Forecasting Future Trends of Under Five Mortality Rate for the Dominican Republic Using Artificial Neural Networks

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Abstract - **This study uses annual time series data on under five mortality rate (U5MR) for the Dominican Republic from 1960 to 2020 to predict future trends of U5MR over the period 2021 to 2030. Residuals and forecast evaluation criteria indicate that the applied ANN (12, 12, 1) model is stable in forecasting under five mortality rate. ANN model projections suggest that annual U5MR will hover around 35 deaths per 1000 live births over the out of sample period. Therefore, the Dominican Republic must allocate more resources to the maternal and child health (MNCH) program and attend to all the problems that significantly contribute to under five mortality.**

Keywords: ANN, Forecasting, U5MR.

I. INTRODUCTION

The agenda 2030 for sustainable development was launched in September 2015 at the United Nations Headquarters in New York. The purpose of the meeting was to attend to the fundamental needs of different countries and regions across the globe (UN, 2016; UN, 2015). The outcome document with 169 targets formed a foundation for achieving the three dimensions of sustainable development by 2030. Developing and developed countries are both included in the global agenda and the aim is to leave no one behind. All countries have done a tremendous job in addressing all the major challenges that affect communities in the entire world. However, Sub-Saharan Africa and South Asia are trailing behind in most of the sustainable development goals especially maternal, newborn and under five mortality (Kayode *et al.* 2017). Countries should aim to reduce neonatal and under five mortality to levels as low as 12 neonatal deaths per 1000 live births and 25 under five deaths per 1000 live births by 2030 (UN, 2020; WHO, 2019; UNICEF, 2019; UNICEF, 2018). In line with agenda 2030, this study applies the artificial neural network technique to forecast future trends of under-five mortality in the Dominican Republic. We anticipate the study findings to highlight likely future trends of under-five mortality rate to guide policy, planning and allocation of resources to MNCH program activities to end all preventable under five deaths.

II. LITERATURE REVIEW

Li *et al.* (2021) determined the proportion of mothers with history of neonatal deaths using the most recent Demographic and Health Surveys from 56 low- and middle-income countries. Logistic regression models were used to assess the association between maternal history of neonatal death and subsequent neonatal mortality. The adjusted models controlled for socioeconomic, child, and pregnancy-related factors. Country-specific analyses were performed to assess heterogeneity in this association across countries. Study findings highlighted that maternal history of neonatal death could be an effective early identifier of high-risk pregnancies in resource-poor countries. A cross-sectional study conducted by Weddhi *et al.* (2019) examined factors associated with neonatal mortality at a Referral Hospital in Nouakchott, Mauritania. The study concluded that neonatal mortality remains a significant burden in Mauritania. A descriptive study was carried out by McNamara *et al.* (2018) to reveal intrapartum fetal deaths and unexpected neonatal deaths in Ireland from 2011 to 2014. Anonymised data pertaining to all intrapartum fetal deaths and unexpected neonatal deaths for the study time period was obtained from the national perinatal epidemiology centre. The findings of the study revealed that the corrected intrapartum fetal death rate was 0.16 per 1000 births and the overall unexpected neonatal death rate was 0.17 per 1000 live births. Caluza (2018) utilized data mining technique using decision tree called J48 algorithm in classifying child mortality rate, life expectancy at birth, annual population growth, and the gross domestic product. Results showed that annual population growth is highly correlated in predicting child mortality and generate three distinct rules. The generated model had high acceptability with 97.4% ROC curve result of the three classes in predicting child mortality under five years old. Saravanou *et al.* (2016) studied the infant mortality prediction using features extracted from birth certificates. Training of classification models to decide whether an infant will survive or not was carried out. The authors focused on exploring and understanding the importance of features in subsets of the population and compared models trained for individual races to general models. The study concluded that the applied methodology outperformed standard classification methods used by epidemiology researchers.

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 annual under five mortality rate for the Dominican Republic.

Data Issues

This study is based on annual under five mortality rate in the Dominican Republic for the period 1960 – 2020. The out-of-sample forecast covers the period 2021– 2030. All the data employed in this research paper was gathered from the World Bank online database.

IV. FINDINGS OF THE STUDY

ANN Model Summary

Table 1: ANN model summary

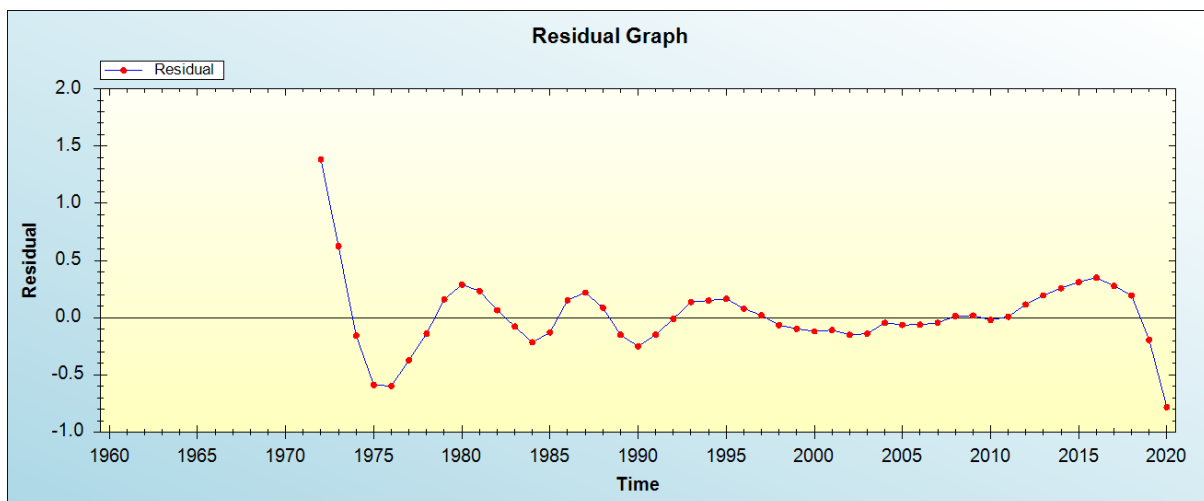| Variable	D
Observations	49 (After Adjusting Endpoints)
Neural Network Architecture:	
Input Layer Neurons	12
Hidden Layer Neurons	12
Output Layer Neurons	1
Activation Function	Hyperbolic Tangent Function
Back Propagation Learning	
Learning Rate	0.005
Momentum	0.05
Criteria:	
Error	0.000688
MSE	0.099623
MAE	0.208824

Residual Analysis for the Applied Model

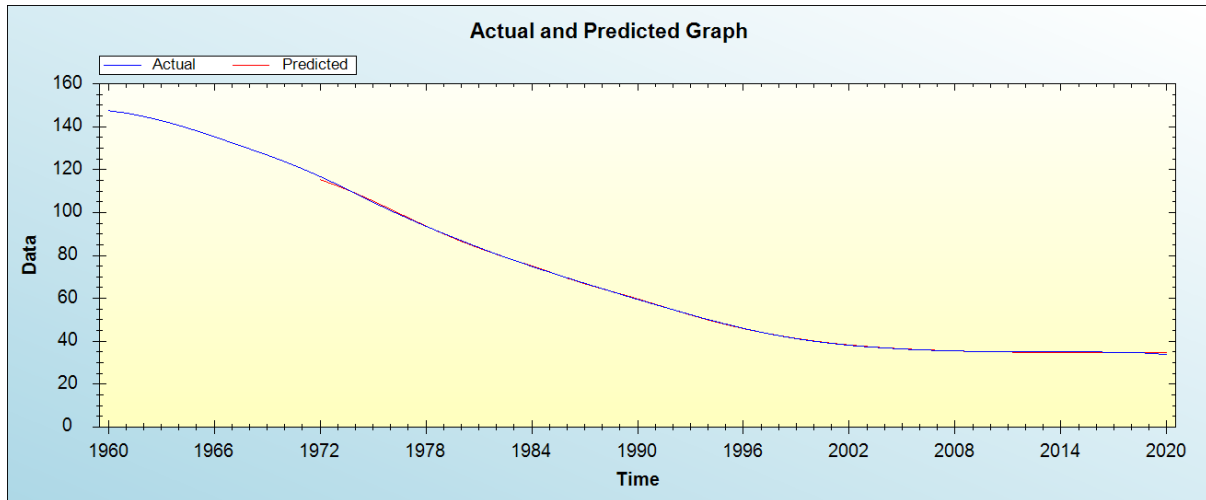Figure 1: Residual analysis

In-sample Forecast for D

Figure 2: In-sample forecast for the D series

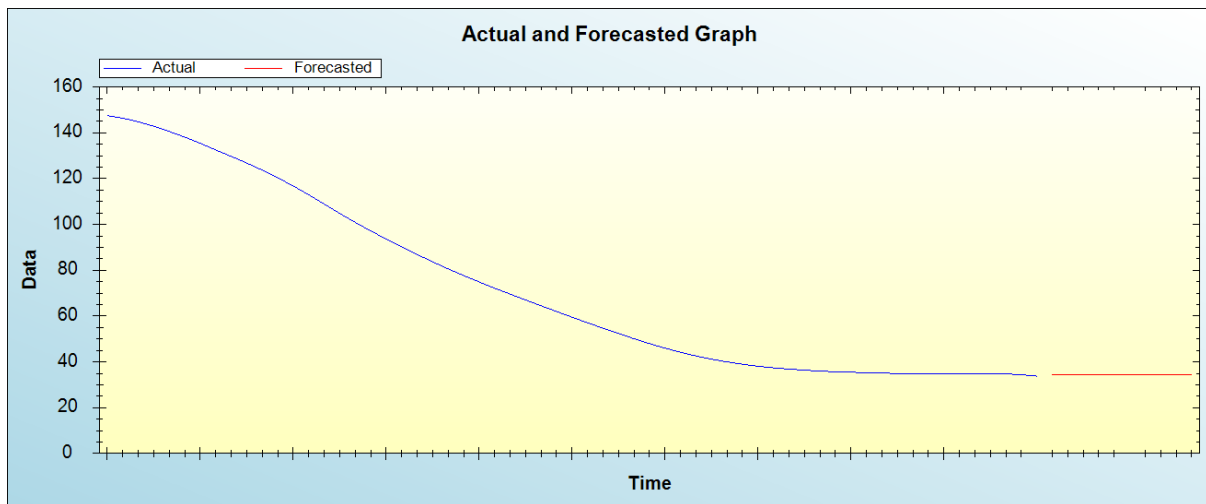Out-of-Sample Forecast for D: Actual and Forecasted Graph

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

Out-of-Sample Forecast for D: Forecasts only

Table 2: Tabulated out-of-sample forecasts

2021	34.5786
2022	34.5724
2023	34.5412
2024	34.5306
2025	34.5015
2026	34.5032
2027	34.5140
2028	34.5348
2029	34.5068
2030	34.4839

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 annual U5MR will hover around 35 deaths per 1000 live births over the out of sample period.

V. POLICY IMPLICATION & CONCLUSION

Under five mortality remains a public health problem all over the world. Crafting new strategies will help in the substantial reduction of mortality among under five children. This study applied the ANN model to analyze U5MR in the Dominican Republic and forecast results indicate that annual U5MR will hover around 35 deaths per 1000 live births over the out of sample period. Therefore, health authorities in the Dominican Republic must allocate more resources to the maternal and child health (MNCH) program and attend to all the problems that significantly contribute to under five mortality.

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