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Prediction of Infant Mortality Rate in Gambia Using Artificial Neural Networks

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***Abstract* - In this research article, the ANN approach was applied to analyze infant mortality rate (IMR) in Gambia. 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 Gambia. The applied ANN (12, 12, 1) model projected that IMR will generally be around 34/1000 live births per year in the out-of-sample period. Therefore the Gambian government is encouraged to allocate more resources towards maternal and child health programs with the aim of retaining skilled labor force in primary health care and referral hospitals, procuring medical supplies needed for maternity emergencies and essential newborn care, and continuous health education among communities.**

Keywords: ANN, Forecasting, infant mortality rate.

I. INTRODUCTION

The application of artificial intelligence (AI) in public health has drawn much attention due to the advances in machine learning (ML) methods involving multiple layers of artificial neural networks trained on big data (Topol, 2019; Lee et al, 2017). AI is expected to improve various aspects of medicine tremendously although it is associated with much hype (Park et al, 2019). AI technologies are currently being used in clinical practice especially in the developed world for screening, prognosis, diagnosis and predictive purposes (Park et al, 2019; Panch et al, 2018). These technologies are used in public health to provide better quality of care for patients, improve healthcare outcomes and for public health surveillance (Zhao et al, 2020; Nyoni et al, 2020; Panch et al, 2018; Weng et al, 2017). Machine learning is a component of AI and its application has grown over the past decade. ML algorithms have proven to be superior to traditional statistical techniques due to their ability to deal with big data sets by performing nonlinear modeling. Examples of such algorithms include artificial neural networks, tree-based models, support vector machine, K-nearest neighbors and Bayesian networks.

In this paper we aim to model and forecast infant mortality in Gambia using the artificial neural network approach. The multilayer perceptron (MLP) will be used in this paper because of its popularity and accurate forecasts. The model is made up of 3 layers of neurons namely the input, hidden and output layer which are connected by acyclic links called connection weights (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). The findings of this study will reveal the future trends of infant mortality rate in Gambia and facilitate health planning and allocation of resources for health in order to reduce infant mortality in the country.

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 applied ARIMA model projections suggested that the number of infant deaths per year, over the out of sample period would follow a downward trend. In another 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 best 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. 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. Bashir et al (2013) analyzed data from the Sudan Household Health Survey 2nd round, which was carried out in 2010. Total of 6,198 live-born

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infants delivered within the two years preceding the survey were included as the study population. Multivariate logistic regression was used to model neonatal mortality as a function of maternal health parameters, socioeconomic indicators and the sex of the child. The authors concluded that Public health interventions which target neonatal mortality reduction should adopt a risk-factor-based approach to detect pregnancy complications early and once identified, the health system should be strengthened so that these complications can be dealt with adequately.

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. Generally, 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 Gambia.

Data Issues

This study is based on annual infant mortality rates in Gambia 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	P
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	0.011529
MSE	0.571267
MAE	0.613251

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Residual Analysis for the Applied Model

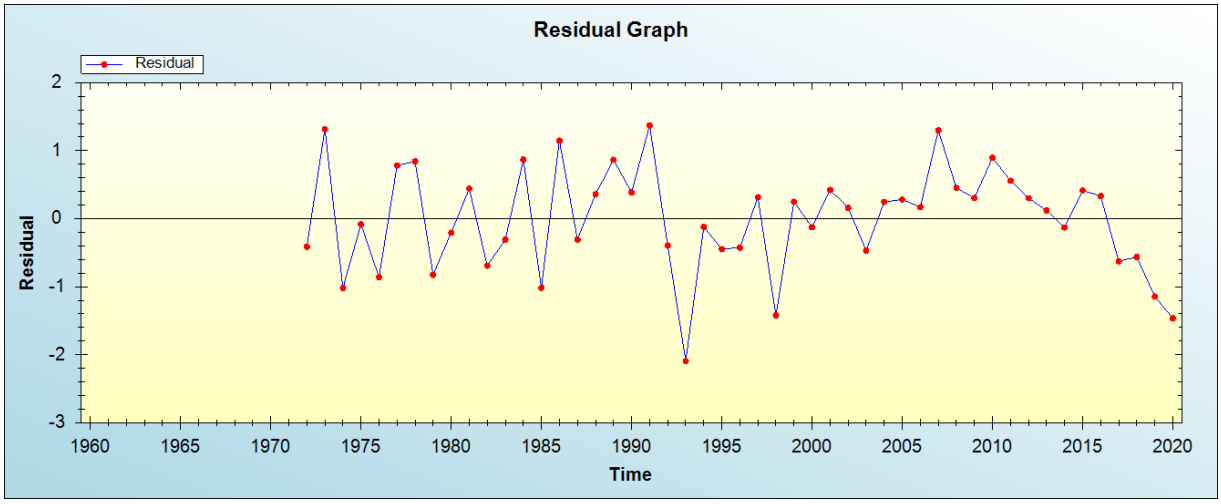

Figure 1: Residual analysis

In-sample Forecast for P

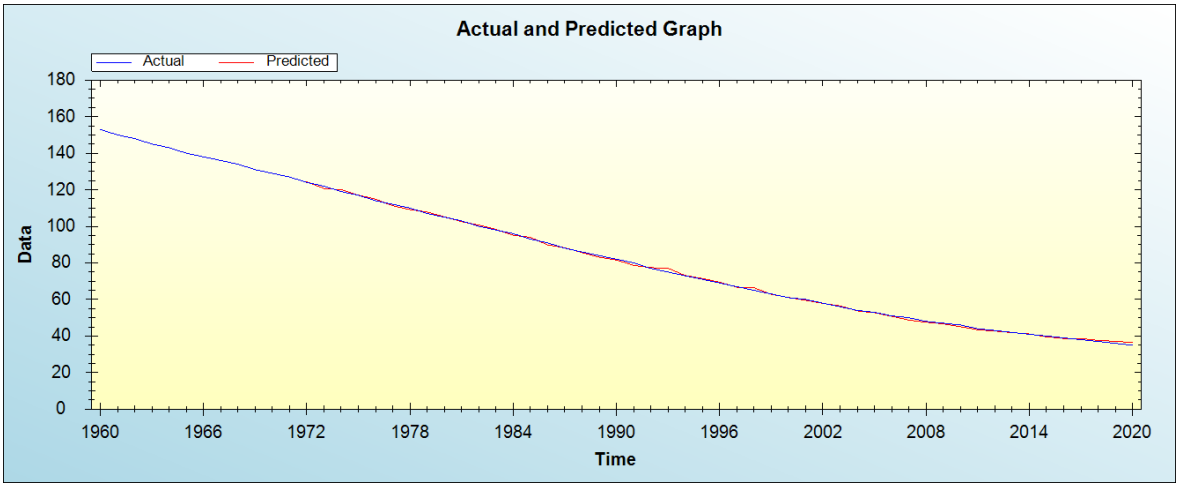

Figure 2: In-sample forecast for the P series

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

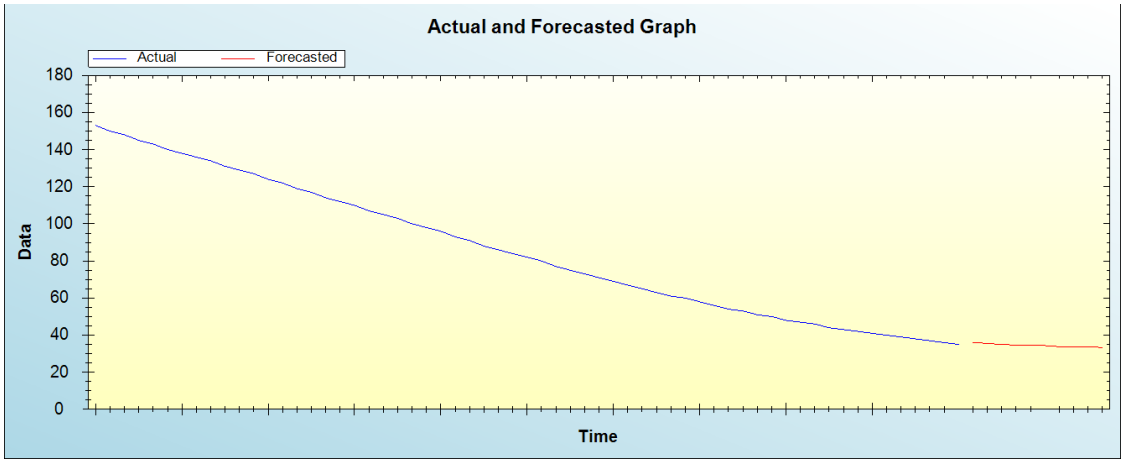

Figure 3: Out-of-sample forecast for P: actual and forecasted graph

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Out-of-Sample Forecast for P: Forecasts only

Table 3: Tabulated out-of-sample forecasts

Year	Forecasts
2021	36.1145
2022	35.5288
2023	34.9313
2024	34.7029
2025	34.6783
2026	34.3968
2027	33.8123
2028	33.8347
2029	33.6496
2030	33.3449

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 Algeria is likely to remain around 34/1000 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 Gambia. 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 Gambia. The applied model is the ANN model. In order to make sure that infant mortality in the country significantly declines, the government of Gambia 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 Gambia.

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

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

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