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Forecasting Infant Mortality Rate in Kenya Using an Artificial Intelligence Technique

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***Abstract* - In this study, the ANN approach was applied to analyze infant mortality rate (IMR) in Kenya. 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 IMR in Kenya. The ANN (12, 12, 1) model projections indicated that IMR will be around 30/1000 live births per year over the next 10 years. Therefore, in line with the suggested policy prescriptions; the Kenyan authorities should allocate more resources towards maternal and child health programs with the goal to capacitate primary health care facilities with medical supplies, equipment and skilled human resources in order to sufficiently tackle maternal and child health problems to curb neonatal and infant mortality in the country.**

Keywords: ANN, Forecasting, infant mortality rate.

I. INTRODUCTION

The history of artificial intelligence (AI) dates back to the 1950s when Allan Turing introduced the idea of computers performing intelligent tasks (Park et al, 2020; Turing, 1950).AI has computer programs that can learn, adapt and predict (Topol, 2019; Ertel et al, 2017; Bahrammirzaee, 2010). AI applications are widely used in health care where there is a large amount of data in electronic records and enhanced computational power (Topol, 2019;Takahashi et al, 2017; Powles et al, 2017; Jha et al, 2016;Gulshan et al,2016). The objective of AI in health care is to improve the quality of care for patients. The algorithms identify abnormal trends in infectious diseases and help in health planning and decision making (Lancet, 2018; Cvetkovic et al, 2016; Patel, 2009; Lisboa & Taktak, 2006; Kaplan, 2001). In this paper we aim to model and forecast infant mortality rate in Kenya using artificial neural networks. The multilayer perceptron is widely used in time series forecasting problems and is being applied in this study. The model is composed of three layers of neurons which are the input, hidden and output layers. Two mechanisms are involved in the learning process 1) the input signal is transmitted in the forward direction from the input layer through the hidden layer until it reaches the output layer and 2) the error signal produced is propagated back through hidden layer to the input layer thereby creating weights. This process happens several times in order to create minimum error (Nyoni et al, 2020; Zhao et al, 2020; Kaushik & Sahi, 2018; Yan et al, 2018; Fojnica et al, 2016, Zhang, 2003; Kishan, 1997; Patterson, 1995).

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. In a similar 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 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) gave a detailed presentation of how they used 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.

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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 Kenya.

Data Issues

This study is based on annual infant mortality rates in Kenya 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	L
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	0.014837
MSE	0.514234
MAE	0.558261

Residual Analysis for the Applied Model

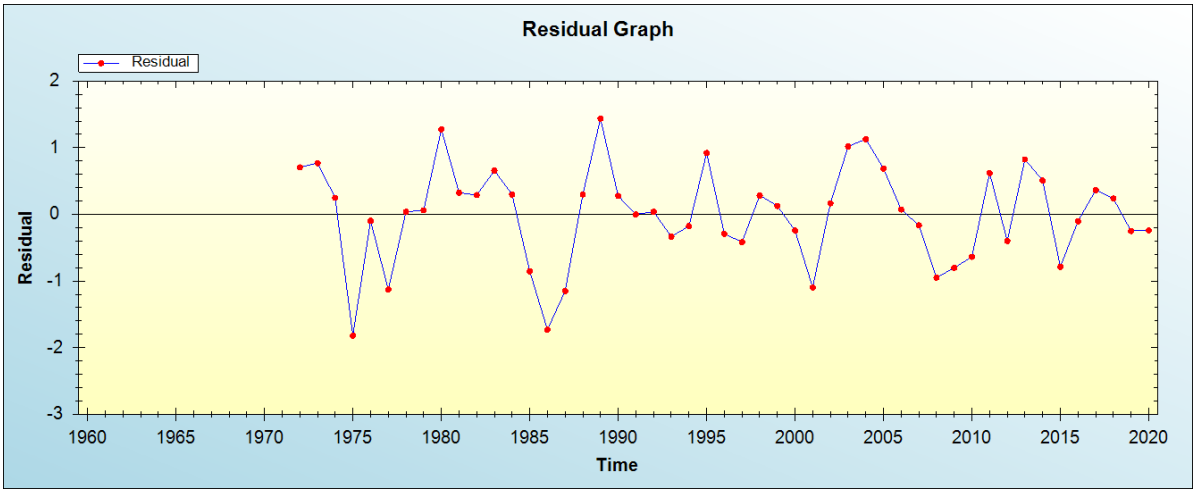

Figure 1: Residual analysis

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In-sample Forecast for L

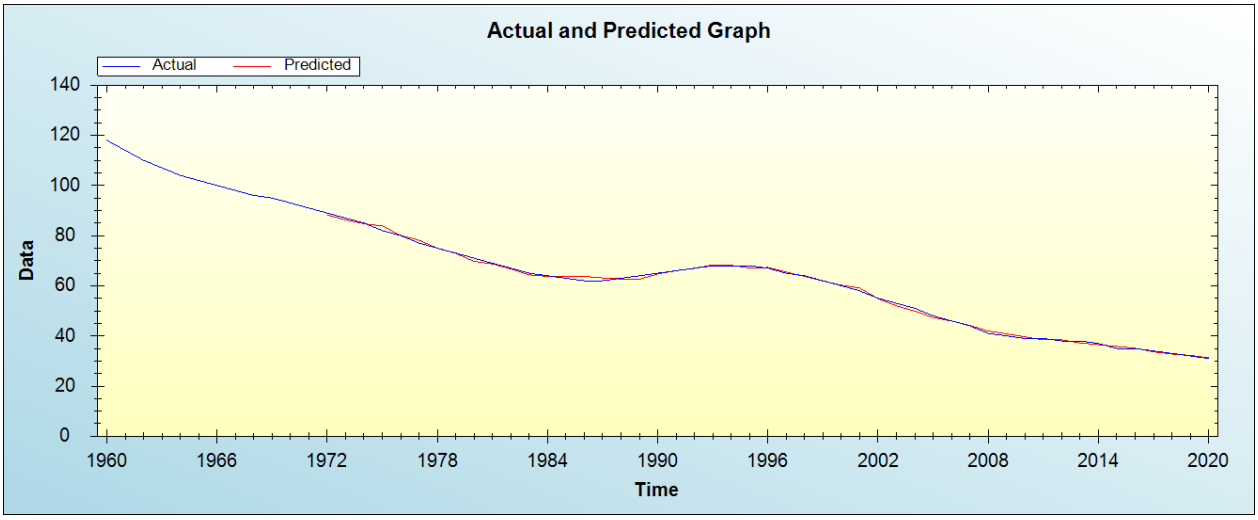

Figure 2: In-sample forecast for the L series

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

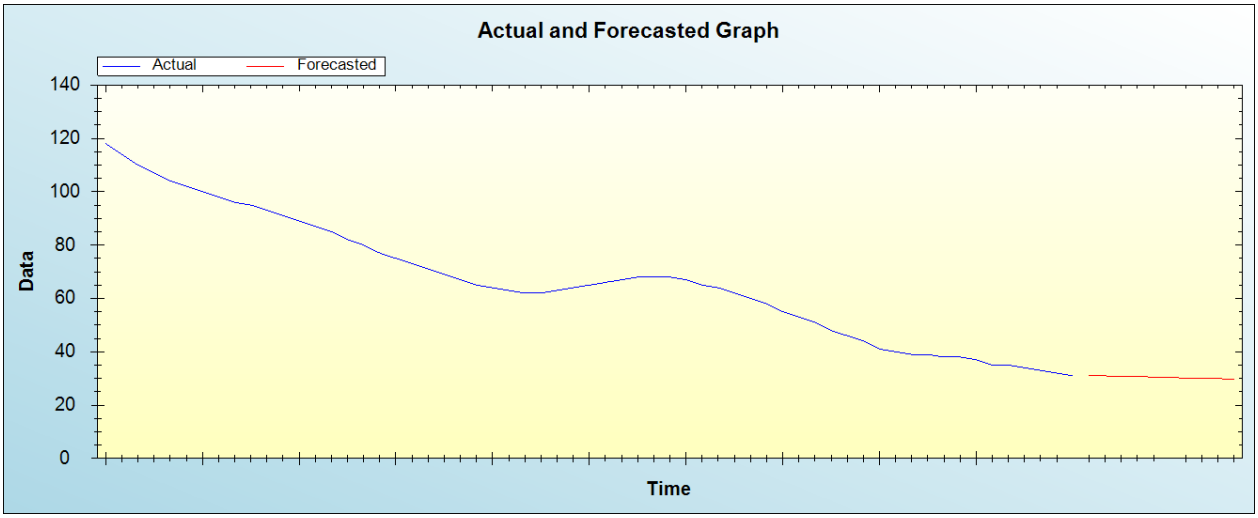

Figure 3: Out-of-sample forecast for L: actual and forecasted graph

Out-of-Sample Forecast for L: Forecasts only

Table 3: Tabulated out-of-sample forecasts

Year	Forecasts
2021	31.1345
2022	30.9614
2023	30.7117
2024	30.6643
2025	30.5663
2026	30.3699
2027	30.1607
2028	30.0624
2029	29.9322
2030	29.8092

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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 Kenya is likely to remain around 30/1000 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 Kenya. The Kenya government remains committed to ending preventable deaths infants in the country. The study used annual data to analyze the trends of infant mortality in Kenya. The applied model is the ANN model. In order to make sure that infant mortality in the country significantly declines, the government of Kenya ought to consider the following policy suggestions:

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

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

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

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

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

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