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Forecasting Infant Mortality Rate in Benin Using Artificial Neural Networks

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***Abstract* - In this research article, the ANN approach was applied to analyze infant mortality rate in Benin. The employed data covers the period 1960-2020 and the out-of-sample period ranges over the period 2021-2030. The residuals and forecast evaluation criteria (Error, MSE and MAE) of the applied model indicate that the model is stable in forecasting infant mortality rate in Benin. The model predictions suggest that infant mortality rate is likely to decline by almost 4 deaths/1000 live births per year over the next decade. Therefore the government is encouraged to prioritize increasing coverage for mother and child immunizations amongst the suggested policy directions.**

Keywords: ANN, Forecasting, infant mortality rate.

I. INTRODUCTION

Time series forecasting methods for public health are under-utilized in developing countries yet these nations are hard hit by several incidences of health conditions both communicable and non-communicable diseases. Low and middle income countries are battling epidemics of TB, HIV and Malaria. Furthermore, countries in Sub-Saharan Africa have been devastated by poverty, hunger, poor health infrastructure, bad road networks and civil conflicts. They rely mainly on donor funds to sustain their public health systems and withdrawal of donor funds will result in collapse of the health systems especially reversing the gains achieved so far in reducing maternal and child mortality. Time series predictive models are essential in detecting disease outbreaks, changes in trends of infectious diseases and to evaluate health intervention programs. Machine learning algorithms have been widely applied as a surveillance tool in public health in developed countries such as USA, China and the UK. Machine learning methods such as artificial neural networks, K- nearest neighbors, support vector machine, tree-based models and Bayesian networks have wide application (Nyoni et al, 2020; Zhao et al, 2020; Yan et al, 2018; Kaushik & Sahi, 2018; Weng et al, 2017). In this paper we applied the artificial neural network approach to predict infant mortality rate in Benin. The applied ANN (12, 12, 1) model is called the Multilayer Perceptron (MLP) with 12, 12, 1 representing the number of input, hidden and output nodes respectively. The model is based on the structure and function of the human brain (Zhao et al, 2020; Nyoni et al, 2020; Yan et al, 2018; Kaushik & Sahi, 2018, Fojnica et al, 2016; Zhang, 2003, Kishan, 1997; Patterson, 1995). The results this study are envisioned to reveal the likely future trends of infant mortality rate and facilitate the evaluation of maternal and child health intervention programs in Benin.

II. METHODOLOGY

The Artificial Neural Network (ANN), which we intend to apply in this study; is a data processing system consisting of a huge number of simple and highly interconnected processing elements resembling a biological neural system. It has the capability of learning from any data-set to describe the nonlinear and interaction effects with great accuracy. No strict rules exist for the determination of the ANN structure hence 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 infant mortality rates in Benin.

Data Issues

This study is based on annual infant mortality rates in Benin for the period 1960 – 2020. The out-of-sample forecast covers the period 2021 to 2030. Infact mortality rate, which is simply a proxy for infant deaths; for the purposes of this study, is defined as the number of infants dying before reaching one year of age, per 1000 live births in a given year. All the data employed in this paper was gathered from the World Bank.

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III. FINDINGS OF THE STUDY

ANN Model Summary

Table 1: ANN model summary

Variable	Y
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

Residual Analysis for the Applied Model

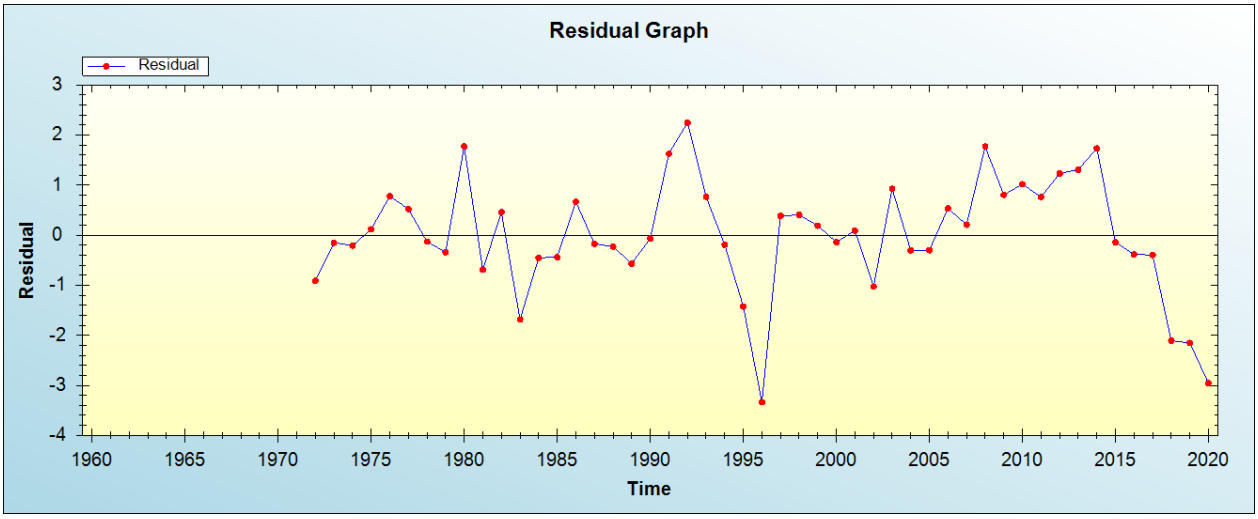

Figure 1: Residual analysis

In-sample Forecast for Y

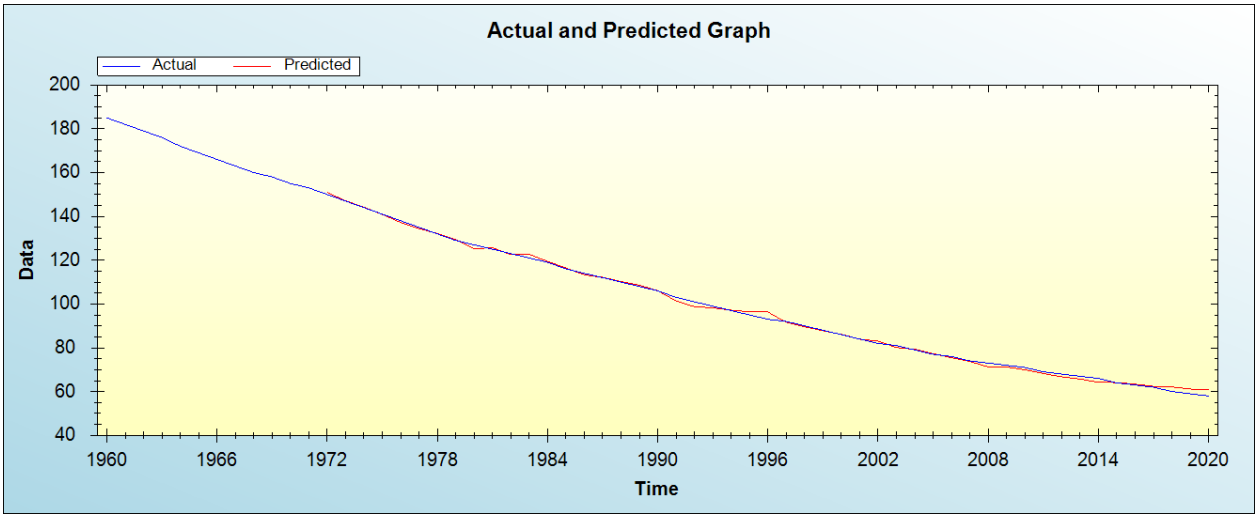

Figure 2: In-sample forecast for the Y series

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

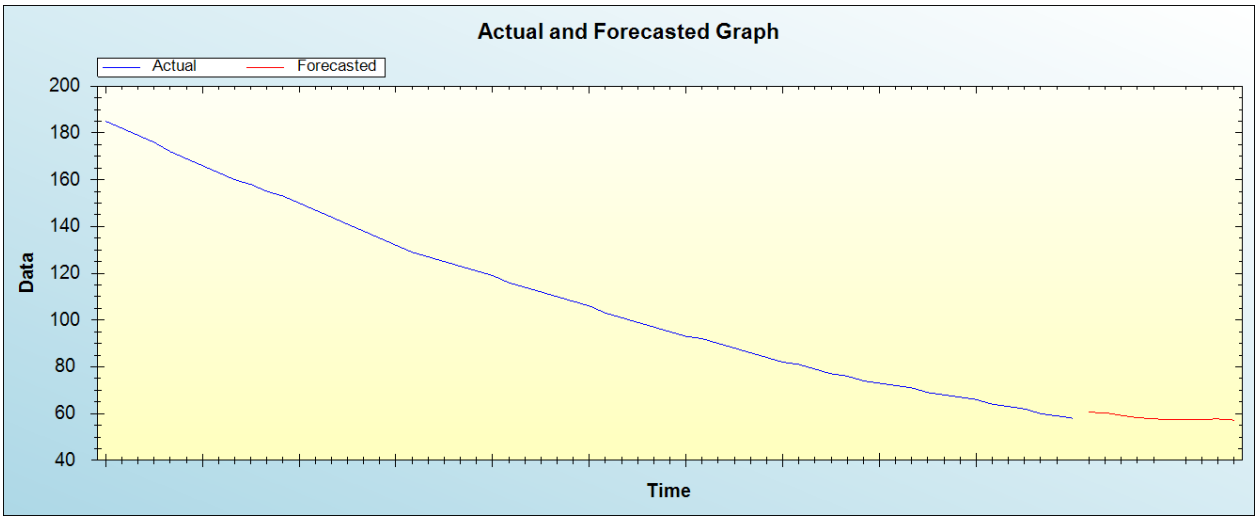

Figure 3: Out-of-sample forecast for Y: actual and forecasted graph

Out-of-Sample Forecast for Y: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecasts
2021	60.5847
2022	60.3333
2023	59.1718
2024	58.2719
2025	57.7459
2026	57.4852
2027	57.2917
2028	57.6174
2029	57.7078
2030	57.1995

The main results of the research are shown in table 1. It is clear that the model is stable as confirmed by the residual plot of the model shown in figure 1. It is projected that infant mortality in Benin is likely to decline from approximately 61 (this year) to almost 57 deaths/1000 live births annually by 2030.

IV. CONCLUSION AND POLICY RECOMMENDATIONS

Preventing infant mortality remains one of the main objectives of the health ministry in Benin. The government of Benin remains committed to ending preventable deaths infants in the country. The study used annual data to analyze the trends of infant mortality in Benin. The applied model is the ANN model. In order to make sure that infant mortality in the country significantly declines, the government of Benin ought to consider the following policy suggestions:

i. The Benin government should continue to encourage mothers to breast-feed their babies adequately.
ii. There is need for all child-bearing women in Benin to be vaccinated against common illnesses.
iii. There is need to prevent birth defects in Benin.
iv. The government of Benin should address preterm birth, low birth-weight and their outcomes.
v. The government of Benin should also ensure adequate access to pre-pregnancy and prenatal care.
vi. There is need to educate, especially, mothers on the importance of creating a safe infant sleep environment in Benin.

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vii. Healthcare providers in Benin need to use newborn screening activities in order to detect hidden conditions.

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