

Forecasting Covid-19 Mortality in Guatemala

¹Dr. Smartson. P. NYONI, ²Mr. Thabani NYONI, ³Mr. Tatenda. A. CHIHOHO

¹ZICHIRE Project, University of Zimbabwe, Harare, Zimbabwe

²SAGIT Innovation Center, Harare, Zimbabwe

³Independent Health Economist, Harare, Zimbabwe

Abstract - In this study, the ANN approach was applied to analyze COVID-19 deaths in Guatemala. The employed data covers the period 1 January 2020 to 20 April 2020 and the out-of-sample period ranges over the period 21 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 the daily COVID-19 deaths in Guatemala are likely to be between 0 and 65 deaths per day over the out-of-sample period. Therefore there is need for the government of Guatemala to ensure adherence to safety guidelines while continuing to create awareness about the COVID-19 pandemic and scale up COVID-19 vaccination.

Keywords: ANN, COVID-19, Forecasting.

I. INTRODUCTION

Infectious disease modeling is among the top priorities during this COVID-19 pandemic. The COVID-19 outbreak started in Wuhan City of China in December 2019 (WHO, 2020; Chan et al, 2020). Predictive modeling of infectious diseases is an important tool in public health surveillance as it provides the future trends of diseases, helps detect outbreaks, and it is a useful tool in the evaluation of health intervention activities (Teutsch & Churchill, 2000). For predictive modeling to be successful there is need to document all processes, activities or events in order to capture all the important information so that reliable and accurate forecasts can be obtained. Therefore it is critical to have a strong health information system that enables data collection to take place at all levels including the lowest level of the health care delivery system. Supervision of lower level cadres is required to ensure adequate and accurate information is recorded in relevant primary source documents.

There are many empirical studies on COVID-19 at global level however in this paper we will highlight some of them. Islam et al (2021) estimated the direct and indirect effects of the covid-19 pandemic on mortality in 2020 in 29 high income countries with reliable and complete age and sex disaggregated mortality data. The study concluded that approximately one million excess deaths occurred in 2020 in these 29 high income countries. Age standardized excess death rates were higher in men than women in almost all countries. Excess deaths substantially exceeded reported deaths from covid-19 in many countries. A global systematic literature review to summarize trends in the modelling techniques used for Covid-19 from January 1st, 2020 to November 30th, 2020 was carried by Gnanvi et al (2021). The findings suggested that while predictions made by the different models are useful to understand the pandemic course and guide policy-making, some were relatively accurate and precise while others are not. Ayoobi et al (2020) predict new cases and death rate for seven days ahead. Deep learning methods and statistical analysis model these predictions for 100 days. Six different deep learning methods are examined for the data adopted from the WHO website. Three methods are known as LSTM, Convolutional LSTM, and GRU. The results showed that the Bi-directional models have lower error than other models. Berec et al (2020) developed an age-structured model of COVID-19 epidemic, distinguished several types of contact, and divided the population into 206 counties. They calibrated the model by sociological and population movement data and used it to analyze the first wave of COVID-19 epidemic in Czechia. The main finding of the study was that tracing and quarantine or just local lockdowns can effectively compensate for any global lockdown if the numbers of confirmed cases not exceedingly high.

Various techniques are used to predict epidemic incidences or the evolution of infectious diseases. Some of the models are the ARIMA, exponential smoothing and machine learning methods. The popularity of machine learning algorithms is due to their ability to model nonlinear complex data sets and their high predictive accuracy (Nyoni et al, 2020; Zhao et al, 2020; Danish et al, 2018; Weng et al, 2017; Kaushik & Sahi, 2021; Fojnica et al, 2016). In this study we propose to apply a machine learning algorithm to predict daily COVID-19 deaths in Guatemala. The findings of this piece of work will provide highlights of the future trends of COVID-19 mortality in the country thereby guiding planning and allocation of resources for the COVID-19 response in Guatemala.

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 Guatemala.

Data Issues

This study is based on daily COVID-19 deaths in Guatemala 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 | G |
|------------------------------|---------------------------------|
| 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 | 3.500498 |
| MSE | 25.016599 |
| MAE | 4.084137 |

Residual Analysis for the Applied Model

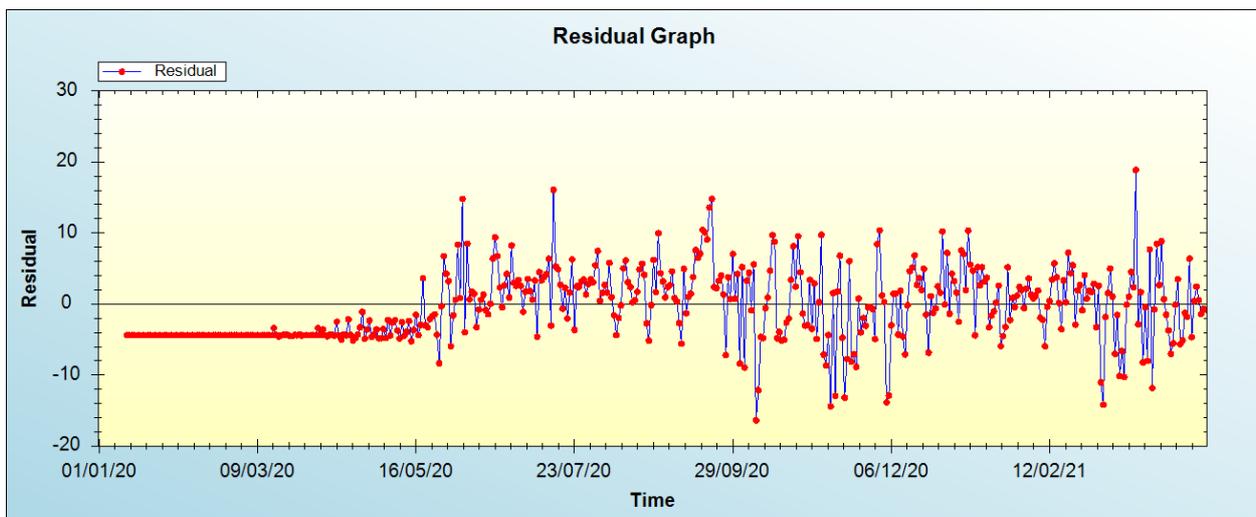


Figure 1: Residual analysis

In-sample Forecast for G

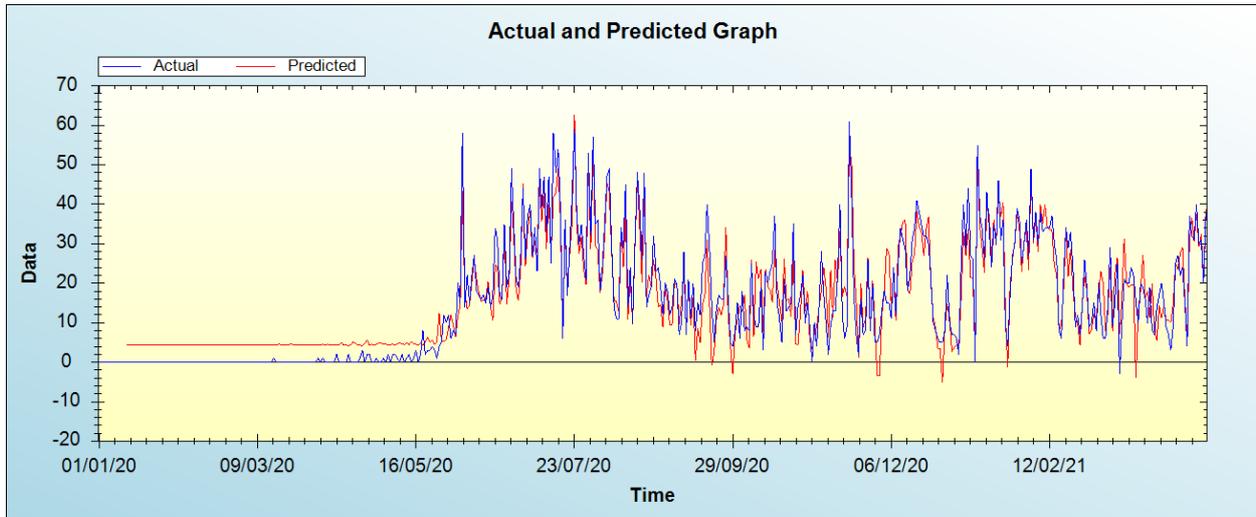


Figure 2: In-sample forecast for the G series

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

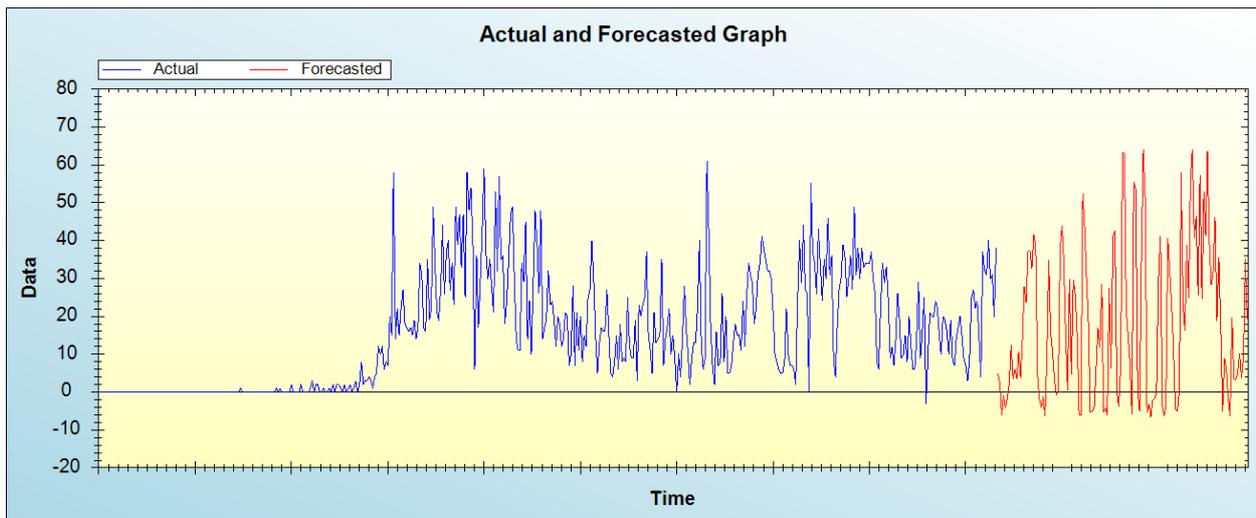


Figure 3: Out-of-sample forecast for G: actual and forecasted graph

Out-of-Sample Forecast for G: Forecasts only

Table 2: Tabulated out-of-sample forecasts

| Day/Month/Year | Projected COVID-19 deaths |
|----------------|---------------------------|
| 21/04/21 | 4.8277 |
| 22/04/21 | 2.4333 |
| 23/04/21 | -6.1480 |
| 24/04/21 | -0.9269 |
| 25/04/21 | -4.0815 |
| 26/04/21 | -1.7787 |
| 27/04/21 | 2.1344 |
| 28/04/21 | 12.3264 |
| 29/04/21 | 3.5866 |
| 30/04/21 | 6.0099 |
| 01/05/21 | 3.5257 |
| 02/05/21 | 10.5814 |
| 03/05/21 | 3.7402 |
| 04/05/21 | 13.8169 |

| | |
|----------|---------|
| 05/05/21 | 27.8747 |
| 06/05/21 | 23.5444 |
| 07/05/21 | 37.1716 |
| 08/05/21 | 37.2840 |
| 09/05/21 | 32.5796 |
| 10/05/21 | 41.7132 |
| 11/05/21 | 38.4213 |
| 12/05/21 | 4.7031 |
| 13/05/21 | -1.9936 |
| 14/05/21 | -3.9956 |
| 15/05/21 | -1.0701 |
| 16/05/21 | -6.4544 |
| 17/05/21 | 9.7788 |
| 18/05/21 | 34.6899 |
| 19/05/21 | 15.7092 |
| 20/05/21 | 10.4428 |
| 21/05/21 | 3.2693 |
| 22/05/21 | -0.6772 |
| 23/05/21 | 0.1374 |
| 24/05/21 | 37.7440 |
| 25/05/21 | 43.8544 |
| 26/05/21 | 34.6112 |
| 27/05/21 | 14.4485 |
| 28/05/21 | 0.4959 |
| 29/05/21 | 29.8031 |
| 30/05/21 | 4.8265 |
| 31/05/21 | 29.5369 |
| 01/06/21 | 25.7638 |
| 02/06/21 | 14.8192 |
| 03/06/21 | -5.8949 |
| 04/06/21 | -6.0587 |
| 05/06/21 | 52.3652 |
| 06/06/21 | 43.4287 |
| 07/06/21 | 30.4791 |
| 08/06/21 | 18.6990 |
| 09/06/21 | -5.4316 |
| 10/06/21 | -5.0541 |
| 11/06/21 | -4.2801 |
| 12/06/21 | 5.9573 |
| 13/06/21 | 16.9198 |
| 14/06/21 | 11.7515 |
| 15/06/21 | 28.5644 |
| 16/06/21 | -5.3534 |
| 17/06/21 | -4.2202 |
| 18/06/21 | -6.1222 |
| 19/06/21 | 27.3973 |
| 20/06/21 | 6.1915 |
| 21/06/21 | 40.9940 |
| 22/06/21 | 42.6628 |
| 23/06/21 | 0.0284 |
| 24/06/21 | -3.8630 |
| 25/06/21 | 6.7002 |
| 26/06/21 | 63.1181 |
| 27/06/21 | 63.0229 |
| 28/06/21 | 21.9056 |
| 29/06/21 | 14.6420 |
| 30/06/21 | 7.8443 |
| 01/07/21 | -5.8586 |
| 02/07/21 | 55.3400 |
| 03/07/21 | 53.5431 |
| 04/07/21 | 0.6781 |
| 05/07/21 | -5.0593 |
| 06/07/21 | 35.7649 |
| 07/07/21 | 64.0167 |

| | |
|----------|---------|
| 08/07/21 | 51.0308 |
| 09/07/21 | -5.4186 |
| 10/07/21 | -3.2669 |
| 11/07/21 | -6.5370 |
| 12/07/21 | -2.0093 |
| 13/07/21 | -1.7321 |
| 14/07/21 | -0.3640 |
| 15/07/21 | 29.7994 |
| 16/07/21 | 41.2479 |
| 17/07/21 | -3.5979 |
| 18/07/21 | -6.4631 |
| 19/07/21 | -3.5796 |
| 20/07/21 | 40.5882 |
| 21/07/21 | 31.8231 |
| 22/07/21 | 22.9843 |
| 23/07/21 | 12.3357 |
| 24/07/21 | -4.5534 |
| 25/07/21 | -5.1243 |
| 26/07/21 | 0.2879 |
| 27/07/21 | 57.8465 |
| 28/07/21 | 22.8857 |
| 29/07/21 | 16.3885 |
| 30/07/21 | 38.8217 |
| 31/07/21 | 24.8297 |
| 01/08/21 | 56.3117 |
| 02/08/21 | 64.0636 |
| 03/08/21 | 40.7512 |
| 04/08/21 | 46.4880 |
| 05/08/21 | 25.5202 |
| 06/08/21 | 57.1746 |
| 07/08/21 | 24.5144 |
| 08/08/21 | 52.8508 |
| 09/08/21 | 41.2404 |
| 10/08/21 | 63.6138 |
| 11/08/21 | 38.2677 |
| 12/08/21 | 28.2826 |
| 13/08/21 | 31.4783 |
| 14/08/21 | 46.1125 |
| 15/08/21 | 18.7775 |
| 16/08/21 | 35.6287 |
| 17/08/21 | 16.7341 |
| 18/08/21 | -5.0765 |
| 19/08/21 | 8.9205 |
| 20/08/21 | 6.2905 |
| 21/08/21 | -2.0410 |
| 22/08/21 | -6.3723 |
| 23/08/21 | 19.7822 |
| 24/08/21 | 3.4963 |
| 25/08/21 | 3.2384 |
| 26/08/21 | 5.0283 |
| 27/08/21 | 10.1451 |
| 28/08/21 | 3.8697 |
| 29/08/21 | 8.8220 |
| 30/08/21 | 34.9637 |
| 31/08/21 | 19.4114 |

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 Guatemala are likely to be between 0 and 65 deaths per day over the out-of-sample period.

IV. CONCLUSION AND POLICY RECOMMENDATIONS

The ongoing COVID-19 pandemic still remains a serious global health threat, however governments should strengthen their health delivery systems and improve on emergency preparedness by putting aside resources for emergence response. Priority should be given to improving access to health services for people living in resource limited settings where the majority of people have little or no access to basic services such as water, food, primary healthcare and education. In this study we predict daily COVID-19 deaths using the multilayer perceptron neural network (MLP). The model predictions suggest that that daily COVID-19 deaths in Guatemala are likely to be between 0 and 65 deaths per day over the out-of-sample period. Therefore we encourage the authorities in Guatemala to address COVID-19 vaccine hesitancy problems in order to quickly achieve herd immunity.

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