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# Prediction of TB Incidence in Cambodia Using the Multilayer Perceptron Neural Network

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***Abstract* - Cambodia is among the 30 countries in the World with high TB disease burden. Modelling and forecasting the incidence of the disease will help in planning and responding to the epidemic appropriately and timeously. In this research paper, the ANN approach was applied to analyze TB incidence in Cambodia. 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 Cambodia. The model predictions suggest that TB incidence will continue to decline but will still remain high around 290 cases/100000 populations/year. We implore the government to intensify TB surveillance and control programs, allocate more financial resources towards TB/HIV program and continue health education among communities to curb the spread of TB.**

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

## I. INTRODUCTION

Tuberculosis (TB) is an infectious disease whose causative agent is mycobacterium tuberculosis (MTB). This disease has led to the death of millions of people worldwide with many people getting hospitalized as a result of complications from both pulmonary and extra-pulmonary TB (WHO, 2017; Nyoni & Nyoni, 2019a & b). The National TB prevalence Survey by individuals above 15 years of age in 2011reported an active TB prevalence of 817 per 100 000 population (Cambodia Ministry of Health, 2012). The National TB program is facing a myriad of challenges which include poor TB drug adherence ,social stigma to TB and the emergence of multi-drug resistant TB. Overcrowding and poverty aggravates the burden of the disease in the country (Getnet et al,2017; de Vries et al, 2017; Laxminarayan et al, 2008 ). The TB treatment and care services are largely provided by the government. The private sector on the hand provides 61% of the health care services (WHO, 2016). The government adopted the directly observed treatment Short course (DOTS) in 1994. The aim of the DOTS strategy is to ensure that all TB infected patients receive their medications under direct observation by healthcare workers and community-based health care workers. This strategy helps to improve adherence and treatment outcomes. When DOTS is implemented consistently it is expected to see a reduction in the morbidity & mortality due to TB and community transmission of TB (Hill &Tan Eang, 2007; Khieu et al, 2007).

The diagnosis of TB in Cambodia is done according to the WHO guidelines. This includes the following; History taking, clinical assessment, Chest X-ray and laboratory tests. The laboratory investigations include sputum microscopy, Gene X-pert machine analysis and culture based methods (WHO, 2018). Early detection and treatment is very critical in the control of the TB epidemic .TB surveillance in this country is one of the main components the original WHO framework for effective TB control (WHO, 2017).Routine surveillance data is used to assess disease burden and epidemiological trends as well as identifying underserved populations and potential outbreaks .This is important for decision making therefore it is imperative to capture all the relevant TB data using appropriate tools and the information should be communicated between the lower and higher levels in the health system.

In this paper we apply artificial neural networks, ANN (9,12,1) model to predict the annual incidence of TB in Cambodia. The results of the study will reveal the future trends of TB over the period 2019-2023 and this is expected to trigger an appropriate health response to the TB epidemic in the country.

## II. LITERATURE REVIEW

Morishita et al (2015) analyzed TB case notification data in Cambodia for the period 2000-2013 for national level and the subnational level for 2013.The study concluded that there was an increase in TB screening, decline in the smear positive rate and

 

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decline in notified smear positive TB cases. This reflects a long term positive impact of the National TB programme. Prem K et al (2018) developed a Bayesian Hierarchical model for the 2011 National TB Prevalence Survey to estimate the differential effect of age ,sex and geographic stratum on active TB prevalence. These estimates were then married with high resolution geographic information system layers to project prevalence across Cambodia. The study concluded that synthesis of health and geographic data allows likely disease rates to be mapped at a high resolution to facilitate resource planning while demographic modeling allows scenarios to be projected, demonstrating the need for the acceleration of control efforts to achieve a substantive impact on the future burden of TB in Cambodia. Ribeiro et al (2019) applied the autoregressive integrated moving average (ARIMA), simple exponential smoothing (SES) and the Holt-Winters' Exponential smoothing (HWES) models to compare their TB incidence forecasting performance using monthly TB cases from January 2001 to June 2018. The HWES (0.2,0.1,0.1) was found to be the best model in predicting monthly TB incidence. Nyoni & Nyoni (2019a) developed a SARIMA model to predict monthly TB notifications at Zengeza clinic in Zimbabwe. The study utilized monthly TB notification data for the period covering January 2013 to December 2018. The optimal model SARIMA (2,0,2) $(1,0,1)_{12}$ projected that the TB notifications would decline over the out of sample period. In a similar study, Nyoni &Nyoni (2019b) constructed a SARIMA model to predict monthly TB notifications at Silobela District Hospital in Zimbabwe. The optimal model SARIMA (1,0,1) $(0,1,1)_{12}$ predicted that TB notifications would decline over the out of sample period.

## III. METHOD

The Artificial Neural Network (ANN), which we shall apply; 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 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 Cambodia 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 (cases per 100 000 population/year) [referred to as C 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 gathered from the World Bank online database.

## IV. FINDINGS OF THE STUDY

### DESCRIPTIVE STATISTICS

**Table 1: Descriptive statistics**

| Mean | Median | Minimum | Maximum |
|---|---|---|---|
| 450.84 | 451.00 | 302.00 | 578.00 |
| Std. Dev. | C.V. | Skewness | Ex. kurtosis |
| 83.407 | 0.18500 | -0.13262 | -1.0750 |
| 5% Perc. | 95% Perc. | IQ range | Missing obs. |
| undefined | 578.00 | 142.00 | 0 |

### ANN MODEL SUMMARY FOR ANNUAL TB INCIDENCE FOR CAMBODIA

**Table 2: ANN model summary**

| | |
|---|---|
| Variable | C |
| Observations | 10(After Adjusting Endpoints) |
| Neural Network Architecture: | |
| Input Layer Neurons | 9 |
| Hidden Layer Neurons | 12 |
| Output Layer Neurons | 1 |

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| | |
|---|---|
| Activation Function | Hyperbolic Tangent Function |
| Back Propagation Learning: | |
| Learning Rate | 0.005 |
| Momentum | 0.05 |
| Criteria: | |
| Error | 0.017287 |
| MSE | 7.025765 |
| MAE | 2.259849 |

*Residual Analysis for the ANN model*

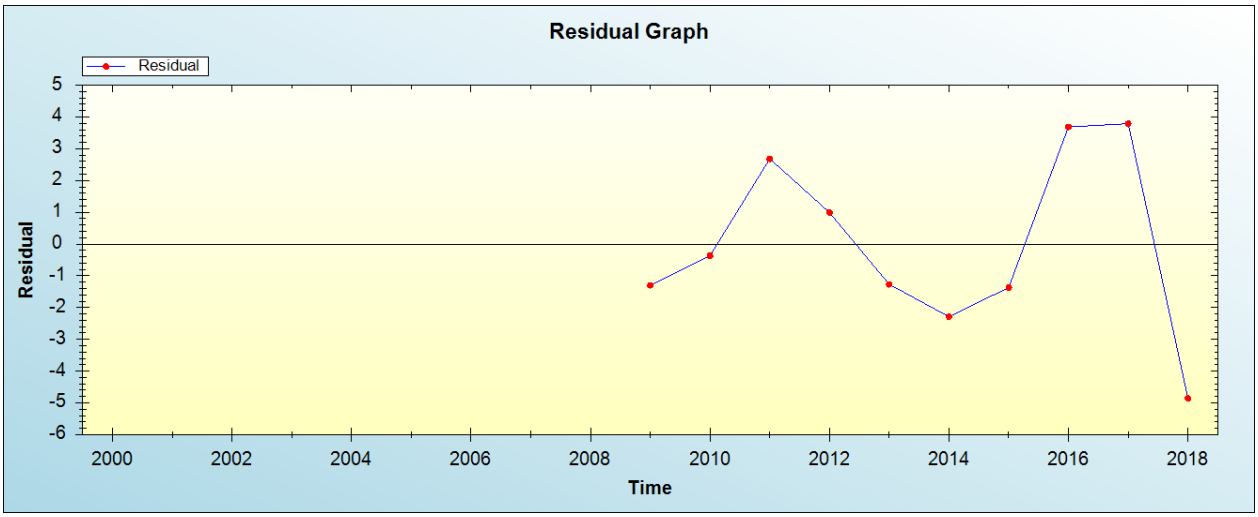


**Figure 1: Residual analysis**

*In-sample Forecast for C*

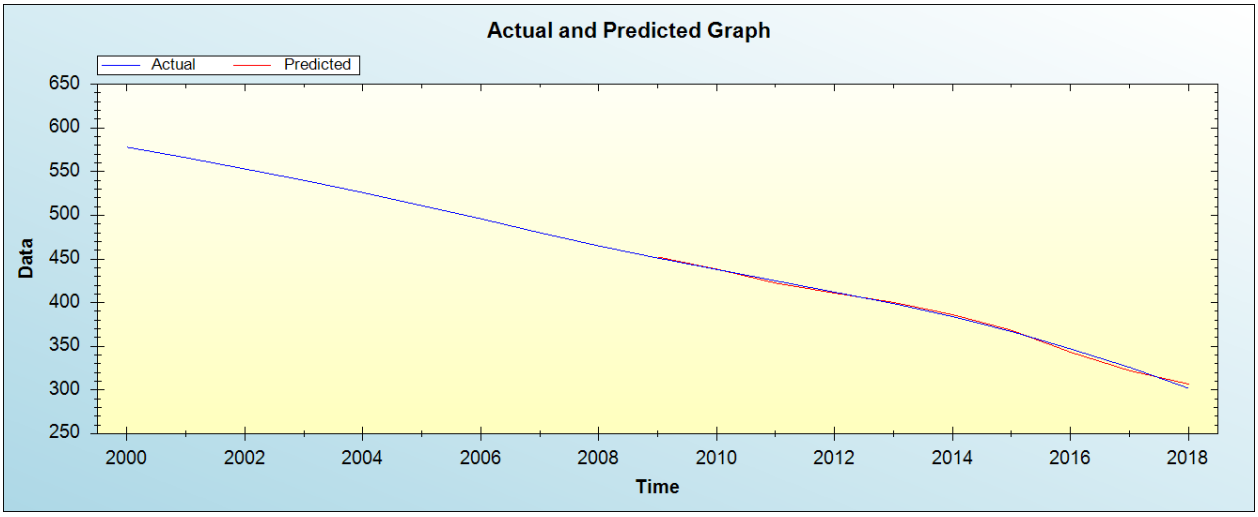


**Figure 2: In-sample forecast for the C series**

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

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

 

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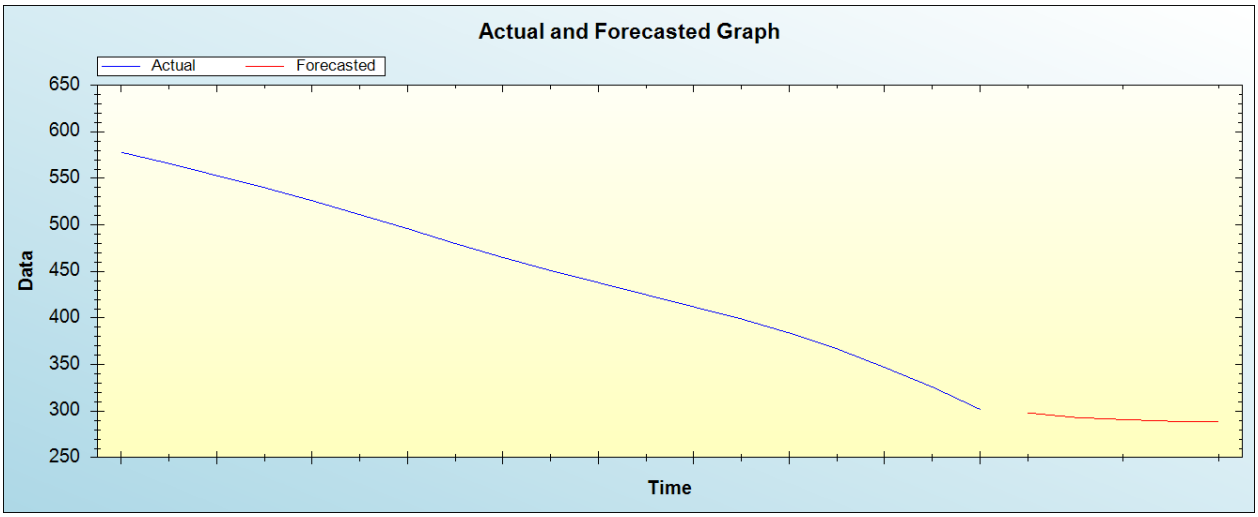


**Figure 3: Out-of-sample forecast for C: actual and forecasted graph**

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

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

| Year | Forecasts |
|---|---|
| 2019 | 298.1677 |
| 2020 | 293.1943 |
| 2021 | 290.9348 |
| 2022 | 289.0873 |
| 2023 | 288.7013 |

Table 1 show that over the study period average TB incidence was 451.0 cases per 100 000 population /year. The minimum and maximum incidence was 302 and 578 cases per 100 000 population/year over the period 2000-2018.The applied data is positively skewed and platykurtic. The residual graph and model evaluation statistics indicate that the applied ANN (9,12,1) model is stable and suitable for forecasting TB incidence in Cambodia. The in-sample forecasts reveal that the applied model simulates observed values very well. The model predicts that the TB incidence over the period 2019-2023 will continue to decline slowly and will likely record figures around 290 cases per 100 000 population/year.

## V. CONCLUSION & RECOMMENDATIONS

Cambodia is a high TB burden country however the government has demonstrated its commitment to end TB by 2030. The country recorded a downward trend in TB incidence over the period 2000-2018 and this is commendable. The model predicts that the incidence of TB will continue to drop over the period 2019-2023 but still it will be high around 290 cases per 100 000 population/year. We encourage the government to intensify TB surveillance and control programs, continuous health education to the public and allocate more financial resources towards TB/HIV programs.

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