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

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***Abstract* - In this research article, the ANN approach was applied to analyze child immunization against measles in Philippines. The employed annual data covers the period 1982-2019 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 stable in forecasting immunization coverage in the country. The ANN (12, 12, 1) model projections suggest that child immunization against measles in Philippines is likely to decline to around 4% by 2030. The Philippines government is encouraged to intensify child health surveillance and control programs in a manner that is consistent with the policy directions suggested in this study.**

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

I. INTRODUCTION

Measles is an acute viral illness caused by a virus and still one of the causes of child mortality. Vaccination is perhaps the only means of fighting the measles reduce the number of cases globally and stop the spread of the infection and mortality. Measles continues to infect about 30 to 40 million infants every year and this has categorized it as a major killer of children around the world. Measles forecasting is especially essential to reduce the risk of being unvaccinated. Health institutions and governments generally estimate measles vaccine requirements using some formulae based on the history of the amount of consumption and size of the target population. The rate of measles vaccination in the Philippines, has declined steadily from 80% in 2008 to just below 70% in 2017, (WHO, 2019). As a result, numerous children are now susceptible to measles infection. World Health Organization (WHO), 2019 goes on to estimates that 2.6 million Filipino children under the age of five years are vulnerable to measles. The Expanded Program on Immunization (EPI) was established in 1976, with one dose of the measles vaccine given at nine months of age, the later vaccination program was introduced nationwide in 1983,(Ylade, M.C, 2018).Philippines was amongst the first states in the world to introduce the Haemophilus influenzae type b vaccine, and among the earliest nations in the Western Pacific region to introduce the rotavirus and pneumococcal conjugate vaccine, Kriss*et al* (2017). To date the measles vaccines is available at government health facilities, free of charge, with the first dose is given when a child is nine months old, and the second dose is given when a child is 12 months old, (Phillipines-Department of Health, 2019) The WHO has reported that immunisation rates were well below the target of 95 per cent and decreasing.

Kriss*et al* (2017) used the World Health Organization (WHO) Measles Programmatic Risk Assessment Tool to estimate the measles vaccine requirement assessment, results provided vital information for the improvement of the immunization campaign planning, and intensified surveillance. Uyar*et al* (2019) used the Adaptive Neuro-Fuzzy Inference System (ANFIS), to forecast the monthly measles cases in Ethiopia, results showed that forecasting enabled governments to have enough stocks of the measles vaccine. Alegado *et al* (2021), aimed to find a model to forecast Phillipines' monthly measles immunization coverage using Autoregressive Integrated Moving Average (ARIMA). Results from the model proved that they may be used for forecasting future immunization coverage and would help decision-makers to establish strategies, priorities, and proper use of immunization resources. Talirongan *et al* (2021), utilized the time series data for trend analysis and data forecasting using the ARIMA model to visualize the measles cases in the Philippines. Results were that there was an increasing pattern of the disease from 2016 to 2019. However, none of them are focused on forecasting measles immunization modelling and forecasting. Moreover, this study will contribute to existing knowledge of applying the ANNin forecasting immunization coverage. The study will further a forecast monthly measles infant immunization coverage. The forecasting and modelling results generated by the model may serveas the

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foundation for formulating accurate monthly volumes of the measles vaccine. By doing so, this will help to achieve a high level of coverage and improve measles immunization planning and program.

II. 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 Philippines.

Data Issues

This study is based on annual rates of immunization of children against measles in Philippines for the period 1982 – 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	W
Observations	26 (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	0.047808
MSE	4.859640
MAE	1.580117

Residual Analysis for the Applied Model

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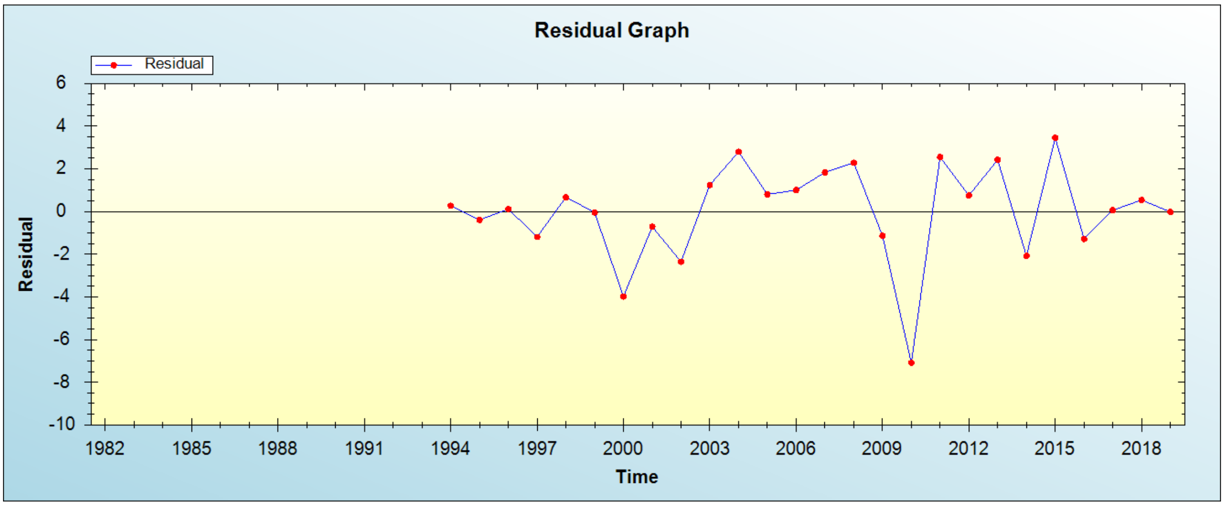

Figure 1: Residual analysis

In-sample Forecast for W

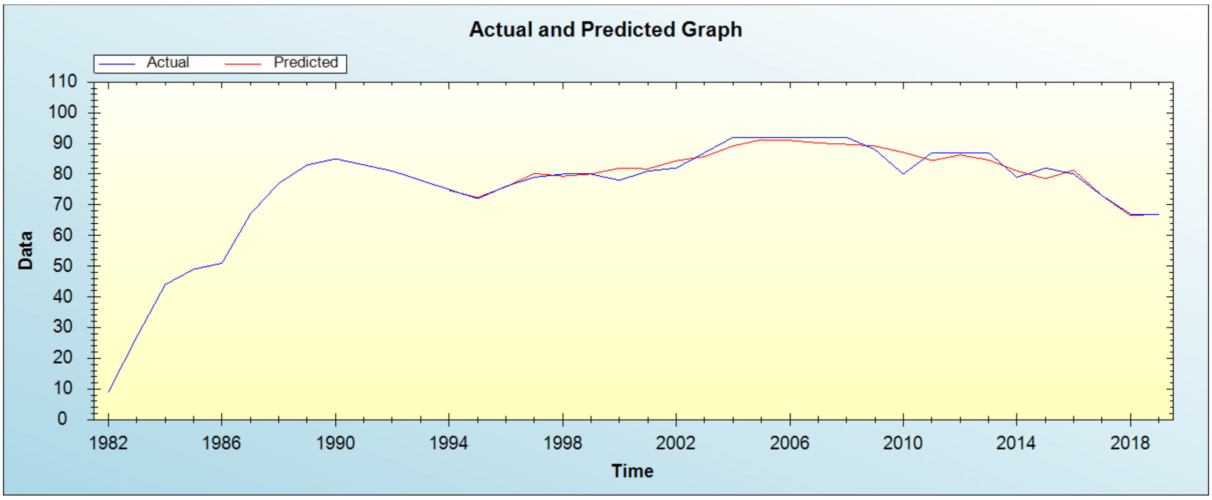

Figure 2: In-sample forecast for the W series

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

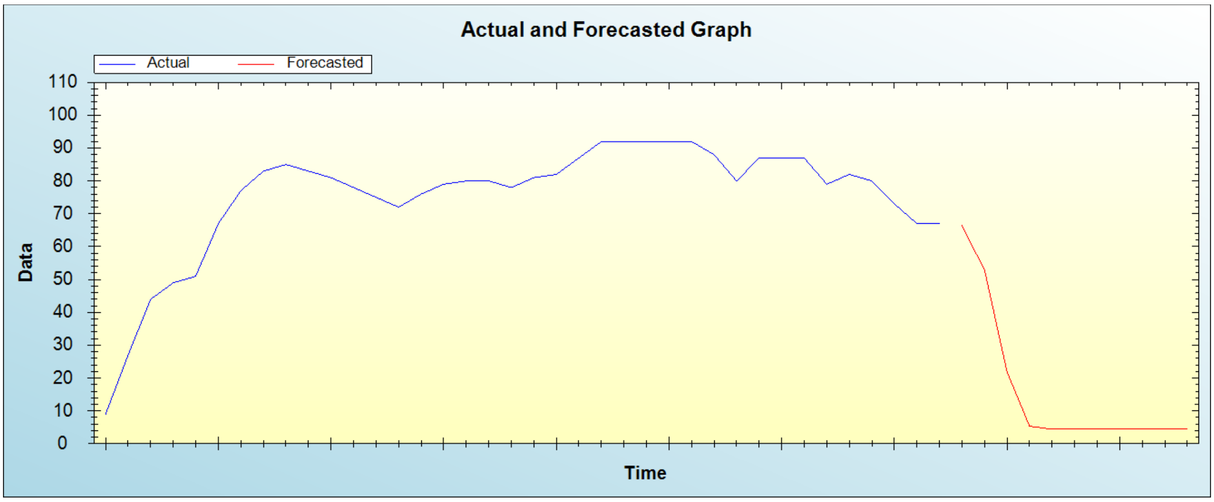

Figure 3: Out-of-sample forecast for W: actual and forecasted graph

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Out-of-Sample Forecast for W: Forecasts only

Table 3: Tabulated out-of-sample forecasts

Year	Forecasts
2020	66.4114
2021	52.9098
2022	21.8489
2023	5.3434
2024	4.4448
2025	4.4657
2026	4.5544
2027	4.5159
2028	4.4544
2029	4.4341
2030	4.4842

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 Philippines is likely to decline to around 4% by 2030.

IV. CONCLUSION AND POLICY RECOMMENDATIONS

Finding forecasted data on the incidences of measles cases is extremely helpful to the administration and designing of preventive measures against the spread of cases. In the study, the ANN tool successfully presented the trends of the disease in the country. The work is aimed at pointing out some critical information on what to expect in the coming months to those who deal with planning and organizing the necessary health services to provide medication to people in need. Emphasis is for authorities to support vaccination campaigns against measles through intensified information dissemination on measles prevention. Efforts to maintain high routine vaccination coverage should also be emphasized and strengthen the vaccination coverage if below 95%. Precise intervention such as immunization awareness day and knowledge; attitude and practices survey sought to be held in a way that reaches unvaccinated children and those who did not develop protective immune response; this helps in lessening the number of susceptible individuals.

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