

Prediction of Infant Mortality Rate in India Using a Machine Learning Technique

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

Keywords: ANN, Forecasting, infant mortality rate.

I. INTRODUCTION

Infant mortality rate (IMR) is defined as the number of deaths in children less than 1 year of age per 1000 live births occurring in the same year (Deb et al, 2017). An estimated 2.6 million stillbirths and 2.7million neonatal deaths occur worldwide each year (Bills et al, 2020; UNICEF, 2016). The majority of these deaths (99 %) occur in developing countries (WHO, 2016). India recorded an estimated number of neonatal deaths in 2012 of around 760 000 (Bills et al, 2020). In 2013, the country had a perinatal mortality rate of 28 per 1000 total births (RGI, 2012). India has made a significant progress in reducing overall child mortality over the years, however neonatal deaths are still high (UNICEF, 2015). The sample registration system of India (SRS) reported a decrease in IMR from 72/1000 live births in 1998 to 57/1000 live births in 2006 and 39/1000 live births in 2014 (Rai et al, 2017; SRS, 2016; SRS, 2008; SRS, 2000). In India the majority of deliveries happen in the rural areas therefore infant deaths are higher in the rural area than the urban areas (SRS, 2016). The individual states in the country differ in their socio-economic development, population size, experience of epidemiological transition and capacity. They are responsible for their own healthcare systems (Bhatia et al, 2019). Several studies identified various causes of infant and neonatal mortality which include sepsis and congenital disorders in the early neonatal period, and diarrhea and pneumonia in the post neonatal period. In this paper we aim to model and forecast infant mortality in India using the artificial neural network approach. The ANN (12, 12, 1) model was applied to predict IMR and the hyperbolic tangent was the appropriate and more efficient activation function. The model is composed of 3 layers of neurons namely the input, hidden and output layers. The layers are connected by weights. The neural network framework is a feed forward neural network type (Nyoni et al, 2020; Zhao et al, 2020; Kaushik & Sahi, 2018; Yan et al, 2018; Fojnica et al, 2016; Zhang, 2003). The finding of this study will be as an early surveillance tool to track the trends of infant mortality rate and assist in the prevention and control of infant deaths in the country.

II. LITERATURE REVIEW

Bhatia et al (2019) analyzed the patterns and trends in the mortality rates of infants and children under the age of 5 in India (1992–2016) and quantified the variation in performance between different geographical states through three rounds of nationally representative household surveys. Three rounds of cross-sectional survey data. The study is conducted at the national level: India and its selected good-performing states, namely Haryana, Kerala, Maharashtra, Punjab and Tamil Nadu, and selected poor-performing states, namely Bihar, Chhattisgarh, Madhya Pradesh and Uttar Pradesh. The study revealed that attempts to reduce infant and child mortality rates in India are heading in the right direction although there is huge variation in performance between states. Bills et al (2018) described the demographic characteristics and clinical outcomes of neonates born within 7 days of public ambulance transport to hospitals across five states in India. It was a prospective observational study. Five Indian states using a centralized emergency medical services (EMS) agency that transported 3.1 million pregnant women in 2014. Participants Over 6 weeks in 2014, this study followed a convenience sample of 1431 neonates born to women using a public-private ambulance service for a 'pregnancy related' problem. Initial calls were deemed 'pregnancy related' if categorized by EMS dispatchers as 'pregnancy', 'childbirth', 'miscarriage' or 'labor pains'. Inter-facility transfers, patients absent on ambulance

arrival, refusal of care and neonates born to women beyond 7 days of using the service were excluded. Main outcome measures: death at 2, 7 and 42 days after delivery. The study revealed that perinatal mortality rate associated with this cohort of patients with high-acuity conditions of pregnancy was nearly two times the most recent rate for India as a whole (28 per 1000 births. Rai et al (2017) did a study to identify the medical causes of death and contribution of non-biological factors towards infant mortality by a retrospective analysis of routinely collected data using verbal and social autopsy tools. The study site was Health and Demographic Surveillance System (HDSS), Ballabgarh, North India Participants All infant deaths during the years 2008– 2012 were included for verbal autopsy and infant deaths from July 2012 to December 2012 were included for social autopsy. Outcome measures were cause of death ascertained by a validated verbal autopsy tool and level of delay based on a three-delay model using the INDEPTH social autopsy tool were the main outcome measures. The level of delay was defined as follows: level 1, delay in identification of danger signs and decision making to seek care; level 2, delay in reaching a health facility from home; level 3, delay in getting healthcare at the health facility. The study concluded that there is a high proportion of preventable infant mortality which exists in an area which is under continuous health and demographic surveillance.

III. METHODOLOGY

The Artificial Neural Network (ANN), which we intend to apply in this research; 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 India.

Data Issues

This study is based on annual infant mortality rates in India 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	0.011639
MSE	0.728526
MAE	0.689107

Residual Analysis for the Applied Model

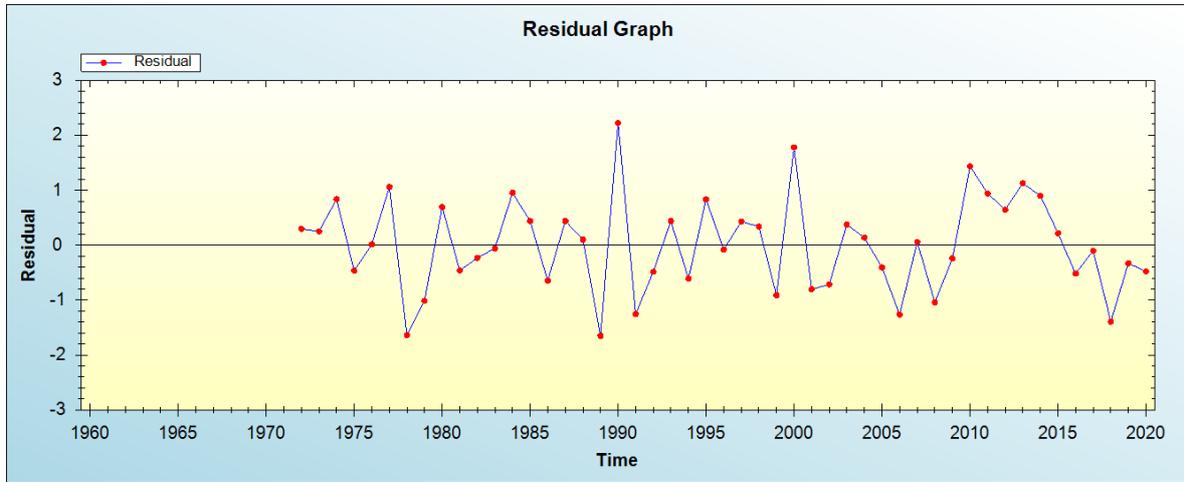


Figure 1: Residual analysis

In-sample Forecast for B

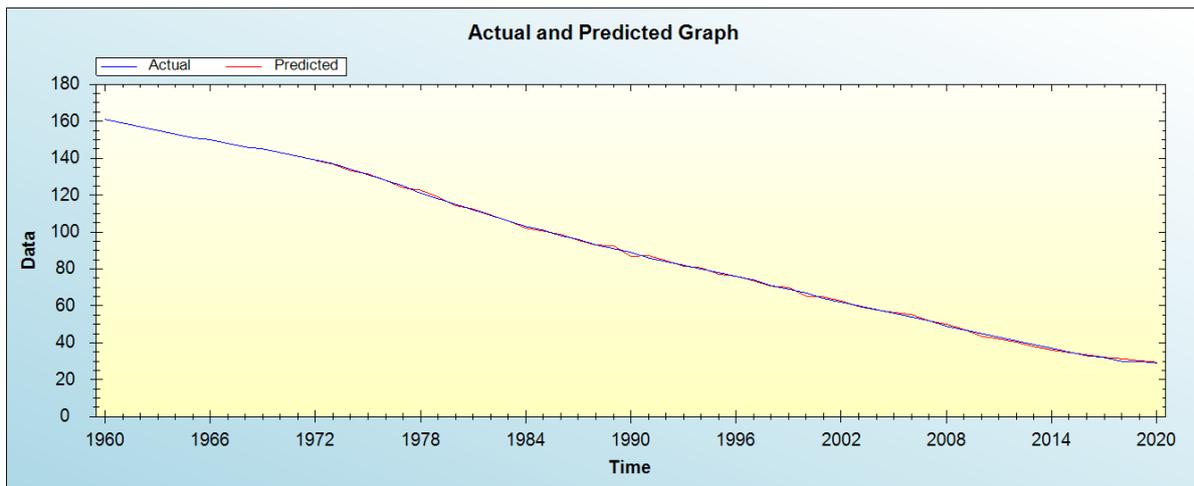


Figure 2: In-sample forecast for the B series

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

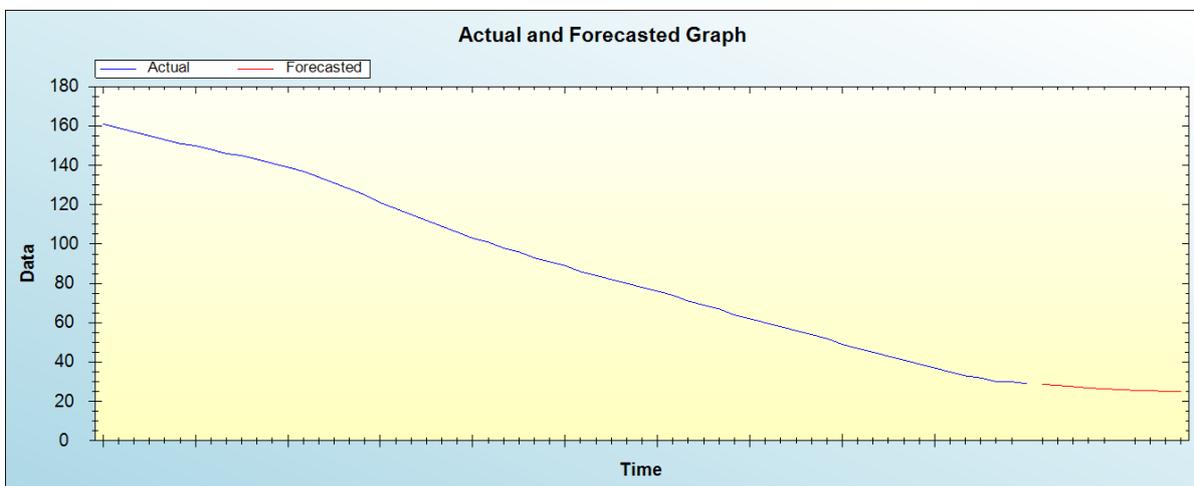


Figure 3: Out-of-sample forecast for B: actual and forecasted graph

Out-of-Sample Forecast for B: Forecasts only

Table 3: Tabulated out-of-sample forecasts

Year	Predictions
2021	28.8039
2022	28.1471
2023	27.5707
2024	26.8793
2025	26.4161
2026	26.0244
2027	25.6385
2028	25.4073
2029	25.2413
2030	25.0284

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 India is likely to decline from the current estimated 29 to almost 25/1000 live births per year by 2030.

V. CONCLUSION AND POLICY RECOMMENDATIONS

Preventing infant mortality remains one of the main objectives of the health ministry in India. The Indian government remains committed to ending preventable deaths infants in the country. The study used annual data to analyze the trends of infant mortality in India. The applied model is the ANN model. In order to make sure that infant mortality in the country significantly declines, the government of India ought to consider the following policy suggestions:

- i. The Indian government should continue to encourage mothers to breast-feed their babies adequately.
- ii. There is need for all Indian child-bearing women to be vaccinated against common illnesses.
- iii. There is need to prevent birth defects in India.
- iv. The government of India should address preterm birth, low birth-weight and their outcomes.
- v. The government of India 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 India.
- vii. Healthcare providers in India need to use newborn screening activities in order to detect hidden conditions.

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