Forecasting Infant Mortality Rate in Egypt Using a Machine Learning Technique

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Abstract - **In this research paper, the ANN approach was applied to analyze infant mortality rate (IMR) in Egypt. 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 Egypt. The applied ANN (12,12, 1) model predicted that IMR will be around 17/1000 live births per year in the out-of-sample period. Therefore the government in line with our policy suggestions, is encouraged to allocate more resources for primary healthcare in order to provide quality maternal and neonatal care especially in rural areas.**

Keywords: ANN, Forecasting, infant mortality.

I. INTRODUCTION

Infant mortality rate (IMR) is an important indicator of health status of a population and predicts the health of the next generation (Elida et al, 2019; NCHS, 2001). Infant mortality is the death of a child during the first year of life. The known cause of infant deaths include congenital anomalies, sepsis, diarrhea and pneumonia (CDC, 2008). Egypt has an estimated population of around 99 million people (World Bank, 2019). The country reported a total of 2.7 million births in 2014 which is 46 % from 1.9 million in 2006 (UNFPA, 2016). Health care in Egypt is provided by modern and traditional healthcare providers such as governmental, parastatal, military, private sector, NGOs and traditional practitioners (WHO, 2006; USAID, 2005). The overall mortality has declined in Egypt but infant mortality remains high. Several previous studies have shown that factors influencing infant mortality include demographic, socio-economic and proximate factors (UNFPA, 2007; Kabir, 2001; Bairagi et al, 1999). The government like other countries has successfully implemented programs such as child immunizations, Vitamin A supplementation, integrated management of childhood illnesses and exclusive breastfeeding for at least 6months (Khan & Awan, 2017;Rubayet et al, 2012).

In this paper we aim to model and forecast infant mortality rate in Egypt using the Multilayer perceptron (MLP). The model is biologically inspired and is composed of three layers of nodes namely input, hidden and output layers connected by weights (Zhao et al, 2020; Nyoni et al, 2020; Kaushik & Sahi, 2018; Yan et al, 2018; Weng et al, 2017;Fojnica et al, 2016;Zhang, 2003; Kishan, 1997; Patterson, 1995). The findings of this study will help in health planning and decision making in order to allocate resources for maternal and child health programs.

II. LITERATURE REVIEW

Nyoni & Nyoni (2020) modelled and forecasted infant deaths in Zimbabwe using the 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 findings of the study indicated that the number of infant deaths per year, over the out-of-sample period, would follow a downward path. 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. Kurniasih et al (2018) applied the α-Sutte Indicator in forecasting data. To see the accuracy of the methods, the forecasting results of the α-Sutte Indicator was evaluated by comparing with the ARIMA and the Holt-winters method. Based on the results of forecasting, it was found that α-Sutte Indicator has MSE and MAPE values that are lower than the other methods (ARIMA and Holt-Winters). This is supported by MSE data from α-Sutte Indicator smaller than ARIMA (2, 2, 2) and Holt-Winters i.e. 0.03; 3.06; and 3.15. 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 χ2 test and SPSS 19.0 software. An autoregressive integrated moving average (ARIMA) model was fitted to forecast U5MRs between 2016 and 2020 using the Reviews' 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 Egypt.

Data Issues

This study is based on annual infant mortality rates in Egypt 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	S
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	0.007689
MSE	0.693785
MAE	0.686823

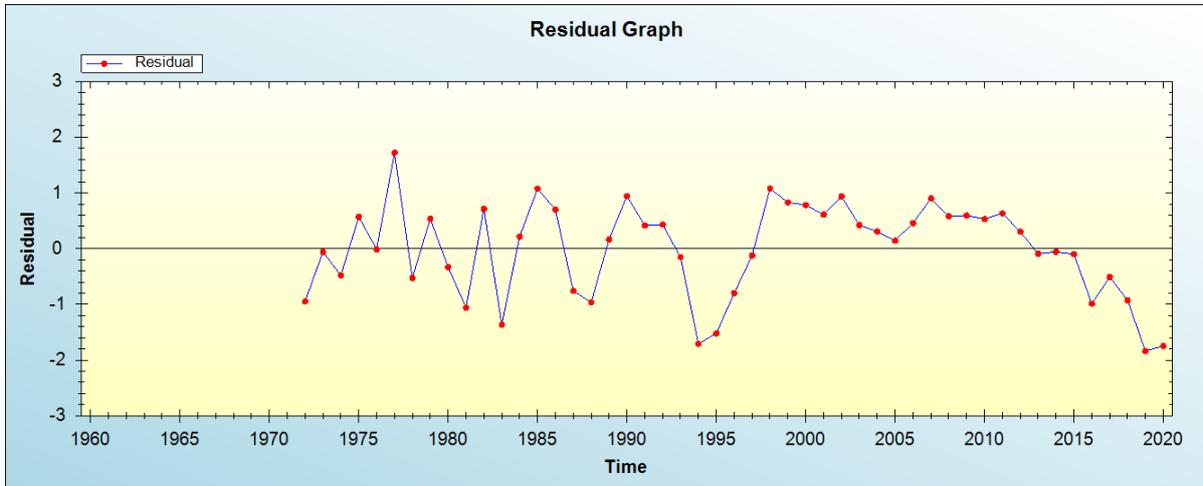*Residual Analysis for the Applied Model*

Figure 1: Residual analysis
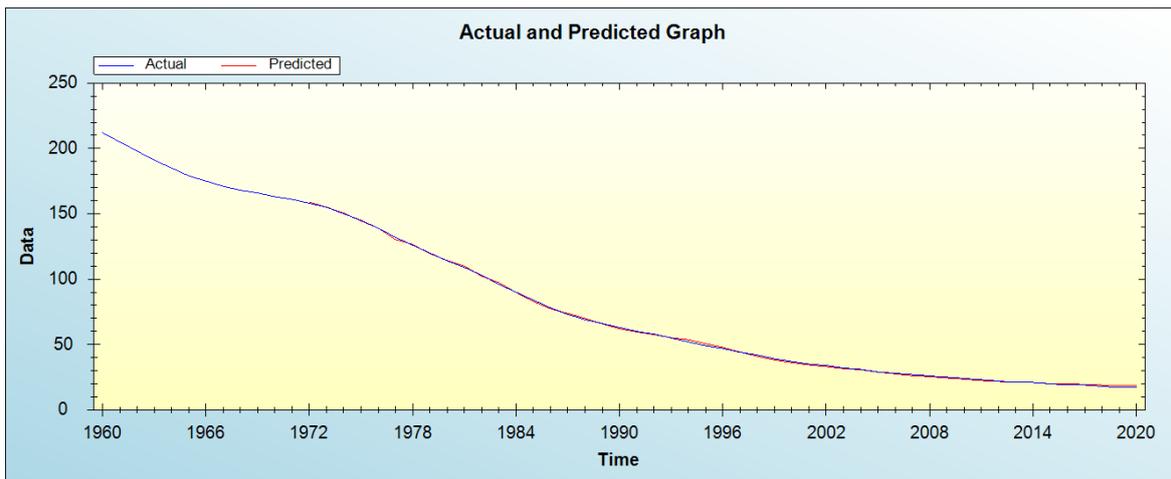
In-sample Forecast for S

Figure 2: In-sample forecast for the S series

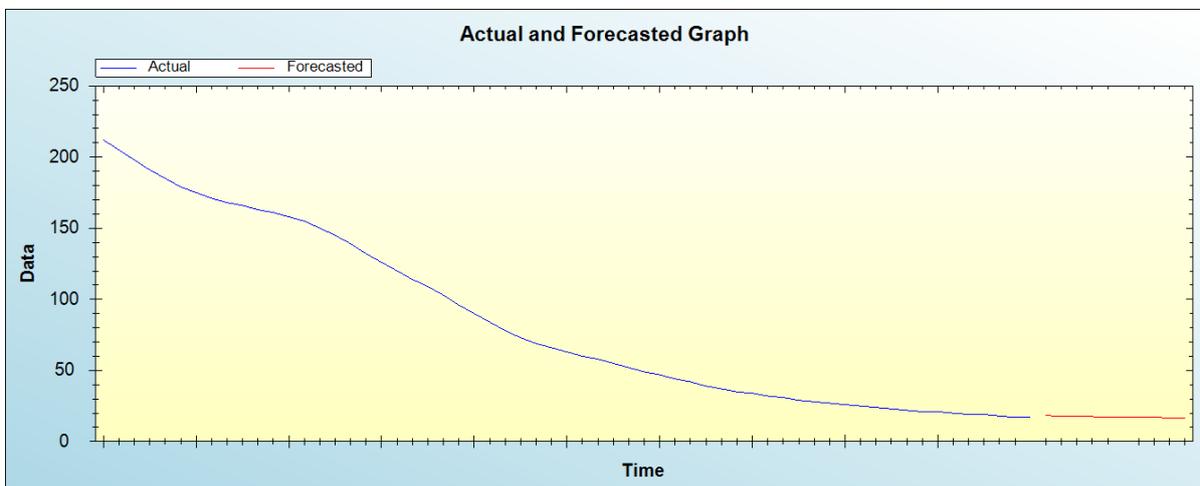*Out-of-Sample Forecast for S: Actual and Forecasted Graph*

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

Out-of-Sample Forecast for S: Forecasts only

Table 3: Tabulated out-of-sample forecasts

Year	Forecasts
2021	18.4079
2022	17.7109
2023	17.6004
2024	17.5480
2025	16.9222
2026	17.0306
2027	17.0502
2028	17.0299
2029	16.7953
2030	16.5117

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 Egypt is likely to remain around 17/1000 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 Egypt. 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 Egypt. The applied model is the ANN model. In order to make sure that infant mortality in the country significantly declines, the government of Egypt 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 Egypt.

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

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

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