

Prediction of Infant Mortality Rate in Indonesia Using a Machine Learning Algorithm

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

Keywords: ANN, Forecasting, infant mortality rate.

I. INTRODUCTION

Infant mortality rate (IMR) is measured based on the number of infant deaths in one year per 1000 live birth. IMR is an important indicator of the health status in any country (Elida et al, 2019) and is an acceptable global indicator of socio-economic level in a population. Approximately 5 million children die during the first year of life worldwide (Elida et al, 2019). According to the Indonesia Demographic and Health survey 2012, IMR over the period 2008-2012 was 32 deaths per 1000 live births. It also revealed that there was a decline in IMR from 68 deaths per 1000 live births during the period 1987-1991 to 32 deaths per 1000 live births over the period 2008-2012 (SDKI, 2012). Many studies have been done in developing countries to investigate factors associated with infant mortality and have concluded that maternal age, birth weight, delivery type, place of delivery and interval from previous delivery can affect the occurrence of infant mortality (Elida et al, 2019) Given the mentioned predictors of infant mortality developing countries must work towards improving their health systems in order to reduce infant deaths. These governments must channel their resources towards improving health infrastructure, status of roads for easy accessibility of health services, promotion of institutional deliveries and procurement of medical supplies and equipment for essential newborn care and obstetric emergencies. Modeling and forecasting IMR is vital in order to understand the future trends of infant mortality in the country and to improve the quality of maternal and child health services. In this study we applied the artificial neural network, ANN (12, 12, 1) model to forecast IMR in Indonesia. The applied model is based on the basic model of the human brain with capability of learning and generalization (Patterson, 1995). The basic computing element in the biological system is the neuron which receives electrochemical signals from different neurons and then generates electrical impulses to be transmitted to the other neurons. A neural network is a modeling tool which can capture both linear and nonlinear relationships directly from the data (Kishan et al, 1997). The applied model is composed of 3 layers: input, hidden and output layers. The layers are connected by acyclic links called connection weights. The neural network framework is a feed forward neural network (Zhao et al, 2020; Nyoni et al, 2020; Kaushik & Sahi, 2018; Yan et al, 2018, Fojnica et al, 2016; Zhang, 2003; Kishan, 1997; Patterson, 1995). Based on the learning strategy three categories of ANN can be described, supervised, re-enforcement and supervised learning. Supervised learning occurs when the algorithm learns a hypothesis function when input and output values are provided whereas finding hidden structures or patterns from the input data is called supervised learning (Weng et al, 2017).

II. LITERATURE REVIEW

Irawaty et al (2020) analyzed the causes of infant mortality in rural Indonesia and suggested strategies for its reduction. The study was an analytical cross-sectional design based on the 2017 Indonesian Demographic and Health Survey (IDHS) dataset for children. The information on infant deaths collected from those mothers who experienced infant deaths. Series of logistic regression models were used to select the significant factors affecting infant mortality in rural Indonesia. Infant mortality is associated with intermediate social determinants such as birth order, birth weight, and breastfeeding status. Socio-demographic factors such as the educational status of mothers, wealth quintile, the smoking habit of the mother, age of mother at first delivery,

and sex of the baby are also related to infant mortality. The study concluded the most crucial factors in rural Indonesia were the age of first-time mothers. Elida et al (2019) analyzed the influence of maternal age, parity, and education to infant mortality in West Aceh Regency. The research was quantitative with case control design, a case group was 45 mothers whose babies died when they were under one years old and a control group was 45 mothers whose babies were alive when they were under one year old. The matching was done on the babies based on their age and sex. The Data analyzed by using univariate and bivariate analysis with Mc Nemar test, meanwhile, multivariate analysis with conditional logistic regression test at the significant level of 0.25. The Result of analysis in this research showed that maternal age and parity significantly influence of infant mortality. In the other hand, maternal education did not significantly influence infant mortality. The most significant variable which influences infant mortality was maternal age (OR=4.745). Surpami et al (2016) examined the contribution of low birth weight on neonatal mortality in Indonesia. Data from the Indonesia Demographic and Health Survey (IDHS) conducted in 2012 were used in the analysis. A total of 18021 live births in the last five years preceding the survey were reported from the mothers. Completed information of their children (14837 children) was taken for this analysis. The adjusted relative risk with cox proportional hazard regression analysis was used to assess the strength of association to neonatal mortality. Results of the study revealed that children born in a low birth weight and born from younger mothers had higher risk of neonatal mortality.

III. METHODOLOGY

The Artificial Neural Network (ANN), which we intend to apply in this piece of work; 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 Indonesia.

Data Issues

This study is based on annual infant mortality rates in Indonesia 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	G
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	0.009331
MSE	0.447163
MAE	0.549896

Residual Analysis for the Applied Model

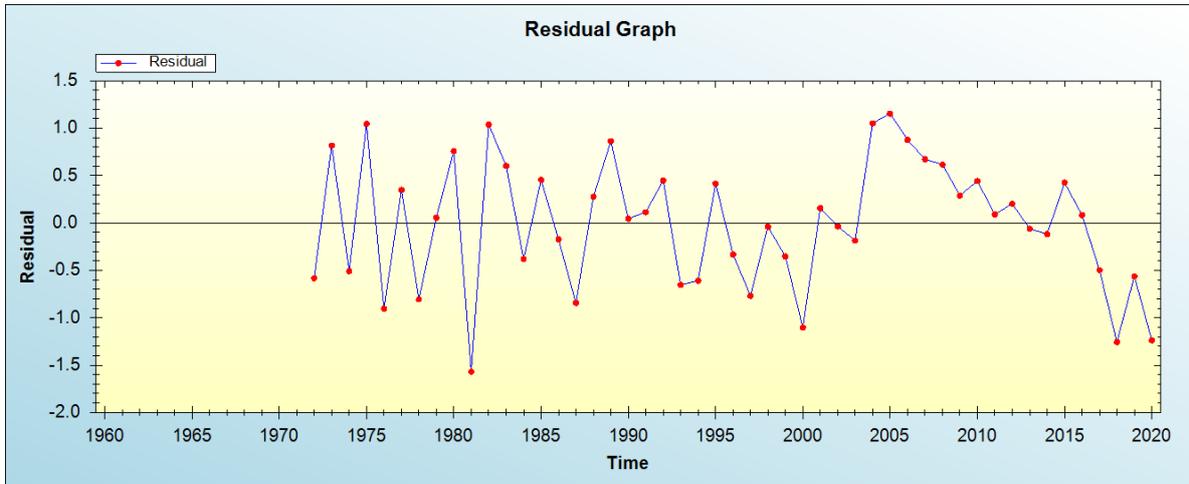


Figure 1: Residual analysis

In-sample Forecast for G

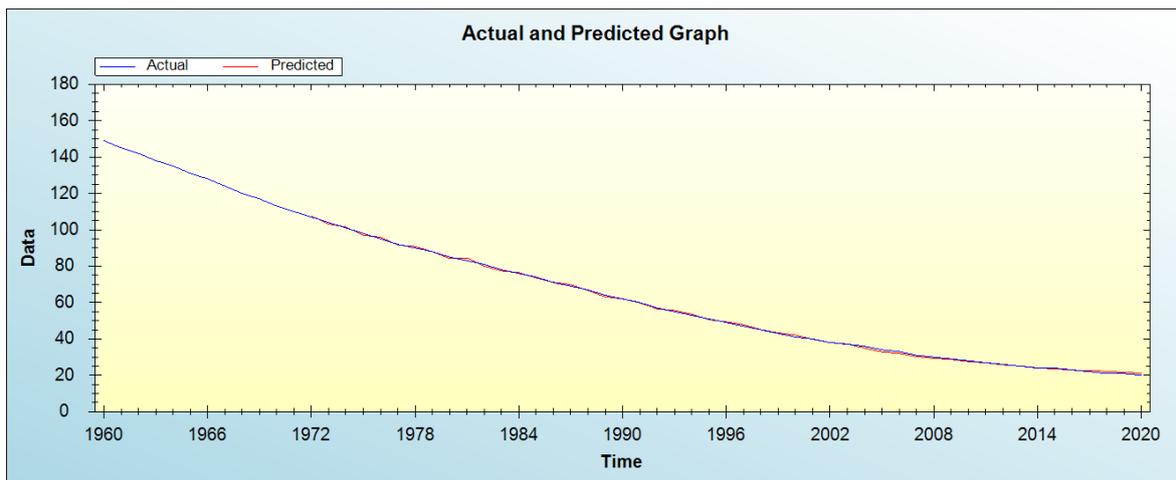


Figure 2: In-sample forecast for the G series

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

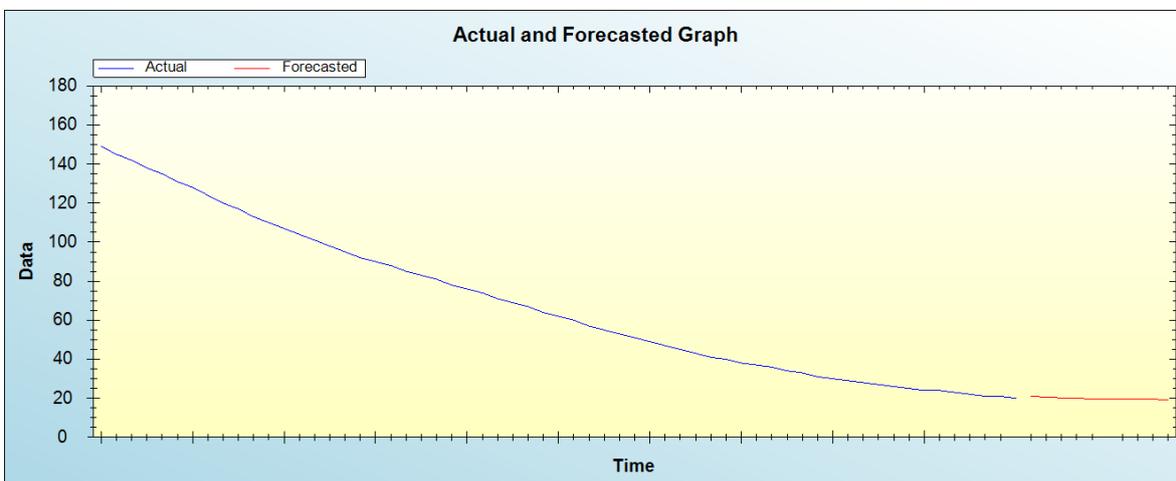


Figure 3: Out-of-sample forecast for G: actual and forecasted graph

Out-of-Sample Forecast for G: Forecasts only

Table 3: Tabulated out-of-sample forecasts

Year	Forecasts
2021	21.0597
2022	20.5655
2023	20.2116
2024	20.1716
2025	19.5496
2026	19.5227
2027	19.5210
2028	19.4273
2029	19.4598
2030	19.3323

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

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

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