Websites:
http://www.nbmedicine.org
http://www.sciencepub.net/nurse

Emails:
editor@sciencepub.net
nbmeditor@gmail.com

Biomedicine and Nursing

MARSLAND PRESS
Multidisciplinary Academic Journal Publisher

Haematological Abnormalities Among HIV Positive Patients on Antiretroviral Treatment in a Nigerian State, South of the Niger Delta.

Aaron, U. U[1*]., Okonko, I. O.[2] and Frank-Peterside, N.[2]

[1]Department of Medical Microbiology and Parasitology, University of Port Harcourt, Nigeria.
[2]Virus Research Unit, Department of Microbiology, University of Port Harcourt.
*Corresponding Author: umasoye.aaron@uniport.edu.ng

Abstract: Haematological indices abnormalities occur when one or more of your blood cell types are lower or high er than they should be, especially among people living with HIV. Two hundred confirmed HIV-positive subjects we re randomly recruited from two health facilities in the Rivers States and sent to the laboratory immediately. These s amples were assayed for full blood count using Mindray BC-6800 automated system. Study shows that the lowest a nd highest blood cell count/L for haematological indices were WBC 1.3-11.9 x109L, Lymphocyte 0.3-6.4 x109L, Monocyte 0.2-2.6 x109L, Granulocyte 0.1-5.1 x109L and Platelet 30-550 x109L. This study supports the assertion t hat HIV infection comes with its attendant health challenges, including anaemia, leukocytopenia, and thrombocytop enia.

[Aaron, U. U., Okonko, I. O. and Frank-Peterside, N. **Haematological Abnormalities Among HIV Positive Patie nts on Antiretroviral Treatment in a Nigerian State, South of the Niger Delta**. *Biomedicine and Nursing* 2021;7 (3):1-7]. ISSN 2379-8211 (print); ISSN 2379-8203 (online). http://www.nbmedicine.org.
1. doi:10.7537/marsbnj070321.01

Key Words: *Lymphocytes, Granulocytes, Monocytes, HIV Infection, Prevalence, Full Blood Count.*

1. Introduction:

Changes in the appearance of the complete blood count are amid the numerous typical indications of human immunodeficiency virus (HIV) infection and a notable hurdle for managing acquired immunodeficiency syndrome (AIDS) within the Niger Delta region of Nigeria. However, the human immunodeficiency virus (HIV), one of the members of the lentivirus family, cause a range of symptoms anchored on the reduced immune function of its host by causing devastating effects on the host's innate immune capabilities, thus, permitting HIV replication in the host cell, leading ultimately to the HIV to infect new immune cells, and resulting into the susceptibility of the host to the infections. This condition is referred to as the Acquired Immunodeficiency Syndrome, AIDS (Aaron *et al.,* 2017; UNAIDS, 2019).

Certainly, Cytopenia may ensue at the point where one or more of your blood cell types is less than what it should be. Blood is constituted of red blood cells (erythrocytes, carrying oxygen and nutrients around your body), White blood cells (i.e., leukocytes responsible for fighting infections and unhealthy battle bacteria), and Platelets (essential for blood clotting). Specific cause, severity, and mode of action of cytopenia, when identified, could lead to a definite treatment or intervention that may indicate its correction (Goulet *et al.*, 2007). However, some conditions that could result in cytopenia could be complicated and varied. Nevertheless, amidst those conditions exists the following: infections, peripheral blood cell destruction, and side effects of the medicine. Two types of cytopenia related to the underlying cause of the low blood cell count are autoimmune cytopenia and refractory cytopenia (Holland and Falck, 2018).

Despite improving HAART access among HIV-infected subjects in Nigeria (Odili *et al*., 2017), morbidity and mortality attributable to the disease remain a significant burden and of public health concern for health authorities in the country as the life expectancy of people undergoing antiretroviral treatment remains lower compared with uninfected people (Ndashimye and Arts, 2019).

Consequently, in Rivers State, Nigeria, it had been reported that there were variations in the HIV prevalence of the different locations of the studies evaluated in this review. For example, in 2009, Okonko and Okoli, carrying out a hospital-based cross-sectional study among pregnant women in Port Harcourt, Nigeria, reported that most HIV seropositive females (41.2%) were within the age range of 31–42 years. However, mild anaemia among HIV-positive subjects has been seen in many studies as an effect of highly active antiretroviral therapy (HAART) (Owiredu *et al.*2008; Meidani, 2012; Gedefa, 2013; Fenta 2020), even when most of the haematological abnormalities in HIV are said to be prevented, alleviated, or corrected using HAART. This study aims to evaluate the

haematological indices of HAART experienced patients in Rivers State, with rugged terrains for adequate access to medical care in health emergencies.

2. Materials and Methods

2.1. Study Population: This present study involves 200 persons admitted randomly from two teaching hospitals in the state with referrals from all parts of Rivers States. This study accommodated people from all works of life, races, tribes, and religion.

2.2. Sampling Technique: All samples of confirmed HIV positive (n=200) patients were collected via venous puncture unto EDTA bottle and transported immediately to the laboratory for instant analysis.

2.3. Laboratory Analysis: Haematology indices were analyzed using Mindray BC-6800, an auto Haematology analyzer system, Mindray BC-6800. The machine is a highly specialized flow cytometer that works based on a combination of light scattering, electrical impedance, fluorescence, light absorption, and electrical conductivity principle to generate an entire red blood cell, platelet, and leukocyte counts/analysis. The whole blood was placed under the whole blood aspirator after proper mixing of the EDTA. Then, the sample mode is selected on the automatic haematology analyzer to allow for the aspiration of the well-mixed EDTA blood by the whole blood aspirator tip (inserted at least 1 inch into the blood) and put on the start button to activate. After 90 seconds, a complete full blood count report of the blood sample will be released, and results displayed on the auto Analyzer screen and then printed out within minutes.

Data collated were grouped based on WHO criteria and statistical analysis done using the SPSS version 21.

3. Results:

This study showed that 26.5% of study participants did not show any form of anaemia, 38% showed mild anaemia, 25.5% showed moderate anaemia, and 10% of the studied population had severe anaemia (Figure 1).

Also, in this study, the prevalence of leucopenia was 26%, thrombocytopenia was 32%, while anaemia was 73.5% (Figure 2).

Result from this study shows that the lowest and highest blood cell count/L for haematological indices were WBC 1.3-11.9 x109L, Lymphocyte 0.3-6.4 x109L, Monocyte 0.2-2.6 x109L, Granulocyte 0.1-5.1 x109L and Platelet 30-550 x109L (Table 1).

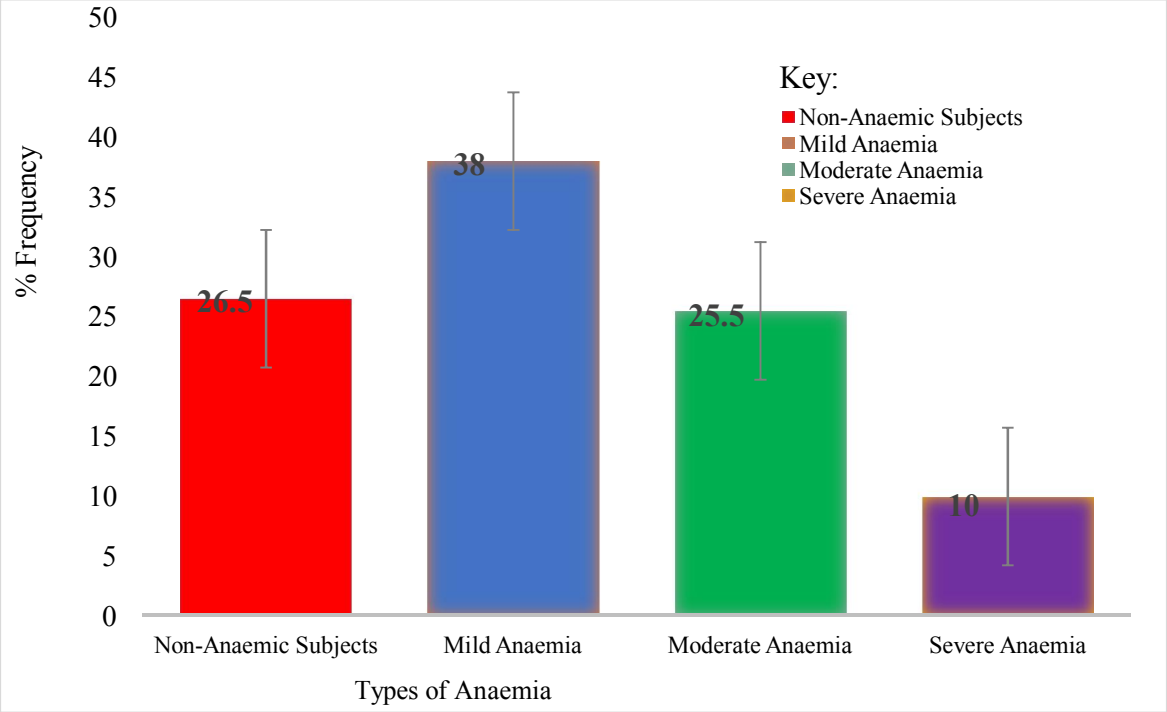

Fig. 1: Bar Chart Showing Percentage Frequency of Anaemia Types Observed in the Study

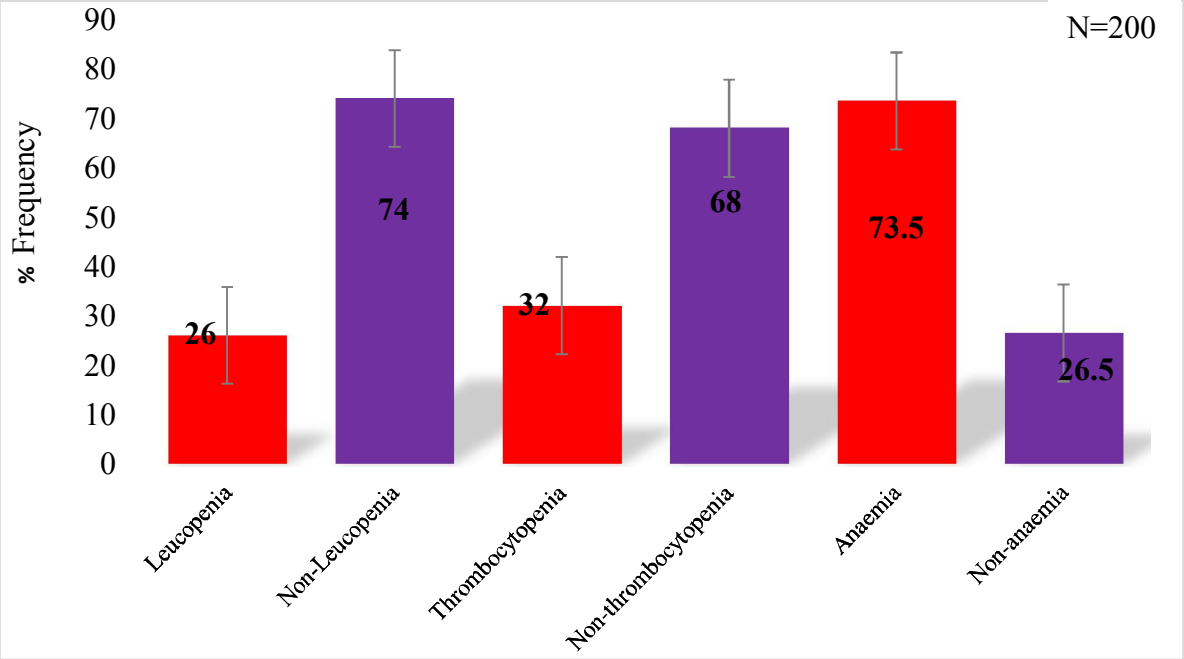

Fig. 2: Bar Chart Showing Percentage Frequency of Haematological Abnormalities in the Study

Table 1: Table Showing the Effect of Haematological Parameters on HIV Based on Age

Variable	Parameters	Mean±SD	F-value	P-value	Implication
White Cell Indices	WBC x10^9L	5.52±1.85	2.25	0.000	Significant
	LYM	50.78±15.69	2.59	0.000	Significant
	MON	15.93±8.68	2.79	0.000	Significant
	GRAN	33.28±18.05	2.64	0.000	Significant
	LYM x10^9L	2.74±1.14	2.79	0.000	Significant
	MONO x10^9L	0.83±0.48	3.48	0.000	Significant
	GRAN x10^9L	1.94±1.30	2.25	0.000	Significant
Red Cell Indices	RBC x10^{12}L	4.42±0.75	3.93	0.000	Significant
	HB (g/dl)	10.49±2.30	2.73	0.000	Significant
	HCT	40.52±6.99	3.03	0.000	Significant
	MCV (fL)	92.03±6.68	2.23	0.000	Significant
	MCH (pg)	23.43±2.32	2.07	0.000	Significant
	MCHC (g/dL)	25.46±1.23	3.48	0.000	Significant
	RDWCV	14.27±1.38	1.23	0.200	Not Significant
	RDWSD (fL)	49.00±3.29	3.44	0.000	Significant
	MPV (fL)	9.51±1.00	2.79	0.000	Significant
Platelet Indices	PLT x10^9L	223.10±84.52	2.90	0.000	Significant
	PDW (fL)	13.04±5.23	2.56	0.000	Significant
	PCT	0.46±2.39	0.92	0.620	Not Significant
	PLCR	25.17±7.01	2.45	0.000	Significant
	PLCC x$10^{9/}$L	52.51±17.07	3.36	0.000	Significant

***Key**: SD= Standard Deviation of Mean; WBC=White Blood Cell; LYM=Lymphocytes; MON=Monocytes; RDW-SD: Red Cell Distribution Width–Standard Deviation; PLT: Platelets; MPV: Mean Platelet Volume; PDW: Platelet Distribution Width; PCT: Plateletcrit; P-LCC/L: Platelet large cell count. Within parameters and across interactive measures, means ± SD with different superscripts is significantly different at p<0.05. Significance Level: p<0.05; Not Significant (p>0.05). N=200.*

4. Discussion:

The rate of progression of HIV patients into complicated diseases will largely be proportional to the degree of suppression of the immune system and the extensive reduction in the full blood count indices of the patients. This study showed that the lowest and highest count/L for haematological indices were WBC 1.3-11.9 x109L, Lymphocyte 0.3-6.4 x109L, Monocyte 0.2-2.6 x109L, Granulocyte 0.1-5.1 x109L and Platelet 30-550 x109L. After analysis, there was observed a significant difference in the study subjects when compared against their ages.

Similarly, there was a significant difference in the haematological parameters based on the gender of the studied subjects and Lymphocyte count (2.742+1.14) (P=0.046), granulocyte count (1.943+1.39) (P=0.000), and platelet count (223.10+84.52) (P= 0.023). Contrastingly, there were no significant observable differences in the Monocyte count (0.838+0.48) (P=0.494) of the study subjects.

These differences in the haematological indices of the subjects will most likely be associated with the effect of HIV infection on hemopoiesis, even though the origin of haematological disorders in HIV infection remains inadequately understood. Still, some worth attributed to dysfunctional hematopoiesis in bone marrow caused by several other factors. These intrinsic factors may include severe nutritional stress in advanced stages of HIV infection, suppression of the bone marrow by invading opportunistic infections or neoplasm, chronic disease-associated changes, and toxic side effects of antiretroviral compounds (Parinitha and Kulkarni, 2012).

However, this leads to the conclusion that adherence to the therapeutic regimen influences the development of thrombocytopenia. A recent study shows that, among those PLWHA who were ART-naïve, the prevalence of thrombocytopenia was 64.6%, whereas, among HIV-infected individuals on ART, the prevalence of thrombocytopenia is 6.9% (Marchionatti and Paris, 2020).

Furthermore, this study showed that the introduction of antiretroviral therapy (ART) also seems to have a dichotomous effect on the haematological compartment, which, in some cases, may exacerbate anaemia (Mildvan *et al*., 2007) and reduction thrombocytopenia due to reduction in cellular breakage and release of viral particles, products of HIV reproduction (Marchionatti and Paris, 2020). However, the mechanism of thrombocytopenia in HIV infection appears to involve increased platelet destruction and ineffective platelet production (Henry *et al*., 2005).

Most utmost reports indicate significant platelet sequestration and destruction in the spleen in HIV-associated thrombocytopenia (Marchionatti and Paris, 2020). Some have reported platelet destruction is predominant and early in the disease, whereas decreased platelet production was the dominant factor later (Henry *et al*., 2005). Studies of megakaryocytes from HIV-infected patients have shown viral RNA and proteins suggesting that these cells are infected in vivo (Louache *et al*., 1991; Henry *et al*., 2005).

Although there was no observable statistical difference in the red cell indices of the studied population, the results showed a mean haemoglobin value of 10.49g/dl, which was in the same range as that produced by Parinitha and Kulkarni (2012) study. This study referred to World Health Organization (WHO) haematological reference ranges and as used. This study will define anaemia as Hb<12.0g/dL for females and Hb<13.0g/dL for male subjects. Regarding the above, and for the interpretation of results of this present study, Hb of 10.0 to 12.0 g/dL (for females) or 10.0 to 13.0 g/dL (for males) was considered mild anaemia. In comparison, moderate anaemia was defined as Hb between 8.0 and 10.0 g/dL for both sexes, and Hb < 8.0 g/L. Thus, this study showed an average haemoglobin level of 10.49 g/dl and a 9.5% (19/200) prevalence of severe anaemia, 22.5% (51/200) prevalence of moderate anaemia, and mild anaemia 54.5%.

Comparatively, the result of this present study was in line with the reports of Meidani *et al.* (2012) and agreed with many previous studies from various research in Nigeria; Pennap and Abubakar (2015) reported 64% anaemia prevalence among HIV infected subjects from Keffi while Omoregie *et al*., (2013) reported a prevalence of 69.7% in Benin.

In other climes of Africa, 77.4% anaemia was reported in Tanzania (Johannessen *et al*., 2011), 25.8% anaemia was reported in South Africa (Takuva *et al*., 2013), 34.6% in Ethiopia (Zerihun *et al*., 2019), and 23.8% anaemia was observed among HIV patients in Ghana (Obirikorang *et a*l., 2016).

And in other parts of the world, an anaemia prevalence of 85% was observed among ART-naïve patients in India Sah *et al*., 2020), a result that was slightly higher than this study's anaemia prevalence among the HIV infected individuals investigated, while another report from northern India (16.2%) (Sah *et al*., 2020) was incomparable with the result of this study.

Consequently, variations within full blood count could lead to cytopenia. However, this could be made worse with the resource-poor and tropical settings we find ourselves in; anaemia is mainly caused by underlying nutritional deficiencies and endemic parasitic infections, such as malaria and helminths, which lead to red blood cells destruction, decreased production, or loss. In sub-Saharan Africa, hemoglobinopathies such as sickle cell disease represent an additional cause of anaemia in HIV patients (Odhiambo *et al*., 2015; Asemota *et al*., 2018).

Similarly, other situations frequently linked to cytopenia range from cancers of the blood (like leukaemia, multiple myeloma or Hodgkin's or non-Hodgkin's lymphoma), bone marrow disease, severe B-12 deficiency, chronic liver disease, autoimmune disease, viral infections, including HIV, hepatitis, and malaria, blood diseases that destroy blood cells or prevent blood cell production, such as paroxysmal nocturnal, hemoglobinuria and aplastic anaemia (Kallianpur *et al.,* 2016; Falck and Holland, 2018).

5. Conclusion

This study supports the assertion that HIV infection comes with its attendant health challenges, including anaemia, leukocytopenia, and thrombocytopenia at varying proportions based on several other factors. In this present study, the distribution of blood cell line abnormalities was not dependent on gender but largely depended on the age of study participants. This study further buttressed that HAART, when consistently administered, may not altogether exempt an HIV patient from having any cytopenia. Perhaps, this supports the assertion that HIV patients, in addition to antiretroviral treatment, need utmost rest between activities and should avoid or cease forth with such events that make you short of breath or make your heartbeat faster, eat a balanced diet with adequate protein and vitamins and drink plenty of non-caffeinated and non-alcoholic fluids to enhance their haematological indices and boost their general health to fight the disease.

References

[1]. Ogbonna, C. N., Innocent, I. C., Martin A. N., Abali C. and Ejele O. (2013). The Relationship between Haematologic Indices/Immunologic Markers and HIV Disease in Antiretroviral-Native HIV Seropositive Individuals in the Niger Delta Region of Nigeria. *IOSR Journal of Dental and Medical Sciences*, 4(5). DOI: 10.9790/0853-0454650.

[2]. Eziuzo, C.I., Chinko, B.C. and Dapper, D. V. (2017). Comparative Assessment of Some White Blood Cell and Platelet Parameters among Normotensive and Hypertensive Subjects in Port Harcourt, Nigeria. *Nigerian Medical Journal: Journal of the Nigeria Medical Association*, 58(4),131-137.

[3]. Azuonwu, O., Frank-Peterside, N., Ibe, S. N., and Erhabor, O. (2012). Correlates between HIV/AIDS Antibody with some Immuno-Hematological Variables of Infected Subjects in Niger Delta Communities. *Journal of Applied Pharmaceutical Science*, 2 (8), 85-91.

[4]. Abdulqadir, I., Sagir, G. A., Kuliya, A.G., Tukur, A., Yusuf, A. A. and Musa, A. U. (2018). Hematological parameters of human immunodeficiency virus-positive pregnant women on antiretroviral therapy in Aminu Kano Teaching Hospital Kano, North-Western Nigeria. *Journal of Laboratory Physicians*, 10(1), 60–63.

[5]. Chemocare (2021). Low Blood Count. Retrieved from http://chemocare.com/chemotherapy/side-effects/low-blood-counts.aspx on 14th June 2021.

[6]. Holland, K. and Falck, S. (2018). What is Cytopenia https://www.healthline.com/health/cytopenia#types

[7]. Vishnu, P. and Aboulafia, D. M. (2015). Haematological Manifestations of Human Immune Deficiency Virus Infection. *British Journal of Haematology*, 171(5), 695–709.

[8]. Mildvan, D., Creagh, T., Leitz, G. and Anemia Prevalence Study Group (2007). Prevalence of anemia and correlation with biomarkers and specific antiretroviral regimens in 9690 Human-Immunodeficiency-Virus Infected Patients: Findings of the Anemia Prevalence Study. *Current Medical Research Opinion*, 23(2), 343–355.

[9]. Kallianpur A. R., Wang, Q., Peilin, J., Hulgan, T., Zhao, Z., Letendre, S. L., Ellis, R. J., Heaton, R. K., Donald, R. F., Barnholtz-Sloan, J., Collier, A. C., Marra, C. M., David, B. C., Benjamin, B. G., Justin, C. M., Morgello, S., David, M. S., McCutchan, J. A., and Igor Grant, for the CHARTER Study Group (2016). Anemia and Red Blood Cell Indices Predict HIV-Associated Neurocognitive Impairment in the Highly Active Antiretroviral Therapy Era. *Journal of Infectious Diseases,* 213(7), 1065–1073.

[10]. Coyle, T. E. (1997). Hematologic Complications of Human Immunodeficiency Virus Infection and the Acquired Immunodeficiency Syndrome. Medicine Clinic of North America, 81(2),449-470.

[11]. Ejele, O. A, Nwauche, C.A.and Erhabor, O (2004). The prevalence of Hepatitis B surface antigenaemia in HIV positive patients in the Niger Delta Nigeria. Niger Journal of Medicine, 13(2), 175-179.

[12]. Frank-Peterside, N., Okonko, I.O., Okerentugba, P. and Jaja, N. (2012). Detection of HIV 1 and 2 Antibodies among Pregnant Women in Port Harcourt, Rivers

State, Nigeria. World Applied Sciences Journal, 16 (4), 589-598.
[13]. Gebremedhin, K.B. and Haye, T.B (2019). Factors associated with anemia among people living with HIV/AIDS taking ART in Ethiopia. Advanced Hematology, 1–8.
[14]. Goulet, J. L., Fultz, S. L., McGinnis, K. A. & Justice, A.C. (2005). HIV Drug Resistance. AIDS 19 (3), S99–105.
[15]. Goulet, J. L., Fultz, S. L., Rimland, D., Butt, A., Gilbert, C., Rodriguez-Barriadas, M., Bryant, K., & Justice, A. C. (2007). Do Patterns of Comorbidity Vary by HIV Status, Age, and HIV Severity? Clin Infect Dis., 45(12): 1593–1601.
[16]. Gregory T. R. (2007). Understanding Natural Selection: Essential Concepts and Common Misconception. Clinical Microbiology Reviews, 20(4), 550–578.
[17]. Hemelaar, J., Gouws, E., Ghys, P. D. and Osmanov, S. (2005). Global and regional distribution of HIV-1 genetic subtypes and recombinants in 2004. AIDS, 20(16), 13–23.
[18]. Holguín, A., Suñe, C., Hamy, F., Soriano, V. and Klimkait, T. (2006). Natural polymorphisms in the protease gene modulate the replicative capacity of non-B HIV-1 variants in the absence of drug pressure. Journal Clinical Virology, 36(4), 264-271.
[19]. Holland, J., Spindler, K. and Horodyski, F. (2019). Rapid evolution of RNA genomes. Science, 215, 1577.
[20]. Honess, R. W., Buchan, A., Halliburton, I. W. and Watson, D. H. (1980). Recombination and linkage between structural and regulatory genes of herpes simplex virus type I: study of the functional organization of the genome. Journal of Virology, 34, 716.
[21]. Huisman, W., Martina, B.E.E., Rimmelzwaan, G.F., Gruters, R. A., and Osterhaus, A.D.M.E. (2009). Vaccine-induced enhancement of viral infections. Vaccine, 27(4), 505–512.
[22]. I-base (2016). Treatment Training Manual: Use of CD4 Count for Starting Therapy (ART). Retrieved from https://i-base.info/ttfa/section-1/13-use-of-cd4-count-for-starting-therapy/ on 9/1/2021.
[23]. Macfarlane, S. B. (1997). Conducting a Descriptive Survey: Choosing a Sampling Strategy. Tropical Doctors, 27(1), 14-21.
[24]. Mbakwem-Aniebo C., Ezekoye, C.C. and Okonko, I.O. (2012) Detection of HIV-1 and -2 Antibodies among freshman of the University of Port Harcourt, Port Harcourt, Southern Nigeria
[25]. Meidani, M., Farshid, R., Mohammad, R. M., Majid, A. and Katayoun, T. (2012). Prevalence, severity, and related factors of anemia in HIV/AIDS patients. Journal of Resources in Medical Science, 17(2), 138–142.
[26]. Moir, S., Chun, T. & Fauci A. S. (2011). Pathogenic Mechanisms of HIV Disease. Annual Review of Pathology: Mechanisms of Disease, 6, 223-248.
[27]. Moore, R. D. (1999). Human Immunodeficiency Virus Infection, Anemia, and Survival. Clinical Infectious Diseases, 29(1),44–49.
[28]. Murrell, D. (2020). Facts About HIV: Life Expectancy and Long-Term Outlook. https://www.healthline.com/health/hiv-aids/life-expectancy. Retrieved 28/12/2020.
[29]. NACA (2017). National Strategic Framework on HIV and AIDS: 2017 -2021. Retrieved from www.naca.gov.ng. on 23rd December 2019.
[30]. Naing, L., Winn, T., and Rusli, B.N. (2006). Practical issues in calculating the sample size for prevalence. Studies Archives of Orofacial Sciences, 1, 9–14.
[31]. National Agency for the Control of AIDS (2015). End of Term Desk Review Report of the 2010-2015 National HIV/AIDS Strategic Plan, Abuja, Nigeria, Pp. 46.
[32]. National Agency for the Control of AIDS (2017). Federal Republic of Nigeria Global AIDS Response Country Progress Report Nigeria GARPR 2017. Abuja, Nigeria, Pp: 46. http://www.unaids.org/sites/default/files/country/documents/NGA_narrative_report_2017.pdf. Retrieved on May 28, 2020.
[33]. National Agency for the Control of AIDS (NACA) and Joint United Nations Programme on AIDS-UNAIDS. (2019). Nigeria HIV/AIDS Indicator and Impact Survey (NAIIS). https://www.unaids.org/en/resources/presscentre/pressreleaseandstatementarchive/2019/march/20190314_nigeria. Retrieved on August 16, 2019.
[34]. National Population Commission (2006). The 2006 Nigeria Demographic and Health Survey. Federal Republic of Nigeria, Abuja, Nigeria. Retrieved from www.npc.gov.ng on 13 January 2021.
[35]. Ndashimye, E. and Arts, E. J. (2019). The urgent need for more potent antiretroviral therapy in low-income countries to achieve UNAIDS 90-90-90 and complete eradication

of AIDS by 2030. Infectious Diseases of Poverty, 8, 63. https://idpjournal.biomedcentral.com/articles/10.1186/s40249-019-0573-1.

[36]. Niel, C. (2001). Antigen Testing; HIV Viral Antigen Assays. HIV InSite Knowledge Base Chapter. http://hivinsite.ucsf.edu/insite?page=kb-02-02-02-02 accessed on 29th December 2020.

[37]. Obirikorang, C., Issahaku, R. G., Osakunor, D. N. M and Osei-Yeboah, J. (2016). Anaemia and iron homeostasis in a cohort of HIV-infected patients: a cross-sectional study in Ghana. *AIDS Research and Treatment,* 2016, 1–8.

[38]. Okonko, I. O. and Okoli, M. (2019). Determination of antibodies to human immunodeficiency virus type 1, 2, O and P24 – antigen in pregnant women in Port Harcourt Nigeria. *Journal of Immunoassay and Immunochemistry,* 41(2), 208-218, DOI: 10.1080/15321819.2019.1708387.

[39]. Omoregie, R., Omokaro, E. and Palmer, O. (2009). Prevalence of anaemia among HIV-infected patients in Benin City, Nigeria. Tanzanian Journal of Health Resources, 11(1), 546-561.

[40]. Parinitha, S. S. and Kulkarni, M. H. (2012). Haematological Changes in HIV Infection with correlation to CD4 cell count. Australias Medical Journal, 5(3), 157–162.

[41]. Pennap, G. R. and Abubakar, K. (2015). Prevalence of anemia among human immunodeficiency virus-infected patients accessing healthcare in federal medical centre Keffi, Nigeria. International Journal of Tropical Disease Health, 10(3),1–7.

[42]. Redig, A. J. and Berliner, N. (2013). Pathogenesis and Clinical Implications of HIV-Related Anemia in 2013. ASH Educational Program Book, 2013(1), 377–381.

[43]. UNAIDS (2017). Fact Sheet. https://www.unaids.org/sites/default/files/media_asset/20150901_FactSheet_2017_en.pdf. Retrieved on 24th August 2019.

[44]. UNAIDS (2021). Gender and HIV/AIDS: Taking stock of research and programmes—1211 Geneva 27 — Switzerland. www.unaids.org. retrieved on 23rd May 2021.

[45]. UNAIDS/WHO (2018). Global HIV & AIDS statistics — 2019 fact sheet. Retrieved from https://www.unaids.org/en/resources/fact-sheet. Retrieved 21st December 2019.

[46]. United Nations AIDS Programme, UNAIDS (2017). Global Statistics, 2030 -Ending the AIDS epidemic. The Joint United Nations Programme on HIV/AIDS (UNAIDS) Fact Sheet 2017, pp1-16.

[47]. United Nations AIDS Programme, UNAIDS (2018). HIV/AIDS: State of the Epidemic. UNAIDS Joint United Nations Programme on HIV/AIDS, UNAIDS/JC2929E, Geneva, Switzerland, pp370. https://www.unaids.org/sites/default/files/media_asset/unaids-data-2018_en.pdf. Retrieved on 24th August 2019.

[48]. World Health Organization (2014). HIV report on Nigeria. Retrieved from www.who.hiv-fact-sheet/nigeria on 23rd October 2019.

[49]. World Health Organization. HIV/AIDS Fact Sheet. July 2018. Available at http://www.who.int/mediacentre/factsheets/fs360/en/ Accessed 7 February 2019.

8/12/2021