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ANALYZING NEW HIV INFECTIONS IN PREGNANT WOMEN AT GWERU DISTRICT HOSPITAL USING ARTIFICIAL NEURAL NETWORKS

DR. SMARTSON. P. NYONI,
ZICHIRe Project, University of Zimbabwe, Harare, Zimbabwe

THABANI NYONI
Department of Economics, University of Zimbabwe, Harare, Zimbabwe

ABSTRACT
In this paper, the ANN model is applied to forecast the number of new HIV infections in pregnant women at Gweru District Hospital (GDH). The data employed in this research is taken from the GDH Health Information Department and ranges over the period January 2020 to December 2019. The out-of-sample forecasts will cover the period January 2020 to December 2021. The applied ANN (12, 12, 1) model is adequate as shown by its residuals and minimum forecast evaluation statistics. The results of the study basically reveal that new HIV infections in pregnant women will most likely decline over the period January 2020 to December 2021. This could be a positive towards an HIV/AIDS-free Zimbabwe. Therefore, in order to facilitate the realization of such projections, GDH has a role to play with regards to the following recommendations: [i] GDH should engage in community-based pre-pregnancy assessment and advice campaigns for all known HIV positive women who are of child-bearing age. In this regard, issues such as optimization of HIV treatment, safety of any treatment in pregnancy, model of birth as well as breastfeeding should be discussed. [ii] GDH should offer antenatal screening for HIV for all pregnant women in the first trimester bloods or when they present/book. [iii] GDH ought to engage in more HIV/AIDS awareness programmes, with special emphasis on HIV in pregnant women.

KEYWORD: -ANN, Forecasting, HIV Infections, Pregnant Women

INTRODUCTION
The first cases of AIDS in Zimbabwe were identified in the mid 1980s (WHO, 2005). Today, the country has a generally mature epidemic which is tracked by a comprehensive monitoring and evaluation system (Ministry of Health & Child Care, 2018), even though it has one of the highest HIV prevalences in Sub-Saharan Africa (SSA) at 12%, with approximately 1.3 million people living with HIV in 2018 (UNAIDS, 2019). The HIV epidemic in Zimbabwe is largely driven by unprotected heterosexual sex. Women are disproportionally affected, especially adolescent girls and young women (UNAIDS, 2018). HIV/AIDS prevention is never easy (He et al., 2018) and therefore, modeling and forecasting of new HIV infections is crucial for planning and monitoring of trends at national, regional and worldwide level (Nyoni & Nyoni, 2019). The main purpose of this study is to forecast cases of HIV infections in pregnant women attended to at Gweru District Hospital (GDH) in Gweru, Zimbabwe.

LITERATURE REVIEW
Demissew (2015) made use of the ARIMA technique to model and forecast the incidence of HIV/AIDS in Ethiopia using an annual data set ranging over the period 1990 – 2013. The study showed that the ARIMA (2, 3, 2) model was the best model and that the model showed that HIV/AIDS prevalence in Ethiopia was increasing sharply. He et al. (2018) made use of the Baidu Search Index (BSI) to model and forecast the incidence of HIV/AIDS in China. The authors used a panel data set consisting of 30 provinces with a time-frame covering the period January 2009 to December 2013. Their study revealed that the Pooled Mean Group (PMG) model showed that the BSI positively predicts the increase in HIV/AIDS incidence, generally with a 1% increase in HIV/AIDS incidence on average. Nyoni & Nyoni (2019), in a Zimbabwean study, forecasted HIV infections at Silobela District Hospital (SDH) using the Box-Jenkins SARIMA technique, based on a univariate series on new HIV infections covering the period January 2014 – December 2018 and found out that new HIV infections in the community of Silobela will decline over the out-of-sample period.

METHODOLOGY

There is a growing interest in the domain artificial neural networks for modeling and forecasting various health-related data sets (Nyoni & Nyoni, 2020a; b; c; d; & e). In the same vain, in this research article, we apply the multi-layer perceptron neural network type of the Artificial Neural Network technique in order to model and forecast HIV infections in pregnant women at GDH.

Data Issues

This study is based on newly diagnosed monthly HIV cases (reffered to as NHP series in this study) in pregnant women aged 16 – 49 years at GDH. The data covers the period January 2010 to December 2019 while the out-of-sample forecast covers the period January 2020 to December 2021. All the data employed in this paper was gathered from GDH Health Information Department.

FINDINGS OF THE STUDY

DESCRIPTIVE STATISTICS

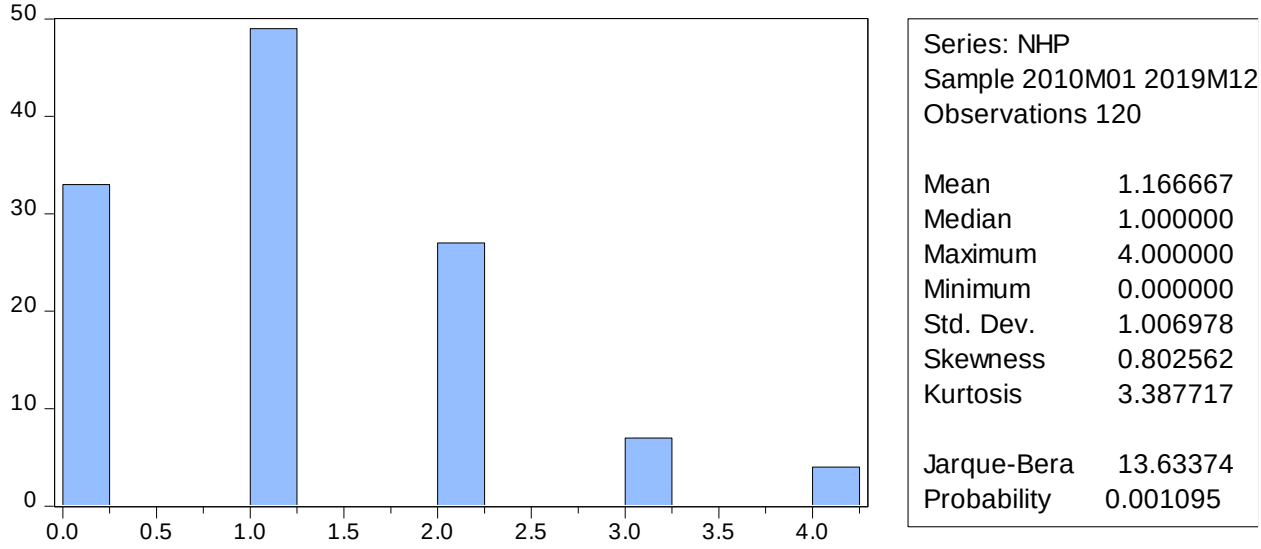

Figure 1: Descriptive statistics

Figure 1 above indicates that, on average, approximately 1 pregnant mother is infected with HIV over the study period. A maximum of 4 mothers have been infected with HIV over the same period. For a district hospital such as GDH, these are not large numbers, although it is not desirable to have new HIV infections. The implication is that GDH has a role to play in bringing the numbers to 0 and this is possible.

ANN Model Summary

Table 1: ANN model summary

Variable	NHP
Observations	108 (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	0.141593
MSE	0.099005
MAE	0.265054

The table above shows the main results of the ANN (12, 12, 1) model applied this endeavor.

Residual Analysis for the ANN model

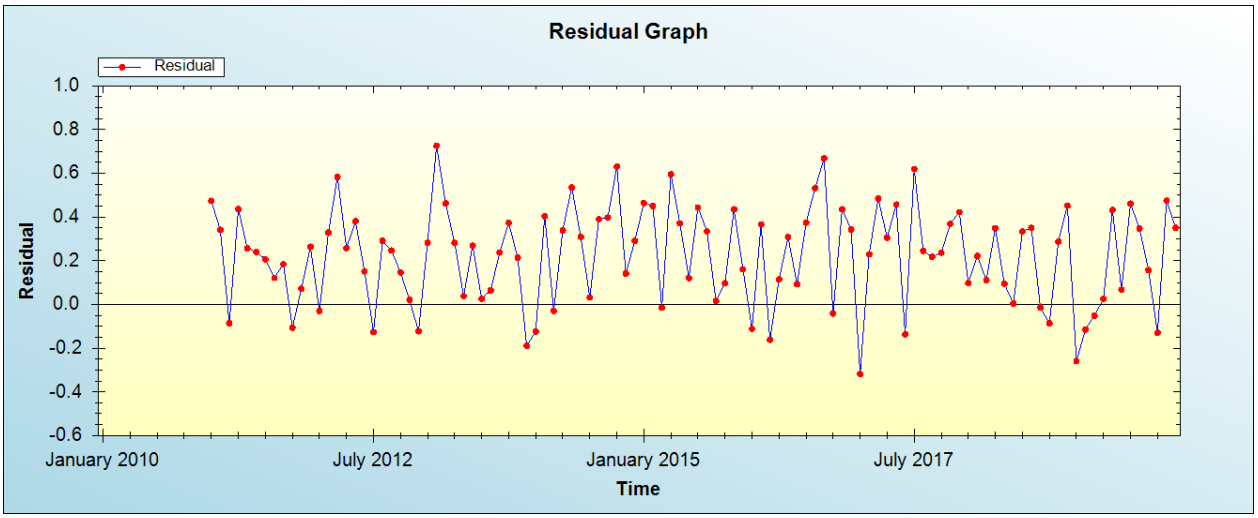

Figure 2: Residual analysis

The residuals of the applied model are very close to zero and this confirms the stability of the applied model.

In-sample Forecast for NHP

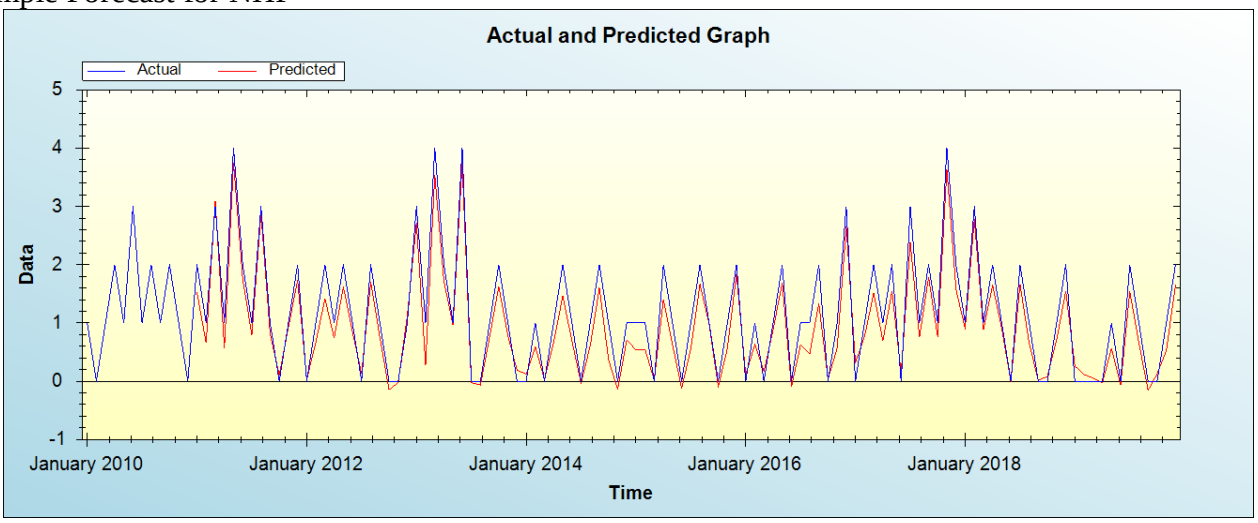

Figure 3: In-sample forecast for the NHP series

Figure 3 is the in-sample forecast of the applied model.

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

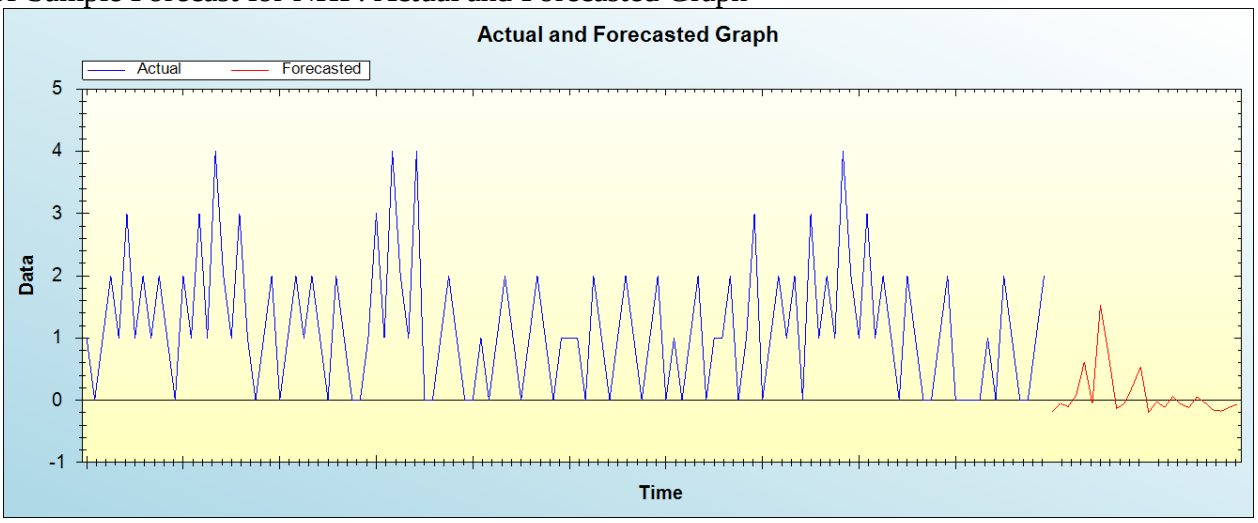

Figure 4: Out-of-sample forecast for NHP: actual and forecasted graph

Out-of-Sample Forecast for NHP: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Month/Year	Predicted NHP
January 2020	-0.1803
February 2020	-0.0484
March 2020	-0.1045
April 2020	0.0824
May 2020	0.6145
June 2020	-0.0548
July 2020	1.5277
August 2020	0.7427
September 2020	-0.1323
October 2020	-0.0530
November 2020	0.2227
December 2020	0.5356
January 2021	-0.1956
February 2021	-0.0249
March 2021	-0.1124
April 2021	0.0579
May 2021	-0.0635
June 2021	-0.1169
July 2021	0.0552
August 2021	-0.0411
September 2021	-0.1544
October 2021	-0.1738
November 2021	-0.1132
December 2021	-0.0624

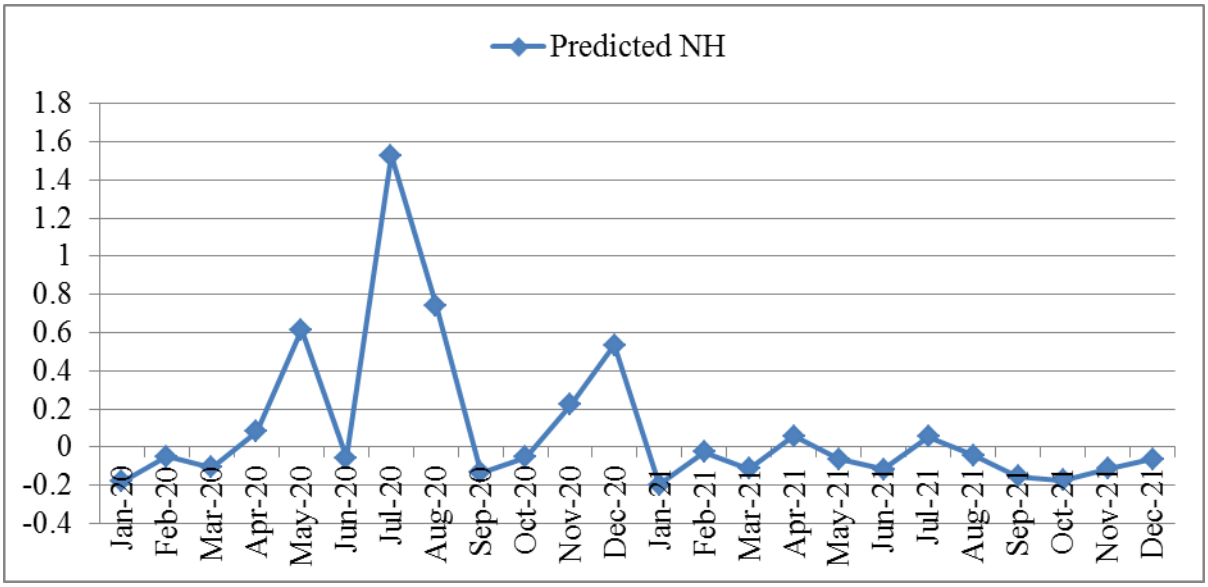

Figure 5: Graphical presentation of out-of-sample forecasts

Figure 4 and 5 as well as table 2 are out-of-sample forecasts of the applied model. The overall trend of the predicted cases of new HIV infections in pregnant women is generally declining over the period January 2020 to December 2021. The projections indicate that if the current policy stance on HIV is continuously intensified, between 0 and 2 new infections per month could be recorded at GDH and this could be a huge gain in terms of saving both pregnant mothers and the newborns. This is a desirable outcome and it basically points the fact that GDH is on the winning side in terms of preventing and controlling HIV in Gweru urban district.

CONCLUSION & RECOMMENDATIONS

The burden of HIV in pregnant women is quite significant in Zimbabwe. Preventive measures ought to be put into serious consideration. This study, being the first attempt in the country, forecasted the number of cases of HIV infections in pregnant women who attended GDH. The results of the study are expected to go a long way in reducing further infections such as from mother to child. GDH must take into consideration the following policy directions:

i. GDH should engage in community-based pre-pregnancy assessment and advice campaigns for all known HIV positive women who are of child-bearing age. In this regard, issues such as optimization of HIV treatment, safety of any treatment in pregnancy, model of birth as well as breastfeeding should be discussed.
ii. GDH should offer antenatal screening for HIV for all pregnant women in the first trimester bloods or when they present/book.
iii. GDH ought to engage in more HIV/AIDS awareness programmes, with special emphasis on HIV in pregnant women.

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