Forecasting Covid-19 Mortality in Ethiopia

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Abstract - **In this study, the ANN approach was applied to analyze COVID-19 deaths in Ethiopia. The employed data covers the period1 January 2020 to 20 April 2021 and the out-of-sample period ranges over the period21 April to 31 August 2021. The residuals and forecast evaluation criteria (Error, MSE and MAE) of the applied model indicate that the model is quite stable. The results of the study indicate that daily COVID-19 deaths in Ethiopia are likely to be between 0-50 deaths per day over the out-of-sample period. Therefore there is need for the government of Ethiopia to ensure adherence to safety guidelines while continuing to create awareness about the COVID-19 pandemic and COVID-19 vaccination.**

Keywords: ANN, COVID-19, Forecasting.

I. INTRODUCTION

The African continent has actually recorded lower COVID-19 mortality rates (WHO, 2020). By 24 January 2021 the African continent had reported 462 083 confirmed cases and 57 962 deaths (WHO, 2020). Ethiopia is second from South Africa in terms of the number of confirmed cases and deaths with an overall case fatality ratio of around 1.5% (WHO, 2020). The first case of COVID-19 in Ethiopia was reported on the 13th of March 2020 (Makoni, 2020). As of 24 January 2021 the country had reported 133 298 positive cases and 2063 COVID-19 deaths (WHO, 2020). Predictive modeling is an essential tool to analyze COVID-19 mortality in Ethiopia. It provides an insight of the likely future trends of COVID-19 deaths and hence the likely negative health impact of the COVID-19 epidemic. Furthermore, it helps to evaluate the impact of the COVID-19 mitigation measures or intervention activities to control the spread of the SARS-COV2 virus. In this study we apply the multilayer perceptron neural network to predict daily COVID-19 mortality in Ethiopia due to the popularity and high predictive accuracy of the technique (Nyoni et al, 2021; Maradze et al, 2021; Nyoni et al, 2020; Zhao et al, 2020; Kaushik & Sahi, 2018; Fojnica et al, 2016; Zhang, 2003). An appropriate COVID-19 response will be guided by the predictions of the applied model.

II. LITERATURE REVIEW

The Box-Jenkins methodology is a popular statistical technique hence Asmelash et al, (2021) applied it to predict the spread of COVID-19 in Ethiopia. Data on the daily spread between 13 March, 2020 and 31 August 2020 were collected for the development of the autoregressive integrated moving average (ARIMA) model. Forecasts showed that confirmed and recovered COVID-19 cases in Ethiopia would increase on a daily basis for the next 60 days. Gebremeskel(2021) proposed a compartmental epidemic model of COVID-19 to predict the transmission dynamics of the disease in Ethiopia. Analytically, the basic reproduction number is determined. Numerical simulations demonstrated the suitability of the proposed model for the actual COVID-19 data in Ethiopia. Trentini et al (2021) assessed how socio-demographic factors and observed mixing patterns can influence the COVID-19 disease burden in Ethiopia, by simulating SARS-CoV-2 transmission in remote settlements, rural villages, and urban neighborhoods, under school closure mandate. Their findings highlighted that socio-demographic factors can also determine marked heterogeneities across different geographical contexts within the same region, and they contribute to understand why sub-Saharan Africa is experiencing a relatively lower attack rate of severe cases compared to high-income countries. Argawu (2020) applied Pearson's correlation analysis and the linear regression model to predict COVID-19 new cases and new deaths based on the available data from 12th May to 10th June 2020 in Ethiopia. The results indicated that there was a significant positive correlation between COVID-19 new cases and new deaths with different related variables. In the multiple linear regression model, variables such as the number of days, the number of new laboratory tests, and the number of new cases from AA city significantly predicted the COVID-19 new cases. In this model, the number of days and new recoveries significantly predicted new deaths of COVID-19.

III. METHODOLOGY

The Artificial Neural Network (ANN) approach, which is flexible and capable of nonlinear modeling; will be applied in this study. The ANN is a data processing system consisting of a large number of highly interconnected processing elements in architecture inspired by the way biological nervous systems of the brain appear like. Since no explicit guidelines exist for the determination of the ANN structure, the study applies the popular ANN (12, 12, 1) model based on the hyperbolic tangent activation function. This paper applies the Artificial Neural Network (ANN) approach in predicting COVID-19 deaths in Ethiopia.

Data Issues

This study is based on daily COVID-19 deaths in Ethiopia for the period 1 January 2020 – 20 April 2021. The out-of-sample forecast covers the period 21 April – 31 August 2021. All the data employed in this research paper was gathered from the Johns Hopkins University (USA).

IV. FINDINGS OF THE STUDY

ANN Model Summary

Table 1: ANN model summary

Variable	E
Observations	464 (After Adjusting Endpoints)
Neural Network Architecture:	
Input Layer Neurons	12
Hidden Layer Neurons	12
Output Layer Neurons	1
Activation Function	Hyperbolic Tangent Function
Back Propagation Learning:	
Learning Rate	0.005
Momentum	0.05
Criteria:	
Error	2.247878
MSE	17.156839
MAE	2.936372

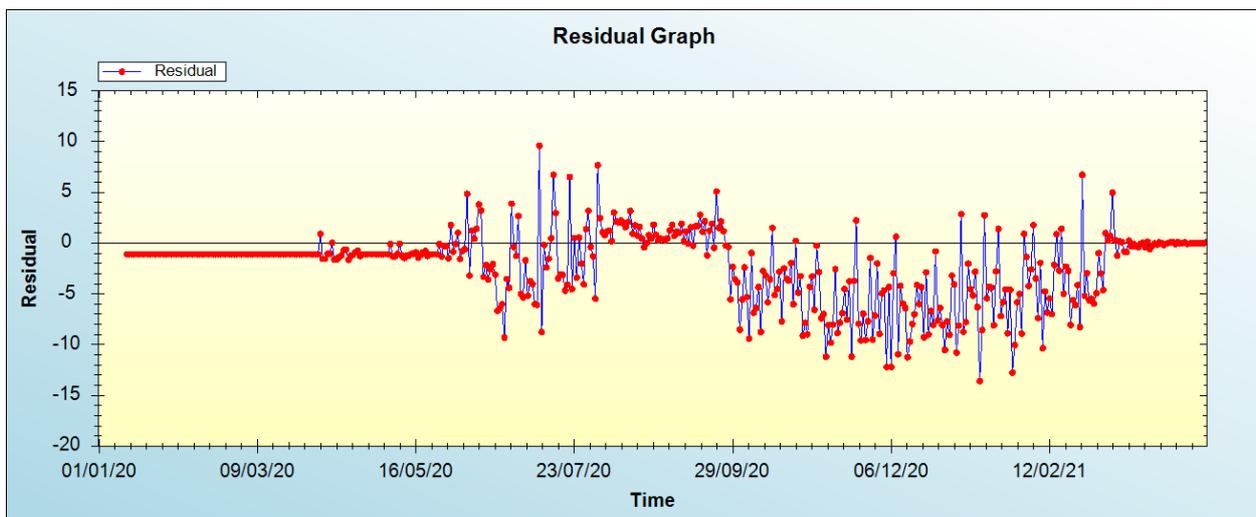Residual Analysis for the Applied Model

Figure 1: Residual analysis
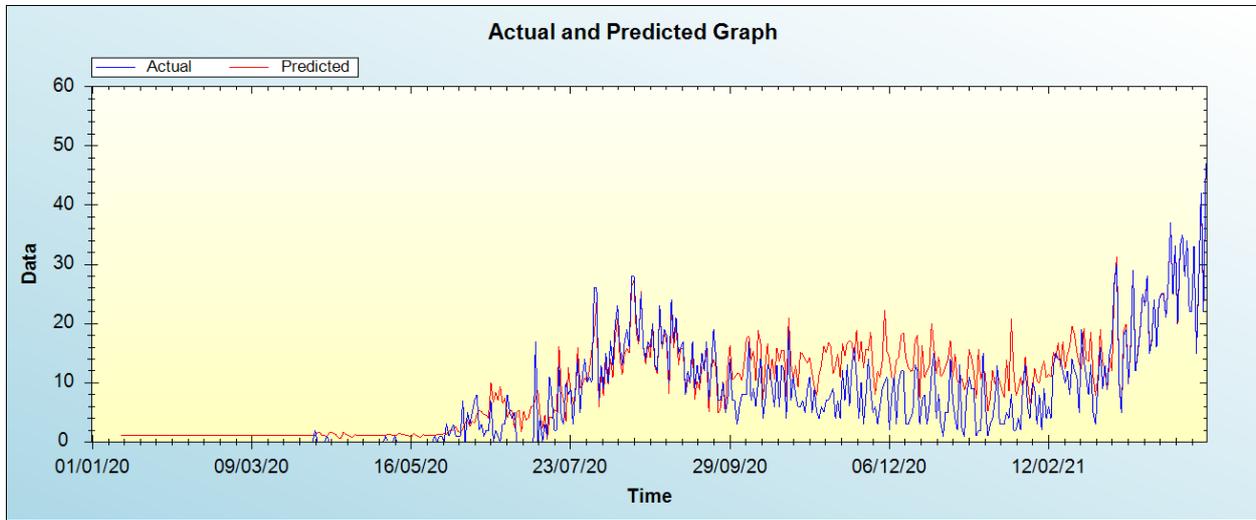
In-sample Forecast for E

Figure 2: In-sample forecast for the E series

Out-of-Sample Forecast for E: Actual and Forecasted Graph
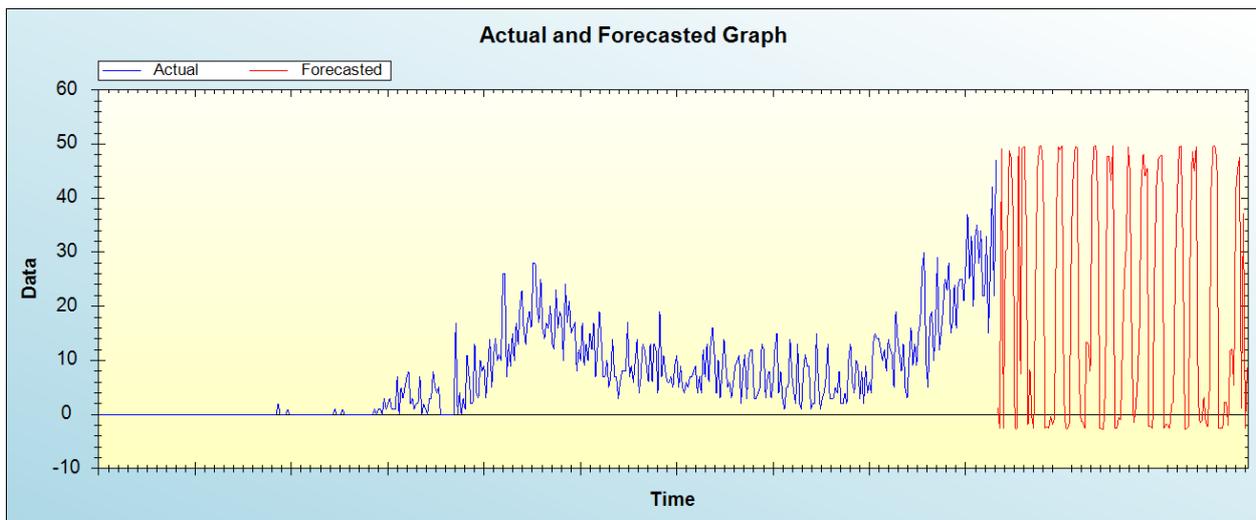

Figure 3: Out-of-sample forecast for E: actual and forecasted graph

Out-of-Sample Forecast for E: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Day/Month/Year	Projected COVID-19 deaths
21/04/21	1.2297
22/04/21	-2.5069
23/04/21	49.1613
24/04/21	-2.4756
25/04/21	30.2756
26/04/21	30.5770
27/04/21	48.7158
28/04/21	47.5453
29/04/21	37.3876
30/04/21	-2.5994
01/05/21	-2.6078
02/05/21	49.6086

03/05/21	7.3775
04/05/21	49.1318
05/05/21	49.5641
06/05/21	37.0805
07/05/21	-1.9467
08/05/21	8.3137
09/05/21	-0.5676
10/05/21	-2.4962
11/05/21	24.9476
12/05/21	45.4970
13/05/21	49.6060
14/05/21	49.6098
15/05/21	45.5866
16/05/21	-2.5142
17/05/21	-2.2313
18/05/21	-2.6060
19/05/21	-0.4459
20/05/21	-1.7696
21/05/21	-0.8289
22/05/21	36.5695
23/05/21	49.5422
24/05/21	48.9527
25/05/21	49.6029
26/05/21	3.7775
27/05/21	-2.6000
28/05/21	-2.6110
29/05/21	-1.4814
30/05/21	31.0482
31/05/21	44.9353
01/06/21	49.3681
02/06/21	49.4193
03/06/21	7.7654
04/06/21	-1.1892
05/06/21	-1.3273
06/06/21	-2.5355
07/06/21	13.4446
08/06/21	13.0273
09/06/21	8.0090
10/06/21	44.2792
11/06/21	49.6062
12/06/21	49.6111
13/06/21	38.5593
14/06/21	-2.6031
15/06/21	-2.6101
16/06/21	-2.6081
17/06/21	5.8394
18/06/21	47.7151
19/06/21	47.6243
20/06/21	43.2459
21/06/21	49.5918
22/06/21	-2.6082
23/06/21	-2.5769
24/06/21	-0.5571
25/06/21	-0.9888
26/06/21	13.3208
27/06/21	25.5681
28/06/21	31.3162
29/06/21	49.4498
30/06/21	45.0937
01/07/21	11.7232
02/07/21	-1.5658
03/07/21	1.1199
04/07/21	6.6467
05/07/21	16.6596

06/07/21	42.9509
07/07/21	48.1567
08/07/21	44.0436
09/07/21	45.5330
10/07/21	-2.1728
11/07/21	-2.2444
12/07/21	-2.5798
13/07/21	26.1924
14/07/21	42.0833
15/07/21	47.2700
16/07/21	47.7916
17/07/21	47.9183
18/07/21	-2.6062
19/07/21	-1.7541
20/07/21	-2.0530
21/07/21	-2.4942
22/07/21	1.8213
23/07/21	2.2138
24/07/21	27.7383
25/07/21	40.3927
26/07/21	49.4699
27/07/21	49.6106
28/07/21	30.4019
29/07/21	-2.6067
30/07/21	-2.6083
31/07/21	-2.2551
01/08/21	34.9283
02/08/21	48.6184
03/08/21	45.0429
04/08/21	49.4669
05/08/21	3.2055
06/08/21	-1.5026
07/08/21	-1.1255
08/08/21	3.1331
09/08/21	-1.2299
10/08/21	-2.2590
11/08/21	4.2323
12/08/21	42.1412
13/08/21	49.6093
14/08/21	49.6041
15/08/21	46.8441
16/08/21	-2.5901
17/08/21	-2.4880
18/08/21	-2.6111
19/08/21	2.2211
20/08/21	2.1536
21/08/21	-2.0042
22/08/21	11.7293
23/08/21	12.1291
24/08/21	5.3337
25/08/21	41.3316
26/08/21	45.2570
27/08/21	47.4686
28/08/21	1.2621
29/08/21	37.1678
30/08/21	-2.6105
31/08/21	8.5732

The main results of the study are shown in table 1. It is clear that the model is stable as confirmed by evaluation criterion as well as the residual plot of the model shown in figure 1. It is projected that daily COVID-19 deaths in Ethiopia are likely to be between 0-50 deaths per over the out-of-sample period.

V. CONCLUSION AND POLICY RECOMMENDATIONS

The African continent was not spared by the COVID-19 pandemic, however the continent has witnessed lower COVID-19 mortality rates as compared with others. The pandemic is still ongoing and people in Africa are still dying from the scourge. COVID-19 mortality forecasting is important in order to understand the likely trends of COVID-19 deaths and evaluate the impact of mitigation measures such as vaccination against COVID-19. In this paper we applied the artificial neural network approach to predict daily COVID-19 deaths in Ethiopia. The results of the study indicate that daily COVID-19 deaths in Ethiopia are likely to be between 0-50 deaths per over the out-of-sample period. Therefore we implore the government to address issues related COVID-19 vaccine hesitancy in order to scale up COVID-19 vaccination.

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