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Biological and Immunological Profile of HIV Voluntary Consultants with HCV and *Plasmodium* Coinfection in One Accredited Treatment Center in Cameroon

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Abstract: Malaria and HIV share common determinants of vulnerability and, HIV/HCV coinfection accelerates the progression to AIDS causing millions of deaths each year worldwide. The aim of the study was to determine epidemiological and immunological profile of HIV in HCV and *Plasmodium* coinfection context. All adults (≥ 17 years) volunteers for HIV testing and attending the Voluntary Testing Center of Douala Laquintinie Hospital were consecutively recruited over a period of seven months. Anonymous questionnaire was used to explore demographics, circumstances and reasons for testing, knowledge, attitudes, and behaviors. HIV diagnosis were performed using Rapid Diagnostic Test (RDT) and ELISA, whereas RDT were used for HCV and *Plasmodium falciparum* infection diagnosis. Quantification of HIV-1 specific CD4 and transaminases were based on FACS Count and spectrophotometer respectively. Overall, 25.6%, 6.4% and 24.8% of 125 adults had HIV, HCV and *Plasmodium* infection respectively. HIV/*Plasmodium*, HCV/*Plasmodium* and HIV/HCV coinfection was reported in 9, 2 and 1 consultant(s) respectively. Based on the WHO classification, severe immunosuppression (CD4 count < 200 cells/mm^3) was recorded in HIV and Plasmodium monoinfected individuals: 12.5% and 6.6% respectively. For HIV mono-infected consultants, 12.5% were highly immunocompromised and 43.75% had a CD4 count between 500 and 2000 cells/mm^3. Severe immunosuppression was more marked in HIV/*Plasmodium* (22.2%). HIV and *Plasmodium* mono-infected patients had higher hyperparasitemia compared to non-infected and the same result was observed with HCV/Plasmodium co-infected patients (42.8%) and HCV/*Plasmodium* co-infected patients. Severe immunosuppression was recorded in both HIV and *Plasmodium* monoinfected individuals. This severe immunosuppression was more pronounced in HIV/*Plasmodium* and HIV/HCV/*Plasmodium* coinfected patients. HIV and *Plasmodium* mono-infected patients had more pronounced hypertransaminasemia in women than in men.

Keywords: HIV, HCV, *Plasmodium*, Coinfection, CD4, Transaminases, Voluntary Counseling and Testing, Cameroun

1. Introduction

Human Immunodeficiency Virus (HIV)/Hepatitis C virus (HCV) co-infections currently represent a major public health problem due to their high frequency. This can cause complications and a higher risk of death compared to HIV or HCV mono-infection one of the main causes of death in HIV patients [1-3]. The prevalence of HIV/HVC coinfection varies widely depending on the studies and especially the modes of transmission of viral infections (up to 30% in Western countries [4] and between 1% and 40% in African countries) [5-8]. Malaria and HIV infection both have potentially serious effects in particular and many impacts of infection one to another are many [9, 10]. In environments where malaria transmission is unstable, adults infected with HIV are at increased risk of complicated and severe malaria and death [11] and malaria treatment failures are more frequently observed in patients co-infected adults whose CD4 count is low [11-13]. Some studies also show a significant increase of hepatic transaminases well in co-infected adults [14-16] than in children [17] compared to those with a mono-infection. They are no recent survey published and reflecting the impact of *Plasmodium* or HCV infection on HIV patients. It should be noted that the rates found in blood transfusion centers may differ from those found in the general population because the population tested does not accurately reflect the overall population. Screening for HCV infection is important due to high prevalence (2.5%) in our context, its potential morbidity and chronicity of the disease [18] that requires, a minimum regular medical supervision to prevent complications and adverse impact on people living with HIV. In Cameroon, the HCV screening is not routine in the VTC. This is understandable since unlike other countries, there is no national plan against hepatitis C that should increase access to screening, improving the management, reduce the risk of new infections by HCV, improve knowledge of HCV and hepatitis C, monitor and evaluate the evolution of the epidemic and assess the national program against hepatitis C. Malaria is not the least of these with a prevalence of 13.5% [19].

Due to increasing HCV in HIV and malaria endemic area of Cameroun, the aim of this study was to perform biological and immunological Profile of HIV Voluntary Consultants in one Voluntary Testing Center in the Douala Laquintinie Hospital (VTC/DLH), the main community hospital in and around the coastal region of Cameroon.

2. Materials and Experiments

2.1. Study Design and Population

A cross-sectional study was conducted for seven months (August 2014 to February 2015) among adults and, attending the Anonymous and free Voluntary Counseling and Testing (AHTC) of DLH located at the Douala 1st district of the Littoral region in Douala, Cameroun. With an estimated average annual population growth rate of 5% the last 30 years and a current population of approximately 2.500.000 inhabitants (officially 1.931.977), Douala is therefore the largest city in Cameroon with an estimated annual average population growth rate of 5% the last 30 years. The DLH houses an AVCT (91% of participants are adults vs 9% of children and adolescents) and a virology laboratory to evaluate HIV infections. In 2014, the DLH monitored about 5.000 peoples living with HIV, including about 4.500 on antiretroviral therapy.

We used a convenience sampling a non-probability sampling applicable in the study when the members of the population are convenient to sample. For limit the selection and information biases, participants were enrolled systematically and consecutively.

The survey's target population was all people of 17 years old and over with unknown HIV status and who presented to the AHTC of DLH for request a voluntary HIV testing. The voluntaries were asked verbally when they came to the AHTC whether they would like to HIV testing or not and if it is the first time except for blood dons. If the answer was "no", they will be excluded. If yes, they will be approached to participate in the study.

This study was conducted in accordance with the ethical guidelines for human research in Cameroon. All procedures were approved by the Medical Ethics Committee of the DLH and a permit has been issued for this study. Ethical clearance was also obtained from the Institutional Ethics Committee of the University of Douala N° CEI-UD/190/02/2015/M. Before to registration and administration of the questionnaire, subjects were informed of the purpose and process of the survey (background, objectives, methodology, study constraints, data confidentiality, and rights to withdraw from the study) and signed informed consent was obtained from all participants who had agreed to participate in the study in accordance with the Helsinki Declaration. Participation was voluntary, anonymous and no incentives were offered to complete the questionnaire.

2.2. Study Questionnaire

The data were collected using a pre-defined anonymous questionnaire. The questionnaire was first prepared in French and translated into English to ensure consistency and comparability. The questionnaire was administered independently on the same day by two individuals (Senior Investigator-Interviewer 1 and Health Staff-2) to estimate inter-interviewer reproducibility. The questions were formulated so as not to influence the participants in their answers. After the necessary modifications were made for ambiguous questions, the collection of actual data took place among the study subjects. Fact sheets on Malaria, HCV and HIV/AIDS infections were distributed after the interview and administration of the questionnaire to all participants.

2.3. Biological Tests

i) Two blood samples of approximately 5 ml from a venous puncture were collected to perform HIV, HCV and *Plasmodium* infections test, ii) level of transaminases (SGOT

and SGPT) measure and iii) CD4 count determination.

According to the current algorithm of HIV diagnosis at the VTC/DLH, the first test used was the immunochromatographic RDT "Alere Determine™ HIV-1/2". When the result was positive, we switched to the OraQuick-Advance® Rapid HIV-1/2 antibody immunochromatographic test, which is a confirmation of the first test. The enzyme-linked immunosorbent assay (Genscreen™ ULTRA HIV Ag-ab) was used in case of discrepancy between the first 2 tests. A negative result by the OraQuick-Advance® Rapid HIV-1/2 antibody test after a positive test by the Alere Determine™ HIV-1/2 test was evidence of a discrepancy requiring a confirmatory ELISA test.

HCV diagnosis was performed using CTK BIOTECH® OnSite HCV Ab Combo Rapid Test for the qualitative detection of hepatitis C virus in serum.

The "SD BIOLINE® Malaria Antigen P.f/Pan" immuno-chromatographic RDT was used for the qualitative detection of *P. falciparum* antigens in whole blood.

A flow cytometry (FACScount) was used to determine CD4 cells counts.

The amount of SGOT and SGPT in blood samples were determine using the transaminase blood assays (BIOLABO SAS kit) and, the detection technique include UV absorbance at 160 nm by KENZA Biochemistry spectrophometer.

2.4. Statistical Analysis

Categorical variables were expressed as frequencies, whereas numerical variables (Age) were presented as means and Standard deviation (SD), as data is normally distribution. Comparing proportions, we used Chi-square test or Fisher'exact test. Numerical values were compared using a parametric test, the Student-test. Only the variables significant in the univariate model were analyzed in a multivariate logistic regression model and taking into account all confounding factors. All statistical analyzes were performed using Stata software (version 11SE) and, only p-values <0.05 were considered significant in all analyses.

3. Results

3.1. Characteristics of Participants in Population Survey

A total of 155 individuals attending the AHTC of DLH had been asked verbally whether they would like to do *Plasmodium*, HCV and HIV test, among them 30 participants were excluded due to a health check-up requested. Finally, 125 participants who came for HIV testing and agreed to participate were enrolled. Overall, the male/female sex ratio was 1/1.4 (53/72) and, the mean age was not significantly different between male and female (Table 1).

Table 1. *Characteristics by gender of participants attending the AHTC of DLH.*

Variables	Female	Male	Total	p
	72 (57.6)	**53 (42.4)**	**125**	
Average age (Sd), years	35 (10.9)	38.5 (12.9)	36.5 (11.9)	
[18-26]	14 (19.4)	11 (20.7)	25 (20.0)	
[26-36]	29 (40.3)	12 (22.6)	41 (32.8)	0.116
[36-46]	18 (25.0)	16 (30.2)	34 (27.2)	
≥46	11 (15.3)	14 (26.4)	25 (20.0)	
Marital Status				
Married	30 (41.7)	26 (49.0)	56 (44.8)	
Single	40 (55.5)	25 (47.2)	65 (52.0)	0.630
Divorced or widower	2 (2.8)	2 (3.8)	4 (3.2)	
School-education				
Primary	16 (22.2)	10 (18.9)	26 (20.8)	
Secondary	41 (56.9)	30 (56.6)	71 (56.8)	0.075
University	15 (20. 8)	13 (24.5)	28 (22.4)	
Occupation				
Unemployed	31 (43.1)	19 (35.8)	50 (40.0)	
Workers	19 (26.4)	12 (22.6)	31 (24.8)	0.657
Executing Agent/ Masterings	15 (20.8)	15 (28.3)	30 (24.0)	
Public / Private workers	7 (9.7)	7 (13.2)	14 (11.2)	

Data are number and proportion (%), unless otherwise indicated.

3.2. Prevalence of HIV Infection and Related Factors

The prevalence of HIV infection for all consultants was 25.6%. It was higher for all women compared to men (65.6% vs 34.4%). Overall, there was a significant difference according to the school-education (p=0.009) and the prevalence of HIV infection was higher among consultants with a primary education (42.4%). This difference is also more marked when comparing high school versus university consultants (p=0.009). Although the majority of infected persons came from the Western region (53.1%) and the Littoral (18.7%), no significant difference was observed in the frequency of HIV infection according to region of origin. Overall, there was no significant difference in occupation when comparing the two groups, however in the HIV+ men were mostly unemployed while the HIV- were clerks (p=0.143). Marital status appeared to be

associated with HIV infection (p=0.026) and there were twice as many infected persons among married consultants as among single ones. Overall, people who reported risky behavior were more infected with HIV (Table 2).

Table 2. *Prevalence of HIV infection and related factors.*

Variables	HIV positive	HIV negative	p
	32 (25.60)	***93 (74.40)***	
Sex			
Women	*21 (65.6)*	*51 (54.8)*	*0.196*
Men	*11 (34.4)*	*42 (45.2)*	
Average age (Sd), years	*39 (11.6)*	*35.6 (11.9)*	*0.140*
Marital Status			
Married	*11 (16.92)*	*54 (83.08)*	*1*
Single	*19 (33.93)*	*37 (66.07)*	*0.026*
Divorced or widower	*2 (50.00)*	*2 (50.00)*	*0.158*
School-education			
Primary	*11 (42.31)*	*15 (57.69)*	*1*
Secondary	*18 (25.35)*	*53 (74.65)*	*0.088*
University	*3 (10.71)*	*25 (89.29)*	*0.009*
Occupation			
Unemployed	*15 (46.88)*	*35 (37.63)*	*1*
Workers	*7 (21.88)*	*24 (25.81)*	*0. 321*
Executing Agent/ Masterings	*5 (15.63)*	*25 (26.88)*	*0.143*
Public / Private workers	*5 (15.63)*	*9 (9.68)*	*0.458*
Risk behaviors			
Unprotected sex	*21 (65.63)*	*47 (50.54)*	*1*
Relations with prostitutes	*2 (06.25)*	*7 (07.53)*	*0.532*
Multiple partners	*4 (12.50)*	*12 (12.90)*	*0.339*
Prior transfusion	*7 (21.87)*	*25 (78.12)*	*0.124*
Tattoos / piercings	*11 (34.38)*	*21 (22.58)*	*0.502*
Intravenous drugs use	*0 (00.00)*	*0 (00.00)*	*/*
Place of residence			
Douala I	*9 (29.03)*	*22 (70.97)*	*1*
Douala II	*3 (27.27)*	*8 (72.73)*	*0.618*
Douala III	*13 (25.49)*	*38 (74.51)*	*0.459*
Douala IV	*1 (33.33)*	*2 (66.67)*	*0662*
Douala V	*6 (20.69)*	*23 (79.31)*	*0.328*

3.3. Prevalence of HCV Infection and Related Factors

The prevalence of anti-HCV antibodies was 6.4% with a slightly higher prevalence in women (62.5% of those infected are women) (Table 3). The 8 HCV+ persons are all those who have more than one risk behavior and no significant difference was observed.

Table 3. *Prevalence of HCV infection and related factors.*

Variables *N (%)*	HCV positive	HCV negative	p
	8 (6.4)	***117 (93.6)***	
Sex			
Women	*5 (62.5)*	*67 (57.2)*	1
Men	*3 (37.5)*	*50 (42.74)*	*0.538*
Average age (Sd), years	*44.8 (17.3)*	*35.8 (11.2)*	*0.176*
Marital Status			
Married	*4 (7.1)*	*52 (92.8)*	*0.783*
Single	*4 (6.1)*	*61 (93.8)*	*1*
Divorced or widower	*0 (00.0)*	*4 (100.0)*	*0.227*
School-education			
Primary	*2 (7.6)*	*24 (92.3)*	*1*
Secondary	*6 (8.4)*	*65 (91.5)*	*0.635*
University	*0 (00.0)*	*28 (100.0)*	*0.009*
Occupation			
Unemployed	*3 (37.5)*	*47 (62.5)*	*1*
Workers	*2 (25.0)*	*29 (75.0)*	*0.210*
Executing Agent/ Masterings	*3 (60.0)*	*27 (40.0)*	*0.745*
Public / Private workers	*0 (00.0)*	*14 (100.0)*	*0.227*

Variables *N (%)*	HCV positive	HCV negative	p
	8 (6.4)	*117 (93.6)*	
Risk behaviors			
Unprotected sex	*3 (37.5)*	*5 (62.5)*	*0.461*
Relations with prostitutes	*2 (25.0)*	*6 (75.0)*	*0.103*
Multiple partners	*2 (25.0)*	*6 (75.0)*	*0.272*
Prior transfusion	*0 (00.0)*	*6 (100.0)*	*0.647*
Tattoos / piercings	*1 (6.7)*	*14 (93.3)*	*0.653*
Intravenous drugs use	*0 (00.0)*	*0 (00.0)*	*1*

3.4. Prevalence of Plasmodium Infection and Associated Factors

The prevalence of malaria infection is presented in Table 4. Nearly one in four (24.8%) were carriers of *Plasmodium* and most of them were concentered in Doula I and III subdivision. *Plasmodium falciparum* infections accounted for 51.61% (16/31) of infections. Four cases of *Plasmodium* co-infection and 11 (35.48% of malaria infections) cases of malaria mono-infection other than *falciparum* were reported. The distribution of plasmodium species differed between the areas with a high representation of those living in Douala III (45.16%) although the difference was not significant (p=0.541). No significant difference was also found according to other variable.

Table 4. *Prevalence of Plasmodium Infection and associated factors.*

Variables	*Plasmodium+*	*Plasmodium-*	p
	31 (24.8)	*94 (75.2)*	
Sex			
Women	*19 (26.3)*	*53 (73.6)*	*1*
Men	*12 (22.6)*	*41 (77.3)*	*0.396*
Average age (Sd), years	*35 (12.4)*	*36.9 (11.9)*	*0.294*
Marital Status			
Married	*12 (38.7)*	*44 (46.8)*	*0.280*
Single	*18 (58.0)*	*47 (50.0)*	*1*
Divorced or widower	*1 (3.2)*	*3 (3.1)*	*0.697*
School-education			
Primary	*7 (26.9)*	*19 (73.0)*	*1*
Secondary	*17 (23.94)*	*54 (76.0)*	*0.477*
University	*7 (25.0)*	*21 (75.0)*	*0.558*
Occupation			
Unemployed	*8 (25.8)*	*42 (44.6)*	*1*
Workers	*9 (29.0)*	*22 (23.4)*	*0.132*
Executing Agent/ Masterings	*7 (22.5)*	*23 (24.4)*	*0.299*
Public / Private workers	*7 (22.5)*	*7 (7.4)*	*0.014*
Preventive plan action			
Use of the mosquito net	*6 (19.3)*	*22 (23.4)*	*1*
Not use of the mosquito net	*25 (88.65)*	*72 (76.60)*	*0.422*
Place of residence			
Douala I	*8 (25.8)*	*23 (74.4)*	*1*
Douala II	*4 (12.9)*	*7 (7.45)*	*0.382*
Douala III	*14 (45.1)*	*37 (39.3)*	*0.541*
Douala IV	*1 (3.2)*	*2 (2.1)*	*0.616*
Douala V	*4 (12.9)*	*25 (26.6)*	*0.202*
Paludal epidemiological facies and region of origin			
Sahelian (Far north)	*0 (00.0)*	*2 (2.1)*	*1*
Equatorial (North, Adamawa)	*2 (6.6)*	*3 (3.1)*	*0.476*
Tropical (Coast, Center, Northwest, West, Southwest, South)	*28 (93.43)*	*89 (94.6)*	*0.583*

3.5. Distribution of Subjects' CD4 Rates by Type of Infection

The mean CD4 count for all HIV positive subjects was 462±201/mm^3. Based on the WHO classification, severe immunosuppression (CD4 count < 200 cells/mm^3) was recorded in HIV and Plasmodium monoinfected individuals: 12.5% and 6.6% respectively. For HIV mono-infected consultants, 12.5% were highly immunocompromised and 43.75% had a CD4 count between 500 and 2000 cells/mm^3. This severe immunosuppression was more marked in HIV/*Plasmodium* (22%) (Table 5).

Table 5. *Distribution of subjects' CD4 rates by type of infection.*

	CD4 cells count, number of cells / mm^3			
	< 200	**[200-350]**	**[350-500]**	**[500-2000]**
Mono-infection HIV$^+$				
N (%)	4 (12.5)	4 (12.5)	10 (31.2)	14 (43.75)
OR [95%CI]	13.3 [10.0 – 23.9]	1	22.5 [15.1 – 47.3]	39.4 [26.5 – 60.9]
p	0.081		0.007	0.005
Mono-infection HCV$^+$				
N (%)	0 (00.0)	0 (00.0)	3 (37.5)	5 (62.5)
OR [95%CI]	-	1	10.9 [3.95 – 71.0]	37.2 [28.9 – 96.0]
p	-		0.210	0.317
Mono-infection Plasmodium+				
N (%)	2 (6.6)	3 (10.0)	3 (10.0)	19 (63.3)
OR [95%CI]	6.8 [2.2 – 15.5]	4.7 [0.7 – 20.7]	1	53.6 [46.0 – 80.5]
p	0.215	0.640		0.0001
Co-infection HIV/HCV				
N (%)	2 (4.6)	1 (2.3)	7 (16.28)	30 (69.7)
OR [95%CI]	3.8 [1.6 – 10.9]	1	10.3 [5.2 – 27.3]	62.4 [56.0 – 83.4]
p	0.557		0.026	0.0001
Co-infection HIV/Plasmodium				
N (%)	2 (22.2)	3 (33.3)	2 (22.2)	2 (22.2)
OR [95%CI]	13.6 [4.9 – 49.3]	10.8 [2.5 – 64.1]	9.7 [4.9 – 49.3]	1
p	0.215	0.599	0.324	
Co-infection HCV/Plasmodium				
N (%)	0 (00.0)	0 (00.0)	2 (50.0)	2 (50.0)
OR [95%CI]	-	1	5.4 [1.0 – 99.0]	5.4 [1.0 – 99.0]
p	-		0.210	0.210

3.6. Transaminases Rate and Infections

HIV and *Plasmodium* mono-infected patients had higher hyperparasitemia compared to non-infected. The same was observed with HCV/Plasmodium co-infected patients (42.8%) and HCV/*Plasmodium* co-infected patients (Table 6).

Table 6. *Distribution of transaminase level in infections groups.*

	Hypotransaminemia		**Normal**		**Hypertransaminemia**	
	Men	**Women**	**Men**	**Women**	**Men**	**Women**
	[10-50UI/L]	**[10-35UI/L]**	**<10UI/L**	**<10UI/L]**	**>35UI/L]**	**>35UI/L**
HIV infection						
HIV+	3 (27.2)	12 (57.1)	0 (0.0)	1 (4.7)	3 (34.3)	8 (38.1)
HIV-	17 (88.1)	33 (64.7)	1 (2.3)	5 (09.8)	4 (09.5)	13 (25.4)
HCV infection						
HCV +	3 (100)	5 (100)	0 (0.0)	0 (0.0)	0 (0.0)	4 (80.0)
HCV-	12 (84.0)	44 (65.6)	1 (2.0)	6 (08.9)	7 (14.0)	17 (25.3)
Plasmodium infection						
Plasmodium +	8 (66.6)	10 (52.6)	0 (0.0)	2 (10.53)	4 (33.3)	7 (36.8)
Plasmodium-	27 (90.2)	35 (66.0)	1 (02.4)	7 (07.55)	3 (07.3)	14 (26.4)
Co-infections						
HIV / HCV	0 (100)	2 (100)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
HIV / Plasmodium	0 (0.0)	4 (57.1)	0 (0.0)	0 (0.0)	3 (42.8)	0 (0.0)
HCV / Plasmodium	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	2 (100)
HIV / HCV / Plasmodium	1 (100)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)

4. Discussion

This study represents a first and unique perspective on people undergoing voluntary HIV testing at VCT. A total of 125 asymptomatic and completely HIV-naive subjects were included in our study and 30 were excluded because they came for a check-up. Our study reveals a prevalence of HIV infection of 25.6%. Although this prevalence was higher in women (29.1% vs 20.7%), no significant difference was found unlike the study conducted in Ethiopia [20]. In our study HIV infection was significantly higher among individuals with secondary education (8.4%) and married individuals (7.1%). Similar results were also reported in Ethiopia who also found a high prevalence of infection among married people [20]. They also found a high prevalence among people with a professional activity, who do paid work for the day and among housewives [20]. A population-based study conducted among people over 15 years of age (in 3 villages in Cameroon), as in our population, also found that the seroprevalence of HIV infection is very high

among women [15]. The fourth demographic and health survey conducted in the Cameroonian population in 2011 found that women are also more likely to be HIV positive than men [21]. About three out of five PLHIV are women and young women seem to be particularly vulnerable to HIV. Our prevalence is significantly higher than the prevalence estimated in the general population through the same survey and that found in studies conducted among blood donors in the same hospital structure with a seroprevalence <4% [22, 23] or in other sites in Cameroon [15]. For the Cameroonian population as a whole, HIV seroprevalence was around 2.7% in 2021 and 6.4% of people with HIV had secondary or higher education while 3% of people with HIV did not have a primary school certificate. According to the same survey for the Littoral region, HIV prevalence is around 4.6% and the city of Douala maintains the status quo with a prevalence rate of 4.6% [21]. There are several explanations for this difference: from a quantitative point of view, the results are limited; from a qualitative point of view, the risk factors associated with a higher HIV prevalence than that of the general population remain history of transfusion, risky sexual relations and drug use. One of the explanations for the non-representativeness of the general population and the high prevalence observed is that 80% of our population had engaged in risky behavior for at least seven months, when it is known that HIV seroconversion takes six months [24].

The seroprevalence of HCV in our study was 6.4%. Although we found a high prevalence among women as in other population-based studies in Cameroon [25] and Gabon [26]. On the other hand, another study found the opposite results, the seroprevalence of HCV infection was associated with age [15]. Madhava also found a relationship between high prevalence of HCV infection and ethnicity in Cameroon [27]. Although the prevalence of HCV infection in the general Cameroonian population has declined from 13.8% in 2002 with regional variations to 10.5% in 2012 [27, 28], it remains high. The estimated prevalence are mostly derived from national transfusion centers [21, 23, 27, 29], as Cameroon does not have a recent survey reflecting the situation of the general population. It should be noted that the rates found in blood centers may differ from those found in the general population, as the population tested does not accurately reflect the whole population. On the other hand, the differences could be explained by the fact that our study population was smaller and by the use of different tests between the different studies.

In our study, the malaria prevalence was 24.8%. This prevalence is close to that found in companies (28.2%) but lower than that found in the population (33.4%) by Lehman in 2013 [30]. The differences observed may be due to the different technique used for diagnosis. In our study, malaria was diagnosed by RDT (qualitative) while the other authors used classical microscopy or fluorescence (quantitative) whose reading is highly microscopist dependent, which could underestimate in one case or overestimate in the other case the positive cases.

The prevalence of HIV/HCV+ co-infection was 7.6% in our study, lower than that found (12%) in a cohort of HIV patients [15]. One of the main differences between these studies is the method of diagnosis of HCV infection by ELISA only in the study. HIV/HCV co-infection is higher in men than in women (25% vs 0.0%), trends found in 2007 [25]. In Cameroon, epidemiological studies on HIV/HCV co-infection are mostly conducted among blood donors and do not accurately reflect the general population [23, 29, 31].

The CD4 count is an eligibility criterion for ARV treatment in HIV-positive patients. Thus, only patients who were positive for one of the infections had a determined CD4 count, i.e. 71/125 (56.8%) of the individuals. According to the WHO, CD4+ levels up to 500/mm^3 allow patients to live without the need for ART, but below 350/mm^3, ART is recommended. Below 200/mm^3, the patient is highly immunocompromised and has a high risk of suffering from multiple opportunistic diseases related to AIDS. Our HIV-positive subjects were divided according to these criteria. It is important to note that with the "test and treat" approach, the CD4 count is no longer a criteria for eligibility for antiretroviral treatment; any person newly diagnosed as HIV positive is systematically initiated on treatment. For HIV mono-infected consultants, 12.5% were highly immunocompromised and 43.7% had a CD4 count between 500 and 2000 cells/mm^3 with a statistically significant difference (p=0.005). Our results are different from those obtained by other authors with a higher prevalence of highly immunocompromised people both in Africa (23% in Burkina) [32] and in Europe (31% in France) [4]. The difference observed with our results could be explained by the fact that contrary to our consultants (totally naïve of their serology), theirs had already been on ART for at least three (03) months, more over their sample was larger than ours. Associations were established between the CD4 count and the type of infection (*Plasmodium*, p<10-4) or even coinfection (HIV/HCV, p=0.026 and <10-4).

Transaminases (ALT and AST) were measured in the entire population and were grouped into normal, hypo and hypertransaminasemia on the basis of the reference values set. In total, 72.0% had normal values, 5.6% hypo and 22.4% hypertransaminasemia. In our study, the majority of HIV patients had normal transaminase values. Among HCV positive consultants, more than half were hypertransaminasemic compared to 25.3% among HCV-consultants. Among PALU+ consultants, 36.8% were hypertransaminasemic compared to 26.4% among non-PALU+ consultants. These results confirm those established by some authors who indicated that an increase in transaminase levels does not necessarily reflect an abnormality [33], as high transaminase frequencies were found in negative subjects. Transaminases increase in the blood when liver cells are destroyed, and this is the case in all liver diseases: viral, infectious or toxic hepatitis and liver cancer [34]. An increase in transaminases can also be linked

to autoimmune diseases, obesity and overweight, alcoholism, myopathies, myocardial infarction, parasitosis or pancreatitis. Muscular effort or muscular trauma can also increase the transaminase level. On the other hand, a decrease in transaminases can be related to pregnancy or vitamin B6 deficiency [35].

5. Conclusion

In conclusion, we found a high prevalence of HIV infection compared to the general population, with a significant risk factor for women and people with a low level of education. A high prevalence was also found for the other two infections and cases of co-infections were reported with HIV/*Plasmodium* co-infection being the most important. Severe immunosuppression was recorded in HIV and *Plasmodium* mono-infected individuals. This severe immunosuppression was more pronounced in HIV/*Plasmodium* and HIV/HCV/*Plasmodium* co-infected patients. HIV and *Plasmodium* mono-infected patients had more pronounced hypertransaminasemia in women than in men. This findings highlight the need to step up effort to implement screening of *Plasmodium* and HCV infections in PLHIV preventing probable immunological failures. Further study of the impact of *Plasmodium* infection on HIV/AIDS progression is needed.

Availability of Data and Materials

All data underlying the findings have been presented within the manuscript.

Abbreviations

AHTC: Accredited HIV/AIDS Treatment Center, ART: antiretroviral therapy (ART), AVCT: Anonymous and free Voluntary Counseling and Testing, DLH: Douala Laquintinie Hospital, PLHIV: people living with HIV.

Consent for Publication

Consent to publish has been obtained from all included persons in the study.

Competing Interest

The authors declare that they have no competing interest.

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