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Forecasting Infant Mortality in Mozambique Using Artificial Neural Networks

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***Abstract* - In this research article, the ANN approach was applied to analyze infant mortality rate in Mozambique. The employed data covers the period 1964-2020 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 Mozambique. The results of the study indicate that IMR will be around 52/1000 live births per year in the out-of-sample period. The government is strongly encouraged to capacitate primary care health facilities in the remote areas so that they are able to conduct safe deliveries and provide basic essential newborn care.**

Keywords: ANN, Forecasting, Infant mortality.

I. INTRODUCTION

A time series is a sequential set of data points measured typically over successive times (Zhang, 2003). The main objective of time series modelling is to carefully collect and study past observations or historical data of a particular time series in order to develop or build an ideal model which accurately represents the structure of the series (Zhang 2020; Zhang, 2003). The optimal model is then used to generate forecasts or future values of the time series. Time series modeling and forecasting is a very important tool in public health surveillance. It helps to detect or identify abnormal patterns or trends of infectious diseases or health conditions (Zhang, 2014). It useful for prediction, health planning and service delivery. It is a powerful tool for developing effective control strategies for infectious diseases. Statistical and Machine learning methods are used in time series forecasting. Hybrid models have also been extensively utilized and have demonstrated high predictive accuracy (Yan et al, 2010; Ren et al, 2013; Zhang et al, 2013; Yan et al, 2014). Autoregressive integrated moving average (ARIMA) models are widely used in time series forecasting of infectious diseases such as TB, Hepatitis, hemorrhagic fever, and influenza (Chen et al, 2012; Kumar et al, 2014; Akhtar et al, 2009; Li et al, 2012; Gharbi et al, 2011; Zhu et al, 2011; Babu & Reddy, 2014). The ARIMA (p, d, q) is the basic ARIMA model form where p and q are the nonseasonal autoregressive and moving average parts and d represents the number of non-seasonal differences (Nyoni & Nyoni, 2020; Nyoni & Nyoni , 2019 a & b). The ARIMA model building process is a 3 stage iterative process meant to select an optimal model. Artificial neural networks are machine learning techniques which are widely used in nonlinear time series forecasting problems (Hornik et al, 1989; Cross et al, 1995). In this paper we apply the Multilayer Perceptron to model and forecast infant mortality rate in Mozambique. The results of the study will help decision makers to plan and implement corrective measures in order to reduce infant mortality in Mozambique.

II. LITERATURE REVIEW

Nyoni & Nyoni (2020) modelled and forecasted infant deaths in Zimbabwe using ARIMA model. The study utilized annual time series data on total infant deaths in Zimbabwe from 1960 to 2018. The ARIMA (1, 2, 5) model was found to be the parsimonious model based on AIC. The model predicted that the number of infant deaths per year, over the out-of-sample period, would follow a downward trajectory. Nyoni & Nyoni (2020) used monthly time series data on neonatal deaths cases at Chitungwiza Central Hospital (CCH) from January 2013 to December 2018; to forecast neonatal deaths over the period January 2019 to December 2020 using the Box-Jenkins SARIMA approach. The parsimonious model was found to be the SARIMA (0, 0, 3) (2, 0, 0)12 model and its predictions indicate slow but steady decrease in neonatal deaths at CCH. Dwomoh et al (2019) investigated the factors contributing to the decline in child mortality throughout the MDG period. This study used Demographic and Health Surveys (DHS) from 2003, 2008 and 2014 and data from World Bank Development Indicators (2000–2018).They employed modified Poisson with robust SE and multivariate decomposition approach to assess risk factors of child mortality using DHS data from 2003, 2008 and 2014. Penalized regression was used assess the effect of 25 country-level contextual factors on child survival The study found that multiple births and shorter birth spacing are associated with increased risk of infant and under-five deaths over the last decade. Increased in FLFP, and the proportion of children sleeping under bed-net are associated with

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reduced risk of both infants and under-five deaths. 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. Goncalves & Moultrie (2012) examined the risk of child mortality associated with short preceding birth intervals in Mozambique. The researchers applied a piecewise log-rate model to a pooled dataset comprising 36,305 live births from the 1997 and 2003 Mozambique Demographic and Health Surveys (DHS). The results revealed that the effects of short preceding intervals are strongest during the first month of life, particularly the first week, indicating prenatal maternal depletion as the dominant pathway. The rapid decline in mortality rates from intervals of less than six months to the category 30 to 35 months suggests an optimal waiting period of at least 30 months between one birth and the next pregnancy.

III. 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 Mozambique.

Data Issues

This study is based on annual infant mortality rates in Mozambique for the period 1964 – 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.

IV. FINDINGS OF THE STUDY

ANN Model Summary

Table 1: ANN model summary

Variable	H
Observations	45 (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	0.016655
MSE	0.446821
MAE	0.993961

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Residual Analysis for the Applied Model

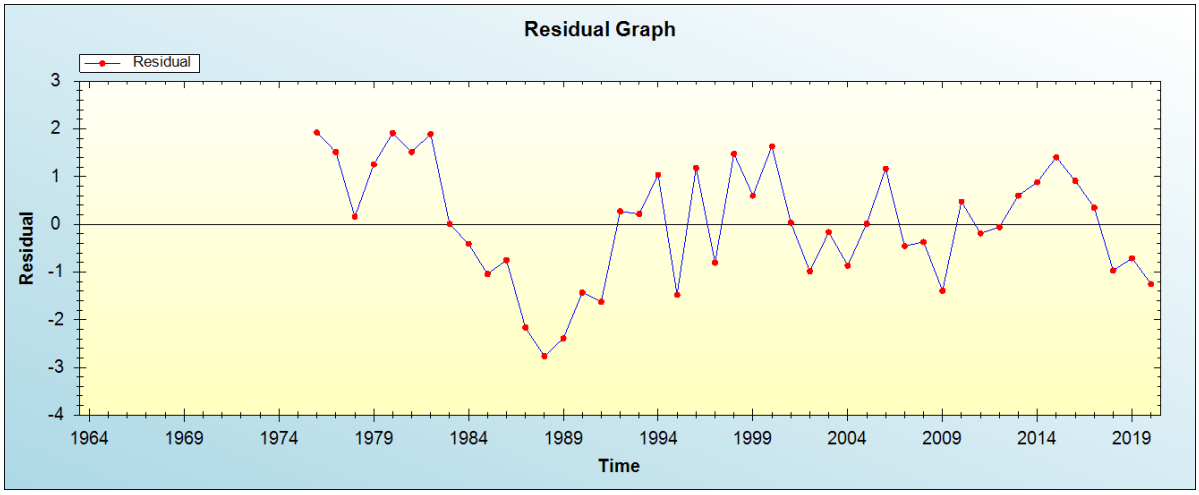

Figure 1: Residual analysis

In-sample Forecast for H

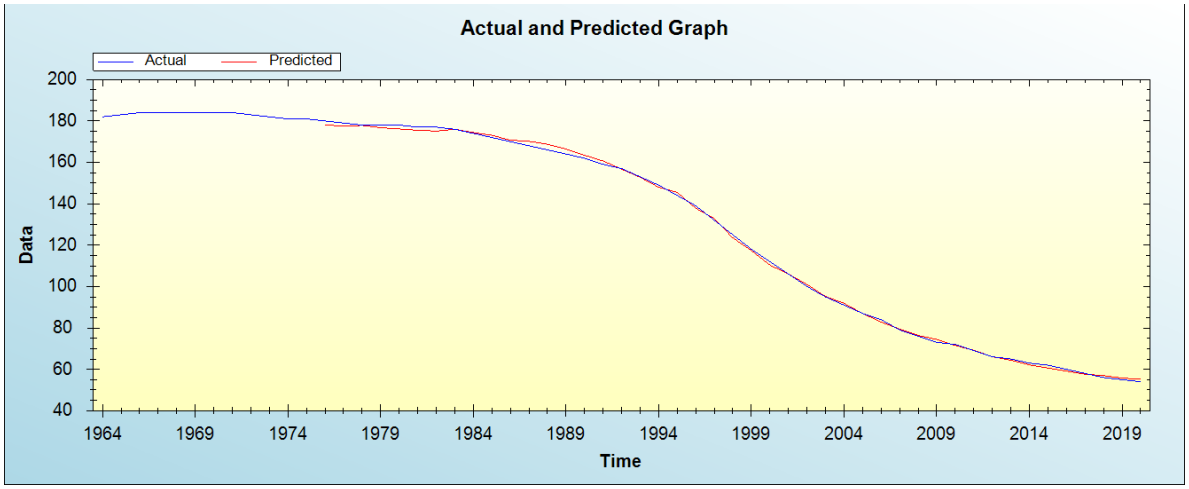

Figure 2: In-sample forecast for the H series

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

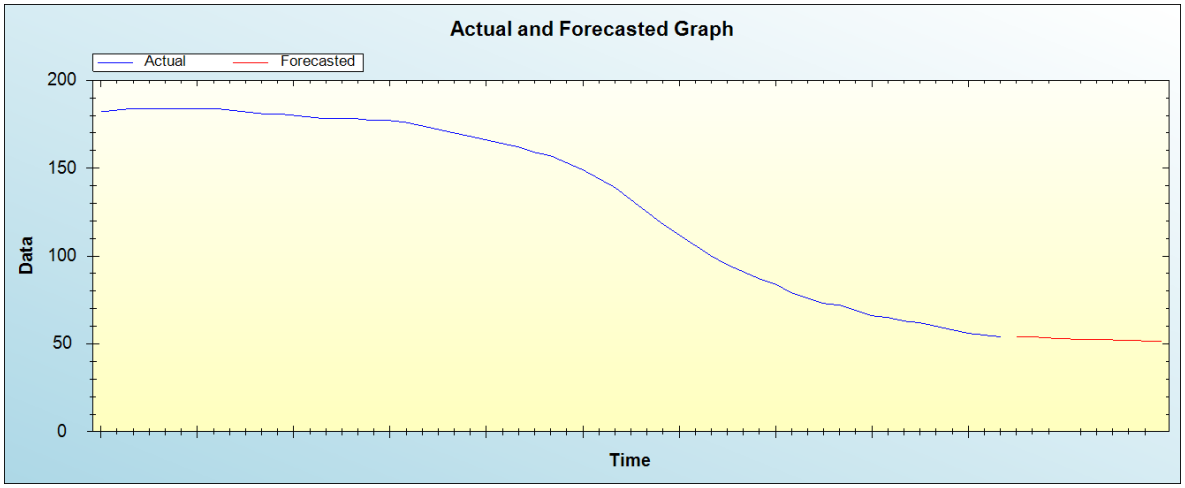

Figure 3: Out-of-sample forecast for H: actual and forecasted graph

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Out-of-Sample Forecast for H: Forecasts only

Table 3: Tabulated out-of-sample forecasts

Year	Forecasts
2021	54.1805
2022	53.9920
2023	53.3383
2024	52.8162
2025	52.6996
2026	52.4314
2027	52.2406
2028	51.9716
2029	51.7055
2030	51.4801

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 infant mortality in Mozambique is likely to remain around 52/1000 live births per year over the next decade.

V. CONCLUSION AND POLICY RECOMMENDATIONS

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

i. The government should continue to encourage mothers to breast-feed their babies adequately.

ii. There is need for all child-bearing women to be vaccinated against common illnesses.

iii. There is need to prevent birth defects in Mozambique.

iv. The government of Mozambique should address preterm birth, low birth-weight and their outcomes.

v. The government of Mozambique 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 the country.

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

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