Advances in Life Science and Technology
ISSN 2224-7181 (Paper) ISSN 2225-062X (Online)
Vol.48, 2016

Effects of Human Immunodeficiency Virus Infection on Hematological Parameters Among Antenatal Clinic Attendees at Jaramogi Oginga Odinga Teaching and Referral Hospital

Nancy Ogejo Asewe
Department of Medical Laboratory Sciences, School of Health Sciences, Mount Kenya University, P O BOX 342 - 01000, Thika - Kenya

Abstract
Human Immunodeficiency Virus has been a major health challenge in many parts of the world. WHO and UNAIDS estimated that 35.3 million people were living with HIV at the end of 2012. Sub-Saharan Africa had 70% of all new HIV infections and Kenya had the third largest population of people living with HIV. In Kenya the average national HIV prevalence among people aged 15 – 64 years was at 5.6% in 2012. There are no studies that have been carried out in Nyanza province in Kenya to check on point prevalence of HIV in relationship to hematological parameters at the ante natal clinic thus a literature gap exists. The aim of this study was to find out if there is any effect of human immunodeficiency virus infection on hematological parameters among antenatal clinic attendees and also to provide information on the hematological parameters that HIV had an effect on thus to show necessity of hematological parameters being part of tests to be carried out in routine ante natal clinic exam. The study involved screening of 197 ante natal clinic attendees using normal continuous sampling technique. Determine® and Unigold® were used to determine their HIV status. Hematological parameters were analyzed using Beckman coulter counter. Data was collected using questionnaire by interviewing the ante natal clinic attendees and individual laboratory results recorded in case report form. Data was analyzed using IBM SPSS version 21 the data was expressed as mean $\pm$ standard error of means. Analysis of Variance (ANOVA) was carried out to compare differences between HIV status and hematological parameters. Results showed that majority of the respondents 76.6% 151 were married. Most of the respondents 55.3% 109 had secondary education. Majority of the respondent 76.1% were not employed. The results indicated that none of the social status was significant with HIV status at $P < 0.05$ level. HIV status in relation to hematological parameters eosinophils was significant at $P < 0.05$ with a value of 0.015. Other parameters significant were HCT 0.049, MCV at 0.000, MCHC 0.029, Platelets 0.032, MPV 0.002, and PDW 0.008. The conclusion was that it is necessary to have hematological parameters checked as part of the routine ante natal clinic test so as to help treat opportunistic infections at an early stage.
Keywords: Ante natal clinic attendees

1. Introduction

Human Immunodeficiency Virus (HIV) is a retrovirus that infects immune competent cells causing an impairment of host defense. After the introduction of Highly Active Antiretroviral Therapy (HAART) in 1996 HIV infection epidemiology has changed turned a fatal disease in a treatable chronic infection with an improved quality of life and a reduction of morbidity and mortality (Palella et al, 1998). Africa has the largest burden of HIV infection and AIDS worldwide (UNAIDS, 2006). WHO and UNAIDS estimates 35.3 million people were living with HIV at the end of 2012 (UNAIDS, 2013). Two thirds of HIV infections were in sub-Saharan Africa (WHO, 2014). Sub-Saharan Africa had 70% of all new HIV infections in 2012. Kenya had the third largest population of people living with HIV in sub-Saharan Africa according to UNAIDS report in 2013. In Kenya, the average national HIV prevalence among people aged 15 – 64 years was at 5.6% in 2012 (KAIS 2012). "HIV infects and depletes CD4+ T lymphocytes and monocytes /macrophages, putting patients at risk for opportunistic infection and malignancy, the major causes of death due to HIV and AIDS" (Hochman et al, 2012). Women are most infected by the Acquired Immunodeficiency Syndrome (AIDS) in Africa; a region which accounts for 70% of Human Immunodeficiency Virus (HIV) infection (UNAIDS 2009). Current HIV prevention behavioral messages on abstinence, faithfulness and condom promotion have had limited impact on HIV incidence rates in women, especially in sub-Saharan Africa, where young women bear the greatest HIV burden (Abdool et al, 2009).

1.1 HIV TRANSMISSION

HIV is transmitted by three main routes: sexual intercourse, exposure to infected body fluids or tissues and from mother to child during pregnancy, delivery or breastfeeding (known as vertical transmission) (Thorne 2007). The most frequent mode of transmission of HIV is through sexual intercourse with an infected person. Risk of HIV transmission increases in the presence of many sexually transmitted infections (Anderson 2012). HIV transmission is directly related to the infected individual's viral load (Quinn et al, 2000). It is believed that

genital ulcers appear to increase the risk approximately by fivefold (Beyrer 2012).

1.2 COURSE OF HIV INFECTION

There are three main stages of HIV infection: acute infection, clinical latency and AIDS.

1.2.1 Acute infection

"The initial period following the contraction of HIV is called acute HIV, primary HIV or acute retroviral syndrome" (James et al. 2006). Many individuals develop an influenza like illness or a mononucleosis like illness 2 to 4 weeks post exposure while others have no significant symptoms (Marshal 2008). Symptoms occur in 40 to 90% of cases and most commonly include fever, large tender lymph nodes, throat inflammation, rash, headache and/or sores of the mouth and genitals. Gastrointestinal symptoms such as nausea, vomiting or diarrhea may occur as may neurological symptoms of peripheral neuropathy. The duration of the symptoms varies but is usually one or two weeks (Vogel et al. 2010). Acute infections are responsible for 89% of HIV transmission (Pinkerton 2008).

1.2.2 Clinical latency

The initial symptoms are followed by a stage called clinical latency, asymptomatic HIV or chronic HIV. This stage can last 3 to over 20 years. While typically there are few or no symptoms at first near the end of this stage many people experience fever, weight loss, gastrointestinal problems and muscle pains (Evian 2006).

1.2.3 Acquired Immunodeficiency Syndrome

Acquired immunodeficiency syndrome (AIDS) is defined in terms of either a CD4 T cell count below 200 cells per µl or the occurrence of specific diseases in association with an HIV infection. The most common initial conditions that alert to the presence of AIDS are cachexia in the form of HIV wasting syndrome in (20%) cases and esophageal candidiasis. Other common signs include recurring respiratory tract infections (Vogel 2010). Opportunistic infections may be caused by bacteria, viruses, fungi and parasites that are normally controlled by the immune system (Chu 2011). There are also systemic symptoms such as prolonged fevers, sweats (particularly at night), swollen lymph nodes, chills, weakness and weight loss (Sestak 2005). The neurologic sequel of HIV range from asymptomatic neurocognitive impairment to minor/moderate cognitive motor disorder and HIV-1 associated dementia commonly referred to as HIV-associated neurocognitive disorders (HAND). They have been shown to affect 23–50% of those infected with HIV-1 (Joska et al. 2010). Sub-acute AIDS encephalitis (SAE), referred to as HIV-associated dementia is characterized pathologically by cerebral atrophy, diffuse microglial proliferation and focal microglial nodules, multinucleated giant cells and foci of demyelination with associated gliosis (Snider et al. 1983). Clinically, individuals with HIV-associated dementia have progressive psychomotor slowing, apathy, memory loss, and difficulty with concentration (Price et al. 1988).

2. MATERIALS AND METHOD

2.1 STUDY SITE, AREA AND POPULATION

The study was conducted at Jaramogi Oginga Odinga Teaching and Referral Hospital in Kisumu. The hospital is centrally located in Kisumu County. The hospital is a referral hospital serving the western Kenya region. Kisumu city has an approximate population of 578,865 as projected by central bureau of statistics by 2006 in western Kenya (Central Bureau of Statistics, 1999). The population served by the hospital is drawn mainly from Kisumu town but a substantial part comes from other parts of Kisumu County, neighboring counties and other parts of Kenya.

2.2 STUDY DESIGN

The study was cross sectional descriptive study.

2.3 SAMPLING AND SAMPLE SIZE

Normal continuous sampling technique was used. Both HIV positive and HIV negative ante natal clinic attendee's samples were collected.

The sample size was calculated using (Daniel, 1999).

$$N = \frac{Z^2PQ}{d^2}$$

Where:

N = the sample size

Z^2 = the standard normal deviate.

P = proportion in the target population estimated to have characteristic being measured.

Q = 1 - P

d = the level of significant set.

Therefore: Z = 1.96

P = 15.1% proportion of target population which is also the prevalence of HIV in Nyanza ANC. (KAIS, 2012)
d = 0.05 the level of accuracy.

$$N = \frac{1.96^2 \times 0.151 \times (1 - 0.151)}{0.05^2}$$

$$N = \frac{3.8416 \times 0.151 \times 0.849}{0.0025}$$

N = 196.995
N ~197
The sample size was 197.

2.4 DATA COLLECTION TOOLS

Ante natal clinic attendees filled consent form then a questionnaire was administered.

2.5 LABORATORY PROCEDURE

The study samples were collected at the JOOTRH ante natal clinic so as to ensure participants confidentiality as they attend their regular ANC checkup. Pre testing and post testing counseling was carried out by the counselor in the ANC clinic. After informed consent a questionnaire was administered by the ANC nurse. The PI collected the blood samples with the assistance of the ANC clinic staff during their regular ANC checks immediately after the questionnaire had been filled. ANC attendee were requested to allow blood sample to be collected from the vein on their mid arm using aseptic conditions with minimal stasis using a dry, sterile disposable syringe and needle. The blood was dispensed into tubes containing the anticoagulant ethylene diamine tetra acetic-acid (EDTA). The EDTA (Becton Dickinson, Franklin Lakes NJ) samples were kept at room temperature until processing, which was done within 4 hours of collection.

Routine hematological parameters were done same day they included total white blood cell count (TWBC), differential WBC count percentages for neutrophils, basophils, eosinophils, and monocytes, Hemoglobin level (Hb), red blood cell count (RBC), hematocrit (Hct), mean cell volume (MCV), mean cell hemoglobin (MCH), mean cell hemoglobin concentration (MCHC), red blood cell distribution width (RDW), packed cell volume (PCV), platelet count and mean platelet volume (MPV). The hematological parameters were determined using a Coulter A-T Pierce hematology analyzer (Beckman Coulter, Inc. Fullerton, CA. USA). Daily quality assurance checks were performed and commercial standards used in accordance with the manufacturer's instructions. HIV serology was done using Determine™ (Abbot Laboratories, Tokyo, Japan) and Unigold™ (Trinity Biotech Plc, Bray, Ireland) for confirmation of positive cases. Each blood sample was mixed well and then approximately 20 µl was aspirated by allowing the analyzer's sampling probe into the blood sample and depressing the start button. Results of the analysis were displayed after about 30 seconds after which the analyzer generated a paper copy of the results on thermal printing paper. All laboratory results will be recorded in the case report form.

2.6 DATA MANAGEMENT AND ANALYSIS

Data entry management and preliminaries was done in Microsoft Excel™ (2010) spreadsheets software program. Other statistical analysis were performed using Statistical Package of Social Sciences (SPSS) version 21 (IBM, Armonk, NY, USA) a statistical analysis software. One way ANOVA was used to determine whether there was significant difference in the various hematological parameters. Participants were categorized based on their HIV status. The descriptive data was presented as means ± standard deviation (SD). A P value of <0.05 was considered statistically significant for *t*-test comparisons. HIV status and hematological parameters were compared among participants. Descriptive, correlation analyses were used with the dependent variable being the HIV status and independent variable being hematological parameters. Significant testing was done using chi square. Analysis results were presented in form of tables, charts and graphs.

2.7 ETHICAL CONSIDERATIONS

Approval and permission to carry out the research was requested from the ethical review committee of JOOTRH reference number: ERC.1B/VOL.I/143 and Mount Kenya University reference number: MKU/DR&D/001/2015/015. Written informed consent was sought from the participants by them filling consent form prior to study initiation. Pre testing and post testing counseling was done to all participants individually. Participant's confidentiality was enforced and their names won't be disclosed nor recorded. Soft copy of the data was protected using a password and hard copy protected under lock and key.

3. RESULTS

A total of 197 ante natal clinic attendees participated in the study. 31(15.7%) were HIV seropositive and 166 (84.3%) were HIV seronegative. All participants met eligibility criteria for the study.

Table 1 Effect of HIV on Hematological Parameters

HEMATOLOGICAL PARAMETERSN=197	HIV POS			HIV NEG			P = 0.05
	LOW	NOR	HIGH	LOW	NOR	HIGH	
WBC	7	24	0	18	144	4	0.025
Neutrophils	15	14	2	69	94	3	0.344
Lymphocyte	4	20	7	10	119	37	0.288
Monocyte	11	18	2	70	72	24	0.458
Eosinophil	16	9	6	98	60	8	0.094
Basophil		7	24		19	147	0.047
RBC	20	11	0	58	104	4	0.001
Hemoglobin	28	3	0	136	28	2	0.123
HCT	28	3	0	108	54	3	0.002
MCV	9	16	6	32	131	3	0.297
MCH	23	1	7	116	4	46	0.302
MCHC	28	3		119	47		0.014
RDW		29	2		164	2	0.029
Platelet	0	28	3	16	146	4	0.005
PCT	0	31		10	156		
MPV	8	23		12	154		
PDW		23	8		151	15	

Key:
POS – Positive
NEG – Negative

The researcher found out that the hematological parameters that had an effect on HIV status were WBC 0.025, basophil 0.047, RBC 0.001, HCT 0.002, MCHC 0.014, RDW 0.029 and Platelets 0.005 at P value of 0.05 levels.

Table 2 HIV Status against Hematological Parameters

Dependent Variable	Independent variable	Significance P < 0.05	Status (√ - Yes, X – No)
HIV Status	WBC	0.146	X
HIV Status	Neutrophils	0.209	X
HIV Status	Lymphocytes	0.384	X
HIV Status	Monocytes	0.248	X
HIV Status	Eosinophils	0.015	√
HIV Status	Basophils	0.093	X
HIV Status	RBS	0.007	√
HIV Status	HB	0.484	X
HIV Status	HCT	0.049	√
HIV Status	MCV	0.000	√
HIV Status	MCH	0.822	X
HIV Status	MCHC	0.029	√
HIV Status	RDW	0.057	X
HIV Status	Platelets	0.032	√
HIV Status	PCT	0.374	X
HIV Status	MPV	0.002	√
HIV Status	PDW	0.008	√
HIV Status	PCT	0.184	X

The researcher did cross tabulation on HIV status * Hematological indices and found out that eosinophil was significant at P < 0.05 with a value of 0.015. Other parameters which were significant were HCT 0.049, MCV at 0.000, MCHC 0.029, Platelets 0.032, MPV 0.002 and PDW 0.008. The rest did not show any level of significance as shown on the table above.

Table 3 HEMATOLOGICAL PARAMETERS

Descriptive _1_Hematological parameters									
HIV status		WBC	Neutrophils	Lymphocytes	Monocytes	Eosinophils	Basophils	RBC	MCH
HIV positive	N	31	31	31	31	31	31	31	31
	Mean	1.774	1.581	2.097	1.710	1.677	2.77	1.355	1.484
	Std. Error of Mean	.0763	.1114	.1073	.1057	.1421	.076	.0874	.1529
	Std. Deviation	.4250	.6204	.5975	.5884	.7911	.425	.4864	.8513
	% of Total Sum	14.7%	15.6%	15.3%	15.6%	17.7%	15.2%	13.1%	14.9%
HIV negative	N	166	166	166	166	166	166	166	166
	Mean	1.916	1.602	2.163	1.723	1.458	2.89	1.675	1.578
	Std. Error of Mean	.0276	.0409	.0394	.0545	.0457	.025	.0403	.0695
	Std. Deviation	.3552	.5266	.5082	.7017	.5888	.319	.5189	.8961
	% of Total Sum	85.3%	84.4%	84.7%	84.4%	82.3%	84.8%	86.9%	85.1%

Descriptives_2_Hematological parameters										
HIV status		HB	HCT	MCV	MCHC	RDW	Platelets	PCT	MPV	PDW
HIV positive	N	31	31	31	31	31	31	31	31	31
	Mean count	1.097	1.097	1.903	1.097	2.065	2.10	2.0000	1.742	2.258
	Std. Error of Mean	.0540	.0540	.1258	.0540	.0449	.054	.00000	.0799	.0799
	Std. Deviation	.3005	.3005	.7002	.3005	.2497	.301	.00000	.4448	.4448
	% of Total Sum	14.7%	11.3%	16.3%	13.8%	16.1%	16.9%	16.2%	14.4%	16.8%
HIV negative	N	166	166	166	166	166	166	166	166	166
	Mean count	1.193	1.605	1.825	1.283	2.012	1.93	1.9352	1.928	2.090
	Std. Error of Mean	.0330	.2451	.0331	.0351	.0085	.026	.02037	.0202	.0223
	Std. Deviation	.4252	3.1579	.4259	.4519	.1094	.341	.26246	.2597	.2876
	% of Total Sum	85.3%	88.7%	83.7%	86.2%	83.9%	83.1%	83.8%	85.6%	83.2%

Table 4

ANOVA Table

			Sum of Squares	df	Mean Square	F	Sig.
WBC * HIV status	Between Groups	(Combined)	.523	1	.523	3.885	.040
	Within Groups		26.239	195	.135		
	Total		26.761	196			
Neutrophils * HIV status	Between Groups	(Combined)	.012	1	.012	.042	.838
	Within Groups		57.307	195	.294		
	Total		57.320	196			
Lymphocytes * HIV status	Between Groups	(Combined)	.113	1	.113	.415	.520
	Within Groups		53.318	195	.273		
	Total		53.431	196			
Monocytes * HIV status	Between Groups	(Combined)	.005	1	.005	.010	.922
	Within Groups		91.640	195	.470		
	Total		91.645	196			
Eosinophils * HIV status	Between Groups	(Combined)	1.260	1	1.260	3.233	.074
	Within Groups		75.979	195	.390		
	Total		77.239	196			
Basophils * HIV status	Between Groups	(Combined)	.324	1	.324	2.839	.094
	Within Groups		22.245	195	.114		
	Total		22.569	196			
RBC * HIV status	Between Groups	(Combined)	2.673	1	2.673	10.113	.002
	Within Groups		51.531	195	.264		
	Total		54.203	196			
HB * HIV status	Between Groups	(Combined)	.241	1	.241	1.443	.231
	Within Groups		32.541	195	.167		
	Total		32.782	196			
HCT * HIV status	Between Groups	(Combined)	6.758	1	6.758	.800	.372
	Within Groups		1648.115	195	8.452		
	Total		1654.873	196			
MCV * HIV status	Between Groups	(Combined)	.159	1	.159	.693	.406
	Within Groups		44.643	195	.229		
	Total		44.802	196			
MCH * HIV status	Between Groups	(Combined)	.233	1	.233	.295	.588
	Within Groups		154.224	195	.791		
	Total		154.457	196			
MCHC * HIV status	Between Groups	(Combined)	.907	1	.907	4.860	.029
	Within Groups		36.402	195	.187		
	Total		37.310	196			
RDW * HIV status	Between Groups	(Combined)	.072	1	.072	3.645	.058
	Within Groups		3.847	195	.020		
	Total		3.919	196			
Platelets * HIV status	Between Groups	(Combined)	.747	1	.747	6.666	.011
	Within Groups		21.842	195	.112		
	Total		22.589	196			
PCT * HIV status	Between Groups	(Combined)	.110	1	.110	1.879	.172
	Within Groups		11.366	195	.058		
	Total		11.476	196			
MPV * HIV status	Between Groups	(Combined)	.902	1	.902	10.300	.002
	Within Groups		17.068	195	.088		
	Total		17.970	196			
PDW * HIV status	Between Groups	(Combined)	.735	1	.735	7.317	.007
	Within Groups		19.580	195	.100		
	Total		20.315	196			

4. DISCUSSION

HIV prevalence was at 15.7% (31 participants were HIV positive) at JOOTRH ANC clinic in 2014. Kenya adult HIV prevalence among people aged 15 to 64 as per the KAIS studies in 2012 were at 5.6%. Sentential study in ANC in 2010 Nyanza had a prevalence of 17.9% while country wide 7.6% ANC attendees were positive (Kenya National Bureau of Statistics 2010). This is a 2.2% difference between JOOTRH in 2014 against Nyanza in 2010 study. Our study was carried out in Nyanza Province, western Kenya and it is also the region with the highest HIV prevalence in Kenya (15%) (KAIS, 2012). There was correlation between HIV status and WBC, basophils, RBC, HTC, MCHC, RDW, platelets, MPV and PDW. There was effect of HIV on various hematological parameters, they had a p value greater than 0.05. They included neutrophils, lymphocytes, monocytes, eosinophil, hemoglobin, MCV and MCH for the participants who were HIV positive. Hematological parameters and eosinophil was significant at $P < 0.05$ with a value of 0.015. Other parameters which were significant were HCT 0.049, MCV at 0.000, MCHC 0.029, Platelets 0.032, MPV 0.002 and PDW 0.008. Similar with other African studies, (Kibaya et al, 2008) was a high eosinophil and low WBC and neutrophil values. The eosinophilia may be attributed to increased parasitemia, since our study area is endemic for schistosomiasis, helminthic infections and perennial malaria (Handzel et al, 2003). Eosinophil counts were much lower than two studies within the region which screened participants from a rural population (Zeh et al, 2011). The low neutrophil count observed in our population could possibly be attributed to African genetics, environment or diet (Ezeilo, 1974). Low MCV is an indirect marker of iron deficiency (Tefferi, 2003). Hb values were much higher than those from a study within the same region that screened out malaria infected participants (Kibaya et al, 2008). There was effect of HIV on various hematological parameters and they had a p value greater than 0.05. This included neutrophils, lymphocytes, monocytes, eosinophil, hemoglobin, MCV and MCH for the participants who were HIV positive. Leucocytes increased in number in response to introduction of foreign particles in the body such as an infection. The leucocytes that were determined included: eosinophils, neutrophils, basophils, monocytes and lymphocytes. Previous studies have shown that eosinophils are produced in large numbers during parasite infection. Reduced levels of eosinophils denote a reduced immunity (Butterwort et al. 1997). Eosinophil mediated cytotoxixity is not enhanced by lymphocytes, monocytes and neutrophils (Butterwort et al. 1997).

5. CONCLUSION AND RECOMENDATION

The researcher found out that the hematological factors that had effect on HIV status were WBC 0.025, basophils 0.047, RBC 0.001, HCT 0.002, MCHC 0.014, RDW 0.029 and Platelets 0.005 at P, 0.05 level. 15.7 % were HIV positive thus an increase as compared to KAIS study in 2012. It will be necessary to add the hematological parameters as part of HIV monitoring while carrying out the CD4 values. Prenatal HIV screening is accurate; more evidence is needed to fully understand short- and long-term maternal and infant effects in regards to hematological parameters. Given that the number of persons receiving ante natal clinical services who are HIV positive is expected to increase substantially in sub-Saharan Africa, there is a need for the evaluation of hematological parameters in the laboratory to ensure appropriate general health assessment, treatment monitoring, and efficient implementation of HIV management. The study recommend that WBC, basophils, RBC, HTC, MCHC, RDW, platelets, MPV and PDW be estimated in the HIV positive individuals when they come for ANC as the study results indicate that they are affected. This will aid in management of opportunistic infections. The government should formulate policy to include hematological indices in HIV monitoring. More research is needed to understand the clinical significance of the hematologic abnormalities. Pregnant women should be offered screening for anaemia. Screening should take place early in pregnancy (at the booking appointment) and at 28 weeks when other blood screening tests are being performed. This allows enough time for treatment if anaemia is detected. Hemoglobin levels outside the normal range for pregnancy (that is, 11 g/100 ml at first contact and 10.5 g/100 ml at 28 weeks) should be investigated and iron supplementation considered if indicated. If the mean corpuscular hemoglobin is below 27 picograms, laboratory screening (preferably high-performance liquid chromatography) should be offered.

ACKNOWLEDGEMENT

We acknowledge the entire team at Jaramogi Oginga Odinga Teaching and Referral Hospital, department of medical laboratory sciences staff of Mount Kenya University, my supervisors and everyone else who made the completion of this work possible.

REFERENCES

Abdool Karim, S.S., Churchyard, G.J., Abdool Karim, Q., Lawn, S.D. (2009), “HIV infection and tuberculosis in South Africa: an urgent need to escalate the public health response”, Lancet 374:921–933.

Anderson, J. (2012), “Women and HIV: motherhood and more”, Current Opinion in Infectious Diseases 25 (1): 58–65.

Beyrer, C., Baral. S.D., Van Griensven, F. Goodreau, S.M., Chariyalertsak S., Wirtz A.L. and Brookmeyer R.

(2012), "Global epidemiology of HIV infection in men who have sex with men", Lancet 380 (9839): 367–77.

Butterworth, A.E., David, J.R., Franks, D.. Mahmuod, A.F., David, P.H., Sturrock, R.F., Houba, V. (1997). "Antibody dependent eosinophil mediated damage to CR-Labeled schistosomula of schistosoma mansoni: Damage by purieid eosinophils", Journal of experimental medicine 135, 145-150.

Central Bureau of Statistics. (1999), "Ministry of Planning and National Development Population distribution by administrative areas and urban centers, Kenya", 1999 Population and Housing Census. Vol. 1 Nairobi, Kenya: Central Bureau of Statistics.

Chu, C. and Selwyn, P.A. (2011), "Complications of HIV infection: a systems-based approach", American family physician 83 (4): 395–406.

Daniel, W.W. (1999), "Biostatistics: A Foundation for Analysis in the Health Sciences", 7th edition. New York: John Wiley & Sons.

Evian Clive. (2006), "Primary HIV/AIDS care: a practical guide for primary health care personnel in a clinical and supportive setting", pg 29.

Ezeilo, G.C. (1974), "The aetiology of neutropenia in healthy Africans", East African Medical Journal. 51:936–942.

Handzel, T., Karanja, D.M., Addiss, D.G., Hightower, A.W., Rosen, D.H. et al. (2003), "Geographic distribution of schistosomiasis and soil-transmitted helminths in Western Kenya: implications for anthelminthic mass treatment", Journal of Tropical Medicine and Hygiene. 69:318–323.

Hochman, S. and Kim, K. (2012), "The impact of HIV coinfection on cerebral malaria pathogenesis", Journal of neuroparasitology. 3: 235547. PMC3336366

http://www.unicef.org/publications/files/pub_youngpeople_hivaids_en.pdf.

James William, D. and Berger Timothy, G. (2006), "Andrews' Diseases of the Skin: clinical Dermatology", Pg 416.

Joska, J. A., Fincham, D. S., Stein, D. J., Paul, R. H., Seedat, S. (2010), "Clinical correlates of HIV-associated neurocognitive disorders in South Africa", AIDS Behavior. 14:371–378.

Kenya AIDS Indicator Survey. Preliminary report, (2012), Pg 8 http://nascop.or.ke/library/3d/Preliminary%20Report%20for%20Kenya%20AIDS%20indicator%20survey%202012.pdf Retrieved 15 April 2014.

Kenya National Bureau of Statistics, ICF Macro (2010), Kenya Demographic and Health survey 2008-09.

Kibaya, R.S., Bautista, C.T., Sawe, F.K., Shaffer, D.N., Sateren, W.B., Scott, P.T., et al. (2008), "Reference ranges for the clinical laboratory derived from a rural population in Kericho, Kenya", PLOS One. 3:e3327 doi: 10.1371/journal.pone.0003327.

Marshall Cavendish (2008), "Diseases and disorders". pg 25.

Pinkerton, S.D. (2008), "Probability of HIV transmission during acute infection in Rakai, Uganda", AIDS Behaviour.12 (5):677-84.

Price, R.W., Brew, B., Sidtis, J., Rosenblum, M., Scheck, A.C., Cleary, P. (1988), "The brain in AIDS: central nervous system HIV-1 infection and AIDS dementia complex", Science. 239:586–592.

Quinn, T.C., Wawer, M.J., Sewankambo, N., Thomas, C., Quinn, M.D., Maria J. Wawer, M.D., Nelson Sewankambo, M.B., David Serwadda, M.B., Chuanjun Li, M.D., Fred Wabwire-Mangen, Ph.D., Mary O. Meehan, B.S., Thomas Lutalo, M.A., and Ronald, H. Gray., et al (2000), "Viral load and heterosexual transmission of Human Immunodeficiency Virus Type I", New England Journal of medicine 342 (13):921-9.

Sestak, K. (2005), "Chronic diarrhea and AIDS: insights into studies with non-human primates", Curr. HIV Res. 3 (3): 199–205.

Snider, W. D., Simpson, D. M., Nielsen, S., Gold, J.W., Metroka, C.E., Posner, J.B. (1983), "Neurological complications of acquired immune deficiency syndrome: analysis of 50 patients", Ann Neurology. 14:403–418.

Tefferi, A. (2003), "Anemia in adults: a contemporary approach to diagnosis", Mayo Clinical Proc. 78: 1274–1280 14531486

Thorne, C. and Newell, M.L. (2007), "HIV. Seminars in fetal & neonatal medicine", 12 (3): 174–81.

UNAIDS. (2006), "Report on the global AIDS epidemic Geneva, Switzerland", Joint United Nations Program on HIV/AIDS.

UNAIDS. (2009), "WHO. AIDS Epidemic Update", Joint United Nations Programme on HIV/AIDS and World Health Organisation; Geneva.

Vogel, M., Schwarze-Zander, C., Wasmuth, J.C., Spengler, U., Sauerbruch, T. and Rockstroh, J.K. (2010), "The treatment of patients with HIV". Deutsches Arzteblatt international 107 (28–29): 507–15; quiz 516.

World Health Organization (2014), "To the 2013 consolidated guidelines on the use of antiretroviral drugs for treating and preventing HIV infection recommendations for a public health approach", pg.77.

www.who.int Retrieved 15 April 2014.

Zeh, C., Amornkul, P. N., Inzaule, S., Ondoa, P., Oyaro, B., Mwaengo, D.M., et al. (2003), "Population-based biochemistry, immunologic and hematological reference values for adolescents and young adults in a rural population in Western Kenya", PLOS One. 6:e21040 doi: 10.1371/journal.pone.002104021713038.