STATISTICAL MODELLING OF COVID-19 PANDEMIC

[1]Badmus, Nofiu Idowu; [2]Efuwape, Biodun Tajudeen; [3]Hammed, Fatai Akangbe and Ige, [4]Sikiru A.

[1]Department of Mathematics, University of Lagos, Akoka, Nigeria
[2&3]Department of Mathematical Science, Olabisi Onabanjo University, Ago-Iwoye, Nigeria
[4]Department of Mathematics, Yaba College of Technology, Yaba, Lagos, Nigeria
Corresponding Author Email: nibadmus@unilag.edu.ng

ABSTRACT

Coronavirus pandemic data is a family of clinical data which requires the attention of flexible model for modeling its nature. In this study, modeling and analysis based on the available data gathered from each state by the Nigeria Centre for Disease Control are carried-out on Nigerian cases of COVID-19 pandemic using some selected univariate continuous models include: Cauchy, Gumbel, Logistic, Lognormal and Weibull model to fit each data set from each case such as confirmed, discharged, deaths and total active case. Percentage of each case in the affected state are obtained and presented to ascertain the level at which each state has been affected by COVID-19. Secondary data collected from Nigeria centre for disease control site are used for the study; and the data consists 36 states including FCT Abuja. Therefore, with all indications the results shown from exploratory data analysis, goodness-of-fit criteria and statistics that Lognormal model has better fit to all the cases considered in the study than other models despite the outliers in the data sets of all cases.

Keywords: Cauchy, Clinical data, Coronavirus, Gumbel, Logistic, Lognormal, Outliers, Weibull

Accepted Date: *20 Nov., 20*

Introduction

Coronavirus is shortened as COVID-19 and was identified in Wuhan, China in December 12, 2019. World Health Organization (WHO, 2020) declared in January 30, 2020 that COVID-19 outbreak as the sixth public health emergency of international concern and called it pandemic in March 11, 2020. It was first identified in Lagos, Nigeria in February 27, 2020 and second case was in Ewekoro, Ogun State, Nigeria; (Olayiwola, 2020). In Nigeria as at Wednesday July 1, 2020; sample tested was: 141,525, confirmed cumulative 26,484 (male – 17,549 (66%) and female – 8,935 (34%)), discharged cumulative cases 10,152, confirmed cumulative fatalities603 affected states including FCT with 36 states in the country. Global updates: confirmed cases 10,357,662 and deaths cases 508,055 countries and territories affected is 213; the data is obtained from the official website of (NCDC) and assessed on July 2nd, 2020.

Recently, several authors and researchers have studied and proposed on the pandemic nationally and internationally. We review and report some of the works done on the pandemic as follows: (Olayiwola, 2020) statistically and critically based their work on modelling COVID-19 in Nigeria: The Lagos experience. (Ebenso & Out, 2020) asked that: Can Nigeria contain the COVID-19 outbreak using lessons from recent epidemics? Others like: (Miller *et al*., 2020), (Otitoloju *et al*., 2020), (Vaughan, 2020), (World Bank, 2020), (Nature Medicine, 2020), (Martinez-Alvarez *et al*., 2020) have written one thing or the other on the pandemic.

In this note, we based this study on modelling and analysis of four cases in Nigeria (confirmed, discharged, deaths and active) using some selected continuous univariate models such as: Cauchy, Gumbel, Logistic, Lognormal, Normal and Weibull model to fit data from each case. Percentage of each case in the affected states are obtained and presented to ascertain the level at which each state has been affected by COVID-19. Secondary data is used for the study and the data are from 36 states including FCT Abuja. We also used excel and R packages for the analysis.

The aim of this study is to detect the model that followed and fitted the distribution of each data set through goodness-of-fit statistics and criteria. Then, to analyze the data sets and summarize the characteristics of the data sets; and estimate the percentage of each case in each state and plotting the trend of COVID-19 in Nigeria to know whether is upwards or downwards in nature.

The rest of the article are arranged as follows: material and methods (models) are presented in section two. Section three contains results from the analysis, tables and figures are depict in section four, while section five consists both discussion and conclusion drawn from the study.

Materials and Methods

Cauchy Distribution

This distribution is one of the family of continuous distributions and it looks like the normal distribution with taller peak than a normal distribution. Unlike the normal distribution with fat tails. The Physists known and called it Lorentz distribution, while mathematicians relate it to the Poisson Kernel with fundamental solution for the Laplace equation in the upper half-plane. It is a stable distribution with probability density function (pdf) that can be expressed analytically. https://en.m.wikipedia.org/wiki/Cauchy_distribution.

Its density and distribution function is given as:

$$f_{t\{\alpha_0,\ \beta\}} = \frac{1}{\pi\beta\left[1+\left(\frac{t-\ \alpha_0}{\beta}\right)^2\right]} \qquad (2.1.1)$$

and

$$F_{t\{\alpha_0,\ \beta\}} = \frac{1}{\pi}\arctan\left(\frac{t-\ t_0}{\beta}\right)+\frac{1}{2} \qquad (2.1.2)$$

where, α_0 and β are location and scale parameter.

This distribution is used for robustness studies. It can also be used to model energy of unstable state in quantum mechanics (Grewel & Andrews, 2015). Some researchers have done great works on Cauchy distribution with other distributions e.g (Arnold & Beaver, 2000b) introduced the skew Cauchy distribution, the beta-Cauchy distribution by (Alshawarbeh *et al*., 2012), the beta-half-Cauchy distribution by (Cordeiro & Lemonte, 2011c) and so on.

Gumbel distribution

The Gumbel distribution can be used in probability theory and Statistics to model both maximum and minimum of a number of samples of different distributions. https://en.m.wikipedia.org/wiki/Gumbel_distribution.

The pdf, cdf, survival and hazard rate function are given below:

$$f_{t\{\alpha,\ \beta\}} = \frac{1}{\beta}\exp\left(-\ \frac{t-\ \alpha}{\beta}\right)\exp\left[-\exp\left(-\ \frac{t-\ \alpha}{\beta}\right)\right] \qquad (2.2.1)$$

its associating cdf is

$$F_{t\{\alpha,\ \beta\}} = \exp\left[-\ \exp\left(-\ \frac{t-\ \alpha}{\beta}\right)\right] \qquad (2.2.2)$$

Survival and hazard rate functions are:

$$R_{t\{\alpha,\ \beta\}} = 1-\ F_{t\{\alpha,\ \beta\}} = 1-\ \exp\left[-\ \exp\left(-\ \frac{t-\ \alpha}{\beta}\right)\right] \qquad (2.2.3)$$

and

$$FR_{t\{\alpha,\ \beta\}} = \frac{f_{t\{\alpha,\ \beta\}}}{R_{t\{\alpha,\ \beta\}}} = \frac{1}{\beta}\exp\left(-\ \frac{t-\ \alpha}{\beta}\right) \qquad (2.2.4)$$

Different authors have worked on mixture of Gumbel distribution with other distributions such as (Nadarajah & Kotz, 2004) had the beta Gumbel distribution, (Cordeiro *et al.,*2012), (Andrade *et al*., 2015), (Al-Aqtash*et al*., 2014)worked on Gumbel-Weibull, exponential and Gumbel distribution etc.

The Logistic Distribution

This is a distribution used in a certain type of regression called the logistic regression. It can also be used for growth model and modeling lifetime data. (Meeker & Escobar, 1998) discussed in their work that the shape of both logistic and normal distribution look very much alike. The density, distribution, survival and hazard function are:

$$f_{t\{\alpha,\ \beta\}} = \frac{e^{\left(\frac{t-\alpha}{\beta}\right)}}{\sigma\left(1+e^{\left(-\frac{t-\alpha}{\beta}\right)}\right)^2}, \quad -8 < t < 8, -8 < \alpha < 8, \beta > 0 \qquad (2.3.1)$$

where, α and β are location and rate parameter. The cdf is

$$F_{t\{\alpha,\ \beta\}} = \frac{e^{\left(\frac{t-\alpha}{\beta}\right)}}{1+e^{\left(-\frac{t-\alpha}{\beta}\right)}} \qquad (2.3.2)$$

The survival and hazard function are also given below:

$$R_{t\{\alpha,\ \beta\}} = 1 - F_{t\{\alpha,\ \beta\}} = \frac{1}{\left(1+e^{\left(-\frac{t-\alpha}{\beta}\right)}\right)} \qquad (2.3.3)$$

and

$$FR_{t\{\alpha,\ \beta\}} = \frac{f_{t\{\alpha,\ \beta\}}}{R_{t\{\alpha,\ \beta\}}} = \frac{e^{\left(\frac{t-\alpha}{\beta}\right)}}{\sigma\left(1+e^{\left(-\frac{t-\alpha}{\beta}\right)}\right)} \qquad (2.3.4)$$

https://reliawiki.org/index.php/The_Logistic_Distribution.

Meanwhile, several authors in literature have proposed logistic distribution with other distributions like: (Olapade, 2004), (Gupta & Kundu, 2007), (Tahir *et al.,* 2016), (Hassan *et al.*, 2017) digged deep on logistic family of distributions with applications to mention but few.

Lognormal Distribution

Taking the logarithm (transformation) of normal gives lognormal and the pdf is given as:

$$f_{t\{\alpha,\ \beta\}} = \left(t\sqrt{2\pi\beta}\right)^{-1}\exp[-(\log t - \alpha)^2/2\beta^2], \quad t > 0 (2.4.1)$$

where, , α and β are the location and dispersion parameter. Its cdf, survival and hazard function are as follows:

$$F_{t\{\alpha,\ \beta\}} = P(T \leq t) = \int_0^t f_{t\{\alpha,\ \sigma\}}dt = \Phi\left[\frac{(\log t - \alpha)}{\beta}\right] \qquad (2.4.2)$$

where, $\Phi(t)=\left(\sqrt{2\pi}\right)^{-1}\int_{-\infty}^{t} e^{-\frac{t^2}{2}dt}$.

The reliability function is

$$R_{t\{\alpha,\ \beta\}} = \int_{\ln(t)}^{8} f_{t\{\alpha,\ \beta\}}dt = \left(\beta\sqrt{2\pi}\right)^{-1}\exp[-(\log t - \alpha)^2/2\beta^2]dt \qquad (2.4.3)$$

and the failure rate function is also

$$FR_{t\{\alpha,\ \beta\}} = \frac{f_{t\{\alpha,\ \beta\}}}{R_{t\{\alpha,\ \beta\}}} = \frac{(\beta\sqrt{2\pi})^{-1}\exp[-(\log t - \alpha)^2/2\beta^2]}{\int_{(t)}^{\infty}(\beta\sqrt{2\pi})^{-1}\exp[-\log(t-\alpha)^2/2\beta^2]dt} \qquad (2.4.4)$$

Lognormal distribution also has been mixed with other distributions by several authors such as: (Dey & Kundu, 2009). (Dey & Kundu, 2010), (Montenegro & Cordeiro, 2013),(Goh *et al.,* 2014) vice versa.

Normal Distribution

The normal distribution is also known as the Gaussian distribution with two parameters namely: the scale (rate) and dispersion parameter .The pdf is given as:

$$f_{t\{\alpha,\ \beta\}} = (t\sqrt{2\pi\beta})^{-1} \exp[-(t-\alpha)^2/2\beta^2], \quad t > 0 \qquad (2.5.1)$$

where, α and β are the rate and dispersion parameter. Its cdf and other functions are as follows:

$$F_{t\{\alpha,\ \beta\}} = P(T = t) = \int_0^t f_{t\{\alpha,\ \beta\}} dt = \Phi\left(\frac{(t-\alpha)}{\beta}\right) \qquad (2.5.2)$$

where, $\Phi(t) = \left(\sqrt{2\pi}\right)^{-1} \int_{-\infty}^{t} e^{-\frac{t^2}{2}dt}$.

The survival function is

$$R_{t\{\alpha,\ \beta\}} = \int_t^\infty f_{t\{\alpha,\ \beta\}} dt = \left(\beta\sqrt{2\pi}\right)^{-1} \exp[-(t-\alpha)^2/2\beta^2]\, dt \qquad (2.5.3)$$

and the hazard function is also

$$FR_{t\{\alpha,\ \beta\}} = \frac{f_{t\{\alpha,\ \beta\}}}{R_{t\{\alpha,\ \beta\}}} = \frac{\left(\beta\sqrt{2\pi}\right)^{-1} \exp[-(t-\alpha)^2/2\beta^2]}{\int_t^\infty \left(\beta\sqrt{2\pi}\right)^{-1} \exp[-(t-\alpha)^2/2\beta^2]\, dt} \qquad (2.5.4)$$

This distribution has been used in various ways by many researchers in statistics and beyond. Some of them are: (Eugene *et al*., 2002), (Cordeiro *et al*., 2012), (Correa *et al*., 2012), (Cordeiro *et al.,*2014)etc.

Weibull Distribution

This distribution is a flexible, powerful and widely used distribution in various fields according to the literature. It has been used in conjunction with other distribution to form more robust distribution most include: (Hassan *et al*., 2016), (Hassan *et al*., 2017) (Elgarhy *et al*., 2017) to mention but few.

The pdf, cdf, survival and hazard function are given as follows:

$$f_{t\{\alpha,\ \beta\}} = \alpha\beta t^{\beta-1} \exp(-\alpha t^{\beta}) \qquad (2.6.1)$$

where α and β are the scale and shape parameter. The associative distribution function is given as:

$$F_{t\{\alpha,\ \beta\}} = P(T \le t) = \int_0^t f_{t\{\alpha,\ \beta\}} dt = 1 - \exp(-\alpha t^{\beta}) \qquad (2.6.2)$$

The survival and hazard functions are

$$R_{t\{\alpha,\ \beta\}} = 1 - \int_0^t f_{t\{\alpha,\ \beta\}} dt = \exp(-\alpha t^{\beta}) \qquad (2.6.3)$$

and

$$FR_{t\{\alpha,\ \beta\}} = \frac{f_{t\{\alpha,\ \beta\}}}{1 - F_{t\{\alpha,\ \beta\}}} = \alpha\beta t^{\beta-1} \qquad (2.6.4)$$

Results

In this section, we report based on the outcomes from the analysis on each case. Tables 1,3, 5 and 7 have the summary statistics of the data used which show the characteristics of the data set of each case and the values of the skewness (SK) and kurtosis (KT) indicate excessive skewness and kurtosis. These also reflect in figures 1 to 4 in the models plots. It means that they require flexible model to fit the data sets. In Tables 2, 4, 6 and 8 contain the goodness-of-fit criteria and statistics for model selection. The Lognormal model has smallest values in all the data sets among other models: for example; from table 2 we have LL = 265.2128, AIC = 534.4256, BIC = 537.5927, KS = 0.1054, CM = 0.0475 and AD=0.3486. The first-two plots (boxplot and histogram) in figures 1 to 4 shown the outlier in the observations for each case and the histogram pdf, empirical cdf, QQ and PP plots reveal that lognormal model represents, follows the distribution of each data set and flexible enough to capture the outliers in each case better than other models considered in the study.

Table 5contains the Cases and their percentage (in parenthesis) of each case in each states in Nigeria. This will allow us to know the percentage each state has in each case and know the level of operations of each state against COVID-19 in the country. Then, the results on the table goes thus: According to the outcomes from the computations of the percentage of each case in each state, it shows that Lagos has highest values in all cases for instance in confirmed cumulative cases10,630 (40%) followed by FCT 1,935 (7%), Oyo 1,391 (5%) Kano 1,257 (5%), Edo 1,165 (4%) … but from Niger to Kogi recorded (0%). This percentage results show that Lagos has been tested people more than other states and not only this, there is tendency that Lagos has equipment such as test kits, laboratory, Ventilator machine, adequate health workers and other instruments than other state. Furthermore, where they have (0%) shows that those states have not started testing their citizens or there are no equipment to carry out the test and other things.

Generally speaking, the same thing applied to other cases as the results shown in the tables below. However, figure 4.5 depicts the line graph of the confirmed cases in Nigeria since February 29, 2020 to July 1, 2020. The line indicates upwards trend and this means there is probability that in the next two weeks (from July 1, 2020) the confirmed cumulative cases in Nigeria will increase to 30,000 from what will have in figure 5 below.

Tables and Figures

Analysis of Data Set of Confirmed Cumulative Cases

The descriptive statistics, goodness of fit criteria and statistics (Choulakian & Stephens, 2001) include: log-likelihood (LL), Akaike Information Criterion (AIC), Bayesian Information Criterion (BIC), Kolmogorov-Smirnov (KS), Cramer-Von Mises (CM) and Aderson-Darling (AD) statistics for each model are estimated and their resulting values are listed for the four cases considered in the table below as follows:

Table 1: Summary Statistics of the Confirmed Cumulative Data set

Min	Q_1	Median	Mean	Q_3	Max	SK	KT
0.00	85.5	322.5	735.7	634.8	10630.0	5.1507	29.4802

Table 2: Goodness of Fit of the Distributions with Confirmed Cumulative Data set

Model, Statistics and Criteria	-2LL	AIC	BIC	KS	CM	AD
Lognormal	**265.2128**	**534.4256**	**537.5927**	**0.1054**	**0.0475**	**0.3486**
Weibull	267.5326	539.0652	542.2323	0.1123	0.0880	0.6946
Cauchy	277.7476	559.4952	562.6623	0.2228	0.4074	2.6521
Gumbel	289.3884	582.7767	585.9438	0.2280	0.4757	2.8241
Logistic	299.1426	602.2852	605.4523	0.2764	0.5049	3.3010
Normal	319.5715	643.1429	646.3100	0.3365	1.4105	7.4515

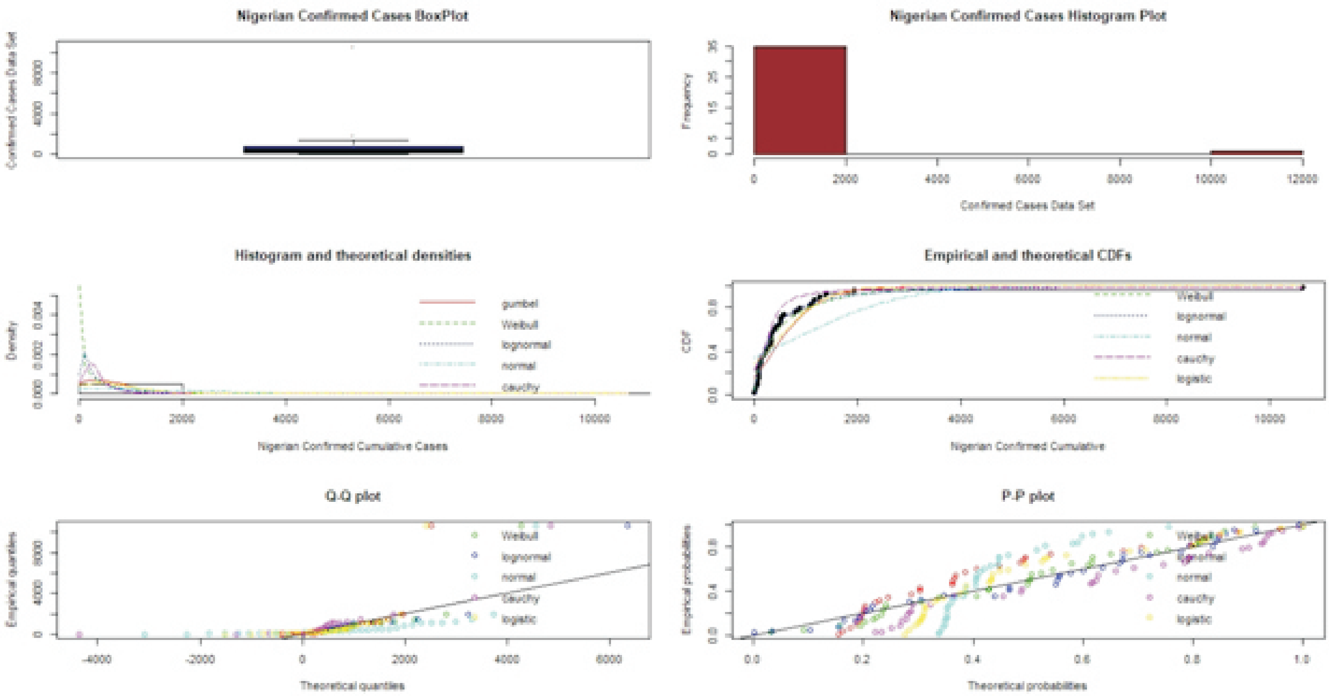

Figure 1: Boxplot, Histogram Plot, PDFs, CDFs, QQ and PPplots of the Models Confirmed Cumulative Data set

Analysis of Data Set of Discharged Cumulative Cases Data Set

Table 3: Descriptive Statistics of the Discharged Cumulative Data set

Min	Q_1	Median	Mean	Q_3	Max	Skewness	Kurtosis
0.00	53.0	282.0	130.5	421.5	1610.0	2.1367	8.4889

Table 4: Goodness of Fit of the Distributions with Discharged Cumulative Data set

Model, Statistics and Criteria	-2LL	AIC	BIC	KS	CM	AD
Lognormal	**232.2142**	**468.4283**	**471.5390**	**0.1208**	**0.0860**	**0.5297**
Weibull	233.3388	470.6775	473.7882	0.1203	0.0961	0.5999
Gumbel	242.2810	488.5619	491.6726	0.1975	0.2675	1.6319
Cauchy	247.6614	499.3228	502.4335	0.2553	0.6983	4.3936
Logistic	248.8108	501.6216	504.7323	0.1954	0.2664	1.8099
Normal	252.3009	508.6017	511.7124	0.2003	0.4023	2.3827

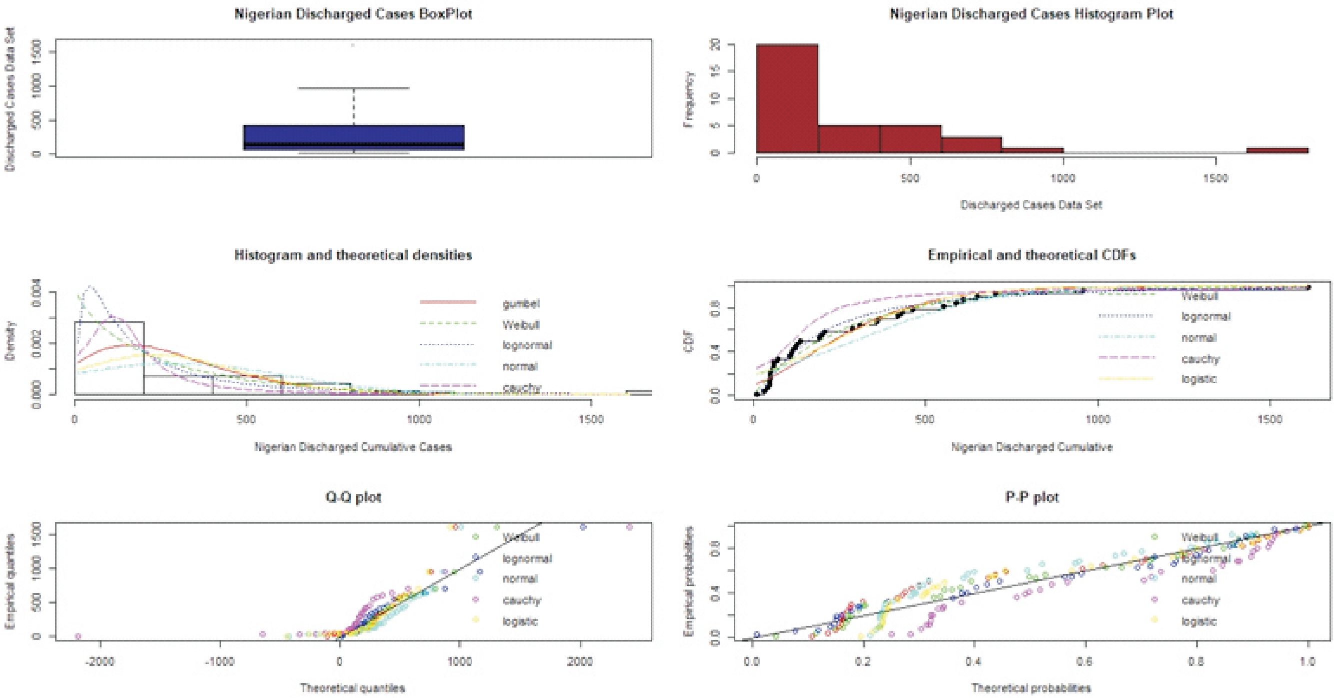

Figure 2: Boxplot, Histogram Plot, PDFs, CDFs, QQ and PP plots of the Models with Discharged Cumulative Data set

Analysis of Data Set of Deaths Cumulative Cases Data Set

Table 5: Descriptive Statistics of the Deaths Cumulative Data set

Min	Q_1	Median	Mean	Q_3	Max	Skewness	Kurtosis
0.00	5.75	9.00	16.75	19.00	129.00	3.5247	17.3726

Table 6: Goodness of Fit of the Distributions with Deaths Cumulative Data set

Model, Statistics and Criteria	-2LL	AIC	BIC	KS	CM	AD
Lognormal	**128.8593**	**261.7186**	**264.7713**	**0.0758**	**0.0355**	**0.2209**
Weibull	131.7673	267.5347	270.5874	0.1239	0.1083	0.6770
Cauchy	137.0265	278.0530	281.1057	0.1785	0.3513	2.3302
Gumbel	138.0907	280.1814	283.2341	0.1885	0.2321	1.3776
Logistic	145.5177	295.0354	298.0881	0.1952	0.2771	1.9620
Normal	154.5750	313.1499	316.2027	0.2426	0.6649	3.7287

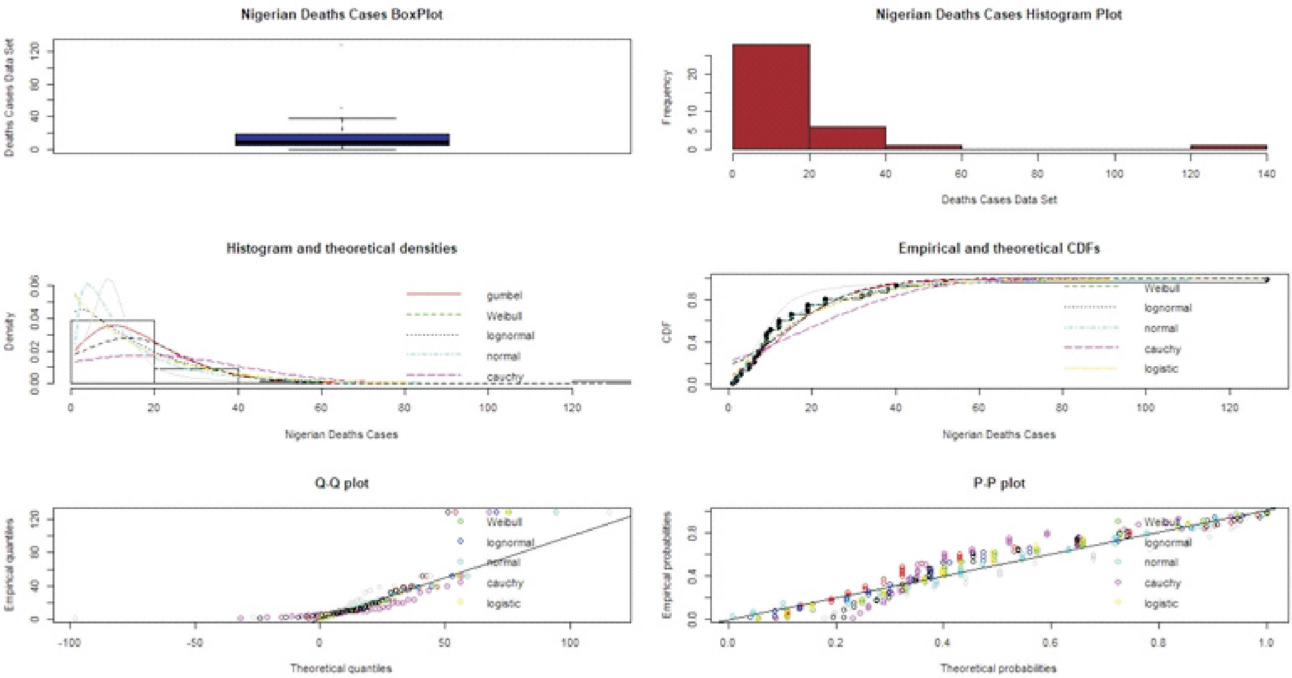

Figure 3: Boxplot, Histogram Plot, PDFs, CDFs, QQ and PP plots of the Models with Deaths Cumulative Data set

Analysis of Data Set of Active Cumulative Cases Data Set

Table 7: Descriptive Statistics of the active Cumulative Data set

Min	Q_1	Median	Mean	Q_3	Max	Skewness	Kurtosis
0.00	26.0	91.5	436.9	242.5	8891.0	5.4248	31.5251

Table 8: Goodness of Fit of the Distributions with Active Cumulative Data set

Model, Statistics and Criteria	-2LL	AIC	BIC	KS	CM	AD
Lognormal	**224.6693**	**453.3386**	**456.4493**	**0.0938**	**0.0523**	**0.3271**
Weibull	226.6278	457.2556	460.3663	0.1186	0.0665	0.5034
Cauchy	242.9091	489.8183	492.9290	0.2709	0.5952	3.8342
Gumbel	270.8313	545.6627	548.7734	0.3066	0.9948	5.3277
Logistic	281.8587	567.7173	570.8280	0.3573	0.9620	5.4604
Normal	305.0469	614.0938	617.2045	0.3806	1.8388	9.2188

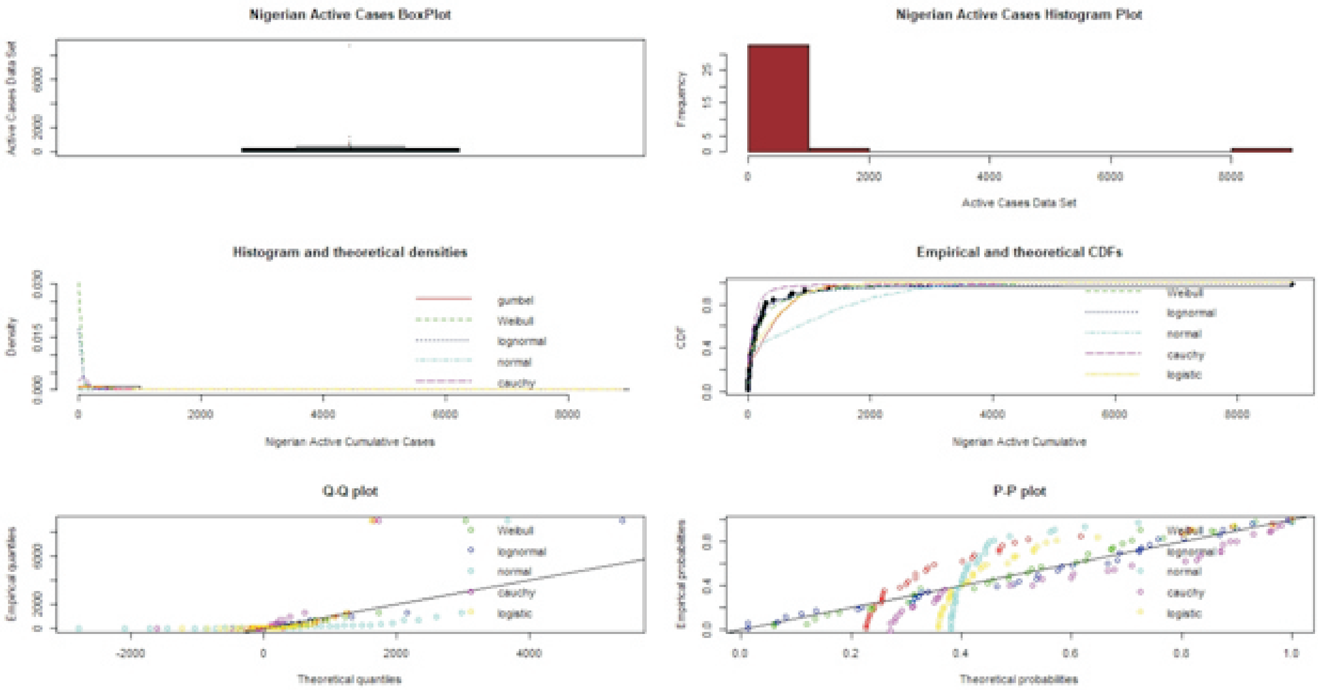

Figure 4: Boxplot, Histogram Plot, PDFs, CDFs, QQ and PP plots of the Models with Active Cumulative Data set

Table 9: Contains the Cases and their percentage (in parenthesis) of each case in each affected states

States	Confirmed Cum Cases (%)	Discharged Cum Cases (%)	Deaths Cum Cases (%)	Active Cum Cases (%)
Lagos	10,630 (40%)	1,610 (16%)	129 (21%)	8,891 (57%)
FCT	1,935 (7%)	588 (6%)	34 (6%)	1,313 (8%)
Oyo	1,391 (5%)	703 (7%)	12 (2%)	676 (4%)
Kano	1,257 (5%)	958 (9%)	52 (9%)	247 (2%)
Edo	1,165 (4%)	418 (4%)	40 (7%)	707 (4%)
Delta	1,131 (4%)	190 (2%)	23 (4%)	918 (6%)
Rivers	1,088 (4%)	648 (6%)	38 (6%)	402 (3%)
Ogun	869 (3%)	609 (6%)	19 (3%)	241 (2%)
Kaduna	805 (3%)	552 (5%)	12 (2%)	241 (2%)
Katsina	578 (2%)	285 (3%)	23 (4%)	270 (2%)
Gombe	507 (2%)	363 (4%)	19 (3%)	125 (1%)
Bauchi	505 (2%)	461 (5%)	12 (2%)	32 (0%)
Borno	493 (2%)	432 (4%)	32 (5%)	29 (0%)
Ebonyi	438 (2%)	357 (4%)	3 (0%)	78 (0%)
Plateau	382 (1%)	197 (2%)	10 (2%)	175 (1%)
Imo	352 (1%)	50 (0%)	6 (1%)	296 2%)
Enugu	327 (1%)	126 (1%)	9 (1%)	192 (1%)
Ondo	325 (1%)	110 (1%)	19 (3%)	196 (1%)
Abia	320 (1%)	207 (2%)	3 (0%)	110 (1%)
Jigawa	318 (1%)	308 (3%)	9 (1%)	1 (0%)
Kwara	235 (1%)	135 (1%)	9 (1%)	91 (1%)
Bayelsa	234 (1%)	105 (1%)	15 (2%)	114 (1%)
Nasarawa	213 (1%)	113 (1%)	8 (1%)	92 (1%)
Sokoto	151 (1%)	119 (1%)	15 (2%)	17 (0%)
Osun	127 (0%)	48 (1%)	5 (1%)	74 (0%)
Niger	116 (0%)	45 (0%)	7 (1%)	64 (0%)
Akwa Ibom	86 (0%)	54 (1%)	2 (0%)	30 (0%)
Adamawa	84 (0%)	47 (0%)	6 (1%)	31 (0%)
Kebbi	81 (0%)	58 (1%)	7 (1%)	16 (0%)
Zamfara	76 (0%)	71 (1%)	5 (1%)	0 (0%)
Anambra	73 (0%)	57 (1%)	9 (1%)	7 (0%)
Benue	65 (0%)	30 (0%)	1 (0%)	34 (0%)
Yobe	61 (0%)	48 (0%)	8 (1%)	5 (0%)
Ekiti	43 (0%)	40 (0%)	2 (0%)	1 (0%)
Taraba	19 (0%)	10 (0%)	0 (0%)	9 (0%)
Kogi	4 (0%)	0 (0%)	0 (0%)	4 (0%)
Total	**26484 (100%)**	**10152 (100%)**	**603 (100%)**	**15729 (100%)**

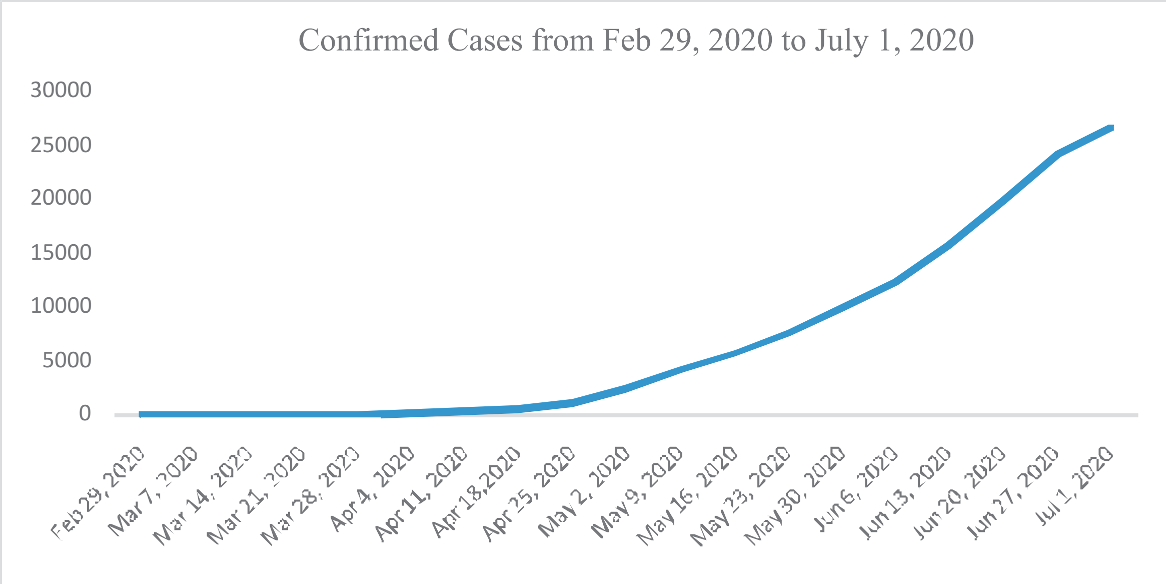

Figure 5. The plot of Confirmed Cases in Nigeria from Feb 29, 2020 to July 1, 2020.

Discussion and Conclusion

Discussion

This article investigate the statistical modelling of Nigerian data for COVID-19 pandemic with some selected univariate continuous models like Cauchy, Gumbel, Logistic, Lognormal, Normal and Weibull models, where discussions were made on each model pdf, cdf, reliability and hazard rate functions. In the study also, analysis and summarization of the characteristics of the data sets are presented on Boxplot and histogram plot for each case data set, histogram pdf, empirical cdf, QQ and PP plots. While, the goodness-of-fit criteria and Statistics on LL, AIC, BIC, KS, CM and AD are obtained.Estimation of the percentage of cases led us to determine the levels and readiness of both federal and state government in combating the coronavirus in Nigeria. Then, trend line of confirmed cumulative cases data set from February 29, 2020 to July 1, 2020are used to determine the direction of COVID-19 pandemic in Nigeria.

Conclusion

In view of the above discussions, lognormal model fitted and represented all data sets of all cases better than any other competing models with its values from the goodness-of-fit criteria and statistics. This also implies that the distribution of each data set requires flexible model like lognormal model to captures the excessive skewness, kurtosis and accommodate the outliers in each data set of each case without removing any observation; and this reflects in figures 1 to 4 above. Meanwhile, the study showed that majority of the states government are yet to start serious testing on COVID-19 for their citizens in their respective states as it was reflected on Table 4.5 above under confirmed cumulative cases and other cases because by comparing total samples tested **141,525**as at 1st of July, 2020to the population of 200 million in the country. This could be due to the lack of equipment and instruments to fight against the virus like test kits, laboratory, ventilator machine, isolation centres, health workers etc in various states.

Finally, figure 5 clearly depict the trend of COVID-19 in Nigeria as the trend line followed upwards trend/direction as at July 1, 2020; which indicates that there is probability of increasing in numbers of coronavirus pandemic in the country to 30,000 and above in the next two weeks and beyond. Therefore, some measures are spelt-out in preventing and curbing the spread of COVID-19 both locally and internationally. These include:

- Regular Hand-washing with soap and tap water running for 20 seconds
- Wearing of face masks in the public
- Using of alcohol-based sanitizer

- Avoid social gathering/social distancing like 6 feets
- Regular covering of the nose and mouth when coughing and sneezing using bent elbow or tissue paper and discard it into a waste bin and wash the hands thereafter.
- Total avoidance of handshaking and hugging etc. (WHO & NCDC, 2020).

Hence, federal, state and local government should rise-up to the task and their responsibilities in combating coronavirus pandemic in Nigeria. Also, citizens should support the government by adhere to the rules and regulations against the virus in reducing the spread of the virus if not eradicates. Always stay safe, COVID-19 pandemic is real.

Acknowledgment: Authors appreciate the efforts of those who had one way or the other used their time and comments to improve the quality of this article.

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