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Prediction of Infant Mortality Rate in Bangladesh Using Artificial Neural Networks

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***Abstract* - In this research article, the ANN approach was applied to analyze infant mortality rate in Bangladesh. 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 really stable in forecasting infant mortality rate in Algeria. The ANN (12, 12, 1) model projections suggest that infant mortality in Bangladesh will decline from approximately 26 deaths this year to nearly 24 deaths per 1000 live births by 2030. The government is encouraged to intensify maternal and child health surveillance and control programs amongst other measures in order to curb infant mortality in Bangladesh. This can be specifically done by embracing the suggested 7-fold policy recommendations.**

Keywords: ANN, Forecasting, Infant mortality rate.

I. INTRODUCTION

Bangladesh has made significant progress in improving child survival and lowering infant mortality (Abir et al, 2015). The country reported 351 000 infant deaths in 1990 and 105 000 in 2011 (You, 2011). This positive trend was as a result of many factors which include Vitamin A supplementation, immunization, integrated management of childhood illnesses (Abir et al, 2015),increase in coverage of births in health centres, skilled birth attendants, antenatal visits and exclusive breast feeding for at least 6months (Khan & Awan, 2017,Rubayet et al, 2012). Although child mortality rate is declining over time, the country has not managed to bring it down to achieve sustainable development goals (NIPORT, 2016; MOH Bangladesh, 2014). Several studies have identified various reasons which lead to infant mortality such as social, demographic and proximate variables (Hobcraft et al, 1985; Bairagi et al, 1999; Kabir 2001; Grepin & Bharadwaj, 2015; Ronsmans, 1996; Gubhaju, 1985; UNFPA, 2007). Other factors which can influence infant mortality are immunization status of children and delivery practices (Breinman et al, 2004; Tura et al, 2013; Ezeh et al, 2015). Time series modeling and forecasting is an important component of public health especially in providing early surveillance of diseases and other health related problems. Application of these techniques in this paper is relevant in order to track infant mortality rate and institute preventive and control measures to curb infant deaths. Various techniques can be used which include the Autoregressive integrated moving average (ARIMA), exponential smoothing and machine learning methods (Nyoni et al, 2020; Zhao et al, 2020; Weng et al, 2017). In this study we choose to apply the multilayer perceptron (MLP) to forecast IMR in Bangladesh. The model is made up layers of neurons namely the input, hidden and output layers which are connected by acyclic links called weights (Nyoni et al, 2020; Zhao et al, 2020; Kaushik & Sahi, 2018; Yan et al, 2018; Fojnica et al, 2016; Zhang, 2003). The model is a feed forward neural network type and uses supervised learning.

II. RELATED STUDIES

Hossain et al (2019) explored the trends in and determinants of perinatal deaths in Bangladesh. The data used for this study was extracted from four rounds of Bangladesh Demographic and Health Surveys (BDHSs) 2004, 2007, 2011 and 2014. The authors considered the outcome of the 26604 pregnancies reaching seven months of their gestation. The trends of perinatal mortality was assessed using the Cochran–Armitage test, while the logistic regression with generalized estimating equation (GEE) to account for the clustering effect was implemented to explore the association between perinatal mortality and its risk factors. The study highlighted the importance of strengthening proper postnatal care services in the healthcare facilities. In another paper, Soest & Saha (2018) used dynamic panel data techniques to analyze the causal effects of infant mortality on birth intervals and fertility, as well as the causal effects of birth intervals on mortality in rural Bangladesh, accounting for unobserved heterogeneity and reverse causality. Simulations based upon the estimated model show whether (and to what extent) mortality and fertility can be reduced by breaking the causal links between short birth intervals and infant mortality. The authors found a replacement effect of infant mortality on total fertility of about 0.54 children for each infant death in the comparison area with standard health services. Eliminating the replacement effect would lengthen birth intervals and reduce the total number of births, resulting in a fall

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in mortality by 2.45 children per 1000 live births. These effects are much smaller in the treatment area with extensive health services and information on family planning, where infant mortality is smaller, birth intervals are longer, and total fertility is lower. In both areas, the authors found evidence of boy preference in family planning. Khan and Awan (2017) explored the trends and identified the factors associated with mortality in children aged less than 5years in Bangladesh. Data from three repeatedly cross-sectional Bangladesh Demographic and Health Surveys (BDHSs) for the year 2007, 2011 and 2014 were used. A stratified two-stage sampling method was used to collect information on child and maternal health in these surveys. Cox's proportional hazards models with community and mother level random effects (or frailty models) were fitted to identify the associated factors with under-five mortality. The study concluded that community-based educational programs and public health interventions focused on birth spacing may turn out to be the most effective. Moreover, unobserved community and familial effects need to be considered along with significant programmable determinants while planning for the child survival.

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 Bangladesh.

Data Issues

This study is based on annual infant mortality rates in Bangladesh 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	B
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	0.009863
MSE	0.666555
MAE	0.709119

Residual Analysis for the Applied Model

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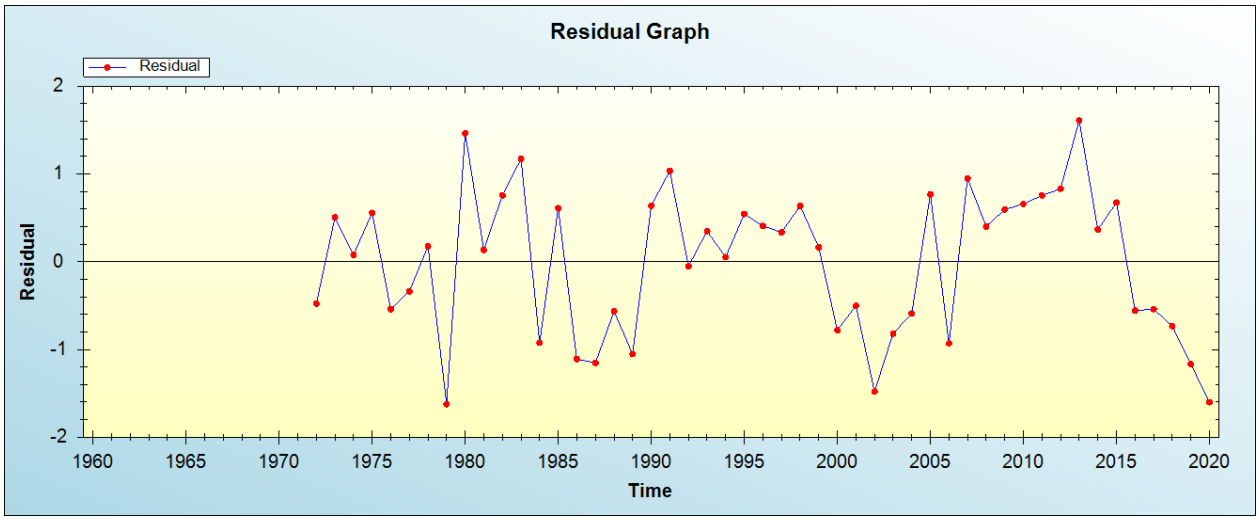

Figure 1: Residual analysis

In-sample Forecast for B

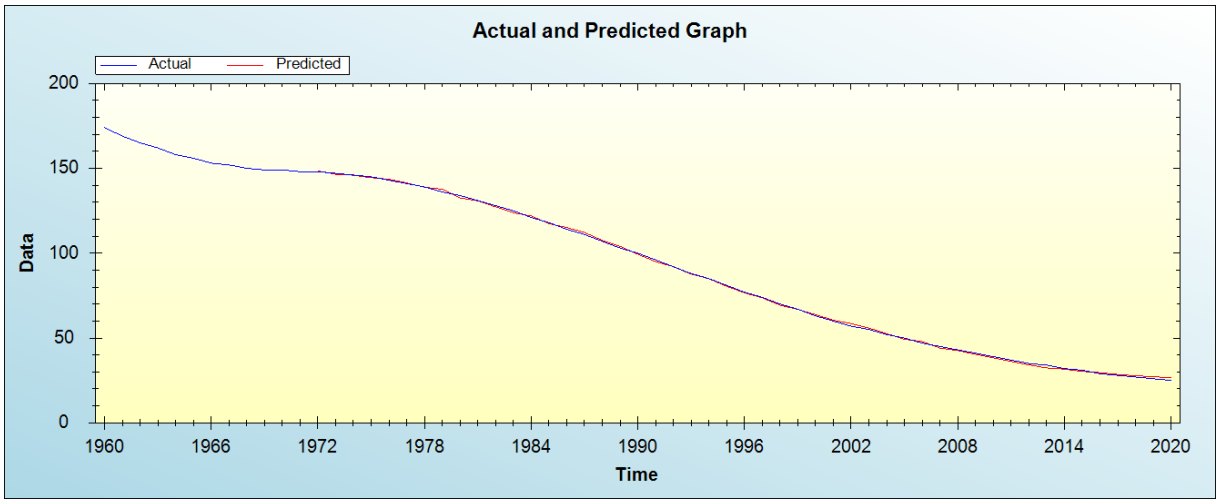

Figure 2: In-sample forecast for the B series

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

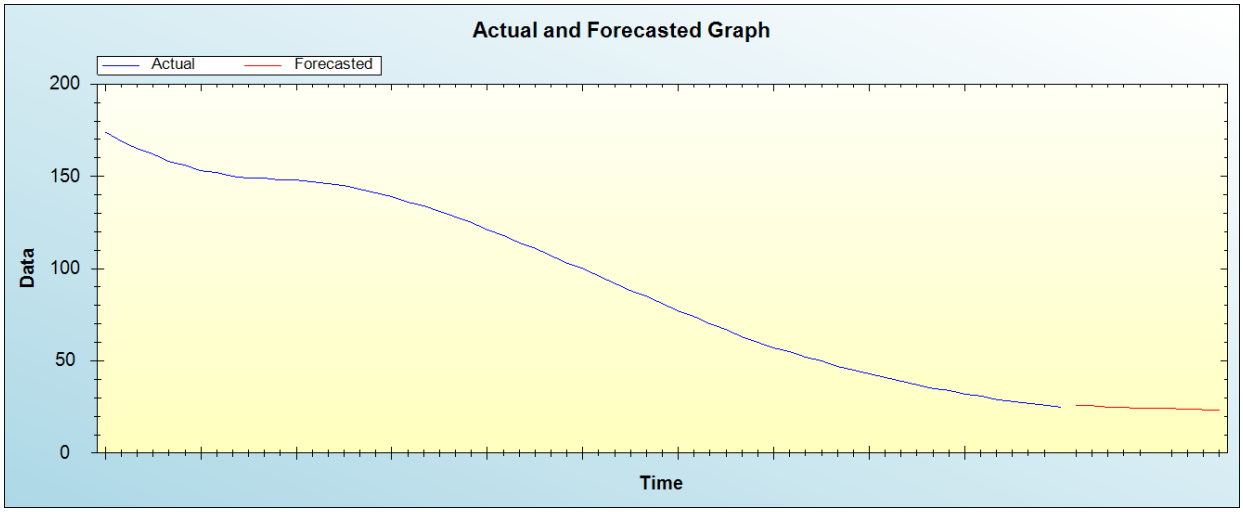

Figure 3: Out-of-sample forecast for B: actual and forecasted graph

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Out-of-Sample Forecast for B: Forecasts only

Table 3: Tabulated out-of-sample forecasts

Year	Predictions
2021	26.0430
2022	25.7154
2023	24.9267
2024	24.7168
2025	24.4345
2026	24.2873
2027	24.1962
2028	23.8359
2029	23.5810
2030	23.5474

The main results of the study are as shown in table 1. It is clear that the model is quite 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 Bangladesh will decline from approximately 26 in 2021 to about 24 infant deaths/1000 live births by 2030.

V. CONCLUSION AND POLICY RECOMMENDATIONS

Preventing infant mortality remains one of the main objectives of the health ministry in Bangladesh. The government of Bangladesh remains committed to ending preventable deaths infants in the country. The study used annual data to analyze the trends of infant mortality in Bangladesh. The applied model is the ANN model. In order to make sure that infant mortality in the country significantly declines, the government of Bangladesh 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 in Bangladesh to be vaccinated against common illnesses.
iii. There is need to prevent birth defects in Bangladesh.
iv. The government of Bangladesh should address preterm birth, low birth-weight and their outcomes.
v. The government of Bangladesh 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 Bangladesh.
vii. Healthcare providers in Bangladesh need to use newborn screening activities in order to detect hidden conditions.

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