Forecasting Art Coverage in the Philippines Using Artificial Neural Networks

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Abstract - **In this research article, the ANN approach was applied to analyze ART coverage in the Philippines. 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 ART coverage in the Philippines. The results of the study indicate that ART coverage will remain very low over the period 2019-2023. Therefore the government is strongly advised to intensify demand creation for HIV testing and ART services and improve access to antiretroviral therapy for the key populations amongst other measures.**

Keywords: ANN, ART coverage, Forecasting.

I. INTRODUCTION

The HIV epidemic in the Philippines has been rapidly changing and expanding from a low and slow to a fast and furious epidemic, the number of diagnosed HIV infections has increased dramatically to 32 cases per day (Country progress report, 2019). The HIV epidemic is concentrated among the key populations which are Men who have sex with men (MSM), transgender women and sex workers (Country progress report, 2019). The national ART (antiretroviral treatment) program is committed to the goal of ending the HIV epidemic by 2030. The country aims to achieve this through increasing HIV testing services and ART coverage especially among the key populations. The combined HIV prevention strategy is being implemented to prevent HIV infection among key populations and this strategy involves pre exposure prophylaxis, voluntary medical circumcision, harm reduction, condom distribution and use. Just like other countries, the Philippines have the responsibility of increasing knowledge of HIV and to sexual and reproductive health services. High knowledge of HIV among female sex workers (FSW) has been observed in several studies that it improves HIV testing, ART initiation and HIV prevention (Chanda et al, 2017; Lafort et al, 2016; Luchters et al, 2013; Tran et al, 2013; Deering et al, 2011; Wang et al, 2011; Kerrigan et al, 2003). Furthermore the national ART program is implementing the prevention of mother to child transmission of HIV (PMTCT) and there are existing linkages between HIV and TB care and treatment programs. Program linkages are critical in order to maximize detection and treatment of HIV and TB cases and this is anticipated to reduce morbidity and mortality related TB and HIV/AIDS.

In this study we aim to predict ART coverage in the Philippines using the Multilayer Perceptron (MLP). This artificial neural network framework is widely used in time series forecasting .The model has three layers of neurons which are the input, hidden and output layers which are joined by acyclic links called connection weights. The type of the ANN is the feed forward neural network (Yan et al, 2018; Kaushik & Sahi, 2018; Zhao et al, 2020; Fojnica et al, 2016; Zhang, 2003). The findings of this study will provide highlights of the future trends of ART coverage in the Philippines and to assess the progress towards achieving the global targets by 2030.

II. LITERATURE REVIEW

Piamonte & Ditangco (2020) did a formative study aimed to identify the awareness of men who have sex with men (MSM) from Metro Manila, Philippines towards HIVST as well as their willingness to pay for a self-test kit. Two-hundred fifty MSM who received a non-reactive HIV screening test result from a community-based voluntary counseling and testing center were recruited. Results indicated that slightly more than half of the respondents (56%) have heard about HIVST, indicating moderate level of awareness among MSM. The social media and the internet were the most prominent source of awareness about it. Frequent testers and being exclusively or more attracted to the same sex are more likely to be aware of HIVST. The results implicate that efforts to inform MSM about HIVST should be initiated to increase awareness. Should it be available, HIVST services can be optimized if done through saliva test and if provided at low price. Hemingway et al (2019) carried out a study which aimed to develop a playable and acceptable game for health, targeted at young key populations in the Philippines. Authors

identified a range of user-centered design methods to be used in tandem from published literature. The resulting design process involved a phased approach, with 40 primary and secondary users engaged during the initial ideation and prototype testing stages. Selected methods included participatory design workshops, playtests, playability heuristics, and focus group discussions. Subject domain experts were allocated roles in the development team. Data were analyzed using a framework approach. Conceptual frameworks in health intervention acceptability and game design guided the analysis. In-game events were captured through the Unity Analytics service to monitor uptake and game use over a 12-month period. The study revealed that User-centered design activities supported the identification of important contextual requirements. Multiple data collection methods enabled triangulation of findings to mediate the inherent biases of the different techniques. Game acceptance is dependent on the ability of the development team to implement design solutions that address the needs and desires of target users. Ronquillo et al (2017) measured the level of understanding of the community on HIV/AIDS as part of measuring the impact of decentralized initiative against HIV/AIDS. It applied the Systems' Theory of Policy Process developed by David Easton. The study showed that: age, gender, civil status and religion have nothing to do with the level of understanding of the HIV/AIDS. The study revealed that respondents' of the issue of HIV/AIDS as measured in terms of knowledge, attitudes and beliefs fall within the median range of scores: 2.89 for knowledge, 2.59 for beliefs and 2.93 for attitudes. The study further concluded that there is no significant relationship between the personal profile of the respondents and their level of understanding. The study found that heightened understanding of HIV/AIDS among Rural Health Unit 4 respondents was due to decentralized mass information and dissemination campaign of the Local Government Unit.

III. METHOD

The Artificial Neural Network (ANN); is a data processing system made up 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 and or real data set to describe the nonlinear and interaction effects with great accuracy. ANN-based curve fitting technique is one of the widely applied artificial intelligence methods that are used for forecasting and prediction purpose. It consists of basically 3 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 Philippines 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 coverages (referred to as P series in this study) in all age groups in the Philippines. 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
13.105	8.0000	0.00000	44.000
Std. Dev.	C.V.	Skewness	Ex. kurtosis
13.936	1.0634	0.89604	-0.39681
5% Perc.	95% Perc.	IQ range	Missing obs.
Undefined	44.000	23.000	0

ANN MODEL SUMMARY FOR ART COVERAGE IN THE PHILIPPINES

Table 2: ANN model summary

Variable	P
Observations	10(After Adjusting Endpoints)
Neural Network Architecture:	
Input Layer Neurons	9
Hidden Layer Neurons	12

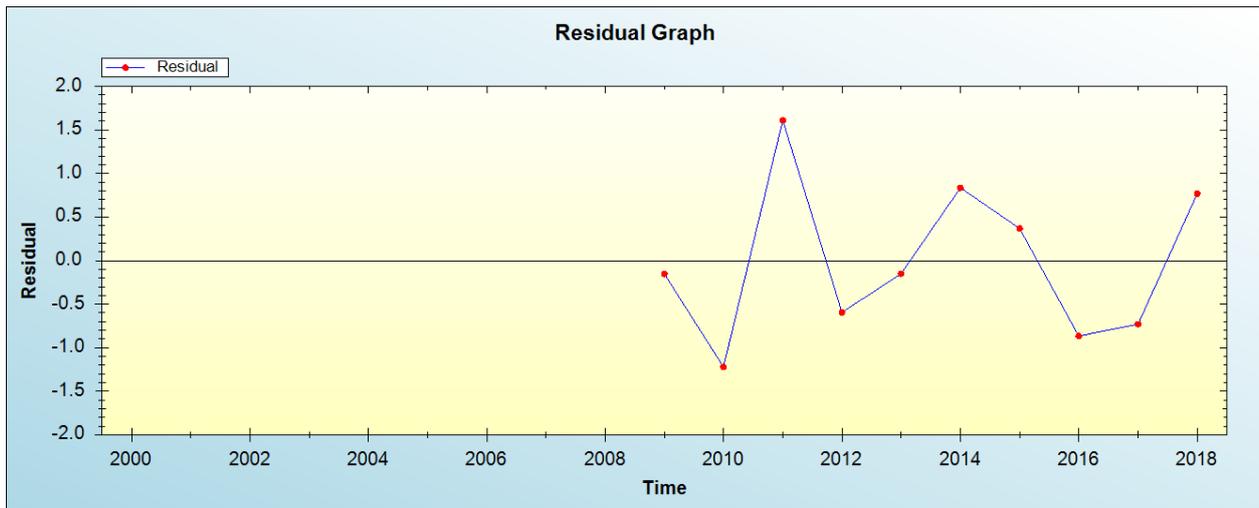|	
Output Layer Neurons	1
Activation Function	Hyperbolic Tangent Function
Back Propagation Learning:	
Learning Rate	0.005
Momentum	0.05
Criteria:	
Error	0.034700
MSE	0.719472
MAE	0.729688

Residual Analysis for the ANN model

Figure 1: Residual analysis

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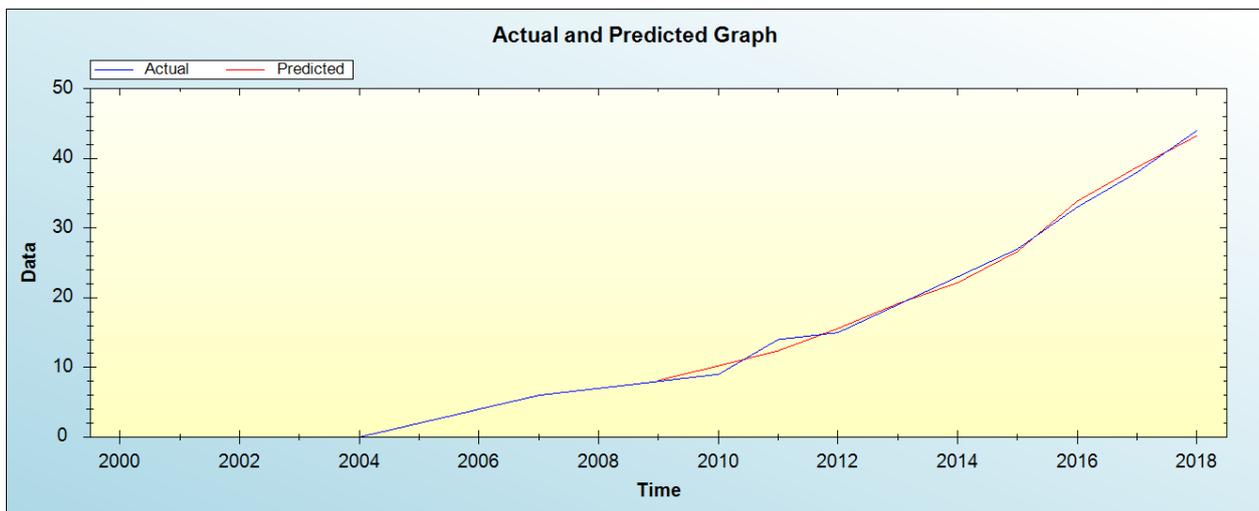
Figure 2: In-sample forecast for the P series

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

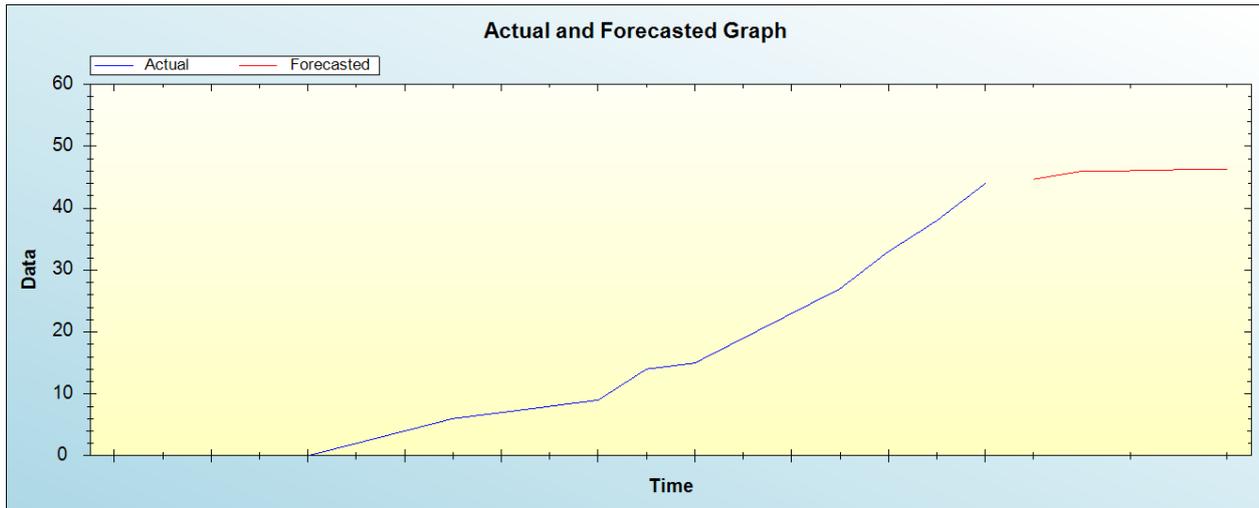*Out-of-Sample Forecast for: Actual and Forecasted Graph*

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

Out-of-Sample Forecast for P: Forecasts only

Table 3: Tabulated out-of-sample forecasts

Year	Forecasted ART coverage
2019	44.6723
2020	45.9918
2021	46.0528
2022	46.2239
2023	46.2976

Over the study period, the minimum and maximum ART coverage was 0 and 44 % respecively with an average of 13 %. There was zero reporting of ART covering over the period 2000-2004 because the ART program was rolled out in 2005. The data utilized in this study is positively skewed with an excess kurtosis of -0.39681. The residual graph and model evaluation criteria indicate that the applied ANN (9,12,1) model is stable and suitable for forecasting ART coverage in the Philippines . Figure 2 shows the in-sample forecasts which clearly indicate that the model simulates the observed data reliably. The model predictions suggest that ART coverage will remain low over the period 2019-2023.

V. CONCLUSION & RECOMMENDATIONS

The Philippines are struggling to control the HIV epidemic as suggested by the data utilized in this study. The ANN model predicted that this trend will continue over the period 2019-2023. The government is strongly encouraged to intensify demand creation for HIV testing and ART services and improve ART access to key populations in the country amongst other measures.

REFERENCES

[1] Chanda M M., Perez-Brumer A G., Ortblad K F., Mwale M., Chongo S., Kamungoma N (2017). Barriers and Facilitators to HIV Testing Among Zambian Female Sex Workers in Three Transit Hubs. AIDS Patient Care STDs. 2017; 31:290–6. https://doi.org/10.1089/apc.2017.0016 PMID: 28581820

[2] Country progress report (2019). Philippines Global AIDS Monitoring 2019.

[3] Deering KN., Bhattacharjee P., Bradley J., Moses SS., Shannon K., & Shaw SY (2011). Condom use within non-commercial partnerships of female sex workers in southern India. BMC Public Health. 11 Suppl 6:S11. https://doi.org/10.1186/1471-2458-11-S6-S11 PMID: 22376171

[4] 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.

[5]   Kaushik AC & Sahi. S (2018). Artificial neural network-based model for orphan GPCRs.Neural.Comput.Appl. 29,985-992.

[6]   Kerrigan D., Ellen JM., Moreno L., Rosario S., Katz J., & Celentano DD (2003). Environmental-structural factors significantly associated with consistent condom use among female sex workers in the Dominican Republic. AIDS. 2003; 17:415–23. https://doi.org/10.1097/00002030-200302140-00016 PMID: 12556696

[7]   Lafort Y., Greener R., Roy A., Greener L., Ombidi W., & Lessitala F (2016). HIV prevention and care-seeking behavior among female sex workers in four cities in India, Kenya, Mozambique and South Africa. Trop Med Int Health 2016; 21:1293–303. https://doi.org/10.1111/tmi.12761 PMID: 27479236

[8]   Luchters S., Richter ML., Bosire W., Nelson G., Kingola N., & Zhang X-D (2013). The contribution of emotional partners to sexual risk taking and violence among female sex workers in Mombasa, Kenya: a cohort study. PLoS One. 8:e68855. https://doi.org/10.1371/journal.pone.0068855 PMID: 23950879

[9]   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 | https://doi.org/10.1371/journal.pntd.0008056.

[10]   Tran BX., Nguyen LT., Nguyen NP., Phan HTT (2013) HIV voluntary testing and perceived risk among female sex workers in the Mekong Delta region of Vietnam. Glob Health Action. 6:20690. https://doi.org/ 10.3402/gha.v6i0.20690 PMID: 23866916

[11]   Wang Y., Li B., Pan J., Sengupta S., Emrick C B., & Cohen MS (2011). Factors associated with utilization of a free HIV VCT clinic by female sex workers in Jinan City, Northern China. AIDS Behav. 15:702–10. https://doi.org/10.1007/s10461-010-9703-2 PMID: 20458528

[12]   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

[13]   Zhang G P, "Time series forecasting using a hybrid ARIMA and neural network model", Neuro computing 50: 159–175.

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