

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

¹Mr. Takudzwa. C. Maradze, ²Dr. Smartson. P. NYONI, ³Mr. Thabani NYONI

¹Independent Researcher, Harare, Zimbabwe

²ZICHIRE Project, University of Zimbabwe, Harare, Zimbabwe

³SAGIT Innovation Center, Harare, Zimbabwe

Abstract - In this research article, the ANN approach was applied to assess child immunization against measles in Madagascar. The employed annual data covers the period 1984-2019 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 the series under consideration. The ANN (12, 12, 1) model projections suggest that child immunization against measles in Madagascar is likely to decline from 69% in 2020 to about 62% by 2030. The government of Madagascar is encouraged to intensify child health surveillance and control programs, particularly adopting the suggested policy recommendations.

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

I. INTRODUCTION

The World Health Organization (WHO), 2019, defines measles as an acute, highly contagious viral disease. In the recent years low coverage with measles vaccine combined with a low incidence of measles in Madagascar has led to a significant proportion of a Madagascan populace which is highly susceptible to measles. According to WHO and UNICEF estimates, the measles immunization coverage in Madagascar was 58% in 2017. To add on to the susceptibility is the health problem of malnutrition which increases children's vulnerability to serious complications and death from measles infection. According to WHO and the United Nations International Children's Emergency Fund (UNICEF), the estimated measles immunization coverage in Madagascar was 58% in 2017. Just above half (51%) of the cases reported during the last outbreak had not been vaccinated or had unknown immunization status. According to the World Health Organization (WHO, 2019), Madagascar is said to have the highest proportion (47%) of malnutrition amongst children under five, in the African region. From 4 October 2018 to 7 January 2019, the Ministry of Public Health (MoH) of Madagascar reported 19 539 measles cases. After several years of very low measles incidence, a measles epidemic began in the central parts of Madagascar in September 2018. The outbreak reached all 22 regions of the island, causing nearly 1000 deaths, with more than 100 000 cases reported, Raheindrasana *et al* (2020). Most of these cases are said to have been reported in the mostly densely populated areas of Madagascar, thus Antananarivo-Renivohitra district, and Ambato-Boina district. A developing important public health challenge is how to depict the risk of measles outbreaks and other vaccine preventable infections, and how to learn a lesson from this outbreak to build readiness for future outbreak stoppage and response strategies. WHO, (2020) noted that Madagascar's experience indicates that investment in relevant data streams like case surveillance, to vaccination deployment and serology. These alongside efforts to develop national capacity for integrative analysis of such varied data could help permit deployment of timely targeted vaccination campaigns to avert such outcomes in the future. It is the aim of this paper to forecast and model new measles cases that are likely to be experienced in the country using ANN networks. This will enable the availability of relevant and up to date data streams that enable the relevant ministry of health to be well prepared for new cases and come up with cost efficient campaigns that help reach the marginalized communities.

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 Madagascar.

Data Issues

This study is based on annual rates of immunization of children against measles in Madagascar for the period 1984 – 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	G
Observations	24 (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	0.048198
MSE	4.588713
MAE	1.752928

Residual Analysis for the Applied Model

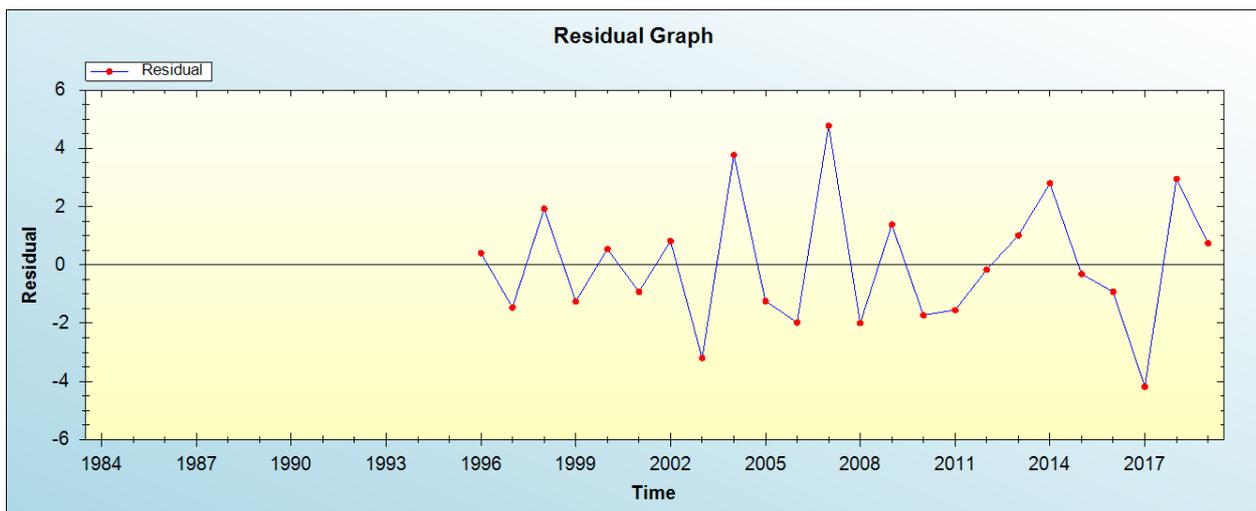


Figure 1: Residual analysis

In-sample Forecast for G

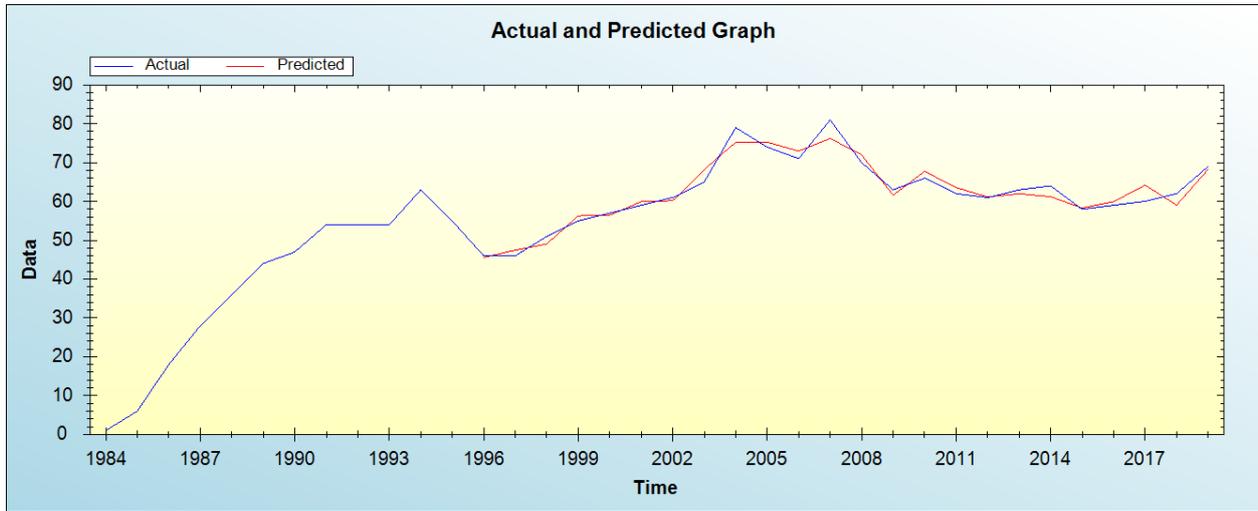


Figure 2: In-sample forecast for the G series

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

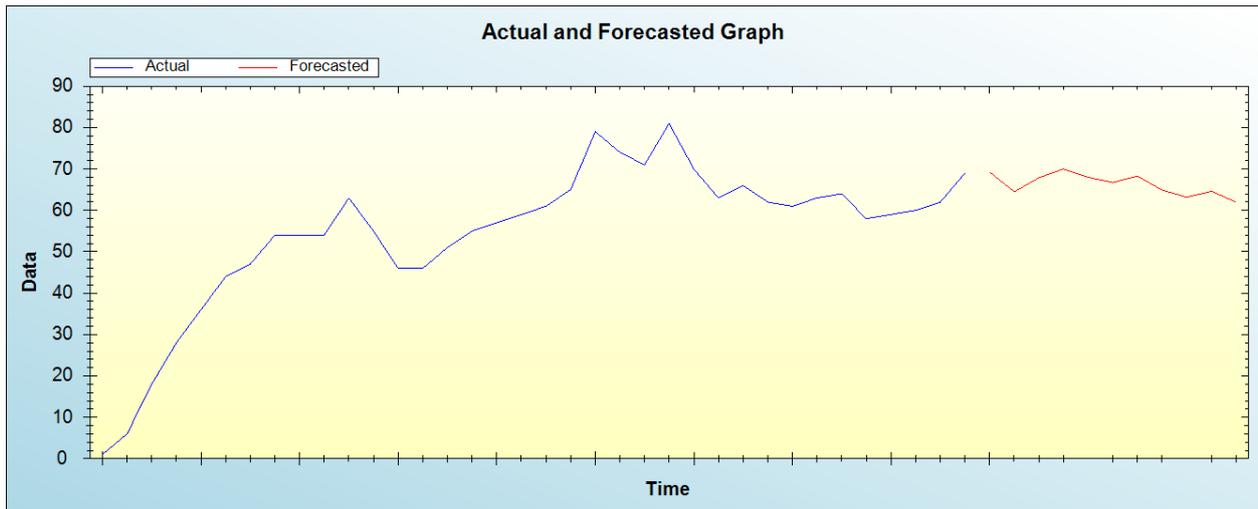


Figure 3: Out-of-sample forecast for G: actual and forecasted graph

Out-of-Sample Forecast for G: Forecasts only

Table 3: Tabulated out-of-sample forecasts

Year	Forecasts
2020	69.2651
2021	64.4843
2022	67.8783
2023	69.9829
2024	67.9873
2025	66.7424
2026	68.2734
2027	64.9100
2028	63.1763
2029	64.6229
2030	62.0117

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 Madagascar is likely to decline from 69% in 2020 to about 62% by 2030.

IV. CONCLUSION AND POLICY RECOMMENDATIONS

The paper helps us to reflect on methods to strengthen health systems, including routine surveillance and immunization in Madagascar. Recommendations for the nation are for it to continuously come up with a broader range of strategies that reduce inequalities in a sustainable way and create conditions that would make future measles elimination feasible. Now, more than ever, political will is required to fund the required operational changes in immunization programs to protect all children against measles. Advise is also for the vaccination coverage to reach of 95%, this may be made possible by ensuring that risk populations without proof of vaccination or immunity i.e., health workers, people working in tourism and transportation (hotel and catering, airports, taxi drivers, etc.), and international travelers especially refugees who are common carriers of the disease. With the help of international organizations there is need for strengthening of epidemiological surveillance and timely detection of all suspected cases of measles in public and private healthcare facilities and ensure samples are sent to laboratories within five days.

REFERENCES

- [1] Agenda, WHO Immunization, and World Health Organization. "2030: a global strategy to leave no one behind." *World Health Organization [Internet]* (2020).
- [2] Chopra, Mickey, ZulfiqarBhutta, Diana Chang Blanc, Francesco Checchi, Anuradha Gupta, Ephrem T. Lemango, Orin S. Levine et al. "Addressing the persistent inequities in immunization coverage." *Bulletin of the World Health Organization* 98, no. 2 (2019): 146.
- [3] World Health Organization. Measles vaccines: WHO position paper, April 2017 - recommendations. *Vaccine* 2019;37:219–22.
- [4] Raherindrasana, Antso, C. Jessica Metcalf, Jean-Michel Heraud, Simon Cauchemez, Amy Winter, Amy Wesolowski, Richter Razafindratsimandresy et al. "Towards better targeting: lessons from a posthoneymoon measles outbreak in Madagascar, 2018–2019." *BMJ global health* 5, no. 10 (2020): e003153.

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