Vol. 6 No. 1

April 2021

Modelling and Forecasting of COVID-19 New Cases in the Top 10 Infected African Countries from February 14 to September 06, 2020

Alemayehu Siffir Argawu
Ambo University, Ambo, Ethiopia
alex089973@gmail.com / alemayehu.siffir@ambou.edu.et

Abstract

Rationale of Study – COVID-19 is a novel coronavirus that has resulted in an outbreak of viral pneumonia around the world. The total case has reached 3,581,783 (shared 78.5%) with 102,201 (84.4%) total deaths and 3,214,512 (78.7%) recoveries in the top 10 infected African countries as of April 28, 2021 at 10:30 am. This study models and forecasts COVID-19 new cases in the top 10 infected African countries from February 14 to September 06, 2020.

Methodology – The COVID-19 new cases data was modelled and forecasted using curve estimation regression model and time series model from February 14 to September 6, 2020.

Findings – The cubic regression models for the data were relatively the best fit for Egypt, Ethiopia, Kenya, Morocco, Nigeria, and South Africa. The quadratic regression models for the data were the best fit for Cameroon, Cote d'Ivoire, and Ghana. The Algerian data was followed by the logarithmic regression model. In the time series analysis, the Algeria, Egypt, and South Africa COVID-19 new cases data have fitted the ARIMA (0,1,0), ARIMA (0,1,0), and ARIMA (0,1,14) models, respectively. The Cameroon, Côte d'Ivoire, Ghana and Nigeria data have fitted the simple exponential smoothing models. Ethiopia, Kenya, and Morocco data have followed the Damped trend, Holt, and Brown exponential smoothing models, respectively.

Implications – The findings of the study may be used for preparedness planning against further spread of the COVID-19 epidemic in African countries. The author recommends that as many countries continue to relax restrictions on movement and mass gatherings, and more are opening of their air spaces and other sectors, strong and appropriate public health and social measures must be instituted to prevent further spread of the virus.

Originality – The paper contributes a model which can be used to predict occurrence of new COVID-19 cases in top 10 infected African countries.

Keywords

COVID-19 cases, African countries, curve estimation regression, time series models

Citation: Argawu, A.S. (2021). Modelling and Forecasting of COVID-19 New Cases in the Top 10 Infected African Countries from February 14 to September 06, 2020. *Regional Journal of Information and Knowledge Management*, 6 (1),60-75.

Published by the

Regional Institute of Information and Knowledge Management

P.O. Box 24358 – 00100 – Nairobi, Kenya

1 Introduction

COVID-19 is a novel coronavirus that has resulted in an outbreak of viral pneumonia around the world. It has spread worldwide and earned its place as a global pandemic. The virus can cause death of people of all ages, particularly those with chronic illnesses or older people. The effect of gender on the susceptibility to COVID-19 is less clear than the age effect but preliminary data suggest that men might be more vulnerable. Besides the health risks, the virus is also affecting economies of nations. COVID-19 pandemic has unprecedentedly affected communities and economies everywhere around the world (Begley, 2020; Kluge, 2020; WHOa, 2020; WHOb, 2020).

On April 28, 2021 as at 10:30 am, the number of total COVID-19 cases was 149,366,430 with 3,149,673 (2.11%) total deaths and 127,047,644 total recoveries globally. These statistics are based on information from Worldometers. In the African region, reports showed that the total cases were 4,562,512 with total deaths of 121,111 (2.7%) and 4,085,694 (89.5%) total recoveries. It was also observed that 3,581,783 (shared 78.5%) total cases, 102,201 (84.4%) total deaths and 3,214,512 (78.7%) were registred only in the top 10 infected African countries. These top 10 countries were South Africa, Morocco, Tunisia, Ethiopia, Egypt, Libya, Nigeria, Kenya, Algeria, and Ghana. These countries have shared 44% (1,577,200), 14.2 % (509,972), 8.5% (303,584), 7.1% (254,044), 6.3% (224,517), 4.9% (176,254), 4.6% (164,912), 4.6% (157,492), 3.4% (121,344), and 2.6% (92,464) COVID-19 cumulative infections, respectively. This is due to an increase in the number of daily laboratory tests in each country. Similarly, the distribution of the virus has increased rapidly as revealed by reports from Worldometer and the WHO (WHO, 2021; Worldometer, 2021). It is evident that the pandemic is highly increasing as compared with the virus distribution on September 06, 2020 (Worldometer, 2020).

This study was designed to give the governments more information on how fast the pandemic is progressing to enable them to take the necessary actions and precautions. For this purpose, the number of COVID-19 new cases data has been modeled and forecasted using the curve estimation regression and time series models in these top 10 infected countries from February 14 and September 6, 2020. As a result of modeling, different time dependent policies should be developed based on the estimated and forecasted models of COVID-19 new infections that may be increased, decreased or constant cubically or exponentially in the future. Thus, the fitted models will guide the development of both health and social policies of the countries. If these specified models are published early, they will provide useful guidelines for goverments and policymakers in the affected countries.

2 Methodology

The study was conducted as explained in this section. It explains the data used in the development of the model as well as how it was collected and analysed.

2.1 Data

The data in this study involves the COVID-19 new cases in the top 10 infected African countries from February 14 to September 6, 2020. The data was downloaded from Our World in Data COVID-19 database and from Worldometer.

2.2 Curve Estimations Regression Models

In this study, the fitted modeled and curve estimations models were made for the countries' COVID-19 new cases in the given period. Some of the curve estimation regression models for Ln (COVID-19 new cases) were given below.

$$\textbf{Linear}: \mathrm{Ln}(\hat{y}) = b_0 + b_1 * t \quad (1)$$

$$\textbf{Quadratic}: \mathrm{Ln}(\hat{y}) = b_0 + b_1 * t + b_2 * t^2 \quad (2)$$

$$\textbf{Cubic}: \mathrm{Ln}(\hat{y}) = b_0 + b_1 * t + b_2 * t^2 + b_3 * t^3 \quad (3)$$

$$\textbf{Logarithmic}: \mathrm{Ln}(\hat{y}) = b_0 + b_1 * \ln(t) \quad (4)$$

$$\textbf{Exponential}: \mathrm{Ln}(\hat{y}) = b_0 * e^{(b_1 * t)} \quad (5)$$

The fitting effectiveness of the models and curves are based on R-squared and the standard error of the estimate. But, the AIC and residual sum-of-squares are more useful to pick the best model then plot the curve to visualise the fit than R^2 in the nonlinear regression model. The smallest standard error of the estimate indicates that the data points are closer to the fitted values (Farebrother, 1976; Tufte, 2015).

2.3 ARIMA Models

ARIMA model becomes AR (p), MA (q), or ARMA (p, q) if the time series is stationary. The expression of ARIMA (p, d, q) model can be defined as follows:

$$Y_t = \phi_1 Y_{t-1} + \cdots + \phi_p Y_{t-p} + \alpha_1 - \theta_1 \alpha_{t-1} - \alpha_2 - \theta_2 \alpha_{t-2} - \cdots - \alpha_q - \theta_q \alpha_{t-q} \quad (6)$$

Where ϕ_p are the parameter values for an autoregressive operator, α_q are the error term coefficients, $\theta_q$are the parameter values for moving average operator, and Y_t is the time series of the original series difference at the degreed (Braiman, Family & Hentschel, 1996; Tekindal et al., 2016).

2.4 Exponential Smoothing Methods

There are four types of non-seasonal exponential smoothing models. These are Simple, Holt's linear trend, Brown's linear trend, and Damped trend models (Braiman et al., 1996; Chiemeke & Oladipupo, 2004; Gourieroux & Monfort, 2010; Armstrong, n.d.; McKenzie & Gardner, 2010).

Simple model: It is used for forecasting a time series when there is no trend or seasonal pattern. The simple exponential smoothing model is given by the model equation:

$$\mathbf{(1 - B)Y_t = (1 - \theta B)a_t} \quad \mathbf{(7)}$$

Where $\theta = 1 - \alpha$ and B represents the backshift operator such that $B^r X_t = x_{t-r}$ for any given time series x_t.

Holt's linear trend model: This model is appropriate for a series with a linear trend and no seasonality. Its relevant smoothing parameters are level and trend, and, in this model, they are not constrained by each other's values. The estimates are made using the equations below.

$$\mathbf{Y'_t = \alpha Y_t + (1 - \alpha)(Y'_{t-1} + B_{t-1})} \quad \mathbf{(8)}$$

Where α and γ are the smoothing constants in the range of [0, 1].

Brown's linear trend model: In this model, the parameters are assumed that the level and trend are equal. In this method, estimates are made using the equations below.

$$\mathbf{Y'_t = \alpha Y_t + (1 - \alpha)(Y'_{t-1})} \quad \mathbf{(9)}$$

Damped trend model: It is well established for an accurate forecasting method. The new stated damped trend model is written as follows:

$$\mathbf{Y_t = l_{t-1} + A_t b_{t-1} + \varepsilon_t} \quad \mathbf{(10)}$$

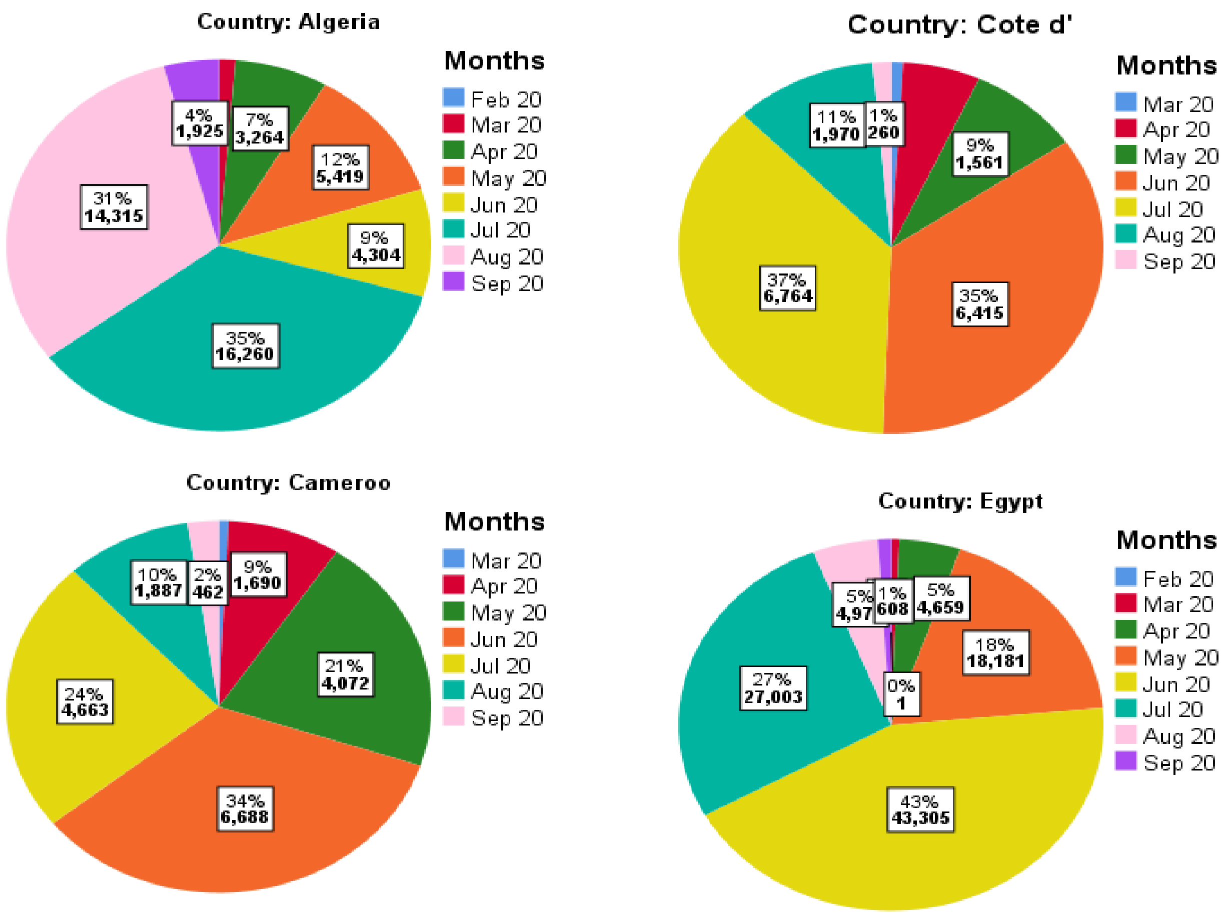
Where Y_t is the observed series, l_t is its level and b_t is the gradient of its linear trend. This model has a single source of error, ε_t.

3 Findings of the study

The author presents and discusses the findings of this study in this section.

3.1 Prevalence of COVID-19 Cumulative Cases

The monthly prevalence of COVID-19 cumulative cases declined in South Africa, Cote d'Ivoire, Egypt, Ghana, Cameron, Nigeria, and Algeria by 31%, 26%, 22%, 20%, 14%, 12%, and 4% from July to August, respectively. However, it rose in Ethiopia, Morocco, and Kenya by 41%, 38%, and 1% from July to August, respectively. Specifically, in Ethiopia and Morocco, 60% and 54% of the cumulative cases have been recorded in August month only, respectively. This indicates that more laboratory tests were conducted in the two countries. The two highly infected countries (South Africa and Egypt) have recorded only 22% and 5% of the countries cases in August month, respectively (Figure 1).



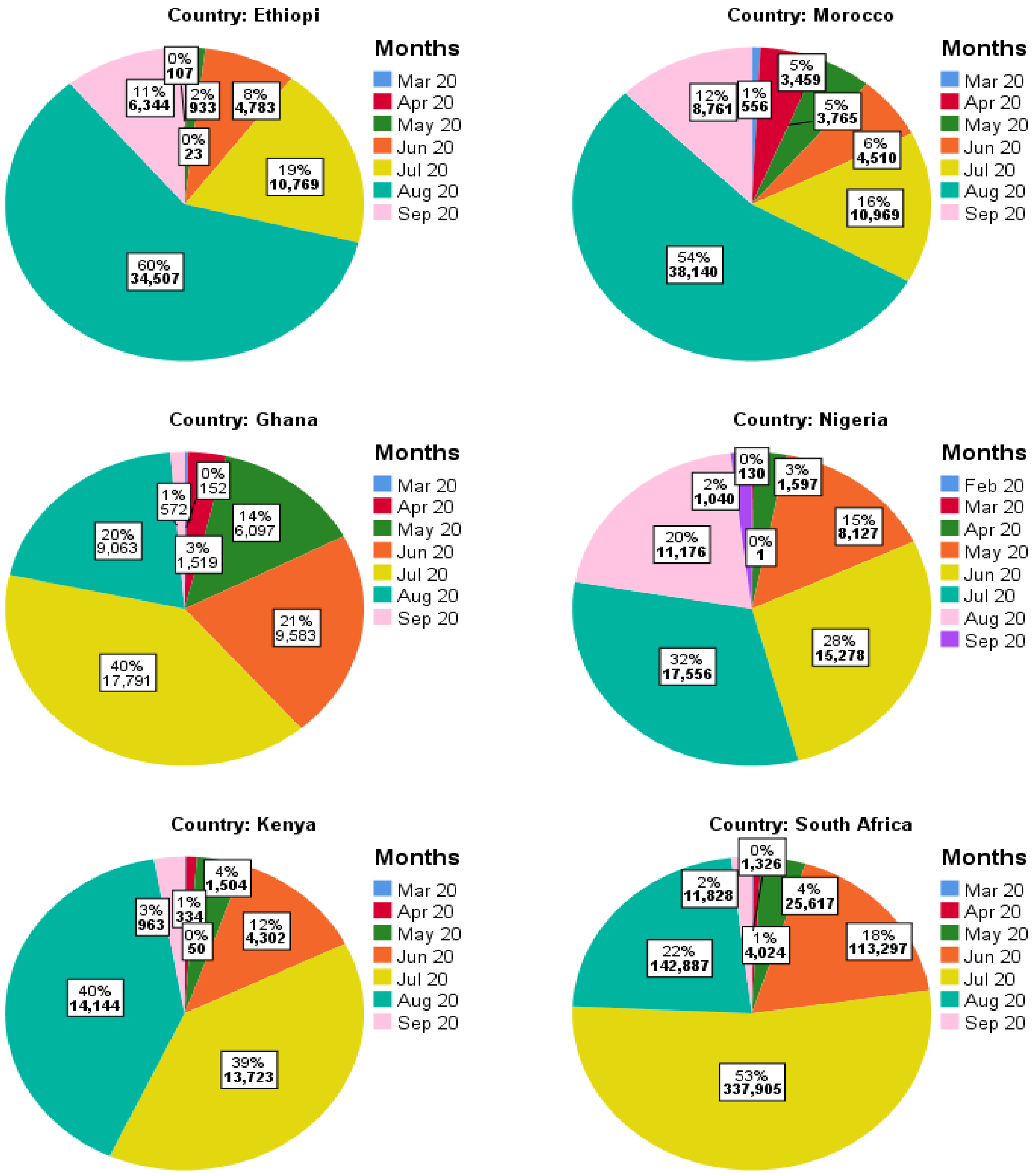


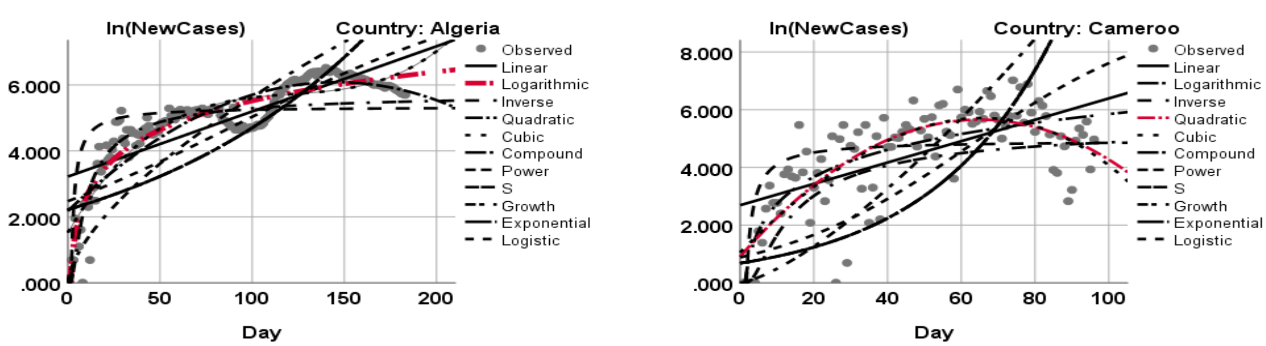
Figure 1. The Pie charts for COVID-19 cumulative new cases by months of the countries from February 14 to September 06, 2020

3.2 Regression Models Summaries

The model with the highest R^2 and the smallest standard error of the estimate (SEE) values was the best-fitted model for the countries' transformed COVID-19 new infections data. Thus, the cubic regression model was the best for Egypt, Ethiopia, Kenya, Morocco, Nigeria, and South Africa data. The quadratic regression model was the best for Cameroon, Cote d'Ivoire, and Ghana new case data. The Algeria data was followed the logarithmic regression model. The fitted models summaries and curve estimation models are given in Table 1 and Figure 2.

Table 1. Summary of the fitted regression models of COVID-19 new cases for the countries from February 14 to September 06, 2020

Countries	Methods	Model Summary					**Fitted models**
		R^2,%	SEE	DF1	DF2	Sig.	
Algeria	Logarithmic	86	0.49	1	181	0.000	$Ln(\hat{y}) = -0.34 + 1.27log(t)$
Cameroon	Quadratic	59	1.1	2	93	0.000	$Ln(\hat{y}) = 0.91 + 0.15t - 0.001t^2$
Cote d'I	Quadratic	68	0.71	2	158	0.000	$Ln(\hat{y}) = 1.23 + 0.08t + 4 * 10^{-4}t^2$
Egypt	Cubic	88	0.57	3	176	0.000	$Ln(\hat{y}) = 0.9 + 0.14t - 0.001t^2 + 1.2 * 10^{-6}t^3$
Ethiopia	Cubic	92	0.68	3	155	0.000	$Ln(\hat{y}) = 0.5 + 0.02t + 0.001t^2 - 3.1 * 10^{-6}t^3$
Ghana	Quadratic	78	0.76	2	133	0.000	$Ln(\hat{y}) = 1.1 + 0.13t - 0.001t^2$
Kenya	Cubic	79	0.49	3	165	0.000	$Ln(\hat{y}) = 1.4 + 0.02t + 0.001t^2 - 3.1 * 10^{-6}t^3$
Morocco	Cubic	76	0.78	3	172	0.000	$Ln(\hat{y}) = 1.6 + 0.11t - 0.001t^2 + 4.7 * 10^{-6}t^3$
Nigeria	Cubic	81	0.41	3	168	0.000	$Ln(\hat{y}) = 0.8 + 0.12t - 0.001t^2 + 1.5 * 10^{-6}t^3$
South A	Cubic	94	0.56	3	178	0.000	$Ln(\hat{y}) = 2 + 0.07t - 2.1 * 10^{-6}t^3$



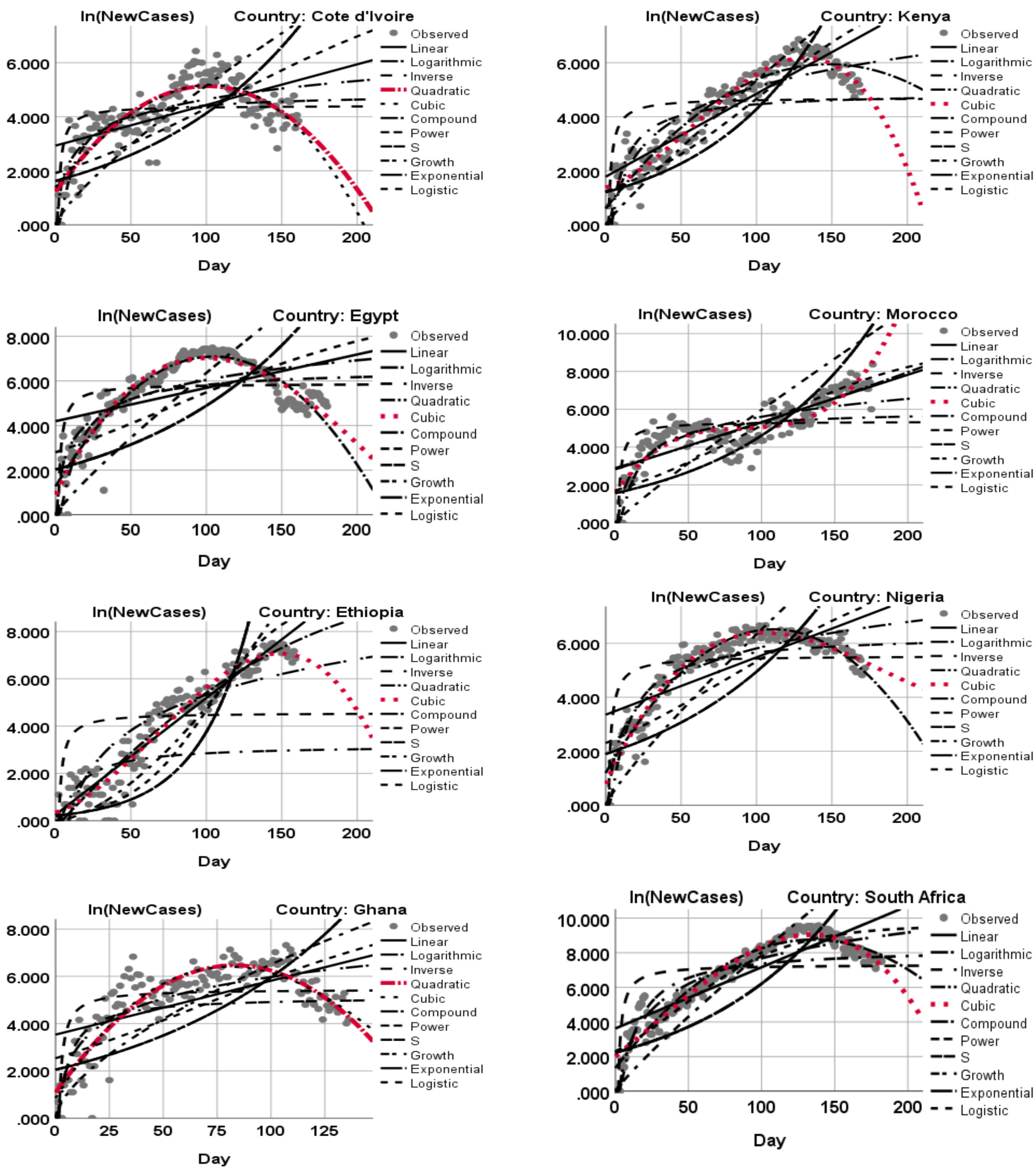


Figure 2. Curve estimates of COVID-19 new cases for the countries from February 14 to September 06, 2020

3.3 Time Series Models Summaries

An appropriate model selection is based on normalised BIC with the smallest value. The Algeria, Egypt, and South Africa COVID-19 new cases data fitted the ARIMA (0,1,0), ARIMA (0,1,0), and ARIMA (0,1,14) models, respectively. The Cameroon, Cote d'Ivoire, Ghana, and Nigeria data fitted the same model type (Simple exponential smoothing model). And, the Ethiopia, Kenya, and Morocco data followed the Damped trend, Holt, and Brown exponential smoothing models, respectively. All of these fitted models have relatively the smallest normalized BIC, root mean square error, and mean absolute percentage error values with the highest stationary R-squared and R-squared values. The ARIMA and exponential smoothing models summaries of the countries' COVID-19 new cases were presented in Table 2. The stationary of the residuals was examined and the ACF and PACF graphics of the series for countries were shown in Figure 3.

Table 2. The ARIMA and exponential smoothing models summaries for COVID-19 new cases for the countries from February 14 to September 06, 2020

Country	Model Type	Model Fit statistics					Ljung-Box Q(18)	
		Stationary R^2	R^2	RMSE	MAPE	Normalized BIC	DF	Sig.
Algeria	ARIMA (0,1,0)	0.638	0.994	15.655	14.669	5.788	18	0.576
Cameroon	Simple	0.438	0.292	183.52	191.19	10.472	17	0.193
Cote d'Ivoire	Simple	0.272	0.679	66.815	56.825	8.435	17	0.000
Egypt	ARIMA (0,1,0)	0.564	0.977	82.233	30.387	9.081	18	0.601
Ethiopia	Damped Trend	0.387	0.899	158.06	53.397	10.222	15	0.033
Ghana	Simple	0.333	0.578	196.80	53.78	10.601	17	0.412
Kenya	Holt	0.787	0.861	84.317	57.394	8.93	16	0.000
Morocco	Brown	0.725	0.721	310.65	184.81	11.507	17	0.005
Nigeria	Simple	0.304	0.84	87.487	28.188	8.973	17	0.553
South A	ARIMA (0,1,14)	0.518	0.974	680.08	91.046	13.303	14	0.464

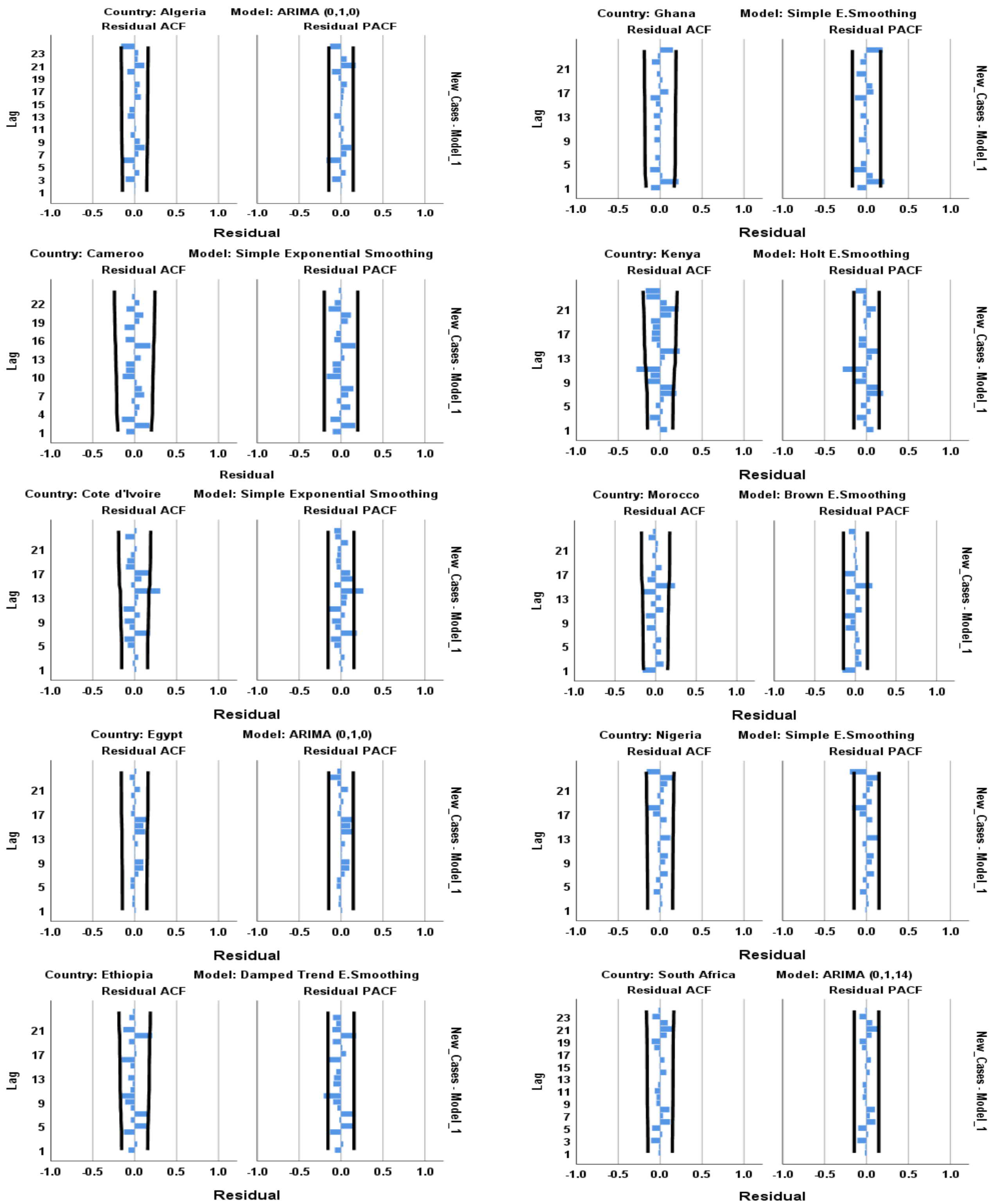


Figure 3. The graphs of ACF and PACF residuas

3.4 Forecasts and Trends of COVID-19 New Cases

In this study, the trends of COVID19 new cases declined only in Algeria and Ethiopia from September 7 to October 6, 2020. It was constant in Cameroon, Cote d'Ivoire, Ghana, and Nigeria. But, the trends was raised slightly in Egypt, Kenya, Morocco, and South Africa. And, from the highest to lowest forecasted COVID-19 new infections were 2,807 in Morocco, 2,444 in South Africa, 789 in Ethiopia, 285 in Kenya, 224 in Egypt, 172, 168 in Nigeria, 96 in Ghana, 59 in Cote d'Ivoire, and 25 in Algeria. Thus, Morocco, South Africa, and Ethiopia had the highest forecasted COVID-19 new infections on 6 October, 2020. The forecasted values and the trend curves of COVID-19 new infections results were presented in Table 3 and Figure 4.

Table 3. Forecast and trends of COVID-19 new cases for the next month for the countries for the countries from February 14 to September 06, 2020

Country	Model Type		Forecasted Values and Trends Status			
		From Date	Values	Trends	LCL	UCL
Algeria	ARIMA(0,1,0)	Sep 7 to Oct 6	289 – 25	Decline	258	197
Cameroon	Simple	Sep 5 to Oct 4	172	Constant	0	726
Cote d'Ivoire	Simple	Sep 5 to Oct 4	59	Constant	0	356
Egypt	ARIMA(0,1,0)	Sep 7 to Oct 6	133 – 224	Increase	63	933
Ethiopia	Damped Trend	Sep 7 to Oct 6	948 – 789	Decline	636	2,141
Ghana	Simple	Sep 6 to Oct 5	96	Constant	0	1,022
Kenya	Holt	Sep 7 to Oct 6	169-285	Increase	3-0	1,222
Morocco	Brown	Sep 7 to Oct 6	1,900-2,807	Increase	1,287	3,858
Nigeria	Simple	Sep 7 to Oct 6	168	Constant	0	543
South Africa	ARIMA(0,1,14)	Sep 7 to Oct 6	2,056-2,444	Increase	1,258	9,229

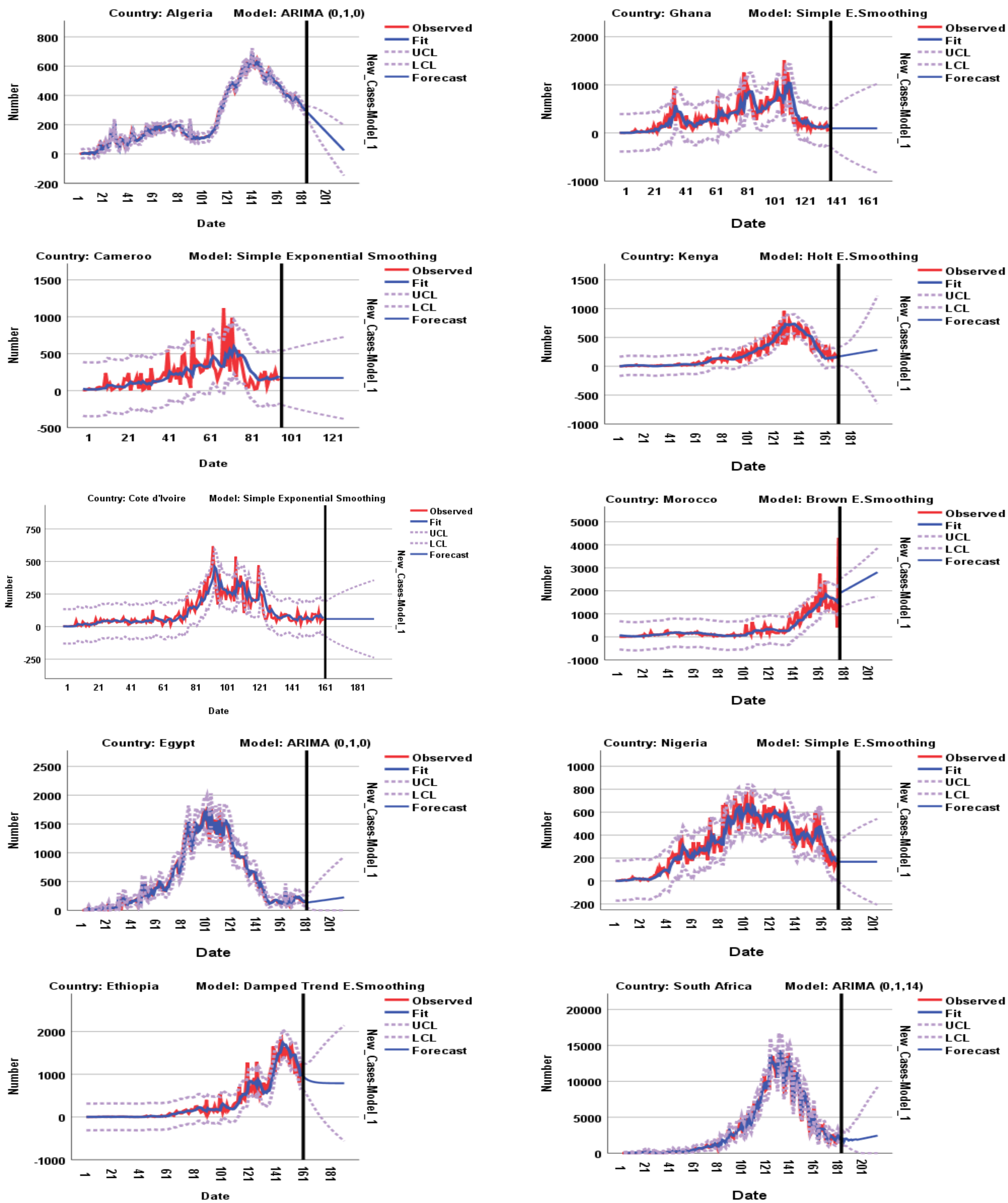


Figure 4. The fitting models and forecasts graphs of COVID-19 new cases for the countries from February 14 to September 06, 2020

4 Discussions

In this study, the findings from curve estimation regression models for Ln transformation of COVID-19 new cases data showed the cubic regression models were relatively the best fit for Egypt (R2=88% & SEE=0.57), Ethiopia (R2=92% & SEE=0.68), Kenya (R2=79% & SEE=0.49), Morocco (R2=76% & SEE=0.78), Nigeria (R2=81% & SEE=0.41) and South Africa (R2=94% & SEE=0.56). The quadratic regression models were the best fit for Cameroon (R2=59% & SEE=1.1), Cote d'Ivoire (R2=68% & SEE=71), and Ghana (R2=78% & SEE=0.76). And, Algeria data was followed the logarithmic regression model (R2=86% & SEE=0.49). All the models were statistically significant at a 1% level of significance. And, the time series models for Algeria, Egypt, and South Africa COVID-19 new cases data fitted the ARIMA (0,1,0), ARIMA (0,1,0), and ARIMA (0,1,14), respectively. The Cameroon, Cote d'Ivoire, Ghana, and Nigeria data fitted the same model type (Simple exponential smoothing model). And, Ethiopia, Kenya, and Morocco data followed the Damped trend, Holt, and Brown exponential smoothing models, respectively.

A similar study in the selected G8 European countries (Germany, United Kingdom, France, Italy, Russian, Canada, Japan, and Turkey) for the number of COVID 19 epidemic cases data fitted the cubic regression models with the curve estimations. And, the number of COVID 19 epidemic cases data were modeled and forecasted that Japan (Holt Model), Germany (ARIMA (1,4,0) and France (ARIMA (0,1,3) were provided statistically significant. The UK (Holt Model), Canada (Holt Model), Italy (Holt Model), and Turkey (ARIMA (1,4,0) were not statistically significant (Yonar and Tekindal 2020).

A study by Likassa (2020) had shown that the spatial and temporal pattern of this novel virus was varying, spreading and covering the entire world within a brief time. In the study, the fitting effect of the cubic model (R2=99.6%) was the best outperforming compared to the other six families of exponentials (Likassa 2020).

And, Achoki et al. (2020) found that the spatial pattern of cumulative COVID-19 cases in Morocco was the leading contributor to the burden of COVID-19 in Northern African on June 30, 2020. Morocco had forecasted 4,459,877 cumulative cases of COVID-19 and this was almost double the estimated number for Algeria, a country with the next highest burden, 2,804,674 by the end of June 2020. In Southern Africa, South Africa and Swaziland are the leading contributors to the pandemic. By the end of June 2020, the countries were expected to have 2,581366 and 254,403 cumulative cases, respectively. In the Western Africa sub-region, cumulative cases of infection were dominated by Cote d'Ivoire and Ghana, despite Nigeria having a larger population than both countries combined. And the numbers of new COVID-19 infections were expected to increase from 2,453,700 cases in April to 5778830 cases in May to 8,044,927 cases by the end of July (Achoki et al., 2020).

Another study using African COVID-19 cases showed that the estimated exponential growth rate was 0.22 per day, and the basic reproduction number (R0) was 2.37 based on the assumption that the exponential growth starting from 1 March 2020. With an R0 at 2.37, we quantified the instantaneous transmissibility of the outbreak by the time-varying effective reproductive number to show the potential of COVID-19 to spread across the African region (Musa et al., 2020).

An earlier study in the African region indicated that the epidemic was controlled in late April with strict control of scenario one, manifested by the circumstance in South Africa and Senegal. Under moderate control of scenario two, the number of infected peoples were increase by 1.43–1.55 times of that in scenario one, the date of the epidemic being controlled was delayed by about 10 days, and Algeria, Nigeria, and Kenya were following this situation. In the third scenario of weak control, the epidemic was controlled by late May, and the total number of infected cases was double that in scenario two, and Egypt was in line with this prediction (Zhao et al., 2020).

5 Conclusions

The measures taken by countries such as the individual attitudes of the societies towards the specified measures and the number of virus tests to be performed are factors that may affect the number of cases. Since this study was conducted with the current measures, the forecasts obtained may differ from the number of cases that occur in the future. Thus, the study findings should be useful in preparedness planning against the further spread of the COVID-19 epidemic in Africa.

6 Recommendations

The author recommends that as many countries continue to relax restrictions on movement and mass gatherings, and more are opening up their airspaces to international travellers with easing of quarantine measures for returning residents and visitors, and the countries' different public and private sectors (like schools, universities, stadiums, and others) are reopening, then strong and appropriate public health and social measures must be instituted on the ground again before the virus is distributed everywhere and attacked more and more. While these are necessary actions, the appropriate public health and social measures must be instituted on the ground. These measures include again, but are not limited to, early detection of suspect cases and tracing contacts to confirmed cases, case management, risk communication, and keeping up with infection prevention and control guidelines. In future studies, more data and healthier evaluations can be made as a matter of course. However, since this study provides information about the levels that the number of cases can reach if the course of the current situation cannot be intervened, it can guide countries to take the necessary measures again. And, the researcher recommended that cumulative cases of COVID-19 will be conducted.

Acknowledgments

The author sincerely thanks anonymous reviewers and the Editor-in-Chief for providing critical comments and suggestions for improving the quality of the paper. He also thanks to WHO, GitHub and Worldometer for COVID-19 data reports, and Ambo University for internet access.

Conflict of Interests

The author confirms that there is no conflict of interest to declare for this publication.

Availability of Data

In this study, the available data were attained based on the reported cases of WHO, GitHub (owid-COVID-19 data) and Worldometer.

References

Achoki, T., Alam, U., Were, L., Gebremedhin, T., Senkubuge, F., Lesego, A., ... & Kinfu, Y. (2020). COVID-19 pandemic in the African continent: forecasts of cumulative cases, new infections, and mortality. MedRxiv.

Armstrong, J. S. (Ed.). (2001). Principles of forecasting: a handbook for researchers and practitioners (Vol. 30). Springer Science & Business Media.

Begley, S. (2020). Who is getting sick, and how sick? A breakdown of coronavirus risk by demographic factors. STATnews.

Braiman, Y., Family, F. & Hentschel, H. G. E. (1996). Introduction to Time Series and Forecasting. 68.

Chiemeke, S. C., & Oladipupo, A.O. (2004). 'Seasonal Time Series Forecasting: A Comparative Study of Arima and Ann Models'. African Journal of Science and Technology (AJST) Engineering 5(2),41-49.

Farebrother, R. W. (1976). Further results on the mean square error of ridge regression. Journal of the Royal Statistical Society. Series B (Methodological), 248-250.

Gourieroux, C., & Monfort, A. (2010). Exponential Smoothing Methods. Time Ser. Dyn. Model, 98-116.

Kluge, H. (2020). Older people are at highest risk from COVID-19, but all must act to prevent community spread. World Health Organization for Europe.

Likassa, H. T., Xain, W., Tang, X., & Gobebo, G. (2021). Predictive models on COVID 19: What Africans should do?. Infectious Disease Modelling, 6, 302-312.

McKenzie, E., & Gardner Jr, E. S. (2010). Damped trend exponential smoothing: A modelling viewpoint. International Journal of Forecasting, 26(4), 661-665.

Musa, S. S., Zhao, S., Wang, M. H., Habib, A. G., Mustapha, U. T., & He, D. (2020). Estimation of exponential growth rate and basic reproduction number of the coronavirus disease 2019 (COVID-19) in Africa. Infectious diseases of poverty, 9(1), 1-6.

Tekindal, M. A. (2016). The modelling of time-series and the evaluation of forecasts for the future: the case of the number of persons per physician in Turkey between 1928 and 2010.

Tufte, E. R. (2015). Non-Linear & Logistic Regression. Available from: https://sites.ualberta.ca/~lkgray/uploads/7/3/6/2/7362679/slides_-_nonlinearlogisticregression.pdf.

WHO. (2020a). Coronavirus Disease 2019 (COVID-19): Situation Report - 51. Vol. 2019.

WHO. (2020b). 'Covid-19 Solidarity Response Fund for WHO'. Help Fight Covid-19.

WHO. (2021). WHO Coronavirus (COVID-19) Dashboard.

Worldometer. (2020). COVID-19 CORONAVIRUS PANDEMIC REPORT ON SEPTEMBER 06, 2020.

Worldometer. (2021). COVID-19 CORONAVIRUS PANDEMIC REPORT ON APRIL 28, 2021.

Yonar, H., Yonar, A., Tekindal, M. A., & Tekindal, M. (2020). Modeling and Forecasting for the number of cases of the COVID-19 pandemic with the Curve Estimation Models, the Box-Jenkins and Exponential Smoothing Methods. EJMO, 4(2), 160-165.

Zhao, Z., Li, X., Liu, F., Zhu, G., Ma, C., & Wang, L. (2020). Prediction of the COVID-19 spread in African countries and implications for prevention and control: A case study in South Africa, Egypt, Algeria, Nigeria, Senegal and Kenya. Science of the Total Environment, 729, 138959.