

Prediction of Art Coverage in Togo Using Artificial Neural Networks

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Abstract - In this research article, the ANN approach was applied to analyze ART coverage in Togo. The employed 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 ART coverage in Togo. The results of the study indicate that ART coverage will be around 62 % over the period 2019-2023. The government is encouraged to create more demand for HIV testing & ART services, strengthen TB/HIV collaboration and improve ART access for key populations.

Keywords: ANN, ART coverage, Forecasting.

I. INTRODUCTION

Diseases surveillance is the collection, analysis, interpretation of data in order to evaluate the effectiveness of preventive and control measures and dissemination of relevant information for public use. Data collection tools must be available at site level to ensure that important information is captured. All critical indicators must be present in all source documents to facilitate data collection and subsequent analysis. Site supervisors in health facilities should ensure that program activities are well and clearly documented without leaving critical information. Even for the HIV care and treatment program clinical staff should ensure that program activities and statistics are documented. Preparation of monthly and quarterly reports must be executed so that the data can be relayed to higher levels of the health delivery system. HIV care and treatment program managers should provide an oversight role to enable the smooth running of the HIV care and treatment program. They should ensure that relevant data collection tools are available at clinic or hospital level and work together with health information officers.

Data analysis is vital in the field of public health because it enables health professionals to extract useful information from the collected data from different health facilities and use it for planning, decision making and in the response to any particular health problem. There are two broad categories of data analysis which are qualitative and quantitative methods. In these two analytical methods, statistical and machine learning techniques can be applied. Statistical methods involve the use of descriptive and inferential statistics. Predictive modelling has become one of the pillars of public health programming in recent decades as it is being used as an early surveillance tool in the control and prevention of infectious and non-infectious diseases. Time series forecasting uses both statistical and machine learning methods to generate reliable forecasts that guide policy makers in decision making. Machine learning methods unlike statistical techniques are not based on assumptions in order to form relationships between variables hence they are useful in modelling complex data.

Machine learning algorithms learn a predictor function from a given dataset in order to generate forecasts. The training process can be supervised or unsupervised learning. In supervised learning the algorithm learns a predictor function from a set of input and output values. If the algorithm finds the hidden or inherent structure in the input data without being given output values then this is referred to as the unsupervised learning. Machine learning techniques include decision trees, artificial neural networks (ANNs), support vector machine (SVM), K -nearest neighbors and Bayesian networks. There are three basic machine learning tasks namely regression, classification and clustering (Nyonni et al , 2020; Zhao et al, 2020; Scavuzzo et al,2018; Gambhir et al, 2018; Laurean-Rosario et al, 2018; Weng et al, 2017; Guo et al, 2017; Althouse et al, 2011).

The support vector machine (SVM) was proposed by Vapnik and his co-workers in 1990. The technique is based on the structural risk minimization principle. The objective of the SVM is to construct an optimal hyper plane or linear decision boundary through a nonlinear mapping of input values to a higher dimensional feature space, H. In support vector for regression (SVR) the optimal hyperplane must be as close as possible to all the data points whereas in support vector for classification the linear decision boundary should separate two classes with a maximum margin through the selection of data points called support

vectors (Weng et al, 2017). There are many artificial neural network frameworks and they include the Multilayer Perceptron (MLP), Generalized Regression Neural Network (GRNN), Radial Basis Function neural network (RBF) and the Recurrent Neural Network (RNN) (Zhao et al, 2020; Bishop, 1995). The MLP is the widely used neural network framework and the model is composed of three layers: input neurons, hidden neurons and the output neurons, feed forward neural network (FNN). The different layers of neurons are connected by acyclic links called connection weights (Kaushik & Sahi, 2018; Yan et al, 2018 Fojnica et al, 2016; Zhang, 2003).

In this study we applied the MLP, ANN (9, 12, 1) model to predict ART coverage in Togo. The findings of this study will provide an insight of the future progress towards achieving the UNAIDS global targets of ending the HIV epidemic as a public health threat by 20230.

II. LITERATURE REVIEW

Bigelow & Verguet (2020) characterized the changes over time in antiretroviral therapy (ART) coverage in sub-Saharan Africa using growth curve models. This was a retrospective observational study. The research used publicly available data on ART coverage levels from 2000 to 2017 in 42 sub-Saharan African countries and developed two ordinary differential equations models, the Gompertz and logistic growth models that allowed for the estimation of summary parameters related to scale-up and rates of change in ART coverage. The research concluded that growth curve models can provide benchmarks to assess country performance in ART coverage evolution. They could be a useful approach that yields summary metrics for synthesizing country performance in scaling up key health services. They fitted non-linear regressions for the two models, assessed goodness of fit using the Bayesian information criterion (BIC), and ranked countries based on their estimated performance drawn from the fitted model parameters. Marukutira et al (2019) conducted community case finding and HIV testing were in home and mobile venues in 15 intervention communities from October 2013-September 2017. In this secondary analysis, the study compared HIV positivity, knowledge of positive HIV-status, and ART status among all citizens and non-citizens assessed at intake in the intervention communities. The study concluded that although non-citizens were less likely to know their HIV-positive status compared to citizens, there were no differences in treatment uptake among non-citizens and citizens who knew their status. Designing interventions for non-citizens that provide HIV testing and treatment services commensurate to that of citizens as well as targeting communities with the largest number of non-citizens may help close a meaningful gap in the HIV care cascade and ensure ethical treatment for all HIV-positive persons. In another study Kabbash et al (2018) investigated the potential facilitators and barriers to antiretroviral therapy in Egypt. Focus groups discussions (FGDs) were conducted with 33 people living with HIV and AIDS (PLWHA) representing most of Egyptian geographical areas. Discussions were designed to cover socio-demographic characteristics of participants, routine investigations, monitoring & follow up measures, problems associated with drug intake, PLWHA needs, stigma, and relevant future concerns. The findings of the study showed that lack of accurate information about HIV and ART, inadequate Monitoring and follow up measures, drug side effects and stigmatizing practices against Egyptian PLWHA represent the most common barriers to ARV therapy.

III. METHOD

The Artificial Neural Network (ANN) is a data processing system consisting of a large number of 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 approach 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 ART coverage in Togo as output data for the network. In this research paper, our ANN is based on the hyperbolic tangent function.

Data Issues

This study is based on annual ART coverage's (referred to as F series in this study) in all age groups in Togo. The 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
20.474	16.000	0.00000	60.000
Std. Dev.	C.V.	Skewness	Ex. kurtosis
19.704	0.96243	0.64885	-0.78891
5% Perc.	95% Perc.	IQ range	Missing obs.
Undefined	60.000	32.000	0

Ann Model Summary for Art Coverage in Togo

Table 2: ANN model summary

Variable	F
Observations	10 (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	0.041641
MSE	1.767161
MAE	1.101961

Residual Analysis for the ANN model

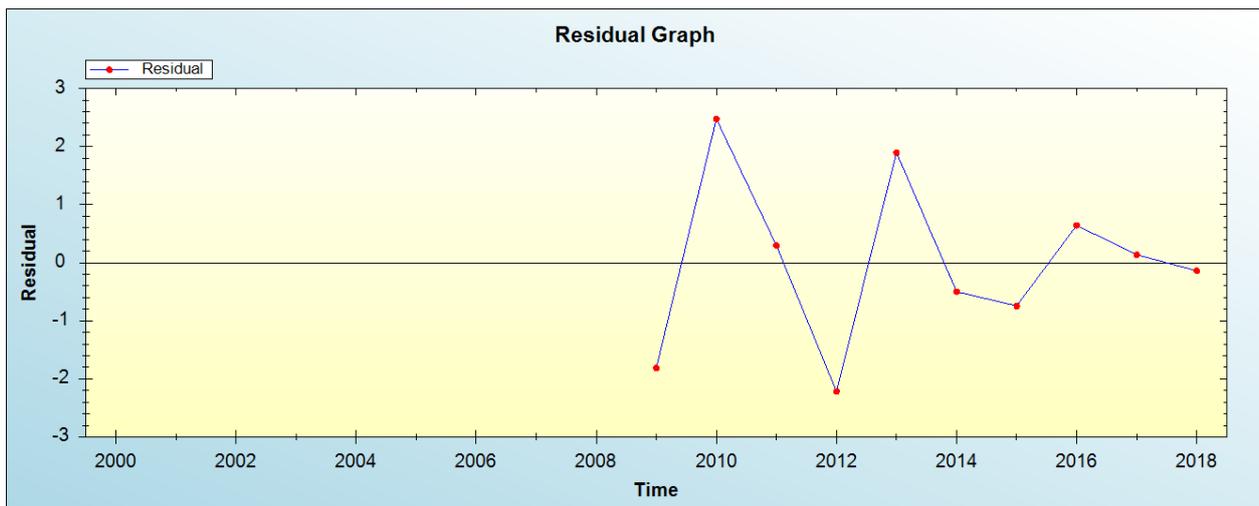


Figure 1: Residual analysis

In-sample Forecast for F

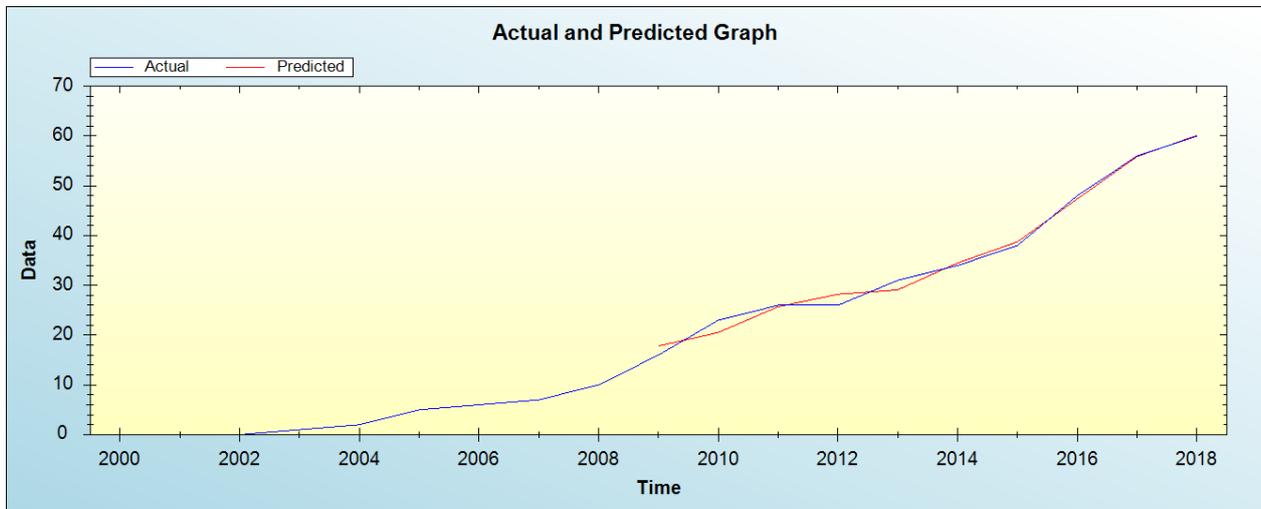


Figure 2: In-sample forecast for the F series

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

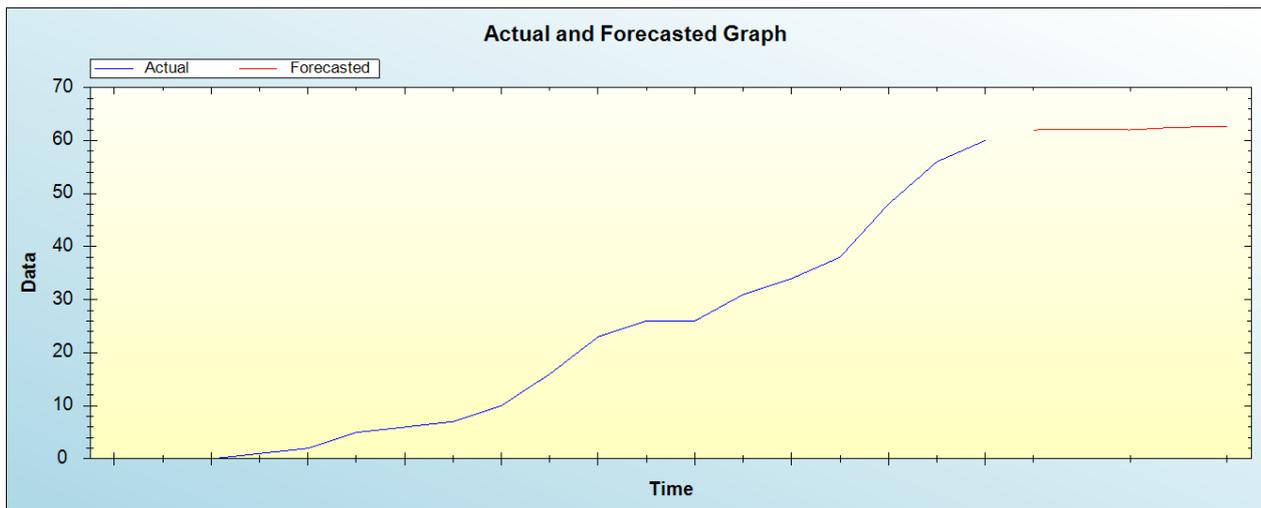


Figure 3: Out-of-sample forecast for F: actual and forecasted graph

Out-of-Sample Forecast for F: Forecasts only

Table 3: Tabulated out-of-sample forecasts

Year	Forecasted ART coverage
2019	61.9981
2020	62.1852
2021	62.0058
2022	62.5214
2023	62.6173

Over the study period the minimum and maximum ART coverage was 0 and 60 % respectively with an average of 20.474. The country started its ART program in 2003, hence zero reporting was observed for the period 2000-2002. The data used in this study is positively skewed with excess kurtosis value of -0.78891. The residual graph and model evaluation criteria indicate that applied model is stable and suitable for forecasting ART coverage in Togo. The in-sample forecasts revealed that the model simulates the observed data very well. The model predicts that ART coverage will be around 62 % over the period 2019-2023.

V. CONCLUSION & RECOMMENDATIONS

Over the period 2000-2018 the country recorded an upward trend in ART coverage showing the government's effort to improve access to antiretroviral therapy for people living with HIV. The model predicts that ART coverage will be around 62 % over the period 2019-2023. The government is encouraged to create more demand for ART services, strengthen TB /HIV collaboration and improve ART access for key populations.

REFERENCES

- [1] Althouse BM & Ng YY (2011). Cummings DAT, Prediction of dengue incidence using serach query surveillance. *PLoS Neglected Tropical Diseases* 2011; 5:e1258.
- [2] Bishop, C.M. (1995). *Neural networks for pattern recognition*. Oxford: Oxford University Press.
- [3] Fojnica, A., Osmanoviae & Badnjeviae A (2016). Dynamic model of tuberculosis-multiple strain prediction based on artificial neural network. In proceedings of the 2016 5th Mediterranean conference on embedded computing pp290-293.
- [4] Gambhir S., Malik SK., & Kumar Y (2018). The diagnosis of dengue disease: An evaluation of three machine learning approaches. *International Journal of Healthcare Information Systems and Informatics* 2018; 13:1–19.
- [5] Guo P., Liu T., Zhang Q., Wang L., Xiao J & Zhang Q (2017). Developing a dengue forecast model using machine learning: A case study in China. *PLoS Neglected Tropical Diseases*.
- [6] Kaushik AC & Sahi. S (2018). Artificial neural network-based model for orphan GPCRs. *Neural.Comput.Appl.* 29,985-992.
- [7] Laureano-Rosario AE., Duncvan AP., Mendez-Lazaro PA., Garcia-Rejon JE., Gomez-Carro S., & Farfan-Ale J (2018). Application of artificial neural networks for dengue fever outbreak predictions in the northwest coast of Yucatan, Mexico and San Juan, Puerto Rico. *Tropical Medicine and Infectious Disease* 2018;3:5.
- [8] Naizhuo Zhao., Katia Charland., Mabel Carabali., Elaine O., Nsoesie., Mathieu MaheuGiroux., Erin Rees., Mengru Yuan., Cesar Garcia Balaguera., Gloria Jaramillo Ramirez., & Kate Zinszer (2020). Machine learning and dengue forecasting: Comparing random forests and artificial neural networks for predicting dengue burden at national and sub-national scales in Colombia. *PLOS Neglected Tropical Diseases*.
- [9] Scavuzzo JM., Trucco F., Espinosa M., Tauro C B., Abril M., & Scavuzzo CM (2018). Modeling dengue vector population using remotely sensed data and machine learning. *Acta Tropica* 185:167–175. <https://doi.org/10.1016/j.actatropica.2018.05.003> PMID: 29777650.
- [10] Smartson. P. Nyoni, Thabani Nyoni, Tatenda. A. Chihoho (2020) PREDICTION OF DAILY NEW COVID-19 CASES IN GHANA USING ARTIFICIAL NEURAL NETWORKS *IJARIII* Vol-6 Issue-6 2395-4396.
- [11] Smartson. P. Nyoni., Thabani Nyoni., Tatenda. A. Chihoho (2020) PREDICTION OF DAILY NEW COVID-19 CASES IN EGYPT USING ARTIFICIAL NEURAL NETWORKS *IJARIII*- Vol-6 Issue-6 2395-4396.
- [12] Vapnik V (1998) "Statistical Learning Theory", New York: Wiley.
- [13] Weng SF., Reys J., Kai J., Garibaldi JM & Qureshi N (2017). Can machine learning improve cardiovascular risk prediction using routine clinical data? *Plos One*.
- [14] Yan C Q., Wang R B., Liu C H., Jiang Y (2019). Application of ARIMA model in predicting the incidence of tuberculosis in China from 2018-2019. *Zhonghua* 40(6):633-637.
- [15] Zhang G P, "Time series forecasting using a hybrid ARIMA and neural network model", *Neurocomputing* 50: 159–175.

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