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Forecasting Art Coverage in Tanzania Using Artificial Neural Networks

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***Abstract* - In this paper, the ANN approach was applied to analyze ART coverage in Tanzania. 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 Tanzania. The results of the study indicate that ART coverage will be around 74 % over the period 2019-2023.Therefore the government needs to intensify the test and treat approach in their HIV program, create more demand for ART services through mass media sensitization, strengthen TB/HIV collaboration and increase pediatric ART initiations.**

Keywords: ANN, ART coverage, Forecasting.

I. INTRODUCTION

The Tanzanian government together with its donor agencies introduced its National ART program in October 2004.The main goal was to provide antiretroviral drugs to all the people living with HIV(Tanzania, 2003, Somi et al, 2009).In late December 2007, 210 health facilities were offering ART(antiretroviral therapy) services in the country. During same year 13.6% of people living with HIV were commenced on ART (Somi et al, 2009).Over the period 2004-2007 the country witnessed an increase in the number of HIV care and treatment centers, geographical coverage of services, the number of enrolled patients and those commenced on ART (Somi et al, 2009).The government launched the ART program with a view to rapidly scale up the provision and access of ART services and to track disease progression (URT, 2003). The programme is funded by the government with assistance from partners such as the Global fund for AIDS, TB and Malaria and PEPFAR (WJCF, 2003).All levels of the health delivery system offer ART services for free. The program has a designed reporting system which enables patient information to be recorded, analyzed and relayed to a higher level. The control of the HIV epidemic in the country has been achieved by a combination strategy which includes scaling up care and treatment of HIV using antiretroviral drugs, Prevention of Mother to Child transmission of HIV (PMTCT), advocacy and behavioral change interventions (UNAIDS 2014). In 2015 approximately 47% of people living with HIV were on ART (Wang et al, 2016). In 2014 about 567 892 HIV positive patients were commenced on ART (PEPFAR, 2015).The main challenge in the ART program is that pediatric ART initiations are lagging behind in the country there by hindering the national and global efforts to attain the 90-90-90 target (UNAIDS, 2014a; UNAIDS, 2017; UNAIDS, 2019; TACAIDS, 2018; Newell et al, 2004; Jolly, 2018; Urassa et al, 2018). In this study we applied the ANN model to forecast ART coverage in Tanzania. The findings of this piece of work will reveal the future trends of ART coverage in the country. This enables the government to assess the impact of the government's interventions to scale up ART initiation and access for children and adults and thus corrective measures can be put in place in time.

II. LITERATURE REVIEW

Urassa et al (2018) conducted a cross sectional study in Kahama district, Tanzania, to determine the magnitude and factors associated with ART uptake among children living with HIV .The study was conducted among pairs of children aged 0-14 years and their caregivers. A total of 423 randomly selected caregivers of HIV positive children were interviewed using structural questionnaire. The outcome variable was ART uptake. The study revealed that one in every three HIV positive children miss their routine scheduled ART clinics in Kahama and tailored interventions should target caregivers of such interventions who are divorced or widowed and those with low or no education while addressing distance and transportation challenges. Tun et al (2019) conducted an implementation science study of a community based ART distribution program for HIV positive female sexworkers (FSW) whereby clients received ART services through community based mobile and home based platforms .6months treatment related outcomes were compared for the intervention group and the standard group (Clinic ART services). The study showed that internalized stigma and receiving community based ART were significantly associated with ART initiation. Levira et al (2015)

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evaluated adult ART and pre ART care coverage by age and sex at CD4 <200 ,<350 and all people living with HIV in the Rufiji district of Tanzania from 2006 to 2010. The ALPHA model was used to predict the number in need of pre ART and ART by age and sex at CD4 <200 and CD4 <350. The study concluded that ART coverage in the Rufiji District was unevenly distributed and far from universal coverage target of 80% in particular among young men. In another study, Exavery et al (2020) examined factors associated with uptake of ART among HIV positive orphans and vulnerable children (OVC). HIV positive OVC aged 0-14 years who were enrolled in the USAID Kizazi Kipya Project from January 2017 to September 2018 were analyzed .ART status was the outcome variable and multivariate analysis was done using logistic regression. The study found out that the majority of orphaned and vulnerable children living with HIV in the study were on ART (95%) at enrollment. ART uptake by OVC was dependent on external factors hence advancing ART uptake may require targeting OVC of female caregivers, OVC of HIV negative caregivers as well as OVC of caregivers of undisclosed HIV status and rural areas.

III. METHOD

The Artificial Neural Network (ANN), which we intend to 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 Tanzania 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 annual ART coverage (referred to as T series in this study) in all age groups in Tanzania. 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
23.737	16.000	0.00000	71.000
Std. Dev.	C.V.	Skewness	Ex. kurtosis
24.209	1.0199	0.65504	-0.97725
5% Perc.	95% Perc.	IQ range	Missing obs.
Undefined	71.000	45.000	0

ANN MODEL SUMMARY FOR ART COVERAGE IN TANZANIA

Table 2: ANN model summary

Variable	T
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

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Criteria:	
Error	0.022320
MSE	0.775107
MAE	0.780631

Residual Analysis for the ANN model

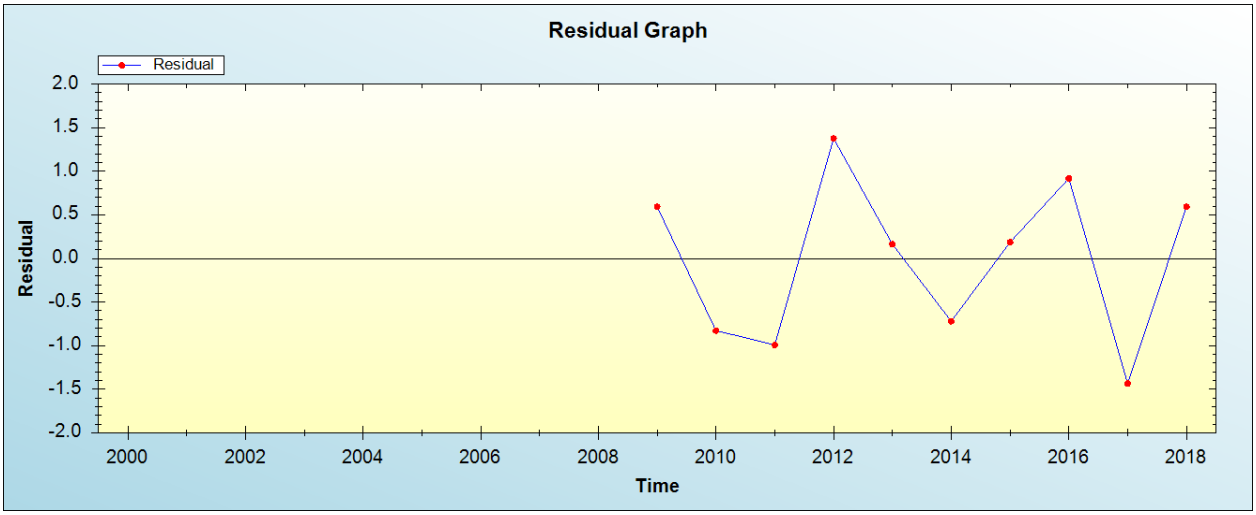

Figure 1: Residual analysis

In-sample Forecast for T

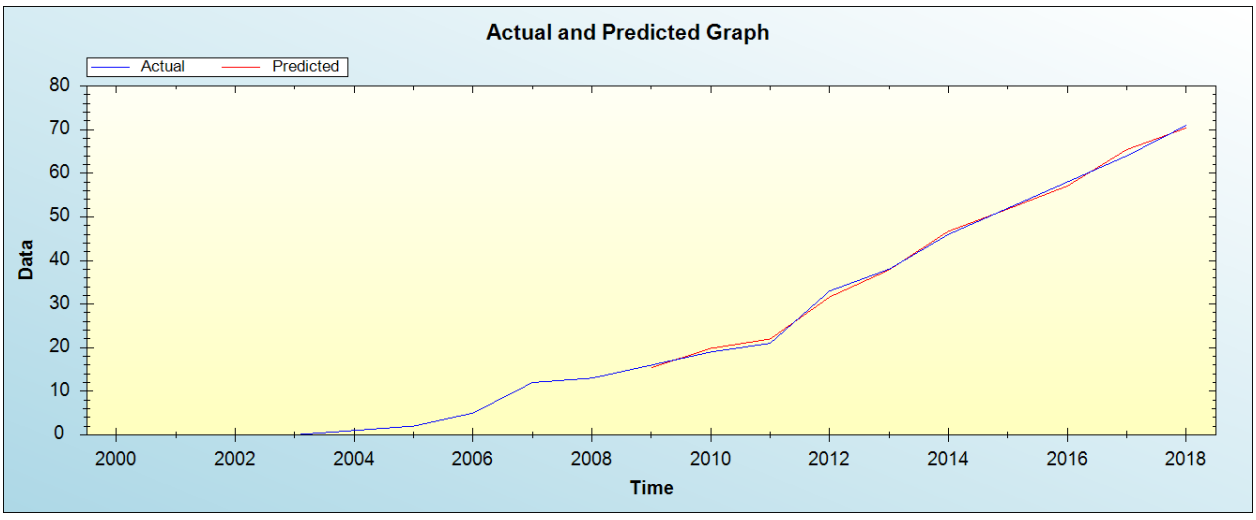

Figure 2: In-sample forecast for the T series

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

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

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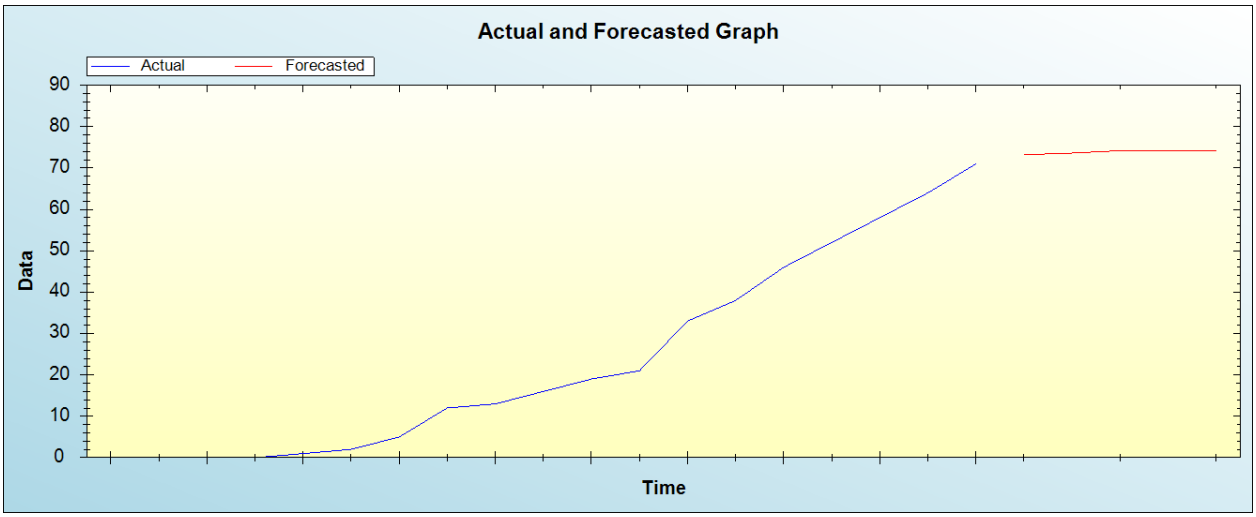

Figure 3: Out-of-sample forecast for T: actual and forecasted graph

Out-of-Sample Forecast for T: Forecasts only

Table 3: Tabulated out-of-sample forecasts

Year	Forecasted ART coverage
2019	73.2074
2020	73.6020
2021	74.1829
2022	74.1623
2023	74.1838

Over the study period, the minimum and maximum ART coverage was 0 and 71 % respectively with an average of 23.737. The recorded zero ART coverage for the period 2000-2003 because the ART program was initiated in 2004. The data used in this study is positively skewed with an excess kurtosis of -0.97725 meaning that the data is not normally distributed. The residual graph and model evaluation criteria indicate that the applied model is stable and suitable for forecasting ART coverage in Tanzania. The in-sample forecasts clearly show that the model simulates the observed data very well. The predictions from the model suggest that ART coverage will be around 74 % throughout the period 2019-2023.

V. CONCLUSION & RECOMMENDATIONS

Over the period 2000-2018, the Tanzania has recorded an increase in ART coverage which indicates the government's effort in improving access to antiretroviral therapy to people living with HIV. The model predicted that ART coverage will be around 74 % in the out of sample period. We encourage the Tanzanian authorities to intensify the test and treat approach in the ART program to ensure more HIV infected people are on antiretroviral treatment. It is important for the authorities to strengthen TB/HIV collaboration, create more demand for ART services through mass media communication and intensify pediatric ART initiations.

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