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Comparative Analysis of Hematological Parameters and Trace Element Concentrations in HIV-Positive and HIV-Negative Individuals

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Abstract

Introduction: This study investigates the impact of HIV on heavy and trace metal concentrations in blood.

Methods: Blood samples from 20 HIV/AIDS patients and 20 healthy controls were collected using standard methods. Metal levels (Mn, Fe, Cu, and Zn) were measured using the Perkin Elmer Model 306 Atomic Absorption Spectrometer.

Results: The analysis revealed significant differences in metal concentrations between the HIV/AIDS group and the healthy group. Mn, Fe, Cu, and Zn levels were found to be 28.23%, 2.88%, 2.64%, and 1.92% higher, respectively, in the healthy group compared to the HIV/AIDS group. In the HIV/AIDS group, Mn and Cu showed increased likelihood of life-threatening occurrences, while Fe displayed a lower likelihood, and Zn levels remained within normal distribution. Hematological parameters, including LYM, MID, RBC, MCV, and MCH, displayed lower risks in HIV/AIDS patients, with WBC showing higher risk. In non-HIV individuals, WBC and MCH had standard distributions, while LYM, MID, NEU, RBC, HGB, PCV, MCV, MCHC, PLT, and PCT had reduced risks.

Conclusion: These findings emphasize the significant alterations in metal concentrations and hematological parameters associated with HIV/AIDS, suggesting their potential as indicators for disease progression and risk assessment.

Keywords: HIV • Hematological parameters • Trace elements • Disease progression • Biomarkers

Introduction

Trace metals in the environment are metals that usually occur at very low levels. Living things requires a very small amount of trace elements but high levels of these trace elements such as Fe, Cu, Zn, and Mn and heavy metal Pb can be very toxic to the human body [1,2]. HIV (Human Immunodeficiency Virus) can be transmitted through contact with infected blood, pre-seminal fluid, rectal fluids, breast milk of an infected person, semen or vaginal fluids [3]. HIV causes AIDS (Acquired Immunodeficiency Syndrome) which is the most advanced stage of HIV infection and interferes with the body's ability to fight infections. However, treatment can help but cannot be cured. Globally, 38.4 million (33.9–43.8 million) people were living with HIV as at the end of 2021 [4].

Excessive exposure to trace elements and heavy metals generally has a harmful effect on living organisms including humans, but their occurrence in low levels pose no harm. The degree of harm depends on the nature and extent of the trace elements and heavy metals produced, inhalation or ingestion and the biochemical properties of the elements; with increased risk of cancer the most usual consequence [5].

Ttrace elements, heavy metals and biomarkers in terms of Non-Communicable Diseases (NCD) in the blood has been a major problem in the present world [6,7]. Non-communicable diseases infections such as; cancers, heart disease, lung disease and diabetes are the biggest cause of death worldwide [6]. The increasing burden of NCDs and the growing pressure to combat them is likely to have an impact on HIV. This could be a negative impact through loss of funding and political

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attention or a positive impact by a greater commitment to investing in health care for chronic diseases, and a willingness to learn from the HIV response to develop better systems for care of chronic health problems. NCDs are becoming a developing problem in people with HIV as they live on successful antiretroviral treatment. Some antiretroviral drugs may increase the risk of heart disease and diabetes, while HIV itself increases the risk of some cancers. NCDs might develop in people with HIV because they are living on active treatment. Many NCDs are diseases that increase in frequency as people age. They may be present before HIV infection and could be made worse by HIV and some antiretroviral drug [6]. This study will evaluate the concentration of trace/heavy metals and how they are accumulated in HIV and non-HIV persons. The study will give a progression for comprehending the health implications of high-level exposure to trace/heavy metals and the high risk of non-communicable diseases.

Findings from the research work will also show the best ways of mitigating against the accumulation of trace metals in negative HIV patients and positive HIV patients with a view of providing better ways of controlling non-communicable diseases and health risk factors in the human health [8]. The research work will serve as a reference material to other researchers who might want to carry out a similar study in a related or close field as it is hoped that discoveries can be generalized to other topographical locations since the problem of trace/heavy elements concentration in human body and non-communicable diseases is a global occurrence. The main aim of the study is to carry out a statistical evaluation and the relationship of trace metals, biomarkers in HIV and non-HIV patients. It will evaluate trace metals content in the human blood for patients with and without HIV and further analyze human blood through series of lab tests to determine the biomarkers to find out possible links between rates of selected diseases within Ondo state.

Study area

This study was carried out in Ondo city, Nigeria, between March and September 2022. Ondo city is referred to as the second largest city in Ondo state, Nigeria. According to the more recent population estimate as at 2016 approximately 4,671,700 people were living in the Ondo state. The state has more of urban dwellers compared to rural dwellers and the indigenes become scheming in management and industry than other Yoruba sub-group [9]. The sampling location used in this study is the University of Medical Sciences Teaching Hospital, Ondo (UNIMEDTH) situated in Ondo city, Ondo state, South West of Nigeria. The University of Medical Sciences Teaching Hospital was established about 12 years ago.

Materials and Methods

The main materials used in the research study includes; Laborex HM–200x, Atomic Absorption Spectrometry (AAS), Octave and Excel. Laborex HM-200X Auto Hematology Analyzer is a quantitative, automated hematology analyzer and 3-part differential counter for *in vitro* diagnostic use in clinical laboratories. The analyzer is used for the quantitative determination of the cellular components of the blood and differentiating the White Blood Cells (WBCs) into 3 major categories; neutrophils, lymphocytes and MID (monocytes, eosinophils and basophils). Other cells include the Red Blood Cell count (RBC), Hemoglobin concentration (HGB), Hematocrit (HCT), Platelet count (PLT), Mean Corpuscular Volume (MCV), Mean Corpuscular Hemoglobin (MCH), Mean Corpuscular Hemoglobin Concentration (MCHC), Red Blood Cell Distribution Width Coefficient of Variation (RDW-CV), Red Blood Cells Distribution Width-Standard Deviation (RDW-SD), Mean Platelet Volume (MPV), Platelet Distribution Width (PDW), Plateletcrit (PCT), White Blood Cell Histogram (WBC) Histogram, Red Blood Cell Histogram (RBC) Histogram, Platelet Histogram (PLT) Histogram. These parameters were measured in the standard international unit as follows: WBC (c/mm^3), LYM (%), MID (%), NEU (%), RBC (10^{12}/L), HGB (g/dL), PCV (%), MCV (fL), MCH (Pg), MCHC (g/L), PLT (c/mm^3), PCT (%).

Atomic Absorption Spectrometry (AAS) is a spectrum analytical procedure for the quantitative determination of chemical elements using the absorption of optical radiation (light) by free atoms in the gaseous state. The principle of operation of the AAS is that, radiation from a hollow cathode lamp (in which the cathode is made from the element of interest) is modulated and passed through a flame into which is sprayed the solution for analysis. The radiation then passes to a monochromator where the particular resonance line required is isolated, and any absorption of due to the atomic vapour in the flame is measured by means of photomultiplier. The photocurrent is amplified, demodulated and fed either directly to a meter or to a logarithmic converter.

Two groups (A and B) of equal sex/age were sampled accordingly, twenty HIV positive subjects attending the Antiretroviral Clinic of University of Medical Sciences Teaching Hospital, Ondo Centre (UNIMEDTH) and twenty HIV negative subjects were recruited for the current study. The consent of each of the subjects was sought and obtained before including them in the study. A total of 40 apparently healthy, sero-negative, age-matched subjects were drawn from patients on routine medical check-up between the ages of 12 and 65 years for the study. Staff and students of the University constituted the HIV (-) control group. From the 40 samples collected, average number of samples were selected randomly for analysis. 5 ml of whole veinous blood were collected from each participant in this study into a potassium Ethylene Diamine Tetra Acetic Acid (EDTA K2) bottle using standard blood collection technique and centrifuged. Clotted samples were rejected no matter how little the clot was. Lyzed sample was rejected as well. Forty samples comprising 20 HIV/AIDS cases and 20 healthy age and sex matched controls were collected. Hematology assays were done after sample collection. After carrying out the full blood count on the blood samples, the samples were sun-dried for 7 days converting the blood samples to a dried form.

0.5 g of the dried blood sample was weighed and transferred into a sample vessel including. 15.0 mLs of concentrated HNO_3: $HOCl_3$ (3:1) and heated at a temperature of 102°C for 20 minutes until it dissolves and gives a clear solution. The residue was allowed to cooled and filtered into a 10.0 mLs standard volumetric flask. The digested samples were allowed to further cooled, filtered and make the

filtrate up to the mark of 50.0 mLs in a 50.0 mLs standard volumetric flask. Portion of this solution were used to analyze for metals using the AAS at the Central Science Laboratory, Obafemi Alowolo University, Ile-Ife-Nigeria. Table 1, shows how the sample was analyzed using the instrumental conditions.

Elements/Metals	λ_{max}	Current I(A)	Energy	Slit width	Detection limit (mg/l)
Cu	324.75	15	80	2.7/0.8	0.001
Fe	248.33	30	66	1.8/1.35	0.005
Mn	279.48	20	62	1.8/1.35	0.001
Pb	283.31	10	75	2.7/1.05	0.025
Zn	213.86	15	47	2.7/1.8	0.002

Table 1. The instrumental conditions for the sample analysis.

Results and Discussion

The results of the positive HIV blood samples and negative HIV blood samples of the measured trace elements and heavy metal are shown in Table 2 below. As revealed in Table 2, the average value of Mn, Fe, Cu and Zn were 15.06 mg/l, 1517.38 mg/l, 6.15 mg/l and 103.65 mg/l respectively for HIV positive individuals of twenty persons while for HIV negative individuals were 178.76 mg/l, 4142.89 mg/l, 14.44 mg/l and 193.76 mg/l respectively of twenty persons (same sex, same age). The observed differences in the concentrations between HIV-positive and HIV-negative individuals could be influenced by verities factors, including immune activation, inflammation, and nutritional status. HIV infection usually leads to increased inflammation and altered immune function, affecting trace metal metabolism. Furthermore, HIV-negative individuals can exhibit higher metal levels due to differences in dietary intake or other health conditions. The complex interplay of these factors contributes to the observed differences in the average values of Mn, Fe, Cu, and Zn levels in the study population. The use of antiretroviral drugs in HIV-positive individuals may impact trace metal absorption, excretion, or utilization. Geographical location and environmental factors can contribute to differences in trace metal concentrations. Individuals living in different regions may have varied exposure to trace elements through air, water, or food sources. To gain a more accurate understanding of the observed differences (Table 2), a thorough statistical analysis was conducted which involved, the standard deviation (± SD), minimum, maximum, skewness and kurtosis of the measured trace metal concentrations which described the central tendency and the variation of around the mean as well as the distribution of the concentrations across the blood of both HIV (+) and HIV (-) individuals.

SP (sex/age)	Mn (mg/l)	*Mn (mg/l)	Fe (mg/l)	*Fe (mg/l)	Cu (mg/l)	*Cu (mg/l)	Zn (mg/l)	*Zn (mg/l)
F1 (F/50)	178.1	17.9	4141.6	1040.64	15.66	7.99	195.2	79.18
F2 (F/46)	181.65	23.16	4157.7	1837.85	15.66	4.69	188.94	115.26
F3 (F/38)	180.92	21.93	4142.4	1790.99	12.59	9.03	198.9	118.17
F4 (F/45)	176.5	4.35	4125.9	1806.23	13.67	5.48	188.62	100.56
F5 (F/21)	181.28	17.28	4135.4	1558.66	13.97	5.99	192.02	100.86
F6 (F/59)	177.07	2.44	4163.4	1285.9	15.54	3	188.51	111.47
F7 (F/62)	175.01	1.76	4128.3	1094.3	14.13	4.35	197.16	76.91
F8 (M/14)	180.27	3.23	4129.1	1536.15	15.55	7.51	196.33	105.8
F9 (F/57)	175.04	27.59	4141.3	1914.14	14.65	9.01	190.36	106.24
F10 (F/53)	176.8	11.13	4160.4	1427.09	12.74	6.6	197.28	82.87
F11 (F/53)	175.1	20.72	4139.4	1365.59	15.47	5.76	190.75	126.27
F12 (M/45)	180.66	31.76	4138.6	979.94	15.11	8.87	196.67	80.17
F13 (F/30)	181.21	2.24	4127.9	927.57	13.41	3.19	198.46	127.78
F14 (F/45)	178.65	16.28	4135	1958.85	14.64	6.36	197.81	126.92

F15 (F/47)	180.89	23.23	4154.6	1850.76	13.63	3.79	191.35	123.24
F16 (F/39)	176.55	16.53	4161.8	1276.47	13.62	4.04	196.09	97.06
F17 (F/12)	178.57	32.04	4150.7	2011.23	13.86	6.25	189.95	107.23
F18 (F/43)	180	4.22	4127.3	1753.83	15.12	8.56	194.69	86.95
F19 (F/45)	180.88	20.23	4135.7	1514.67	15.02	8.39	197.13	86.78
F20 (F/35)	179.98	3.23	4161.3	1416.79	14.74	4.08	188.98	113.27
Av. Val.	178.76	15.06	4142.89	1517.38	14.44	6.15	193.76	103.65
Max. Val.	181.65	32.04	4163.4	2011.23	15.66	9.03	198.9	127.78
Min. Val.	175.01	1.76	4125.9	927.57	12.59	3	188.51	76.91
Std. Dev	2.31	10.28	12.99	341.99	0.97	2.04	3.75	16.96
Skew Val.	-0.42	0.05	0.35	-0.26	-0.38	0.03	-0.17	-0.16
Kurt. Val.	-1.34	-1.28	-1.33	-1.13	-0.95	-1.36	-1.72	-1.24

Note: *Represent HIV (+)

Table 2. Results of trace metal concentration in the blood of both HIV (+) and HIV (-) groups with descriptive statistical analysis.

In descriptive statistic, skewness, measures the asymmetry of distribution of a random variable that is real in nature and positive skewness indicates a distribution with asymmetric tail extending towards the values that are more positive while negative skewness revealed a distribution with asymmetric tail extending towards values that are more negatives. In this study, negative values and low skewness values of the trace metal concentration were obtained for Mn (-0.42), Cu (-0.26), Zn (-0.38) in the HIV (-) group and *Fe (-0.17), *Zn (-0.17) for HIV (+) group indicating a distribution with asymmetric tail extending towards values that are more negative and general normal distribution. These shows that the Mn, Fe, Cu and Mg are not evenly distributed between the HIV (+) and (-) patients in their blood. Also, the positive skewness values of the concentrations of the trace elements implied that the distributions are asymmetric in nature. The skew value of 0.05 for *Mn, 0.35 for Fe, and 0.03 for *Cu which are moderately skewed. This indicates that, the Mn, Cu for HIV (+) group and Fe for HIV (-) group are moderately distributed among the two groups of study. This shows that the differences between the two groups depends on individual factors.

Kurtosis characterizes the relative peakedness or flatness of a distribution compared with the normal distribution. Positive kurtosis indicates a relatively peaked distribution while Negative kurtosis indicates a relatively flat distribution. Higher kurtosis means that more of the variance is the result of infrequent extreme deviations (outliers), as to frequent modestly sized deviations. In the present study, the results of the kurtosis analysis of the concentrations of the two groups were low and negative values. This implies a relatively flat distribution and lack of extreme deviation in the trace metal concentrations. In this study, the trend of the average (± SD) of the concentrations in the HIV (+) group are Fe>Mn>Zn>Cu while for the HIV (-) group are, Fe>Zn>Mn>Cu respectively.

The bar chart comparison of Mn, Fe, Cu, and Zn from the two set of groups A and B are show in Figure 1 below. From Figure 1 (A-D), the ratio value of Mn/*Mn, Fe/*Fe, Cu/*Cu and Zn/*Zn were 28.23, 2.88, 2.64 and 1.92 respectively. Generally, this study has reported both decreases in the trace metals levels in individuals with HIV compare to high values levels in individuals with non-HIV especially in the case of Mn with a value of 28.23% multiplication factor. This suggest that the HIV-positive individuals may have lower Mn levels due to increased utilization by the immune system, while others report elevated levels of only 2.88%, 2.64% and 1.92% for Fe/*Fe, Cu/*Cu and Zn/*Zn as a result of inflammation and immune activation. This study further indicates that the relationship between trace metals and HIV is not straightforward, and multiple factors can influence the concentrations of these metals in individuals with and without HIV.

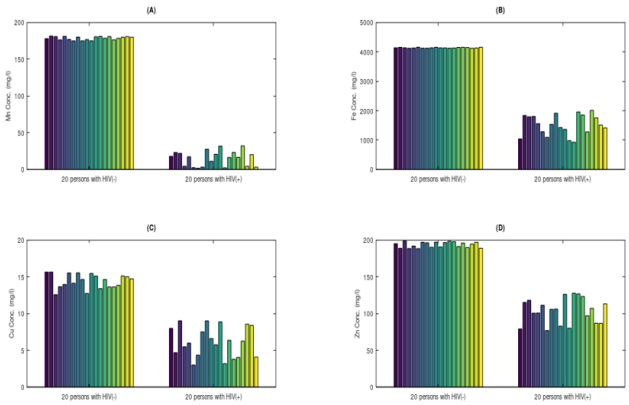

Figure 1. Results of trace metal concentrations in both HIV (+) and HIV (-) individuals (A-D).

From Table 3, with respect to WBC, it was observed that with patient F13 and age 30 which is a female, the minimum value was obtained to be 1100. With patient F8 and age 14 which is a male, the maximum value was obtained to be 7300. The average value was obtained to be 2555 with a skew value of 1.97 which is highly (positive) skewed. The kurtosis value is 4.74 which is leptokurtic (positive), that is; WBC has a greater likelihood of extreme events in the HIV patients. The LYM was observed for F10 (age 53, female) a minimum value of 48.7 while F4 (age 45, female), the maximum value of 84.5 was obtained. The average value was obtained to be 68.81 with a skew value of -0.19 which is fairly (negative) skewed. The kurtosis value is -1.16 which is platykurtic (negative) because LYM has a lower likelihood of extreme events in the HIV patients. For MID (Table 3), it was observed that with F17 (age 12, female), the minimum value was 5.6 while F1 (age 50, female), the maximum value of 29.5 was obtained. The average value of 15.43 with a skew value of 0.53 (moderately (positive) skewed). The kurtosis value is -0.69 which is platykurtic (negative) because MID has a lower likelihood of extreme events in the HIV patients. For NEU, it was observed that F4 (age 45, female), the minimum value was obtained to be 8.6 while F10 (age 53, female), the maximum value was obtained to be 30.4. The average value was obtained to be 15.77 with a skew value of 0.96 which is moderately (positive) skewed. The kurtosis value is 0.14 which is mesokurtic (positive), that is; NEU has a standard normal distribution in the HIV patients.

SP (sex/ age)	WBC	LYM	MID	NEU	RBC	HGB	PCV	MCV	MCH	MCHC	PLT	PCT
F1 (F/50)	1400	54.9	29.5	15.6	5.62	18.8	59.8	106.3	33.4	31.4	113000	0.13
F2 (F/46)	2600	61.3	28.4	10.3	4.68	12	40.4	86.3	25.7	29.8	42000	0.05
F3 (F/38)	1500	61.9	18.3	19.8	4.23	16.4	54.4	128.6	38.8	30.2	66000	0.07
F4 (F/45)	3900	84.5	6.9	8.6	4.99	15.3	49.7	99.7	30.6	30.7	241000	0.25
F5 (F/21)	2000	61.3	20.6	18.1	4.02	12.8	41.2	102.5	31.8	31	188000	0.2
F6 (F/59)	1900	59.8	13.8	26.4	6.37	19.5	64.1	100.1	30.5	30.4	14000	0.02
F7 (F/62)	2000	51.5	28	20.5	4.81	15.5	51.5	107.1	32.2	30.1	112000	0.13
F8 (M/14)	7300	80.5	6.4	13.1	7.1	15.4	53.6	75.5	21.6	28.6	300000	0.32
F9 (F/57)	1500	64.6	21.6	13.8	3.74	10.9	35.2	94.1	29.1	30.9	67000	0.07
F10 (F/53)	2000	48.7	20.9	30.4	5.72	14.8	50.7	88.7	25.9	29.2	64000	0.06
F11 (F/53)	2300	76.3	14.5	9.2	4.77	15.5	49.9	104.6	32.5	31.1	104000	0.1
F12 (M/45)	2600	74.8	14.8	10.4	3.59	11.5	36	100.3	32.2	32.1	90000	0.1
F13 (F/30)	1100	68	16.6	15.4	3.61	9.9	31.8	88.2	27.5	31.2	39000	0.04
F14 (F/45)	3400	76	11.1	12.9	6.98	21.2	68.9	98.7	30.3	30.8	86000	0.1
F15 (F/47)	4700	79.4	7.7	12.9	8.01	24.5	77.4	96.7	30.6	31.6	71000	0.09
F16 (F/39)	1500	68.1	10.1	21.8	6.09	16.7	54.7	89.8	27.4	30.5	51000	0.05
F17 (F/12)	3500	83.8	5.6	10.6	6.61	19.3	61.5	93.1	29.2	31.4	73000	0.08
F18 (F/43)	1200	77.4	11.1	11.5	4.58	14.6	49.1	107.2	32	32	134000	0.13
F19 (F/45)	1700	61.2	15.5	23.3	5.27	17	56.9	107.9	32.3	30	85000	0.09
F20 (F/35)	3000	82.1	7.1	10.8	6.16	19.3	61.9	100.5	31.3	31.2	48000	0.06
Av. Val.	2555	68.81	15.43	15.77	5.35	16.05	52.44	98.8	30.25	30.71	99400	0.11
Max. Val.	7300	84.5	29.5	30.4	8.01	24.5	77.4	128.6	38.8	32.1	300000	0.32
Min. Val.	1100	48.7	5.6	8.6	3.59	9.9	31.8	75.5	21.6	28.6	14000	0.02
Std. Dev	1478.08	11.07	7.53	6.13	1.26	3.68	11.65	10.94	3.55	0.89	70457.45	0.07
Skew Val.	1.97	-0.19	0.53	0.96	0.38	0.36	0.08	0.5	-0.22	-0.66	1.71	1.72
Kurt. Val.	4.74	-1.16	-0.69	0.14	-0.66	0.08	-0.1	2.31	1.94	0.42	2.85	2.98

Note: *Represent HIV (+)

Table 3. Results of biomarkers in the blood of HIV (+) group with descriptive statistical analysis.

With respect to RBC (Table 3), it was observed that with F12 (age 45, male), the minimum value was obtained to be 3.59 while F15 (age 47, male), the maximum value was obtained to be 8.01. The average value was obtained to be 5.35 with a skew value of 0.38 which is fairly (positive) skewed. The kurtosis value is -0.66 which is platykurtic (negative) because RBC has a lower likelihood of extreme events in the HIV patients. For HGB (Table 3), it was observed that F13 (age 30, female), the minimum value was obtained to be 9.9 while F15 (age 47, male), the maximum value was obtained to be 24.5. The average value was obtained to be 16.05 with a skew value of 0.36 which is fairly (positive) skewed. The kurtosis value is 0.08 which is mesokurtic (positive), that is; HGB has a standard normal distribution in the HIV patients.

From Table 3, with respect to PCV, a minimum value of 31.8 was observed for F13 (age 30, female), while F15 (age 47, male), the maximum value was obtained to be 77.4. The average value was obtained to be 52.44 with a skew value of 0.08 which is fairly (positive) skewed. The kurtosis value is -0.10 which is mesokurtic (negative), that is; PCV has a standard normal distribution in the HIV patients. With respect to MCV (Table 3), it was observed that F8 (age 14, male), the minimum value was obtained to be 75.5 while F3 (age 38, female), the maximum value was obtained to be 128.6. The average value was obtained to be 98.79 with a skew value of 0.50 moderately (positive) skewed. The kurtosis value is 2.31 which is platykurtic (positive) because MCV has a lower likelihood of extreme events in the HIV patients. For MCH (Table 3), it was observed that F8 (age 14, male), the minimum value was obtained to be 21.6 while F3 (age 38, female), the maximum value was obtained to be 38.8. The average value was obtained to be 30.25 with a skew value of -0.22 which is fairly (negative) skewed. The kurtosis value is 1.94 which is platykurtic (positive) because MCH has a lower likelihood of extreme events in the HIV patients.

With respect to MCHC (Table 3), it was observed that with F8 and age 14 which is a male, the minimum value was obtained to be 28.6 with F12 and age 45 which is a male, the maximum value was obtained to be 32.1. The average value was obtained to be 30.71 with a skew value of -0.66 moderately (negative) skewed. The kurtosis value is 0.42 which is mesokurtic (positive), that is; MCHC has a standard normal distribution in the HIV patients.

With respect to PLT, it was observed that with F6 and age 59 which is a female, the minimum value was obtained to be 14000 with F8 and age 14 which is a male, the maximum value was obtained to be 300000. The average value was obtained to be 99400 with a skew value of 1.71 highly (positive) skewed. The kurtosis value is 2.85 which is mesokurtic (positive), that is; PLT has a standard normal distribution in the HIV patients.

With respect to PCT, it was observed that with F6 and age 59 which is a female, the minimum value was obtained to be 0.02 with F8 and age 14 which is a male, the maximum value was obtained to be 0.32. The average value was obtained to be 0.11 with a skew value of 1.72 highly (positive) skewed. The kurtosis value is 2.99 which is mesokurtic (positive), that is; PCT has a standard normal distribution in the HIV patients.

From Table 4, with respect to WBC, it was observed that with F1 and age 50 which is a female, the maximum value was obtained to be 15077. With F5 and age 21 which is a female, the minimum value was obtained to be 4979. The average value was obtained to be 8797.3 with a skew value of 0.81 which is moderately (positive) skewed. The kurtosis value is -0.44 which is mesokurtic (negative), that is; WBC has a standard normal distribution in the non-HIV persons.

SP (sex/ age)	WBC	LYM	MID	NEU	RBC	HGB	PCV	MCV	MCH	MCHC	PLT	PCT
F1 (F/50)	15077	62	12	29	3	9	40	101	31.9	33	92453	0.03
F2 (F/46)	10676	58	9	26	4	9	30	103	30.7	34	106149	0.11
F3 (F/38)	7871	42	13	37	4	11	41	101	30.9	30	75431	0.21
F4 (F/45)	6701	41	12	32	3	15	31	100	31	31	198644	0.04
F5 (F/21)	4979	63	8	45	4	10	40	91	31	34	188778	1
F6 (F/59)	5378	65	9	40	4	11	32	97	31	34	177687	0.12
F7 (F/62)	13673	44	11	41	4	15	33	101	31.9	32	187560	1
F8 (M/14)	7948	73	11	49	3	13	30	92	31	35	180265	1
F9 (F/57)	5314	70	11	42	3	15	36	105	29.9	33	164473	1
F10 (F/53)	9467	46	14	18	4	12	36	93	31	34	62981	0.11
F11 (F/53)	9486	71	11	36	4	12	35	100	30	33	78044	1
F12 (M/45)	7997	68	10	34	3	10	39	94	30	35	193820	0.01
F13 (F/30)	14427	41	9	13	4	10	45	94	30.1	30	177883	1

F14 (F/45)	6213	65	11	15	4	13	36	89	31	29	188661	0.01
F15 (F/47)	7430	73	13	15	4	10	32	92	31.9	34	187234	1
F16 (F/39)	6792	46	9	32	4	14	30	90	31.9	30	122493	0.1
F17 (F/12)	9887	43	13	28	4	9	33	89	31	31	193656	0.24
F18 (F/43)	13097	47	11	45	4	12	30	104	31	29	121573	0.14
F19 (F/45)	5830	49	11	20	3	12	44	88	31	34	136537	1
F20 (F/35)	7703	44	10	39	4	12	46	102	31	31	166845	1
Av. Val.	8797.3	55.55	10.9	31.8	3.7	11.7	35.95	96.3	30.96	32.3	150058.4	0.51
Max. Val.	15077	73	14	49	4	15	46	105	31.9	35	198644	1
Min. Val.	4979	41	8	13	3	9	30	88	29.9	29	62981	0.01
Std. Dev	3134.01	12.19	1.62	11.01	0.47	2	5.29	5.66	0.62	2	46016.03	0.46
Skew Val.	0.81	0.17	0.1	-0.35	-0.95	0.33	0.57	0.01	-0.07	-0.33	-0.72	0.17
Kurt. Val.	-0.44	-1.78	-0.62	-1.01	-1.24	-0.92	-0.89	-1.58	-0.32	-1.35	-1.05	-2.13

Table 4. Results of biomarkers in the blood of HIV (-) group with descriptive statistical analysis.

With respect to LYM, it was observed that with person F8 and age 14 which is a male, the maximum value was obtained to be 73. With person F4 and 13 with age 45 and 30 respectively and are both females, the minimum value was obtained to be 41. The average value was obtained to be 55.55 with a skew value of 0.17 which is fairly (positive) skewed. The kurtosis value is -1.78 which is platykurtic (negative), that is; LYM has a lower likelihood of extreme events in the non-HIV persons.

With respect to MID, it was observed that with person F10 and age 53 which is a female, the maximum value was obtained to be 14. With person F5 and age 21 which is a female, the minimum value was obtained to be 8. The average value was obtained to be 10.9 with a skew value of 0.10 which is fairly (positive) skewed. The kurtosis value is -0.62 which is platykurtic (negative), that is; MID has a lower likelihood of extreme events in the non-HIV persons.

With respect to NEU, it was observed that with person serial number 8 and age 14 which is a male, the maximum value was obtained to be 49. With person serial number 13 and age 30 which is a female, the minimum value was obtained to be 13. The average value was obtained to be 31.8 with a skew value of -0.35 which is fairly (negative) skewed. The kurtosis value is -1.01 which is platykurtic (negative), that is; NEU has a lower likelihood of extreme events in the non-HIV persons.

With respect to RBC (Table 4), it was observed that with person's serial number F2, F3, F5, F6, F7, F10, F11, F13, F14, F15, F16, F17, F18 and F20 with age 46, 38, 21, 59, 62, 53, 53, 30, 45, 47, 39, 12, 43 and 35 respectively and are all females except for F14 and F15 who are males, the maximum value was obtained to be 4. With person F1, F4, F8, F9, F12 and F19 with age 50, 45, 57, 45 and 45 and sex F, F, M, F, M and F respectively. The average value was obtained to be 3.7 with a skew value of -0.95 moderately (negative) skewed. The kurtosis value is -1.24 which is platykurtic (negative), that is; RBC has a lower likelihood of extreme events in the non-HIV persons.

With respect to HGB (Table 4), it was observed that with person F4, F7, and F9 with age 45, 62 and 57 which are all females, the maximum value was obtained to be 15. With person F1, F2 and F17 with age 50, 46 and 12 respectively and are all females, the minimum value was obtained to be 9. The average value was obtained to be 11.7 with a skew value of 0.33 which is fairly (positive) skewed. The kurtosis value is -0.92 which is platykurtic (negative), that is; HGB has a lower likelihood of extreme events in the non-HIV persons. The correlation, r, of HGB between the HIV/non-HIV persons reduces because it has a correlation value of -0.09.

From Table 4, with respect to PCV, it was observed that with person F20 and age 35 which is a female, the maximum value was obtained to be 46. With person F2, F8, F16 and F18 with age 46, 14, 39 and 43 and sex F, M, F and F respectively, the minimum value was obtained to be 30. The average value was obtained to be 35.95 with a skew value of 0.57 is moderately (positive) skewed. The kurtosis value is -0.89 which is platykurtic (negative), that is; PCV has a lower likelihood of extreme events in the non-HIV persons.

With respect to MCV (Table 4), it was observed that with person serial number 9 and age 57 which is a female, the maximum value was obtained to be 105. With person serial number 19 and age 45 which is a female, the minimum value was obtained to be 88. The average value was obtained to be 96.3 with a skew value of 0.01 which makes it a normal distribution (positively skewed). The kurtosis value is -1.58 which is platykurtic (negative), that is; MCV has a lower likelihood of extreme events in the non-HIV persons.

With respect to MCH (Table 4), it was observed that with person F1, F7, F15 and F16 with ages 50, 62, 47 and 39 and sex F, F, M and F respectively, the maximum value was obtained to be 31.9. With person serial number 9 and age 57 which is a female, the minimum value was obtained to be 29.9. The average value was obtained to be 30.96 with a skew value -0.07 which is fairly (negative) skewed. The kurtosis value is -0.32 which is mesokurtic (negative), that is; MCH has a standard normal distribution in the non-HIV persons.

With respect to MCHC (Table 4), it was observed that with person serial number 8 and 12 with ages 14 and 45 respectively who are both males, the maximum number was obtained to be 35. With person serial number 14 and 18 with ages 45 and 43 and sex M and F respectively, the minimum value was obtained to be 29. The average value was obtained to be 32.3 with a skew value of -0.33 which is fairly (negative) skewed. The kurtosis value is -1.35 which is platykurtic (negative), that is; MCHC has a lower likelihood of extreme events in the non-HIV persons.

With respect to PLT (Table 4), it was observed that with person serial number 4 and age 45 which is a female, the maximum value was obtained to be 198644. With person serial number 10 and age 53 which is a female, the minimum value was obtained to be 62981. The average value was obtained to be 150058.4 with a skew value of -0.72 which is moderately (negative) skewed. The kurtosis value is -1.05 which is platykurtic (negative), that is; PLT has a lower likelihood of extreme events in the non-HIV persons.

With respect to PCT, it was observed that with person F5, F7, F8, F9, F11, F13, F15, F19 and F20 with ages 21, 62, 14, 57, 53, 30, 47, 45 and 35 and sex F, F, M, F, F, F, M, F and F respectively, the maximum value was obtained to be 1. With person F12 and F14 with ages 45, 45 respectively and are both males, the minimum value was obtained to be 0.01. The average value was obtained to be 0.48 with a skew value of 0.21 which is fairly (positive) skewed. The kurtosis value is -2.08 which is platykurtic (negative), that is; PCT has a lower likelihood of extreme events in the non-HIV persons.

The bar chart comparison plots of the result of WBC (a), LYM (b), MID (c), NEU (d), RBC (e), HGB (f), PCV (g), MCV (h), MCH (i), MCHC (j), PLT (k) and PCT (l) for the two groups (A=HIV (+) and B=HIV (-)) is shown in Figure 2 (a-l). From the charts, it was observed that the average value of the ratios of WBC/*WBC, LYM/*LYM, MID/*MID, NEU/*NEU, RBC/*RBC, HGB/*HGB, PCV/*PCV, MCV/*MCV, MCH/*MCH, MCHC/*MCHC, PLT/*PLT, PCT/*PCT for HIV (-) group with respect to HIV (+) group were 4.57, 0.82, 0.92, 2.31, 0.73, 0.77, 0.73, 0.98, 1.04, 1.05, 2.40 and 6.17 respectively. The highest average value of 6.17% was obtained for PCT/*PCT while the lowest of 0.73% was obtained for RBC/*RBC and PCV/*PCV.

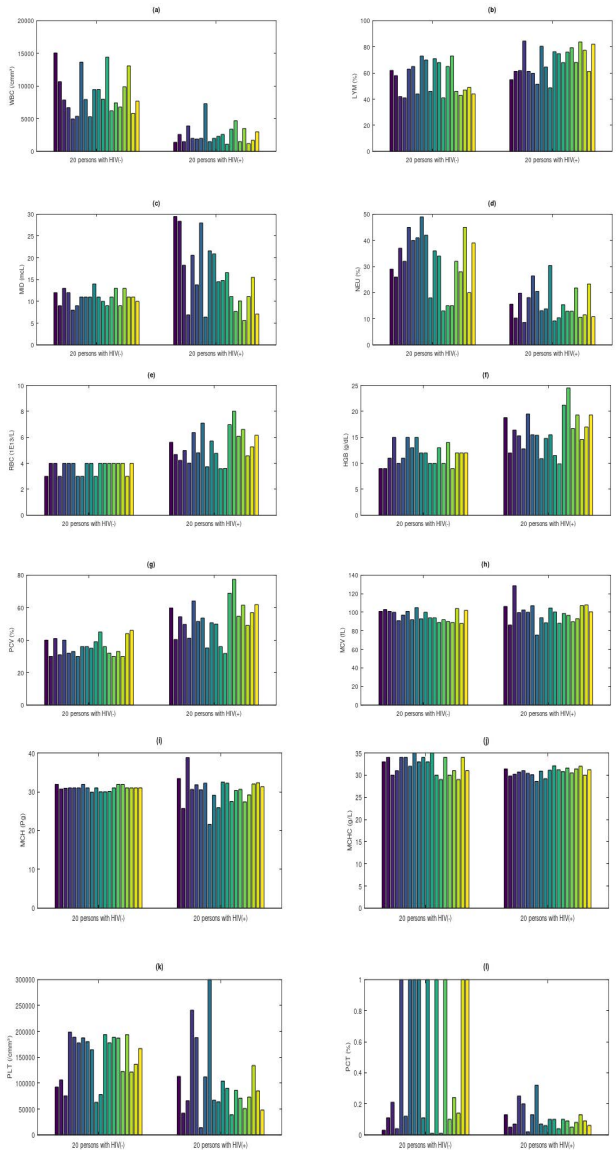

Figure 2: a–l) Results of biomarkers in full blood count of both HIV (+) and HIV (-) individuals.

The mean concentration of Mn, Fe, Cu and Zn were lower in HIV patients than in the healthy control group HIV (-) while the variation in blood trace elements was highest in Fe while Pb was not determined. These elements had been highlighted to be potentially detrimental to human health and pose serious environmental concern when obtained at low and high concentration. These trace elements have been observed to be extremely higher than the threshold values of the trace elements concentration in the blood samples. The excess supplementation of these trace elements is the hallmark of non-communicable diseases. The hematological parameters of the complete full blood count in the HIV patients and healthy controls are shown in Tables 3, 4 and Figure 2 (a–l). The values of the hematological parameters tested in the blood of HIV positive individuals were lower than it is in the healthy control individual. The differences in value in the cells of the two groups of individuals screened were statistically significant. The decrease in the full blood count were progressive with the stages of HIV infection. Several blood

parameters showed variation in value between the HIV infected group and the healthy control group.

The minimum and maximum concentration values for Fe is found to be high compared to other trace elements analyzed in the samples as Fe is known to be the most abundant elements in the most upper and lower earth's crust. This finding suggests that trace elements could be used as biomarkers of the progression of HIV infection alongside the full blood count. Trace elements, particularly the Mn, Zn and Cu, have been reported to decrease in disease conditions suggesting that the low concentrations of cations in blood is not disease specific but may follow a pattern of metabolism. The observed decrease of trace elements in the HIV individuals may be related to massive cells destruction associated with the infection, since some of these trace elements form parts of the enzyme system occurring in some of these cells that may be so destroyed or as a result of other metabolic errors.

Conclusion

This study assessed the concentrations of heavy and trace metals in the blood of individuals with and without HIV, aiming to understand the impact of the virus on these elements. A standard blood collection method was employed, with samples collected from both HIV/AIDS patients and healthy controls. The analysis revealed significant differences in metal concentrations between the HIV/AIDS group and the healthy group. Mn, Fe, Cu, and Zn levels were found to be 28.23%, 2.88%, 2.64%, and 1.92% higher, respectively, in the healthy group compared to the HIV/AIDS group. In the HIV/AIDS group, Mn and Cu showed increased likelihood of life-threatening occurrences, while Fe displayed a lower likelihood, and Zn levels remained within normal distribution. Conversely, in the healthy group, Fe, Zn, and Cu exhibited lower likelihoods of life-threatening situations, while Mn levels were within normal distribution. Additionally, hematological parameters such as Lymphocytes (LYM), Monocytes (MID), red Blood Cell Count (RBC), Mean Corpuscular Volume (MCV), and Mean Corpuscular Hemoglobin (MCH) had lower likelihoods of life-threatening events in the HIV/AIDS group, with White Blood Cell Count (WBC) showing a greater likelihood. Conversely, in non-HIV individuals, WBC and MCH displayed standard normal distributions, while LYM, MID, Neutrophils (NEU), RBC, Hemoglobin (HGB), Packed Cell Volume (PCV), MCV, Mean Corpuscular Hemoglobin Concentration (MCHC), Platelet Count (PLT), and Plateletcrit (PCT) had lower likelihoods of life-threatening events. This study underscores the significant alterations in metal concentrations and hematological parameters associated with HIV/AIDS, highlighting the potential for assessing these factors as indicators of disease progression and risk assessment.

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