Association between blood group, CD4, Viral load and opportunistic infections among patients attending Kericho county referral comprehensive care clinic, Kenya

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ABSTRACT

Erythrocyte antigens bringing about blood groups are considered pathogen receptor sites, including Human Immunodeficiency Virus (HIV), affecting approximately 39.9 million people worldwide, with 3.31% and 3.3% prevalence in Kenya and Kericho County, respectively. Limited studies showing inconsistent results and unpublished perceptions suggest a possible role of blood groups in Human Immunodeficiency Virus disease surveilled by changes in CD4 counts, viral load and opportunistic infections among infected. This study determined the ABO-Rhesus blood group distribution and association with CD4 counts, viral load and opportunistic infections at the Kericho County Referral Hospital Comprehensive Care Clinic in the year 2020. This cross-sectional, retrospective study comprised randomly sampled adults (≥18 years) without bone marrow transplant or transfusion history, with the sample size (n=285) calculated using the Yamane Taro formula. ABO-Rhesus typing was done on venous ethylenediaminetetraacetic acid blood using commercial antisera. Viral load and CD4 counts, determined using Abbott m2000sp/rt and FacsCalibur, respectively, and opportunistic infection data were documented in the data extraction form. Statistical Package for Social Sciences SPSS® version 26 was used to analyse and summarise data as means, standard deviation and prevalence ratios. Z-test, analysis of variance, regression, and chi-square were used to contrast, compare means, assess outcomes among variables, and determine relationships, respectively. Ethical principles were observed during specimens' and participants' information handling. Females were the majority, 174 (61.1%), and the mean age was 42.8 (12.8) years. Blood group O was most prevalent at 138 (48.4%), followed by A at 78 (27.4%), B at 59 (20.7%), and the least was AB. The Analysis of Variance showed a statistically non-significant association between blood groups on both viral load (p=0.74) and CD4 counts (p=0.84). Predictors for viral load change on regression analysis found increased viral load improvement in blood group AB-positive compared to blood group A-positive (OR=6.77, 95% CI [1.82-14.33], p=0.01). Most of the participants did not develop opportunistic infections, n=209 (73.3%). Tuberculosis was more prevalent among blood groups on chi-square: A-positive (16.2%), B-positive (16.4%), O-positive (17.7%), O-negative (12.5%) and B-negative. Blood groups A-negative and AB-negative developed no opportunistic infections. The differences were, however, not significant at the 95% level of significance (p=0.91). The study showed a non-significant association between the ABO blood groups and HIV infection based on CD4 counts, viral load and opportunistic infections. However, group AB-positive and those with good adherence were associated with viral load improvement. Increased CD4 count and body mass index were associated with reduced opportunistic infections. Viral load increase was associated with likelihood of opportunistic infection. Further studies need to be conducted for comparison.

Keywords: ABO-Rhesus Blood Groups, CD4 Count, HIV Infection, Opportunistic Infections, Viral Load

I. INTRODUCTION

Antigens of blood group are found in the surface of red blood cells (RBCs) and they consist of polysaccharides and proteins. The antigenic factors present on the surface of the RBCs determine ABO/Rhesus blood group systems. The presence of antibodies is common to the serum of a person who does not have the antigens in question, which is also the key principle of the ABO and the Rhesus blood group systems (Lendabo et al., 2024). ABO system is identified by three alleles (A, B and O) whereas Rhesus system is regulated by the RHD gene, and the status of Rhesus is

determined by the presence or absence of the antigen RhD. Blood group distribution varies with population, and the differences are believed to be the influence of evolutionary pressures especially the ones associated with resistance to diseases (Dean, 2005). These variations in frequencies have resulted in different prevalence rates in different regions (Anstee, 2010). In the previous years, scholars have investigated the interplay between ABO and Rhesus blood groups and disease outcomes (Liumbruno & Franchini, 2013). Some phenotypes seem to increase susceptibility to some conditions like malaria and anemia, which is an indication that blood group antigens have a role in determining disease susceptibility. An example is a Scottish outbreak in 1996, which disclosed that Escherichia coli O157 affected people with blood type O disproportionately, and the fatality rate was 87.5% (Blackwell et al., 2002). More recently, Yeda et al. (2022) were able to conclude that B-positive individuals had a higher probability of having high Plasmodium falciparum parasitemia as compared to their O-positive counterparts. There is also a genetic factor: CCR5 32 mutation, which provides resistance to Human Immunodeficiency Virus type 1(HIV-1) was historically associated with resistance to smallpox and the Black Death, what explains how infectious disease has influenced the allele frequency over time (Duncan et al., 2005).

Such associations are further brought out in malaria studies. Opi et al. (2023) provided evidence that people with non-O genotypes are particularly vulnerable to severe malaria, whereas Wolofsky et al. (2012) found blood group A as an indicator of more severe P. falciparum infections. Interestingly, Jeremiah et al. (2010) discovered that blood group O as well as RhD-negative were both positively related to the severity of malaria. Other than malaria, the blood group phenotype has been linked with a multiplicity of conditions: ulcers (Edgren et al., 2010), Chagas disease (Teixeira et al., 1987), dengue fever (Kalayanarooj et al., 2007), and even type 2 diabetes, with blood group B found guilty (Sharjeel et al., 2021). The effects of the blood groups spread even into the non-infectious diseases. The non-O types of blood, such as those, have been associated with an almost three-fold higher cardiovascular risk than the type O (Capuzzo et al., 2016). Non-O blood types put individuals who have familial hypercholesterolemia at a twofold risk of cardiovascular events (Paquette et al., 2018). These conclusions indicate the health consequences of ABO systems on a wider scale.

Mechanistically, the antigens themselves may explain these associations. ABO antigens are complex carbohydrate molecules on red blood cells, and their presence or absence can either facilitate or hinder pathogen binding (Kato & Ishiwa, 2015). Secreted A and B antigens may act as decoys, offering some protection, whereas non-secretors who lack soluble antigens may be more vulnerable due to exposed polysaccharides that enhance pathogen attachment (Naeini et al., 2010; Dotz & Wuhrer, 2016). The Rhesus system also plays a critical role in immune responses, most notably in hemolytic disease of the newborn, where Rh-negative mothers develop antibodies against Rh-positive fetal cells, endangering subsequent pregnancies (Anstee, 2010). Given this background, it is reasonable to consider whether blood group antigens influence the course of HIV infection. Since its first identification in 1981 in the United States (Landers et al., 2021), HIV has remained a global health crisis. United Nations programme on HIV/AIDS (UNAIDS) estimates that nearly 40 million people are currently living with HIV, and more than 42 million have died since the epidemic began (Manalu et al., 2025). In 2023 alone, approximately 630,000 HIV-related deaths were reported, with Sub-Saharan Africa accounting for almost 70% new infections (World Health Organization, 2024).

Kenya reflects these global patterns, approximately 1.6 million people are living with HIV, with women disproportionately affected with more cases compared to men. National prevalence remains higher among women (5.2%) than men (4.5%) (Ministry of Health, 2018). In Kericho County, where this study was conducted, the disparity is even more pronounced: prevalence among women (19.1%) is nearly double that of men (11.3%) (Foglia et al., 2008). HIV remains a chronic, life-threatening condition, transmitted primarily through the exchange of infected body fluids.

Interestingly, Rhesus D-positive individuals have been shown to have a weak association with HIV susceptibility in Sub-Saharan Africa (Jacobs et al., 2023). This study aimed to investigate the role of ABO and Rhesus blood groups in HIV progression, focusing on their impact on cluster of differentiation 4 (CD4) counts, viral load, and the occurrence of opportunistic infections in individuals attending the Kericho County Referral Hospital Comprehensive Care Clinic.

1.1 Statement of the Problem

The antigens of the red blood cells lead to the attachment of the viral particles of HIV and subsequent transfer of the viral complexes into the immune cells thereby inducing the infection (Neil et al., 2005). This is believed to cause disparity in HIV infection vulnerability due to the variation of antigen expression among blood groups. Such differences can affect blood group distribution and prevalence across populations. Although there is some evidence suggesting association with immunity and susceptibility, the contribution of ABO-Rhesus blood groups to HIV disease is not well researched and is controversial. Blood group O was found to play some role in preventing blood borne infection compared to Blood Group A individuals who were found to be susceptible to Hepatitis B and HIV infection by Batool et al., (2017). A different study by Noori et al., (2022) revealed that AB carriers were more prone to HIV infection. Within the framework of blood groups in HIV, there is limited literature that can be referred to (Motswaledi et al., 2013)

and no study of such has been conducted in Kericho County. The key issues that this study tries to put across are the differential susceptibility and protectiveness of blood groups, as demonstrated in some studies, and through the sense that is not published. Particularly, there is limited research on the reconstitution of HIV biomarkers including CD4+ T-cell counts and viral load in dissimilar ABO-Rhesus blood groups. This study also addressed the need for understanding on the role of blood groups in occurrence of opportunistic infections following immune system damage in HIV infection.

1.2 Research Objective

i. To examine the distribution of ABO and Rhesus blood groups among HIV-positive individuals attending the Kericho County Referral Comprehensive Care Clinic
ii. To assess their association with key HIV disease markers, including CD4+ T-cell counts, viral load, and the prevalence of opportunistic infections.

II. LITERATURE REVIEW

2.1 Theoretical Review

Erythrocyte surface antigens particularly those governing blood group system are known to act as receptors for various etiologic agents. The following theories support the possible association of blood groups with CD4 counts viral load and opportunistic infections.

2.1.1 Host Susceptibility and genetic determinants theory

Blood groups are genetically determined traits with known polymorphic expression among individuals and populations. Carbohydrate moieties of the ABO blood antigens facilitate adhesion and entry of pathogens into the host cells. The blood group antigens are therefore, receptors for toxins, parasites, and bacteria, and can facilitate colonization or invasion or evade host clearance mechanisms. Blood groups can also serve as false receptors, preventing binding to target tissue (Cooling, 2015). Alternatively, certain pathogens may not bind onto the red blood cells due to absence of blood group antigen carrier, causing the individual to be less vulnerable to that infection.

2.1.2 Immunological theory of HIV pathogenesis

The red blood cell antigen has been shown to bind free viral particles and viral immune complexes and facilitate transmission to the T cells. Blood group antigens allow pathogenesis by viral binding thereby either providing protection or increasing risk of infection. HIV targets and eventually deplete CD4+T cells leading to immune function decline and progression to Acquired Immune Deficiency Syndrome (AIDS)

2.2 Empirical Review

2.2.1 ABO and Rhesus blood groups among HIV infected patients

The ABO and Rhesus blood group have been linked to disease susceptibility including viral diseases (Cooling, 2015). Neil et al. (2005) showed that HIV-1 infected cells have ABO blood group antigens on their cell surface that allow integration into the viral envelop during budding and viral replication. Additionally, the naturally occurring antibodies in human sera do neutralize corresponding ABO antigens carried by the HIV virus by complement activation. In a study by Purna et al. (2024) it appeared that blood group B individuals were more prone to HIV infection with blood group AB being least affected. HIV is classified as the genus Lentivirus in the family of Retroviridae, subfamily Orthoretrovirinae. HIV pandemic affects approximately 39.9 million people worldwide with a prevalence of approximately 3.31% and 3.3% in Kenya and Kericho County respectively. The female and male prevalence in Kenya is 4.46 % and 2.16 % respectively (National Syndemic Disease Control Council (NSDCC), 2024) Kericho County ranks 18 nationwide in the HIV epidemic, with approximately 26,639 individuals living with the virus as per the NSDCC, 2024.The Kericho County percent prevalence in female population is similar to the nationwide prevalence and leads at 4.3% while the male prevalence is 2.3% which also upholds the national prevalence for males in a close proportion.

The HIV virus enters the cell by the surface assimilation of glycoproteins on its surface and fusion facilitated by the cellular receptors. This is followed by combination of the viral envelope with the cell membrane of the target cell and the let out of the HIV capsid into the cell. This process is then followed by; replication, transcription and recombination of the viral proteins before release of virions to infect other cells. There are two types of HIV; HIV-1 and HIV-2 and both have the same mode of transmission. HIV transmission occurs through contact with infected body fluids or tissues. HIV virus causes immune system damage (Raska & Novak, 2010). Literature has few articles describing associations between HIV infection and blood groups. Susceptibility to HIV infection was attributed to having blood group AB (Noori et al., 2022) However, limited studies have been done on HIV in relation to ABO and Rhesus blood groups (Motswaledi et al., 2013). Therefore, this study establishes the prevalence of ABO and Rhesus blood groups among HIV infected patients. With these findings, blood group distribution data in HIV seropositive adults was made

to ascertain the prevalence of various ABO/Rhesus blood groups in adult population at the study site. The data created forms baseline data in the region to be referenced during ABO-Rhesus blood group and HIV disease research not only in the region but nationwide and within the east Africa community.

2.2.2 HIV disease progression by assessing viral load and CD4 T-Cell counts.

Studies carried out in Asia particularly in India revealed that the inheritance of blood groups and the consequent inheritance of certain immunological features may affect the development of the HIV infection (Sayal et al., 1996). This could impact the immune response during HIV infection. Studies have suggested that the HIV virion do acquire host ABO antigens. This could make the virus possibly more infectious or exposed eliciting complement activation. In a study by Motswaledi et.al, 2013, genetic factors were cited as contributors to HIV susceptibility and resistance. Chanzu et al. (2015) concluded that non-secretor phenotype may confer certain degree of protection against HIV. Immune recognition of HIV-1 virion carrying acquired blood group antigens from the host might be neutralized by antibodies in a person with incompatible blood types (Fang et al., 2025) This could impact viral load changes in HIV disease.

The CD4 cell count has been an important component of HIV treatment and care programs since HIV was identified as an infection compromising the immune system. In a study by Neil et al. (2005), it was observed that HIV target cells that express antibody and complement receptors. In the process of opsonization of virions, infection of these cells is enhanced. This requires further investigations into the mechanisms surrounding HIV infection with consideration of the host blood group.

For healthcare providers, the CD4 cell count has guided key clinical decisions ranging from when to start antiretroviral therapy (ART) to whether or not to screen for or provide prophylaxis against opportunistic infections (World Health Organization, 2014). CD4 testing is evolving to be an essential baseline test in the assessment of HIV disease progression and in monitoring advanced HIV disease (Ford et al., 2017). During HIV disease progression the HIV viral burden leads to $CD4^{+}$T cell destruction; the mature cell, progenitor cells and the cell in the central nervous system are all affected. This results in failure of T cell production and immune suppression (Tsukamoto, 2019). In a study by Cassenote et al. (2018) on $CD4^{+}$ T cell count and viral load data, it was observed that $CD4^{+}$ T cell count, and viral load data are the laboratory biomarkers for management and monitoring of HIV disease progression. Therefore, viral load is a very useful marker of early and sustained response in HIV treatment. Limited information is currently available on the relationship between HIV viral load and ABO-Rhesus blood groups whereas for CD4 cell counts there are some studies that have found significant association to ABO blood groups. In one study, a significant association was observed where blood group A and AB had highest CD4 counts with a conclusion that blood group antigens are involved in immune protection thus confer slow disease progression (Bamisaye et al., 2017) Association of these biomarkers with the ABO-Rhesus blood groups in this study contributes to available data and informs future studies thus may inform disease management strategies.

2.2.3 ABO-Rhesus Blood Groups and Disease

Genetic factors, including ABO and Rhesus blood groups, play a crucial role in the development of HIV disease. Studies have suggested that blood group phenotypes could influence susceptibility to viral diseases (Lell et al., 1999). Rhesus blood groups and ABO are the generational hereditary factors influenced by the selection pressure and play a significant role in the blood transfusion and transplantation medicine. These blood groups are relevant in terms of immune reactions particularly rejection and incompatibility as well as have been attributed to negative disorders such as Rhesus disease and abortion (Hassanzandeh et al., 2012). Blood group antigens act as pathogen receptors which enable pathogen colonization, invasion or escape of host immune clearance (Spear et al., 1992). The genetic connection of HIV-related disease, including HIV-Tuberculosis (TB) -associated Immune Reconstitution Syndrome (IRIS), has been examined, although insufficient attention has been given to the importance of blood group differences (Ma et al., 2018). As an example, Botswana study reported that the Rhesus Antigens C and E were correlated with HIV-negative status, whereas the blood group Jka, P1, and Lub was correlated with HIV-positive status indicating that blood group antigens are determinants of HIV disease state.

Immunological responses linked to the occurrence, course, and severity of diseases are linked to blood group antigens (Cooling, 2015). In addition to transfusion medicine, ABO blood groups have been implicated with cardiovascular diseases and cancer among others. Studies on infectious diseases, like malaria, have shown that group O is more prevalent in endemic regions, supporting the hypothesis of evolutionary advantages tied to blood group distribution (Zerihun et al., 2011). Furthermore, blood type O has been observed to have a higher incidence of HIV infection, necessitating further research to explore the role of ABO antigens in HIV disease progression (Siransy et al., 2015). In summary the following ABO blood group antigen mechanisms have been shown to influence HIV disease state; ABO incompatibility where the ABO-expressing virions are neutralized by naturally occurring antibodies (Jacobs et al., 2023), secretor status where incidence of HIV was increased in blood group A secretors in comparison to B, AB and O (Chanzu et al., 2015) and HIV binding made easy by certain ABO antigens (Davison et al., 2018).

2.2.4 Opportunistic infection prevalence per blood group among HIV infected

HIV infected patients develop a clinical latent period between HIV infection and clinical signs and symptoms of AIDs (Clinical stage 1). Minor signs and symptoms begin to appear in clinical stage 2. Life threatening infections begin to develop in clinical stage 3, with wasting and development of opportunistic infections. Patients develop advanced HIV disease or AIDs in clinical stage 4 (Weinberg & Kovarik, 2010).

Enzymes bring about biochemical reactions that are critical in human disease. Enzyme alterations and lack causes variability in glycan expression, thus affecting normalcy or directly contributing to disease causation. Enzyme deficiencies in humans form the basis of blood groups that impact fundamental areas in medicine, including the possibility of infection and severity of infectious disease, bleeding risk, transfusion medicine, and tissue/organ transplantation. (Jajosky et al., 2022). A study by Shahapur and Bidri (2014) shows that pulmonary tuberculosis was the most prevalent opportunistic infection (OI) with 43.6% of all cases. Other OI prevalence was as follows; Candidiasis (30.9%), cryptosporidium diarrhea (21.8%), herpes zoster (16.3%), cryptococcal meningitis (3.63%), *Pneumocystis jirovecii* pneumonia (1.81%), and other miscellaneous diseases (23.6%). One patient was found in HIV infection stage I while 13 patients each were in stage II or stage III. Due to the varying patterns of OIs that differ widely, it is necessary to correlate spectrum of OIs among HIV infected individuals in their specific blood groups (Shahapur & Bidri, 2014).

In another study the overall prevalence of most OIs reduces especially after the introduction of Highly Active Antiretroviral Therapy (HAART). However significant differences exist in the trends of different OIs in different geographical areas (Rubaihayo et al., 2015). The ABO blood group association with opportunistic infections that were nosocomial as per Zhong et al. (2023) found that blood group B and AB were susceptible to *Staphylococcus aureus*, AB was susceptible to urinary tract infections, B was susceptible to skin and soft tissue infection while B and AB were susceptible to deep incision infection. This study was therefore seeking to establish the existing prevalence of opportunistic infections across the different blood groups among HIV infected participants. This is because there is a need for specific factors including genetic factors, in this case the ABO and Rhesus phenotypes to be properly identified to enable the development and implementation of targeted disease management strategies.

III. METHODOLOGY

3.1 Study Design

The current study was cross-sectional and retrospective in nature as it aimed at examining ABO and Rhesus blood groups with respect to HIV-positive patients who were on care at the Kericho County Referral Comprehensive Care Clinic. In addition to mapping these distributions, the study examined the relationship between individual blood group phenotypes and particular HIV disease variables, namely CD4+ T-cells counts, viral load, and the prevalence of opportunistic infections. The cross-sectional design provided a representation of blood group trends at a particular time in this population, which could be utilized in future epidemiological and clinical studies in the area.

3.2 Study Population and Sampling

The subjects were the adult individuals (18 years and above) with HIV who attended the Kericho County Referral Comprehensive Care Clinic in 2020. Patients who had received bone marrow transplants or blood transfusion were excluded because they would confound the study due to the changes of blood group antigens. The total number of participants was calculated to be 285 using the Yamane Taro formula of computing the sample size.

3.3 Data Collection

Data sampling was done by reviewing patient records and direct testing. Blood typing was performed using venous blood samples in ethylenediaminetetraacetic (EDTA) tubes. The ABO and Rhesus blood groups were determined using commercially available antisera. The FACSCalibur flow cytometer, was used to count the CD4 + T-cells, and the viral load were done using the Abbott m2000sp/rt system. Information about opportunistic infections was extracted out of the patient records that had data about the diagnosis and the clinical stage of opportunistic infection based on the World Health Organization (WHO) HIV staging system (Weinberg & Kovarik, 2010).

3.4 Data Analysis

Data analysis was performed in SPSS version 26. The characteristics of the study population were summarized using descriptive statistics (mean, standard deviation, and prevalence). The Chi-square test was used to examine the links between ABO and Rhesus blood groups and the occurrence of opportunistic infections. The statistical test (ANOVA) was employed to establish the presence of significant differences in CD4+ T-cell counts and viral load across the types of blood groups. Regression was performed to assess the predictive potential of blood group on HIV progression indices (CD4 counts and viral load).

3.5 Ethical Considerations

This study was ethically approved by the institutional management of Kericho County Referral Comprehensive Care Clinic. The informed consent of all participants was obtained, and all personal data were de-anonymized to ensure the protection of confidentiality. Every data process was ethically designed to guarantee the privacy and security of patient information.

IV. FINDINGS & DISCUSSIONS

4.1 Demographic Profile of the Study Participants

As presented in Table 1, there were more female (61%), than male study participants (39%) in this study. The majority n= 199 (70%) were married. The ages ranged from 18 to 87 years, with a mean ±SD of 43±13 years. The Nilotic ethnic group constituted the largest proportion, n=248 (87%) The mean weight before ART was 57.85(15.28) after ART was 66.44(14.71). The mean clinical stage before ART (1.68(0.95)) and after ART 1.75(0.99). Mean duration on ART treatment was 6.35(8.15) and mean baseline CD4 was 278.4(265.5). Gender, age and marital status had a statistically insignificant association with CD4 count (>0.05). The differences in blood group distribution across the ethnic groups was however not statistically significant at 5% level of significance (p=0.99) However, there was as significant mean difference between weight before ART and Weight after ART (p<0.05). Across all the three time points in which VL was recorded, the majority, (>80%) had viral loads below the detection limit (LDL). The mean viral load measured six months after initiating ART was 5299.4±4271.1. The mean viral load at an annual routine test was 2797.1±25293.1.

Table 1

Demographic Profile of the Study Participants

Variable	**N (285), Min-Max**	**n (%), mean (SD)**	**p-value**
Gender			
Female	174	61.1	0.146
Male	111	38.9	
Marital status			
Not married	86	30.2	0.591
Married	199	69.8	
Age (years)			
18-24	27	9.5	
25-29	18	6.3	
30-34	34	11.9	
>35	206	72.3	
	18-87	42.8(12.8)	0.486
Ethnicity			
Nilotic	248	87.0	0.99
Bantu	36	12.6	
Cushite	1	0.35	
Clinical			
Weight Before ART (kg)		57.85(15.28)	0.00
Weight After ART (kg)		66.44(14.71)	
Clinical Stage Before ART		1.68(0.95)	
Clinical Stage After ART		1.75(0.99)	
Duration on ART (years)		6.35(8.15)	
CD4+Tcell counts (count/µl)		278.4(265.5)	
Viral Load at six months (copies/ml)		5299.4(4271.1)	
Total LDL at six months		245(86)	
Viral Load at one Year (copies/ml)		1416.1(7714.6)	
Total LDL at one year		243(85.3)	
Annual Routine Viral Load (copies/ml)		2797.1(25293.1)	
Total LDL at annual routine visit		223(78.2)	

4.2 The Distribution of ABO-Rhesus Blood Groups

The first objective was to determine the distribution of ABO-Rhesus blood groups among HIV infected study participants. Most of the study participants were found to have O-positive blood 45.6% (n=130). The A-positive blood group was the second most common at 26.0% (n=74), while AB-negative was the least common, n= 2 (0.7%). The

proportions did not vary significantly from the distribution in the general population. The differences were not statistically significant at 5% level of significance with; p=0.73, p=0.83, p=0.71, p=0.62, p=0.95 and p=0.56 for A+ve, B+ve, AB+ve, O+ve, A-ve, B-ve, O-ve respectively, Table 2 details the results.

Table 2
ABO-Rhesus Blood Groups Distribution

Blood group	Frequency (n)	Percent (%)	General population (percent %) *	Z(p-value)
A +ve	74	26.0	24.0	0.35(0.73)
B +ve	55	19.3	18.0	0.22(0.83)
AB +ve	8	2.8	6.0	0.37(0.71)
O +ve	130	45.6	48.0	0.49(0.62)
A -ve	4	1.4	1.0	0.06(0.95)
B -ve	4	1.4	1.0	0.06(0.95)
AB -ve	2	0.7	0.0	NA
O -ve	8	2.8	4.0	0.57(0.56)

***** Based on analysis of the distribution patterns of ABO and RH D phenotypes in Kenya (Githiomi, et al., 2017)

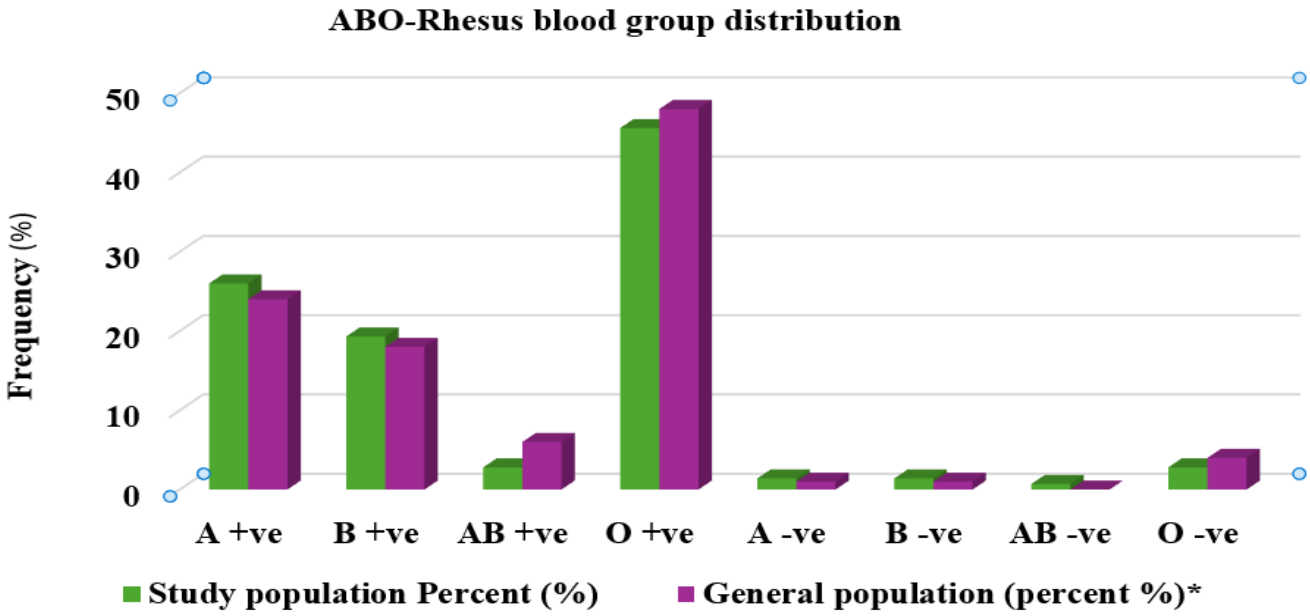

Figure 1
Shows the Overall Frequency of ABO-Rhesus Blood Groups

Based on analysis of the distribution patterns of ABO and RH D phenotypes in Kenya (Githiomi, et al., 2017). Figure 1 shows the overall frequency of ABO-Rhesus blood groups across the study population (study population and the general population) Columns shaded green indicate the study population while the columns shaded purple indicate the general population.

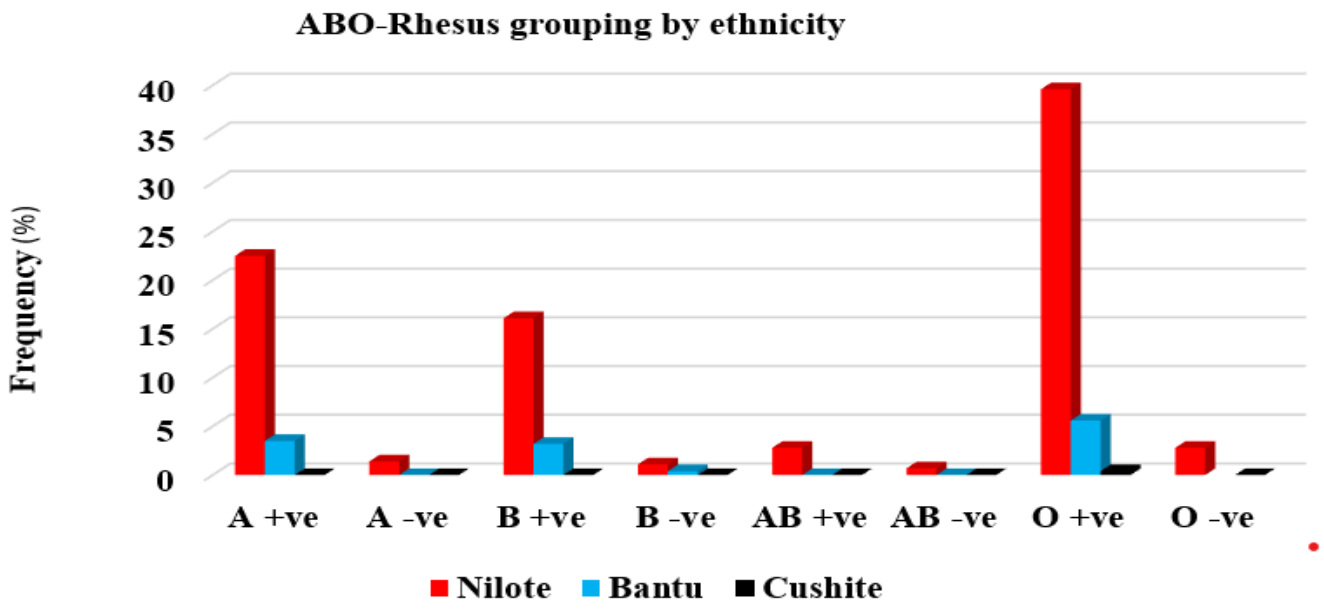

Figure 2
Shows the Overall Frequency of ABO-Rhesus Blood Groups

Figure 2 shows the overall distribution of ABO-Rhesus blood groups across the study population based on ethnicity. Columns shaded red indicate Nilotic population, (22.5%,1.4%,16.1%,1.1%,2.8%,0.7%,39.6% and 2.8%) while the columns shaded blue indicate the Bantu (3.5%,0%,3.2%,0.4%,0%,0%,5.6% and 0%) respectively while the Cushite population were 0.4% blood group O +ve only.

4.3 The Association between ABO-Rhesus Blood Groups and Viral Load, CD4+T-Cell Counts.

The second objective was to assess the association between ABO-Rhesus blood groups and viral load, as well as the $CD4^{+}$T-Cell counts among HIV infected study participants.

4.3.1 Effect of ABO-Rhesus Blood Groups on Annual Routine Viral Load

A one-way ANOVA was conducted to examine the effect of blood group on the annual routine viral load. The results showed that blood group had no significant effect on the annual routine viral load, $F(7,267) = 0.62$, $p = 0.74$, $\eta^2 = 0.02$, as presented in Table 3.

Table 3
ANOVA Results for VL by Blood Group

VL Annual Routine	Sum of Squares	df	Mean Square	F	p value	η^2
Between groups	2780403057.34	7	397200436.763	0.62	0.74	0.02
Within groups	172508768426.20	267	646100256.278			
Total	175289171483.54	274				

4.3.2 Effect of ABO-Rhesus Blood Groups on CD4+Tcell Counts

A one-way ANOVA conducted to examine the effect of blood group on the baseline CD4+T cell count. The results showed that blood group had no significant effect on CD4+Tcell counts, $F(7,194) = 0.49$, $p = 0.84$, $\eta^2 = 0.02$, as presented in Table 4.

Table 4
ANOVA Results for CD4 by Blood Group

Baseline CD4	Sum of Squares	df	Mean Square	F	p value	η^2
Between Groups	245625.54	7	35089.363	0.49	0.84	0.02
Within Groups	13923259.35	194	71769.378			
Total	14168884.89	201				

4.3.3 Viral Load Changes

Changes in viral load were calculated as the difference between the measurement at 6 months after ART initiation (used as the baseline) and the annual routine viral load measurement. Most of the study participants, 75.6% (n=214) had no change in their viral loads between the two times, 12.7% had higher viral loads at the annual routine viral load measurements compared to the baseline, whereas n=33 (11.7%) had reduced viral loads at the annual routine viral load time. Figure 3 illustrates the results.

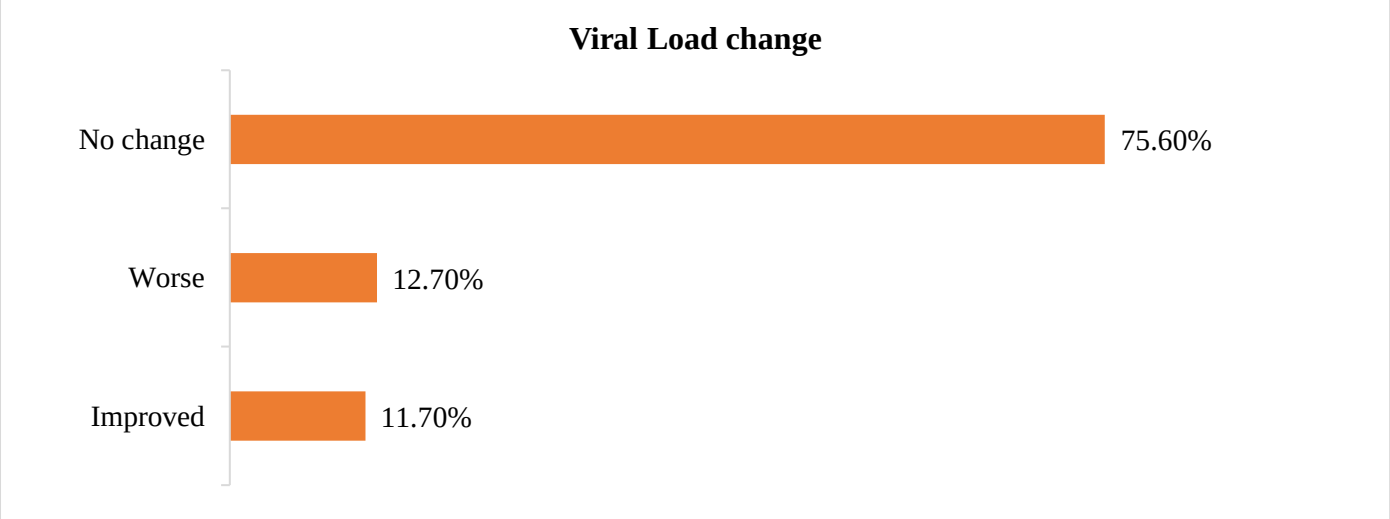

Figure 3
Viral Load Change

4.3.4 Other Predictors for Viral Load Change

To determine the other predictors of VL change, an ordinal logistic regression was used. Study participants with blood group AB-positive were found to be 6.77 times more likely to have an improvement in their viral loads compared to those with A-positive blood group (OR= 6.77, 95% c.i. [1.82-14.33], p= 0.01). Further, those with good adherence to ARV regimen were 4.4 times as likely to have reductions in their viral loads compared to the poorly adherent study participants (OR= 4.38, 95% ci [1.80-13.62], p= 0.04). Table 5 details the results.

Table 5
Predictors of VL Change

Factor	Category	OR (95% c.i)	p value
Blood group and Rhesus	O -ve	1.19(0.19-7.31)	0.85
	AB -ve	0.8(0.38-1.71)	0.57
	B -ve	1.3(0.01-190.11)	0.92
	A -ve	0.54(0.17-1.79)	0.32
	O +ve	1.23(0.62-2.43)	0.55
	AB +ve	6.77(1.82-14.33)	**0.01***
	B +ve	1.62(0.77-3.44)	0.20
	A +ve	REF	
ARV adherence	Good	4.38(1.80-13.62)	**0.04***
	Poor	REF	
WHO clinical staging pretherapy	4	1.26(0.11-14.79)	0.85
	3	1.19(0.58-2.43)	0.63
	2	1.61(0.62-4.18)	0.33
	1	REF	
Age		1.02(0.99-1.04)	0.21
BMI baseline		0.97(0.92-1.03)	1.03(0.97-1.09)

4.4 Opportunistic Infection Prevalence in Relation to Blood Group

Most of the study participants did not develop any opportunistic infection n= 209 (73.3%) Figure 4. Of those who had opportunistic infections, pulmonary tuberculosis was the most prevalent (n=42, 15%), followed by oral candidiasis (n= 13, 4.7%) as shown in Table 6.

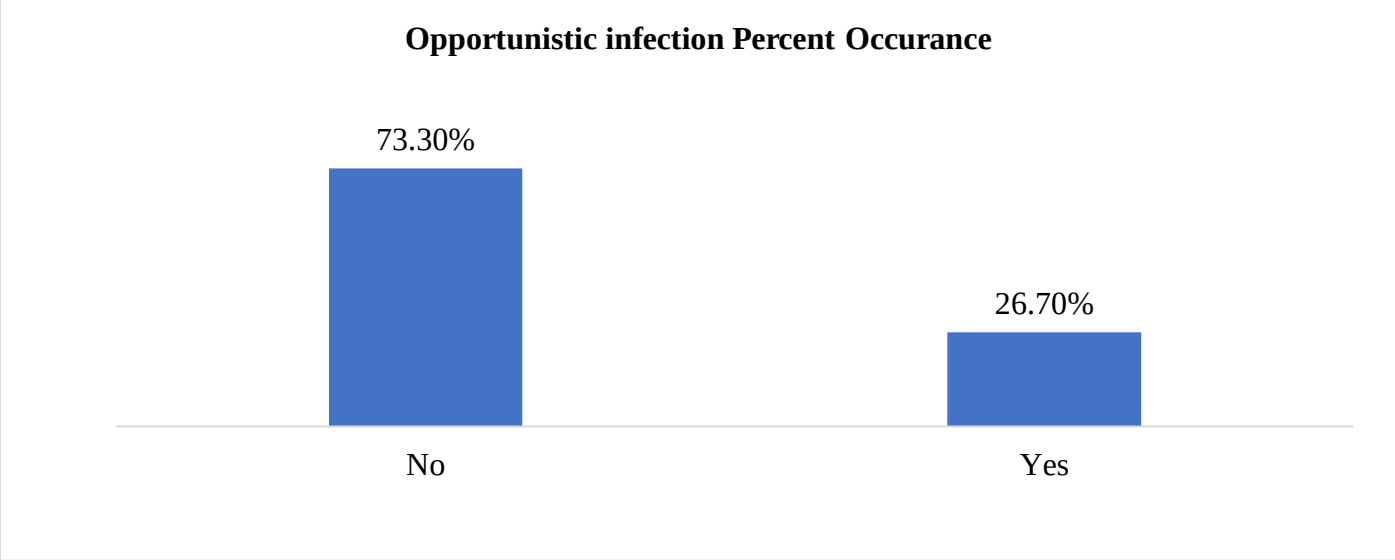

Figure 4
Opportunistic Infections Occurrence

Table 6
Distribution of Opportunistic Infections Prevalence

Infection	Frequency(n)	Percent (%)
None	209	73.3
Pulmonary Tuberculosis	42	14.7
Oral candidiasis	13	4.6
Cryptococcal Meningitis	5	1.8
Extrapulmonary Tuberculosis	7	2.5
Pneumonia	5	1.8
Herpes Zoster	2	0.7
Cancer Cervix	1	0.4
Kaposi Sarcoma	1	0.4

Analyzed by blood group, tuberculosis (both pulmonary and extrapulmonary) was the most prevalent among A-positive blood group (16.2%), B positive (16.4%), O-positive (17.7%), and B-negative. All of those with blood group A-negative, and AB-negative developed no opportunistic infections. These differences were, however, not statistically significant at the 95% level of significance (p= 0.91) as presented in Table 7.

Table 7
Opportunistic Infection Prevalence between Blood Groups

Blood group	Opportunistic Infection					Chi (p value)
	None n (%)	Tuberculosis n (%)	Oral candidiasis n (%)	Cryptococcal meningitis n (%)	Others n (%)	
A +ve	51(68.9)	12(16.2)	5(6.8)	3(4.1)	3(4.1)	18.70(0.91)
B +ve	43(78.2)	9(16.4)	0(0)	0(0)	3(5.5)	
AB +ve	6(75)	1(12.5)	0(0)	1(12.5)	0(0)	
O +ve	94(72.3)	23(17.7)	7(5.4)	1(0.8)	5(3.8)	
A -ve	4(100)	0(0)	0(0)	0(0)	0(0)	
B -ve	3(75)	1(25)	0(0)	0(0)	0(0)	
AB -ve	2(100)	0(0)	0(0)	0(0)	0(0)	
O -ve	6(75)	1(12.5)	1(12.5)	0(0)	0(0)	

As detailed in Table 8, a binary logistic regression was used to determine the predictors of the occurrence of opportunistic infections among the study participants. Both pre-therapy and the routine after therapy clinical staging were found to be significant determinants of opportunistic infection occurrence. Study participants presented at stage 4 pretherapy were 6 times more likely to suffer the infections compared to stage 1 study participants (OR= 6.23, 95% c.i [1.05-12.49]), while those presented with stage 2 were 3 times as likely (OR= 3.36, 95% c.i [1.04-8.67]) as stage 1 pretherapy study participants.

Study participants at stage 4 were determined to be almost thrice as likely as those in stage 1 to develop opportunistic infections (OR= 2.93, 95% c.i [1.74-6.97]), whereas stage 3 study participants were 4% less likely compared to the reference group (OR=0.96, 95% c.i [0.2-4.61]) Every unit increase in the baseline $CD4^{+}$T-Cell count was associated with a 1% reduction in the likelihood of opportunistic infections, while every unit increase in body mass index (BMI) at the baseline was associated with a 13% lower likelihood of opportunistic infections. Additionally, every unit increase in the viral load at six months post initiation was linked with a 1% increase in the likelihood of developing an opportunistic infection (OR= 1.01, 95% c.i [0.99-1.80])

Table 8

Determinants of Opportunistic Infection Occurrence

Factor	Category	OR (95% CI)	P value
Blood group & Rhesus	O -ve	0.11(0.35-3.6)	0.22
	AB -ve	0.96(0.59-1.58)	0.56
	B -ve	0.69(0.39-7.37l)	0.76
	A -ve	0.89(0.64-1.24)	0.53
	O +ve	0.68(0.31-4.74)	0.70
	AB +ve	0.58(0.19-0.83)	
	B +ve	0.47(0.45-4.92)	0.53
	A +ve	REF	
Clinical staging pre-therapy	4	6.23(1.05-12.49)	**0.01***
	3	0.83(2.68-4.28)	0.35
	2	3.36(1.04-8.67)	**0.05***
	1	REF	
Routine after therapy clinical staging	4	2.93(1.74-6.97)	**<0.01***
	3	0.96(0.2-4.61)	**0.04***
	2	1.96(0.82-3.84)	0.13
	1	REF	
Duration on ART		0.9(0.75-1.09)	0.29
Baseline CD4		0.99(0.97-1.01)	**0.03***
BMI baseline		0.87(0.77-0.99)	**0.03***
Routine after therapy BMI		1.04(0.94-1.15)	0.40
VL 6/12		1.01(0.99-1.80)	**0.01***
VL annual routine		1.00(0.99-1.06)	0.20

4.5 Discussion

4.5.1 Demographic Profile of HIV Patients

The demographic data about the study participants indicated that a greater number of individuals were females (61) than males (39), congruent with the National Syndemic Disease Control Council (NSDCC, 2024) report of a greater female prevalence (4.5) relative to males (2.2) in HIV infection. This observation is in line with the results of other researchers who found that the HIV prevalence is also greater in females (Mercy et al., 2020). The average age of the respondents stood at 43 years, which falls under the age group of 35-44 years of age which is reported to be the most affected by HIV (Enquselassie & Girma, 2009). Majority of the participants were married as well, as Foglia et al. (2008) suggested in the Kericho region. This could suggest socio-economic and behavioural predictors of HIV transmission as the marital status could be the determinant of sexual behaviour and access to HIV-related medical care, as well as the relevance of region-specific research. The fact that the study sample is predominantly Nilotic (87%), is suggestive of the ethnic diversity of the Kericho County, but it also shows why region-specific studies are important. It was also established that clinical measures do change significantly with the introduction of ART, including weight gain, which is in line with the effectiveness of ART in improving the nutritional status and overall health.

4.5.2 Distribution of ABO-Rhesus Blood Groups among HIV-Infected Patients

Analysis of the HIV-positive participants revealed that blood group O-positive was the most common (45.6%), followed by A-positive (26%) and B-positive (19.3%). This distribution closely mirrors findings from Gabon (Ngassaki et al., 2018) and Nigeria (Aliyu et al., 2025), where blood group O also predominated. Statistical comparisons indicated no significant deviation from expected patterns, with p-values ranging from 0.73 to 0.95 across the different blood groups. The predominance of Rhesus-positive individuals in this cohort (93.7%) is consistent with broader trends reported in Africa, where Rhesus-positive status is overwhelmingly common (Doku et al., 2022). Establishing this background is important, as it provides a genetic and epidemiological context for interpreting how ABO and Rhesus blood groups may influence the progression of HIV within the Kericho County population.

4.5.3 Association between ABO-Rhesus Blood Groups and Viral Load, CD4+ T-Cell Counts

The results of the One-Way ANOVA indicated no significant difference in the blood group on annual routine viral load ($p = 0.74$) or CD4+T cells ($p = 0.84$) count. This is also in line with the results of Motswaledi et al. (2013), who did not determine any significant association between HIV progression markers and blood group. This implies that, although blood group might play a role in determining the vulnerability to HIV, it did not play any significant role in determining the markers of disease progression such as CD4 + T-cell count or the viral load. However, blood group AB-positive was more likely to have an improvement in viral loads compared to A-positive blood group ($p = 0.01$). This pattern indicates that the blood group AB could also contribute to the inhibition of the viral load and additional investigation is required to establish these results and to identify the mechanisms. This could also be explained by the high adherence to ART by the participants, indicating that, ART compliance as opposed to genetic influences such as blood group may be the more important variable in this cohort in terms of its effects on viral load reduction and restoration of T-cell CD4+.

4.5.4 Opportunistic Infections in Relation to Blood Group

The rates of opportunistic infections (OIs) in the present research were relatively low, as 73.3 percent of the participants did not acquire any OIs. The most frequent OI was pulmonary tuberculosis (TB) (14.7%), and oral candidiasis (4.6%). This discovery that TB was the most common OI is similar to findings as indicated in other case studies held in sub-Saharan Africa e.g. Vajpayee et al. (2003) which indicated that TB is the most prevalent OI among HIV-positives. Nevertheless, no difference was observed in this research between the blood group and the incidence of OIs ($p = 0.91$). This implies that, although blood group can contribute to its disposition to disease, other factors including immune performance, compliance to ART and other co-infections like TB might be more influential in the occurrence of OIs. The results are consistent with those of Bamisaye et al. (2017), who discovered no significant correlation between ABO blood groups and the prevalence of OIs in people with HIV. However, the paper did note that blood group A-negative and AB-negative individuals did not develop any OIs although it was not significant.

4.5.5 Predictors of Opportunistic Infections

The binary logistic regression indicated that pre-therapy and routine clinical staging, baseline CD4+ T-cell count, BMI, and viral load are significant predictors of the presence of opportunistic infection. Those with presentation at clinical stage 4 before therapy were 6 times likely to develop OIs than their counterparts at stage 1 ($p = 0.01$). Correspondingly, individuals in stage 2 were found to be 3 times more prone to OIs ($p = 0.05$). These results highlight the significance of clinical staging with regard to predicting the risk of opportunistic infections, which supports the importance of disease progression in the occurrence of opportunistic infections. It was also found that each unit increment in viral load at six months after the onset of ART was linked to a 1 percent increment in the probability of acquiring an OI ($p = 0.01$). This helps to justify the idea that the constant replication of viruses helps to worsen the state of the immune system, exposing a patient to opportunistic infections.

V. CONCLUSION & RECOMMENDATIONS

5.1 Conclusion

This study examined the distribution of ABO and Rhesus blood groups among HIV-positive individuals attending the Kericho County Referral Comprehensive Care Clinic, with a particular focus on their relationship to key HIV disease markers such as CD4+ T-cell counts, viral load, and the occurrence of opportunistic infections. The blood group distribution did not differ significantly from that of the general population, with blood group O being the most prevalent and blood group AB the least. The analysis did not reveal any significant association between blood group and either viral load or CD4+ counts. This suggests that, although blood group antigens may play a role in susceptibility to HIV infection, they appear to have little influence on the subsequent course of disease progression. An interesting observation was the marginal association between the AB-positive blood group and improved viral load suppression,

though this finding remains tentative and warrants further investigation in larger cohorts. Opportunistic infections were relatively rare in the study population, with tuberculosis emerging as the most common. However, no clear relationship was established between blood group type and the prevalence of these infections. Taken together, these findings underscore the central importance of antiretroviral therapy adherence and clinical staging in the management of HIV progression and related complications, rather than genetic factors such as ABO or Rhesus blood group status.

5.2 Recommendations

According to the results of this study, it is suggested that more studies should be carried out to identify more genetic markers and how they may affect the progression of HIV especially in sub-Saharan Africa. Research into these issues may provide more insight into how genetic characteristics other than ABO and Rhesus blood groups may affect the outcomes of HIV. Moreover, it is important to reinforce ART adherence interventions since adherence is one of the most important interventions that can help enhance the outcomes of treatment and avoid opportunistic infections. The healthcare providers must focus on raising patient awareness on the need for consistent ART use to ensure viral control and improved immune functioning. Moreover, the most appropriate management of HIV should be associated with regular and thorough clinical surveillance, which is necessary and concerned with such important biomarkers as CD4+ T-cell counts, viral load, and clinical staging. This will make it possible to use more individualized treatment methods and interventions. Since there were no substantial results on the blood group relationship with the disease progression in this study, more localized studies in various regions of Kenya are required. These studies may assist in clarifying the role of genetic factors, including those of blood group, in making progression of HIV more noticeable in particular populations. Additionally, genetic factors and adherence to ART should be strengthened as parts of the public health policy included in HIV care programs. Lastly tuberculosis infection surveillance needs to be heightened given the increased chances over other opportunistic infections. This would improve patient outcomes and make HIV management policies more responsive to the needs of diverse populations. With this also, the healthcare systems will be able to enhance the quality of care they offer to people with HIV, especially in areas with similar HIV prevalence rates to that of Kericho County.

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