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TOTAL NEW HIV INFECTIONS IN PHILIPPINES: A BOX-JENKINS ARIMA APPROACH

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Abstract

While HIV infections have declined globally, in the Philippines it is the opposite. The Philippines has an alarming number of new HIV infections (Senate of the Philippines, 2018). Using annual time series data on the total number of new HIV infections in Philippines from 1990 – 2018, the study makes predictions for the period 2019 – 2030. The study applies the Box-Jenkins ARIMA approach. The diagnostic ADF tests show that, E, the series under consideration is an I (2) variable. Based on the AIC, the study presents the ARIMA (0, 2, 2) model as the optimal model. The diagnostic tests further reveal that the presented model is quite stable and its residuals are not serially correlated. The results of the research indicate that the total number of new HIV infections in Philippines, will; over the out-of-sample, increase by a staggering 87% rate!

1.0INTRODUCTION

Globally, there are an estimated total of76.1 million HIV infections, 35 million HIV-related deaths and 36.7 million people living with HIV (UNAIDS, 2018). The Philippines is facing one of the fastest-growing epidemics of HIV in the Asia-Pacific region (Human Rights Watch, 2016). In fact, the HIV epidemic in the Philippines has been rapidly changing and expanding, especially in the past five years. From a low and slow (Balk et al., 1997; Gacad et al., 1998; Lean et al., 2003) to a fast and furious epidemic, the number of diagnosed HIV infections has increased dramatically to 32 cases a day. It is interesting to note that the "low and slow" epidemic in Philippines has never been adequately justified because all the factors for an explosive epidemic, for example, low rate of condom use, unsafe IDU practices, increasing trends in extramarital and premarital sex, lack of education and misconception of HIV/AIDS, the influence of religion in everyday life as well as sexual conservatism (Blood Weekly, 1995; Acquino et al., 2003; USAID, 2008); have always been present in the Philippines (PNAC, 2005). Actually, in Philippines, the reality is that, for every documented case of HIV/AIDS, there is likely to be 3 or 4 cases being missed! (Caccam, 2006). Currently, there are a total of 62029 diagnosed HIV cases from January 1984 to December 2018. Of these, 93% were males. 51% were from the 25-34 age group. The predominant model of transmission is male-to-female sex (HARP, 2019).

The country's growing HIV epidemic has been fueled by a legal and policy environment hostile to evidence-based policies and interventions proven to help prevent HIV transmission. Such restrictions are found in national, provincial and local government policies, and are compounded by the longstanding resistance of the Roman Catholic Church to sexual health education and condom use. Government policies create obstacles to condom access and HIV testing and limit educational efforts on HIV prevention (Human Rights Watch, 2016). The country is at a crucial point in its fight against HIV where it has the opportunity to take a decisive action to reverse the tide and stop the epidemic before it gets out of hand (Senate of the Philippines, 2018). The main goal of this study is to predict the number of new HIV infections in Philippines over the period 2019 – 2030. This paper will go a long way in investigating the possibility of ending the HIV scourge in the Philippines.

2.0 LITERATURE REVIEW

Nyoni & Nyoni (2019) examined new HIV infections in the rural community of Silobela in Zimbabwe. The study used monthly time series data covering the period January 2014 to December 2018. The SARIMA (0, 1, 1)(0, 1, 1)$_{12}$ model was employed. The research indicated that new HIV infections in the community of Silobela will continue to decline over the period 2019 to 2021. Consistently, Nyoni & Nyoni (2020a) investigated the trends of new HIV infections in children aged between 0 and 14 years in Zimbabwe, based on annual time series data and employed the generalized ARIMA model. The paper, whose optimal model was the ARIMA (1, 2, 0) indicates that new pediatric HIV infections will continue to decline in the country over the period 2019 to 2023. In yet, another more recent Zimbabwean study, Nyoni & Nyoni (2020b); employed the ANN model to forecast the number of new HIV infections in pregnant women at Gweru District Hospital (GDH). The data used in the study ranged over the period January 2020 to December 2019. The out-of-sample forecasts covered the period January 2020 to December 2021. The applied ANN (12, 12, 1) model basically showed that new HIV infections in pregnant women will most likely decline over the period January 2020 to December 2021. No similar Asian or Philippines study has been found. This paper will be the first of its kind in Philippines. We adopt a generalized ARIMA approach, already applied by Nyoni & Nyoni (2020a).

3.0 METHODODOLOGY

3.1 The Box – Jenkins (1970) Methodology

The first step towards model selection is to difference the series in order to achieve stationarity. Once this process is over, the researcher will then examine the correlogram in order to decide on the appropriate orders of the AR and MA components. It is important to highlight the fact that this procedure (of choosing the AR and MA components) is biased towards the use of personal judgement because there are no clear – cut rules on how to decide on the appropriate AR and MA components. Therefore, experience plays a pivotal role in this regard. The next step is the estimation of the tentative model, after which diagnostic testing shall follow. Diagnostic checking is usually done by generating the set of residuals and testing whether they satisfy the characteristics of a white noise process. If not, there would be need for model re – specification and repetition of the same process; this time from the second stage. The process may go on and on until an appropriate model is identified (Nyoni, 2018c). This approach will be used to analyze, E, the series under consideration.

3.2 The Applied Box – Jenkins ARIMA Model Specification

If the sequence $\Delta^d E_t$ satisfies an ARMA (p, q) process; then the sequence of E_t also satisfies the ARIMA (p, d, q) process such that:

$$\Delta^d E_t = \sum_{i=1}^{p} \beta_i \Delta^d L^i E_t + \sum_{i=1}^{q} \alpha_i L^i \mu_t + \mu_t \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots [1]$$

where Δ is the difference operator, vector $\beta \in \mathbb{R}^p$ and $\alpha \in \mathbb{R}^q$.

3.3 Data Collection

This study is based on annual observations (that is, from 1990 – 2018) on the total number of new HIV infections, that is, adults (ages 15+) and children (ages 0 – 14) [denoted as E] in Philippines. Out-of-sample forecasts will cover the period 2019 – 2030. All the data was collected from the World Bank online database.

3.4 Diagnostic Tests & Model Evaluation

3.4.1 The ADF Test in Levels

Table 1: with intercept

Variable	ADF Statistic	Probability	Critical Values		Conclusion
E	-1.445462	0.9986	-3.699871	@1%	Non-stationary
			-2.976263	@5%	Non-stationary
			-2.627420	@10%	Non-stationary

Table 1 shows that the variable under consideration is not stationary in levels.

3.4.2 The ADF Test (at First Differences)

Table 2: with intercept

Variable	ADF Statistic	Probability	Critical Values		Conclusion
ΔE	-1.552948	0.4922	-3.699871	@1%	Non-stationary
			-2.976263	@5%	Non-stationary
			-2.627420	@10%	Non-stationary

Table 2 indicate that E is not an I (1) variable.

3.4.3 The ADF Test (at Second Differences)

Table 3: with intercept

Variable	ADF Statistic	Probability	Critical Values		Conclusion
$\Delta^2 E$	-5.702351	0.0001	-3.711457	@1%	Stationary
			-2.981038	@5%	Stationary
			-2.629906	@10%	Stationary

Table 3 indicates that the variable under consideration is I (2).

3.4.4 Evaluation of ARIMA models (without a constant)

Table 4: Evaluation of ARIMA Models (without a constant)

Model	AIC	U	ME	RMSE	MAPE
ARIMA (1, 2, 1)	393.2986	0.93282	74.257	314.29	12.475
ARIMA (1, 2, 0)	393.3368	0.95955	41.883	327.24	13.092
ARIMA (0, 2, 1)	392.6271	0.92849	59.276	322.32	12.85
ARIMA (2, 2, 0)	393.3861	0.91377	58.005	314.77	13.078
ARIMA (0, 2, 2)	**392.6070**	0.92164	77.489	310.01	12.471

A model with a lower AIC value is better than the one with a higher AIC value (Nyoni, 2018b) Similarly, the U statistic can be used to find a better model in the sense that it must lie between 0 and 1, of which the closer it is to 0, the better the forecast method (Nyoni, 2018a). In this research paper, only the AIC is used to select the optimal model. Therefore, the ARIMA (0, 2, 2) model is finally chosen.

3.5 Residual & Stability Tests

3.5.1 Correlogram of the Residuals of the ARIMA (0, 2, 2) Model

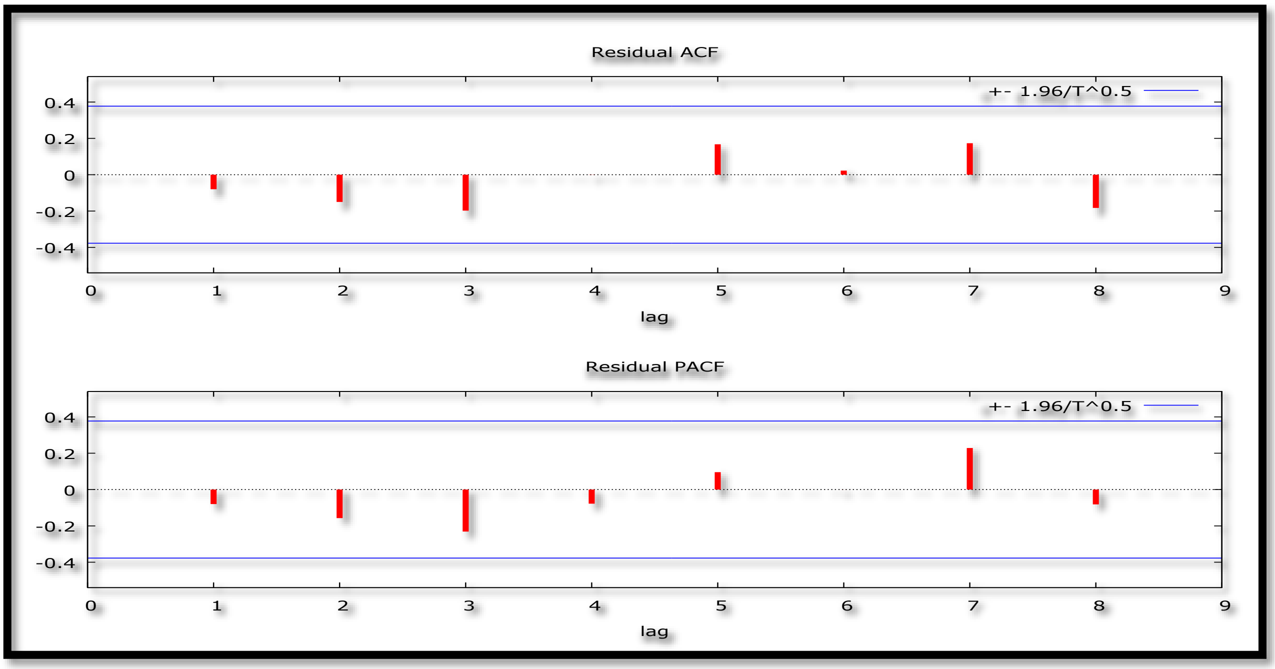

Figure 1: Correlogram of the Residuals

Figure 1 shows that the estimated optimal model is adequate since ACF and PACF lags are quite short and within the bands.

4.0 FINDINGS OF THE STUDY

4.1 Results Presentation

Table 5: Main Results

ARIMA (0, 2, 2) Model:

The chosen optimal model, the ARIMA (0, 2, 2) model can be expressed as follows:

$$\Delta^2 E_t = -0.236635\mu_{t-1} - 0.230319\mu_{t-2} \ldots \ldots \ldots \ldots \ldots \ldots \ldots . \ldots \ldots . . \ldots . . [2]$$

Variable	Coefficient	Standard Error	z	p-value
α_1	-0.236635	0.188644	-1.254	0.2097
α_2	-0.230319	0.190800	-1.207	0.2274

Table 9 shows the main results of the ARIMA (0, 2, 2) model.

Forecast Graph

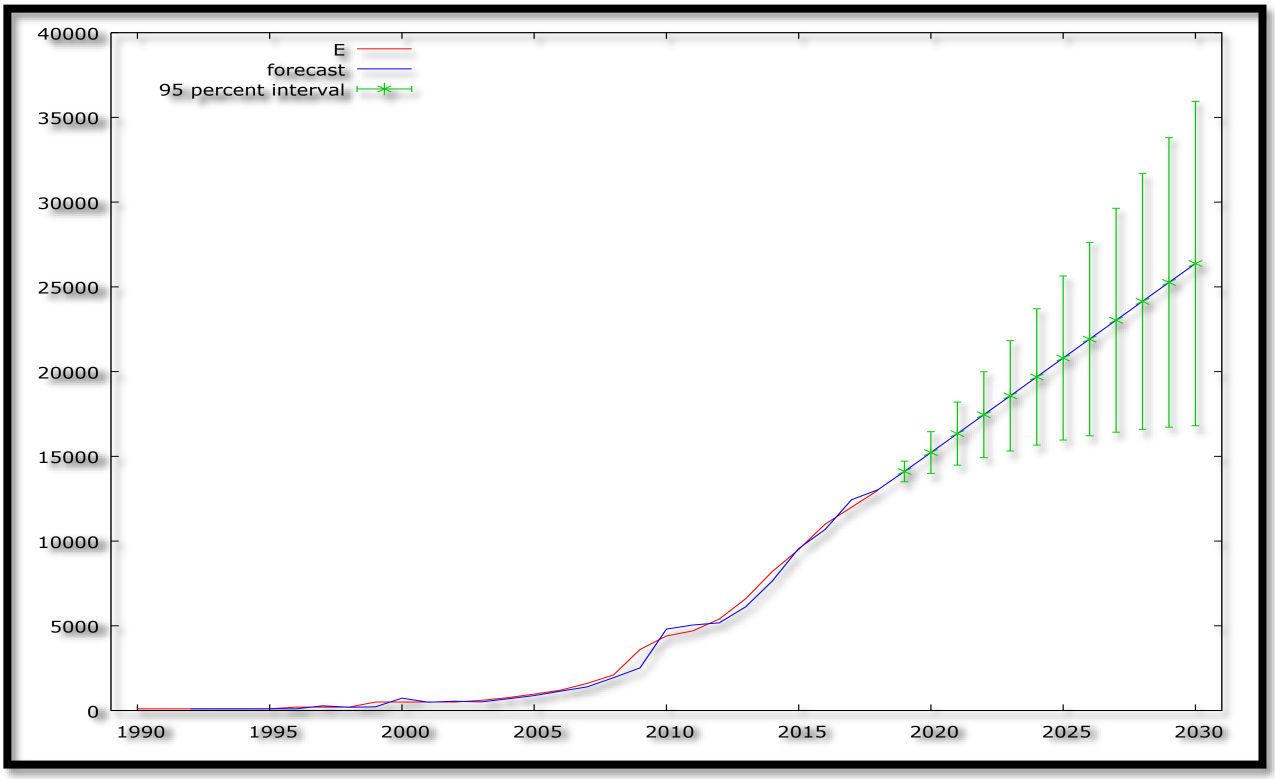

Figure 2: Forecast Graph – In & Out-of-Sample Forecasts

Figure 2 shows the in-and-out-of-sample forecasts of the E series. The out-of-sample forecasts cover the period 2019 – 2030.

Predicted E– Out-of-Sample Forecasts Only

Table 6: Predicted E

Year	Predicted E	Standard Error	95% Confidence Interval
2019	14108.3	310.006	(13500.7, 14715.9)
2020	15223.7	628.438	(13992.0, 16455.4)
2021	16339.1	949.599	(14477.9, 18200.3)
2022	17454.5	1292.72	(14920.9, 19988.2)
2023	18570.0	1660.64	(15315.2, 21824.8)
2024	19685.4	2053.32	(15660.9, 23709.8)
2025	20800.8	2470.01	(15959.7, 25641.9)
2026	21916.2	2909.78	(16213.1, 27619.3)
2027	23031.6	3371.70	(16423.2, 29640.0)
2028	24147.0	3854.89	(16591.6, 31702.5)
2029	25262.5	4358.53	(16719.9, 33805.0)
2030	26377.9	4881.90	(16809.5, 35946.2)

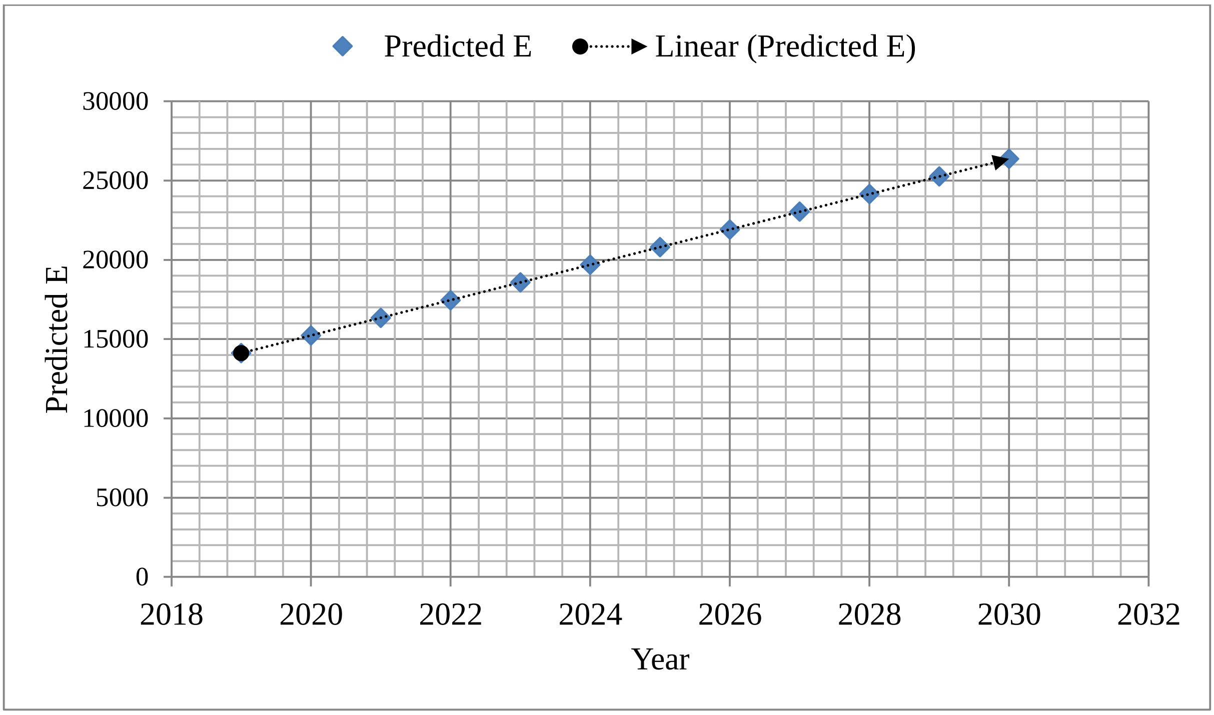

Figure 3: Graphical Analysis of Out-of-Sample Forecasts

Table 6 and figure 3 show the out-of-sample forecasts only. The total number of new HIV infections in Philippines is projected to sharply increase from the estimated 14108 new infections in 2019 to nearly 26378 new infections by 2030, which is tantamount to approximately 86.97% increase over the out-of-sample period. The results of the study are not surprising given the arguments already made by Acquino et al. (2003), Caccam (2006) USAID (2008), the Human Rights Watch (2016) as well as the Senate of the Philippines (2018).

5.0 CONCLUSION

The study shows that the ARIMA (0, 2, 2) model is not only stable but also the most suitable model to forecast the total annual number of new HIV infections in Philippines over the period 2019 – 2030. The model predicts an alarming rate of increase of new HIV infections over the out-of-sample period, that is, almost 87%. The paper recommends that the government of Philippines should strictly scale up HIV prevention and treatment access throughout the country. Special emphasis, targeted at especially at high risk populations such as men who have sex with men as well as female sex workers, must be directed towards behavior change interventions such as increased condom use as well as reduction of sexual partners. As a matter urgency, there is need to engage in massive public health education in Philippines. Philippines, being a low circumcision country, largely due to religious and other cultural reasons; should now begin to upscale voluntary medical male circumcision as an additional HIV prevention strategy.

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