Nepal's TB Program Success to Be Reversed over the Period 2019-2023: Evidence from Artificial Neural Networks

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Abstract - **Tracking the evolution of the TB epidemic in Nepal is important in order to stimulate a timeous evidence based national heath response. In this research article, the ANN approach was applied to analyze TB incidence in Nepal. 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 Nepal. The model predicted that over the period 2019-2023 TB incidences will rise sharply. Therefore, Health authorities in Nepal should seriously consider intensification of TB surveillance and control programs in order to reverse the undesirable model predictions.**

Keywords: ANN, Forecasting, TB incidence.

I. INTRODUCTION

Nepal is a land locked South East Asian country (Poudel,2012).The incidence of all forms TB in 2008 was 173 cases per 100 000 population and the incidence of new smear positive cases was estimated to be 77 per 100 000 people (WHO, 2010). According to the National TB prevalence survey 2018-19 (Nepal, 2020), the prevalence of TB was 416 cases per 100 000 people and the incidence of TB was estimated to be 245 cases per 100 000 population. Globally South East Asia and Africa contribute to the global TB burden 45 % and 25% respectively (WHO, 2018). Poverty and malnutrition are recognized as factors which aggravate the burden of TB in developing countries (Murray & Oxlade, 2011; Hargreeves et al, 2011). The government of Nepal is committed to the prevention and control of TB in the country, however there are several challenges being faced (Adhikari et al, 2019). Some of the problems include the development of drug resistant TB, existence of comorbid conditions such as Diabetes Mellitus and HIV. TB is still associated with stigma which then results in the delay to access or seek TB diagnostic and treatment services (Dingake, 2017). The main goal of the National TB program is to detect TB cases and treat them early in order to reduce morbidity and mortality due to TB. The government hopes to achieve the targets of the 'END TB 'strategy by 2035 through high political commitment, improving access to high quality TB services, creating demand for quality TB services, engaging the private sector in the provision of quality TB services, increasing financial support and human resources to meet the targets of the 'End TB 'strategy by 2035. In Nepal 90% of newly registered TB patients are successfully treated (Annual report, 2015, 2016 & 2017). Despite declining TB case notification and high treatment success rate, TB mortality rate is persistently around 3% (Annual report, 2017). In Nepal TB diagnosis encompasses history taking, clinical assessment and lab confirmatory tests. The required laboratory tests are microscopy, Gene X-pert/MTB RIF machine, culture/DST and LPA methods (Annual report, 2017). This paper will highlight empirical studies on TB. Adhikari et al (2019) reviewed available literature and data sources related to TB prevention, care and control. The study utilized secondary data covering the period 2015-2017 for the situational analysis of TB in Nepal. The study concluded that case notification had reduced gradually and it was difficult to achieve the target envisioned by NSP 2016-21. Kakchapati et al (2010) modeled TB incidence in Nepal. A retrospective study of TB incidence was conducted over a 6-year period 2003-2008.A negative Binomial model with 2 multiplicative components as predictors was used. The results of the study revealed that TB incidence is decreasing but still remains high. Gender difference in TB incidence was noted with a male/female ratio of 1.86. Marahatta (2015) conducted a retrospective study to determine the prevalence of TB and explore the determinants of multi-drug resistant TB using a match case control study. The results indicated that TB case notification, incidence and prevalence rates in central Nepal were found to be 151/100 000; 182/100 000 and 245/100 000 respectively. Injecting drug users have a 5.13 higher risk of developing multidrug resistant TB (MDR-TB). Previous smoking history is an independent risk factor for MDR-TB with an OR =4.5.

II. METHOD

The Artificial Neural Network (ANN), which we intend to apply in this study; 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 Nepal 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 (referred to as Q series in this study) in Nepal. 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 data base.

III. FINDINGS OF THE STUDY

DESCRIPTIVE STATISTICS

Table 1: Descriptive statistics

Mean	Median	Minimum	Maximum
160.53	163.00	151.00	164.00
Std. Dev.	C.V.	Skewness	Ex. kurtosis
4.2735	0.026622	-1.1685	-0.072672
5% Perc.	95% Perc.	IQ range	Missing obs.
undefined	164.00	5.0000	0

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

Table 2: ANN model summary

Variable	Q
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	0.043451
MSE	0.098479
MAE	0.249913

Residual Analysis for the ANN model
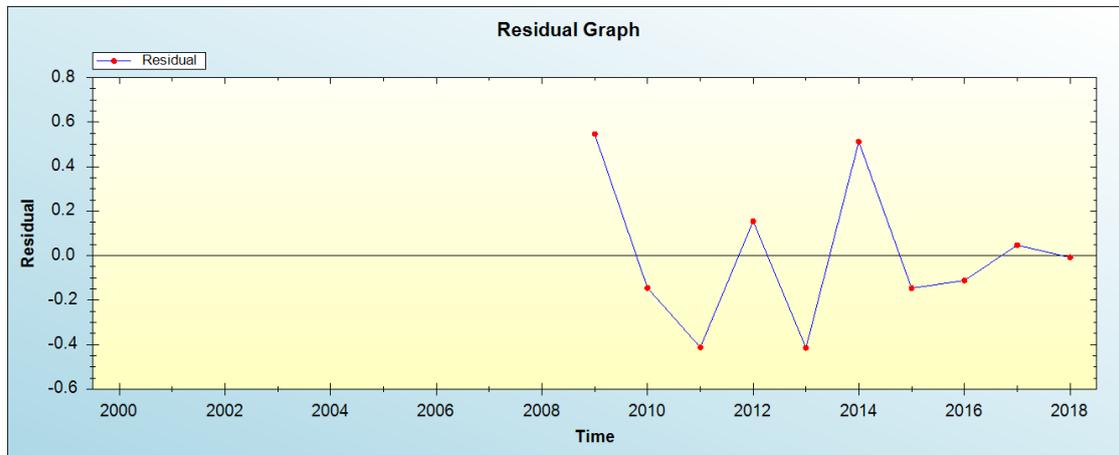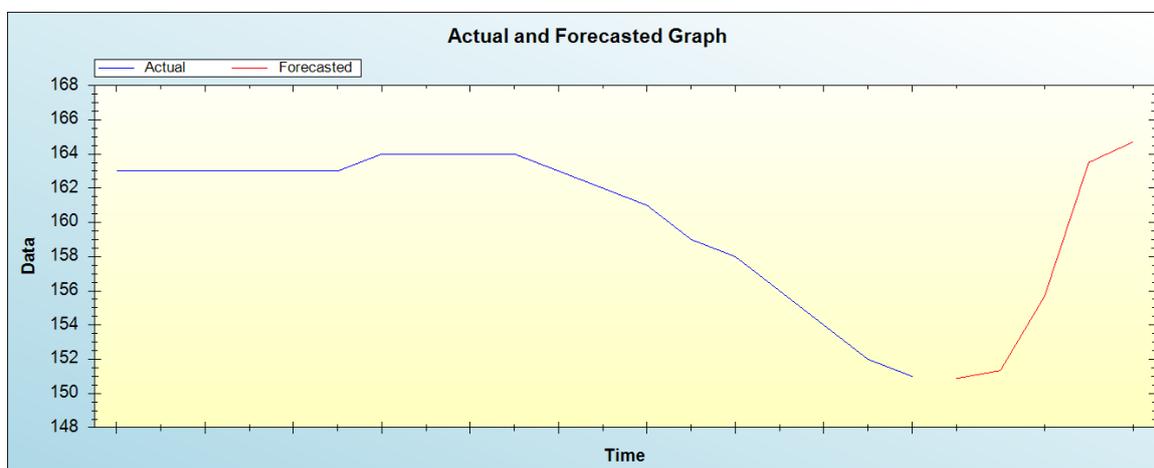

Figure 1: Residual analysis

In-sample Forecast for Q
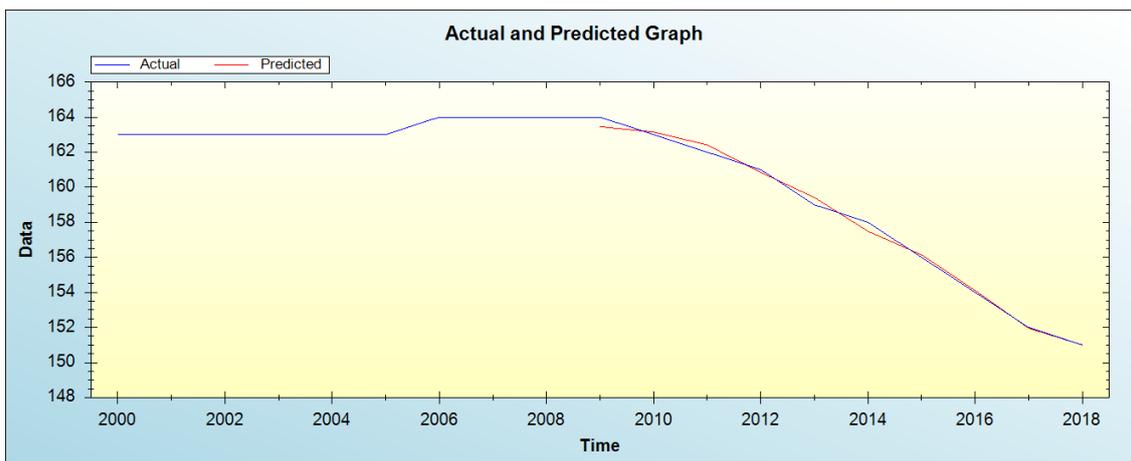
Figure 2: In-sample forecast for the Q series

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

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

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

Out-of-Sample Forecast for Q: Forecasts only

Table 3: Tabulated out-of-sample forecasts

Year	Forecasts
2019	150.8710
2020	151.3413
2021	155.6835
2022	163.5049
2023	164.7012

Table 1 shows that over the study period 2000-2018, the minimum and maximum TB incidence was 151 and 164 cases per 100 000 population/year respectively with an average of 161 cases per 100 000 population/year. The data is negatively skewed and with an excess kurtosis of -0.072672 implying that it is not normally distributed. The residuals and model evaluation statistics indicate that the ANN (9,12,1) model is stable. The in-sample forecasts reveal that the model simulates the observed the data very well. Figure 3 depicts the out of sample forecasts for the period 2019-2023 which shows that the model predicts a sharp increase in TB incidence from about 151 cases per 100 000 population in 2019 to 165 cases per 100 000 population in 2023.

V. CONCLUSION & RECOMMENDATIONS

Nepal has made significant strides in the prevention and treatment of TB. Over the period 2009-2018 the government implemented robust measures and positive results were obtained as the country recorded a gradual decline in the incidence of TB as shown in Figure 3. However, the model predicts that over the period 2019-2023 the incidence of TB will raise sharply raising serious health concerns. Therefore, the health authorities in Nepal should seriously consider intensification of TB surveillance and control programs amongst other measures in order to reverse the model predictions.

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