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Forecasting Infant Mortality Rate in Sierra Leone Using Artificial Neural Networks

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***Abstract* - In this research work, the ANN approach was applied to analyze infant mortality rate in Sierra Leone. The employed annual 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 Sierra Leone. The ANN (12, 12, 1) model predictions suggest that IMR will remain very high in the out-of-sample period. The government is therefore encouraged to allocate more financial resources towards improving health infrastructure especially for primary health care, increasing coverage for child vaccinations and facility based deliveries.**

Keywords: ANN, Forecasting, infant mortality rate.

I. INTRODUCTION

The world is experiencing epidemiologic transition towards chronic non-communicable diseases such as diabetes and cardiovascular disorders (Hosny & Aerts, 2019; Mayor, 2016).Artificial intelligence (AI) has a great potential in public health surveillance especially to detect abnormal trends of diseases or epidemiologic incidence and facilitate health planning and allocation of resources (WHO, 2020; Panch et al, 2018; WHO, 2017).AI is defined as the imitation of the human cognition by computers i.e. reasoning, learning, adaptation, self-correction, sensory understanding and interaction (Jha &Topol, 2016; Topol, 2019). AI based applications have several advantages such as improving performance of health systems which include reducing risks, facilitation of development of affordable and better quality innovations while overcoming local resource constrained environment (Sallstrom et al, 2019; Wahl et al, 2018; Guo & Li, 2018; Oliveira et al, 2017; Kalyanakrishnan et al, 2018; Agarwal et al, 2019). AI can be used to predict the spread of pathologies or vulnerability within certain groups or communities and therefore facilitating the implementation of health interventions (Hosny & Aerts, 2019; Lancet, 2019; Wahl et al, 2018; Weng et al, 2017). AI can play a role in maternal and child health where it can be utilized in the prediction of maternal mortality, child and infant mortality and caesarian section case volumes. In this paper we aim to model and predict infant mortality rate (IMR) in Seira Leone using artificial neural networks (ANNs). The multilayer perceptron is the widely applied ANN framework. It has been widely used in time series forecasting problems and proved to be accurate and reliable. The model is made up of 3 layers of neurons which are the input , hidden and output layer connected by weights (Zhao et al, 2020; Nyoni et al, 2020; Kaushik & Sahi, 2018; Yan et al, 2018; Fojnica et al, 2016; Zhang, 2003). The findings of this piece of work are envisioned to reveal the future trends of infant mortality rate and facilitate health planning and resource allocation.

II. LITERATURE REVIEW

Bariki et al (2020) examined factors affecting infant mortality among the general population of Ethiopia, 2016. A Community-based cross-sectional study was conducted in all regions of Ethiopia from January 18 to June 27, 2016. A total of 10,641 live births were included in the analysis. Data were analyzed and reported with both descriptive and analytic statistics. Bivariable and multivariable multilevel logistic regression models were fitted by accounting correlation of individuals within a cluster. Adjusted odds ratio (AOR) with 95% confidence interval was reported to show the strength of the association and its significance. The study findings indicated that sex of the child, multiple births, prematurity, and residence were notably associated with infant mortality. The risk of infant mortality has also shown differences across different regions. 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 model predictions suggested that the number of infant deaths per year, over the out-of-sample period, would follow a downward trend. In a related study, 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

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the Box-Jenkins SARIMA approach. The optimal 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.

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 Sierra Leone.

Data Issues

This study is based on annual infant mortality rates in Sierra Leone 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	C
Observations	46 (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	0.011048
MSE	0.738420
MAE	0.601435

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Residual Analysis for the Applied Model

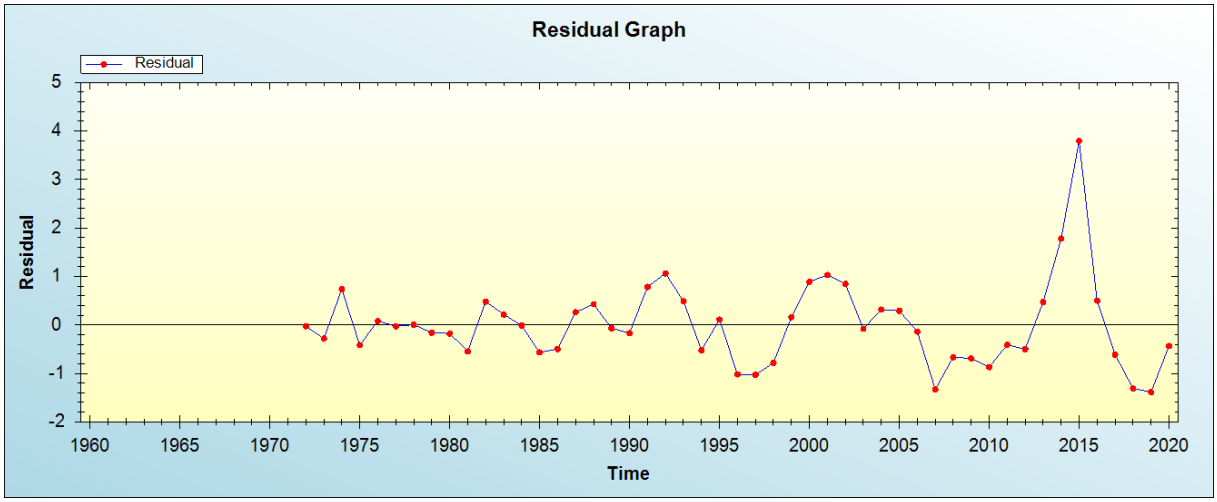

Figure 1: Residual analysis

In-sample Forecast for C

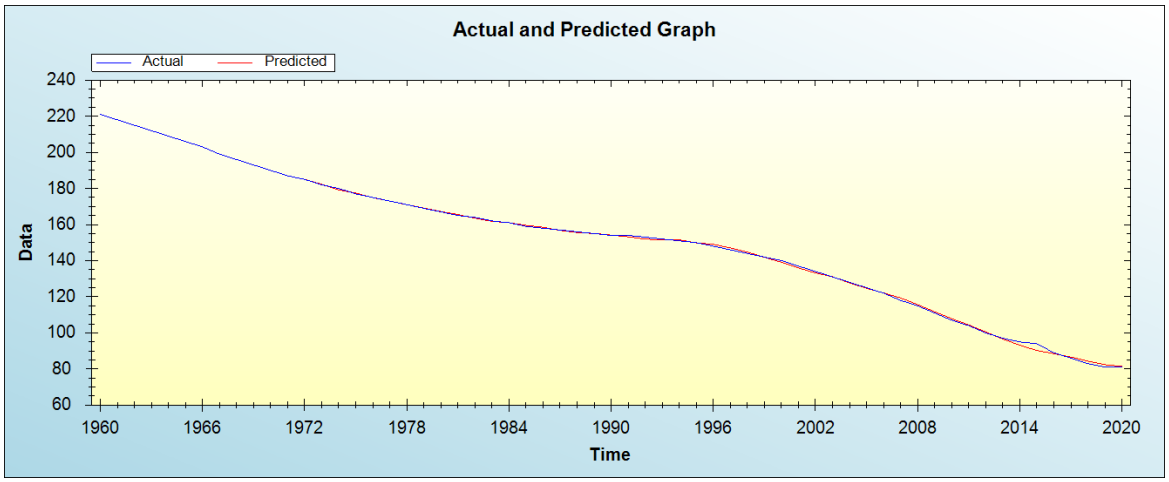

Figure 2: In-sample forecast for the C series

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

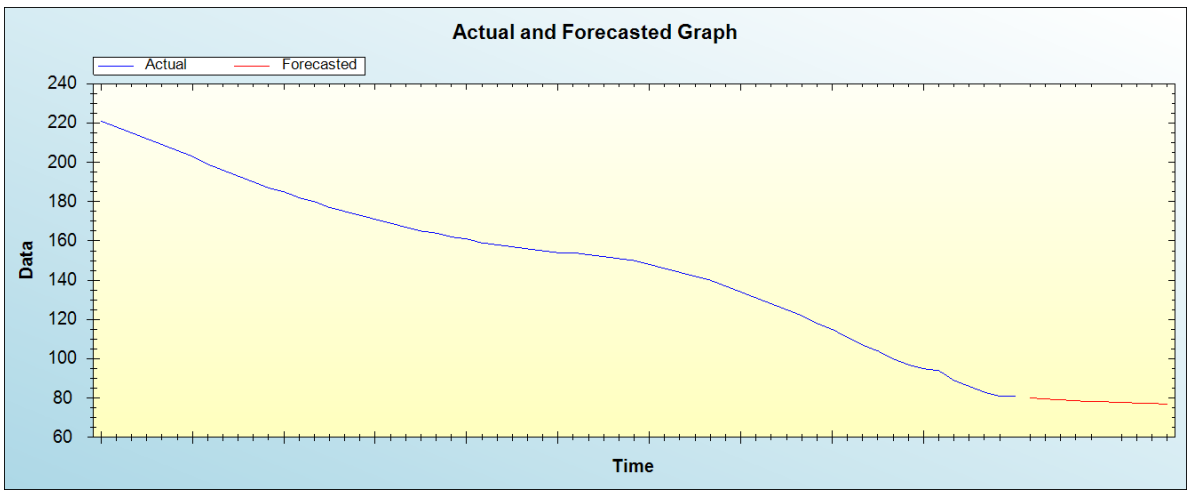

Figure 3: Out-of-sample forecast for C: actual and forecasted graph

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Out-of-Sample Forecast for C: Forecasts only

Table 3: Tabulated out-of-sample forecasts

Year	Forecasts
2021	80.1613
2022	79.5176
2023	79.1875
2024	78.6159
2025	78.2808
2026	78.0910
2027	77.9335
2028	77.4854
2029	77.2646
2030	77.0171

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 Sierra Leone is likely to remain very high over the next decade.

V. CONCLUSION AND POLICY RECOMMENDATIONS

Preventing infant mortality remains one of the main objectives of the health ministry in Sierra Leone. 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 Sierra Leone. The applied model is the ANN model. In order to make sure that infant mortality in the country significantly declines, the government of Sierra Leone 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 Sierra Leone.

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

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

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