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

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Abstract - In this research article, the ANN approach was applied to analyze child immunization rate against in Burundi. 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. The ANN (12, 12, 1) model projections suggest that child immunization will generally be around 88% per annum over the next 10 years in Burundi. The government is encouraged to intensify child health surveillance and control programs in line with the suggested policy directions.

Keywords: Modelling, Measles Disease, Artificial Neural Networks, ANN.

I. INTRODUCTION

Despite enormous reduction in incidence and mortality since the 1980s, measles is a viral disease of worldwide public health importance, Perry et al., (2014).Burundi is one of the sub-Saharan countries that is battling with the endemic of measles disease. Estimated case-fatality rate for measles in low-income and middle-income countries is approximately 2%, (WHO, 2019). Bagcchi S, (2020) notes that the mortality rate for measles are seen to be higher because of high rates of malnourishment, vitamin A deficiency and HIV/AID all of which intensify the risk of severe problems from measles. These are current complementors of measles in most developing countries as they face lower economic growth and have fragile health systems. According to a WHO statement released on May 6, 2020, it reports that the measles outbreak started in November, 2019, with 857 confirmed cases from Burundi's districts Cibitoke, Butezi, Cankuzo and South Bujumbura, as of April 27, 2020. The outbreak is said to have begun in a refugee transit camp in the Cibitoke health district, where refugees from measles-affected provinces in DR Congo remained for 21 days, before being transferred to permanent refugee camps. The outbreak was only recognized when children aged 9 months to 5 years surrounding the refugee transit camp reported suspected measles cases. WHO's report states. Circulation of measles in a population with low immunity is the root of this outbreak. 77% of the cases were either unvaccinated or unsure of their vaccination status. So, one may see that in this case the measles outbreak was imported from DR Congo, however in some cases lack of vaccination within the country. WHO's statement estimates the vaccination coverage for measles in Burundi to be 88%, in 2018, for the first dose and 77% for the second dose, though these figures do not include data for incoming refugees.

Corey and Noyemer (2016) used a mathematical model to analyze the measles outbreak in Muyinga sector in rural Burundi in 1988-1989. Results recommended that supplementary immunization activities (SIAs) should be used in areas where outine vaccination cannot keep up with the snowballing numbers of susceptible people resulting from population growth or from logistical difficulties such as cold chain maintenance. These have been since adopted, however the cases either increase or decrease. Bagcchi S, (2020) notes that with the surge of the COVID-19, Burundi has had a double trouble tragedy as although measles has an adopted vaccine, Covid-19still has to have one approved. This paper will be among the researches that have been encouraged by the Burundi health department so that better forecasting and modelling of the measles endemic is achieved. In this study we will use the ANN to forecast and predict new measles cases so that authorities come up with strategies and policies that will have them geared up and ready for another outbreak of measles on Burundi.

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

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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 Burundi.

Data Issues

This study is based on annual rates of immunization of children against measles in Burundi 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	X
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	0.031131
MSE	1.507881
MAE	0.811295

Residual Analysis for the Applied Model

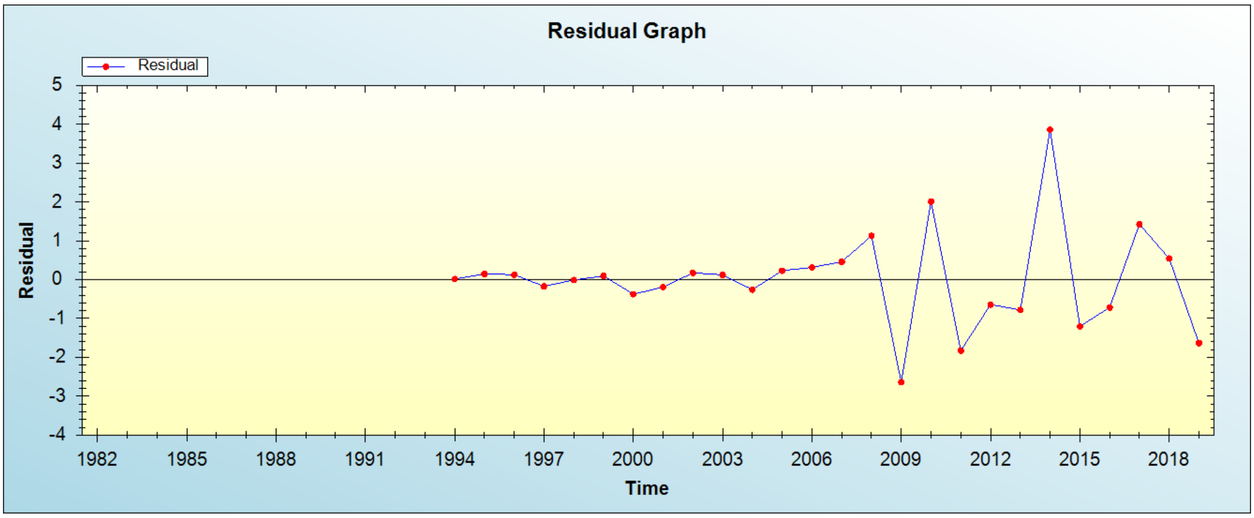

Figure 1: Residual analysis

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In-sample Forecast for X

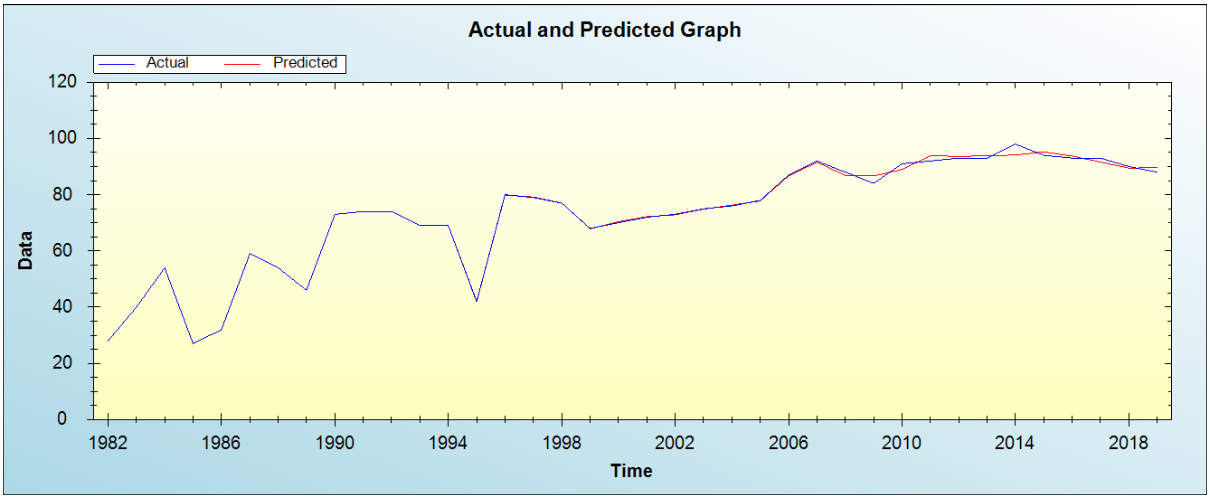

Figure 2: In-sample forecast for the X series

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

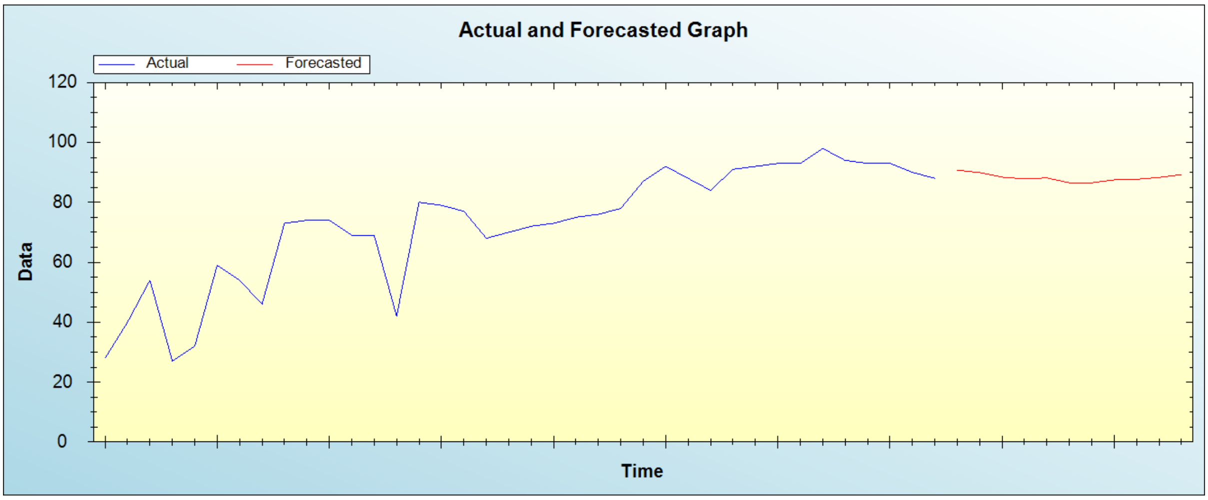

Figure 3: Out-of-sample forecast for X: actual and forecasted graph

Out-of-Sample Forecast for X: Forecasts only

Table 3: Tabulated out-of-sample forecasts

Year	Forecasts
2020	90.7811
2021	89.9383
2022	88.3963
2023	87.8488
2024	88.1584
2025	86.5437
2026	86.5548
2027	87.4947
2028	87.7011
2029	88.3203
2030	89.2916

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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 Burundi is likely to remain around 88% per year over the next decade.

IV. CONCLUSION AND POLICY RECOMMENDATIONS

In the existence of measles outbreaks, children in Burundi have since been exposed to proper vaccination coverage for measles. Continuous use of thoroughly planned approaches premeditated by the country's health authorities and WHO will help the nation to tackle forthcoming outbreaks. To note is the creating of the technical committee to monitor its implementation and also the administration of Vitamin A, particularly in the context of malnutrition, which has helped reduce morbidity and mortality from measles. However, these initiatives have not managed to reach other marginalized communities in the country. This paper recommends that vaccines are administered to risk populations, including refugees, internally displaced persons, young children pregnant women, health workers, people working in tourism and transportation and international travelers. These should be given priority when immunization is conducted to help control the disease. Advice is for the authorities to strengthen surveillance in affected districts, mobilise financial resources, building health-care provider capacity, and actively searching and vaccinating unvaccinated children, emphasis is on the continuation of collaboration with GAVI, WHO and Unicef until the host nation can stand on its own and has a strong health care system that can control the disease.

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