

# Forecasting Infant Mortality Rate in Ghana Using a Machine Learning Algorithm

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**Abstract** - In this research paper, the ANN approach was applied to analyze infant mortality rate (IMR) in Ghana. 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 Ghana. The projections from the applied ANN (12, 12, 1) model revealed that IMR will be around 31/1000 live births per year in the next 10 years. Therefore the government is encouraged to intensify maternal and child health surveillance and control programs in order to achieve the sustainable development goals by 2030.

**Keywords:** ANN, Forecasting, infant mortality rate.

## I. INTRODUCTION

Many developing countries failed to achieve the millennium development goals and are likely going to miss the 2030 targets of sustainable development goals (UN, 2000). Infant mortality rate in Ghana has declined from 79.3 per 1000 live births in 1990 to 35.7 per 1000 live births in 2017 (Dwomoh, 2019). In 2013 approximately 44 % of all under 5 deaths occurred in the first month of life (Wardlaw et al, 2014). Over the period 2009-2014, neonatal mortality rate was estimated to be 29 deaths per 1000live births (GSS, 2015). 68 % of all deaths among children below 5 years in Ghana occur during the first year of life (GSS, 2015). Several factors have been identified as causes of infant mortality in the country and they include prematurity, congenital anomalies, infections, and respiratory distress syndrome (Chowdhury, 2010; Black et al, 2003). The government has put in place measures to reduce infant mortality in the country such as child immunizations, Vitamin A supplementation, and integrated management of childhood illnesses and exclusive breastfeeding of babies up to 6months. Furthermore the government has made tremendous effort to ensure quality services for pregnant mothers during the antenatal, intrapartum and in the post-partum period. In this paper we aim to model and forecast infant mortality rate in Ghana using the artificial neural network approach. The multilayer perceptron is the neural framework specifically chosen for this study due to its popularity and reliable forecasts. The model is biologically inspired. MLP is made of up 3 layers of processing elements (nodes) namely 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; Scavuzzo et al,2018; Gambhir et al, 2018; Laurean-Rosario et al, 2018; Weng et al, 2017; Guo et al, 2017;Althouse et al, 2011 Fojnica et al, 2016; Zhang, 2003; Kishan, 1997; Patterson, 1995). The results of the study are expected to provide an insight of the likely future trends of infant mortality in Ghana and facilitate planning and resource allocation towards maternal and child health programs 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 study findings indicated 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 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 reduced risk of

both infants and under-five deaths. Cao et al (2017) analyzed trends in mortality and causes of death among children aged under 5 years in Beijing, China between 1992 and 2015 and forecasted under-5 mortality rates (U5MRs) for the period 2016–2020. An entire population-based epidemiological study was conducted. Data collection was based on the Child Death Reporting Card of the Beijing Under-5 Mortality Rate Surveillance Network. Trends in mortality and leading causes of death were analyzed using the  $\chi^2$  test and SPSS 19.0 software. An autoregressive integrated moving average (ARIMA) model was fitted to forecast U5MRs between 2016 and 2020 using the EViews 8.0 software. The study concluded that Beijing has made considerable progress in reducing U5MRs from 1992 to 2015. However, U5MRs could show a slight upward trend from 2016 to 2020. Akinwande et al (2016) Analyzed Infant and Child (Under-five) Mortality in Zaria using a regression Analysis Approach. The study was carried out using secondary data from Ahmadu Bello University Teaching Hospital, Zaria, on infant and child (under-five) mortality and delivery rates. Findings from the study showed that both infant and child mortality rates have a direct relationship with delivery rates. The correlation analysis result showed that there is a very strong and positive relationship between mortality and delivery rates. The study revealed that infant and child mortality rates will continue to decrease if there can be improvement in the factors under study.

### 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 Ghana.

#### Data Issues

This study is based on annual infant mortality rates in Ghana 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	M
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	0.015708
MSE	0.630597
MAE	0.610556

Residual Analysis for the Applied Model

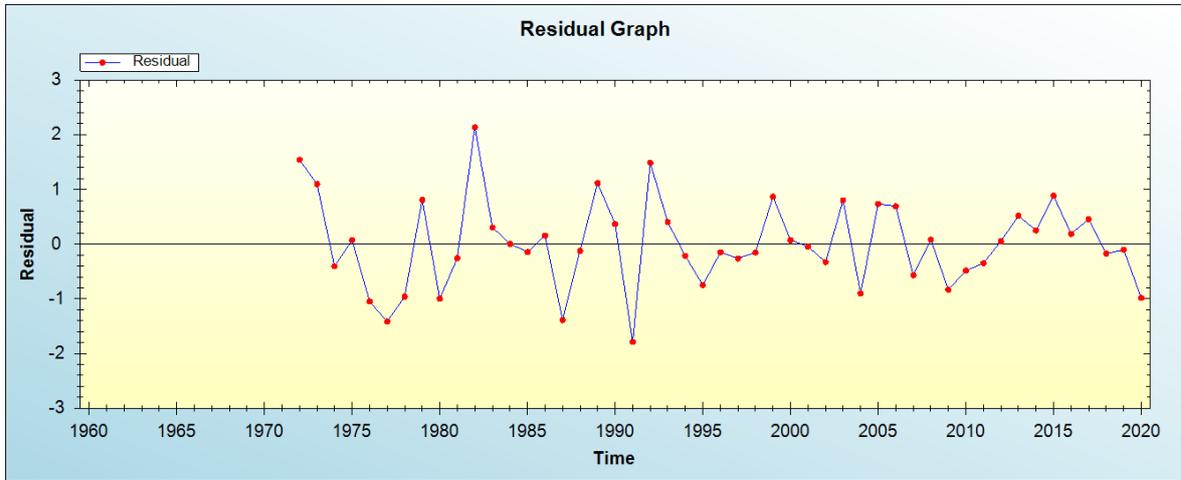


Figure 1: Residual analysis

In-sample Forecast for M

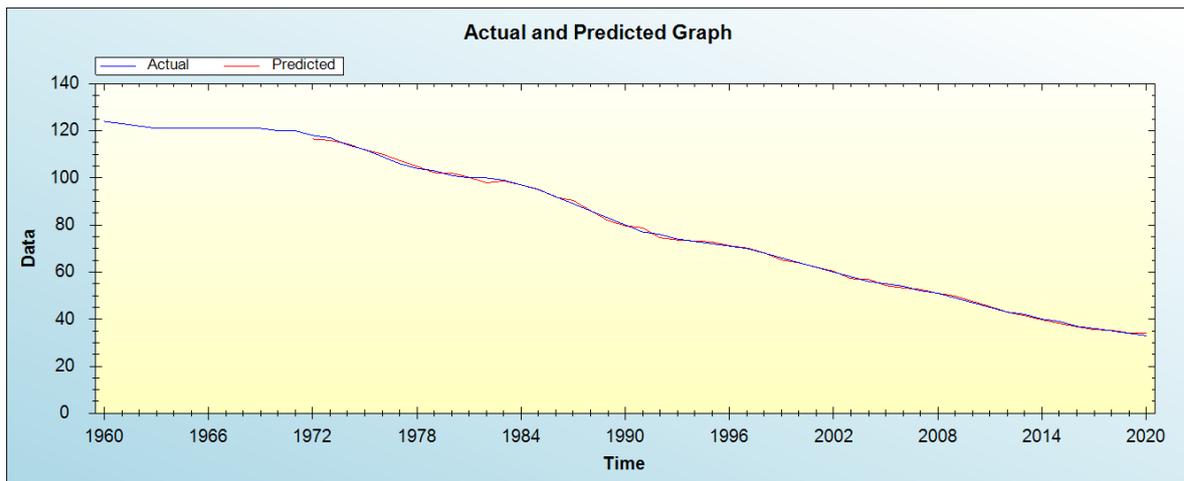


Figure 2: In-sample forecast for the M series

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

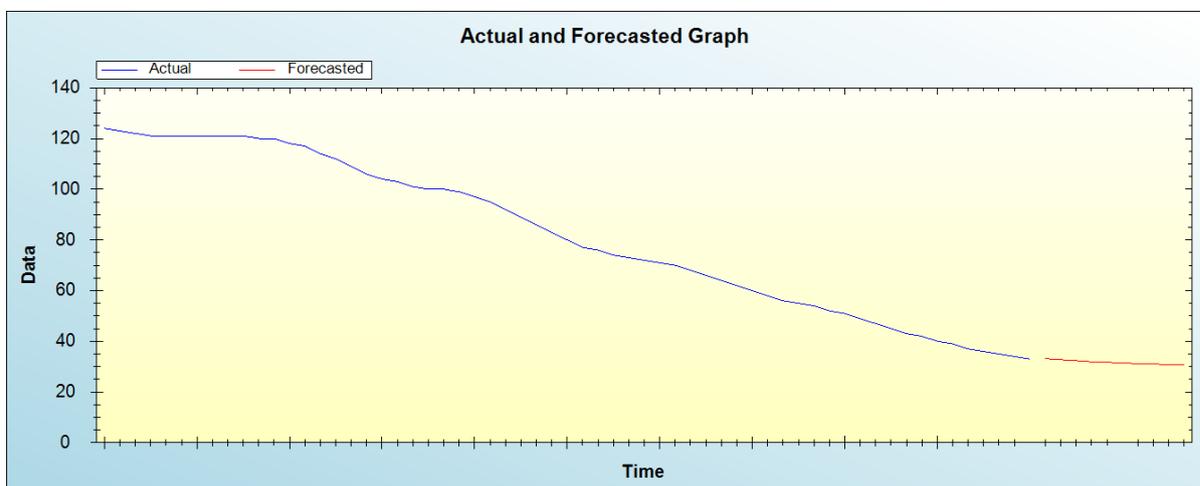


Figure 3: Out-of-sample forecast for M: actual and forecasted graph

Table 3: Tabulated out-of-sample forecasts

Year	Forecasts
2021	33.1769
2022	32.7419
2023	32.3905
2024	31.9139
2025	31.7571
2026	31.3941
2027	31.2518
2028	31.0083
2029	30.8869
2030	30.7225

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 Ghana is likely to remain around 31/1000 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 Ghana. 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 Ghana. The applied model is the ANN model. In order to make sure that infant mortality in the country significantly declines, the government of Ghana 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 Ghana.
- iv. The government of Ghana should address preterm birth, low birth-weight and their outcomes.
- v. The government of Ghana 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 Ghana need to use newborn screening activities in order to detect hidden conditions.

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