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Forecasting Infant Mortality Rate in Seychelles Using Artificial Neural Networks

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***Abstract* - In this research work, the ANN approach was applied to analyze infant mortality rate in Seychelles. The employed annual data covers the period 1960-2020 and the out-of-sample period ranges over the period 2020-2030. 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 Seychelles. The ANN (12, 12, 1) model predictions suggest that IMR will be around 12/1000 live births per year in the next 10 years. Therefore the government is encouraged to strengthen maternal and child health surveillance systems and intensify prevention and control programs in order to significantly reduce infant mortality in the country.**

Keywords: ANN, Forecasting, infant mortality rate.

I. INTRODUCTION

Artificial neural networks (ANNs) are part of machine learning (ML) and have become more significant in public health research nowadays. They are based on the biological neurons in terms of structure and function (Kushin, 1997; Patterson, 1995). ML is a scientific field where computers learn or understand the structure of data using mathematical or statistical techniques. The computer programs enable the computers to learn a predictor or hypothesis function which will be used for generalization (Panch et al, 2018; Weng et al, 2017). Artificial neural networks are able to handle complex data and they are inherently nonlinear which makes them accurate in complex problems (Zhao et al, 2020Zhang, 2003).The multilayer perceptrons are the most widely used ANNs and they use a single hidden layer feed forward network (Yan et al, 2018; Kaushik & Sahi, 2018, Zhang, 2003). The model is composed of 3layers of neurons namely the input, hidden and output layers which are connected by acyclic links called connection weights. Hamzacebi proposed the seasonal artificial neural network (SANN) structure to improve the forecasting accuracy of ANNs for seasonal time series data. The SANN can learn the pattern in the time series without removing them (Hamzacebi, 2008).ANNs have been widely used in public health surveillance to detect disease outbreaks early and to evaluate health intervention programs (Panch et al, 2018; Weng et al, 2017). In this paper we apply the neural network approach to predict infant mortality rate in Seychelles. The results of this study are expected to reveal future trends of infant mortality rate in Seychelles and assist in the assessment of the progress towards achieving the sustainable development goals by 2030.

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 best model based on AIC was the ARIMA (1, 2, 5) model. The study findings indicated that the number of infant deaths per year, over the out-of-sample period, would follow a downward trend. 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. Mishra et al. (2019) applied the ARIMA model to forecast infant mortality rates (2017 – 2025). The forecast of the sample period (1971 – 2016) showed accuracy by the selected ARIMA (2, 1, 1) model. The post-sample forecast with ARIMA (2, 1, 1) model showed a decreasing trend of infant mortality (2017 – 2025). The forecast infant mortality rate for 2025 in India is 15/1000 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 revealed 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.

III. METHODOLOGY

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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 Seychelles.

Data Issues

This study is based on annual infant mortality rates in Seychelles 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.

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	0.013674
MSE	0.229055
MAE	0.399328

Residual Analysis for the Applied Model

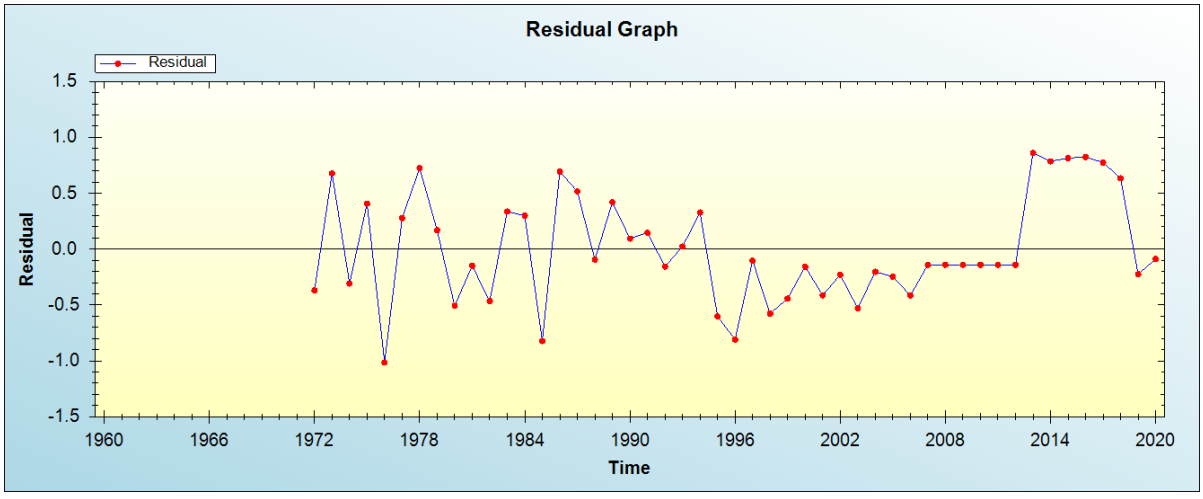

Figure 1: Residual analysis

In-sample Forecast for D

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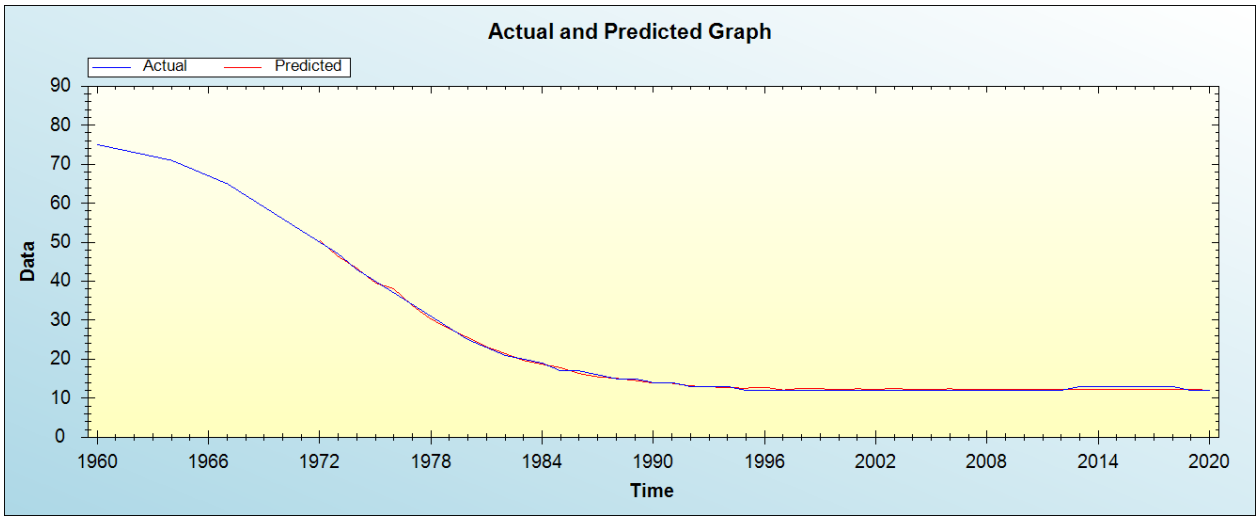

Figure 2: In-sample forecast for the D series

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

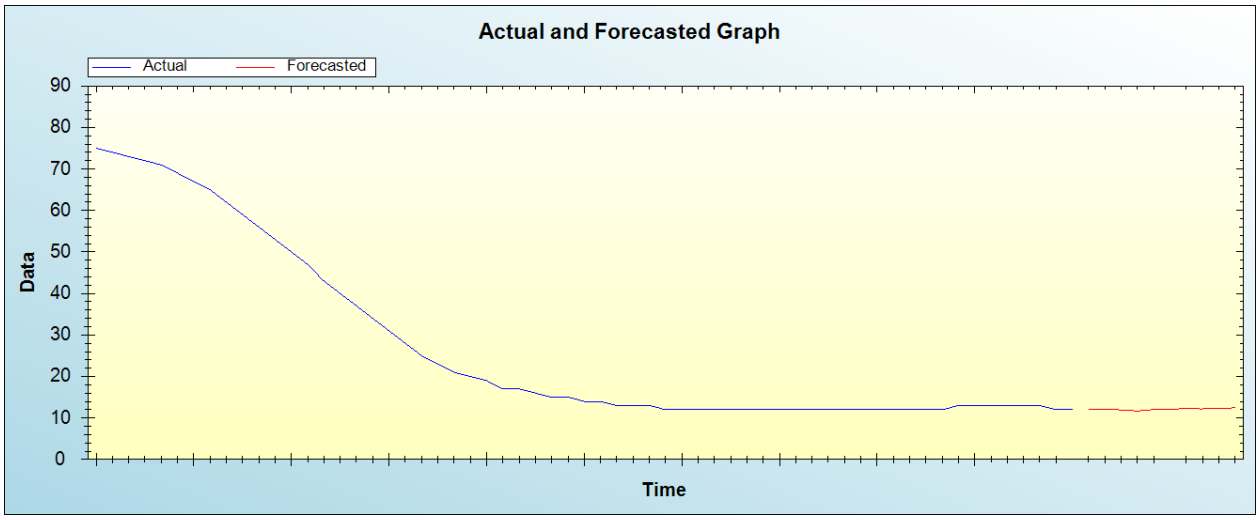

Figure 3: Out-of-sample forecast for D: actual and forecasted graph

Out-of-Sample Forecast for D: Forecasts only

Table 3: Tabulated out-of-sample forecasts

Year	Forecasts
2021	11.9937
2022	12.0426
2023	11.9711
2024	11.6917
2025	12.0487
2026	12.1391
2027	12.2665
2028	12.1969
2029	12.2120
2030	12.4760

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 Seychelles is likely to remain around 12/1000 live births per year over the next decade.

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V. CONCLUSION AND POLICY RECOMMENDATIONS

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

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

v. The government of Seychelles 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 Seychelles need to use newborn screening activities in order to detect hidden conditions.

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