi-Square(2)	0.0000

4.4 Chow Test Analysis to Determine the Impact of Lockdown on the Presents of Number of Confirmed Cases of Covid19 in Nigeria

As discussed in section 3.2.2, the Chow test was used to test whether there exists significant difference for the cases of COVID19 during the lockdown period in Nigeria (30/03/2020 to 03/05/2020) and the number of cases recorded when the lockdown was eases (04/05/2020 to 30/06/2020). The result of the Chow test analysis is presented in Table 6.

The result obtained in Table 5 found F-value of 42.39, log-likelihood ratio value of 62.23 and Wald Statistic of 84.77 with even *P*-value of .00. This result implies that there exists a significant difference in the number of confirmed cases of COVID-19 during the lockdown period and the post lockdown period.

5. CONCLUSION

The call for employing the lockdown measure in reducing the spread of the COVID-19 virus is because there is a high probability that people with either no symptoms or very mild symptoms can spread unnoticed. This study examined the impact of the lockdown measure on the number of confirmed COVID-19 cases in Nigeria. The findings of the study showed that amongst 16 selected West Africa countries which comprise of Benin, Burkina Faso, Cape Verde, Côte D'Ivoire, Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Mali, Mauritania, Niger, Nigeria, Saint Helena, Senegal, Sierra Leone, and Togo, Nigeria currently records the highest number of confirmed COVID19 cases with 25,133 cases while Gambia records the least country 47 confirmed cases as at 30th June 2020.

The number of confirmed COVID19 cases with the observed period was found to have no unit root after the first difference and can be used to make a forecast for future behaviour of the process. The auto ARIMA function was used to identify the appropriate model for estimating the number of confirmed COVID19 cases in Nigeria and it was found that the ARIMA (0, 1, 1) is best for forecasting the confirmed COVID-19 cases in Nigeria within the observed period. The model was found to be adequate for estimating the confirmed COVID-19 cases since there was very little variation between the forecasted and observed cases of COVID19 for June 2020.

It was found that there exists a significant difference in the number of confirmed cases of COVID-19 during the lockdown period and the post lockdown period. This indicates that the ease of the lockdown has increased the number of confirmed cases of the virus in Nigeria. And this has attributed to the loss of more health workers [3]. The findings of the present study revealed that Nigeria has the highest number of confirmed cases of COVID-19 in West Africa; we recommend that the Nigerian government should intervene by using the locals to raise awareness about current preventative measures by the World Organization of healthcare (WHO). Also, we call on the federal and state governments to encourage local production of personal protective equipment (PPE) such as garment, and face marks, which should help healthcare professionals manage effectively those affected without being infected on the front lines.

ETHICAL APPROVAL

As per international standard or university standard guideline ethical approval has been collected and preserved by the authors.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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APPENDIX

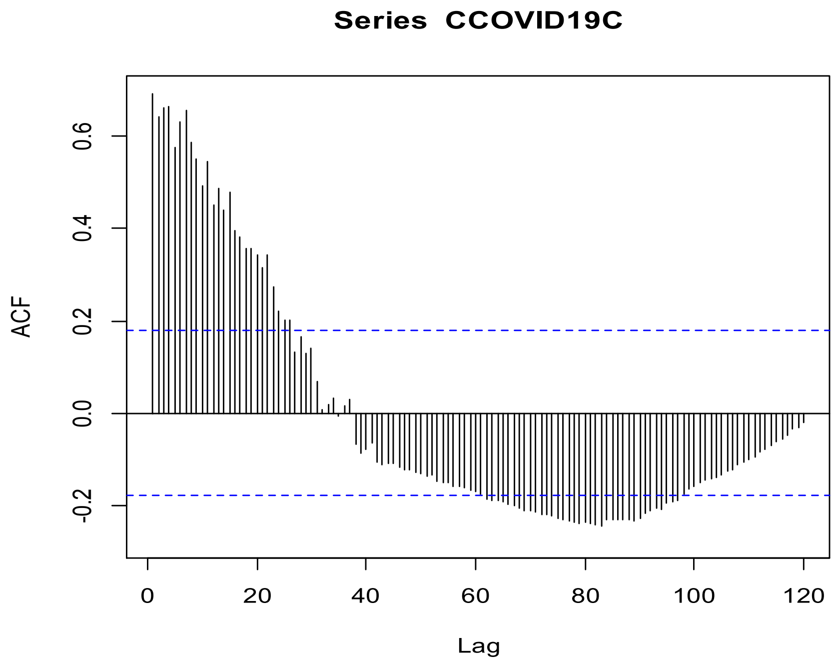

Fig. 2. Graph showing the auto correlation function (ACF) for confirmed COVID-19 cases in Nigeria

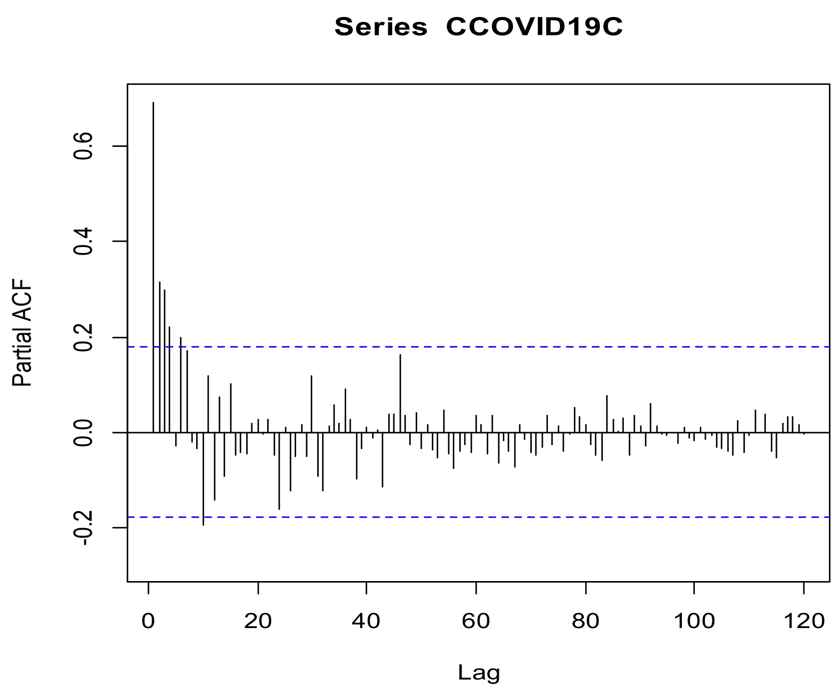

Fig. 3. Graph showing the partial auto correlation function (PACF) for confirmed COVID-19 cases in Nigeria

Table 5. Table showing forecast from ARIMA (0, 1, 1) model and the observed confirmed COVID-19 cases for the month of June 2020

Day	Observed CCOVIDC	Point forecast	Lo80	Hi80	Lo95	Hi95
1	307	355.6	261.21	449.99	211.243	499.957
2	416	358.648	262.618	454.678	211.783	505.514
3	241	361.697	264.055	459.339	212.366	511.027
4	347	364.745	265.517	463.973	212.988	516.501
5	350	367.793	267.004	468.582	213.649	521.937
6	328	370.841	268.515	473.168	214.346	527.336
7	389	373.89	270.048	477.731	215.078	532.701
8	253	376.938	271.604	482.271	215.844	538.032
9	315	379.986	273.18	486.791	216.641	543.331
10	663	383.034	274.777	491.292	217.469	548.6
11	409	386.082	276.392	495.772	218.326	553.839
12	681	389.13	278.026	500.235	219.211	559.05
13	0	392.179	279.678	504.68	220.124	564.234
14	627	395.227	281.347	509.107	221.063	569.391
15	904	398.275	283.032	513.518	222.027	574.524
16	573	401.323	284.734	517.913	223.015	579.632
17	490	404.372	286.45	522.293	224.027	584.716
18	587	407.42	288.182	526.658	225.062	589.778
19	745	410.468	289.928	531.008	226.118	594.818
20	667	413.516	291.688	535.344	227.196	599.836
21	661	416.564	293.461	539.667	228.295	604.834
22	436	419.613	295.248	543.977	229.413	609.812
23	675	422.661	297.047	548.275	230.551	614.771
24	452	425.709	298.858	552.56	231.708	619.71
25	649	428.757	300.682	556.833	232.883	624.632
26	594	431.805	302.517	561.094	234.075	629.535
27	684	434.854	304.363	565.344	235.285	634.422
28	779	437.902	306.22	569.583	236.512	639.292
29	490	440.95	308.088	573.812	237.755	644.145
30	566	443.998	309.966	578.03	239.014	648.982

Source: Authors Computation

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sdiarticle4.com/review-history/59393