

# Prediction of Infant Mortality Rate in Pakistan Using the Artificial Neural Network Approach

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**Abstract** - In this research article, the ANN approach was applied to analyze infant mortality rate in Pakistan. 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 infant mortality rate in Pakistan. The ANN (12, 12, 1) model projections suggest that infant mortality will slightly decline over the next 10 years. The government is encouraged to intensify maternal and child health surveillance and control programs amongst other measures in order to curb infant mortality in Pakistan. This may be specifically done by adopting the suggested 7-fold policy recommendations.

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

## I. INTRODUCTION

Despite a significant reduction in the under-five mortality worldwide, infant deaths still remain a global problem in developing countries. In 2016, the under-five death rate globally was 40 deaths per 1000 live births (UNICEF, 2017). Pakistan is one of the developing countries in the world which is struggling to achieve low infant mortality rate. The country is ranked 150 out of 189 on the Human Development Index (Islam et al, 2020). Infant mortality rate is an important index to demonstrate social health status and mortality (Fattahi, 1985). It is an approved global indicator of human health and socio-economic status of a particular population (Mausner et al, 1985; Park & Park, 1997). Previous studies done in many countries have revealed that most of infant mortality occurs during the neonatal period particularly during the first 7 days of life (Lawoyin, 2001; Esmail et al, 2001). The leading causes of neonatal deaths include prematurity and low birth weight, sepsis and congenital malformations in the early neonatal period (Lawoyin, 2001; Esmail, 2001; Arsh et al, 2001; Leach et al, 1999). Beyond 1 month of life gastrointestinal and respiratory infections become the dominant causes of mortality (Suwal, 2001; Agha, 2000; Yassin, 2000; Al-Nahedh, 1997). Several developing countries have made significant efforts to reduce infant mortality so as to achieve the sustainable development goal number 3 by 2030. Many governments have strengthened their health systems by improving the health infrastructure, training health personnel and supporting primary health care initiatives to ensure equitable access to health care services including maternal and child health services. In this paper we aim to model and forecast infant mortality rate in Pakistan using the Multilayer Perceptron (MLP). Machine learning methods are gaining popularity in the field of Public Health (Nyoni et al, 2020; Zhao et al, 2020). These techniques are capable of handling complex data and can form relationships between variables without basing on assumptions. The MLP is made up of 3 layers of neurons and is a feed forward neural network type. The layers are input, hidden and output layers which are connected by connection weights (Kaushik & Sahi, 2018; Yan et al, 2018; Fojnica et al, 2016; Zhang, 2003).

## II. LITERATURE REVIEW

Aghai et al (2020) did a study to determine the gender differences in neonatal mortality, stillbirths, and perinatal mortality in south Asia using the Global Network data from the Maternal Newborn Health Registry. This study was a secondary analysis of prospectively collected data from the three south Asian sites of the Global Network. The maternal and neonatal demographic, clinical characteristics, rates of stillbirths, early neonatal mortality (1–7 days), late neonatal mortality (8–28 days), mortality between 29–42 days and the number of infants hospitalized after birth were compared between the male and female infants. The authors concluded that the risks of stillbirths, and early neonatal mortality were higher among male infants than their female counterparts. However, there was no gender difference in mortality after 7 days of age. Islam et al (2020) developed a predictive analytics framework to predict the death rates with high accuracy and to find the significant determinants that cause high child mortality. The framework uses an automated method of information gain to rank the information-rich mortality variables for accurate predictions. Ethiopian Demographic Health Survey and Pakistan Demographic Health Survey data sets have

been used for the validation of the proposed framework. These real-world data sets were tested using machine learning classifiers, such as Naive Bayes, decision tree, rule induction, random forest, and multi-layer perceptron, for the prediction task. The study revealed that naïve Bayes classifier predicts the child mortality rate with the highest average accuracy of 96.4% and decision tree helps in identifying key classification rules covering the factors behind children deaths. Ahmed & Won (2017) carried out a study to compare Pakistan’s under-five mortality, neonatal mortality, and postnatal newborn care rates with those of other countries. Neonatal mortality rates and postnatal newborn care rates from the Demographic and Health Surveys (DHSs) of nine low- and middle-income countries (LMIC) from Asia and Africa were analyzed. Pakistan’s maternal, newborn, and child health (MNCH) policies and programs, which have been implemented in the country since 1990, were also analyzed. The results highlighted that postnatal newborn care in Pakistan was higher compared with the rest of countries, yet its neonatal mortality remained the worst. In Zimbabwe, both mortality rates have been increasing, whereas the neonatal mortality rates in Nepal and Afghanistan remained unchanged. An analysis of Pakistan’s MNCH programs showed that there is no nationwide policy on neonatal health.

### III. METHODOLOGY

The Artificial Neural Network (ANN), which want 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 Pakistan.

#### Data Issues

This study is based on annual infant mortality rates in Pakistan 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	0.017757
MSE	1.644610
MAE	0.992788

Residual Analysis for the Applied Model

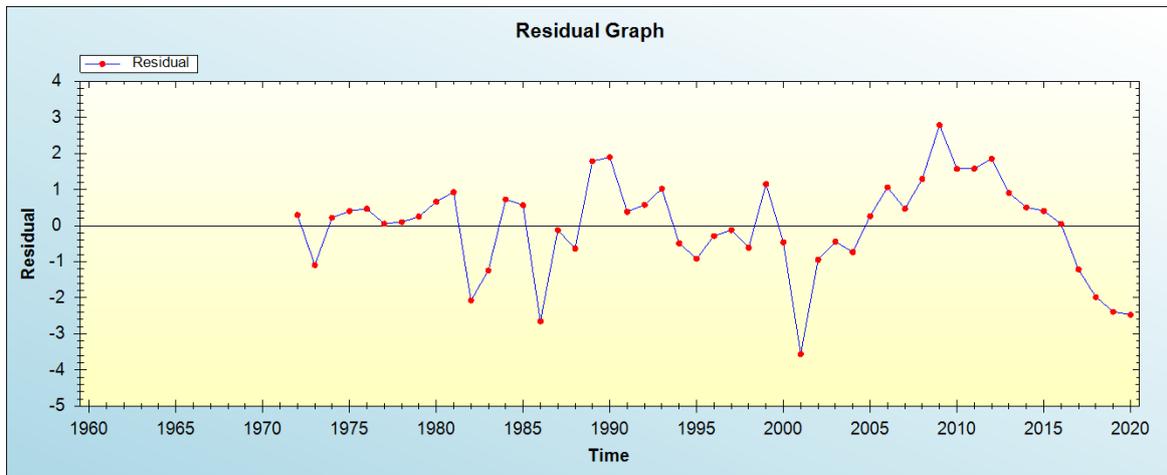


Figure 1: Residual analysis

In-sample Forecast for P

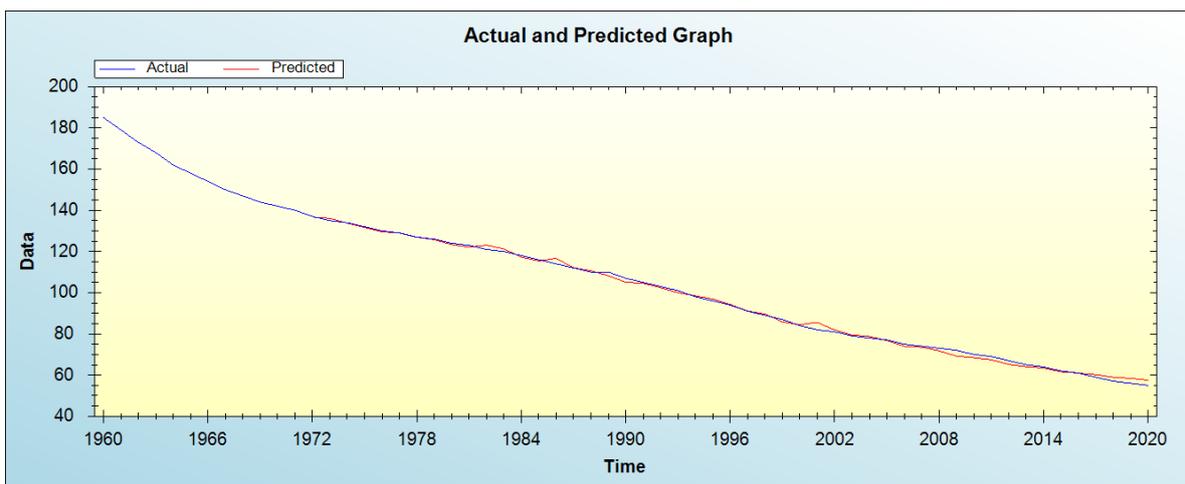


Figure 2: In-sample forecast for the P series

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

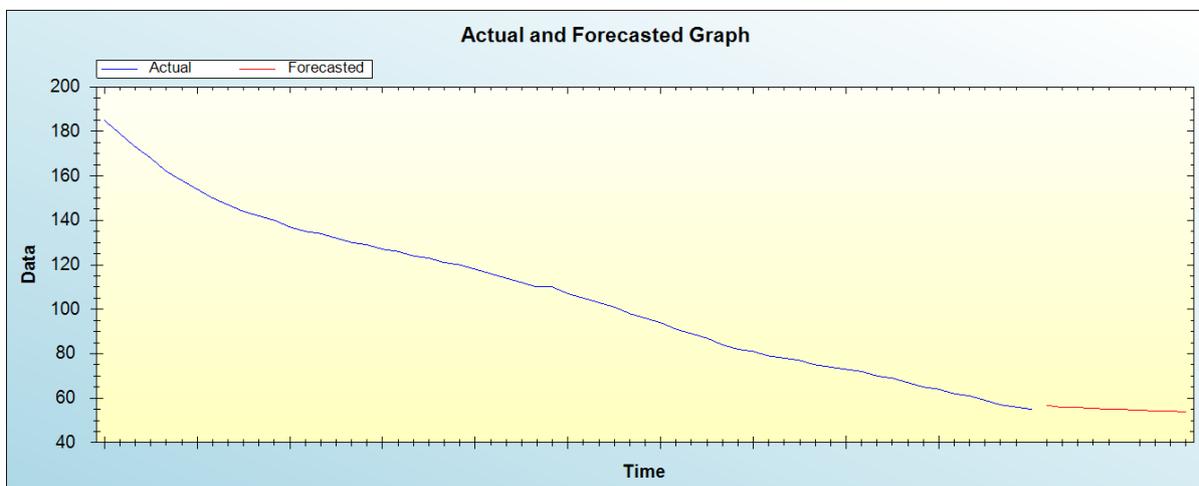


Figure 3: Out-of-sample forecast for P: actual and forecasted graph

Out-of-Sample Forecast for P: Forecasts only

Table 3: Tabulated out-of-sample forecasts

2021	56.7857
2022	55.7971
2023	55.7336
2024	55.4756
2025	54.9000
2026	54.9342
2027	54.5747
2028	54.3271
2029	54.1644
2030	53.8622

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 Pakistan is likely to decline as shown in table 3 above.

## V. CONCLUSION AND POLICY RECOMMENDATIONS

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

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