MODELLING AND FORECASTING DAILY MORTALITY RATE OF COVID-19 IN ECOWAS: EVIDENCE FROM ARIMA MODEL

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Abstract

The Coronavirus Disease 2019 (COVID-19) pandemic which has claimed thousands of lives over the past 6 months and counting, has resulted in great panic by many worldwide, as the number of death cases is now monotonically growing by the day. This paper is aimed at developing a suitable Autoregressive integrated moving average (ARIMA) model, which shall be used to fit a most appropriate model for the daily number of total deaths recorded in ECOWAS that are traceable to the COVID-19 pandemic. We discovered that ARIMA (2, 1, 0) was the most appropriate model for forecasting the number of COVID-19 related deaths recorded in ECOWAS. A forecast of 234 days from 11th May, 2020 to 31th December, 2020, was carried out and we discovered that, the COVID-19 mortality in ECOWAS may likely take a daily upward trend for the next 6 months.

Keywords: ARIMA, COVID-19, Forecasting, Mortality, Time Series.
INTRODUCTION

Corona virus disease 2019 (COVID-19) an illness caused by novel coronavirus now called Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) which was first identified amid an outbreak of respiratory illness cases in Wuhan City, Hubei Provence, China.

The World Health Organisation (WHO) on March 11, 2020, has declared the novel coronavirus (Covid-19) as a pandemic, as the virus moved from China to almost every part of the world now, with number of cases as at April 20, 2020, of about two million, four hundred and seventy two thousand, and sixty two (2,472,062) with over one hundred and seventy thousand (170,000) deaths recorded worldwide (WHO Publication 2020).

In the Economic Community of West African States which includes African countries like: Benin, Burkina Faso, Cabo Verde, Cote D'Ivoire, Gambia, Ghana, Guinea-Bissau, Liberia, Mali, Niger, Nigeria, Senegal, and Sierra Lone, the story is not different as the number of confirmed cases as well as death cases is on the increase by the day. As at 10th May 2020, the total number of confirmed cases of COVID-19 in ECOWAS was about fifteen thousand, six hundred and ninety one thousand persons (15,691), with an average of three hundred and eight cases per day, while the total number of deaths recorded was about three hundred and seventy three (373) cases, with an average of twenty eight deaths per day, in ECOWAS countries (Johns Hopkins University Coronavirus Resource Centre, May, 2020).

This paper aims to fit a suitable Autoregressive Integrated Moving Average (ARIMA) model for the sum of daily death cases of COVID-19 in ECOWAS as a whole.

Several types of ARIMA models have been proposed by different scholars over the years. The Autoregressive Moving Average (ARMA) approach was introduced by Box G., et al. (1970) 1976, in their work on Time series analysis: forecasting and control. This approach is well tested and efficaciously applied by many scholars. For instance, Masukawa et al. (2014) studied the impact of the introduction of a rotavirus vaccine on rates of hospitalization of children less than 5 years old for acute diarrhea. Michael et al. (2004) studied the impact of illicit drug supply reduction on health and social outcomes: the heroin shortage in the Australian Capital Territory. They observed that a sustainable decline in the supply of heroin, as measured by indicators such as drug purity, is related to changes in drug-related health indicator such as ambulance callouts to heroin overdoses.

In further studies, ARIMA models have been fitted to economic variable. For instance Nwuju K., et al. (2019), used Box-Jenkins ARMA model in their work on intervention analysis of daily South African Rand/Nigerian Naira exchange rates. In their work they carried out a time series plot of a realization of daily exchange rates of South African Rand and Nigerian Naira from April 2017 to December, 2017 which showed the occurrence of an intervention on 4th August, 2017. They fitted ARMA (12, 2) model to their data and concluded that management of these exchange rates may be made on the basis of their proposed model. Etuk E. H., et al. (2012) proposed a seasonal Box-Jenkins Model for Nigerian Inflation rate series. They obtained a seasonal difference as well as a non-sessional difference. The correlogram of the differenced
series they obtained, revealed a seasonal nature. It also revealed a seasonal autoregressive component which was shown to be adequate for the data studied.

Materials and Method

Data

The data used in this work are of secondary sources. The data analyzed in this work are daily sum of cases and deaths recorded from COVID-19 in ECOWAS as a whole from 21st March, 2020 to 10th May, 2020. These were obtained from European Centre for Disease Prevention and Control (ECDC) with link: http://www.ecdc.europa.eu/en/publications-data/download-todays-data-geographical-distribution-covid-19-cases-worldwide. The used data is listed in the appendix.

ARIMA Modelling

Autoregressive Moving-Average (ARMA) Model

A time series \( \{X_t\} \) is said to follow an autoregressive moving-average process of order \( p \) and \( q \), i.e \( \text{ARMA}(p, q) \), process if:

\[
X_t = c + \alpha_1 X_{t-1} + \alpha_2 X_{t-2} + \ldots + \alpha_p X_{t-p} + \epsilon_t - \theta_1 \epsilon_{t-1} - \theta_2 \epsilon_{t-2} - \ldots - \theta_q \epsilon_{t-q}.
\]

In summation form we have

\[
X_t = \sum_{k=1}^{p} \alpha_k X_{t-k} - \sum_{k=1}^{q} \theta_k \epsilon_{t-k} + \epsilon_t + c
\]

That ARMA models can be extended to non-stationary series by allowing the differencing of the data series resulting to \( \text{ARIMA}(p, d, q) \) where with three parameters; \( p \) is the order of autoregressive, \( d \) is the degree of differencing, and \( q \) is the order of moving-average.

Thus an \( \text{ARIMA}(p, d, q) \) model is given by:

\[
\nabla^d X_t = \alpha_1 \nabla^d X_{t-1} + \alpha_2 \nabla^d X_{t-2} + \ldots + \alpha_p \nabla^d X_{t-p} + \epsilon_t + \beta_1 \epsilon_{t-1} + \beta_2 \epsilon_{t-2} + \beta_p \epsilon_{t-p}
\]

where \( \{\epsilon_t\} \) is the error term in the equation; a white noise process, a sequence of independently and identically distributed (i.i.d) random variables with \( E(\epsilon_t) = 0 \) and \( \text{var}(\epsilon_t) = \sigma^2 \); i.e. \( \epsilon_t \sim \text{iidN}(0, \sigma^2) \), and the \( \alpha \)'s and \( \beta \)'s are the model parameters.

Distinction between ARMA and ARIMA is the integrated component which brings us back to the subject of stationarity. In reality, most economic variables are non-stationary, hence they have to go through a transformation process called differencing before they become stationary.
The autoregressive (AR) order may be determined by the lap at which the partial autocorrelation function (PACF) cuts off. The moving average (MA) order may be estimated as the lap at which the autocorrelation function (ACF) cuts off. Estimation of $\alpha$’s and $\beta$’s may be done by the method of least squares.

**Box-Jenkins Model Selection Approach**

Stage 1: Identification  
Choose one or more ARIMA parsimonious models(s)

Stage 2: Estimation  
Estimate the parameters of the model(s) selected in stage 1

Stage 3: Diagnostic  
Check selected model(s) for suitability

Stage 1: Forecasting

Is model satisfactory?

Yes  
No

Figure 1: Flowchart of Stages in the Box-Jenkins iterative approach

All plots and numerical computations will be carried out using Eviews version 10 on a Windows 10 personal computer with the following specifications.

Processor: Intel® Core i5-3230M CPU @ 2.60GHz

Installed Memory (Ram): 4.00GB

System type: 64-bits Operating System.
RESULTS AND DISCUSSION

The time plot of the realization of the time series used in this work is shown in Figure 1. This plot shows that the number of death cases of COVID-19 in ECOWAS countries, follows an irregular upward-downward pattern, showing both upward and downward movement over 51 days. They are adjudged stationary by the Augmented Dickey Fuller Test (See Table 1, Table 2, Table 3 and Table 4).

Figure 1: Time plot of daily death cases of Covid-19 in ECOWAS
Figure 2: Correlogram of actual death cases data showing a nonstationary behaviour of the data.

Figure 3: Time plot of 1st difference of the actual death case data.
Table 1: Augmented Dickey-Fuller Test Result of differenced Death cases data showing a stationary behaviour.

Null Hypothesis: D(DEATH) has a unit root  
Exogenous: Constant  
Lag Length: 1 (Automatic - based on SIC, maxlag=10)

| Augmented Dickey-Fuller test statistic | t-Statistic | Prob.* |
|----------------------------------------|-------------|--------|
| Test critical values:                  |             |        |
| 1% level                               | -3.574446   |        |
| 5% level                               | -2.923780   |        |
| 10% level                              | -2.599925   |        |

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation  
Dependent Variable: D(DEATH,2)  
Method: Least Squares  
Date: 05/13/20   Time: 07:32  
Sample (adjusted): 4 51  
Included observations: 48 after adjustments

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|----------|-------------|------------|-------------|-------|
| D(DEATH(-1)) | -2.268733  | 0.224839  | -10.09050  | 0.0000 |
| D(DEATH(-1),2) | 0.525408  | 0.129877  | 4.045432   | 0.0002 |
| C         | 0.765629    | 0.594203  | 1.288498   | 0.2042 |

R-squared  0.807303  Mean dependent var  0.187500  
Adjusted R-squared  0.798739  S.D. dependent var  9.131792  
S.E. of regression  4.096714  Akaike info criterion  5.718709  
Sum squared resid  755.2378  Schwarz criterion  5.835659  
Log likelihood  -134.2490  Hannan-Quinn criter.  5.762904  
F-statistic  94.26392  Durbin-Watson stat  1.989604  
Prob(F-statistic)  0.000000

ADF of 1st difference of actual death case data showing a stationary behaviour.
Figure 4: Correlogram of first difference of actual death cases data.
Table 2: Estimation of parsimonious Models for the Death Cases data.

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|----------|-------------|------------|-------------|-------|
| C        | 0.285817    | 0.065807   | 4.343266    | 0.0001|
| AR(1)    | -1.052442   | 0.079310   | -13.26996   | 0.0000|
| AR(2)    | -0.949022   | 0.163784   | -5.794369   | 0.0000|
| AR(5)    | -0.002283   | 0.196019   | -0.011647   | 0.9908|
| MA(1)    | 0.177642    | 0.603931   | 0.294143    | 0.7701|
| MA(3)    | -0.931366   | 3.786159   | -0.245992   | 0.8069|
| MA(5)    | -0.232400   | 2.182132   | -0.106501   | 0.9157|
| SIGMASQ  | 9.640604    | 43.29980   | 0.222648    | 0.8249|

R-squared: 0.644043  Mean dependent var: 0.420000
Adjusted R-squared: 0.584717  S.D. dependent var: 5.257026
S.E. of regression: 3.387759  Akaike info criterion: 5.580402
Sum squared resid: 482.0302  Schwarz criterion: 5.886326
Log likelihood: -131.5101  Hannan-Quinn criterion: 5.696900
F-statistic: 10.85596  Durbin-Watson stat: 1.878135
Prob(F-statistic): 0.000000

Inverted AR Roots: .07-.11i, .07+.11i, -.14, -.53+.82i, -.53-.82i
Inverted MA Roots: 1.00, .03-.48i, .03+.48i, -.61+.79i, -.61-.79i

From the parsimonious models estimation following the significant lags of the PACF for the AR(p) and ACF for the MA(q) of the correlogram of the first differenced data above, only AR(1) and AR(2) are significant at a 0.05 confidence level.

Thus for the death cases data, ARIMA (2, 1, 0) is chosen as the best fitted model.

The equation representing the model is:

\[ \nabla X_t = 0.2858170 - 1.052442 \nabla X_{t-1} - 0.949022 \nabla X_{t-2} + \epsilon_t \]

Future forecast for 234 (May 11 2020 to December 31 2020) days was carried out using the on E-views using the model in (5) above.
Figure 5: Actual and fitted death case plot using ARIMA (2, 1, 0).

Residual Diagnostics

Figure 6: Correlogram of residuals from the fitted ARIMA (5, 1, 5) model showing no significant lag spike.
Figure 7: Actual, fitted and residual plot for the death case.
Table 3: Actual, Fitted, and Residuals of the model.

| obs | Actual | Fitted | Residual | Residual Plot |
|-----|--------|--------|----------|---------------|
| 2   | 3.00000| 1.31839| 1.68161  |               |
| 3   | -3.00000| -1.62543| -1.37457 |               |
| 4   | 3.00000| 1.72629| 1.27371  |               |
| 5   | -1.00000| -0.50630| -0.49370 |               |
| 6   | 0.00000| 0.15020| -0.15020 |               |
| 7   | -2.00000| 0.13451| -2.13451 |               |
| 8   | 3.00000| 3.05407| -0.05407 |               |
| 9   | 5.00000| -0.04757| 5.04757  |               |
| 10  | -7.00000| -4.62798| -2.37202 |               |
| 11  | 7.00000| 3.79567| 3.20433  |               |
| 12  | -8.00000| -3.40888| -4.59112 |               |
| 13  | 6.00000| 4.07604| 1.92396  |               |
| 14  | -2.00000| -1.47701| -0.52299 |               |
| 15  | -3.00000| 1.21319| -4.21319 |               |
| 16  | 4.00000| 2.83426| 1.16574  |               |
| 17  | 7.00000| 1.38410| 5.61590  |               |
| 18  | -11.00000| -6.34048| -4.65952 |               |
| 19  | 4.00000| 4.23235| -0.23235 |               |
| 20  | 4.00000| 3.05351| 0.94649  |               |
| 21  | -7.00000| -3.41321| -3.58679 |               |
| 22  | 0.00000| 2.61036| -2.61036 |               |
| 23  | 6.00000| 7.08487| -1.08487 |               |
| 24  | -6.00000| -2.70999| -3.29001 |               |
| 25  | 3.00000| 2.92475| 0.07525  |               |
| 26  | -1.00000| 4.79650| -5.79650 |               |
| 27  | -1.00000| 1.37544| -2.37544 |               |
| 28  | 4.00000| 2.54752| 1.45248  |               |
| 29  | 9.00000| 3.90889| 5.09111  |               |
| 30  | -9.00000| -9.37519| 0.37519  |               |
| 31  | -1.00000| 1.82140| -2.82140 |               |
| 32  | 3.00000| 5.84095| -2.84095 |               |
| 33  | -3.00000| -2.58101| -0.41899 |               |
| 34  | 3.00000| 2.43100| 0.56900  |               |
| 35  | 0.00000| 3.00698| -3.00698 |               |
| 36  | -3.00000| -1.56251| -1.43749 |               |
| 37  | 3.00000| 3.81269| -0.81269 |               |
| 38  | 4.00000| 3.20874| 0.79126  |               |
| 39  | -7.00000| -4.97884| -2.02116 |               |
| 40  | 7.00000| 5.53161| 1.46839  |               |
| 41  | 1.00000| 0.02425| 0.97575  |               |
| 42  | -1.00000| -4.54719| 3.54719  |               |
| 43  | 3.00000| 0.18599| 2.81401  |               |
| 44  | 8.00000| -0.90309| 8.90309  |               |
| 45  | -15.00000| -12.4120| -2.58800 |               |
| 46  | 1.00000| 5.75655| -4.75655 |               |
| 47  | 4.00000| 4.28785| -0.28785 |               |
| 48  | -5.00000| -2.77168| -2.22832 |               |
| 49  | 4.00000| 4.18095| -0.18095 |               |
| 50  | 2.00000| 2.22442| -0.22442 |               |
| 51  | 6.00000| -1.78995| 7.78995  |               |
Figure 8: Histogram: normality test of residual for fitted death cases
Forecast

Dependent Variable: DEATHFORECAST
Method: ARMA Maximum Likelihood (BFGS)
Date: 10/05/20   Time: 21:40
Sample: 6 51
Included observations: 46
Convergence achieved after 4 iterations
Coefficient covariance computed using outer product of gradients

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|----------|-------------|------------|-------------|-------|
| AR(1)    | -0.207072   | 0.226731   | -0.913293   | 0.0000|
| AR(2)    | -0.222709   | 0.187012   | -1.190877   | 0.0000|
| SIGMASQ  | 52.58093    | 11.62927   | 4.521431    | 0.0000|

R-squared  0.289487  Mean dependent var  7.302895
Adjusted R-squared 0.238736  S.D. dependent var 8.697625
S.E. of regression 7.588718  Akaike info criterion 6.976988
Sum squared resid 2418.723  Schwarz criterion 7.136000
Log likelihood -156.4707  Hannan-Quinn criter. 7.036555
Durbin-Watson stat 1.851382

Inverted AR Roots -.10-.46i  -.10+.46i
CONCLUSION

The Coronavirus Disease 2019 (COVID-19) pandemic which has claimed thousands of lives over the past 6 months and counting, has resulted in great panic by many worldwide, as the number of death cases is now monotonically growing by the day. This paper was aimed at developing a suitable ARIMA model which was used to fit a most appropriate model for the daily number of total deaths recorded in ECOWAS traceable to the COVID-19 pandemic. We discovered that ARIMA (2, 1, 0) was the most appropriate for forecasting the number of COVID-19 related deaths recorded in ECOWAS. A forecast of 235 days from 11th May, 2020 to 31th December, 2020, was carried out and we discovered that, the COVID-19 mortality in ECOWAS may likely take a daily upward trend for the next 7 months.
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Appendix 1: Daily Total Death Cases of Covid-19 in ECOWAS from 3rd April, 2020 to 10th May, 2020.

| S/N | DATE       | Daily Total Death Cases of Covid-19 in ECOWAS | S/N | DATE       | Daily Total Death Cases of Covid-19 in ECOWAS |
|-----|------------|-----------------------------------------------|-----|------------|-----------------------------------------------|
| 1   | 3/21/2020  | 0                                             | 26  | 4/15/2020  | 4                                             |
| 2   | 3/22/2020  | 3                                             | 27  | 4/16/2020  | 3                                             |
| 3   | 3/23/2020  | 0                                             | 28  | 4/17/2020  | 7                                             |
| 4   | 3/24/2020  | 3                                             | 29  | 4/18/2020  | 16                                            |
| 5   | 3/25/2020  | 2                                             | 30  | 4/19/2020  | 7                                             |
| 6   | 3/26/2020  | 2                                             | 31  | 4/20/2020  | 6                                             |
| 7   | 3/27/2020  | 0                                             | 32  | 4/21/2020  | 9                                             |
| 8   | 3/28/2020  | 3                                             | 33  | 4/22/2020  | 6                                             |
| 9   | 3/29/2020  | 8                                             | 34  | 4/23/2020  | 9                                             |
| 10  | 3/30/2020  | 1                                             | 35  | 4/24/2020  | 9                                             |
| 11  | 3/31/2020  | 8                                             | 36  | 4/25/2020  | 6                                             |
| 12  | 4/1/2020   | 0                                             | 37  | 4/26/2020  | 9                                             |
| 13  | 4/2/2020   | 6                                             | 38  | 4/27/2020  | 13                                            |
| 14  | 4/3/2020   | 4                                             | 39  | 4/28/2020  | 6                                             |
| 15  | 4/4/2020   | 1                                             | 40  | 4/29/2020  | 13                                            |
| 16  | 4/5/2020   | 5                                             | 41  | 4/30/2020  | 14                                            |
| 17  | 4/6/2020   | 12                                            | 42  | 5/1/2020   | 13                                            |
| 18  | 4/7/2020   | 1                                             | 43  | 5/2/2020   | 16                                            |
| 19  | 4/8/2020   | 5                                             | 44  | 5/3/2020   | 24                                            |
| 20  | 4/9/2020   | 9                                             | 45  | 5/4/2020   | 9                                             |
| 21  | 4/10/2020  | 2                                             | 46  | 5/5/2020   | 10                                            |
|    | Date     | Page |    | Date     | Page |
|----|----------|------|----|----------|------|
| 22 | 4/11/2020| 2    | 47 | 5/6/2020 | 14   |
| 23 | 4/12/2020| 8    | 48 | 5/7/2020 | 9    |
| 24 | 4/13/2020| 2    | 49 | 5/8/2020 | 13   |
| 25 | 4/14/2020| 5    | 50 | 5/9/2020 | 15   |
|    |          |      | 51 | 5/10/2020| 21   |
## Appendix 1: TABLE: Forecasted daily total death cases of Covid-19 in ECOWASs.

| S/N | DATE       | FORECASTED TOTAL DAILY DEATH CASES IN ECOWAS STATES | S/N | DATE       | FORECASTED TOTAL DAILY DEATH CASES IN ECOWAS STATES |
|-----|------------|----------------------------------------------------|-----|------------|----------------------------------------------------|
| 1   | 5/11/2020  | 8                                                  | 41  | 6/20/2020  | 21                                                 |
| 2   | 5/12/2020  | 8                                                  | 42  | 6/21/2020  | 21                                                 |
| 3   | 5/13/2020  | 8                                                  | 43  | 6/22/2020  | 21                                                 |
| 4   | 5/16/2020  | 8                                                  | 44  | 6/23/2020  | 21                                                 |
| 5   | 5/15/2020  | 8                                                  | 45  | 6/24/2020  | 21                                                 |
| 6   | 5/16/2020  | 9                                                  | 46  | 6/25/2020  | 21                                                 |
| 7   | 5/17/2020  | 9                                                  | 47  | 6/26/2020  | 21                                                 |
| 8   | 5/18/2020  | 9                                                  | 48  | 6/27/2020  | 21                                                 |
| 9   | 5/19/2020  | 10                                                 | 49  | 6/28/2020  | 21                                                 |
| 10  | 5/20/2020  | 10                                                 | 50  | 6/29/2020  | 21                                                 |
| 11  | 5/21/2020  | 10                                                 | 51  | 6/30/2020  | 21                                                 |
| 12  | 5/22/2020  | 11                                                 | 52  | 7/1/2020   | 21                                                 |
| 13  | 5/23/2020  | 11                                                 | 53  | 7/2/2020   | 21                                                 |
| 14  | 5/24/2020  | 12                                                 | 54  | 7/3/2020   | 21                                                 |
| 15  | 5/25/2020  | 12                                                 | 55  | 7/4/2020   | 21                                                 |
| 16  | 5/26/2020  | 13                                                 | 56  | 7/5/2020   | 21                                                 |
| 17  | 5/27/2020  | 13                                                 | 57  | 7/6/2020   | 21                                                 |
| 18  | 5/28/2020  | 14                                                 | 58  | 7/7/2020   | 21                                                 |
| 19  | 5/29/2020  | 14                                                 | 59  | 7/8/2020   | 21                                                 |
| 20  | 5/30/2020  | 15                                                 | 60  | 7/9/2020   | 22                                                 |
| 21  | 5/31/2020  | 15                                                 | 61  | 7/10/2020  | 22                                                 |
| 22  | 6/1/2020   | 16                                                 | 62  | 7/11/2020  | 22                                                 |
| 23  | 6/2/2020   | 16                                                 | 63  | 7/12/2020  | 22                                                 |
| 24  | 6/3/2020   | 17                                                 | 64  | 7/13/2020  | 22                                                 |
| 25  | 6/4/2020   | 17                                                 | 65  | 7/14/2020  | 22                                                 |
| 26  | 5/5/2020   | 17                                                 | 66  | 7/15/2020  | 23                                                 |
| 27  | 6/6/2020   | 18                                                 | 67  | 7/16/2020  | 23                                                 |
| 28  | 6/7/2020   | 18                                                 | 68  | 7/17/2020  | 23                                                 |
| 29  | 6/8/2020   | 19                                                 | 69  | 7/18/2020  | 24                                                 |
| 30  | 6/9/2020   | 19                                                 | 70  | 7/19/2020  | 24                                                 |
| 31  | 6/10/2020  | 19                                                 | 71  | 7/20/2020  | 24                                                 |
| 32  | 6/11/2020  | 20                                                 | 72  | 7/21/2020  | 24                                                 |
| 33  | 6/12/2020  | 20                                                 | 73  | 7/22/2020  | 25                                                 |
| 34  | 6/13/2020  | 20                                                 | 74  | 7/23/2020  | 25                                                 |
| 35  | 6/14/2020  | 20                                                 | 75  | 7/24/2020  | 26                                                 |
| 36  | 6/15/2020  | 20                                                 | 76  | 7/25/2020  | 26                                                 |
| S/N | DATE       | FORECASTED TOTAL DAILY DEATH CASES IN ECOWAS STATES | S/N | DATE       | FORECASTED TOTAL DAILY DEATH CASES IN ECOWAS STATES |
|-----|------------|-----------------------------------------------------|-----|------------|-----------------------------------------------------|
| 81  | 7/30/2020  | 28                                                  | 121 | 9/8/2020  | 35                                                  |
| 82  | 7/31/2020  | 28                                                  | 122 | 9/9/2020  | 35                                                  |
| 83  | 8/1/2020   | 28                                                  | 123 | 9/10/2020 | 35                                                  |
| 84  | 8/2/2020   | 29                                                  | 124 | 9/11/2020 | 36                                                  |
| 85  | 8/3/2020   | 29                                                  | 125 | 9/12/2020 | 36                                                  |
| 86  | 8/4/2020   | 30                                                  | 126 | 9/13/2020 | 36                                                  |
| 87  | 8/5/2020   | 30                                                  | 127 | 9/14/2020 | 36                                                  |
| 88  | 8/6/2020   | 30                                                  | 128 | 9/15/2020 | 37                                                  |
| 89  | 8/7/2020   | 30                                                  | 129 | 9/16/2020 | 37                                                  |
| 90  | 8/8/2020   | 31                                                  | 130 | 9/17/2020 | 37                                                  |
| 91  | 8/9/2020   | 31                                                  | 131 | 9/18/2020 | 37                                                  |
| 92  | 8/10/2020  | 31                                                  | 132 | 9/19/2020 | 38                                                  |
| 93  | 8/11/2020  | 31                                                  | 133 | 9/20/2020 | 38                                                  |
| 94  | 8/12/2020  | 32                                                  | 134 | 9/21/2020 | 38                                                  |
| 95  | 8/13/2020  | 32                                                  | 135 | 9/22/2020 | 39                                                  |
| 96  | 8/14/2020  | 32                                                  | 136 | 9/23/2020 | 39                                                  |
| 97  | 8/15/2020  | 32                                                  | 137 | 9/24/2020 | 39                                                  |
| 98  | 8/16/2020  | 32                                                  | 138 | 9/25/2020 | 39                                                  |
| 99  | 8/17/2020  | 33                                                  | 139 | 9/26/2020 | 40                                                  |
| 100 | 8/18/2020  | 33                                                  | 140 | 9/27/2020 | 40                                                  |
| 101 | 8/19/2020  | 33                                                  | 141 | 9/28/2020 | 40                                                  |
| 102 | 8/20/2020  | 33                                                  | 142 | 9/29/2020 | 41                                                  |
| 103 | 8/21/2020  | 33                                                  | 143 | 9/30/2020 | 41                                                  |
| 104 | 8/22/2020  | 33                                                  | 144 | 10/1/2020 | 41                                                  |
| 105 | 8/23/2020  | 33                                                  | 145 | 10/2/2020 | 42                                                  |
| 106 | 8/24/2020  | 33                                                  | 146 | 10/3/2020 | 42                                                  |
| 107 | 8/25/2020  | 33                                                  | 147 | 10/4/2020 | 42                                                  |
| 108 | 8/26/2020  | 34                                                  | 148 | 10/5/2020 | 42                                                  |
| 109 | 8/27/2020  | 34                                                  | 149 | 10/6/2020 | 43                                                  |
| 110 | 8/28/2020  | 34                                                  | 150 | 10/7/2020 | 43                                                  |
| 111 | 8/29/2020  | 34                                                  | 151 | 10/8/2020 | 43                                                  |
| 112 | 8/30/2020  | 34                                                  | 152 | 10/9/2020 | 43                                                  |
| 113 | 8/31/2020  | 34                                                  | 153 | 10/10/2020| 44                                                  |
|   |   |   |   |   |   |
|---|---|---|---|---|---|
| 114 | 9/1/2020 | 34 | 154 | 10/11/2020 | 44 |
| 115 | 9/2/2020 | 34 | 155 | 10/12/2020 | 44 |
| 116 | 9/3/2020 | 34 | 156 | 10/13/2020 | 44 |
| 117 | 9/4/2020 | 34 | 157 | 10/14/2020 | 44 |
| 118 | 9/5/2020 | 35 | 158 | 10/15/2020 | 45 |
| 119 | 9/6/2020 | 35 | 159 | 10/16/2020 | 45 |
| 120 | 9/7/2020 | 35 | 160 | 10/17/2020 | 45 |
| S/N | DATE       | FORECASTED TOTAL DAILY DEATH CASES IN ECOWAS STATES | S/N | DATE       | FORECASTED TOTAL DAILY DEATH CASES IN ECOWAS STATES |
|-----|------------|-----------------------------------------------------|-----|------------|-----------------------------------------------------|
| 161 | 10/18/2020 | 45                                                  | 201 | 11/27/2020 | 53                                                  |
| 162 | 10/19/2020 | 45                                                  | 202 | 11/28/2020 | 53                                                  |
| 163 | 10/20/2020 | 45                                                  | 203 | 11/29/2020 | 53                                                  |
| 164 | 10/21/2020 | 45                                                  | 204 | 11/30/2020 | 54                                                  |
| 165 | 10/22/2020 | 46                                                  | 205 | 12/1/2020  | 54                                                  |
| 166 | 10/23/2020 | 46                                                  | 206 | 12/2/2020  | 54                                                  |
| 167 | 10/24/2020 | 46                                                  | 207 | 12/3/2020  | 54                                                  |
| 168 | 10/25/2020 | 46                                                  | 208 | 12/4/2020  | 55                                                  |
| 169 | 10/26/2020 | 46                                                  | 209 | 12/5/2020  | 55                                                  |
| 170 | 10/27/2020 | 46                                                  | 210 | 12/6/2020  | 55                                                  |
| 171 | 10/28/2020 | 47                                                  | 211 | 12/7/2020  | 55                                                  |
| 172 | 10/29/2020 | 47                                                  | 212 | 12/8/2020  | 56                                                  |
| 173 | 10/30/2020 | 47                                                  | 213 | 12/9/2020  | 56                                                  |
| 174 | 10/31/2020 | 47                                                  | 214 | 12/10/2020 | 56                                                  |
| 175 | 11/1/2020  | 47                                                  | 215 | 12/11/2020 | 56                                                  |
| 176 | 11/2/2020  | 47                                                  | 216 | 12/12/2020 | 56                                                  |
| 177 | 11/3/2020  | 47                                                  | 217 | 12/13/2020 | 57                                                  |
| 178 | 11/4/2020  | 48                                                  | 218 | 12/14/2020 | 57                                                  |
| 179 | 11/5/2020  | 48                                                  | 219 | 12/15/2020 | 57                                                  |
| 180 | 11/6/2020  | 48                                                  | 220 | 12/16/2020 | 57                                                  |
| 181 | 11/7/2020  | 48                                                  | 221 | 12/17/2020 | 57                                                  |
| 182 | 11/8/2020  | 48                                                  | 222 | 12/18/2020 | 58                                                  |
| 183 | 11/9/2020  | 49                                                  | 223 | 12/19/2020 | 58                                                  |
| 184 | 11/10/2020 | 49                                                  | 224 | 12/20/2020 | 58                                                  |
| 185 | 11/11/2020 | 49                                                  | 225 | 12/21/2020 | 58                                                  |
| 186 | 11/12/2020 | 49                                                  | 226 | 12/22/2020 | 58                                                  |
| 187 | 11/13/2020 | 49                                                  | 227 | 12/23/2020 | 58                                                  |
| 188 | 11/14/2020 | 50                                                  | 228 | 12/24/2020 | 59                                                  |
| 189 | 11/15/2020 | 50                                                  | 229 | 12/25/2020 | 59                                                  |
| 190 | 11/16/2020 | 50                                                  | 230 | 12/26/2020 | 59                                                  |
| 191 | 11/17/2020 | 50                                                  | 231 | 12/27/2020 | 59                                                  |
| 192 | 11/18/2020 | 51                                                  | 232 | 12/28/2020 | 59                                                  |
| 193 | 11/19/2020 | 51                                                  | 233 | 12/29/2020 | 60                                                  |
| 194 | 11/20/2020 | 51                                                  | 234 | 12/30/2020 | 60                                                  |
| 195 | 11/21/2020 | 51                                                  | 235 | 12/31/2020 | 60                                                  |

|            |            | TOTAL FORECASTED CASES | 8303 |
|            |            | AVERAGE                | 35   |
| Date   | Cases Forecasted |
|--------|------------------|
| 11/25/2020 | 52               |
| 11/26/2020 | 53               |