

Research Article

Factors Associated with Time to Viral Load Suppression Among People Living with HIV in Chingola District: A Retrospective Cohort Study

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Abstract

Improving health outcomes and lowering human immunodeficiency virus (HIV) transmission among people living with human immunodeficiency virus (PLHIV) requires achieving viral load suppression. In this study, people living with HIV in Zambia's Chingola District had their survival rates and factors related to viral suppression assessed. The research aimed at analysing factors associated with time to viral suppression among PLHIV in Chingola District using survival analysis. A retrospective cohort study design was used, utilising 385 clinical records of PLHIV in Chingola district, with the focus on 15 months period (January 2022 to April 2023). Cox proportional hazards regression models and Kaplan-Meier survival analysis were used as statistical techniques. The age group 50+ years accounted the highest proportion (45.5%), while 40–49 age group accounted for the least proportion (15.3%). Males dominated (56.6%) whereas 43.4% were females. The median time to attain viral suppression was 12 months. Consequently, frequent clinic visits significantly decreased suppression time (aHR = 2.026, $p = 0.001$), and PLHIV with comorbidity experienced faster viral suppression (aHR = 1.438, $p = 0.017$). None substance users had 1.392 times increased chances of achieving Viral load suppression higher than substance users (aHR = 1.392, $p = 0.036$). The intervention that increased the chance of suppression was case conferencing (aHR = 7.309, $p = 0.001$). The results highlighted how crucial it is to design interventions specifically for high-risk groups to enhance viral load results. Suggestions include implementing focused interventions for PLHIV with comorbidities and substance abusers, expanding case conferences, and fortifying adherence support networks.

Keywords

Adherence, HIV, Viral Load Suppression, Survival Analysis, Zambia

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1. Introduction

Past research has demonstrated the global importance of antiretroviral therapy (ART) in attaining viral load control and suppression [1, 2]. In a worldwide setting, it was shown two decades ago by that longevity of viral load suppression with multi-drug ART over a three-year period [3]. According to literature the likelihood of viral load failure reduces with prolonged suppression, highlighting the significance of continued antiretroviral therapy [4].

Globally, HIV/AIDS continues to be a major public health concern, with sub-Saharan Africa suffering the most. In the region, there were over 25.6 million people with HIV as of 2021. The adult HIV prevalence rate of Zambia, which is situated in this high-prevalence area, is 11.1% [5]. The HIV management landscape in sub-Saharan Africa has changed significantly. High rates of viremia and resistance during first-line ART were discovered in earlier research conducted in South Africa, indicating early difficulties in ART treatment [6, 7]. While studies underscored the crucial significance of prompt retention in HIV care for the purpose of suppressing viral infection, promoting a test-and-treat strategy to enhance results in the area [8].

Results from a meta-analysis found that HIV-infected children in low- and middle-income countries have inadequate viral suppression rates, underscoring the need for specialised therapy [9]. The multidimensional character of viral load suppression in the region was illustrated by in Ethiopia, identified parameters linked with virological non-suppression, including socio-economic position and adherence levels [10]. The necessity for context-specific interventions to improve ART outcomes in sub-Saharan Africa is highlighted by these contemporary studies [11].

Although ART is widely accessible in Zambia, treatment outcomes are impacted by socioeconomic factors and discrepancies in healthcare access [12, 20]. Like many other places, Chingola District experiences particular difficulties, such as socioeconomic hurdles, limits in the healthcare infrastructure, and inconsistency in PLHIVs' adherence to ART [13, 14].

The HIV epidemic in Zambia offers special difficulties as well as chances for action. The influence of behavioural determinants on ART outcomes was highlighted by a previous study on HIV-infected injectable drug users, which demonstrated significant longitudinal changes in care participation and viral suppression [15]. The difficulty of attaining long-term viral suppression in Zambia was highlighted by this preliminary study.

More thorough assessments have been presented by recent studies. Critical limitations in ART delivery and adherence were identified using a multistage-sampling-based technique to estimate retention and viral suppression rates [16]. This is consistent with the findings of Byrd *et al.*, who highlighted the contribution of community-based interventions to increased

viral suppression and adherence [17]. These recent studies emphasise how crucial it is to incorporate behavioural, clinical, and socioeconomic aspects into ART management plans in Zambia. Therefore, this research used survival analysis to pinpoint how demographic, clinical and behavioural factors related to the duration of viral load suppression, which can help improve public health initiatives in Zambia and other comparable settings.

2. Methods and Materials

2.1. Study Design

This was a retrospective cohort study that was conducted in selected health facilities [Chawama, Chiwempala, and Kabundi-East Clinic] of Chingola district in Zambia, which aimed at identifying factors influencing the time to viral suppression among PLHIV for 15 months between January 2022 to April 2023.

2.2. Study Population

The study population included all individuals who were HIV-infected and receiving ART in Chingola District selected health facilities, whose population remained unknown due to fluctuations in Smart Care but meet the inclusion criteria in the research [18, 19].

2.3. Inclusion and Exclusion Criteria

The inclusion criteria comprised HIV-positive individuals aged 18 years and above who were initiated on ART and had at least one documented viral load result during the study period in selected Chingola facilities. Exclusion criteria included patients with incomplete records, transferred-out cases, and those without follow-up viral load data. Further, using the inclusion and exclusion criteria approach above, 385 patient records were utilised to ensure a comprehensive representation across the demographic and health statuses from the clinical records of PLHIV in Chingola [21].

2.4. Data Analysis

The study population was described using descriptive statistics such as means, medians, percentages and frequencies. The data was collected from SmartCare. The predominant data source was medical records and patient registries due to their thorough and systematically documented nature. The variables were Demographic characteristics (age, sex, marital status, profession, residential area), Clinical parameters (initial viral load, CD4 count, type of ART regimen, presence of comorbidities such as tuberculosis or diabetes), Treatment

history (date of ART initiation, patterns of adherence, missed appointments, changes in regimens), and Monitoring viral load calendars (e.g., time intervals between tests, suppression status, episodes of viral rebound).

Data analysis techniques included the use of survival analysis, cox proportional hazards regression using STATA/MP17 software packages [22], these methods were used to examine the time to viral load suppression and identify the significant predictors. This model was chosen for its abilities to handle censored data and simultaneously assess the impact of multiple covariates on survival time. The hazard function was expressed as:

$$h(t) = h_0(t) \exp (b_1X_1 + b_2X_2 + b_3X_3 + \dots + b_nX_n)$$

The Kaplan-Meier technique was used to estimate survival functions, providing the probability of the individuals who were not viral suppressed over time [23]. This method accommodated censored data and allowing for a visual representation of the survival probabilities over time.

3. Results

3.1. Background and Descriptive Statistics

Table 1, the age distribution indicated that those aged 50 years and older accounted for the highest proportion of the interpreted age group (45.5%), suggesting that older people constitute a large proportion of the ART clientele population in Chingola District. In contrast, the 40–49 age group accounted for the least proportion (15.3%), suggesting potential differences in the HIV burden or healthcare-seeking behaviours that may exist across age cohorts. The gender distribution was male dominated (56.6%) with 43.4% being female.

Marital status was another salient characteristic, with 80.0% of patients entered as married, indicating a high rate of partner cohabitation among HIV-positive individuals. Conversely, the fewest participants were widowed (3.4%), possibly either simply owing to lower life expectancy among HIV-positive widows/widowers where they survive, and/or trends towards remarriage. In terms of economic stability, 45.5% of respondents were financially unstable while 54.5% were stable.

Table 1. Background and descriptive.

Background characteristics	Freq.	Percent
Age		
20-29	78	20.3
30-39	73	19.0
40-49	59	15.3
50 and above	175	45.5
Sex		
Female	167	43.4
Male	218	56.6
Marital status		
Never married	40	10.4
Married	308	80.0
Divorced	24	6.2
Widowed	13	3.4
Economic stability		
No	175	45.5
Yes	210	54.5
Total	385	100

Table 2. Log-rank Test of survival estimate of time to viral load suppression by sex.

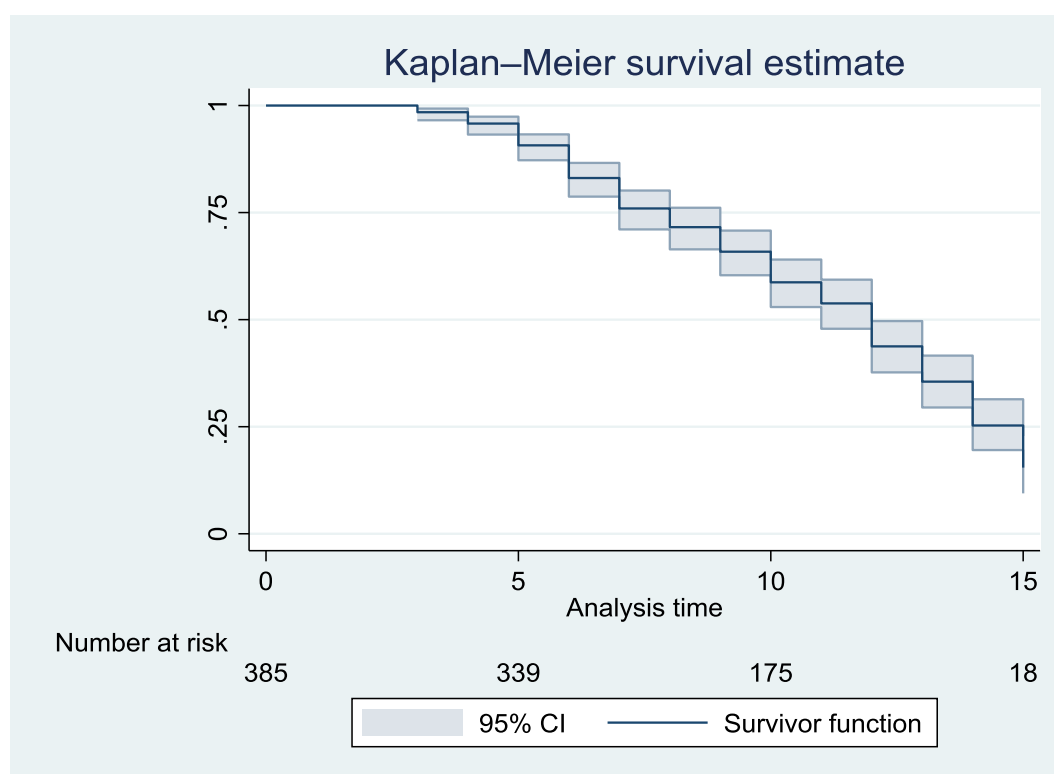
Sex	Observed events	Expected events	p-value
Female	91	91.6	0.9343
Male	114	113.4	

*p<0.05

3.2. Survival Function and Hazard Rate of Time to Viral Load Suppression Among HIV-infected Individuals

Figure 1 shows the Kaplan-Meier survival estimate for the

time to viral load suppression in HIV patients. On median survival probability, half (50%) of the patients had their viral load suppressed by approximately end of 12 months after ART initiation. The small confidence intervals demonstrate the accuracy of survival estimates.

**Figure 1.** Kaplan-Meier survival estimate of time to viral suppression.

3.2.1. Survival Estimates of Time to Viral Load Suppression by Sex

Figure 2 shows the Kaplan-Meier survival estimate of HIV patients' time to reduction in viral load of HIV by sex. Since

the curves cross, it cannot be concluded which survival rate estimations were different. The log-rank test was performed to determine whether the survival function of time to viral load suppression is the same for males and females.

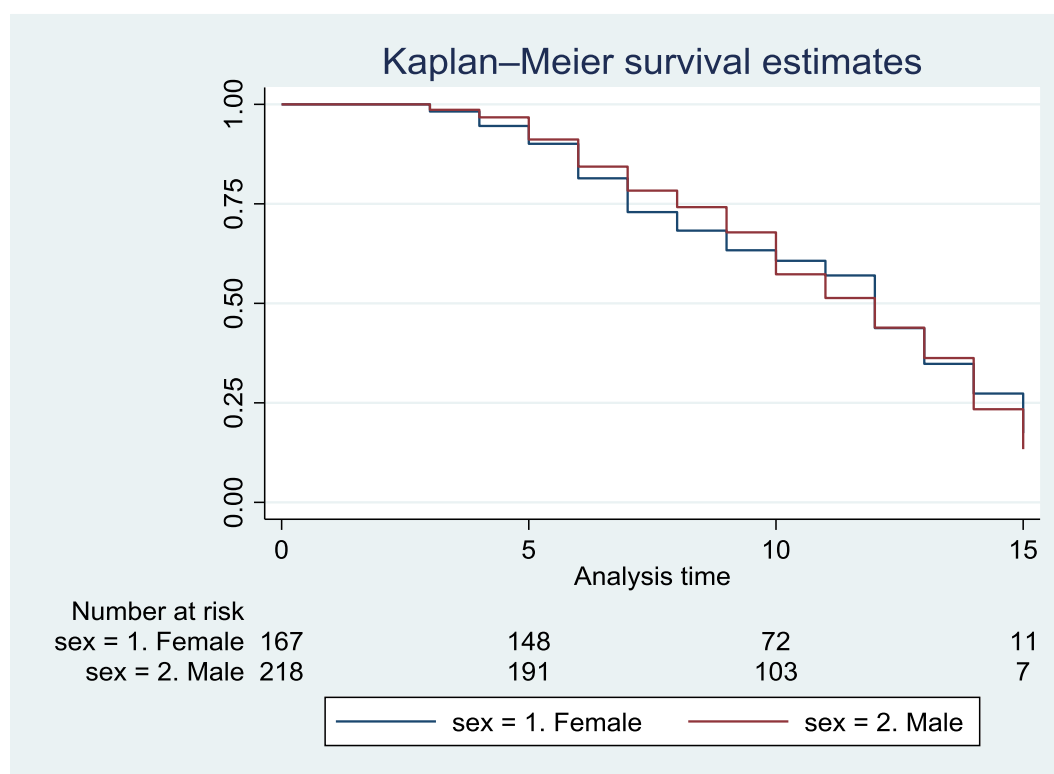


Figure 2. Kaplan-Meier survival estimate of time to viral suppression by sex.

3.2.2. Log-rank Test of Survival Estimate of Time to Viral Load Suppression by Sex

Table 2 indicates that the log-rank test results assessing time to viral load suppression for males and females fail to show statistical significance ($p = 0.9343$). As such, patients' sex does not statistically affect the longitudinality of the viral load to be suppressed, manifested by the fact that the survival function does not differ significantly across sexes.

3.3. Demographic, Clinical, and Behavioural Factors Associated with Shorter or Longer Time to Viral Load Suppression

The cox proportional hazards regression model of demographic, clinical and behavioural characteristics and the adjusted hazard ratios for time to viral load suppression are shown in table 3 after adjustment for other model variables.

There was no significant association between age and the timing of viral load suppression. Older patients (30 – 39: aHR = 0.920, 40 – 49: aHR = 0.819, 50+: aHR = 0.783) had lower hazard ratios when compared to individuals aged 20-29. Sex did not significantly influence time to viral load suppression, with males having a hazard ratio of 0.972 (95% CI: 0.731–1.293, $p = 0.847$) compared to females. Further, marital status showed no significant association with time to viral load suppression. Compared to those who never married, married (aHR = 1.247, 95% CI: 0.755 - 2.062, $p = 0.389$), divorced

(aHR = 0.952, 95% CI: 0.425 - 2.131, $p = 0.904$), and widowed patients (aHR = 1.005, 95% CI: 0.992 - 1.010, $p = 0.991$) had no statistically significant differences in viral load suppression rates.

Furthermore, economic stability was not significantly associated with time to viral load suppression. Patients who were economically stable had higher likelihood of viral load suppression compared to those who were not economically stable (aHR = 1.120, 95% CI: 0.840–1.493, $p = 0.442$). The health facility attended by the patient did not significantly influence time to viral load suppression. Patients at Chiwempala (aHR = 0.788, 95% CI: 0.553 - 1.123, $p = 0.187$) and Kabundi (aHR = 1.151, 95% CI: 0.804 - 1.648, $p = 0.441$) had lower hazard ratios and showed no statistically significant differences compared to those at Chawama health facility.

By ART regimen, the patients belonging to the 2nd line ART regimen were 1.151 times higher to have their viral load suppression (aHR = 1.151, 95% CI: 0.778–1.704, $p = 0.482$), compared to those in 1st line. However, the difference was not statically significant. Baseline viral load (aHR = 1.000, $p = 0.516$) and CD4 count (aHR = 1.000, $p = 0.641$) were not significantly associated with time to viral load suppression. Patients who had other diseases aside HIV had a significantly shorter time to viral load suppression (aHR = 1.438, 95% CI: 1.067–1.939, $p = 0.017$) compared to those who never had any other diseases.

Additionally, patients who frequently visited the clinic appointments were 2.026 times more likely have shorter time to viral load suppression, compared to those with less frequent

visits (aHR = 2.026, 95% CI: 1.511–2.716, $p < 0.001$). Patients who reported no substance use had a significantly shorter time to viral suppression compared to substance users (aHR = 1.392, 95% CI: 1.022–1.895, $p = 0.036$). Patients with medium sexual activity had a significant slightly shorter time to viral suppression compared to those with high sexual activity (aHR = 1.090, 95% CI: 0.735–1.616, $p = 0.036$).

3.4. Effect of Interventions on Time to Viral Load Suppression Using Survival Analysis

The results in table 4 of the Cox proportional hazards regression analysis show the effect of various interventions on the time to viral load suppression in individuals. The analysis state that case conferencing is reported to have resulted in a significant increase in the likelihood of viral load suppression compared to no meeting attendance for the case-conferencing participants (aHR = 7.309, 95% CI: 4.559–11.717, $P < 0.001$).

The number of Enhanced Adherence Counselling (EAC) Sessions attended by the patient is not statistically significant on the time to viral load suppression (aHR = 1.001, 95% CI: 0.996–1.006, $p = 0.634$). Patients who do not know about HIV viral load have less, but not significant, likelihood of getting viral load suppression than knowledgeable patients (aHR = 0.780, 95% CI: 0.450–1.351, $p = 0.375$).

Membership in support groups does not affect time to viral load suppression significantly from being outside support groups (aHR = 0.973, 95% CI: 0.739–1.281, $p = 0.844$). Patients on nutritional support were less likely to be virally suppressed compared to those who did not receive nutritional support (aHR = 0.988, 95% CI: 0.747–1.306, $p = 0.932$).

4. Discussion

This study examined the time to viral suppression among people living with HIV (PLHIV) in Chingola District, Zambia using survival analysis techniques. The Median time from diagnosis to viral suppression was 12 months, with no significant sex difference between males and females, consistent with Kanter et al. [24] finding of no differences by sex within Sub-Saharan Africa; Mills et al. [25], because of their higher adherence, females suppress early. Sikazwe et al. [15] who found that equal access to HIV care reduces gender disparities, though contrasting with [25] who found that women suppressed earlier due to higher adherence.

Cox proportional hazards regression showed no strong associations between demographic factors (age, sex, marital status, economic stability) and time to viral suppression, although a trend toward slower suppression with increasing age was noted, similar to Sikazwe et al. [15]. Zhang et al. [26] proposed that biological difficulties in older patients may postpone suppression. Substance use was highly linked with delayed suppression, which is consistent with Damulak et al. [27]. Frequent clinic visits were associated with faster suppression, supporting previous research findings [28, 29].

Unlike Mody et al. [30], timing of suppression was independent of baseline viral load and CD4 count, possibly due to regional ART regimen differences or more clinical attention to sicker patients, explaining co-morbidities' association with faster suppression.

The effectiveness of interdisciplinary treatment was shown in China by Zhang et al. [26] where case conferencing and other therapies significantly reduced the time to achieve viral suppression [26]. More focused counselling increased the number of suppressors, but better adherence EAC had little impact which may suggest delivery inequitably biased impact [31]. Focusing patient encouragement of the viral load and dietary aid or aid groups hardly influenced suppression time. This argument supports previous research and contradicts other findings that suggest the benefit of ART regimens, or the method of intervention implementation diverged differently [25].

This study contributes local data on survival patterns and factors linked to viral suppression in Chingola District. Kaplan-Meier analysis revealed a 50% suppression by 12 months. More frequent clinic visits quadrupled suppression speed (aHR=2.026), whereas case conferencing increased suppression odds more than sevenfold (aHR=7.309). ART universal access also enhanced suppression (aHR=1.392).

5. Conclusion

The findings contribute to the emerging body knowledge of survival trends and time to viral load suppression among PLWHIV in Chingola District. Importantly, median time to viral suppression was 12 months, demonstrating that ART works to achieve viral load suppression in all people living with HIV.

A multivariate analysis identified several factors that were critical for achieving viral suppression, including more frequent visits to the clinic and integrated care models like case conferencing and multidisciplinary meetings. Demographic and clinical characteristics (such as age, sex, economic status, etc.) had no apparent effects on the time to suppress.

Nonetheless, high-risk PLHIV with substance abuse backgrounds and those with several comorbidities were recognized to need proactive measures to improve their treatment outcome. The results indicate both a need to develop targeted treatment strategies as well as to design public health interventions to sustainably improve viral suppression and health-related quality of life among PLWHIV in the Chingola District.

5.1. Limitations

- 1) *Lack Randomization*: Considering this study was observational and retrospective, it lacked the randomisation perspective, which could have resulted in skewed treatment effect estimates.
- 2) *Change in Treatment Guidelines*: HIV programming treatment recommendations and practices are constantly

evolving.

5.2. Recommendations for Future Research

Longitudinal Study of Intervention Efficacy: are models such as case conferencing and adherence counselling on viral suppression.

5.3. Ethics Approval

In reference to this paper, ethical approval was obtained from the National Health Research Authority (NHRA) and University of Lusaka, Research Ethics Committee (UNILUS-REC) approval number FWA00033228-461(08)/(08)/{2024} as per standard procedures. The Ministry of Health (MoH) was consulted for administrative permission to get access to medical records of patients at specific Health Facilities where the study was conducted. This also ensured informed consent, as each health facility received a complete overview of the study's objectives, methods, risks, and potential benefits. Patient's record remained anonymous during the study, and data was de-identified to maintain participant confidentiality. Following these precautions, it ensured that participants were protected, ethical standards were maintained, and the integrity of the research results was validated.

Abbreviations

AIDS	Acquired Immunodeficiency Syndrome
ART	Antiretroviral Therapy
CD4 count	Cluster Differentiation 4
HIV	Human Immunodeficiency Virus
MoH	Ministry of Health
NHRA-Z	National Health Research Authority-Zambia
PLHIV	Person or People Living with HIV
PEPFER	United States Presidential Emergency Plan for AIDS Relief
MER	Monitoring, Evaluation and Reporting
UNAID	United Nations Aid
UNILUSREC	University of Lusaka Research Ethical Committee
VL	Viral Load
VLC	Viral Load Coverage
VLS	Viral Load Suppression
WHO	World Health Organization
ZNPHI	Zambia National Public Health Institute

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Author Contributions

Bryson Musonda: Conceptualization, Data curation,

Formal Analysis, Investigation, Methodology, Resources, Software, Visualization, Writing – original draft

Eustarckio Kazonga: Formal Analysis, Project administration, Software, Supervision, Writing – review & editing

Tyson Chipokoso: Investigation, Methodology, Validation, Visualization, Writing – review & editing

Kelvin Mwangilwa: Investigation, Methodology, Validation, Visualization, Writing – review & editing

Thanthwe Mangani: Investigation, Methodology, Validation, Writing – review & editing

Kawanga Lackeby: Investigation, Methodology, Validation, Writing – review & editing

Conflicts of Interest

The authors declare no conflict of interest.

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