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Predictors of Unsuppressed HIV Viral Load and Low CD4 Count Among ZIMPHIA 2020 Survey Participants

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Abstract

Unsuppressed Viral load and low CD4 counts pose a significant challenge to HIV/AIDS management. Understanding the predictors of unsuppressed viral load and CD4 is critical for developing strategies to mitigate its impact. This study aimed to identify predictors of unsuppressed HIV viral load and low CD4 counts among Zimbabwe population-based HIV impact assessment survey (ZIMPHIA 2020) study participants. We analysed data from the ZIMPHIA 2020 survey. Data collection was done using structured interviews, home-based HIV testing and laboratory testing. Blood samples from participants were tested for HIV and those positive were analysed for CD4 counts and Viral load tests. We then calculated odds ratios for predictors of unsuppressed viral load (viral load ≥1000 copies/mL) and low CD4 counts (CD4< 350). The prevalence of unsuppressed viral load and low CD4 count were 20.7% and 34.7%, respectively. Males were more likely to be virally unsuppressed (25.1%) than females (18.8%) adjusted odds ratio (aOR) (95% confidence interval) 1.74 (1.43-2.11) p-value < 0.001. The odds of having a low CD4 count were higher among males (41%) than females (19%) aOR (95% confidence interval) 3.07 (2.57-3.66). Urban dwellers were more likely to have a low CD4 count (31.1%0 than rural dwellers (23.8%) aOR (95% confidence interval) 1.45 (1.21-1.73) p-value <0.001. The common predictors of both unsuppressed viral load and low CD4 were gender, never tested for HIV and never had a viral load test.

Keywords: *CD4 Counts, HIV/AIDS, Predictors, Unsuppressed Viral Load Zimbabwe.*

Introduction

The 95-95-95 targets which were set by the Joint United Nations Programme on HIV/AIDS (UNAIDS) state that by 2025, 95% of all HIV-positive individuals should be aware of their status, 95% of all HIV-positive individuals

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should be receiving continuous antiretroviral therapy, and 95% of all recipients of antiretroviral therapy should have viral suppression [1]. By the end of 2022, approximately 29.8 million of the 39 million people living with HIV were receiving antiretroviral therapy (ART). Thus 76% were on ART treatment and 71% of them had suppressed HIV viral load [2]. There is a need to scale up efforts to reach the third 95 of HIV viral load suppression.

The prevalence of HIV among adults in Zimbabwe was 12.9%, which corresponds to approximately 1,225,000 adults living with HIV according to ZIMPHIA 2020 report [3]. It was also found that 86.8% of adults living with HIV were aware of their status and of those aware, 97.0% were on antiretroviral treatment (ART). Viral load and CD4 testing services are offered free of charge at public health facilities in Zimbabwe with local and international partners involved in the viral load testing scale-up [4].

Unsuppressed HIV Viral load is a term used to describe the situation when the HIV is not suppressed by the antiretroviral therapy (ART) that a person is taking. This means that the virus can continue to destroy the immune system and increase the risk of transmitting HIV to others.

According to WHO unsuppressed HIV viral load is a viral load greater than 1000 copies/ml [5]. A low CD4 count for adults and children who are five years and older is defined as a CD4 count of less than 200 cells/mm^3, which is the stage of advanced HIV disease [6]. Unsuppressed HIV viral load continue to be a major public health concern among people living with HIV [7].

Unsuppressed viral load and low CD4 count can limit the efficacy of available drugs for the management of HIV/AIDS leading to reduced quality of life for those who are affected [7, 8]. Although the purpose of CD4 count evaluations has been muddled with the introduction of universal antiretroviral medication (ART) and the expansion of HIV viral load testing, CD4 count remains a reliable indicator of mortality for HIV-positive individuals and plays a crucial role in identifying patients who may be at risk of developing advanced HIV disease [9-11].

Monitoring viral load suppression and CD4 counts serves as a valuable performance indicator for antiretroviral therapy (ART) programs. Regular CD4 and viral load (VL) monitoring enables the early identification of suboptimal adherence. Achieving viral suppression is linked to reduced HIV disease progression, low risk of mother-to-child transmission, reduced mortality among individuals living with the human immunodeficiency virus and preventing HIV transmission to sexual partners [2, 12]. Continuous assessment of virological status provides crucial initial and precise information regarding potential treatment failure. It guides a decision on regimen adjustments, minimizes mutations resulting from drug resistance and ultimately leads to desired treatment outcomes. Ensuring viral suppression in individuals with HIV is crucial for enhancing health and preventing sexual transmission [2, 5].

Consequently, the VL test plays a vital role in preventing unnecessary switches to more expensive medications or continuation of effective therapy, which could otherwise contribute to drug resistance and adverse health outcomes. Some of the factors that contribute to unsuppressed HIV viral load include poor adherence to ART, alcohol consumption, non-disclosure of HIV status, bad perception towards the HIV whole life treatment, lack of ART regimen switching and older age [13-16].

Identifying factors that predict the development of unsuppressed HIV viral load and low CD4 can help healthcare providers better manage the disease and improve patient outcomes. This study is part of the Zimbabwe Population-based HIV Impact Assessment (ZIMPHIA 2020) project, which was a national survey that aimed to measure the impact of

HIV/AIDS in Zimbabwe. The findings of the study can inform policy decisions and resource allocation for HIV/AIDS prevention and treatment in Zimbabwe.

Materials and Methods

Study Design and Population

The methodology of ZIMPHIA 2020 has been described elsewhere [3], Briefly, ZIMPHIA 2020 survey was a nationally representative, cross-sectional population-based survey of households across Zimbabwe using a stratified multistage probability sampling design. The first stage selected 356 enumeration areas (EAs) systematically with probability proportional to size, where the size of an EA was defined by the number of households in that EA based on population projections for 2020 derived from the 2012 census. The EAs were stratified by urban-rural status and then geographically within urban-rural status before sample selection. During the second stage, a sample of households was randomly selected within each EA, or cluster, using an equal probability method, where the average number of households selected per cluster would be 35. Lastly, in each sample household, all eligible persons who were 15 years or older and were present in the household the night before the interview were included in the study. Written informed consent was administered.

Measurements

Blood for biomarkers was collected, and HIV testing was done at the household following the Zimbabwe national HIV testing algorithm. Samples that were positive for HIV, were shipped to the central laboratory and confirmed using the Genius HIV 1/2 Supplemental Assay (Bio-Rad, Hercules, California, United States). HIV viral load was tested using COBAS AmpliPrep/ Taqman 96 assay on the COBAS AmpliPrep /COBAS TaqMan (CAP/CTM) HIV-1, v2.0 Test (Roche Molecular Diagnostics, Branchburg, New Jersey, United States) respectively. CD4 test was done using Pima™ CD4 Analyzer (Abbott Molecular Inc., Chicago, IL, USA, formerly Alere). See figure1 below.

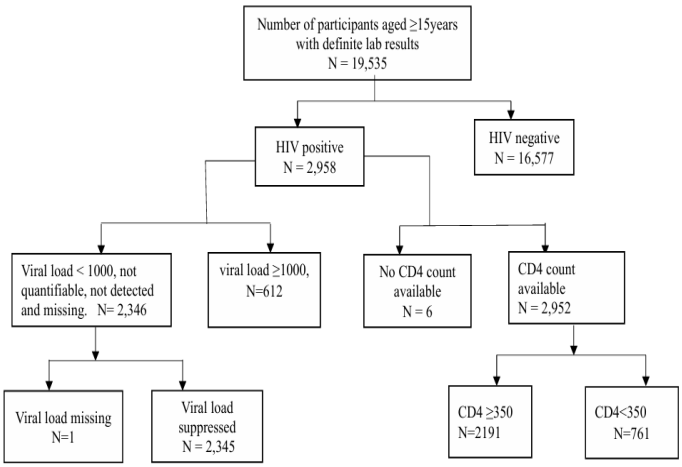

Figure 1. Flow diagram of Inclusion of ZIMPHIA 2020 Participants Tested VL and CD4

Data Analysis

We conducted secondary data analysis of 2957 participants who were HIV positive and had a viral load result adjusted for ARV intake. Simple proportions were used to describe the baseline demographic characteristics. Pearson chi-square tests were done to determine predictors of unsuppressed viral load and low CD4. For variables not normally distributed, the Wilcoxon rank-sum test was used, and the median interquartile ranges were calculated and

presented. Simple logistic regression was used for risk estimation and the odds ratio, and their 95% confidence intervals were calculated and presented. The significance level was kept at p = 0.05.

Results

A total of 2957 participants who tested HIV positive and had adjusted viral loads in this survey were included in the analysis. The recorded HIV prevalence in ZIMPHIA 2020 was 12.9% [3]. About 30% were males and close to the same percentage resided in rural areas, consistent with the population distribution in Zimbabwe. The majority (n = 2810, 95.1%) had ever attended school and more than half (n = 1568, 58.6%) were in marital union, while about a quarter (n = 775, 26.2%) were in the poorest wealth quintile (See Table 1).

Table 1. Baseline Demographic Characteristics of the HIV Infected Individuals from ZIMPHIA 2020 Survey

Variable	HIV Infected	
	N=2957	**%**
Age in years		
15-24	246	8.4
25-34	542	18.3
35-49	1320	44.6
50+	849	28.7
Gender		
Male	906	30.6
Female	2051	69.4
Area		
Urban	806	27.7
Rural	2151	72.7
Ever attended school		
Yes	2810	95.1
No	146	4.9
Ever Worked		
Yes	1359	46
No	1596	54
Current Marital Status		
Married	1,568	58.6
Living together	92	3.4
Widowed	556	20.7
Divorced	229	8.6
Separated	232	8.7
Wealth quintile		
Poorest	775	26.2

Second	682	23.1
Middle	560	18.9
Fourth	475	16.1
Richest	465	15.7

Predictors of Viral Suppression

The odds of being virally unsuppressed increased with decreasing age categories. The odds of viral unsuppression were higher for males OR=1.45, 95% CI (1.20-1.74) p value< 0.001, staying in urban areas than those staying in rural OR=1.35, 95% CI (1.12- 1.64) p value =0.002, those who ever attended school than those who never attended school, OR = 1.90, 95% CI (1.15 – 3.14) p value=0.012, those who ever worked than those who never worked, OR = 1.51, 95% CI (1.26-1.80) p value < 0.001, increasing number of sex partners in the last 12 months, OR = 1.27, 95% CI (1.15-1.41) p-value < 0.001, not using condom at last sexual act compared to those who used a condom, OR 2.21, 96%CI (1.77-2.78) p-value < 0.001. It decreased with an increasing number of years since the first HIV-positive result, OR = 0.97, 95% CI (0.93-1.00). It increased for those who never tested for HIV compared to those who ever tested, OR = 11.56, 95% CI (7.41-18.02), those who never had a viral load test compared to those who ever had, OR = 3.04, 95% CI (2.34-3.94), those with a CD4 count of < 350 compared to those with a CD4 count ≥350, OR = 8.09, 95% CI (6.65-9.84) and those who had little or no interest in doing things in the last two weeks, OR = 1.23, 95% CI (1.02-1.48).

In adjusted analysis controlling for age, gender, area of residence and wealth index the factors that remained statistically significant are age, gender, ever worked, no condom use at last sexual encounter, ever testing for HIV, ever having a viral load test, low CD4 count, having little interest in doing things in last two weeks and depressed in the last two weeks. More details of proportions are in Table 2.

Table 2. Predictors of Viral Load Suppression Among HIV Positive Participants, N=2957

Variable	Virally Unsuppressed		Virally Suppressed		Odds Ratio (OR)	95% -C. I	p-value	Adjusted Odds Ratio (aOR)	95% -CI	p-value
	N=612	%=20.7	N=2345	%-79.3						
Age in years										
50+	96	11.3	753	88.7	1			1		
35-49	251	19.0	1069	81.0	1.38	1.01-1.89	**0.046**	1.91	1.48-2.47	**<0.001**
25-34	170	31.4	372	68.6	2.68	2.00-3.59	**<0.001**	3.96	2.97-5.26	**<0.001**
15-24	95	38.6	151	61.4	4.93	3.54-6.89	**<0.001**	5.21	3.71-7.30	**<0.001**
Gender										
Female	385	18.8	1666	81.2	1			1		
Male	227	25.1	679	74.9	1.45	1.20-1.74	**0.001**	1.74	1.43-2.11	**<0.001**
Area										
Rural	415	19.3	1736	80.7	1			1		
Urban	197	24.4	609	75.6	1.35	1.12-1.64	**0.002**	1.02	0.71-1.46	0.932
Ever attended school										
No	18	12.3	128	87.7	1			1		
Yes	593	21.1	2217	78.9	1.9	1.15-3.14	**0.012**	1.07	0.63-1.82	0.792

Ever Worked										
No	281	17.6	1315	82.4	1			1		
Yes	331	24.4	1028	75.6	1.51	1.26-1.80	**0.001**	1.34	1.11-1.62	**0.003**
Age in years of sexual debut in years, Median IQR	18	17.0-21.0	18	17.0-20.0	1	(0.97-1.03)	0.934	1.01	0.98-1.04	0.475
Number of lifetime sexual partners, Median IQR	3	2-5	3	2-5	0.99	(0.98-1.01)	0.391	1	0.98-1.01	0.801
Number of sexual partners in the last 12 months, Median IQR	1	0-1	1	0-1	1.27	1.15-1.41	**0.001**	1.06	0.95-1.20	0.295
Condom use at last sex										
Yes	151	15.9	798	84.1	1			1		
No	259	29.5	618	70.5	2.21	1.77-2.78	**0.001**	2.23	1.76-2.82	**<0.001**
Condom use with nonmarital nonregular partner										
Yes	81	24.5	250	75.5	1			1		
No	59	29.8	139	70.2	1.31	0.88-1.94	0.18	1.27	0.83-1.93	0.266
Drinks alcohol										
No	446	19.3	1864	80.7	1			1		
Yes	164	25.5	480	74.5	1.43	1.16-1.75	**0.001**	1.2	0.94-1.52	0.139
Sex while drunk										
No	310	21.7	1118	78.3	1			1		
Yes	93	24.5	286	75.5	1.17	0.90-1.53	0.24	1.21	0.92-1.59	0.174
Duration in years since first HIV-positive result, Median (IQR)	7	3-10	7	4-11	0.97	0.93-1.00	**0.026**	1	0.97-1.04	0.836
Duration in years on ART Median (IQR)	3	2-3	3	2-3	0.92	0.78-1.08	0.344	1.11	0.94-1.30	0.218
Ever tested for HIV										

Yes	537	18.8	2317	81.2	1			1		
No	75	72.8	28	27.2	11.56	7.41-18.0	**<0.001**	10.7	6.68-17.15	**<0.001**
Ever switched ARVs										
Yes	61	7.8	726	92.3	1			1		
No	151	9.3	1469	90.7	1.22	0.90-1.67	0.203	1.17	0.85-1.61	0.324
Ever had a viral load test?										
Yes	149	7.9	1730	92.1	1			1		
No	123	20.7	470	79.3	3.04	2.34-3.94	**<0.001**	3.04	2.33-3.98	**<0.001**
CD4 Count										
>=350	236	10.8	1955	89.2	1			1		
<350	376	49.4	385	50.6	8.09	6.65-9.84	**<0.001**	9.7	7.79-12.07	**<0.001**
Any TB symptom during the last clinic visit										
No	150	10.6	1267	89.4	1			1		
Yes	130	11.9	964	88.1	1.15	0.9-1.48	0.306	1.12	0.87-1.45	0.38
Travel time in hours to pick ARV, Median (IQR)	2	1-3	2	1-3	1.02	0.90-1.16	0.743	1.04	0.90-1.19	0.606
Having little interest in doing things in the last two weeks										
No	386	19.6	1588	80.5	1			1		
Yes	224	23.1	748	77.0	1.23	1.02-1.48	**0.028**	1.3	1.07-1.58	**0.008**
Depressed in last 2 weeks										
No	369	19.8	1495	80.2	1			1		
Yes	239	22	847	78.0	1.14	0.95-1.37	0.152	1.21	1.00-1.47	**0.045**
Wealth quintile										
Poorest	151	19.5	624	80.5	1			1		
Second	124	18.2	558	81.8	0.92	0.71-1.20	0.526	0.97	0.74-1.27	0.832
Middle	107	19.1	453	80.9	0.98	0.74-1.29	0.863	0.95	0.72-1.27	0.747
Fourth	109	23.0	366	77.1	1.23	0.93-1.63	0.143	1.18	0.80-1.73	0.409
Richest	121	26.0	344	74.0	1.45	1.11-1.91	**0.007**	1.43	0.93-2.21	0.105

*95-CI- 95%-Confidence Interval

Predictors of Low CD4 Count

The odds of lower CD4 count were higher among males than females and among people living in urban areas compared to those living in rural areas, OR = 2.94, 95% CI (2.48-3.50) and OR = 1.45, 95% CI (1.21-1.73), respectively. This was also higher among those who had ever worked compared to those who never worked, OR = 1.32, 95% CI (1.12-1.56). It increased with the increasing age of sexual debut, as well as an increasing number of lifetime sexual partners and sexual partners in the last 12 months. It was higher among people who drink alcohol compared to those who don't, OR = 1.79, 95% CI (1.48-2.17). It was also associated with duration since the first HIV-positive result, duration on ART and history of HIV testing. Other significant factors were a history of viral load testing and a history of any tuberculosis symptoms at the last clinic visit.

In an adjusted analysis controlling for age, gender, area of residence and wealth index, the

factors that remained significant were gender, area of residence, condom use at last sexual encounter, duration since the first HIV-positive result, duration of art, history of HIV testing, history of viral load testing, history of any tuberculosis symptom at last clinic visit and travel time to pick ARVs. More details are in Table 3 below.

Table 3. Predictors of Low CD4 Count, N=2952

Variable	CD4 Count <350		CD4 Count ≥350		Odds Ratio	*95% -CI	p-value	Adjusted Odds Ratio	*95% -CI	p-value
	N=761	%=25.8	N=2191	N=74.2						
Age in years										
15-24	59	24.0	187	76.0	1			1		
25-34	140	25.9	401	74.1	1.11	0.78-1.57	0.571	1.21	0.84-1.74	0.300
35-49	339	25.7	979	74.3	1.10	0.80-1.51	0.566	1.06	0.77-1.48	0.708
50+	223	26.3	624	73.7	1.13	0.81-1.58	0.46	1.03	0.73-1.45	0.861
Gender										
Female	390	19.1	1656	80.9	1			1		
Male	371	41.0	535	59.1	2.94	2.48-3.50	**<0.001**	3.07	2.57-3.66	**<0.001**
Area										
Rural	511	23.8	1638	76.2	1			1		
Urban	250	31.1	553	68.9	1.45	1.21-1.73	**<0.001**	1.5	1.06-2.13	**0.022**
Ever attended school										
No	32	22.1	113	77.9	1			1		
Yes	729	26.0	2077	74.0	1.24	0.83-1.85	0.295	0.93	0.61-1.44	0.774
Ever Worked										
No	371	23.3	1220	76.7	1			1		
Yes	390	28.7	969	71.3	1.32	1.12-1.56	**0.001**	1.06	0.89-1.27	0.489
Age of sexual debut in years, Median (IQR)	19	(17.0-21.0)	18	(17.0-21.0)	1.03	1.01-1.06	**0.008**	1.01	0.98-1.03	0.688
Number of lifetime sexual partners, Median (IQR)	3	(2-6)	3	(1-4)	1.03	1.02-1.04	<0.001	1	0.98-1.01	0.568
Number of sexual partners in the last 12 months, Median (IQR)	1	(0-1)	1	(1-1)	1.14	1.03-1.26	**0.009**	0.98	0.88-1.10	0.773

Condom use at last sex										
Yes	237	25.1	709	75.0	1			1		
No	251	28.6	626	71.4	1.20	0.97-1.48	0.086	1.34	1.08-1.67	**0.008**
Condom use with a non-marital nonregular partner										
Yes	90	27.2	241	72.8	1			1		
No	56	28.3	142	71.7	1.06	0.71-1.56	0.786	1.06	0.71-1.60	0.764
Drinks alcohol										
No	534	23.2	1771	76.8	1			1		
Yes	226	35.1	418	64.9	1.79	1.48-2.17	**<0.001**	1.03	0.83-1.27	0.816
Sex while drunk										
No	380	26.7	1045	73.3	1			1		
Yes	103	27.2	276	72.8	1.03	0.80-1.32	0.842	1.09	0.84-1.42	0.521
Duration in years since first HIV-positive result, Median (IQR)	6	(3-9)	8	(4-11)	0.92	0.90-0.94	**<0.001**	0.91	0.89-0.94	**<0.001**
Duration in years on ART Median (IQR)	3	(2-3)	3	(2-3)	0.72	0.64-0.80	**<0.001**	0.70	0.62-0.79	**<0.001**
Ever tested for HIV										
Yes	713	25.0	2136	75.0	1			1		
No	48	46.6	55	53.4	2.61	1.76-3.89	<0.001	2.08	1.37-3.16	**0.001**
Ever switched ARVs										
No	156	19.9	630	80.2	1			1		
Yes	350	21.7	1266	78.3	1.12	0.90-1.11	0.307	1.19	0.95-1.48	0.128
Ever had a viral load test?										
Yes	356	19.0	1520	81.0	1			1		
No	179	20.3	412	69.7	1.86	1.50-2.29	<0.001	1.89	1.51-2.35	**<0.001**
Any TB symptom during the last clinic visit										
No	284	20.1	1128	79.9	1			1		
Yes	270	24.7	824	75.3	1.30	1.08-1.57	0.007	1.29	1.06-1.57	0.012
Travel time in hours to pick ARV, Median (IQR)	2	(1-3)	2	(1-3)	1.05	0.96-1.15	0.299	1.13	1.02-1.25	0.016

Having little interest in doing things in the last two weeks										
No	500	25.4	1469	74.6	1			1		
Yes	259	26.7	713	73.4	1.07	0.90-1.27	0.465	1.15	0.96-1.38	0.133
Depressed in last 2 weeks										
No	492	26.5	1367	73.5	1			1		
Yes	267	24.6	819	75.4	0.91	0.76-1.08	0.260	0.98	0.81-1.17	0.795
Wealth quintile										
Poorest	191	24.7	584	75.4	1			1		
Second	162	23.8	518	76.2	0.96	0.75-1.22	0.715	0.98	0.76-1.26	0.872
Middle	130	23.3	429	76.7	0.93	0.72-1.20	0.558	0.90	0.69-1.17	0.424
Fourth	135	28.4	340	71.6	1.21	0.94-1.57	0.140	0.94	0.65-1.36	0.737
Richest	143	30.9	320	69.1	1.37	1.06-1.77	0.017	1.06	0.69-1.60	0.801

*95-CI: 95%-Confidence Interval

Discussion

This study aimed to identify predictors of unsuppressed HIV viral load and low CD4 counts among ZIMPHIA 2020 study participants. A total of 2957 participants were HIV positive and 612 (20.7%) were virally unsuppressed. This is similar to what was reported in other studies where the unsuppressed viral load rate was about 20% or more [17-20]. It is important to note that, the high rates of viral load suppression show the effectiveness of the HIV programme and the way countries are moving towards achieving the third 95 UNAIDS target. However, there is still more work that needs to be done to reach epidemic control. The data also showed a higher proportion of HIV-positive people in rural areas compared to urban areas. This disparity could be attributed to differences in access to healthcare services, education, HIV awareness programs and the fact that 61.4% of Zimbabweans live in rural areas hence they were also a large percentage of the survey [21, 22]. Targeted interventions focusing on rural areas are essential to address this disparity and improve HIV-related outcomes in these areas. There was a high percentage of married individuals (58.6%) who were HIV positive compared to the widowed, divorced, or separated. Similar results were found in a study done by Hakizayezu et al [15], where 71.6% of HIV-positive participants were married. This underscores the importance of considering relationship dynamics and social factors in HIV prevention and support programs.

Although Zimbabwe has made strong progress towards the UNAIDS 95-95-95 targets, the prevalence of unsuppressed viral load and low CD4 count which were 11% and 25.8% respectively warrants further investigation to determine their predictors if we are to reach epidemic control. This study found that gender was significantly associated with both unsuppressed viral load and low CD4 count in both bivariate and adjusted analyses. Males were more likely to be viral unsuppressed than females and were likely to have a lower CD4 count than females. This is consistent with what other studies found about unsuppressed VL where men are at risk of VL non-suppression [20, 23, 24] and low CD4 count [25]. However, our results are different from what was found by Mapiye et al [26] in SA where the prevalence of having an unsuppressed VL was higher in females than in males or in other studies where gender was not associated with low CD4 count [27, 28]. The observations in our study could be attributed to various factors such as bad healthcare-seeking behaviour of males compared to females, work-related commitments, alcohol use of men and

lastly inflexible operating hours of clinics not being friendly to the nature of men`s work [29, 30].

The area of domiciliary also played a significant role in not achieving viral suppression and having a higher CD4 count. Urban residents had 1.35 times higher odds of being viral unsuppressed than rural residents in bivariate analysis, but this became insignificant in adjusted analysis. Our results are different from what was found in studies in South Africa, where there was no significant difference in achieving viral load suppression between the urban and rural residents [21, 31] but similar to what was found by Waju et al [19], where 84.6% of urban residents on ART did not achieve viral suppression compared to their rural peers. Our results can be explained by the viral load scale which has happened in Zimbabwe resulting in increased availability of viral load testing and ART services in rural areas. Viral load testing scale-up started in 2016 and resulted in improved sample turnaround times due to the availability of sample transportation from facilities to viral load testing laboratories and the availability of reagents. Returning of viral load results to facilities and increased retesting of patients failing ART also improved as a result of improved transport services [4, 20]. Although urban areas often have better healthcare infrastructure, access to services may be more challenging due to overcrowding, long waiting times, and overwhelmed clinics [4]. This is also coupled with the fact that urban lifestyles can be hectic, leading to missed medication doses or irregular clinic visits. All these factors lead to unsuppressed viral load [4].

With regards to CD4 counts, individuals in urban areas had higher odds of low CD4 counts compared to individuals in rural areas in both bivariate and adjusted analyses. Our results are different from what was found in other studies in Africa where there was no significant difference in CD4 counts between rural and urban populations [32, 33]. Our results can be explained by the easy access to care and treatment services in rural areas because of various government and partner-funded ART services such as differentiated service delivery model [34]. Another reason could be that in our study, there was quick sample transportation to the laboratory and processing of CD4 tests which in other studies was mentioned as a limitation in rural areas resulting in delayed testing causing lower-than-expected CD4 count results [32].

It was also noted that individuals who had worked were more likely to be virally unsuppressed than those who had never worked. This was also noted with CD4 counts in bivariate analysis only, where individuals who had ever worked had 1.32 times the odds of having low CD4 counts compared to those who had never worked. This is similar to what was found by Owusu et al [35] who noted employment as one of the determinants of viral load non-suppression. However, Atuhaire et al [36] did not find any association between employment and unsuppressed viral load.Factors such as stress, working environment, healthcare access, time constraints, physical demands of work and treatment adherence could be possible reasons why employment status has a significant impact on viral load and CD4 counts. It is important to tailor-make interventions that address the working class.

The number of sexual partners in the last 12 months was significantly associated with both unsuppressed viral load and low CD4 count in bivariate analysis but not significant in adjusted analysis. This was also noted in other studies where having two or more sexual partners was found to be a predictor of unsuppressed viral load [21, 26, 37]. Individuals with more sexual partners may face challenges in managing their viral load. This finding highlights the importance of safe sexual practices and adherence to ART for better health outcomes.

The other factor that was significantly associated with both unsuppressed viral load and low CD4 counts in bivariate analysis was alcohol drinking. This is similar to what was found in other studies where alcohol drinking was associated with unsuppressed viral load [21, 38, 39] and low CD4 counts [40]. Alcohol drinking has been associated with low ART adherence resulting in patients having unsuppressed viral load count and low CD4 counts [21, 39]. However, our results are different from a study done in the USA where alcohol was not a predictor of unsuppressed VL [41].

People who had never been tested for HIV and never had a viral load test had higher odds of having unsuppressed viral load and low CD4 in both bivariate and adjusted analysis. These results are similar to what was found in other studies where unsuppressed viral load was associated with having never been tested for HIV [21]. HIV awareness is important in the HIV treatment cascade as patients are put on treatment that suppresses their viral load and boosts CD4 count because HIV targets CD4 cells. Therefore, early detection of HIV and testing viral load and CD4 counts early is important.

It is important to continue monitoring the predictors of unsuppressed viral load and low CD4 counts as these tests are crucial. Early identification of unsuppressed viral load and its predictors contribute to reducing the risk of treatment failure, drug resistance and viral transmission. CD4 count testing is crucial in helping identify people with advanced HIV diseases at various stages of care and treatment.

Recommendations for Further Research

Future studies should incorporate longitudinal monitoring of viral load and CD4 count to better understand the temporal dynamics and underlying causes of Unsuppressed viral load and low CD4 counts, which were not accounted for in the current survey.

Conclusion

The prevalence of unsuppressed viral load and low CD4 count was 11% and 25.8% respectively. The common predictors of both unsuppressed viral load and low CD4 counts in adjusted analysis were gender, never tested for HIV and never had a viral load test. These findings highlight the importance of early health-seeking behaviours to improve health outcomes.

It is also important to raise awareness about HIV testing, adherence to treatment, the significance of viral load monitoring and addressing gender-specific needs to enhance care.

Conflict of interests

All authors declare that they have no conflict of interest.

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References

[1]. UNAIDS, 2021, Global AIDS Strategy 2021–2026 End Inequalities. End AIDS. https://www.unaids.org/en/resources/documents/2021/2021-2026-global-AIDS-strategy

[2]. WHO, 2023, New WHO guidance on HIV viral suppression and scientific updates released at IAS 2023, Accessed: May 29, 2024. https://www.who.int/news/item/23-07-2023-new-who-guidance-on-hiv-viral-suppression-and-scientific-updates-released-at-ias-2023

[3]. ICAP, 2021, Zimbabwe Population-based HIV Impact Assessment 2020, Accessed: May 23, 2024. [Online]. Available: http://phia.icap.columbia.edu

[4]. PEPFAR, 2022, Zimbabwe Country Operational Plan (COP) 2022 Strategic Direction Summary (SDS), Accessed: Aug. 03, 2024. [Online]. Available: https://www.state.gov/wp-content/uploads/2022/09/Zimbabwe-COP22-SDS.pdf

[5]. WHO, 2023, THE Role of HIV Viral Suppression in Improving Individual Health and Reducing Transmission Policy Brief., Accessed: Aug. 29, 2024. [Online]. Available: https://iris.who.int/bitstream/handle/10665/360860/9789240055179-eng.pdf?sequence=1

[6]. WHO, 2020, HIV Treatment and Care Team, Accessed: Apr. 23, 2024. [Online]. Available: https://www.who.int/ publications /I/item/point-of-care-test-for-identifying-people-living-with-advanced-HIV-disease

[7]. Ekong, E., Ndembi, N., Okonkwo, P., Dakum, P., Idoko, J., Banigbe, B., Okuma, J., Agaba, P., Blattner, W., Adebamowo, C., & Charurat, M., 2020, Epidemiologic and viral predictors of antiretroviral drug resistance among persons living with HIV in a large treatment program in Nigeria. *AIDS Research and Therapy*, *17*(1), 1–8. https://doi.org/10.1186/S12981-020-0261-Z/TABLES/2

[8]. WHO, 2016, Global Health Sector Strategy on HIV 2016–2021 Towards ending AIDS. Accessed: Aug. 14, 2024.Online]. Available: https://www.who.int/publications/i/item/WHO-HIV-2016.05

[9]. Calmy, A., Ford, N., & Meintjes, G., 2018, The Persistent Challenge of Advanced HIV Disease and AIDS in the Era of Antiretroviral Therapy. *Clinical Infectious Diseases*, *66*(suppl_2), S103-SS105. https://doi.org/10.1093/CID/CIX1138

[10]. Ford, N., Meintjes, G., Vitoria, M., Greene, G., & Chiller, T., 2017, The evolving role of CD4 cell counts in HIV care. *Current Opinion in HIV and AIDS*, *12*(2), 123–128. https://doi.org/10.1097/COH.0000000000000348

[11]. Rice, B., Boulle, A., Schwarcz, S., Shroufi, A., Rutherford, G., & Hargreaves, J., 2019, The Continuing Value of CD4 Cell Count Monitoring for Differential HIV Care and Surveillance. *JMIR Public Health and Surveillance*, *5*(1), e11136. https://doi.org/10.2196/11136

[12]. Andarge, D. E., Hailu, H. E., & Menna, T., 2022, Incidence, survival time and associated factors of virological failure among adult HIV/AIDS patients on first line antiretroviral therapy in St. Paul's Hospital Millennium Medical College—A retrospective cohort study. *PLOS ONE*, *17*(10), e0275204. https://doi.org/10.1371/JOURNAL.PONE.0275204

[13]. Sithole, Z., Mbizvo, E., Chonzi, P., Mungati, M., Juru, T. P., Shambira, G., Gombe, N. T., & Tshimanga, M., 2018, Virological failure among adolescents on ART, Harare City, 2017- a case-control study. *BMC Infectious Diseases*, *18*(1), 1–8. https://doi.org/10.1186/S12879-018-3372-6/TABLES/5

[14]. Jackson, C., Rehman, A. M., McHugh, G., Gonzalez-Martinez, C., Ngwira, L. G., Bandason, T., Mujuru, H., Odland, J. O., Corbett, E. L., Ferrand, R. A., & Simms, V., 2022, Risk factors for sustained virological non-suppression among children and adolescents living with HIV in Zimbabwe and Malawi: a secondary data analysis. *BMC Pediatrics*, *22*(1), 1–9. https://doi.org/10.1186/S12887-022-03400-4/TABLES/5

[15]. Hakizayezu, F., Biracyaza, E., Niyompano, H., & Umubyeyi, A., 2022, The Frequency and Predictors of Unsuppressed HIV Viral Load Among People with HIV in Nyaruguru District, Rwanda. *HIV/AIDS*

(Auckland, N.Z.), *14*, 381–395. https://doi.org/10.2147/HIV.S376053

[16]. Melku, M., Gesesew, H. A., & Ward, P. R., 2022, Magnitude and predictors of HIV-Drug resistance in Africa: A protocol for systematic review and meta-analysis. *PLOS ONE*, *17*(4), e0267159. https://doi.org/10.1371/JOURNAL.PONE.0267159

[17]. Chikwari, C. D., Kranzer, K., Simms, V., Patel, A., Tembo, M., Mugurungi, O., Sibanda, E., Mufare, O., Ndlovu, L., Muzangwa, J., Vundla, R., Chibaya, A., Hayes, R., Mackworth-Young, C., Bernays, S., Mavodza, C., Hove, F., Bandason, T., Dauya, E., & Ferrand, R. A., 2024, Differentiated care for youth in Zimbabwe: Outcomes across the HIV care cascade. *PLOS Global Public Health*, *4*(2 February). https://doi.org/10.1371/journal.pgph.000255

[18]. Ssemwanga, D., Asio, J., Watera, C., Nannyonjo, M., Nassolo, F., Lunkuse, S., Salazar-Gonzalez, J. F., Salazar, M. G., Sanyu, G., Lutalo, T., Kabuga, U., Ssewanyana, I., Namatovu, F., Namayanja, G., Namale, A., Raizes, E., Kaggwa, M., Namuwenge, N., Kirungi, W., Kaleebu, P., 2020, Prevalence of viral load suppression, predictors of virological failure and patterns of HIV drug resistance after 12 and 48 months on first-line antiretroviral therapy: a national cross-sectional survey in Uganda. *Journal of Antimicrobial Chemotherapy*, *75*(5), 1280. https://doi.org/10.1093/JAC/DKZ561

[19]. Waju, B., Dube, L., Ahmed, M., & Assefa, S. S., 2021, Unsuppressed viral load level in public health facilities: nonvirological predictors among adult antiretroviral therapy users in southwestern ethiopia. *HIV/AIDS (Auckland, N.Z.)*, *13*, 513. https://doi.org/10.2147/HIV.S304653

[20]. Mhlanga, T. T., Jacobs, B. K. M., Decroo, T., Govere, E., Bara, H., Chonzi, P., Sithole, N., Apollo, T., Van Damme, W., Rusakaniko, S., Lynen, L., & Makurumidze, R., 2022, Virological outcomes and risk factors for non-suppression for routine and repeat viral load testing after enhanced adherence counselling during viral load testing scale-up in Zimbabwe: analytic cross-sectional study using laboratory data from 2014 to 2018. *AIDS Research and Therapy*, *19*(1). https://doi.org/10.1186/s12981-022-00458-z

[21]. Soogun, A. O., Kharsany, A. B. M., Zewotir, T., North, D., Ogunsakin, E., & Rakgoale, P., 2022, Spatiotemporal variation and predictors of unsuppressed viral load among hiv-positive men and women in rural and peri-urban kwazulu-natal, south africa. *Tropical Medicine and Infectious Disease*, *7*(9), 232. https://doi.org/10.3390/TROPICALMED7090232/S1

[22]. ZimStat, 2022, 2022 Population and housing census- preliminary report on population figures, Accessed: Aug. 12, 2024.Online]. Available: https://www.zimstat.co.zw/wp-content/uploads/2022/07/Census 2022_ Preliminary_Report.pdf

[23]. Wisaksana, R., Hartantri, Y., & Hutajulu, E., 2024, Risk Factors Associated with Unsuppressed Viral Load in People Living with HIV Receiving Antiretroviral Treatment in Jawa Barat, Indonesia. *HIV/AIDS - Research and Palliative Care*, *16*, 1–7. https://doi.org/10.2147/HIV.S407681

[24]. Nyaradzo, B., Kudya, N., Mbofana, E., Masaka, S., Garone, D., Chen, C.-Y., Mulingwa, A., Uzande, C., Isaakidis, P., & Ndlovu, Z., 2019, Scaling up HIV viral load monitoring in Manicaland, Zimbabwe: challenges and opportunities from the field. *Public Health Action*, *9*(4), 177–181. https://doi.org/10.5588/PHA.19.0024

[25]. Asfaw, A., Ali, D., Eticha, T., Alemayehu, A., Alemayehu, M., & Kindeya, F., 2015, CD4 Cell Count Trends after Commencement of Antiretroviral Therapy among HIV-Infected Patients in Tigray, Northern Ethiopia: A

Retrospective Cross-Sectional Study. *PLOS ONE*, *10*(3), e0122583. https://doi.org/10.1371/JOURNAL.PONE.0122583 doi:10.1371/JOURNAL. PONE.0122583

[26]. Mapiye, M., Ravhuhali, K., de Voux, A., & Kufa, T., 2024, Factors associated with an unsuppressed viral load among HIV-positive individuals attending STI services in South Africa, 2019. *BMC Infectious Diseases*, *24*(1), 1–8. https://doi.org/10.1186/S12879-023-08756-1/TABLES/2

[27]. Gezie, L. D., 2016, Predictors of CD4 count over time among HIV patients-initiated ART in felege hiwot referral hospital, northwest Ethiopia: Multilevel analysis. *BMC Research Notes*, *9*(1), 1–9. https://doi.org/10.1186/S13104-016-2182-4/TABLES/6

[28]. Montarroyos, U. R., Miranda-Filho, D. B., César, C. C., Souza, W. V., Lacerda, H. R., Albuquerque, M. D. F. P. M., Aguiar, M. F., & Ximenes, R. A. D. A., 2014, Factors related to changes in CD4+ T-cell counts over time in patients living with HIV/AIDS: a multilevel analysis. *PloS One*, *9*(2). https://doi.org/10.1371/JOURNAL.PONE.0084276

[29]. Bukenya, D., Mayanja, B. N., Nakamanya, S., Muhumuza, R., & Seeley, J., 2019, What causes non-adherence among some individuals on long term antiretroviral therapy? Experiences of individuals with poor viral suppression in Uganda. *AIDS Research and Therapy*, *16*(1). https://doi.org/10.1186/S12981-018-0214-Y

[30]. Mantell, J. E., Masvawure, T. B., Mapingure, M., Apollo, T., Gwanzura, C., Block, L., Bennett, E., Preko, P., Musuka, G., & Rabkin, M., 2019, Engaging men in HIV programmes: a qualitative study of male engagement in community-based antiretroviral refill groups in Zimbabwe. *Journal of the International AIDS Society*, *22*(10). https://doi.org/10.1002/JIA2.25403

[31]. Weissman, S., Duffus, W. A., Iyer, M., Chakraborty, H., Samantapudi, A. V., & Albrecht, H., 2015, Rural-urban differences in HIV viral loads and progression to AIDS among new HIV cases. *Southern Medical Journal*, *108*(3), 180–188. https://doi.org/10.14423/SMJ.0000000000000255

[32]. Malaza, A., Mossong, J., Bärnighausen, T., Viljoen, J., & Newell, M. L., 2013, Population-based CD4 counts in a rural area in South Africa with high HIV prevalence and high antiretroviral treatment coverage. *Plos One*, *8*(7), e70126–e70126. https://doi.org/10.1371/JOURNAL.PONE.0070126

[33]. Adoga, M. P., Pennap, G. R., John, P. A., Shawulu, P. T., Kaba, S. V., Forbi, J. C., & Agwale, S. M., 2012, CD4- and CD3-T lymphocyte reference values of immunocompetent urban and rural subjects in an African nation. *Scandinavian Journal of Immunology*, *76*(1), 33–38. https://doi.org/10.1111/J.1365-3083.2012.02700.X

[34]. Ministry of Health and Child Care, Zimbabwe, AIDS & TB Programme for the Prevention, Care and Treatment of HIV in Zimbabwe, 2022, Operational and Service Delivery Manual 2022 Edition. operational and service delivery manual for the prevention, care and treatment of hiv in zimbabwe operational and service delivery manual 1 content abbreviations 2 background and rationale for the manual 3.

[35]. Owusu, L. B., Ababio, C., Boahene, S., Zakaria, A. F. S., Emikpe, A. O., Dwumfour, C. K., Appiagyei, K. A., & Apiribu, F., 2023, The predictors of unsuppressed viremia among PLHIV: a cross-sectional study in Ghana. *BMC Public Health*, *23*(1). https://doi.org/10.1186/S12889-023-16032-9

[36]. Atuhaire, P., Hanley, S., Yende-Zuma, N., Aizire, J., Stranix-Chibanda, L., Makanani, B., Milala, B., Cassim, H., Taha, T., & Fowler, M.

G., 2019, Factors associated with unsuppressed viremia in women living with HIV on lifelong ART in the multi-country US-PEPFAR PROMOTE study: A cross-sectional analysis. *PLoS ONE*, *14*(10). https://doi.org/10.1371/JOURNAL.PONE.0219415

[37]. Tomita, A., Vandormael, A., Bärnighausen, T., Phillips, A., Pillay, D., De Oliveira, T., Tanser, F., & South, A., 2019, Sociobehavioral and community predictors of unsuppressed HIV viral load: multilevel results from a hyperendemic rural South African population HHS Public Access. *AIDS*, *33*(3), 559–569. https://doi.org/10.1097/QAD. 00000 000 000 02100

[38]. Hicham, T., Ilyas, E., Tarik, H., Noureddine, B., Omar, B., Rachid, F., Naoufal, H., & Mohammed, B., 2019, Risk factors associated with unsuppressed viral load in HIV-1 infected patients at the first antiretroviral therapy in Morocco. *International Journal of Mycobacteriology*, *8*(2), 113–117. https://doi.org/10.4103/IJMY.IJMY_41_19

[39]. Myers, B., Lombard, C., Joska, J. A., Abdullah, F., Naledi, T., Lund, C., Petersen Williams, P., Stein, D. J., & Sorsdahl, K. R., 2021, Associations Between Patterns of Alcohol Use and Viral Load Suppression Amongst Women Living with HIV in South Africa. *AIDS and Behavior*, *25*(11), 3758–3769. https://doi.org/10.1007/S10461-021-03263-3

[40]. Malbergier, A., Do Amaral, R. A., & Cardoso, L. D., 2015, Alcohol dependence and CD4 cell count: is there a relationship? *AIDS Care*, *27*(1), 54–58. https://doi.org/10.1080/09540121.2014.947235

[41]. Lesko, C. R., Nance, R. M., Lau, B., Fojo, A. T., Hutton, H. E., Delaney, J. A. C., Crane, H. M., Cropsey, K. L., Mayer, K. H., Napravnik, S., Geng, E., Mathews, W. C., McCaul, M. E., & Chander, G., 2021, Changing Patterns of Alcohol Use and Probability of Unsuppressed Viral Load Among Treated Patients with HIV Engaged in Routine Care in the United States. *AIDS and Behaviour*.