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Modelling and Forecasting Immunization against Measles Disease in Indonesia Using Artificial Neural Networks (ANN)

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***Abstract* - In this research article, the ANN approach was applied to analyze child immunizations against measles in Indonesia. The employed annual data covers the period 1983-2019 and the out-of-sample period ranges over the period 2020-2030. The residuals and forecast evaluation criteria (Error, MSE and MAE) of the applied model indicate that the model is indeed stable. The ANN (12, 12, 1) model projections suggest that child immunization against measles in Indonesia is likely to remain around 77% per year over the next decade. The government of Indonesia is encouraged to intensify child health surveillance and control programs by adopting the suggested recommendations.**

Keywords: Modelling, Forecasting, Artificial Neural Networks, ANN.

I. INTRODUCTION

Measles is one of the most contagious diseases; hence any non-immune child contracts measles if exposed to the virus. Measles is an acute viral illness caused by a virus from the paramyxo virus family, (Ministry of Health, 2018) As a respiratory disease, the measles virus normally breeds in the cells that line the back of the lungs and throat. Till now measles remains a leading cause of death among young children despite the availability of a safe and effective vaccine for the past 40 years, Rosadi et al (2019). More than 562,000 children per year die worldwide in 2000 due to complications from measles (Indonesian Ministry of Health, 2017). Measles in Indonesia in 2015, were estimated to be 30,463,(Ministry of Health, 2018).Indonesia is amongst the nations with the most cases of measles in the world. In 2017, with suspected measles cases spread in nearly all provinces in Indonesia. The reported suspected cases of measles were 15,104, they were higher than those of 2016, which were 12,681 cases (Ministry of Health, 2018). In the Global Vaccine Action Plan (GVAP), measles was targeted to be eliminated in 5 WHO regions by 2020. Measles cannot be treated, the treatment given to patients was only supportive, and however measles can be prevented by immunization (RI Ministry of Health, 2018). Measles immunization helps protect children from disability and deaths induced by ailments like pneumonia, diarrhea, brain damage, cerebral and congenital heart disease (Indonesian Ministry of Health, 2017).The Indonesian Ministry of Health (MoH) is dedicated to attain measles immunization coverage, preferred estimates are 95% in which research proves that it will give herd immunity to the populace and help break measles' chain of transmission, (Ministry of Health, 2017) Despite these insistent efforts to reach the target, measles immunization coverage tends to decrease. Hence the need of this paper to model and forecast measles immunization and ensure it is consistent and sustainable. Modeling of measles vaccination provides a better understanding of collected data and dynamics of measles, this helps produce effective and efficient control strategies. Ntirampeba *et al* (2017) advocates for the estimation and mapping of the risks of measles by utilizing, more data on the measles cases is needed to understand the interplay between religion, politics, personal beliefs, and economics that influence individual and community decisions around vaccination So far progress in measles transmission modeling has given a chance for researchers to help shape up the health policy decisions. This paper aims to use Artificial Neural Networks (ANN), which have not been used before, to model and forecast new measles cases involving vaccination and to help policy makers make informed decisions from such.

II. RELATED STUDIES

A discrete-time seasonal model of measles transmission was proposed by Zhenguo Bai and Liu in 2015 who examined the seasonal fluctuation of measles cases in China. Rosadi *et al* (2019),carried out a cross-sectional study in Indonesia, to analyze the determinants of measles immunization uptake in infants. Results showed that Measles-Rubella immunization uptake increased

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with high maternal education, high maternal knowledge, strong family support, high perceived susceptibility, high perceived severity, strong perceived benefit, high cues to action, and high self-efficacy. It was seen to decrease with strong perceived barrier. Harapan et al (2021), evaluates the changes in measles vaccination coverage in Indonesia between 1991 and 2017 and compares vaccination coverage between Muslims and non-Muslims in Indonesia. Using multiple imputation analysis and binomial regression models, results were that Measles vaccination increased in both Muslims and non-Muslims in Indonesia but has stagnated in recent years. This is due to the increased attention among Muslim groups on haram materials in vaccines since 2017.Hartoyo*et al* (2017), investigated an outbreak with measles symptoms occurred in children in Banjarmasin, South Kalimantan, Indonesia using nasal swabs and detected measles virus genotype D8. Fakhruddin *et al* (2017), aimed to analyze and to investigate measles transmission in Jakarta, Indonesia using a SIHR epidemic model involving vaccination from January to December 2017. The most sensitive parameter was the hospitalized rate, which can be considered to be one of the essential factors to reduce the number of cases for policymakers. An SEIR epidemic model was performed to investigate the impact of exposed individuals in the dynamics of measles transmission Momoh *et al* (2013). The optimal policy for controlling measles was examined through an SIRV model using supplemental immunization activities with separation of vaccinated compartment, Verguet*et al* (2015).

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. Arguably, explicit guidelines 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 rates of immunization of children against measles in Indonesia for the period 1983 – 2019. The out-of-sample forecast covers the period 2020 to 2030. Child immunization; for the purposes of this study, is defined as the percentage of children aged 12-23 months who received the measles vaccination in a given year. All the data employed in this paper was gathered from the World Bank.

III. FINDINGS OF THE STUDY

ANN Model Summary

Table 1: ANN model summary

Variable	H
Observations	25 (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	0.035345
MSE	2.592613
MAE	1.230207

Residual Analysis for the Applied Model

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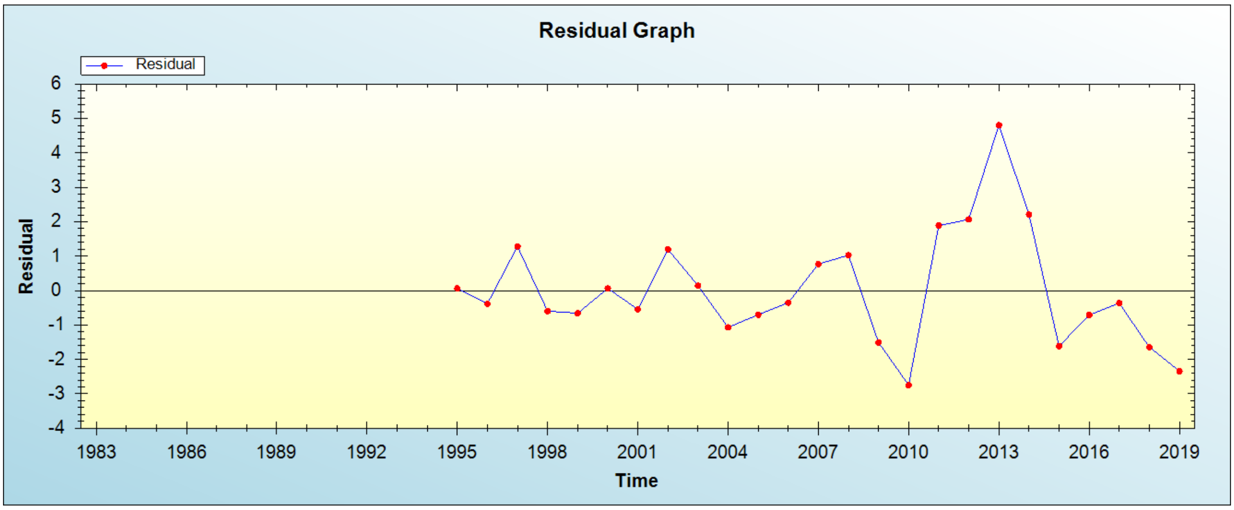

Figure 1: Residual analysis

In-sample Forecast for H

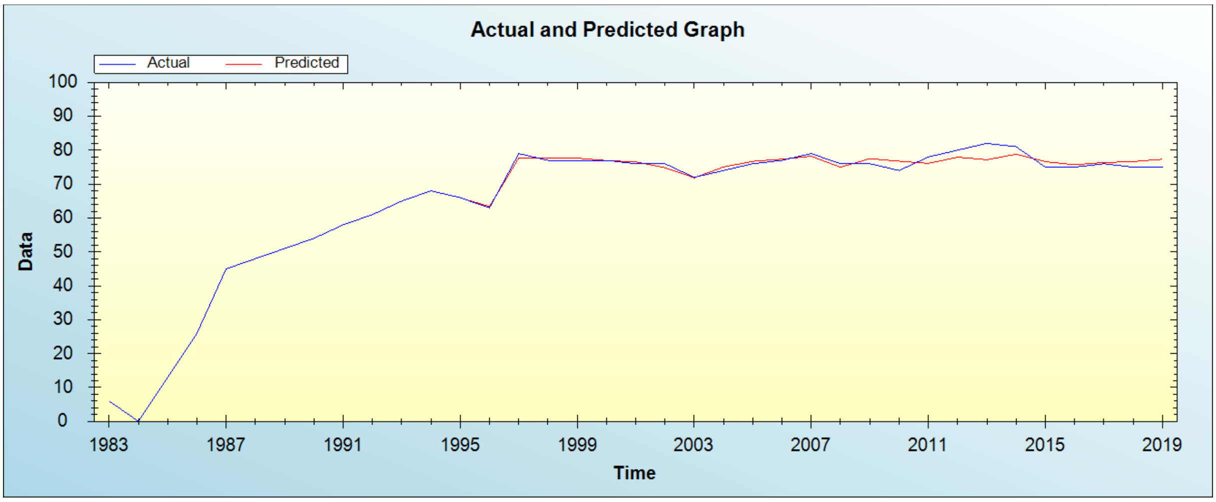

Figure 2: In-sample forecast for the H series

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

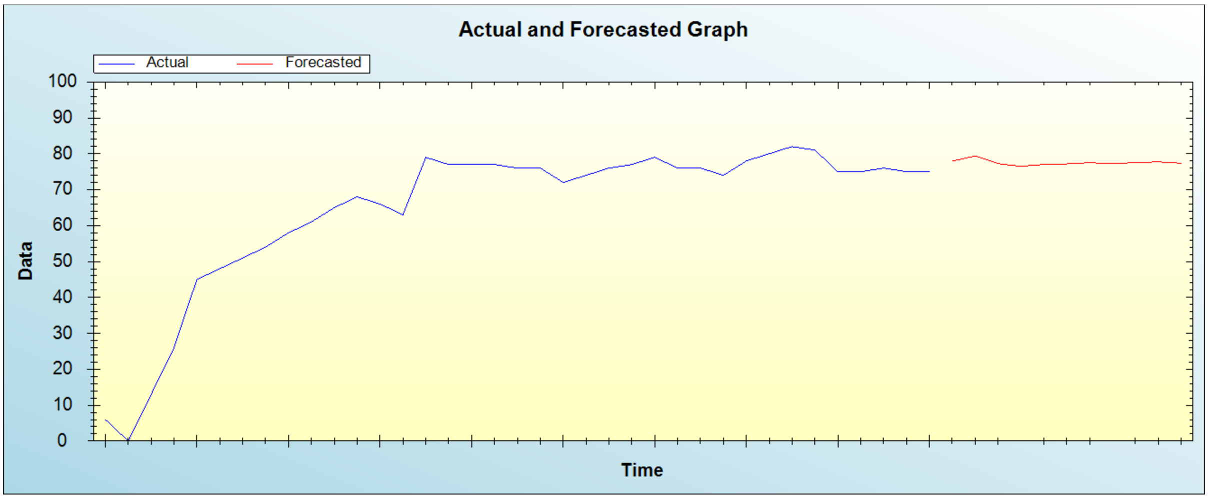

Figure 3: Out-of-sample forecast for H: actual and forecasted graph

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Out-of-Sample Forecast for H: Forecasts only

Table 3: Tabulated out-of-sample forecasts

Year	Forecasts
2020	77.9398
2021	79.4148
2022	77.2362
2023	76.5065
2024	77.0171
2025	77.1869
2026	77.5216
2027	77.2063
2028	77.5604
2029	77.7332
2030	77.3725

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 child immunization against measles in Indonesia is likely to remain around 77% per year over the next decade.

IV. CONCLUSION AND POLICY RECOMMENDATIONS

Predicting and forecasting measles cases in Indonesia may provide valuable information for decision-makers that are aiming to improve access to health care networks. Predictions show that vaccine coverage is of utmost importance in reducing the spread of the virus. We hence propose a control strategy which is providing treatment accesses easier than vaccinating when an outbreak occurs. In cases where the vaccination has already been delayed a catch-up campaign offers a 2nd opportunity to the susceptible group of children and a way to maintain population immunity against measles and sustain high measles vaccination coverage.

Vaccine hesitancy is on the rise globally and Indonesia's experience is cautionary, Coombes R (2017). Political leaders and health practitioners ought to be persistent in deliberating with religious scholars and societies to generate both a common understanding and clear-cut messaging regarding the benefits of immunisation. Since much of the Indonesian population is Islamic, dialogue with the leaders of the Organisation of Islamic Cooperation (OIC) is important. In addition, we recommend that all community health centers and authorities to conduct a strict measles surveillance and notification system and effected area must notify border districts' authorities to control the measles transmission in the future.

In a bid to create independence and sustainability, new self-financing system and other public health efforts must be increased to decrease the burden of infectious disease as Indonesia develops a stronger immunization system. Lastly, public health efforts must be increased to, in turn, decrease the burden of infectious disease as Indonesia develops a stronger immunization system. Increasing the dispersal of information through mass media and populations peers on the importance of breast feeding and good hygiene is paramount as it educated the masses on the benefits of the vaccine.

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