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Forecasting Covid-19 Deaths in Bolivia

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***Abstract* - In this study, the ANN approach was applied to analyze COVID-19 deaths in Bolivia. The employed data covers the period 1 January 2020 to 20 April 2021 and the out-of-sample period ranges over the period 21 April 2021 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 Bolivia are likely to rise to almost 2000 deaths per day over the out-of-sample period. Therefore there is need for the government of Bolivia to ensure adherence to safety guidelines while continuing to create awareness about the COVID-19 pandemic and speed up COVID-19 vaccination in order to achieve herd immunity.**

Keywords: ANN, COVID-19, Forecasting.

I. INTRODUCTION

The impact of the COVID-19 health crisis has been felt in Latin America with its negative effects on the economy, society and health sector requiring urgent attention (Congressional Research service, 2021). Brazil, Mexico, Colombia, Argentina and Peru have been hard hit by the pandemic. Vaccine roll out in the region is far below the expected levels (Congressional Research service, 2021). Bolivia reported the first case of COVID-19 on the 11th of March 2020 (Nyoni et al, 2020). According to Worldometer, by the 19th of June 2021 the country had recorded 419 313 confirmed cases, 16 009 deaths and 335 285 recoveries. As of 18 June 2021, a total of 1 615 514 people had received at one COVID-19 vaccine dose (14.0 %) and 565 938 people had been fully vaccinated representing 4.9 % of the total population (Our world in data, 2021). The government of Bolivia responded to the COVID-19 epidemic by implementing a raft of mitigation measures which included quarantine, isolation, wearing masks, social distancing, hygiene practice and treatment of cases (Bojanic& Jordan, 2020). The purpose of this study is to predict daily COVID-19 deaths in Bolivia using a machine learning technique. The findings of this paper is expected to reveal the likely trends of COVID-19 mortality in the country and facilitate decision making and resource allocation towards COVID-19 response.

II. 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 Bolivia.

Data Issues

This study is based on daily COVID-19 deaths in Bolivia 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).

III. FINDINGS OF THE STUDY

ANN Model Summary

Table 1: ANN model summary

Variable	B
Observations	464 (After Adjusting Endpoints)
Neural Network Architecture:	

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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	0.082415
MSE	5748.979038
MAE	24.202751

Residual Analysis for the Applied Model

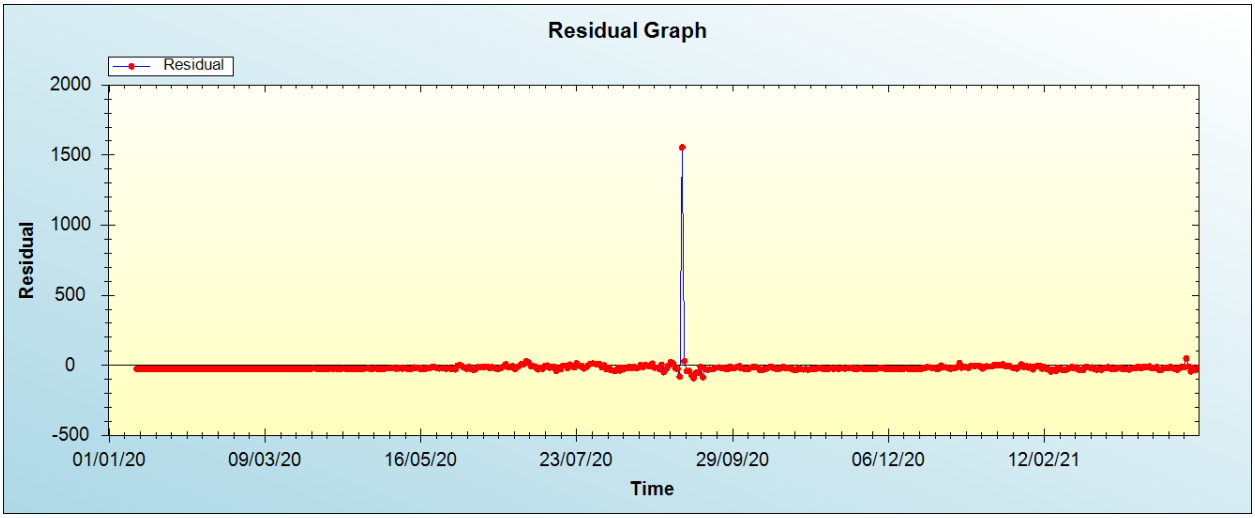

Figure 1: Residual analysis

In-sample Forecast for B

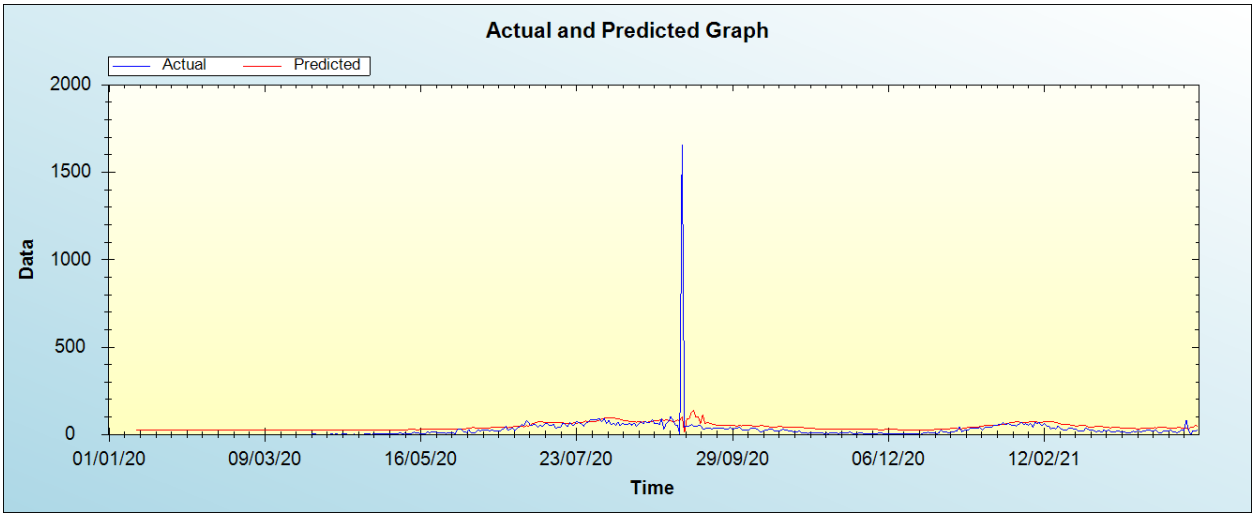

Figure 2: In-sample forecast for the B series

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

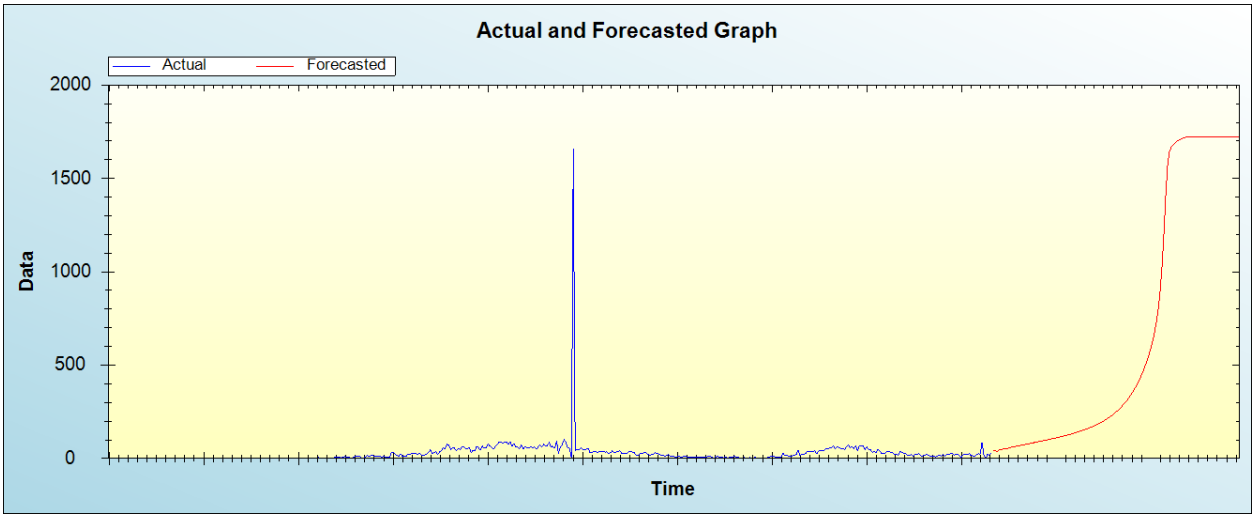

Figure 3: Out-of-sample forecast for B: actual and forecasted graph

Out-of-Sample Forecast for B: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Date	Forecasts
21/04/21	43.6762
22/04/21	44.0116
23/04/21	33.5013
24/04/21	46.4599
25/04/21	47.7758
26/04/21	48.1130
27/04/21	53.4813
28/04/21	53.0000
29/04/21	54.0012
30/04/21	57.7579
01/05/21	61.7314
02/05/21	61.6491
03/05/21	65.0374
04/05/21	66.7940
05/05/21	68.2416
06/05/21	71.1112
07/05/21	73.1857
08/05/21	74.9461
09/05/21	76.8276
10/05/21	79.2808
11/05/21	80.8960
12/05/21	83.2087
13/05/21	85.2738
14/05/21	87.1382
15/05/21	89.2454
16/05/21	91.3388
17/05/21	93.4198
18/05/21	95.4469
19/05/21	97.6682
20/05/21	99.6968
21/05/21	101.8940
22/05/21	104.1059
23/05/21	106.3090
24/05/21	108.5697
25/05/21	110.8681
26/05/21	113.2176

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27/05/21	115.5816
28/05/21	118.0545
29/05/21	120.5292
30/05/21	123.0896
31/05/21	125.7137
01/06/21	128.4044
02/06/21	131.1736
03/06/21	134.0244
04/06/21	136.9697
05/06/21	139.9971
06/06/21	143.1454
07/06/21	146.3926
08/06/21	149.7660
09/06/21	153.2680
10/06/21	156.9100
11/06/21	160.7035
12/06/21	164.6596
13/06/21	168.7955
14/06/21	173.1173
15/06/21	177.6507
16/06/21	182.4044
17/06/21	187.4019
18/06/21	192.6616
19/06/21	198.2062
20/06/21	204.0598
21/06/21	210.2483
22/06/21	216.8025
23/06/21	223.7508
24/06/21	231.1309
25/06/21	238.9776
26/06/21	247.3329
27/06/21	256.2405
28/06/21	265.7480
29/06/21	275.9071
30/06/21	286.7725
01/07/21	298.4045
02/07/21	310.8655
03/07/21	324.2241
04/07/21	338.5521
05/07/21	353.9271
06/07/21	370.4329
07/07/21	388.1609
08/07/21	407.2146
09/07/21	427.7138
10/07/21	449.8053
11/07/21	473.6765
12/07/21	499.5802
13/07/21	527.8719
14/07/21	559.0706
15/07/21	593.9586
16/07/21	633.7461
17/07/21	680.3553
18/07/21	736.9150
19/07/21	808.6147
20/07/21	904.0064
21/07/21	1035.8406
22/07/21	1215.0541
23/07/21	1420.5731
24/07/21	1575.7644
25/07/21	1645.5189
26/07/21	1670.1206
27/07/21	1681.0384
28/07/21	1689.6617
29/07/21	1698.2872

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30/07/21	1705.3990
31/07/21	1710.9905
01/08/21	1715.4272
02/08/21	1718.7754
03/08/21	1721.0986
04/08/21	1722.4391
05/08/21	1723.0404
06/08/21	1723.2429
07/08/21	1723.3130
08/08/21	1723.3560
09/08/21	1723.3902
10/08/21	1723.4189
11/08/21	1723.4416
12/08/21	1723.4602
13/08/21	1723.4758
14/08/21	1723.4876
15/08/21	1723.4949
16/08/21	1723.4986
17/08/21	1723.5000
18/08/21	1723.5005
19/08/21	1723.5007
20/08/21	1723.5009
21/08/21	1723.5010
22/08/21	1723.5011
23/08/21	1723.5011
24/08/21	1723.5012
25/08/21	1723.5013
26/08/21	1723.5013
27/08/21	1723.5013
28/08/21	1723.5013
29/08/21	1723.5013
30/08/21	1723.5013
31/08/21	1723.5013

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 Bolivia are likely torise to almost 2000 deaths per day over the out-of-sample period.

IV. CONCLUSION AND POLICY RECOMMENDATIONS

Many countries around the world are struggling to control the COVID-19 pandemic due to dwindling resources. Mobilization of resources should be done timeously in order to minimize the impact of the pandemic especially in developing countries which are characterized by civil conflict, poverty, hunger and poor healthcare infrastructure and also in developed countries which have no breathing space as a result of incessant COVID-19 waves. Predictive modeling therefore is necessary to guide policy and decision making so that adequate resources can be mobilized early. In this paper we applied the artificial intelligence method to forecast daily COVID-19 deaths in Bolivia. The results indicate that daily COVID-19 deaths in Bolivia are likely to rise to almost 2000 deaths per day over the out-of-sample period. Hence the authorities in Bolivia are strongly encouraged to scale up COVID-19 vaccination and address issues leading to vaccine hesitancy.

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