Experimentation And Modeling Of Infective Treatment And Recovery Of HIV Patients (A Case Study Of Kwara State)

Ajayi S. K., Adeoye O. A, Aiyelabegan A. B

***Abstract*— The outbreak and spread of diseases have been studied for many years. The ability to make predictions about diseases could enable scientists to evaluate inoculation/vaccination or isolation plans and may have a significant effect on the mortality rate of a particular epidemic. Therefore this research experimentation and modeling of infective treatment and recovery of HIV patients (a case study of kwara state) will study the rate at which people contact the HIV, investigate how many people a person can infect at a particular point in time. , develop model for male and female with HIV, develop estimating functions for such a model and determine the control measures and sensitivities to change in parameter. Regression analysis, Chi – square and SIR model were use to analyse the data. Result of the analysis using regression analysis give the fitted model Y= 12.302 + 0.00009X and Y= 13.077 + 0.00007X for male and Female respectively. The result shows that the fitted model is adequate and the rate at which people contact HIV is increasing. Also chi - square analysis revealed that contacts of HIV is not depend on gender and that there are differences in respondents health when taking drugs recommended by health workers. Further analysis using SIR model shows that there will likely be epidemic on HIV and that 29% of the male that have HIV must be treated to avoid epidemics 9% of the female that have HIV must be treated to avoid epidemics. And we recommend that Health Planner should administer enough drugs to HIV patient on regular basis and Health Planner should educate people more on HIV and the preventive measure should be thought.**

***Index Terms*—HIV, AIDS, Helth, Modeling, Kwara**

I. INTRODUCTION

Human Immune Deficiency Virus (HIV) is a lent virus of the retrovirus family that causes Acquired Immune Deficiency Syndrome (AIDS). HIV infection is considered pandemic by world health organization (WHO). Since its discovery in 1981 to 2006, AIDS and HIV have killed more than 25 million people (Joint United Nations, 2006). HIV was first reported in the United State of America in 1981, but the causative agent was not identified until 1983 [1,4,6,8,] and was later named HIV type 1. In 1996, another sub type was discovered in men who migrated from Guinea Bissau. This was later name HIV type -2 [4,5,6,7,9]. Ever since, HIV infection has become a serious global public health problem, Africa being the hardest hit continent (Abdlazeez and Alo, 2006 According to a 2013 special report issued by the Joint United Nations Programme on HIV/AIDS (UNAIDS), the number of HIV positive people in Africa receiving anti-retroviral treatment in 2012 was over seven times the number receiving treatment in 2005, "with nearly 1 million added in 2012. The number of AIDS-related deaths in Sub-Saharan Africa in 2011 was 33 percent less than the number in 2005. The number of new HIV infections in Sub-Saharan Africa in 2011 was 25 percent less than the number in 2001.

HIV epidemic has assumed an alarming rate in Nigeria since it was identified in 1985 and reported at an international HIV conference in 1986 [1,2,3,].

The joint United Nations programme on HIV estimates that 3.5 million Nigeria adult and children were living with HIV in 2009. This increased to 3.6 million in 2011 and 6 million in 2013. However, there was a decline in number of people living with HIV in Nigeria to 2.6 million by the end of 2014. In Nigeria, the HIV prevalence rate among adults ages 15 – 49 is 3.9 percent. Nigeria has the third-largest number of people living with HIV (National Bureau of Statistics Bulleting 2013). The HIV epidemic in Nigeria is complex and varies widely from region to region. In some states, the epidemic is more concentrated and driven by high-risk behaviors, while other states have more generalized epidemics that are sustained primarily by multiple sexual partnerships in the general population. Youth and young adults in Nigeria are particularly vulnerable to HIV, with young women at higher risk than young men. The risk factors that contributed to the spread of HIV, includes; prostitution, high-risk practices among itinerant workers, high prevalence of sexually transmitted infections (STI), clandestine high-risk heterosexual and homosexual practices, international trafficking of women, and irregular blood screening etc.

Nigeria is emerging from a period of military rule that accounted for almost 28 of the 52 years since independence in 1960. Consequently, the policy environment is not fully democratized. Civil society was weak during the military era, and its role in advocacy and lobbying remains weak. The size of the population and the nation pose logistical and political challenges particularly due to the political determination of the Nigerian Government to achieve health care equity across geopolitical zones. The necessity to coordinate programs simultaneously at the Federal, State and Local Government levels introduces complexity into planning. The private sector is largely unregulated and, more importantly, has no formal connection to the public health system where most HIV interventions are delivered. Training and human resource developments are severely limited in all sectors and will hamper program implementation at all levels. Care and support are also limited because existing staff are

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overstretched and most have insufficient training in key technical areas to provide complete HIV services.

Health care in Nigeria is influenced by different local and regional factors that affect the quality or quantity present in one location. Due to the aforementioned, the health care system in Nigeria has shown spatial variations in terms of availability and quality of facilities in relation to need. However, this is largely as a result of the level of state and local government involvement and investment in health care programs and education. Also, the Nigerian Ministry of Health usually spends about 70% of its budget in urban areas where 30% of the population resides. It is assumed by some scholars that the health care service is inversely related to the need of patients.

II. HIV/AIDS SITUATION IN NIGERIA

The spread of HIV has increased significantly in Nigeria since the report of the first case in 1986. The result of periodic national surveys among anti-nantal clinic attendees has shown a progressive increase in the adult HIV zero prevalence rate from 1.85 in 1991 through 4.5% in 1996 to peak at 5.8% in 2001 before declining to 5.0% and 4.4% in 2003 and 2005 respectively. Going by the 2005 HIV prevalence, about 2.9 million people in Nigeria are estimated to be living with HIV and AIDS (FMOH, 2006b). Nigeria is currently experiencing a generalized epidemic with every state having a prevalence of over 1%, the 2005 national sero-prevalence rates showed that the HIV prevalence among the states ranged from 1.6% in Ekiti to 10.0% in Benue [4,5] in general, HIV prevalence is higher in urban areas than in rural areas.

HIV and AIDS have extended beyond the commonly classified high-risk groups and are now common in general population. HIV infection in Nigeria cuts across both sexes and all age groups. However, youth rates of 4.9% from 25 – 29 age group and 4.7% 20 – 24 age group. The number of HIV positive children is increasing. With mother to child transmission as the principal route of the infection. The number of children orphaned by AIDS is also increased substantially to an estimated 1.2 million [4.5]. From all indications, the HIV and AIDS epidemic has continue to grow largely through heterosexual unprotected sexual relationships, mother to child transmission and contaminated blood and blood products. Among the high risk groups, however, the findings from 2007 IBB85 showed that the most affected group is female sex workers (FSW) with HIV prevalence of 34% followed by men having sex with men (MSM) and injecting drug users (IDU) with prevalence of 13.5% and 5.6% respectively and the last is members of the Armed forces with HIV prevalence of 3.1% [4].

III. STATEMENT OF THE PROBLEMS

Health care in Nigeria is influenced by different local and regional factors that affect the quality or quantity present in a location. The health care system in Nigeria has shown spatial variations in terms of availability and quality of facilities in relation to need. However, this is largely as a result of the level of state and local government involvement and investment in health care programs and education

Youth and young adults in Nigeria are particularly vulnerable to HIV, with young women at higher risk than young men. The risk factors that contribute to the spread of HIV, includes; prostitution, high-risk practices among itinerant workers, high prevalence of sexually transmitted infections (STI), clandestine high-risk heterosexual and homosexual practices, international trafficking of women, and irregular blood screening etc therefore this research is aim study is to study the rate at which people contact the HIV and to investigate how many people a person can infect at a particular point in time.

IV. SIGNIFICANT OF THE STUDY

Identification of new infectious diseases, including the Lyme disease, the human immunodeficiency virus (HIV) as the etiological agent of the acquired immunodeficiency syndrome (AIDS), hepatitis C, or the severe acute respiratory syndrome (SARS), frequent reappearance of such infections as plague, cholera, and viral hemorrhagic fevers (Ebola, Marburg, etc.), emergence of antibiotic resistant strains of tuberculosis or gonorrhea, or an apparently never-ending fight to malaria, all keep a general interest in infectious diseases and their control . This interest is also fed by many recent popular books, movies and TV series that have given us exciting accounts of the emergence and detection of new disease.

It is obvious that human or animal invasions of new ecosystems, increased international travel, and changes in social and economic patterns will continue to provide opportunities for new and existing infectious diseases. Scientific experiments are usually the way to obtain information and to test hypotheses. Experiments in epidemiology are often difficult or impossible to design. Even if we are able to arrange an experiment, there are serious ethical questions involved in withholding treatment from a control group. Sometimes data may be collected from reports of epidemics or of endemic disease levels, but they are often incomplete or inaccurate. Hence, parameter estimation and model fitting are very difficult. As a result of this, an ecological and public health challenge shows that presence of infectious diseases has been addressed with mathematical models. In particular, understanding the transmission characteristics of infectious diseases can lead to better approaches to reducing the transmission of these diseases. Therefore this study will Provide conceptual results such as thresholds for disease invasion or plausibility of parasite eradication , analysis of epidemiological surveys, especially by suggesting crucial data that should be collected and this study can be used as experimental tools for testing control measures and determining sensitivities to changes in parameter values; and understanding the fundamental mechanisms that drive the spread of infectious diseases and suggesting strategies for the control

V. SCOPE OF THE RESEARCH

The sixteen local government areas of Kwara State and the following comprehensive centre's were covered UTIH, Cottage hospital Adewole ,Specialist Hospital Alagbado,comprehensive Health Centre Songa, General Hospital Omu aran, General Hospital offa, General Hospital Lafiagi, Sabo oke Health centre, General Hospital kaima, Specialist Heath centre Jebba, Children Specialist Hospital Centre gboro, Kwara state civil service clinic Ilorin and Kwara state civil service clinic Ilorin .

VI. METHODOLOGY

Use of Questionnaire was adopted as follows

- Pilot survey
- Proper Survey
- Post enumeration survey

The stage of the research project covers:

- Designing of questionnaire
- Administration of the questionnaire for various groups of people with HIV, health providers and general public.
- Data were collected, summarized and presented for analysis.

METHOD OF DATA ANALYSIS

SIR EPIDEMIC DISEASE MODEL

The SIR Epidemic Disease model characterized people into three classes: susceptibles, infective I and removed R. Removed individuals are no longer susceptible or infective for whatever reasons. For instance, they have recovered from the disease and now immune or they have been vaccinated or they have been isolated from rest of the population or perhaps they have died from the disease. Expected outcomes are based on the assumption that infective leave the I class with constant rate of recovery and move them directly into R class, such that

$$I(t+\Delta_t) = I_t + \beta\Delta_t S_t I(t) - \gamma I\Delta_t$$

$$\frac{dI}{dt} = \beta SI - \gamma I \quad \ldots (1)$$

$$S_{(t+\Delta_t)} = S_{(t)} - \beta\Delta_t S_{(t)} I_{(t)}$$

$$\frac{dS}{d_t} = -\beta SI \qquad \ldots (ii)$$

$$R_{(t+\Delta t)} = R_{(t)} + I\gamma\Delta_t$$

$$\frac{dR}{dt} = I\gamma \qquad \ldots (iii)$$

Where β is the infective rate and γ is the recovery rate

The SIR model addresses two fundamental questions: (1) Under what condition does an epidemic occur and (2) If an epidemic occurs, what fraction of the population needs to be immunized to control transmission of a disease? There will be an epidemic if $R_o = \beta\frac{N}{\gamma} > 1$ or an endemic if $R_o = \beta\frac{N}{\gamma} \prec 1$ Herd immunity threshold $H_t = \frac{B_R - 1}{B_R} = 1 - \frac{1}{B_R}$ percentage of the population that needs to be immune to control transmission of a disease.

Population S + I + R = N is constant, where

S--- Susceptible

I---Infective

R---Removed with immunity

β ---Contact Rate

R_o ----Basic Reproductive Number

N-----Total Population

S_o ----Number of initial susceptible individual

γ -----recovery rate

Linear Regression: $Y_i = \beta_0 + \beta_1 X_i + \varepsilon_i$

- Y_i - Outcome of Dependent Variable (response) for i[th] experimental/sampling unit
- X_i - Level of the Independent (predictor) variable for i[th] experimental/sampling unit
- $\beta_0 + \beta_1 X_i$ - Linear (systematic) relation between Y_i and X_i (aka also known as conditional mean)
- β_0 - Mean of Y when X=0 (Y-intercept)
- β_1 - Change in mean of Y when X increases by 1 (slope)
- ε_i - Random error term

Note that β_0 and β_1 are unknown parameters. We estimate them by the least squares method.

VII. RESULTS OF SURVEY

Table1: Shows that those that are married have the highest frequency total of 4820 with a percentage of 30.7% , those that are single has a percentage of 25.7%, Divorce has a percentage of 19.7%, single parent has a percentage of 15% ,Widow has a percentage of 8.9%.

Table 1: Shows Marital Status of the Respondents

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Single	4041	25.7	25.7	25.7
	Married	4820	30.7	30.7	56.4
	Divorce	3102	19.7	19.7	76.1
	Single parent	2366	15.0	15.0	91.1
	Widow	1394	8.9	8.9	100.0
	Total	15723	100.0	100.0	

Source: Survey 2017 by Ajayi, S.K ,Adeoye O.A , and Aiyelabegan A. B

Table 2: Showed that those with O'Level certificate has the highest frequency percentage of 23.8% , HND/BSC/PGDE has the percentage of 15.4%, ND/NCE has a percentage of 14.8% , Primary school certificate has the percentage of 13.4%, Vocational and MSC/MBA/MPhil both have the same percentage of 10.4% . Non-formal education has a percentage of 8.3%, while PhD has the percentage of 3.5%.

Table 2: Shows Educational Qualifications of the Respondents

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No formal Education	1311	8.3	8.3	8.3
	Primary School certificate	2100	13.4	13.4	21.7
	Vocational	1630	10.4	10.4	32.1
	O/Level	3741	23.8	23.8	55.9
	ND/NCE	2320	14.8	14.8	70.6
	HND/BSC/PGE	2429	15.4	15.4	86.1
	MSC/MBA/MPHIL	1640	10.4	10.4	96.5
	Ph.D	552	3.5	3.5	100.0

Table 2: Shows Educational Qualifications of the Respondents

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No formal Education	1311	8.3	8.3	8.3
	Primary School certificate	2100	13.4	13.4	21.7
	Vocational	1630	10.4	10.4	32.1
	O/Level	3741	23.8	23.8	55.9
	ND/NCE	2320	14.8	14.8	70.6
	HND/BSC/PGE	2429	15.4	15.4	86.1
	MSC/MBA/MPHIL	1640	10.4	10.4	96.5
	Ph.D	552	3.5	3.5	100.0
	Total	15723	100.0	100.0	

Source: Survey 2017 by Ajayi, S.K ,Adeoye O.A , and Aiyelabegan A. B

Table 3: Showed that Islam has the highest frequency percentage of 53.4%, while Christianity has a percentage of 39.0%. Table 3: Showed that Islam has the highest frequency percentage of 53.4%, Christianity has a percentage of 39.0%. while Traditional have 7.6%

Table 3: Shows Religion Distribution of the Respondents

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Christianity	6130	39.0	39.0	39.0
	Islam	8401	53.4	53.4	92.4
	Traditional	1192	7.6	7.6	100.0
	Total	15723	100.0	100.0	

Source: Survey 2017 by Ajayi, S.K ,Adeoye O.A , and Aiyelabegan A. B

Table 4: Shows if they really know how they got infected through what means. Through sexual intercourse has the highest frequency total of 4064 with a percentage of 41.0%, sharp objects has a percentage of 20.8%, mother to child infection has a percentage of 4.8%.

Table 4: Shows Through means of getting infected

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Through sexual intercourse	4064	25.8	41.0	41.0
	Through the use of sharp objects	3264	20.8	32.9	73.9
	Through blood transfusion	1839	11.7	18.5	92.4
	Through mother to child infection	750	4.8	7.6	100.0
	Total	9917	63.1	100.0	
Missing	System	5806	36.9		
	Total	15723	100.0		

Source: Survey 2017 by Ajayi, S.K ,Adeoye O.A , and Aiyelabegan A. B

Table 5 : Shows the rate at which people contact HIV

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	14141.895[a]	1	.000		
Continuity Correction[b]	14138.001	1	.000		
Likelihood Ratio	18180.541	1	.000		
Fisher's Exact Test				.000	.000
Linear-by-Linear Association	14140.996	1	.000		
N of Valid Cases	15723				

Source : Survey 2017 by Ajayi, S.K ,Adeoye O.A , and Aiyelabegan A. B

H_0 : the rate at which people contact HIV is not increasing

H_1 : the rata at which people contact HIV is increasing

Test statistic: Chi Square with Pvalue = 0.0000

Decision rule: Reject H_0 if P-value $\leq \alpha$ (0.05) , otherwise do not reject H_0

Decision: H_0 is rejected

Conclusion: Result of the analysis revealed that the rate at which people contact HIV is increasing

Table 6: Shows the rate at gender affect contact with HIV

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	1984.101[a]	1	.000
Likelihood Ratio	2052.982	1	.000
Linear-by-Linear Association	1400.434	1	.000
N of Valid Cases	15723		

Source : Survey 2017 by Ajayi, S.K ,Adeoye O.A , and Aiyelabegan A. B

H_0: contact of HIV is dependent on gender

H_1 : contact of HIV does not depend on gender

Test statistic: Chi Square with Pvalue = 0.0000

Decision rule: Reject H_0 if P-value $\leq \alpha$ (0.05) , otherwise do not reject H_0

Decision: H_0 is rejected

Conclusion: Result of the analysis revealed that contact of HIV is not depend on gender.

H_0 : there is no significant difference between my health status

Table 7 : Shows the male model on HIV

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	12.302	10.810		-11.961	.00
	MALE	0.00009	.142	.968	16.807	.00

Source : Survey 2017 by Ajayi, S.K ,Adeoye O.A , and Aiyelabegan A. B

The model is Y= 12.302 + 0.00009X for the male
H_0 : the model does not fit the data
H_1 : the model fits the data
Test statistic: P-value = 0.0000
Decision rule: Reject H_0 if P-value ≤ α (0.05) , otherwise do not reject H_0

Table 8 : Shows the ANOVA summary on male HIV model

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	18073.0	1	18073.089	291.7	.000[b]
	Residual	1176.91	19	61.943		
	Total	19250.0	20			

Source : Survey 2017 by Ajayi, S.K ,Adeoye O.A , and Aiyelabegan A. B
H_0 : the model does not fit the data
H_1 : the model fit the data
Test statistic: P-value = 0.0000
Decision rule: Reject H_0 if P-value ≤ α (0.05) , otherwise do not reject H_0
Conclusion: Since Pvalue less than α we reject H0 and conclude that the model fits the data .

Table 9 : Shows that the female model on HIV

				Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	13.07	11.08		-12.3	.00
	FEMALE	0.000	.145	.969	17.0	.00

Source : Survey 2017 by Ajayi, S.K ,Adeoye O.A , and Aiyelabegan A. B
The model is Y= 13.077 + 0.00007X for the Female

Table 10: Shows the ANOVA summary on female HIV model

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	18073.0	1	18073.0	291.7	.00
	Residual	1176.9	19	61.9		
	Total	19250.0	20			

Source : Survey 2017 by Ajayi, S.K ,Adeoye O.A , and Aiyelabegan A. B
H_0 : the model does not fit the data
H_1 : the model fit the data
Test statistic: Pvalue = 0.0000
Decision rule: Reject H_0 if P-value ≤ α (0.05) , otherwise do not reject H_0

Conclusion: Since Pvalue less than α we reject H_0 and conclude that the model fit the data .
Table 12: Shows the reproductive number of male and female

Table 12: Shows the reproductive number of male and female

	B	Γ	R_0	Ht
Male	0.00009	0.99991	1.4151	0.71
Female	0.00007	0.99993	1.1006	0.91

Source : Survey 2017 by Ajayi, S.K ,Adeoye O.A , and Aiyelabegan A. B
Since R_0 greater than 1 there will be likely epidemic on HIV and that 29% of the male that have HIV must be treated to avoid epidemics 9% of the female that have HIV must be treated to avoid epidemics.

VIII. Summary of Findings of the Study

Result of the analysis revealed that the rate at which people contact HIV will be increasing and also revealed that contact of HIV is not depended on gender. Moreover there are differences in the health status of HIV patient when taking drugs recommended by health workers. Regression analysis shows that the model is for male patients is Y= 12.302 + 0.00009X and model for female patient is Y= 13.077 + 0.00007X and both model fitted the data. Further analysis revealed that since R0 (Reproductive Number) greater than 1 there will be likely epidemic on HIV patient for male and that 29% of the male that are HIV must be treated to avoid epidemics and also 9% of the female that are HIV positive must be treated to avoid epidemics.

IX. RECOMMENDATION

1. Health Planner should educate people more on HIV and the preventive measures.
2. Health Planner should administer enough drugs to HIV patient on regular basis.
3. Government at federal, states and local government should encourage HIV patient to present themselves for test.
4. All agencies involve in educating the masses on HIV and AIDS should be funded adequately.
5. Government at federal, states, and local government should embark on a massive enlightenments and awareness at rural areas were 70% of the population resides.
6. More skill workers be engage as care and support group.

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