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

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

[1]Independent Researcher, Harare, Zimbabwe
[2]ZICHIRe Project, University of Zimbabwe, Harare, Zimbabwe
[3]SAGIT Innovation Center, Harare, Zimbabwe

**Abstract - In this research article, the ANN approach was applied to analyze child immunization against measles in Nigeria. 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 child immunization coverage in the country. The ANN (12, 12, 1) model projections suggest that immunization against measles in Nigeria is likely to decline from 51% in 2020 to about 23% by 2030.The Nigerian government is encouraged to intensify child health surveillance and control programs, in line with our policy prescriptions.**

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

## I. INTRODUCTION

Measles is considered a highly infectious viral disease with an incubation period of ten-twelve days. It is caused by a virus that belongs to the group of Morbilliviruses of the family Paramyxoviridae, WHO (2019). Transmission is over aerosol droplets or direct contact with then as al and oral secretions of an infected person to susceptible individuals, especially children between the ages of 9 months to 15 years, WHO, (2019). This disease is considered as an endemic especially in the developing countries with a peak of transmission from October to March. Measles carries with it a high morbidity and mortality especially when clinical cases are not properly managed, Rima *et al* (2006).The potential obstructions to the eradication of measles include the lack of appreciation of disease severity, spread among adults, diminishing immunity; the possibility of spread from subclinical cases, misinformation, quality; intensity and duration of vaccine-induced immunity; weakened vaccination rates and coverage, the mushrooming acquired immune deficiency syndrome(AIDS) epidemic, vaccine failures, worldwide travel and international spread of measles, and the threat from bioterrorism, Kerksiek (2009).Key issues in developing countries are on the duration of vaccine efficacy, coverage and cost, WHO(2010). Despite intense efforts to eradicate it, measles still infects 30–40 million people worldwide and sources half a million deaths a year, WHO(2010). It is the leading killer disease among vaccine-preventable diseases and causes an estimated 44% of the 1.7 million vaccine-preventable deaths among children each year, WHO(2009).Measles is the fifth cause of childhood death in Nigeria and has caused disability and death of over 3,000,000 children, infants are vaccinated against measles at the age of 9 months, and this has led to a noteworthy reduction in morbidity and mortality from measles in the Nigeria. In spite of this, Nigeria still ranks amongst the African Sub-Saharan countries with the top endemic and continuous transmission numbers of measles infection yearly, WHO (2014). WHO, 2014 reports that Immunization and vaccination are the most important public health interventions that establish a cost-effective strategy to reduce both the morbidity and mortality associated with measles. A record of two million deaths are delayed through immunization each year globally, Odusunya et al (2008), WHO (2010). Despite this fact, vaccine-preventable diseases. Given the magnitude of destruction caused by the endemic in the country, there is need for more studies in order to improve policy formulation in Nigeria. In an attempt to predict how measles has managed to still spread in Nigeria and has influenced public health interventions in the country to achieve the greatest impact, the current study will model and forecast daily measles cases among infants in Nigeria.

In spite of the rise in measles immunization coverage aimed at building population immunity against the ailment, it is evident that measles outbreaks still occur especially in the developing countries like Nigeria. According to the WHO, in 2019 measles is ranked top among the burden of vaccine preventable diseases across the globe with worst picture seen in the developing countries that are not unconnected to malnutrition and overcrowding. The periodic measles outbreaks observed are often fatal and cause deaths for those under the age of 5 years. Interrupting the trend in transmission of this fatal disease needs an effort to attain

 

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population immunity of at least 95%. This demands the need to review the present strategies so that the control of this fatal but preventable disease is ensured. It is the aim of this study to forecast and come up with a model that helps control measles and have strategies that ensure a routine vaccination program for the Nigerian infants.

## II. RELATED STUDIES

Ophori, *et al* (2014), carried out a research on the National Programme on Immunization (NPI) and results showed that it suffers recurrent obstructions due to many factors including ethnicity and religious beliefs thus thenleads to lack of adherence to an immunization structure especially if its donor funded. Diddy A (2009), carried out a research to assess Immunization coverage in many parts of Nigeria, using a Multilevel multivariable regression analysis and results were that the determinants of full immunization were both at individual and community level. These included ethnicity, mothers' occupation, mothers' household wealth and whether the mother had a hospital delivery or not. Masresha *et al* (2018), in an attempt to determine the country's progress towards the elimination of measles, reviewed routine and supplemental measles immunization coverage data. Results disclosed that Nigeria achieved 84.5% coverage by following the 2015 countrywide measles supplemental immunisation activities (SIAs) and that the pattern of confirmed cases indicated a constant shift inepidemiological susceptibility together with older age children. Sibeudu *et al* (2020), aimed to determine the cost per child immunized and cost structure of a follow-up supplemental immunization activity (SIA) for measles immunization to children in Nigeria. He used the ingredient approach and found out that the cost per child immunized with measles containing vaccine through SIA is relatively high in Nigeria. Zimmermann et al (2019),used an agent-based disease transmission model to investigate cost savings and burden reduction that could be achieved by adjusting the inter-campaign interval by region. Results proved that a national vaccination strategy that incorporates regional SIA targeting in contexts with a high level of sub-national variation would lead to improved health outcomes and/or lower costs. Faneye *et al* (2015), investigated measles infection in vaccinated and unvaccinated children presenting who had fever and macula papular rash during measles outbreaks in Nigeria. Findings were that a high number of children are still being infected with measles, despite their vaccination status.

## 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 Nigeria.

### Data Issues

This study is based on annual rates of immunization of children against measles in Nigeria 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.

## IV. FINDINGS OF THE STUDY

### ANN Model Summary

**Table 1: ANN model summary**

| Variable | F |
|---|---|
| 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: | |

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| | |
|---|---|
| Learning Rate | 0.005 |
| Momentum | 0.05 |
| Criteria: | |
| Error | 0.030793 |
| MSE | 0.885268 |
| MAE | 0.641460 |

*Residual Analysis for the Applied Model*

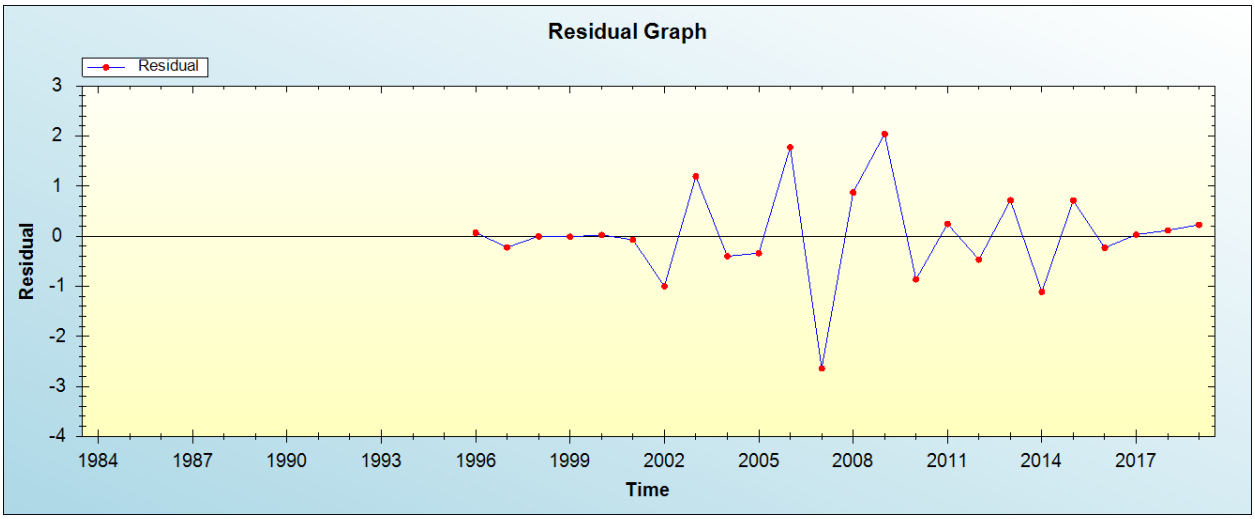


**Figure 1: Residual analysis**

*In-sample Forecast for F*

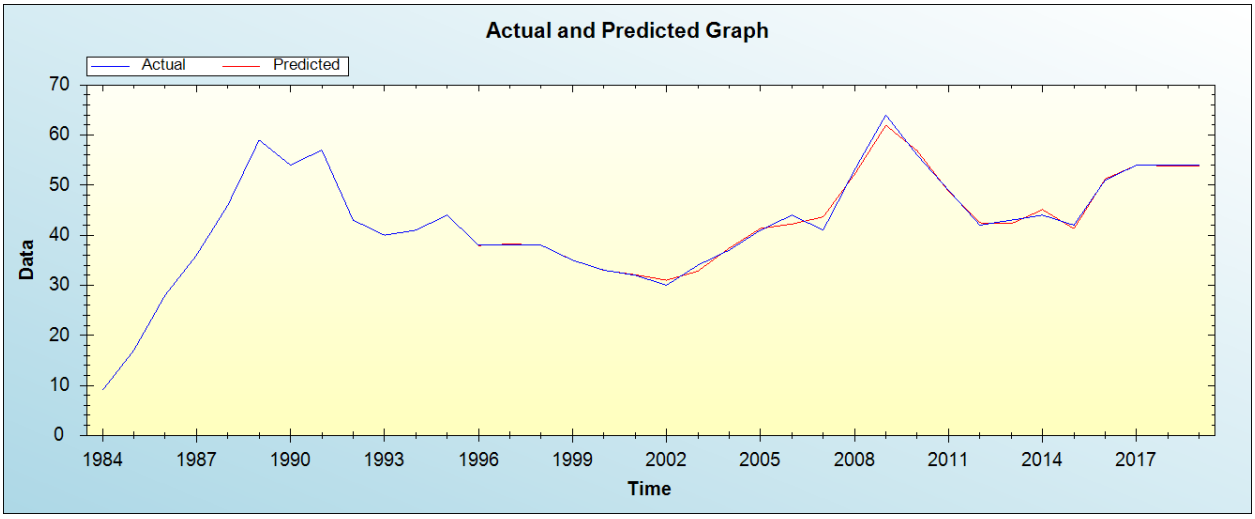


**Figure 2: In-sample forecast for the F series**

*Out-of-Sample Forecast for F: Actual and Forecasted Graph*

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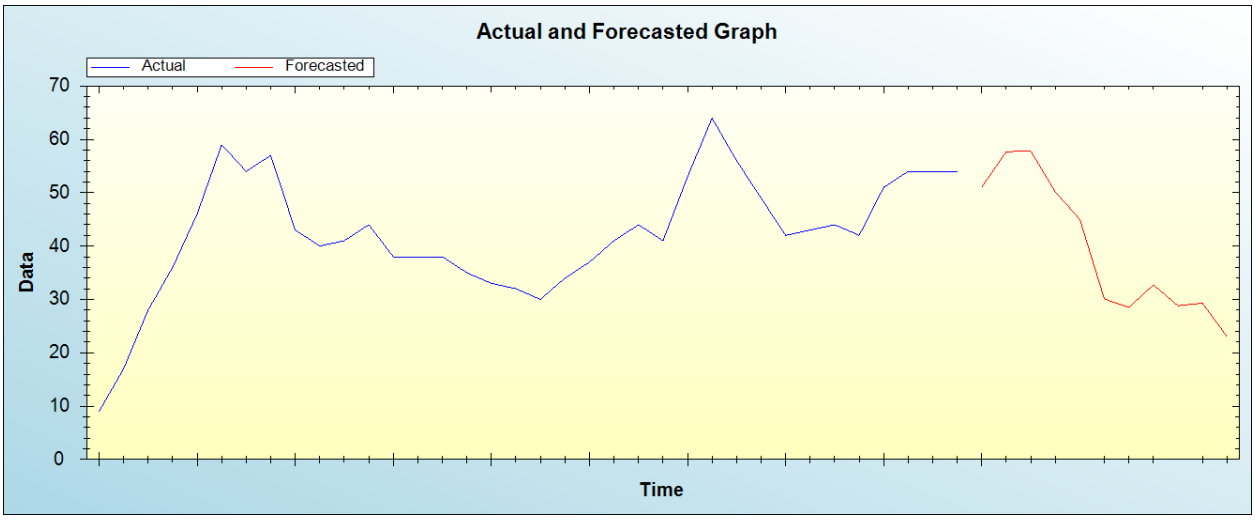


**Figure 3: Out-of-sample forecast for F: actual and forecasted graph**

*Out-of-Sample Forecast for F: Forecasts only*

**Table 3: Tabulated out-of-sample forecasts**

| Year | Forecasts |
|---|---|
| 2020 | 51.0324 |
| 2021 | 57.6884 |
| 2022 | 57.7821 |
| 2023 | 50.1735 |
| 2024 | 45.0082 |
| 2025 | 30.0929 |
| 2026 | 28.5209 |
| 2027 | 32.7279 |
| 2028 | 28.8191 |
| 2029 | 29.3104 |
| 2030 | 23.0438 |

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 immunization against measles in Nigeria is likely to decline from 51% in 2020 to about 23% by 2030.

## IV. CONCLUSION AND POLICY RECOMMENDATIONS

Nigeria accepted the African Regional measles elimination targets and has been implementing the recommended strategies to date. Nigeria offers routine measles vaccination for children aged 9 months free of charge. Furthermore, since 2006, nationwide measles supplemental Immunization activities (SIAs) are being carried out every 2 years, there also has been the establishment of a measles case-based surveillance program, advise is for the country and its relevant ministry is to control implementing these strategies at a larger scale and more committed level. Below are some recommendations this paper saw fit to be considered in the fight to eradicate measles for good in Nigeria

i. Government ought to effectively mobilize resources and improve the quality of planning and coverage outcome of SIAs, this will ensure population immunity on a sustainable basis and also help address systemic barriers in advance.
ii. Massive campaigns on the benefits of being vaccinated should be done on a large scale so that they reach those in remote areas, cold chain equipment should also be purchased so that vaccines are transported to all Nigerian states.

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