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# Prediction of TB Incidence in Benin Using the Multilayer Peceptron Neural Network

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***Abstract* - In this paper, the ANN approach was applied to analyze TB incidence in Benin. The employed annual data covers the period 2000-2018 and the out-of-sample period ranges over the period 2019-2023. The residuals and forecast evaluation criteria (Error, MSE and MAE) of the applied model indicate that the model is stable in forecasting TB incidence in Benin. The results of the study indicate that TB incidence will continue to decline at a slower rate over the period 2019-2023. The Benin government is encouraged to strengthen TB/HIV collaboration and to strengthen linkages between the TB/HIV and other healthcare programs.**

***Keywords:*** ANN, Forecasting, TB incidence.

## I. INTRODUCTION

Benin is a West African country with a high TB disease burden. According to UN estimates Benin's population was 8.85million inhabitants in 2010. Life expectancy at birth was 55 years over the period 2005-2010.Mortality rate for children under 5 was 85.5 per 1000 live births for the period 2005-2010(Benin National Health Statistics, 2010; United Nations, 2011). WHO (2011) report indicated that between 8.5-9.2million new TB cases were recorded in 2010 including1.2-1.5million deaths. TB incidence declined from 286 cases per 100 000 people in 2008 to 276 cases per 100 000 people in 2010. The WHO 2010 reported indicated that the prevalence of TB in Benin was estimated to be 149 cases per 100 000 population while incidence was 94 cases per 100 000 people (WHO report, 2011). Benin's National TB program receives substantial support from the Global fund.The main aim of the program is to reduce morbidity and mortality due to TB among communities in Benin. This will be achieved by testing more people and treating all forms of mycobacterium Tuberculosis. The program will ensure a high TB detection rate of sputum positive cases. In addition, improving the capacity of the National TB Reference laboratory is a priority. Benin adopted the DOTS strategy in 1983 in order to effectively fight TB. Under the strategy TB patients are directly observed when taking their medication by clinicians and caregivers. It is crucial for TB patients to adhere to treatment and complete it in order to improve treatment outcomes (WHO, 2018; Dye et al, 2006; Borgodorff et al, 2002; WHO, 2006). In the National TB program all patients presenting with classical symptoms of pulmonary TB during screening must have confirmatory tests namely sputum smear microscopy and chest x-ray. All patients with TB must be tested for HIV and in the same vein all HIV positive patients must be screen for TB. It is strongly recommended that HIV infected patients on antiretroviral therapy must be given isoniazid preventive therapy as long as there are no contraindications. The main challenge in the TB program is the problem of defaulting treatment by some of the patients. The main reasons for defaulting are drug supply challenges, gender, alcoholism, lack of information, stigma of the disease and dissatisfaction with treatment (Thomas, 2005; Sagbakken, 2008).

There are few empirical studies that were done in Benin so far. Serge et al (2016) conducted a study to determine the epidemiology of TB in Benin over the period 2000-2014. A retrospective cohort and time series study of all TB cases notified over the period 2000-2014 was done. The annual number of notified cases increased with highest reported in 2011.New pulmonary bacteriologically confirmed TB cases represented 78% of all the notified cases. The ARIMA model predicted that TB case notifications would decrease over the period 2015-2019. This study seeks to model and forecast the incidence of TB in Benin using the multilayer peceptron. The findings of this study will assist the government to understand the future evolution of TB epidemic. The results will also stimulate an appropriate response to the disease in terms of resource allocation and timeous action to curb the spread of TB in the community.

## II. METHOD

The Artificial Neural Network (ANN) is a data processing system consisting of a large number of simple and highly interconnected processing elements resembling a biological neural system. It has the capability of learning from an experimental

 

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or real data set to describe the nonlinear and interaction effects with great accuracy. ANN-based curve fitting technique is one of the extensively applied artificial intelligence methods that are used for forecasting and prediction purpose. It consists of basically three layers i.e., input layer, hidden layer, and output layer, the present work includes the number of years as input layer and the annual TB incidence in Benin as output data for the network. In this paper, our ANN is based on the hyperbolic tangent function.

**Data Issues**

This study is based on TB incidences (new cases per 100 000 population/year) [referred to as N series in this study). The annual data covers the period 2000-2018 while the out-of-sample forecast covers the period 2019-2023. All the data employed in this research paper was gather from the World Bank online database.

## III. FINDINGS OF THE STUDY

### DESCRIPTIVE STATISTICS

**Table 1: Descriptive statistics**

| Mean | Median | Minimum | Maximum |
|---|---|---|---|
| 69.053 | 69.000 | 56.000 | 86.000 |
| Std. Dev. | C.V. | Skewness | Ex. Kurtosis |
| 8.5536 | 0.12387 | 0.35270 | -0.71637 |
| 5% Perc. | 95% Perc. | IQ range | Missing obs. |
| Undefined | 86.000 | 14.000 | 0 |

### ANN MODEL SUMMARY FOR TB INCIDENCE (cases per 100 000 population/year) IN BENIN

**Table 2: ANN model summary**

| Variable | N |
|---|---|
| Observations | 10 (After Adjusting Endpoints) |
| Neural Network Architecture: | |
| Input Layer Neurons | 9 |
| 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 | 0.03901 |
| MSE | 0.319248 |
| MAE | 0.428817 |

*Residual Analysis for the ANN model*

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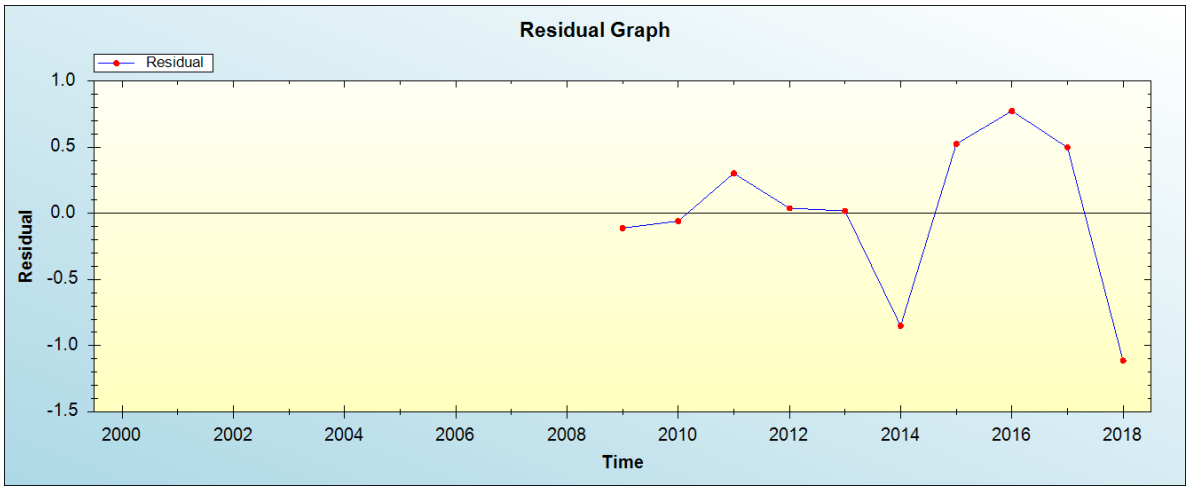


**Figure 1: Residual analysis**

*In-sample Forecast for N series*

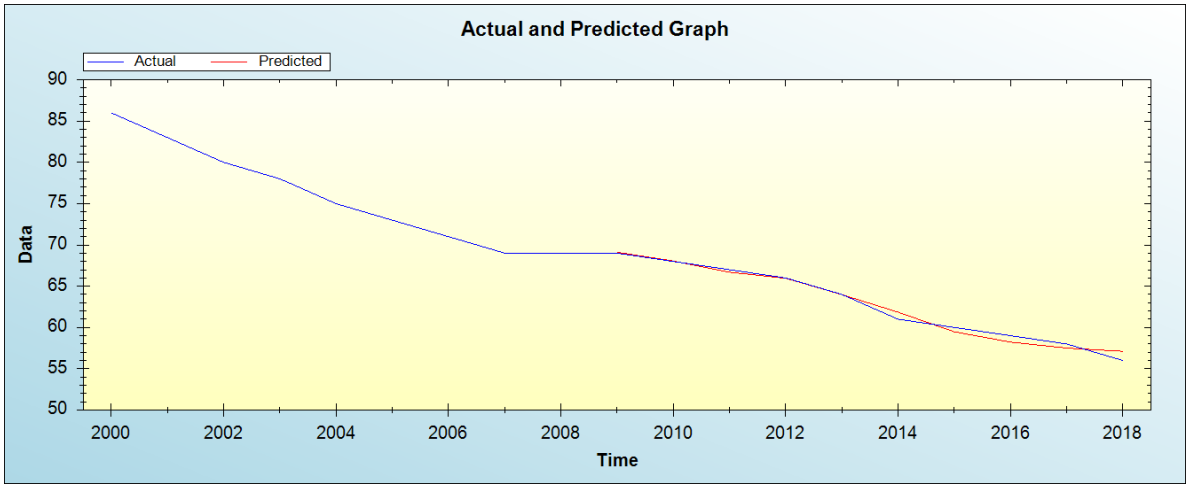


**Figure 2: In-sample forecast for the N series**

Figure 2 shows the in-sample forecast for N series.

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

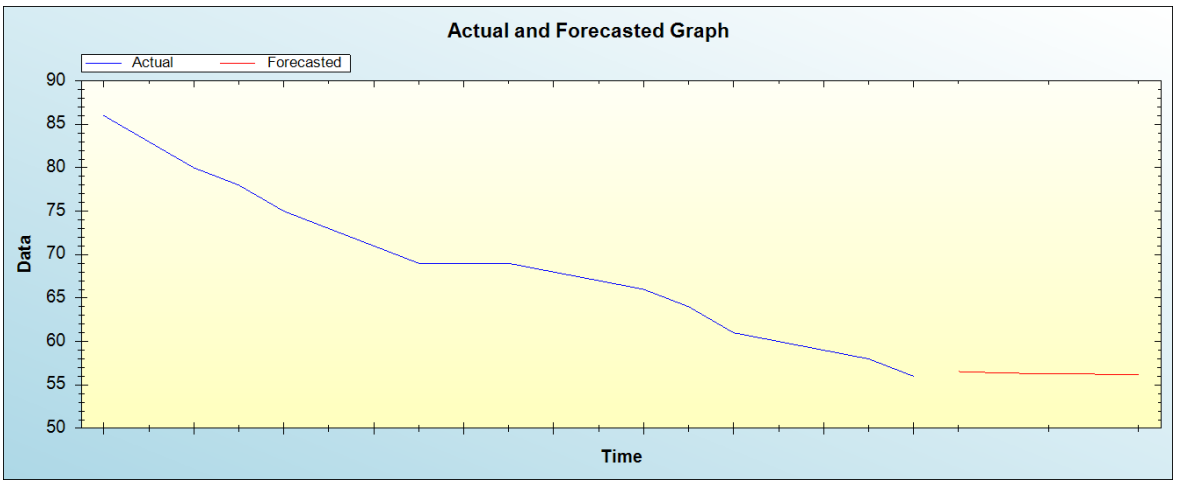


**Figure 3: Out-of-sample forecast for N: actual and forecasted graph**

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

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

| Year | Forecasted TB incidence |
|---|---|
| 2019 | 56.5449 |
| 2020 | 56.3688 |
| 2021 | 56.2928 |
| 2022 | 56.2451 |
| 2023 | 56.1778 |

Table 1shows that over the study period 2000-2018, the Incidence of TB has been gradually declining characterized by a minimum and maximum of 56.00 and 86.00 cases per 100 000 population /year respectively and an average TB incidence of 69 cases per 100 000 population/year. Summary statistics indicate the data is positively skewed and platykurtic. The model is stable and suitable for forecasting TB incidence in Benin as suggested by the residual graph and evaluation criteria (Error, MSE, MAE). In sample forecasts show that the ANN (9,12,1) model simulates the observed values very well. The out of sample forecasts indicate that the expected TB incidence will continue on a downward trend but at slower rate around 56 cases per 100 000 population/year over the period 2019-2023.

## IV. CONCLUSION & RECOMMENDATIONS

The government of Benin has made significant strides in the fight against the TB epidemic. The country has experienced a downward trend in the incidence of TB over the period 2000-2018. The model predicts that this downward trend is going to continue but at a very slower rate over the period 2019-2023. The authorities are encouraged to continue strengthening TB/HIV collaboration and strengthening linkages amongst all health program in order to further reduce the incidence of TB.

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