MULTIVARIATE TIME SERIES ANALYSIS OF PREVALENCE OF HIV/AIDS INFECTIONS IN GOMBE STATE, NIGERIA

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ABSTRACT

HIV/AIDS is a major health problem in Nigeria, it is among the greatest health challenges that affect vast majority of people undermining all sectors of economic and social wellbeing of any nation. The studies fits a multivariate time series model on the cases of HIV/AIDS infection among three groups, Male, Female (non-pregnant) and pregnant women attending anti natal clinic in Gombe State, Nigeria. The data were monthly observations collected from government and private hospitals in Gombe State which span from 2011 – 2015 in Gombe State Agency for the Control of Aids (SACA) office record. The Vector Autoregressive (VAR) model was employed on the data, time series model selection criteria were performed to ensure model parameter adequacy. The result show that a vector Error Correction (VEC) model of lags two with at least one co integrating vector fits the data, equation of a long run equilibrium relationship between the variables shows that for every increase in female case will amount to an increase of at least two cases in male, on model adequacy for forecast, portmanteau test of serial auto correlation showed no correlation among the residual, Jarque Bera test showed that the residuals are normally distributed. The data under study shows an erratic (non-stationary) behavior. The forecast data shows an increase in female cases due to their vulnerability for the period of 24 month. The percentage proportion of yearly cases showed an increase in female case with highest percentage of 57.14% in 2015, with unnoticeable cases of infection in pregnant women attending antenatal clinic until when it became more pronounce in 2013 with 14.5% out of total case recorded.

Keywords: HIV/AIDS, Time Series Analysis, Multivariates time series, Vector Autoregressive, Vector Error correction Model

INTRODUCTION

The New York Director of UNAIDS, expressed a deep concern on the alarming increase in HIV and AIDS among adolescents Bland (2015). He reported that it has become imperative to be worried about adolescents because there has been a tripling in the death rate of adolescents since the beginning of the millennium. He said it is not a time for triumphalism; nor time for complacency as each year two million people become infected, over a million people die, and in some parts of the world there is little or no progress at all, Bland (2015) also reported that HIV and AIDS infection is the second largest cause of death for adolescents globally, adding that there are 26 new adolescent infections every hour. The director further documented that adolescent girls were disproportionately affected, making it seven out of 10 new infections globally, influenced considerably by high infection rates among girls in Sub-Saharan Africa.

HIV/AIDS awareness initiative is a collective responsibility that is not limited to the health sector only but to all and sundry. It could be termed a global crisis with victims all around the entire globe. Inadequate information regarding the spread of this global disease could pose a devastating effect on economic growth and social sustainability of the entire world. Therefore, creativity, synergy and collaboration from all sectors of society are required to finding solution to mitigate and curb the widespread, UNAID, (2008).

Human Immunodeficiency Virus (HIV)

Since the discovery of Human Immunodeficiency Virus (HIV) as the causative organism of Acquired Immune Deficiency Syndrome (AIDS) in 1983, the infection has attained epidemic proportion globally. HIV/AIDS crisis is both an emergency and a long-term development issue. Tumer, Unal (2000) Assert that HIV/AIDS is one of the most complex health problems of the 21st century. Despite increased funding, political commitments and progress in expanding access to HIV treatment, the AIDS epidemic continues to outpace every global response.

Today the AIDS epidemic has become a pandemic disease that is threatening the world population. As the HIV/AIDS pandemic continues to spread around the world at an alarming rate, the number of people with this disease is been expected to grow significantly by the end of this decade CIHP (2007). Moreover, according to UNAIDS, Henry, J (2014), an estimated 24.7million people are living with HIV/AIDS in sub Saharan Africa. Olaleye (2003) Reported that HIV/AIDS which is acclaimed the fourth- leading cause of death worldwide is estimated to have claimed 25million lives since the beginning of the epidemic.

AIDS is a viral disease caused by HIV that is usually found in body fluids like blood, semen, vagina fluid, and breast milk of infected persons. The virus can be transferred from one infected person to another, mostly through sexual intercourse and sharing of unsterilized instruments like blades, knives, and syringes which had once been used by infected persons Olaleye (2003).

AIDS has rendered many children orphans, many of which were born with HIV infection. AIDS is killing the most productive people in the population, widening the level of development between developed and developing nations. It is also taking toll on the health sector since a lot of fund is channelled towards HIV/AIDS prevention and control. It has been observed that despite the many programme organized to inform people about the problem of HIV/AIDS, the rate of its infection continues to be on the increase Omoniyi, M, Tayo (2006).

However, Cichoki (2010) insists that, HIV testing is the first step to take when trying to find out a person's status. Never should one rely on symptoms of HIV to decide whether one is infected. HIV testing is the only way to know for sure. The importance of early diagnosis of HIV cannot be overstated. Decades of HIV/AIDS researchers have proven that the earlier HIV is diagnosed, the better the prognosis and the likelihood of a long and healthy life. Meanwhile, certain risk behaviours have been associated with high HIV infection rate. These behaviours according to Anochie (2001) are either life style related or health-care provider risk. The life style related risk behaviours include multiple sexual partners, prostitution, sex with prostitute or casual partners, unprotected sex, intravenous, drug abuse and commercial blood donation among others.

Mode of Transmission of HIV/AIDS

HIV infection is a contagious disease and can be transmitted from person to person. It is most commonly transmitted by having sex without a condom or by sharing needles infected with the virus. HIV is found in all the body fluids including saliva, nervous system tissue and spinal fluid, blood, semen, pre-seminal fluid (which is the liquid that comes out before ejaculation), vaginal secretions, secretions from the anus or anal lining walls, tears and breast milk. Only blood, semen, and breast milk have been shown to transmit infection to others Mandal (2015).

MATERIALS AND METHODS

Source of Data

A secondary data has been collected for this study. Recorded data on infected persons from both private and public hospitals in Gombe are collected for a period of 5 years (2011-2015) for male, females (non-pregnant) and pregnant women attending antenatal in the office of Gombe State Agency for control of AIDS (GOMSACA). This data is available on monthly basis from all 11 local governments across the state.

Population of the Study

The study population involved all people of Gombe. This include the males (adult), females (non-pregnant) and Pregnant women Attending Antenatal Care (A.N.C).

Method of Data Analysis

The methods adopted to analyse the data are; Multivariate time series model has been used to fits the model for IV/AIDS infections among the three groups. Descriptive statistics has been computed (in order to show the pattern of HIV/AIDS infection) among the three groups in the study area.

Vector Autoregressive (VAR) Model

The VAR model is one of the most successful, flexible and easy to use models for the analysis of multivariate time series. It is a natural extension of the univariate autoregressive model to dynamic multivariate time series. The VAR model has proven to be especially useful for describing the dynamic behavior of economic, financial and epidemiologic and health time series data and for forecasting Aydin, Cavdar (2015).

Stationary Vector Auto Regressive Model

Let $Y_t = (y_{1t}, y_{2t}, \ldots, y_{nt})'$ denote an $(n \times 1)$ vector of time series variables. The basic p-lag vector Autoregressive (VAR(p)) model has the form, Hamilton (1994).

$$Y_t = C + A_1 Y_{t-1} + A_2 Y_{t-2} \cdots + A_p 1 \quad (1)$$

where C denotes an n x 1 vector of constants and A_j is an n x n matrix of autoregressive coefficients for $j = 1, 2, . . . ,p$. The n x 1 vector ε_t is a vector generalization of white nois $E(\varepsilon_t) = 0$ $E(\varepsilon_t)$ as a covariance matrix

Test of Stationarity

Stationarity is defined as a quality of a process in which the statistical parameters (mean and standard deviation) of the process do not change with time Charles, Kitney (1991).

Augmented Dickey – Fuller Unit Root Test

This is used to test whether a unit root is present in any autoregressive model.

$$\Delta \boldsymbol{Y_t} = \boldsymbol{\alpha Y_{t-1}} + \boldsymbol{Y'_t \delta} + \boldsymbol{\varepsilon_t} \quad (2)$$

Where $\alpha = \rho - 1$ and $\Delta Y_t = Y_t - Y_{t-1}$, $\alpha \; and \; \delta$ are parameters to be estimated, and ε_t is the white noise.

Vector Error Correction (VEC) Models

A Vector Error Correction (VEC) model is used because the series are not stationary and are co-integrated. The VEC has co-integration relations built into the specification so that it restricts the long-run behavior of the endogenous variables to converge to their co-integrating relationships while allowing for short-run adjustment dynamics. The co-integration term is known as the error correction term since the deviation from long-run equilibrium is corrected gradually through a series of partial short-run adjustments.

When the variables are co-integrated, the corresponding error correction representations must be included in the system. By doing so, one can avoid misspecification and omission of the important constraints. Thus, the VAR in (3.1) can be reparameterise as a Vector Error Correction Model (VECM) form: Hamilton (1994)

The VECM model is specified as:

$$\Delta y_t = \alpha\beta^T y_{t-1} + \Gamma_1 \Delta y_{t-1} + \cdots + \Gamma_{p-1}\Delta y_{t-p+1} + \mu_t \quad (3)$$

with $A_i = \alpha\beta^T = -(I - A_1 - \cdots - A_i)$ and $\Gamma_i = -(A_{i+1} + \cdots + A_p)$ $i = 1, --, p-1$

$\beta =$ The long run equilibrium relationships between levels of variables

α = The changes in the variables to bring the system back to equilibrium

Γ_{ii} = The short run changes occurring due to previous changes in the variable

A_i Is an $n \times n$ matrix of autoregressive coefficient, $i = 1, 2, \dots \dots p$

Where the dimensions of α and β is k x r and r is the co-integration rank. The matrix α is the loading matrix and the coefficients of the long-run relationships are contained in β. Ai is a matrix of coefficient. The Γ_i matrices measure the transitory effects. And μ_t is the vector of white noise.

Johansen Co-integration Analyses

The variables in the VAR system may have a long-run equilibrium relationship to which any deviating variable is gradually pulled over time. The long-run equilibrium relationship is called the co-integrating vector. When there is a significant co-integrating vector, the VAR model should be augmented with an Error Correction term. In other words, pure VAR can be applied only when there is no co-integrating relationship among the variables in the VAR system. Hence, a prerequisite before running any VAR model is to run a co-integration test. If there is a set of k integrated variables of order one (I(1)), there may exist up to k-1 independent linear relationships that are I(0).

In general, there can be r≤ k-1 linearly independent co-integrating vectors, which are gathered together into the k x r co-integrating matrix. Thus, each element in the r-dimensional vector is I(0), while each element in the k-dimensional vector is I(1) Engle, granger (1987)

The test statistics is given below

$$\lambda_{trace}(r) = -T\sum_{i=r+1}^{N} \ln(1-\hat{\lambda}i) \qquad (4)$$

Where r is the rank of the matrix of the coefficient of the variable and r_o is the no of variables' is the number of observation $\hat{\lambda}i$ denotes the estimates of the characteristics root of matrix of the coefficient, r is the rank of the matrix of the coefficients.

RESULTS

Descriptive Analysis

In the empirical analysis, the data on HIV/AIDS infections for the three groups were analyzed using some descriptive statistics including the mean, standard deviation, upper and lower limit values of the series under study are presented in table 1 for the period of five years (2011 – 2015). The descriptive statistics presented in table 1 shows that the female group (non-pregnant) has the highest cases in each year followed by male group and pregnant group has the least cases with the lowest been in 2015. The large value of standard deviation indicates the highest dispersion in 2011 shows that female group have the highest infection followed by male group and pregnant women attending ANC has the least cases. The pregnant women group cases are still negligible in 2015 with the least standard deviation among the three groups.

Table 1: Descriptive statistics of HIV/AIDS cases 2011 – 2015

Group	Years	Total Cases	Min	Max	Median	Mean	S. D	Skewness	Kurtosis
Male	2011	1987	83	294	158	165.6	65.57	0.485	0.444
	2012	2038	117	240	173.5	169.8	41.74	0.304	- 1.078
	2013	2111	68	346	166	175.9	86.22	0.493	- 0.395
	2014	2099	110	240	177	174.9	45.91	0.405	0.018
	2015	1438	38	217	113	120	44.52	0.482	1.577
Female	2011	3124	39	525	247.5	260.3	119.3	0.501	1.869
	2012	3443	135	433	273	286.9	81.7	0.317	0.436
	2013	3310	75	442	256.5	275.8	114.1	- 0.061	- 0.813
	2014	2948	71	367	251	245.7	94.3	- 0.308	- 0.880
	2015	2235	123	308	180.5	186.2	58.0	0.775	0.097
Pregnant	2011	681	29	78	58.5	56.6	16.0	- 0.382	- 0.913
	2012	545	24	62	45.5	45.4	11.5	- 0.668	- 0.101
	2013	919	27	125	76.5	76.6	28.2	- 0.046	- 0.304
	2014	456	30	46	38.5	38.0	5.4	- 0.033	- 1.150
	2015	386	18	41	31	32.1	6.6	- 0.624	0.495

Multivariate Time Series Analysis

Test of Stationarity for Individual Series at level

The time series under consideration was checked for stationarity before we attempt to fit a suitable model. That is, variable has been tested for the presence of unit roots and found that the series are not stationary and made stationary at first difference, thereby, the order of integration of each series is determined.

Dickey fuller test for individual stationarity

Hypothesis

Ho: $\alpha = 0$ the data has a unit root (not stationary).

H_1: $\alpha \neq 0$ Data has no unit root (stationary) The time series data are tested for stationarity using adf. test function in tseries package in R. the test result in table 2 below indicates that the null hypothesis above that the series are not stationary could not be rejected for all the three variables. That is, respective P – values are less than the conventional significance level at $\propto = 0.05$. Since the null hypothesis cannot be rejected, in order to determine the order of integration of the non – stationary time series the same test was applied to the difference series. The order of the differencing is the number of unit roots to be used so as to make the series stationary

The Table 2: Result of Dickey Fuller test of stationary of the original series at level

Variable	Dickey-Fuller Statistics	P-Value	Decision
Male	- 2.3076	0.04506	Do not reject Ho
Female	- 3.446	0.0571	Reject Ho
Pregnant Women	- 3.1945	0.967	Do not reject Ho

The result in the table 2 above indicates that the null hypothesis is rejected for the first differences of the three series given that the p – value is less than 5% level of significance. Since the data of the three variables became stationary after the first differencing, implies that the three-time series are integrated of order one.

Table 3: Result of Dickey fuller test of stationary for the difference series at lag=2

Variable	Dickey – Fuller Statistics	p – value	Decision
Male Diff	- 6.5078	0.010	Reject Ho
Female Diff	- 5.0931	0.010	Reject Ho
Pregnant Diff	- 6.724	0.010	Reject Ho

Model lag length selection

In table 4 below shows the estimates of various performance measures for model selection at various lag length, the selection criteria for AIC, HQ and SC shows that lag 2 has the least information criteria, we use lag 2 as the best lag for our model selection.

The table 4: The estimates performance measures for model selection at different lag length.

Criterion	Lag p									
	1	2	3	4	5	6	7	8	9	10
AIC	6.66	6.49	6.52	6.54	6.58	6.64	6.67	6.64	6.54	6.57
HQ	6.67	6.11	6.65	6.70	6.87	6.87	6.94	6.94	6.88	6.94
SC	6.75	6.74	6.84	6.95	7.09	7.24	7.37	7.43	7.43	7.55

Co-integration Analysis

Since the variables are integrated of order one, we proceed to test for co – integration. Johansen (1988) co-integration test is applied at the pre – determined lag 2. In this test, trace statistic is compared to special critical value. The trace statistic test proceeds sequentially from the first hypothesis of no co – integration – to an increasing number of co – integrating vectors.

The Johansen co-integration test

The Johansen test for co-integration will be used to detect the presence and rank of co – integration for P = 2.

The test was carried out for $r = 0, 1, 2$ using function ca.jo contained in the "urca" package in R.The result of co-integration test for the time series data of the three groups in table 4 indicates that at least one co-integrating vector (r > 1) exist in the system at 99% confidence level (estimated test statistics 28.92 <42.38 at 99% critical value).

The presence of co-integration implies that an ordinary VAR model cannot be fitted, therefore, a VECM will be fitted for lag P = 2.

The Table 5: The Johansen co-integration test results using (urca package in R)

Ho	Test Statistics for p=2	1% critical value	Conclusion
r = 0	53.58	12.97	Reject Ho
r = 1	28.92	42.38	Do not reject
r = 2	18.68	68.82	Do not reject

Vector Error Correction Model (VECM) estimation

VECM will be fitted on the series for lag lengths p = 2. Recall that the co – integration rank r is 1.

The models are fitted using ca.jorls functions in package "urca" for p = 2, the VECM is given as:

β_{ij}coefficients $= \begin{pmatrix} 1.000 \\ -1.3904 \\ -0.1000 \\ -0.24483 \end{pmatrix}$ Shows that the Long – Run (LR) equilibrium relationship between levels of variables

α_{ij} coefficients $= \begin{pmatrix} -2.02120 \\ 0.2558 \\ -0.1198 \end{pmatrix}$ Show the amount of changes in the variable to bring the system back to equilibrium

Γ_{ii}coefficients $= \begin{pmatrix} -1.5604 & 0.1804 & 0.1526 \\ 1.4833 & -0.8141 & -0.1225 \\ 0.1061 & -0.0216 & -0.6275 \end{pmatrix}$ Show the short – run changes occurring due to previous changes in the variables.

The co – integration vector is$\beta^T = (1.000, -1.3904, -0.1000, -0.24483)$

$$(1.0000, - 1.39039, - 0.1000, - 0.24483) \begin{pmatrix} Male_t \\ Female_t \\ Pregnant_t \end{pmatrix}$$

And the equation of the long run equilibrium is as

$$Male_t = 1.3903 Female_t + 0.1000 Pregnant_t + 0.244 \quad (5)$$

The value 1.39039 suggests that a unit increase in female cases induces on average an increase of about 1.63522 Male cases, a unit increase of 0.10 in pregnant cases on average bring about an increase in 0.34463 in Male cases.

The VECM model is specified as

$$\Delta y_t = \alpha\beta^T y_{t-1} + \Gamma_1 \Delta y_{t-1} + \mu_t$$

$$\begin{pmatrix} \Delta Malet \\ \Delta Femalet \\ \Delta Pregnant \end{pmatrix} = \begin{pmatrix} -2.02126 \\ 0.25578 \\ -0.11979 \end{pmatrix} (1 - 1.3904 - 0.10000) \begin{pmatrix} \Delta Male_{t-1} \\ \Delta Female_{t-1} \\ \Delta Pregnant_{t-1} \end{pmatrix}$$

$$+ \begin{pmatrix} -1.56042 & 0.18044 & 0.15263 \\ 1.48327 & -0.81412 & -0.12248 \\ 0.10611 & -0.02156 & -0.62749 \end{pmatrix} \begin{pmatrix} \Delta Male_{t-1} \\ \Delta Female_{t-1} \\ \Delta Pregnant_{t-1} \end{pmatrix} \quad (6)$$

VECM for p = 2.

An expansion of the VEC equation above gives equations 1,2 and 3 gives

$\Delta Male_t = -2.021\ (\Delta Male_{t-1} - 1.3904\ \Delta Female_{t-1} - 0.1000\ Pregnant_{t-1} - 0.2448) - 1.5604\ \Delta Male_{t-1} + 0.1804\ Female_{t-1} + 0.1526\ \Delta Pregnant_{t-1}$ 1

$\Delta Female_t = 0.2558\ (\Delta Male_{t-1} - 1.3904\ \Delta Female_{t-1} - 0.1000\ Pregnant_{t-1} - 0.2448) - 1.4833\ \Delta Male_{t-1} - 0.8141\ Female_{t-1} - 0.1225\ \Delta Pregnant_{t-1}$ 2

$\Delta Pregnant_t = -0.1198(\Delta Male_{t-1} - 1.3904\ \Delta Female_{t-1} - 0.1000\ Pregnant_{t-1} - 0.2448) + 0.1061\ \Delta Male_{t-1} - 0.0217\ \Delta Female_{t-1} + 0.6275\ \Delta Pregnant_{t-1}$ 3

Where "Δ" stand for first difference (Δ), the value in the bracket is the error correction term and the values – 2.0213, 0.2558 and -0.1198 are the forces at which $Male_t$, $Female_t$ and $Pregnant_t$ are being pulled to the long-term equilibrium (they are adjustment coefficients which measures speed of convergence to equilibrium).

for $Male_t$, shows that the remaining longterm $Male_t$gap closes by -202 percent in each period (the negative sign ensures that $Male_t$, $Female_t$ and $Pregnant_t$ must be decreased in order to achieve a long run equilibrium).in Eq. 2, $Female_t$ closes by 25.6 percent in each period (this shows that $Male_t$, $Female_t$, and $Pregnant_t$ must be increased in order to achieve the long – run equilibrium) Eq. 1 . In Eq. 3 pregnant closes the gap by – 11.98 percent in each period (the negative sign shows that $Male_t$, $Female_t$, and $Pregnant_t$ must be decrease in order to achieve the long – run equilibrium.

DISCUSSION

HIV/AIDS is a major public health problem in Nigeria, where it affects vast majority of people especially those at tender age. It has been among the leading cause of morbidity and mortality in Nigeria and Gombe in particular, therefore studying the effect of HIV/AIDs disease in Gombe help to outline the relevant policy measures. The analysis was based on monthly data on HIV/AIDS collected from GOMSACA which span from 2011 to December 2015. The series considered were cases for male, female (non-pregnant) and pregnant women attending ANC groups. In the study Vector Autoregressive Model (VAR) was used, descriptive statistics and other relevant graphs were computed in order to describe the trend of the disease.

In order to examine VAR model, the unit root test (Adf test), identification of the number of lags and con-integration analysis were conducted, unit root test indicate that all the series are non-stationary at levels and are stationary at first difference at 5% level of significant, that is over the time period considered, all the three series showed a sign of stationarity after the first differencing. The Johansen co-integration test shows that there is at least one co-integrating vector, which describes the long run relationship between the three groups. The model used is of lag-length (P = 2).

Furthermore, a VEC model was fitted instead of a VAR model. This is as a result of the presence of co-integration of the series. And to ensure that the model is adequate, portmanteau test of serial correlation shows that the series were not serially correlated, Jarque-Bera test for multivariate normality of the series was conducted and the result shows that the variables come from normally distributed population. Forecasting was made using VEC to VAR in levels in order to further ascertain the model adequacy for forecast. The result showed that most of the predicted values have similar behaviors with actual values of the series for 2016-2017 as they are within the upper and lower confidence limit. Therefore, the model is adequate.

Descriptive statistics (such as the mean, median, standard deviation, minimum and maximum) for the HIV/AIDS cases in each group were also computed for the time period (2011-2015).

CONCLUSION

HIV/AIDS disease is a sexually transmitted disease. The study has shown that the female group (non-pregnant) which are at high risk of contracting the disease, A special consideration may be given to women attending antenatal clinic so as to prevent the transmission of mother to child infection. Equation (5) is the estimated Vector Error Correction Model (VECM) developed. This was tasted to forecast the future of HIV/AIDS cases for male, female (non-pregnant), and pregnant women were the fragile among the groups in Gombe. Consequently, there is a need for the government and other health related non-governmental Organizations to consider the results of this study when planning HIV/AIDS control measures, intensify effort of HIV/AIDS treatment and prevention in Gombe State.

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