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Modeling Nigerian Covid-19 cases: A comparative analysis of models and estimators

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ABSTRACT

COVID-19 remains a major pandemic currently threatening all the countries of the world. In Nigeria, there were 1, 932 COVID-19 confirmed cases, 319 discharged cases and 58 deaths as of 30th April 2020. This paper, therefore, subjected the daily cumulative reported COVID-19 cases of these three variables to nine (9) curve estimation statistical models in simple, quadratic, cubic, and quartic forms. It further identified the best of the thirty-six (36) models and used the same for prediction and forecasting purposes. The data collected by the Nigeria Centre for Disease Control for sixty-four (64) days, two (2) months and three (3), were daily monitored and eventually analyzed. We identified the best models to be Quartic Linear Regression Model with an autocorrelated error of order 1 (AR(1)); and found the Ordinary Least Squares, Cochrane Orcutt, Hildreth–Lu, and Prais-Winsten and Least Absolute Deviation (LAD) estimators useful to estimate the models' parameters. Consequently, we recommended the daily cumulative forecast values of the LAD estimator for May and June 2020 with a 99% confidence level. The forecast values are alarming, and so, the Nigerian Government needs to hastily review her activities and interventions towards COVID-19 to provide some tactical and robust structures and measures to avert these challenges.

1. Introduction

Coronavirus Diseases (COVID-19), a respiratory disease characterized by fever, dry cough, and fatigue, and occasional gastrointestinal symptoms, had its initial outbreak in Wuhan city, Hubei, China in late December 2019 [2,9,11,13,21]. Within a month, the disease has escalated in China and further spread to other countries including Thailand, Japan, Republic of Korea, Vietnam, Germany, United States, and Singapore [15,28,31]. On the 30th January 2020, the WHO publicly declared COVID-19 as a disease of international concern [32] and later on 11th March 2020 reported it as a pandemic based on its alarming levels of spread and severity over the world [6].

According to the World Health Organization (WHO) COVID-19 situation report of 29th April 2020, there were 3,018,052 confirmed cases and 207,973 deaths globally. The disease has spread to at least fifteen (15) countries in the Western Pacific Region with 146,720 confirmed cases and 6,037 deaths; fifty-three (53) nations in the European Region with 1,406,899 confirmed cases and 129,311 deaths; ten (10) countries in the South-East Asia Region with 51,351 confirmed cases and 2,001 deaths; twenty-one (21) countries in Eastern Mediterranean Region with 176,928 confirmed cases and 7,304 deaths; thirty-five (35) counties in Region of the Americas with 1,213,088 confirmed cases and 62,404 deaths; and forty-five (45) countries in African Region with 23,254 confirmed cases and 903 deaths of which Nigeria had 1,337 confirmed cases and 40 deaths [29]. Actually, this was the Nigerian situation report of 27th April 2020 [22,30].

The first COVID-19 confirmed case in Nigeria was reported on 27th February 2020, when an Italian citizen in Lagos tested positive for the virus [22,23]. The second case was recorded on the 9th March 2020 in Ewekoro, Ogun State, a Nigerian citizen who had contact with the Italian citizen [30]. Within the first month, the confirmed cases were around 70 but drastically increased to number almost 1,350 cases before the end of the second month. The discharged cases increased from 3 to about 250

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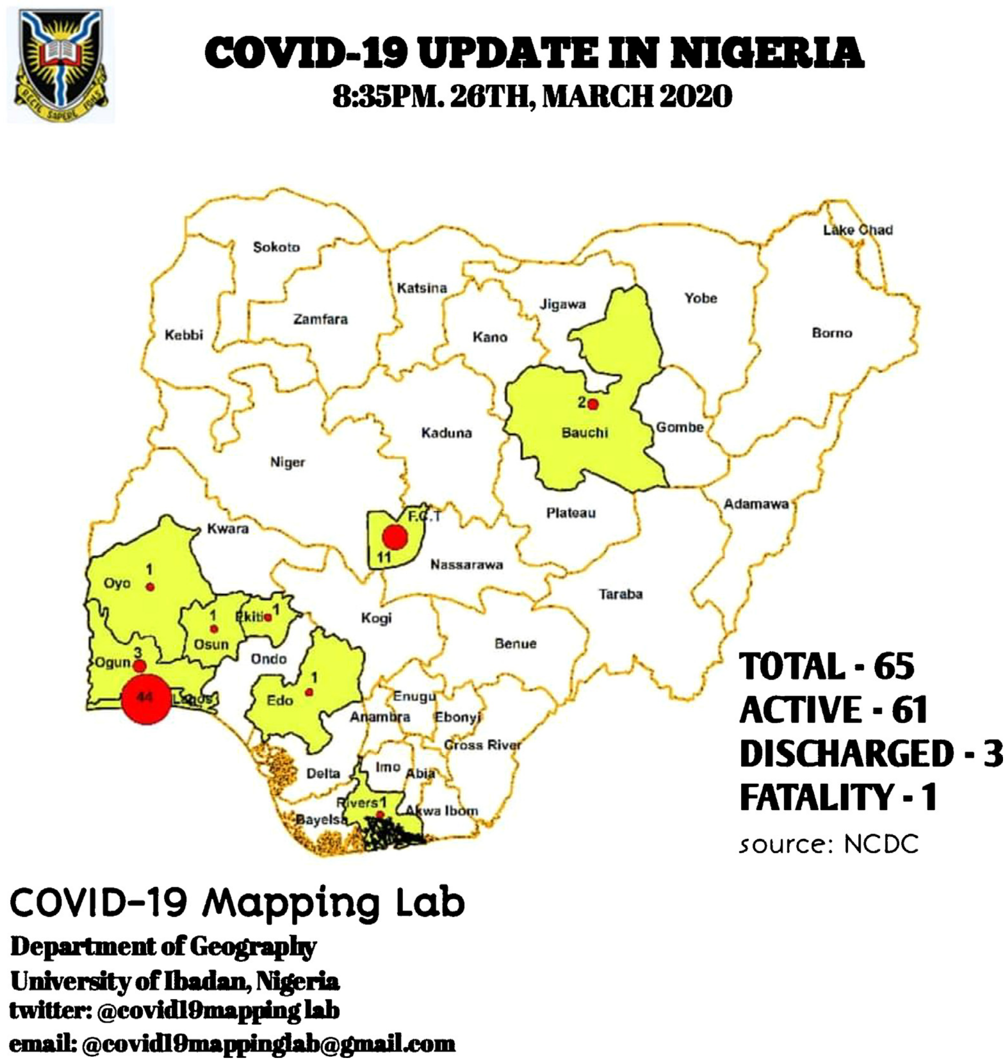

Fig. 1. Nigerian COVID-19 cases after one month of occurrences.

in the first two months. The number of recorded deaths increased from 1 to 40. Figs. 1 and 2 presented the situation over the states of the country between the first and second months of occurrence.

From Figs. 1 and 2, it is not only evident that CIVID-19 cases had increased, but had also spread significantly from eight (8) states to thirty-three (33) (including FCT, Abuja). There were only four states that had no confirmed cases; namely Yobe, Nasarawa, Kogi and Cross River States. At present, only Nasarawa and Yobe States have no record of COVID-19 while Lagos State, Kano State and FCT remained topmost in Nigeria. Fig. 3 presented the cumulative COVID-19 confirmed cases, discharged cases, death cases and yet-to-recover (active) cases. In contrast, Fig. 4 showed the proportion of death cases, the discharged cases and yet-to-recover cases over the cumulative COVID-19 confirmed cases for the periods of the data collection.

The seriousness of this pandemic becomes evident from Figs. 3 and 4. We observed that there was no day within the periods of the data collection that percentage of active / yet-to recover cases is less than 62. Meanwhile, the World Health Organization has listed Nigeria to be among thirteen (13) other African countries with high-risk for the spread of the virus [14].

Apart from the first measure of the Federal Government of Nigeria (FGN) to strengthen surveillance at Enugu, Lagos, Rivers, Kano and FCT International Airports on the 28th January 2020. The FGN on 31st January 2020, set up a group known as Coronavirus Preparedness Group to militate against its should incase it spread to Nigeria [30]. Other measures taken by FGN and various State Governments include the establishment of Presidential Task Force, suspension of all activities and religious gatherings, indefinite closure of public and private schools/institutions, extension of the travel ban to some countries, suspension of the operation of Nigerian Railway Corporation, closing of borders, shops, markets, motor parks, offices, restriction of intra-states and inter-states movements and travelling of the country. However, few states have recently relaxed the lockdown due to difficulties encountered by their citizens [30].

At the beginning of this pandemic, the unavailability of data has made forecasting and predictions a complicated task. A search for numerical models to forecast the epidemic evolution is underway [1,15]. Recent works provided forecasting models for confirmed COVID-19 cases for Germany, Italy, Japan, Canada, Russia, UK, Turkey and France [9,33]. Consequently, this paper attempts to model the daily cumulative reported COVID-19 confirmed cases,

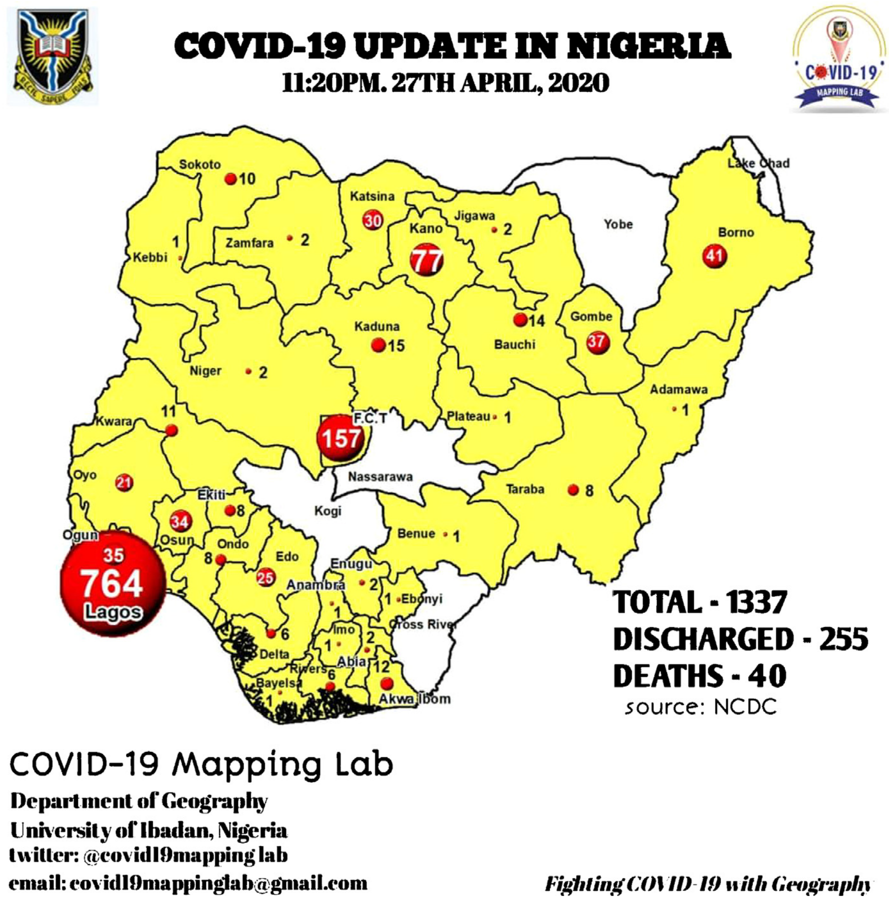

Fig. 2. Nigerian COVID -19 cases after two months of occurrences.

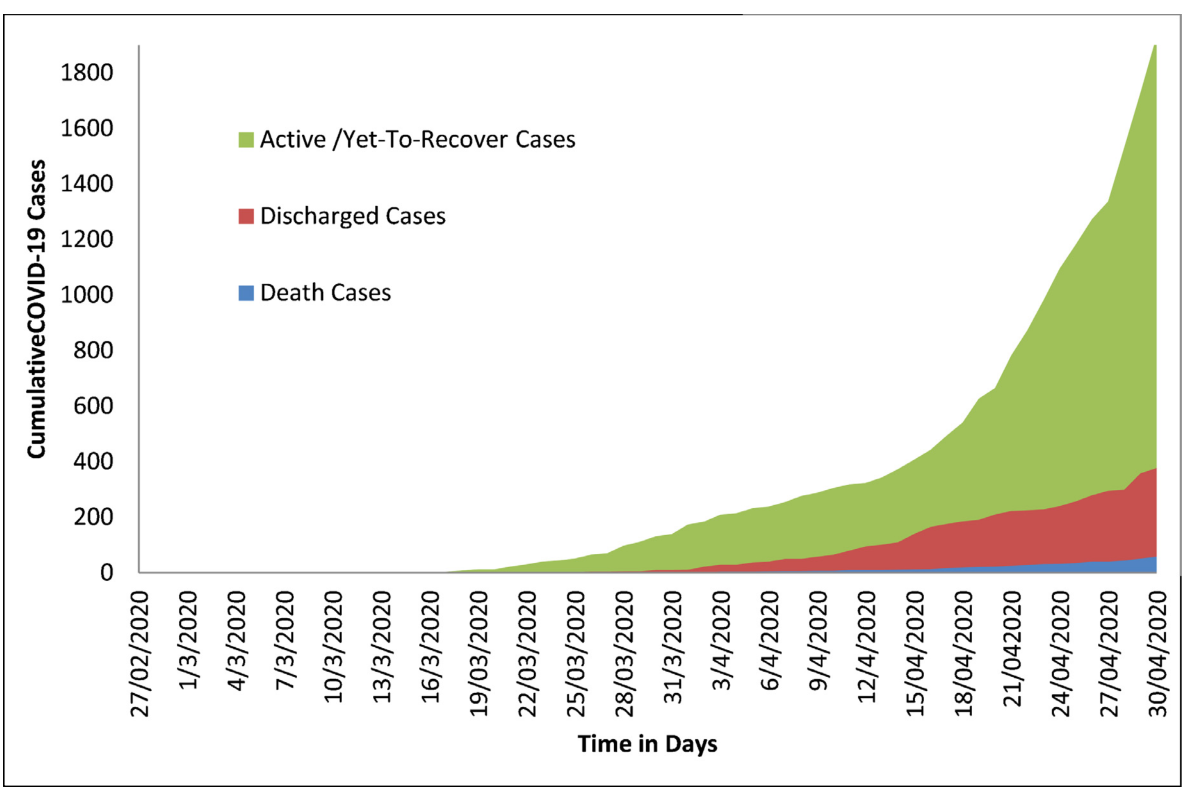

Fig. 3. Nigerian COVID 19 Reported Cases in the First Sixty Four Days.

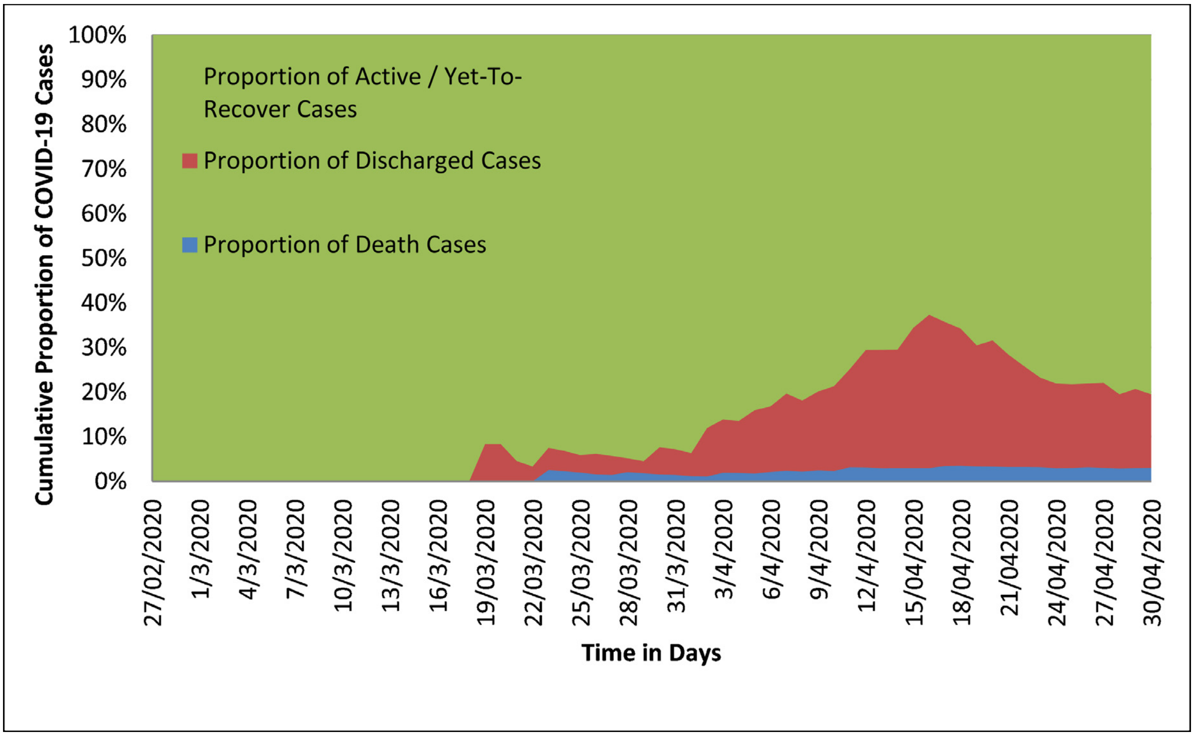

Fig. 4. Proportions of Nigerian Cumulative COVID 19 Cases in First Sixty Four Days.

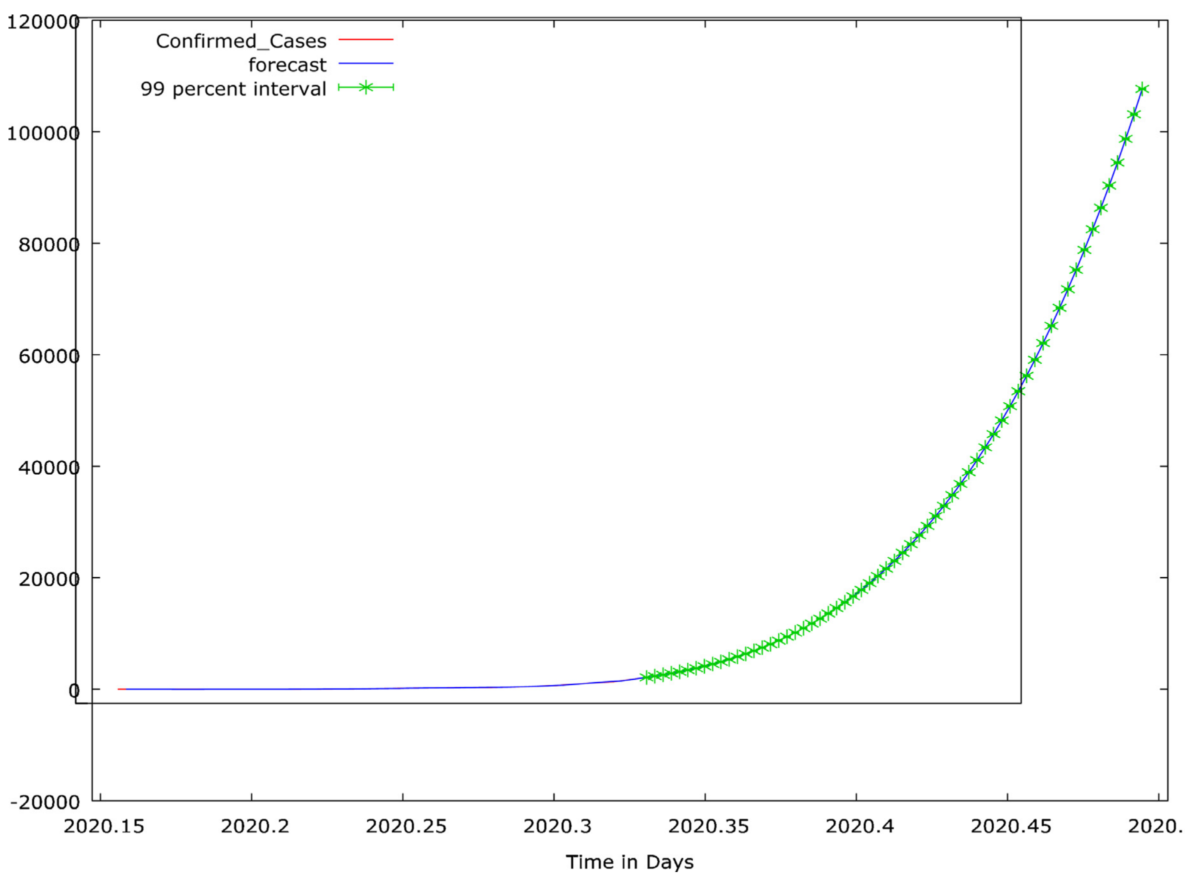

Fig. 5. COVID-19 Confirmed Cases for First Sixty Four Days and its forecast values for May and June, 2020: HILU Estimator.
Source: **Source:** Appendix A

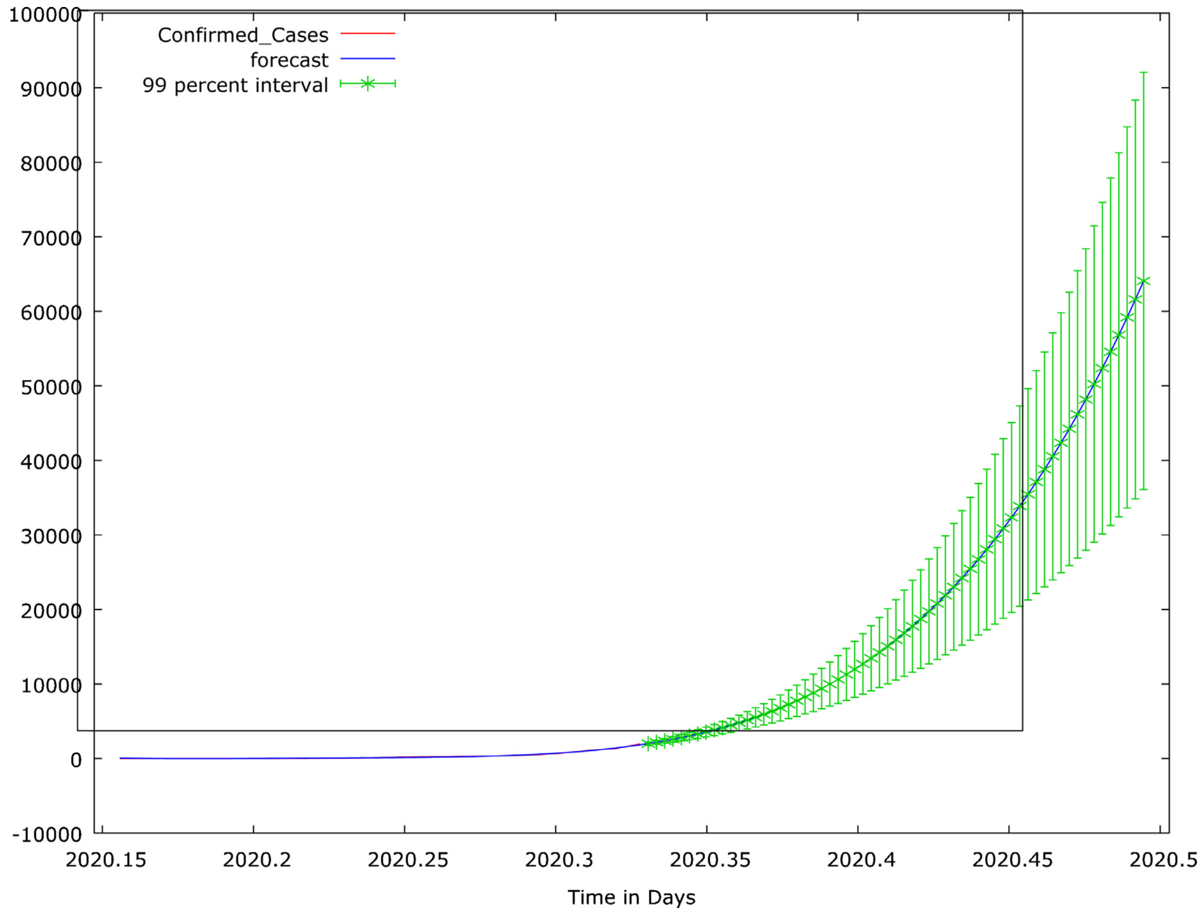

Fig. 6. COVID-19 Confirmed Cases for First Sixty Four Days and its forecast values for May and June, 2020: LAD Estimator.
Source: **Source:** Appendix A

discharged cases and death cases using nine (9) statistical models to identify and utilize the best one for prediction.

2. Methodology

NCDC has been monitoring and reporting the cumulative and the new number of confirmed cases, number of discharged cases and recorded death since the first occurrence of COVID-19 in Nigeria. These data were collected daily on NCDC site [22] over a period over sixty-four days (2 months and three days) beginning from 27th February 2020 (first day of occurrence) until 30th April2020. The first discharged case occurred on the 19th March 2020 while the first death case occurred on 23rd March 2020. With the cumulative nature of the data, the number of cases at a time t depends on previous time t-1. We proposed the following curve estimation models with an autoregressive model of order 1 (AR(1)) in their simple, quadratic, cubic and quartic forms to study the pattern of the data so as to use the best one to forecast for the next two months, May and June 2020.

These Statistical Linear Regression Models are:

1 Classical Linear Regression Model: In the Simple Linear form, the model is defined as:

$$y_t = \beta_0 + \beta_1 t + \mu_t \quad (1)$$

The Quadratic Linear Regression Model is defined as:

$$y_t = \beta_0 + \beta_1 t + \beta_2\, t^2 + \mu_t \quad (2)$$

The Cubic Linear Regression Model: The model is defined as:

$$y_t = \beta_0 + \beta_1 t + \beta_2\, t^2 + \beta_3\, t^3 + \mu_t \quad (3)$$

The Quartic Linear Regression Model: The model is defined as:

$$y_t = \beta_0 + \beta_1 t + \beta_2\, t^2 + \beta_3\, t^3 + \beta_4\, t^4 + \mu_t \quad (4)$$

2 Logarithm Linear Regression Model: In the Simple form, the model is defined as:

$$y_t = \beta_0 + \beta_1 \log_e t + \mu_t \quad (5)$$

The Logarithm Quadratic Linear Regression Model is defined as:

$$y_t = \beta_0 + \beta_1 \log_e t + \beta_2 \log_e t^2 + \mu_t \quad (6)$$

The Logarithm Cubic Linear Regression Model is defined as:

$$y_t = \beta_0 + \beta_1 \log_e t + \beta_2 \log_e t^2 + \beta_3 \log_e t^3 + \mu_t \quad (7)$$

The Logarithm Quartic Linear Regression Model is defined as:

$$y_t = \beta_0 + \beta_1 \log_e t + \beta_2 \log_e t^2 + \beta_3 \log_e t^3 + \beta_4 \log_e t^4 + \mu_t \quad (8)$$

3 Inverse Linear Regression Model: The Simple form of the model is defined as:

$$y_t = \beta_0 + \beta_1 \frac{1}{t} + \mu_t \quad (9)$$

Similarly, the Quadratic, Cubic and Quartic forms are respectively defined as:

$$y_t = \beta_0 + \beta_1 \frac{1}{t} + \beta_2 \frac{1}{t^2} + \mu_t \quad (10)$$

$$y_t = \beta_0 + \beta_1 \frac{1}{t} + \beta_2 \frac{1}{t^2} + \beta_3 \frac{1}{t^3} + \mu_t \quad (11)$$

$$y_t = \beta_0 + \beta_1 \frac{1}{t} + \beta_2 \frac{1}{t^2} + \beta_3 \frac{1}{t^3} + +\beta_4 \frac{1}{t^4} \mu_t \quad (12)$$

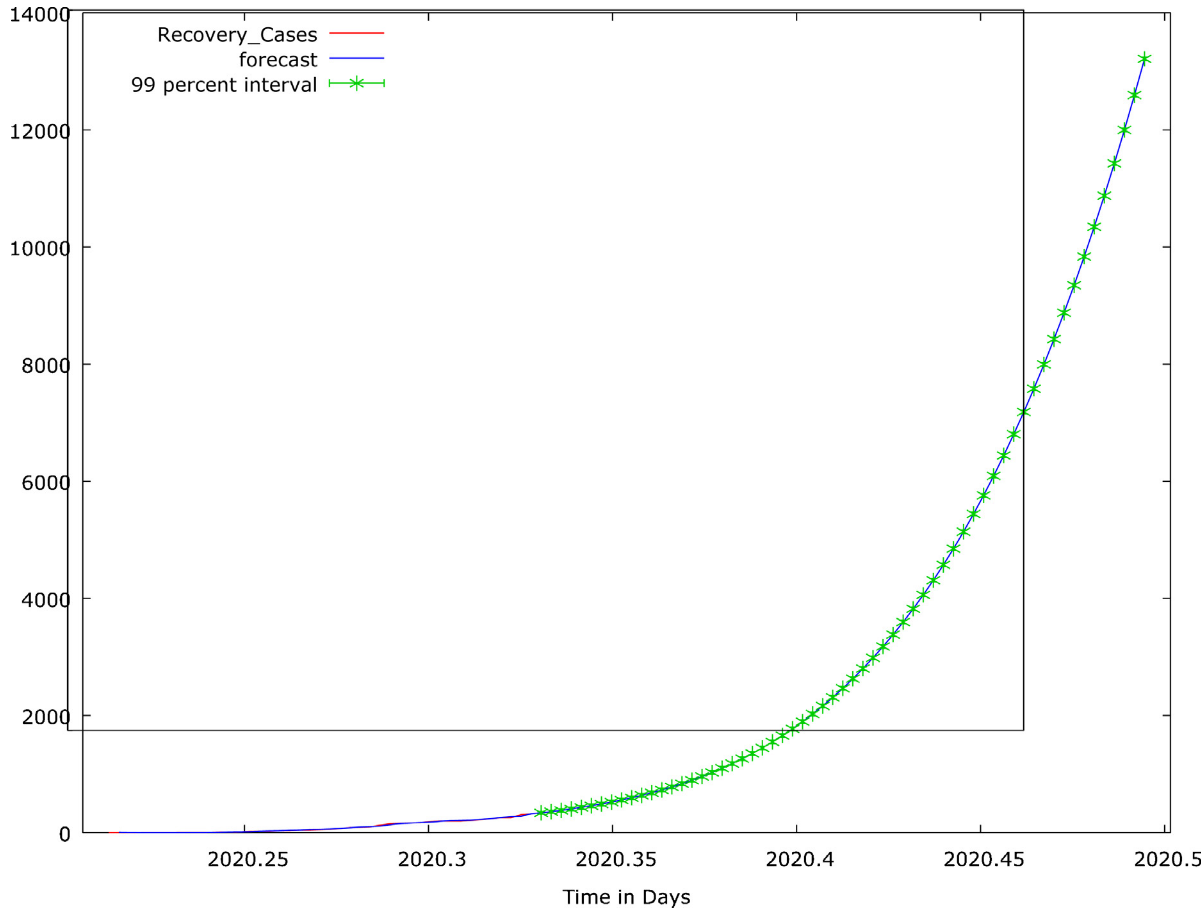

Fig. 7. COVID-19 Discharged Cases for First Sixty Four Days and its forecast values for May and June, 2020: CORC Estimator.
Source: **Source:** Appendix B

4 Power Linear Regression Model: The Simple form of the model is defined as:

$$y_t = \beta_0 t^{\beta_1}\mu_t$$
$$Log_e y_t = Log_e\beta_0 + \beta_1 Log_e t + Log_e\mu_t \quad (13)$$

Similarly, the Quadratic, Cubic and Quartic forms are respectively defined as:

$$Log_e y_t = Log_e\beta_0 + \beta_1 Log_e t + \beta_2 Log_e t^2 + Log_e\mu_t \quad (14)$$

$$Log_e y_t = Log_e\beta_0 + \beta_1 Log_e t + \beta_2 Log_e t^2 + \beta_3 Log_e t^3 + Log_e\mu_t \quad (15)$$

$$Log_e y_t = Log_e\beta_0 + \beta_1 Log_e t + \beta_2 Log_e t^2 + \beta_3 Log_e t^3 + \beta_4 Log_e t^4 + Log_e\mu_t \quad (16)$$

5 Compound Linear Regression Model: In the Simple form, the model is defined as:

$$y_t = \beta_0\beta_1^t\mu_t$$
$$Log_e y_t = Log_e\beta_0 + t\ Log_e\beta_1 + Log_e\mu_t \quad (17)$$

In the same way, the Quadratic, Cubic and Quartic forms are respectively defined as:

$$Log_e y_t = Log_e\beta_0 + t\ Log_e\beta_1 + t^2 Log_e\beta_2 + Log_e\mu_t \quad (18)$$

$$Log_e y_t = Log_e\beta_0 + t\ Log_e\beta_1 + t^2 Log_e\beta_2 + t^3 Log_e\beta_3 + Log_e\mu_t \quad (19)$$

$$Log_e y_t = Log_e\beta_0 + t\ Log_e\beta_1 + t^2 Log_e\beta_2 + t^3 Log_e\beta_3 + t^4 Log_e\beta_4 + Log_e\mu_t \quad (20)$$

6 S– Curve Linear Regression Model: The simple form of the model is defined as:

$$y_t = e^{\beta_0 + \beta_1 \frac{1}{t}}\mu_t$$
$$Log_e y_t = \beta_0 + \beta_1 \tfrac{1}{t} + Log_e\mu_t \quad (21)$$

In the same way, the Quadratic, Cubic and Quartic forms are respectively defined as:

$$Log_e y_t = \beta_0 + \beta_1\frac{1}{t} + \beta_2\frac{1}{t^2} + Log_e\mu_t \quad (22)$$

$$Log_e y_t = \beta_0 + \beta_1\frac{1}{t} + \beta_2\frac{1}{t^2} + \beta_3\frac{1}{t^3} + Log_e\mu_t \quad (23)$$

$$Log_e y_t = \beta_0 + \beta_1\frac{1}{t} + \beta_2\frac{1}{t^2} + \beta_3\frac{1}{t^3} + \beta_3\frac{1}{t^4} + Log_e\mu_t \quad (24)$$

7 Growth Linear Regression Model: The Simple form of the model is defined as:

$$y_t = e^{\beta_0 + \beta_1 t}\mu_t$$
$$Log_e y_t = \beta_0 + \beta_1 t + Log_e\mu_t \quad (25)$$

Similarly, the Quadratic, Cubic, and Quartic forms are respectively defined as:

$$Log_e y_t = \beta_0 + \beta_1 t + \beta_2 t^2 + Log_e\mu_t \quad (26)$$
$$Log_e y_t = \beta_0 + \beta_1 t + \beta_2 t^2 + \beta_3 t^3 + Log_e\mu_t \quad (27)$$
$$Log_e y_t = \beta_0 + \beta_1 t + \beta_2 t^2 + \beta_3 t^3 + \beta_4 t^4 + Log_e\mu_t \quad (28)$$

8 Exponential Linear Regression Model: The simple form of the model is defined as:

$$y_t = \beta_0 e^{\beta_1 t}\mu_t$$
$$Log_e y_t = Log_e\beta_0 + \beta_1 t + Log_e\mu_t \quad (29)$$

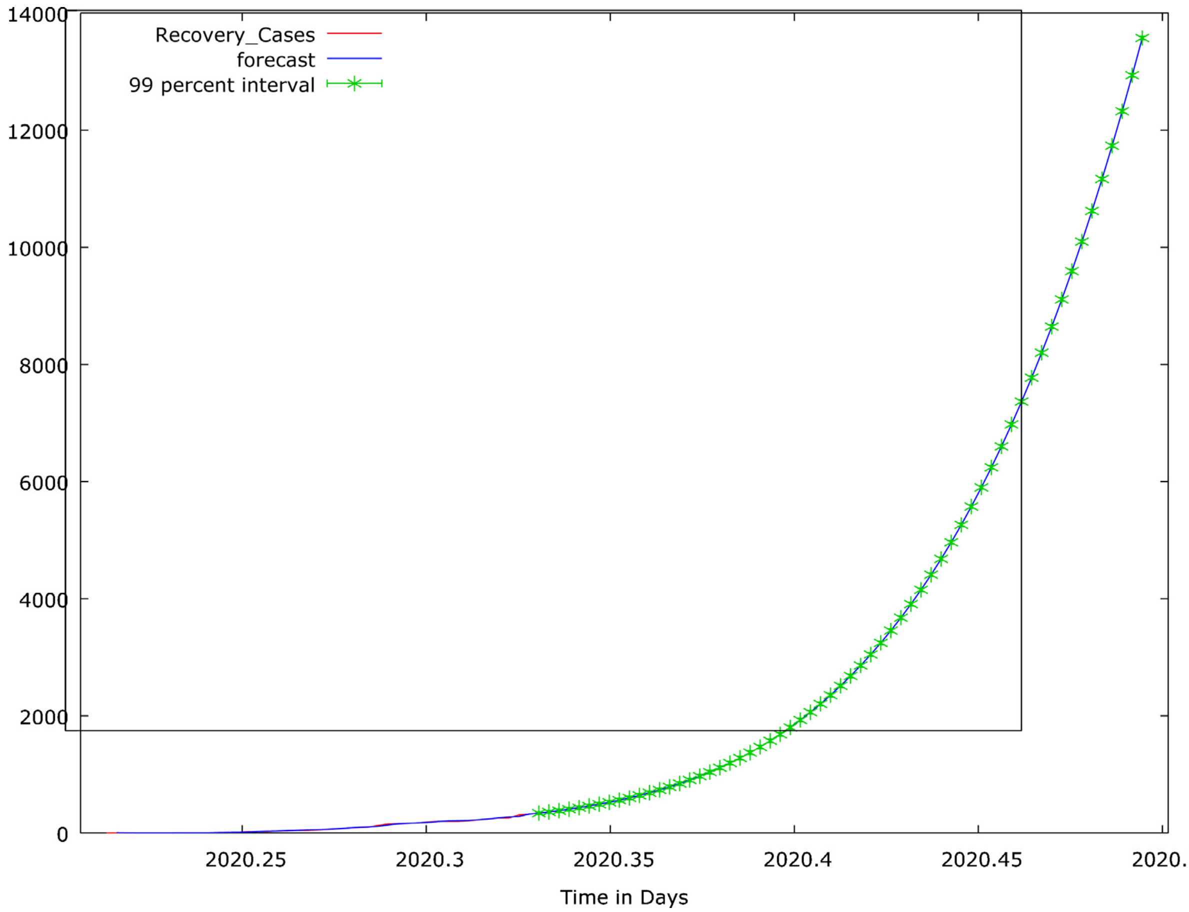

Fig. 8. COVID-19 Discharged/ Recovery Cases for First Sixty Four Days and its forecast values for May and June, 2020: HILU Estimator.

In the same way, the forms of Quadratic, Cubic and Quartic are respectively defined as:

$$Log_e y_t = Log_e \beta_0 + \beta_1 t + \beta_2 t^2 + Log_e \mu_t \tag{30}$$

$$Log_e y_t = Log_e \beta_0 + \beta_1 t + \beta_2 t^2 + \beta_3 t^3 + Log_e \mu_t \tag{31}$$

$$Log_e y_t = Log_e \beta_0 + \beta_1 t + \beta_2 t^2 + \beta_3 t^3 + \beta_4 t^4 + Log_e \mu_t \tag{32}$$

9 Logistic Linear Regression Model: The Simple form of the model is defined as:

$$\begin{aligned} &y_t = \frac{1}{\left(\frac{1}{u} + \beta_0 \beta_1^t \mu_t\right)} \\ &y_t\left(\frac{1}{u} + \beta_0 \beta_1^t \mu_t\right) = 1 \\ &\frac{1}{y_t} - \frac{1}{u} = \beta_0 \beta_1^t \mu_t \\ &Log_e\left(\frac{1}{y_t} - \frac{1}{u}\right) = Log_e(\beta_0) + Log_e \beta_1\, t + Log_e \mu_t \end{aligned} \tag{33}$$

Similarly, the forms of Quadratic, Cubic and Quartic are respectively defined as:

$$Log_e\left(\frac{1}{y_t} - \frac{1}{u}\right) = Log_e(\beta_0) + Log_e \beta_1\, t + Log_e \beta_2\, t^2 + Log_e \mu_t \tag{34}$$

$$Log_e\left(\frac{1}{y_t} - \frac{1}{u}\right) = Log_e(\beta_0) + Log_e \beta_1\, t + Log_e \beta_2\, t^2 + Log_e \beta_3\, t^3 + Log_e \mu_t \tag{35}$$

$$Log_e\left(\frac{1}{y_t} - \frac{1}{u}\right) = Log_e(\beta_0) + Log_e \beta_1\, t + Log_e \beta_2\, t^2 + Log_e \beta_3\, t^3 + Log_e \beta_4\, t^4 + Log_e \mu_t \tag{36}$$

where u is the upper boundary value, which must be a positive number greater than the largest value of y, the dependent variable.

It should be noted that model (5) to (36) are intrinsically linear regression model in that they are all linear in parameters; and that in all the models, the error terms $\mu_t = \rho \mu_{t-1} + \varepsilon_t,\ \varepsilon_t \sim N(0, \sigma^2)$.

Also, the three variables**:** Cumulative COVID-19 Confirmed Cases (CCCOC), Cumulative COVID-19 Discharged Cases (CCDIC), and Cumulative COVID-19 Death Cases (CCDEC) were each considered as dependent variable in this study. The independent variable is time, t, and it takes values 1,2,…,64 for CCCOC; 1, 2,…,43 for CCDIC; and 1,2,…,39 for CCDEC. The model regression parameters are; β_0,β_1,β_2,β_3,β_4, and the auto-correlated parameter, ρ. The Ordinary Least Square (OLS) Estimator is the most common estimator to estimate the parameters of the Classical Linear Regression Model. The estimator is best linear unbiased estimator (BLUE) provided none of the assumptions of the model is violated [5,18,20]. In model (1) to (36), the assumption of independent error terms is not satisfied, leading to the problem of autocorrelated error terms. Using the OLS estimator in this kind of situation produces unbiased but inefficient estimates [3,4]. Researchers had developed estimators to handle linear regression Model with AR(1). These include the Cochrane Orcutt (CORC) estimator developed by Cochrane and Orcutt [7], Prais-Winsten (PW) developed by Prais and Winsten [25], and Hildreth-LU (HILU) estimator developed by Hildreth and Lu [12]. Reports show that the efficiency of these estimators depends on the structure of the explanatory variables [3,16]. Durbin [8] developed the Durbin Watson test **s**tatistic to test for the presence of AR(1) in a regression model after OLS estimation. Also in modeling (1) to (36), it is expected that the error terms are normally distributed. This may not always be true and as a result, hypothesis testing is affected. Saphiro-Wilk (SW) test developed by Shapiro and Wilk [26] and recently recommended

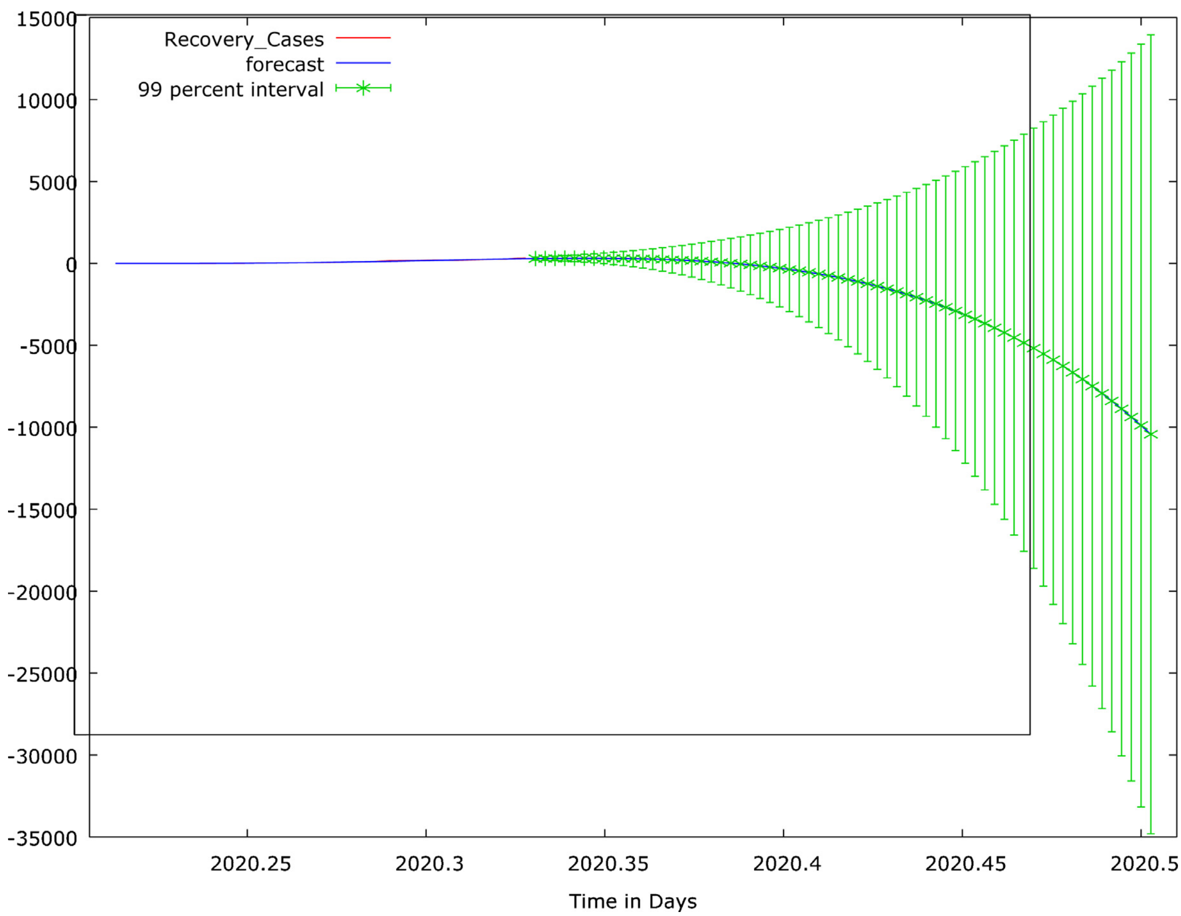

Fig. 9. COVID-19 Discharged Cases for First Sixty Four Days and its forecast values for May and June, 2020: LAD Estimator.

Table 1
Preferred form of the Nine Curve Estimation models with OLS estimator: COVID-19 Confirmed Cases.

Models	Form	Adj. R^2	DW-test		SW-test	
			Value	P-value	Value	P-value
Linear	Quartic	0.9949	0.3204	4.783e-013***	0.9695	0.1137
Logarithm	Simple+	0.3448	0.0312	1.798e-018***	0.7721	1.37e-008***
Inverse	Quartic	0.4137	0.112	1.798e-018***	0.8302	4.32e-007***
Power	Simple+	0.7876	0.0848	1.798e-018***	0.9156	0.0003***
Compound	Quartic	0.9891	0.3768	5.459e-013***	0.9087	0.0002***
S-Curve	Quartic	0.9318	0.526	1.798e-010***	0.9271	0.001***
Growth	Quartic	0.9891	0.3768	5.459e-013***	0.9087	0.0002***
Exponential	Quartic	0.9891	0.3768	5.459e-013***	0.9087	0.0002***
Logistic (u=2000)	Quartic	0.9901	0.5327	1.798e-010***	0.9097	0.0002***

NOTE: (i) Bold implies most preferred of the nine models.
(ii) + implies exact multicollinearity made other forms of the variable to be omitted.
(iii) The maximum COVID-19 confirmed cases for the period of study was1932.

by Kuranga *et al.* [17] is often being used to test for the assumption of normality of error terms; and the Least Absolute Deviation (LAD) estimator, a robust estimation method originated by KF Gauss and PS Laplace as mentioned by Taylor [27], is often recommended for handling parameter estimation of models with non-normal error terms or outliers [19,24]. These test statistics and estimators were also found useful in this study. Consequently in this study, we adopted these five (5) estimators and utilized proportion of variation explained by each estimator through their Adjusted coefficient of determination (Adj. R^2) as a major criterion for a model to be used prediction and forecast purpose. For each of the four (4) forms in a particular model, a form was preferred if it has the highest Adj. R^2 among the four (4) forms; and most preferred if it has the highest Adj. R^2 among the preferred forms and hence called the best model. An estimator was considered best, among the estimators considered, if it gives highest Adj. R^2 when applied to the best model. The best one and the competing ones were employed to produce forecast values. We adopted the [10], to achieve all these in this study.

3. Results and discussion

Results obtained from the analysis carried out on COVID-19 confirmed cases, discharged cases and death cases are presented as follows:

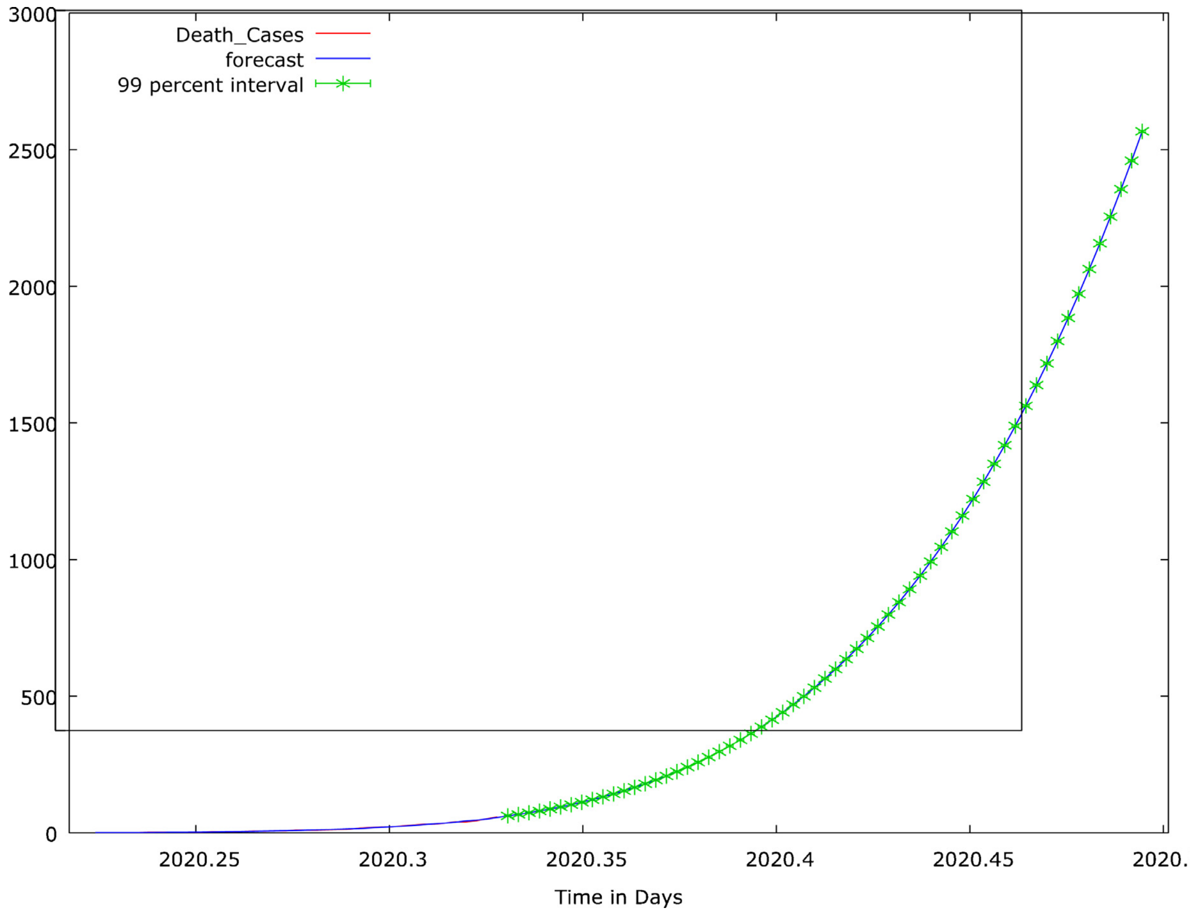

Fig. 10. Death COVID-19 Cases for First Sixty Four Days and its forecast values for May and June, 2020: PW Estimator.
Source: **Source:** Appendix C

3.1. COVID-19 Confirmed Cases

We presented the form of the model that gave the highest value of adjusted coefficient of determination in Table 1 with some other relevant results.

From Table 1, we preferred the quartic form for all the models except under Logarithm and Inverse model. At these exceptions, the simple form is most preferred. However, they were removed by the software due to exact multicollinearity that exists among the independent variables. Also, the Durbin-Watson statistic shows that the models possess autocorrelation problems; and that the residuals are non-normal except in linear model. Thus, the quartic form linear regression model is identified as the most preferred model and hence classified as the best model. The parameter estimation of the most preferred model using OLS estimator is available in Table 2. Result reveals that the data set has an autocorrelation problem (P-value of DW Statistic <0.01); and this was addressed using CORC, HILU, and PW estimators. All these estimators indicated that time factors have a significant contribution to the COVID-19 confirmed cases reported. However, their residuals were not normally distributed (P-value of Shapiro-Wilk <0.001); and this eventually brought in the idea of using the LAD estimator as an alternative estimator. Of all these estimators, the HILU estimator is best. We used HILU and LAD estimator for forecasting. The forecast values for May and June 2020 for the two (2) estimators are provided in Appendix A and pictorially presented in Figs. 5 and 6. From the appendix and Figs. 5 and 6, it is expected that the increase in the next two (2) months shall be alarming; increase from 1,932 cases to 107,678 cases by the HILU estimator and from 1,932 cases to 64,070 cases by the LAD estimator. Therefore, there are needs for a tactical and robust approach for COVID-19 confirmed case number not to get out of control.

3.2. COVID-19 Discharged Cases

By the adjusted coefficient of determinations (Adj.R^2) presented in Table 3, we generally preferred the Quartic form of the models except in Logarithm and Power model. At these instances, the simple form is most preferred. The most preferred model is the Linear Regression Model even though those of Compound, Growth and Exponential compete favourably. Furthermore, we observed that all the models have an auto-regressive error of order one (P-value of DW<0.01) and that the residuals of the models, except Linear and Inverse, are not normally distributed (SW P-value<0.1).

The results of the parameter estimation of the most preferred model using OLS estimator and the other three (3) estimators are available in Table 4. From the OLS results, the two observed problems are in the residual. These are autocorrelation problem (P-value of DW Statistic < 0.05) and problem of non-normality (P-value of SW Statistic < 0.1).

Addressing these problems respectively with CORC, HILU and PW estimators; and the LAD estimator, the best estimators, are identified to be CORC and HILU estimators in that they have the highest Adj.R^2.

Meanwhile, the effect of time as the independent variable is not significant in all the estimators (P-value >0.1). It might be due to the inevitable multicollinearity problem. Furthermore, the non-normality of the residuals of the autocorrelation problem handling

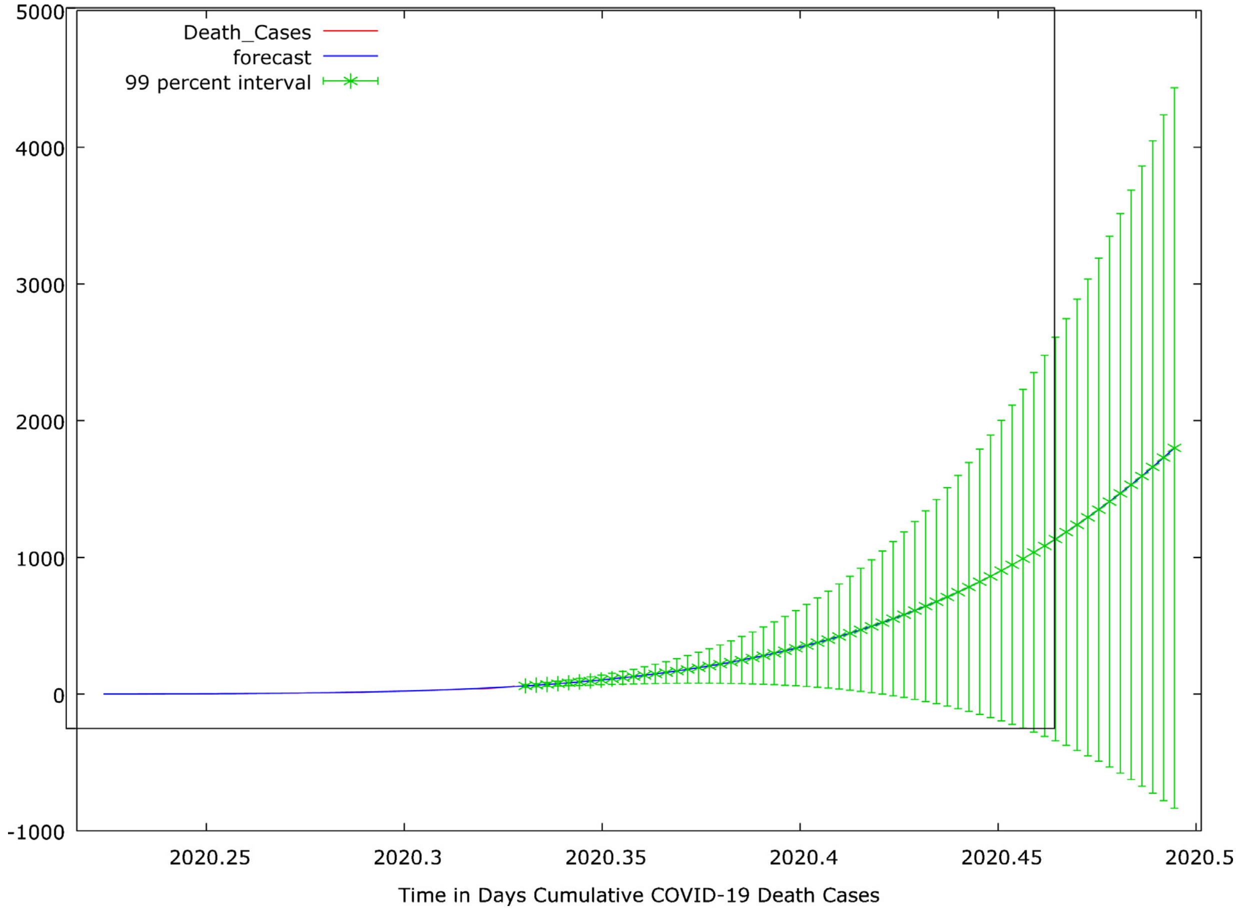

Fig. 11. Death COVID-19 Cases for First Sixty Four Days and its forecast values for May and June, 2020: LAD Estimator.
Source: **Source:** Appendix C

Table 2
Results of the most preferred model with the estimators: COVID-19 Confirmed Cases.

Estimator		Estimation Methods				
		OLS	CORC	HILU	PW	LAD
$\hat{\beta}_0$	Estimate	82.7245	973.484	2202.75	26.5725	86.4171
	Std. Error	22.9895	282.385	657.795	44.5336	53.7316
	T-value	3.598	3.447	3.349	0.5967	1.608
	P-value	0.0007***	0.0011***	0.0014***	0.553	0.1131
$\hat{\beta}_1$	Estimate	-29.3698	-137.069	-236.525	-21.3927	-26.1172
	Std. Error	4.8198	34.8878	65.3742	8.8188	11.6074
	T-value	-6.094	-3.929	-3.618	-2.426	-2.250
	P-value	9.04e-08***	0.0002***	0.0006***	0.0184**	0.0282**
$\hat{\beta}_2$	Estimate	2.4042	7.09748	10.2454	2.1892	2.0848
	Std. Error	0.29825	1.53021	2.4873	0.5831	0.7606
	T-value	8.061	4.638	4.119	3.754	2.741
	P-value	4.3e-011***	2.1e-05***	0.0001***	0.0004***	0.0081***
$\hat{\beta}_3$	Estimate	-0.0673	-0.1533	-0.1984	-0.0676	-0.0587
	Std. Error	0.0069	0.028	0.0414	0.0137	0.0185
	T-value	-9.791	-5.483	-4.791	-4.926	-3.166
	P-value	5.6e-014***	9.5e-07***	1.2e-05***	7.1e-06***	0.0024
$\hat{\beta}_4$	Estimate	0.0007	0.001243	0.0015	0.0007	0.0006
	Std. Error	5.2438e-05	0.0002	0.0003	0.0001	0.0001
	T-value	13.00	6.885	5.920	6.861	4.103
	P-value	5.7e-019***	4.6e-09***	1.8e-07***	4.7e-09***	0.0001***
$\hat{\rho}$				0.889991	0.896892	
Adj. R2		0.995909	0.994873	0.998779	0.998562	0.994562
DW	Stat-value	0.3204	1.7542	1.8352	1.5832	0.3035
	P-value	4.8e-013***				
SW	Stat-value	0.9695	0.8667	0.8484	0.9010	
	P-value	0.113699	6.3e-006***	1.7e-006***	8.7e-005***	

Note: (i)** and *** imply significance at alpha = 0.05 and 0.01 respectively.

Table 3
Results of Preferred Model with OLS estimator in each of the Nine Curve Estimation models: COVID-19 Discharged Cases.

Models	Form	Adj.R^2	DW-test		SW-test	
			Value	P-value	Value	P-value
Linear	Quartic	0.9925	0.6965	4.69e-009 ***	0.9724	0.3819
Logarithm	Simple+	0.5613	0.0656	7.029e-01***	0.8965	0.001***
Inverse	Quartic	0.7682	0.3143	1.798e-010***	0.9733	0.4078
Power	Simple+	0.8857	0.2762	3.954e-012***	0.8803	0.0003***
Compound	Quartic	0.9918	1.448	0.005***	0.9503	0.0613*
S-Curve	Quartic	0.9826	1.172	0.0007***	0.9128	0.0031***
Growth	Quartic	0.9918	1.4478	0.005***	0.0613	0.0613*
Exponential	Quartic	0.9918	1.4478	0.005***	0.0613	0.0613*
Logistic(u=350)	Quartic	0.9916	1.3065	0.0010***	0.9694	0.3003

NOTE: (i) Bold implies most preferred of the nine models.
(ii) + implies exalt multicollinearity made other forms of the variable to be omitted.
(iii) The maximum COVID-19 discharged cases for the period of study was 319.

Table 4
Results of the most preferred model with the estimators: COVID-19 Discharged Cases.

Estimator		Estimation Methods				
		OLS	CORC	HILU	PW	LAD
$\hat{\beta}_0$	Estimate	8.8236	87.4791	91.4391	7.13149	0.4897
	Std. Error	9.3703	69.7831	72.8257	13.8694	5.2657
	T-value	0.9417	1.254	1.256	0.5142	0.093
	P-value	0.3523	0.2179	0.2171	0.6101	0.9264
$\hat{\beta}_1$	Estimate	-3.0062	-19.9917	-20.6673	-3.6692	0.6712
	Std. Error	2.8784	14.5542	15.0457	4.403	2.1814
	T-value	-1.044	-1.374	-1.374	-0.8333	0.3077
	P-value	0.3029	0.1778	0.1778	0.4099	0.76
$\hat{\beta}_2$	Estimate	0.1972	1.4509	1.4928	0.344	-0.1777
	Std. Error	0.2618	1.0268	1.0551	0.4165	0.2679
	T-value	0.7532	1.413	1.415	0.8259	-0.6633
	P-value	0.456	0.166	0.1655	0.414	0.5111
$\hat{\beta}_3$	Estimate	0.0037	-0.0339	-0.035	-0.0036	0.0169
	Std. Error	0.0089	0.0294	0.0301	0.0143	0.0117
	T-value	0.4131	-1.154	-1.164	-0.2496	1.443
	P-value	0.6819	0.2558	0.2517	0.8042	0.1572
$\hat{\beta}_4$	Estimate	-6.89e-05	0.0003	0.0003	3.28e-05	-0.0002
	Std. Error	0.0001	0.0003	0.0003	0.0002	0.0002
	T-value	-0.687	1.101	1.114	0.2032	-1.39
	P-value	0.4963	0.2779	0.2726	0.8401	0.1726
$\hat{\rho}$			0.7133	0.719	0.6968	
Adj. R2		0.992512	0.993402	0.993402	0.993328	0.9932
DW	Stat-value	0.6965	2.0548	2.0669	1.9497	2.06048
	P-value	4.7e-009***				
SW	Stat-value	0.9724	0.8717	0.8676	0.8622	0.8434
	P-value	0.3819	0.0002***	0.0002***	0.0001***	3.6e-005***

Note: (i) *** implies significance at alpha = 0.01.

Table 5
Results of Preferred Model with OLS estimator in each of the Nine Curve Estimation models: COVID-19 Death Cases.

Models	Form	Adj. R^2	DW-test		SW- test	
			Value	P-value	Value	P-value
Linear	Quartic	0.9953	1.3563	0.0021***	0.9581	0.153984
Logarithm	Simple+	0.4988	0.0703	3.63e-011***	0.8552	0.0001***
Inverse	Quartic	0.6856	0.2494	1.798e-015***	0.9449	0.0553*
Power	Simple+	0.842	0.2441	1.798e-015***	0.945971	0.0602*
Compound	Quartic	0.9896	1.6627	0.0345106**	0.97267	0.4513
S-Curve	Quartic	0.9518	0.6449	7.704e-008***	0.9751	0.5301
Growth	Quartic	0.9896	1.6627	0.0345106**	0.97267	0.4513
Exponential	Quartic	0.9896	1.6627	0.0345106**	0.97267	0.4513
Logistic(u=60)	Quartic	0.9824	1.2658	0.00074***	0.941344	0.0422**

NOTE: (i) Bold implies most preferred of the nine models.
(ii) + implies exact multicollinearity made other forms of the variable to be omitted.
(iii) The cumulative death cases recorded within the period was 58.

Table 6
Results of the most preferred model with the estimators: COVID-19 Death Cases.

Estimator		Estimation Methods				
		OLS	CORC	HILU	PW	LAD
$\hat{\beta}_0$	Estimate	1.1464	1.9173	1.9189	1.3449	1.0711
	Std. Error	1.0108	2.447	2.4494	1.2579	0.8036
	T-value	1.134	0.7835	0.7834	1.069	1.333
	P-value	0.2647	0.4389	0.439	0.2925	0.1915
$\hat{\beta}_1$	Estimate	-0.117	-0.3897	-0.3902	-0.2352	-0.0958
	Std. Error	0.3407	0.7087	0.7093	0.43189	0.3297
	T-value	-0.3434	-0.5499	-0.5502	-0.5446	-0.2907
	P-value	0.7334	0.5861	0.5859	0.5896	0.7731
$\hat{\beta}_2$	Estimate	0.0308	0.0591	0.0592	0.0462	0.0252
	Std. Error	0.034	0.0639	0.0639	0.0437	0.0384
	T-value	0.9052	0.9258	0.926	1.058	0.6576
	P-value	0.3717	0.3613	0.3612	0.2973	0.5152
$\hat{\beta}_3$	Estimate	-0.0009	-0.002	-0.002	-0.0015	-0.0005
	Std. Error	0.0013	0.0022	0.0022	0.0016	0.0016
	T-value	-0.6694	-0.8767	-0.8770	-0.9354	-0.2741
	P-value	0.5078	0.3870	0.3868	0.3562	0.7857
$\hat{\beta}_4$	Estimate	2.7e-05	4.13e-05	4.13e-05	3.66e-05	2.007e-05
	Std. Error	1.56e-05	2.63e-05	2.63e-05	2.03e-05	2.323e-05
	T-value	1.717	1.569	1.569	1.801	0.8643
	P-value	0.095*	0.1262	0.1262	0.0805*	0.3935
$\hat{\rho}$			0.347	0.347	0.3389	
Adj. R2	0.995342	0.995638	0.9956	0.995737	0.995047	
DW	Stat-value	1.3563	1.7146	1.7151	1.7056	1.23802
	P-value	0.0021***				
SW	Stat-value	0.9581	0.9576	0.9576	0.9571	0.918514
	P-value	0.15398	0.1585	0.1581	0.1428	0.0078***

Note: (i)*and *** imply significance at alpha = 0.1 and 0.01respectively.

Table 7
Comparison of forecast values with the true values.

COVID-19 Cases	Date	TV	ESTIMATORS							
			CORC		HILU		PW		LAD	
			FV	99%CI	FV	99%CI	FV	99%CI	FV	99%CI
Confirmed	01/05/2020	2170			2134	2091			1998	1776
						2178				2220
	02/05/2020	2388			2355	2297			2177	1912
						2414				2442
	03/05/2020	2558			2596	2528			2369	2056
						2664				2682
	04/05/2020	2802			2856	2783			2574	2206
						2931				2943
	05/05/2020	2950			**3140**	**3061**			2794	2365
						3219				3223
Discharged	01/05/2020	351	338	316	338	316			291	199
				359		359				385
	02/05/2020	385	358	331	358	332			298	184
				385		385				412
	03/05/2020	400	380	351	380	352			304	165
				409		410				443
	04/05/2020	417	404	374	405	375			308	141
				434		435				475
	05/05/2020	481	**430**	**400**	**431**	**401**			311	112
				461		**462**				510
Death	01/05/2020	68					**62**	**59**	60	50
								65		69
	02/05/2020	85					**67**	**64**	**65**	**53**
								70		**77**
	03/05/2020	87					**73**	**70**	**70**	**56**
								76		**86**
	04/05/2020	93					**80**	**77**	76	58
								83		95
	05/05/2020	98					**87**	**84**	83	61
								90		104

Note: Forecast values not conforming to the true values are bold estimators necessitated the use of LAD as an alternative estimator. Thus, we adopted the CORC, HILU and the LAD estimators for forecasting and their forecast values, in Appendix B, are pictorially presented in logarithm form in Figs. 7–9. If existing measures and structures are maintained and improved upon, the recovery cases will increase from 319 to about 13,000 cases. However, the LAD estimator reveals a situation whereby, instead of having recovery cases increasing, it may be static since the cumulative cases can't decrease.

3.3. COVID-19 Death Cases

We employed the OLS estimator to analyse the nine statistical models in Table 5. From the table, the preferred form of the model is generally Quartic except in Logarithm and Power where exact multicollinearity prevented others forms to be used in the analysis. All these preferred models have autocorrelation problem (P-value of DW Statistic < 0.01); only the residuals of Logarithm, Inverse, Power and Logistic do not follow normal distribution (P-value of SW Statistic < 0.1). Thus, the most preferred model is the Linear Regression Model with Quartic form having explained 99.53% of the variation in COVID-19 death cases.

The parameter estimation of the most preferred model using OLS estimator is available in Table 6. From the results, there is the presence of autocorrelation. Addressing the autocorrelation problem with CORC, HILU and PW only produced estimates slightly better than the OLS. Moreover, the quartic time variable only has a significant impact (P-value$<$0.1) on cumulative of COVID-19 death cases using the OLS and PW estimators. Consequently, it became necessary to adopt the LAD estimator, a robust estimation method for comparison. Eventually, we employed the PW and LAD estimators for forecasting because of their performance. The results are provided in Appendix C and shown in Figures 10 and 11. The forecast results for the next two months revealed that death cases would increase from 58 to 1800 and 2567, respectively, with the use of LAD and PW estimator. Moreover, forecast values from LAD estimator indicate a situation whereby cumulative COVID-19 death cases may be static since it can't decrease. This increase in death cases is alarming and therefore, effective planning and action are required to be able to avert this incidence.

3.4. Models Assessment with Observed/True values (TV)

The COVID-19 data for the first five days in May 2020 were further collected and compared with the forecast value (FV). These values are presented as follows in Table 7. From the table, we observed that the observed original values are in agreement with the forecast values except on few cases especially on the fifth day. Notwithstanding, the actual values and forecast values of LAD estimator are most frequently in agreement; and so, we recommend the estimator.

4. Conclusion

This study provided the statistical curve model for the daily cumulative reported COVID-19 confirmed cases, discharged cases and death cases in Nigeria using data collected by the Nigeria Centre for Disease Control (NCDC) for the first sixty-four days of the incidence using five estimation methods. It further identified the best model for each of the variables and used the same to forecast for May and June 2020. Comparing the actual values with the forecast ones in the first five days of May 2020, we recommended the forecast values of the LAD estimator because of its precision. The forecast values are alarming and therefore require serious planning and intervention by the Government to avoid the pandemic becoming a huge health problem for the country.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Forecast vales of COVID-19 confirmed cases for May and June, 2020

	HILU			LAD		
		99% C.I.			99% C.I.	
DATE	F.V	L.V	U.V	F.V	L.V	U.V
1/5/2020	2134.49	2090.91	2178.07	1997.93	1776.17	2219.7
2/5/2020	2355.38	2297.04	2413.71	2177.03	1912.4	2441.67
3/5/2020	2595.81	2528.02	2663.59	2369.03	2055.6	2682.45
4/5/2020	2856.95	2782.53	2931.37	2574.54	2206.24	2942.84
5/5/2020	3140.03	3060.75	3219.31	2794.21	2364.7	3223.72
6/5/2020	3446.29	3363.36	3529.22	3028.69	2531.36	3526.02
7/5/2020	3777.02	3691.3	3862.73	3278.65	2706.58	3850.72
8/5/2020	4133.53	4045.68	4221.38	3544.77	2890.7	4198.84
9/5/2020	4517.19	4427.68	4606.7	3827.75	3084.07	4571.43
10/5/2020	4929.38	4838.58	5020.18	4128.3	3287.02	4969.58
11/5/2020	5371.54	5279.72	5463.35	4447.15	3499.89	5394.41
12/5/2020	5845.12	5752.51	5937.73	4785.03	3723.02	5847.05
13/5/2020	6351.63	6258.4	6444.86	5142.71	3956.74	6328.69
14/5/2020	6892.6	6798.88	6986.32	5520.96	4201.4	6840.51
15/5/2020	7469.61	7375.5	7563.71	5920.55	4457.35	7383.75
16/5/2020	8084.25	7989.84	8178.66	6342.29	4724.93	7959.65
17/5/2020	8738.17	8643.52	8832.83	6787	5004.49	8569.5
18/5/2020	9433.05	9338.21	9527.9	7255.5	5296.4	9214.59
19/5/2020	10170.6	10075.6	10265.6	7748.63	5601.01	9896.25
20/5/2020	10952.6	10857.5	11047.7	8267.26	5918.7	10615.8
21/5/2020	11780.7	11685.5	11876	8812.26	6249.82	11374.7
22/5/2020	12656.9	12561.7	12752.2	9384.52	6594.76	12174.3
23/5/2020	13583	13487.7	13678.4	9984.93	6953.9	13016
24/5/2020	14560.9	14465.5	14656.3	10614.4	7327.62	13901.2
25/5/2020	15592.4	15497	15687.8	11273.9	7716.32	14831.5
26/5/2020	16679.6	16584.2	16775.1	11964.4	8120.38	15808.4
27/5/2020	17824.5	17729	17920	12686.8	8540.2	16833.3
28/5/2020	19029.1	18933.6	19124.6	13442	8976.2	17907.8
29/5/2020	20295.4	20199.9	20390.9	14231.2	9428.77	19033.6
30/5/2020	21625.6	21530.1	21721.1	15055.2	9898.34	20212.1
31/5/2020	23021.8	22926.2	23117.3	15915.1	10385.3	21445
1/6/2020	24486.2	24390.6	24581.7	16812	10890.1	22733.9
2/6/2020	26020.9	25925.4	26116.5	17746.9	11413.2	24080.6
3/6/2020	27628.4	27532.8	27723.9	18720.8	11955	25486.7
4/6/2020	29310.7	29215.2	29406.3	19734.9	12516	26953.9
5/6/2020	31070.3	30974.8	31165.9	20790.2	13096.5	28483.9
6/6/2020	32909.5	32814	33005.1	21887.8	13697	30078.7
7/6/2020	34830.7	34735.2	34926.3	23028.9	14318.1	31739.8
8/6/2020	36836.4	36740.8	36931.9	24214.6	14960	33469.2
9/6/2020	38928.8	38833.3	39024.4	25446.1	15623.5	35268.7
10/6/2020	41110.7	41015.2	41206.3	26724.4	16308.7	37140.1
11/6/2020	43384.5	43288.9	43480.1	28050.9	17016.4	39085.3
12/6/2020	45752.8	45657.2	45848.3	29426.6	17746.9	41106.3
13/6/2020	48218.1	48122.5	48313.7	30852.8	18500.7	43205
14/6/2020	50783.2	50687.6	50878.7	32330.8	19278.3	45383.3
15/6/2020	53450.6	53546.2	53355.1	33861.7	20080.2	47643.3
16/6/2020	56223.2	56127.6	56318.8	35446.9	20906.9	49986.9
17/6/2020	59103.6	59008	59199.2	37087.6	21758.9	52416.2
18/6/2020	62094.7	61999.1	62190.2	38785	22636.8	54933.2
19/6/2020	65199.2	65103.6	65294.7	40540.5	23541	57540
20/6/2020	68420	68324.4	68515.6	42355.4	24472	60238.8
21/6/2020	71760	71664.4	71855.6	44231	25430.4	63031.6
22/6/2020	75222.1	75126.6	75317.7	46168.7	26416.8	65920.6
23/6/2020	78809.4	78713.8,	78904.9	48169.8	27431.5	68908
24/6/2020	82524.7	82429.1	82620.2	50235.6	28475.3	71996
25/6/2020	86371.1	86275.5	86466.6	52367.7	29548.6	75186.8
26/6/2020	90351.6	90256.1	90447.2	54567.3	30652	78482.7
27/6/2020	94469.5	94373.9	94565.1	56836	31786	81886
28/6/2020	98727.8	98632.2	98823.3	59175	32951.2	85398.9
29/6/2020	103130	103034	103225	61585.9	34148.1	89023.8
30/6/2020	107678	107583	107774	64070.2	35377.4	92763

Appendix B. Forecast vales of COVID-19 confirmed cases for May and June, 2020

	CORC			HILU			LAD		
		99% C.I.			99% C.I.			99% C.I.	
DATE	F.V	L.V	U.V	F.V	L.V	U.V	F.V	L.V	U.V
1/5/2020	337.634	315.966	359.302	337.826	316.158	359.494	291.609	198.702	384.516
2/5/2020	358.013	331.397	384.628	358.406	331.718	385.094	298.421	184.439	412.404
3/5/2020	380.186	351.378	408.994	380.802	351.858	409.747	304.034	165.471	442.596
4/5/2020	404.237	374.375	434.098	405.109	375.065	435.154	308.304	141.456	475.152
5/5/2020	430.275	399.892	460.659	431.445	400.847	462.043	311.085	112.018	510.152
6/5/2020	458.431	427.786	489.077	459.948	429.068	490.828	312.225	76.7531	547.696
7/5/2020	488.853	458.075	519.631	490.772	459.748	521.797	311.566	35.2337	587.897
8/5/2020	521.703	490.858	552.548	524.088	492.989	555.188	308.945	-12.9903	630.879
9/5/2020	557.155	526.276	588.035	560.076	528.938	591.214	304.193	-68.3885	676.775
10/5/2020	595.396	564.499	626.293	598.928	567.77	630.086	297.138	-131.449	725.726
11/5/2020	636.621	605.715	667.526	640.848	609.68	672.016	287.6	-202.677	777.878
12/5/2020	681.035	650.125	711.946	686.048	654.874	717.221	275.395	-282.594	833.385
13/5/2020	728.855	697.942	759.767	734.748	703.572	765.925	260.333	-371.74	892.407
14/5/2020	780.301	749.387	811.215	787.181	756.003	818.358	242.219	-470.669	955.107
15/5/2020	835.606	804.692	866.521	843.583	812.405	874.762	220.853	-579.951	1021.66
16/5/2020	895.01	864.095	925.924	904.204	873.025	935.382	196.029	-700.172	1092.23
17/5/2020	958.76	927.845	989.674	969.297	938.118	1000.48	167.535	-831.934	1167
18/5/2020	1027.11	996.196	1058.03	1039.13	1007.95	1070.31	135.157	-975.853	1246.17
19/5/2020	1100.33	1069.41	1131.24	1113.97	1082.79	1145.15	98.6706	-1132.56	1329.9
20/5/2020	1178.68	1147.77	1209.59	1194.1	1162.92	1225.28	57.8505	-1302.71	1418.41
21/5/2020	1262.45	1231.53	1293.36	1279.8	1248.62	1310.98	12.4636	-1486.96	1511.89
22/5/2020	1351.92	1321	1382.83	1371.38	1340.2	1402.56	-37.7276	-1685.99	1610.53
23/5/2020	1447.39	1416.47	1478.3	1469.14	1437.96	1500.32	-92.9663	-1900.49	1714.55
24/5/2020	1549.15	1518.24	1580.07	1573.39	1542.21	1604.56	-153.501	-2131.17	1824.17
25/5/2020	1657.53	1626.62	1688.45	1684.44	1653.26	1715.62	-219.585	-2378.75	1939.58
26/5/2020	1772.84	1741.92	1803.75	1802.64	1771.46	1833.81	-291.478	-2643.98	2061.02
27/5/2020	1895.39	1864.48	1926.31	1928.3	1897.12	1959.48	-369.445	-2927.61	2188.72
28/5/2020	2025.54	1994.62	2056.45	2061.79	2030.61	2092.97	-453.755	-3230.4	2322.89
29/5/2020	2163.61	2132.7	2194.53	2203.45	2172.27	2234.62	-544.682	-3553.14	2463.77
30/5/2020	2309.96	2279.05	2340.88	2353.63	2322.45	2384.81	-642.509	-3896.63	2611.61
31/5/2020	2464.94	2434.03	2495.86	2512.72	2481.54	2543.9	-747.52	-4261.68	2766.64
1/6/2020	2628.92	2598.01	2659.84	2681.08	2649.9	2712.25	-860.007	-4649.13	2929.12
2/6/2020	2802.27	2771.36	2833.19	2859.09	2827.91	2890.27	-980.265	-5059.82	3099.29
3/6/2020	2985.37	2954.46	3016.29	3047.16	3015.98	3078.34	-1108.6	-5494.6	3277.4
4/6/2020	3178.61	3147.69	3209.52	3245.68	3214.5	3276.86	-1245.31	-5954.35	3463.73
5/6/2020	3382.38	3351.46	3413.29	3455.05	3423.87	3486.23	-1390.72	-6439.97	3658.53
6/6/2020	3597.08	3566.16	3627.99	3675.7	3644.52	3706.88	-1545.14	-6952.36	3862.07
7/6/2020	3823.13	3792.21	3854.04	3908.05	3876.87	3939.23	-1708.89	-7492.43	4074.64
8/6/2020	4060.94	4030.02	4091.85	4152.53	4121.35	4183.7	-1882.31	-8061.12	4296.49
9/6/2020	4310.94	4280.02	4341.85	4409.57	4378.39	4440.75	-2065.73	-8659.38	4527.93
10/6/2020	4573.57	4542.65	4604.48	4679.64	4648.46	4710.81	-2259.48	-9288.18	4769.22
11/6/2020	4849.26	4818.34	4880.17	4963.17	4931.99	4994.35	-2463.91	-9948.5	5020.68
12/6/2020	5138.46	5107.55	5169.38	5260.64	5229.47	5291.82	-2679.38	-10641.3	5282.58
13/6/2020	5441.64	5410.72	5472.55	5572.53	5541.35	5603.71	-2906.23	-11367.7	5555.23
14/6/2020	5759.25	5728.34	5790.17	5899.3	5868.12	5930.47	-3144.82	-12128.6	5838.94
15/6/2020	6091.78	6060.86	6122.69	6241.44	6210.26	6272.62	-3395.53	-12925.1	6134.02
16/6/2020	6439.69	6408.77	6470.6	6599.46	6568.28	6630.64	-3658.73	-13758.2	6440.76
17/6/2020	6803.48	6772.56	6834.39	6973.85	6942.67	7005.03	-3934.78	-14629.1	6759.51
18/6/2020	7183.64	7152.72	7214.55	7365.13	7333.95	7396.31	-4224.08	-15538.7	7090.57
19/6/2020	7580.67	7549.76	7611.59	7773.81	7742.63	7804.99	-4527	-16488.3	7434.27
20/6/2020	7995.1	7964.18	8026.01	8200.43	8169.25	8231.61	-4843.95	-17478.8	7790.94
21/6/2020	8427.43	8396.51	8458.34	8645.51	8614.34	8676.69	-5175.32	-18511.6	8160.92
22/6/2020	8878.19	8847.27	8909.1	9109.61	9078.43	9140.79	-5521.52	-19587.6	8544.55
23/6/2020	9347.92	9317	9378.83	9593.28	9562.1	9624.46	-5882.95	-20708.1	8942.17
24/6/2020	9837.15	9806.24	9868.07	10097.1	10065.9	10128.2	-6260.02	-21874.2	9354.13
25/6/2020	10346.4	10315.5	10377.4	10621.5	10590.4	10652.7	-6653.16	-23087.1	9780.77
26/6/2020	10876.4	10845.4	10907.3	11167.3	11136.1	11198.5	-7062.79	-24348	10222.5
27/6/2020	11427.4	11396.5	11458.4	11734.9	11703.7	11766.1	-7489.34	-25658.3	10679.6
28/6/2020	12000.3	11969.4	12031.2	12324.9	12293.7	12356.1	-7933.25	-27019	11152.5
29/6/2020	12595.5	12564.6	12626.4	12938	12906.8	12969.2	-8394.95	-28431.4	11641.5
30/6/2020	13213.6	13182.7	13244.5	13574.7	13543.5	13605.9	-8874.9	-29896.8	12147

Appendix C. Forecast vales of COVID-19 death cases for May and June, 2020

	PW			LAD		
		99% C.I.			99% C.I.	
DATE	F.V	L.V	U.V	F.V	L.V	U.V
1/5/2020	62.1187	59.316	64.9214	60.1645	50.4	69.9291
2/5/2020	67.4243	64.4651	70.3836	65.2303	53.0899	77.3706
3/5/2020	73.4412	70.4645	76.4179	70.6406	55.714	85.5673
4/5/2020	80.0263	77.0476	83.005	76.4128	58.2577	94.568
5/5/2020	87.1501	84.1712	90.1291	82.5647	60.7041	104.425
6/5/2020	94.8222	91.8433	97.8011	89.1144	63.0345	115.194
7/5/2020	103.066	100.087	106.045	96.0807	65.228	126.933
8/5/2020	111.909	108.93	114.888	103.483	67.2626	139.703
9/5/2020	121.384	118.405	124.363	111.341	69.1148	153.566
10/5/2020	131.521	128.542	134.5	119.674	70.7597	168.588
11/5/2020	142.355	139.376	145.334	128.504	72.1715	184.836
12/5/2020	153.92	150.941	156.899	137.851	73.3229	202.379
13/5/2020	166.25	163.271	169.229	147.737	74.1857	221.289
14/5/2020	179.383	176.404	182.362	158.185	74.7306	241.639
15/5/2020	193.354	190.375	196.333	169.216	74.9271	263.506
16/5/2020	208.202	205.223	211.181	180.855	74.7436	286.966
17/5/2020	223.965	220.986	226.944	193.123	74.1476	312.099
18/5/2020	240.683	237.704	243.662	206.047	73.1054	338.988
19/5/2020	258.396	255.417	261.375	219.649	71.5823	367.715
20/5/2020	277.145	274.166	280.124	233.955	69.5425	398.367
21/5/2020	296.974	293.995	299.953	248.99	66.9493	431.031
22/5/2020	317.924	314.945	320.903	264.781	63.7646	465.798
23/5/2020	340.04	337.061	343.019	281.354	59.9497	502.758
24/5/2020	363.366	360.387	366.345	298.735	55.4646	542.006
25/5/2020	387.949	384.97	390.928	316.953	50.2682	583.638
26/5/2020	413.834	410.855	416.813	336.035	44.3185	627.751
27/5/2020	441.07	438.091	444.049	356.009	37.5725	674.445
28/5/2020	469.705	466.726	472.683	376.904	29.986	723.822
29/5/2020	499.787	496.808	502.766	398.75	21.5138	775.985
30/5/2020	531.367	528.388	534.346	421.576	12.1098	831.042
31/5/2020	564.496	561.517	567.475	445.413	1.7266	889.099
1/6/2020	599.225	596.246	602.204	470.291	-9.684	950.266
2/6/2020	635.608	632.63	638.587	496.242	-22.1713	1014.66
3/6/2020	673.699	670.72	676.678	523.297	-35.7858	1082.38
4/6/2020	713.55	710.571	716.529	551.489	-50.5788	1153.56
5/6/2020	755.219	752.24	758.198	580.851	-66.6028	1228.3
6/6/2020	798.76	795.781	801.739	611.415	-83.9112	1306.74
7/6/2020	844.232	841.253	847.211	643.215	-102.559	1388.99
8/6/2020	891.692	888.713	894.671	676.285	-122.601	1475.17
9/6/2020	941.199	938.22	944.178	710.66	-144.094	1565.41
10/6/2020	992.813	989.834	995.792	746.376	-167.096	1659.85
11/6/2020	1046.59	1043.62	1049.57	783.467	-191.665	1758.6
12/6/2020	1102.61	1099.63	1105.58	821.969	-217.862	1861.8
13/6/2020	1160.91	1157.93	1163.89	861.92	-245.747	1969.59
14/6/2020	1221.56	1218.58	1224.54	903.357	-275.381	2082.09
15/6/2020	1284.64	1281.66	1287.62	946.316	-306.828	2199.46
16/6/2020	1350.2	1347.22	1353.18	990.836	-340.152	2321.82
17/6/2020	1418.31	1415.33	1421.28	1036.96	-375.417	2449.33
18/6/2020	1489.03	1486.05	1492.01	1084.71	-412.689	2582.11
19/6/2020	1562.44	1559.46	1565.42	1134.15	-452.036	2720.33
20/6/2020	1638.6	1635.62	1641.58	1185.3	-493.526	2864.13
21/6/2020	1717.58	1714.61	1720.56	1238.21	-537.226	3013.65
22/6/2020	1799.46	1796.48	1802.44	1292.92	-583.209	3169.05
23/6/2020	1884.3	1881.32	1887.28	1349.47	-631.544	3330.49
24/6/2020	1972.18	1969.2	1975.15	1407.9	-682.304	3498.11
25/6/2020	2063.16	2060.18	2066.14	1468.26	-735.562	3672.08
26/6/2020	2157.32	2154.35	2160.3	1530.58	-791.393	3852.56
27/6/2020	2254.75	2251.77	2257.73	1594.92	-849.871	4039.71
28/6/2020	2355.5	2352.52	2358.48	1661.31	-911.074	4233.69
29/6/2020	2459.67	2456.69	2462.64	1729.79	-975.078	4434.66
30/6/2020	2567.32	2564.34	2570.29	1800.42	-1041.96	4642.81

CRediT authorship contribution statement

Kayode Ayinde: Conceptualization, Methodology, Formal analysis, Software, Writing - original draft. **Adewale F. Lukman:** Conceptualization, Methodology, Resources, Writing - original draft. **Rauf I. Rauf:** Conceptualization, Methodology, Resources, Supervision. **Olusegun O. Alabi:** Conceptualization, Methodology, Supervision. **Charles E. Okon:** Conceptualization, Methodology, Writing - original draft. **Opeyemi E. Ayinde:** Conceptualization, Methodology, Resources.

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