Incidence and Predictors of Viral Load Suppression After Enhanced Adherence Counseling Among HIV-Positive Adults in West Gojjam Zone, Amhara Region, Ethiopia

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Background: Viral load suppression among people living with HIV is the main goal of antiretroviral therapy (ART). The most cause for high viral load is poor adherence to ART. World Health Organization (WHO) recommends intensive enhanced adherence counseling for people with a high viral load, which is greater or equal to 1000 RNA copies per mL and at least on treatment for six months. However, little is known about the outcome of enhanced adherence counseling. The study aimed to assess the incidence of viral load suppression after enhanced adherence counseling and its predictors among HIV-positive adults in high case-load health facilities in the Amhara region, Ethiopia.

Methods: An institution-based retrospective follow-up study was employed among 346 HIV-positive adults enrolled in enhanced adherence counseling in a high caseload health facility in the West Gojjam zone from June 2016 to June 2020. The data on relevant variables were collected from the patient’s medical cards by trained data collectors. The collected data were entered into EpiData version 3.1 and then exported to Stata version 14 for analysis. Descriptive analysis was performed to describe the variables. Cox proportional regression model was used to identify independent predictors of viral load suppression after enhanced adherence counseling.

Results: Overall, 51.73% of the study participants achieved viral load suppression after enhanced adherence counseling. The incidence of viral load suppression rate was 11.17 per 100-person month. During the multivariate analysis, it was observed that being female (AHR = 1.50, 95% CI: 1.05–2.15), CD4 count of greater than or equal to 350 cells/mm$^3$ (AHR = 1.98, 95% CI: 1.12–3.51) and no recurrent OI (AHR = 1.85, 95% CI: 1.06–3.24) were an independent predictor of viral load suppression after enhanced adherence counseling.

Conclusion: Incidence of viral load suppression rate was still far from the WHO target (70%). Therefore, higher priority should be given to patients with low CD4 counts with improved enhanced management of opportunistic infections.

Keywords: HIV/AIDS, antiretroviral therapy, viral load suppression, predictors, enhanced adherence counseling, Ethiopia

Background

Human Immunodeficiency Virus (HIV) created an enormous challenge to the survival of human beings. About 36.3 million people have died due to HIV since the beginning of the epidemic according to the UNAIDS report. In 2020, 37.7 million people were living with HIV/AIDS (PLWHA) worldwide. East and
Among this, 35.5% reside in Amhara Regional State. By the end of March 2020, 10,202 people received HIV care and treatment in the West Gojam Zone. Based on WHO recommendations, Enhanced adherence counseling (EAC) for those patients with high viral load ≥1000 RNA per mL addresses all adherence barriers like cognitive, social, behavioral, and emotional using a multidisciplinary team approach for 3 to 6-months results in 70% of viral re-suppression. Viral load re-suppression is a repeat viral load measurement of HIV RNA to less than or equal to 1000 copies/mL while continuing to receive first-line ART regimen after an initial viral load measurement of greater than 1000 copies/mL. Before the repeat, a viral load is taken; the patient should complete the three-month enhanced adherence counseling session, be perfectly adherent for 3 months, and have fever ruled out.

Timely completion of the EAC session and taking of the first viral load within three to six months is crucial for achieving viral re-suppression and reducing virological failure by 22% and 27%, respectively. For each additional month of delay in taking the first viral load (between 2.5 and 9 months), the risk of virological failure increased by 9% and the risk of treatment switching second-line antiretroviral therapy (ART) increased by 13%. Having an unsuppressed viral load while taking ARV medication has been the area of concern in the ART treatment program. In 2019, only 65% of people living with HIV in Ethiopia had achieved viral suppression. The National ART treatment guideline recommends that all patients with initial high viral undergo EAC. Implementation of EAC for patients with high viral load with routine viral load monitoring showed some promising results but failed to achieve the WHO recommended target of 70% viral re-suppression in a patient taking antiretroviral (ARV) medication.

The cause of the high viral load while on EAC has been the area of controversy. Some studies have found that it is linked to earlier ARV medication exposure, while others showed that patients have already developed drug resistance. However, the most common reason associated with high viral load was poor medication adherence.

Unless implementing EAC for the patient with high viral load, HIV will continue to be easily transmitted and result in a rapid decline in CD4 count and re-currying occurrence of opportunistic infections (OIs) eventually leading to death. However, resolving all adherence barriers to ARV medication is often comes up with difficulty. Since there is an individual-level variation of behavioral, cognitive,
and psychosocial barriers associated with ARV medication. Therefore, this study aimed to assess the incidence of viral load suppression after EAC and its predictor among HIV-positive adults in high caseload health facilities in the West Gojjam Zone.

It could also provide important information concerning the aspect of a predictor of re-suppression and forward recommendations to health care providers, health facilities, non-governmental organizations (NGOs), and policy-makers in enhancing the implementation of ART programs and the development of evidence-based interventions to improve the survival of adults on ART.

**Methods and Materials**

**Study Design and Setting**
An institution-based retrospective follow-up study was carried out from September 20/2020 to November 20/2020. The study was conducted in the west Gojjam zone, with high caseload health facilities, which are located in the Amhara region, Ethiopia. Finote-Selam is the capital city of West Gojjam Zone, 178km far from Bahir Dar (the capital city of Amhara Regional state) and 387 km from Addis Ababa. West Gojjam Zone is one of the largest zones in Amhara region with an estimated over 2 million population and has 15 rural districts and 2 city administrations. There are 7 hospitals, 26 health centers, and 1 private hospital providing ART services. By the end of March 2020, 10,202 people were living with HIV in West Gojjam. The study was carried out in health facilities with a high caseload that had a patient greater than or equal to 500 people living with HIV on ART. Six health centers, namely, Adet Health center, Burie health center, Durebete health center, Dembecha health center, Merawi health center, and one hospital, Fenote-Selam hospital, were included. The number of patients enrolled at those ART centers was 1003, 1075, 783, 539, 538, and 1880 adults, respectively. From June 2016 to June 2020, 466 adult patients were registered in these health facilities at EAC.

**Sample Size and Study Participants**
The study populations were all HIV-positive adult patients on ART for the last six months, had viral load results of $\geq 1000$ RNA per mL, and enrolled to EAC in high caseload health facilities in West Gojjam Zone. The sample size was determined using the previous study in North Wollo Zonal public Hospital, the overall viral load suppression after EAC was 64.4%. By considering the factor analysis: gender, period on ART, and baseline viral load count greater than or equal to 1000 copies/mL by using epi info TM 7 stat-Calc, and by assuming a margin of error 5%, power 80%, 95% confidence level, and 10% non-response rate. As a result, the final sample size was 347.

**Sampling Procedure**
All high caseload ART center health facilities were included in the study and the total sample size was allocated proportionally among each ART center based on the number of patients with a viral load count of greater than 1000 copies/mL. The study participants were selected through a simple random sampling technique from a viral load registration book.

**Data Collection Tools and Procedures**
The data extraction tool was prepared based on the Ethiopian National HIV care/ART intake and ART follow-up form on routinely collected patient chronic care. Data were extracted from patient ART follow-up clients with high viral load follow-up charts, and EAC register.

As a result, all charts containing detailed information about ART patients were examined. When there were incomplete data, the data collectors have sought to acquire from several data sources (patient’s chart and follow-up form). If clinical parameters and laboratory results (CD4 count and WHO clinical stage) were not available at the start of enhanced adherence counseling sessions, the most recent data were used as baseline data. Eight BSc degree nurses as data collectors and three ART data managers as supervisors participated in the data collection process.

**Variables**
The main outcome of interest or dependent variable was viral load suppression (suppressed/unsuppressed).

Independent variables included were sex, age, educational status, residency, baseline viral load count, time to start EAC, weight, height, functional status, WHO clinical staging, presence of recurrent OI, baseline CD4 count and baseline hemoglobin level, current ART regimens, regimen change, duration on ART, prior level of adherence, CPT treatment status, INH treatment status, presence of drug interactions, presence of severe drug side effects, history of ART/PMTCT prophylaxis, nutritional status, lack of food, disclosure status, family support, presence of treatment supporter, use of reminder, confidence to take ARVs, presence of depression, presence of substance
abuse, presence of diagnosed mental health illness, unsafe sex practice and discontinue ARVs for remedies.

Measurement
Viral load suppression is the second viral load measurement of less than 1000 RNA copies per mL after 3–6 months of EAC while continuing to receive first-line ART.12

Enhanced Adherence Counseling (EAC)
It is a continual and repeated process that involves a structured assessment of the current level of adherence, and explores the specific barriers the patient must overcome, motivates and assists patients to identify solutions and address barriers and develop an individualized adherence intervention plan. It is recommended for patients with viral load results >1000 copies/mL and has been on treatment within six months, which lasts for 3–6 months.10,12

Level of ART adherence was classified based on patient self-report on the percentage of ARV drugs taken as prescribed. Good ART adherence is defined as ≥95% of doses taken as prescribed and poor adherence, defined as <95% of doses taken as prescribed.21

Censored
Lost, drop out, transfer out, died of other causes, or completed study period before viral load suppression.

Data Quality Assurance
To ensure quality, data was collected by ART-trained health professionals after one day of training on the techniques of data collection. The completeness of the data was checked by two trained ART data clerk supervisors to provide feedback in the data collection process and to correct when necessary. Moreover, pretest was performed on 5% of the sample size to assess the reliability and consistency of the data collection tool.

Data Management and Analysis
The data were checked for completeness, then entered in using EpiData version 3.1, and exported to Stata version 14. Descriptive statistics, including mean and frequency, were used to describe the characteristics of the study participants. Incidence of viral load suppression rate concerning person-time at risk was calculated and reported as many suppressed per 100 Person-months of follow-up by assessing the date of enrolment for EAC. A life table was used to estimate the cumulative viral load suppression probability of adults and the Kaplan–Meier survival curve together with Log rank test was used to compare survival between different categories of independent variables. Bivariate and multivariate Cox proportional hazards models were used to identify predictors. Multivariate Cox analysis was done and hazard ratio with 95% CI and P-value was used to assess the strength of association and statistical significance. Variables significant at a p-value less than 0.25 were included in final multivariate Cox-regression analysis to identify independent predictors of viral load suppression after EAC. The model was built by a backward stepwise procedure and compared by the likelihood ratio test and Harrell’s concordance statistics test. Interactions and confounders were tested. A cut-off point with a beta change greater than 20% was used. Before fitting the covariate into model, all the proportionality assumption was tested by a global test based on Schoenfeld residuals and by examining log minus log plots. The overall goodness of model fitness was checked by Nelson Aalen’s cumulative hazard function against Cox Snell residual. Multi-collinearity was checked using Pearson correlation, tolerance, or variance inflation factor.

Results
Sociodemographic Characteristics
The study contained 347 medical records of adult study participants and 346 (99.7%) records were included in the review. Of the study participants, 126 (36.42%) were located in the 30–39 age group. The mean age of the study participants was 35.6 (±9.42SD). More than half 187 (54%) of the study participants were married and 22% completed primary level of education. Concerning religious status, most of the study participants 329 (95.09%) were Ethiopian Orthodox Christian followers (Table 1).

Clinical and Laboratory Related Characteristics
The median baseline CD4 count was 306.00 cells/mm³ (IQR 183.00–503.00 cells/mm³) and the median HIV viral load was 8793.00 copies/mL (IQR 2296.00–40,456.50 RNA
Table 1 Socio-Demographic, Clinical and Laboratory Characteristics of HIV-Positive Adults Enrolled on Enhanced Adherence Counselling from 2016 to June 2020 at High Caseload Health Facilities of Amhara Region, Ethiopia (n=346)

| Co-Variates          | Category          | Survival Status | Total |  |
|----------------------|-------------------|-----------------|-------|
|                      |                   | Viral Load Suppressed | Censored |  |
|                      |                   | 19–29 | 30–39 | 40 and above |  |
|                       |                   | 45(25.13) | 64(35.75) | 70(39.12) | 95(27.46) |  |  |
|                       |                   | 50(29.94) | 62(37.12) | 55(32.94) | 126(36.42) |  |  |
|                       |                   | 95(27.46) | 126(36.42) | 125(36.13) |  |
| Sex                  | Male | 58(32.40) | 64(35.75) | 70(39.12) | 139(40.17) |  |  |
|                      | Female | 121(67.60) | 126(36.42) | 125(36.13) | 207(59.83) |  |  |
| Marital status       | Single | 40(22.34) | 30–39 | 40(23.95) | 80(23.12) |  |  |
|                      | Married | 89(49.72) | 40(23.95) | 87(54.05) |  |  |
|                      | Divorced | 24(13.4) | 40(23.95) | 41(11.85) |  |  |
|                      | Widowed | 18(10.05) | 40(23.95) | 24(6.94) |  |  |
|                      | Separated | 8(4.49) | 40(23.95) | 14(4.05) |  |  |
| Religion             | Orthodox | 171(95.53) | 30–39 | 158(94.61) | 329(95.09) |  |  |
|                      | Muslim | 6(3.35) | 40(23.95) | 9(5.39) | 15(4.34) |  |  |
|                      | Protestant | 2(1.12) | 40(23.95) | 0 | 2(0.58) |  |  |
| Educational status   | Cannot read & Write | 62(34.63) | 30–39 | 53(31.73) | 115(33.24) |  |  |
|                      | Can read & Write | 35(19.55) | 40(23.95) | 41(24.55) | 76(21.97) |  |  |
|                      | Primary (1–8) | 41(22.90) | 40(23.95) | 36(21.55) | 77(22.25) |  |  |
|                      | Secondary (9–12) | 35(19.55) | 40(23.95) | 31(18.56) | 66(19.08) |  |  |
|                      | College & above | 6(3.37) | 40(23.95) | 6(3.91) | 12(3.47) |  |  |
| Baseline viral load (RNA copies/mL) | ≤ 5000 | 80(44.7) | 30–39 | 51(30.5) | 131(37.8) |  |  |
|                      | 5001–49,999 | 63(35.2) | 40(23.95) | 76(45.5) | 139(40.17) |  |  |
|                      | ≥ 50,000 | 36(20.1) | 40(23.95) | 40(24) | 76(21.97) |  |  |
| Time to start EAC session (weeks) | Within 2 weeks | 87(52.1) | 30–39 | 82(50.9) | 169(51.52) |  |  |
|                      | After 2 weeks | 80(47.9) | 40(23.95) | 79(49.1) | 159(48.48) |  |  |
|                      | Missing record | 18 | 40(23.95) | 18 |  |  |
| Function status      | Ambulatory & bed riding | 2(1.1) | 30–39 | 5(3) | 7(2.02) |  |  |
|                      | Working | 177(98.9) | 40(23.95) | 162(97) | 339(97.98) |  |  |
| WHO clinical staging | Stage I | 163(91.1) | 30–39 | 142(85) | 305(88.15) |  |  |
|                      | Stage II | 12(6.7) | 40(23.95) | 9(5.39) | 21(6.07) |  |  |
|                      | Stage III & IV | 4(2.2) | 40(23.95) | 16(3.6) | 20(5.78) |  |  |
| Presence of recurrent OI | Yes | 20(11.2) | 30–39 | 47(28.1) | 67(19.36) |  |  |
|                      | No | 179(88.8) | 40(23.95) | 120(71.9) | 279(80.64) |  |  |
copies/mL). Moreover, of the study participants, 142 (42.9%), had CD4 count of greater than 350 cells/mm³.

About 40.17% of the study participants had a baseline viral load count between 5000 and 49,999 RNA copies/mL. On the other hand, 305 (88.15%) study participants were WHO had clinical stage one. Most of the participants, 279 (80.64%), had no history recurrent of opportunistic infection. About 169 (51.52%) of the study participants started their EAC session within two weeks after receiving their viral load results. Just 32% of participants in the study completed the EAC session within three months (Table 2).

**ART and Treatment Related Characteristics**

More than half 260 (75.14%) of the study participants were on ART for more than 59 months and 169 (48.84%) of them had a good adherence level to the ARV medications (see Table 3). Cotrimoxazole prophylaxis was used by around 166 (47.98%) study participants and isoniazid prophylaxis was used by 287 (82.95%) at the time of EAC registration (Figure 1).

**Nutrition and Related Characteristics**

The majority of the study participants had a normal BMI of 241 (70.88%) and lack of food was seen only in 66 (19.08%) of them (Table 4).

**Psychosocial, Mental and Behavioral Related Characteristics**

More than half (67.63%) of the study participants who disclosed their HIV status were men and 201 (58.09%) had treatment supporters. A 77.46% of the study participants were confident to take their ARV medication. Around 7.8% of the participants in the study were diagnosed with depression. About 36.13% of the study participants had reported persistent use of a condom (Table 5).

**Incidence of Viral Re-Suppression**

Out of the 346 cohort adults on EAC, 321 (92.7%) were alive, 7 (2.02%) were lost to follow-up, 8 (2.31%) were transferred out to other facilities, and 10 (2.89%) were reported dead. Out of the 179 viral suppressed study participants on EAC 78 (43.57%) were virally suppressed after completion of 6 month EAC session, 18 (10%) in 5 months, 24 (13.4%) in 4 months, and 59 (32.96%) in 3 months.

After starting the EAC session, participants were followed for different periods, which is a minimum of 3 months and a maximum of 6 months with a median follow-up of 5 months, and the cohort contributed to 1602 person-months of follow-up. The overall viral suppression rate of the cohort was found to be 11.17 (95% CI=0.09–0.12) per 100 person-months of observation.

Out of the 179 viral suppressed, the highest incidence of viral suppression was observed after completion of 3 months of EAC session 59 (17.71 per 100 person-month), while other 11.53 per 100 person-month, 9.72 per 100 person-months and 8.90 per 100 person-months at four, five and six months. The cumulative probability of survival at the end of the 3rd, 4th, 5th, and 6th months were 81.56%, 72.71%, 65.16%, and 19.78%, respectively (Table 4).

**Comparison of Viral Suppression Probability Among Categories of Covariates**

Kaplan–Meier survival curve together with Log rank test was used to check for the existence of any significant differences in viral suppression probability between the various categories of variables considered in this study. Accordingly, the study participants who had a baseline CD4 count greater than or equal to 350 cells/mm³ had a significantly higher probability of viral load suppression than those who had a CD4 count of fewer than 200 cells/mm³ (log-rank, P-value less 0.05). Study participants that had a baseline viral load count of greater than 50,000 RNA copies per mL

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**Table 1 (Continued).**

| Co-Variates                  | Category | Survival Status | Total |
|-----------------------------|----------|----------------|-------|
|                             |          | Viral Load Suppressed | Censored |       |
| Baseline CD4 count (cell/mm³) | Less than 200 | 28(16.6) | 66(40.7) | 94(28.4) |
|                             | 201 to 349 | 49(29) | 46(28.4) | 95(28.7) |
|                             | Greater than 350 | 92(54.4) | 50(30.9) | 142(42.9) |
|                             | Missing records | 15 | 15 |       |

**Abbreviation:** OI, opportunistic infections.
had a higher viral load suppression probability compared to those who had a viral load count of less than or equal to 5000 RNA copies per mL (log-rank, P-value less than 0.05).

Study participants who were on DTG-based regimens had a higher viral load suppression probability than those who were on EFV-based regimens (log-rank P-value less than 0.05). However, the p-values of the Log rank test do not show that the mean survival experience of patients among those categories of WHO clinical staging, prior history of adherence, disclosure status, duration on ART, and regimen change (Figure 2).

### Predictors of Viral Load Suppression

In bivariate Cox Proportional hazard, factors such as sex, WHO clinical staging, baseline viral load, CD4 count, presence of recurrent OI, current ART regimen, duration on ART, INH prophylaxis and last adherence level are statistically significant at a 25% level of significance.

When variables that had an association with viral load suppression in the bivariate analysis (P-value < 0.25) were all included in the multivariate Cox proportional hazard model using backward stepwise regression. It was found that sex, CD4 count, and presence of recurrent OI had a statistically significant association with viral load suppression (p-value < 0.05).

In this study, females were 1.50 times more likely to have viral load suppression compared to male participants (AHR=1.50, 95% CI: 1.05–2.15).

The study participants with a CD4 count of greater than or equal to 350 cells/mm$^3$ were estimated to have

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**Table 2** ART and Treatment-Related Characteristics of the HIV-Positive Adults Enrolled on EAC at High Caseload Health Facilities from June 28, 2016, to June 27, 2020, Amhara Region. Ethiopia, 2020 (n=346)

| Co-Variates                  | Category       | Survival Status       |
|------------------------------|----------------|-----------------------|
|                              | Viral Load Suppressed | Censored | Total |
| Current ART regimen         | EFV based       | 104(58.1) | 97(58.1) | 201(58.09) |
|                              | NVP based       | 39(27.7)  | 64(38.3) | 103(29.77) |
|                              | DTG based       | 36(20.1)  | 6(3.6)   | 42(12.14)  |
| Regimen change               | Yes            | 42(23.5)  | 14(8.4)  | 56(16.18)  |
|                              | No             | 137(76.5) | 153(91.6) | 290(83.82) |
| Duration of ART (months)    | ≤ 59 months    | 47(26)    | 39(23.4) | 86(24.86)  |
|                              | > 59 months    | 132(74)   | 128(73.6) | 260(75.14) |
| Prior level of adherence     | Good           | 92(51.4)  | 77(46.1) | 169(48.84) |
|                              | Poor           | 87(48.6)  | 90(53.9) | 177(51.10) |
| CPT treatment status         | Treatment taken| 100(55.9) | 66(39.5) | 166(47.98) |
|                              | On treatment   | 73(40.7)  | 99(59.3) | 172(49.71) |
|                              | Not applicable | 6(3.4)    | 2(1.2)   | 8(2.31)    |
| INH treatment status         | Treatment not taken | 23(12.8) | 36(21.5) | 59(17.05)  |
|                              | Treatment taken| 156(87.2) | 131(78.5) | 287(82.95) |
| Presence of severe drug side effect | Yes           | 1(0.55)   | 0(0)     | 1(0.29)    |
|                              | No             | 178(99.4) | 167(100) | 345(99.71) |
| History ART/PMTCT prophylaxis | Yes           | 5(2.8)    | 6(3.6)   | 11(3.18)   |
|                              | No             | 174(97.2) | 161(96.4) | 335(96.82) |
| Last adherence level         | Good           | 178(99.4) | 159(95.2) | 337(97.4)  |
|                              | Poor           | 1(0.6)    | 8(4.8)   | 9(2.6)     |

**Abbreviations:** EFV, efavirenz; NVP, nevirapine; DTG, dolutegravir; CPT, cotrimoxazole preventive therapy; INH, isonicotinic acid hydrazide.
## Table 3
Psychosocial, Mental, Behavioral and Nutrition-Related Characteristics of HIV Positive Adults Enrolled on EAC at High Caseload Health Facilities of Amhara Region, Ethiopia from June 2016 to June 2020 (n=346)

| Co-Variates                        | Category       | Survival Status |               |               |               |
|------------------------------------|----------------|----------------|---------------|---------------|---------------|
|                                    |                | Viral Load Suppressed | Censored | Total          |               |
| Disclosure status                  | Yes            | 120(67)         | 114(68.3)     | 234(67.63)    |               |
|                                    | No             | 53(33)          | 53(31.7)      | 112(32.37)    |               |
| Family non supportive              | Yes            | 55(30.7)        | 46(27.6)      | 101(29.19)    |               |
|                                    | No             | 124(69.3)       | 121(72.4)     | 245(70.81)    |               |
| Presence of treatment supporter    | Yes            | 104(58.1)       | 97(60.9)      | 201(58.09)    |               |
|                                    | No             | 75(41.9)        | 70(39.1)      | 145(41.91)    |               |
| Use of reminder                    | Yes            | 111(62)         | 88(52.7)      | 199(57.51)    |               |
|                                    | No             | 68(38)          | 79(47.3)      | 147(42.49)    |               |
| Confidence to take ARVs            | Not at all confident | 18(10)        | 35(21)        | 53(15.32)     |               |
|                                    | Confident      | 147(82)         | 121(72.4)     | 268(77.46)    |               |
|                                    | Neither        | 14(8)           | 11(6.6)       | 25(7.23)      |               |
| Presence of depression             | Yes            | 9(5)            | 18(10.8)      | 27(7.8)       |               |
|                                    | No             | 170(95)         | 149(89.2)     | 319(92.2)     |               |
| Presence of substance abuse        | Yes            | 30(16.8)        | 31(18.6)      | 61(17.63)     |               |
|                                    | No             | 149(83.2)       | 136(81.4)     | 285(82.37)    |               |
| Presence of diagnosed mental health illness | Yes        | 0              | 0             | 0(0)          |               |
|                                    | No             | 179(100)        | 167(100)      | 346(100)      |               |
| Condom use                         | Yes            | 68(37.9)        | 57(34.2)      | 125(36.13)    |               |
|                                    | No             | 111(62.1)       | 110(65.8)     | 221(63.87)    |               |
| Discontinue ARVs for remedies      | Yes            | 33(18.4)        | 29(17.4)      | 62(17.92)     |               |
|                                    | No             | 146(81.6)       | 138(82.6)     | 284(82.08)    |               |
| Presence of lack of food           | Yes            | 33(18.4)        | 33(19.8)      | 66(19.08)     |               |
|                                    | No             | 146(81.6)       | 134(80.2)     | 280(80.92)    |               |
| BMI                                | Normal         | 124(69.3)       | 117(70)       | 241(70.88)    |               |
|                                    | Mild malnutrition | 30(16.8)    | 29(17.4)      | 59(17.35)     |               |
|                                    | Moderate malnutrition | 6(3.4)    | 4(2.4)        | 10(2.94)      |               |
|                                    | Severe malnutrition | 2(1.1)      | 1(0.6)        | 13(3.82)      |               |
| MUAC                               | Over weight    | 12(6.7)         | 5(3)          | 17(5)         |               |
|                                    | Normal         | 4(2.2)          | 1(0.6)        | 5(8.33)       |               |
|                                    | Mild malnutrition | 1(0.5)      | 0             | 1(16.67)      |               |

**Abbreviations:** BMI, body mass index; MUAC, middle upper arm circumference.
1.98 (AHR = 1.98, 95% CI: 1.12–3.51) times higher hazard of viral suppression compared to those who had a CD4 count of less than 200 mm$^3$, all other variables held constant.

The hazard of viral load suppression after EAC was 1.85 times more among participants who had no recurrent OI than those who had (AHR = 1.85, 95% CI: 1.06–3.24) (Table 5).

Model Adequacy
After fitting the Cox proportional hazard model, the adequacy was checked by Nelson Aalen cumulative hazard with Cox Snell residual (Figure 3).

Discussion
This study assessed the incidence rate of viral load suppression after EAC and its predictors among HIV-positive adults in high caseload health facilities. A total of 346 adults were followed for 1602 person-month of observation. The study showed that the overall incidence density rate of viral suppression of 11.17 (95% CI = 0.09–0.12) per 100 person-months of observation. Viral load suppression probability at the end of the 3rd, 4th, 5th, and 6th month was 81.56%, 72.71%, 65.16%, and 19.78%, respectively, and the overall median viral load suppression time was 5 months (95% CI: 4–6). Being Female, CD4 count of greater than or equal to 350 cells/mm$^3$ and no history of recurrent OIs associated with a higher rate of viral load suppression.

The study results showed that the average incidence of viral load suppression was 11.17 per 100 months of observation. The study also showed that the highest incidence of viral suppression after 3 months of EAC session was observed. The average incidence of viral load suppression was higher than the study conducted in Kenya, which was 3.9 per 100 months of observation. The disparities in viral suppression rate could be explained by the fact that the two countries may differ in systems for the management of HIV patients. The median time to viral load suppression in this study is comparable to the studies conducted in Oromia, Ethiopia, and South Africa. The study findings showed that the median time to suppression of viral load was longer than the study conducted in Southern Ethiopia but less than the study conducted in Canada and Botswana. This difference might be due to the difference in the follow-up duration of the study participants. This study followed the participants for three to six months, while the participants in other studies followed for a minimum of 12 months. Secondly, it might be associated with the availability of an optimized, potent, and well-tolerable ART regimen that has a significant impact on viremia replication.

Table 4 Actuarial Life Table Cumulative Survival of Adult on Enhanced Adherence Counseling After the Start of at the Interval, High Caseload Health Facilities, Amhara Region, Ethiopia, January 2021

| Time in Months Interval | Study Participants Start of EAC | Viral Suppressed | Censored | Survival Function | 95% CI |
|------------------------|---------------------------------|-----------------|----------|------------------|-------|
| (3,4)                  | 346                             | 59              | 52       | 0.8156           | 0.7686–0.8540 |
| (4,5)                  | 235                             | 24              | 28       | 0.7271           | 0.6727–0.7739 |
| (5,6)                  | 183                             | 18              | 19       | 0.6516           | 0.5924–0.7044 |
| (6,7)                  | 146                             | 78              | 68       | 0.1978           | 0.1434–0.2587 |
In this study, the hazard of viral load suppression after EAC was 1.50 times more among females than males. This finding is supported by studies conducted in North Wollo, North East Ethiopia, and Uganda.17,28 The finding was contrary to the study conducted in South Carolina.29 This might be explained in two forms and be due to the first timely start of the EAC session, which might have contributed to better adherence and response to ART therapy in the female participants. Secondly, in the current study, females had higher level of baseline CD4 count than men, which might contribute to better viral load suppression. Nevertheless, the gender difference in viral load suppression rate should be studied further.10,12

The hazard of viral load suppression after EAC was 1.98 times greater among those who had a CD4 count of greater than or equal to 350 cells/mm³ compared to those who had a CD4 count of less than 200 cells/mm³. This finding is supported by a study conducted in Southern Ethiopia, Zimbabwe, Mumbai, and Swaziland.30–32 It is well known that CD4 T-cell count has an inverse relationship with viral replication. As patients’ immune status declines, the rate of viral replication increases as compared to their immune-competent counterparts. In addition,

| Co-Variates                      | Category | Survival Status | Crude Hazard Ratio (95% CI) | Adjusted Hazard Ratio (95% CI) | P value |
|----------------------------------|----------|----------------|-----------------------------|--------------------------------|---------|
|                                  |          |                |                             |                                |         |
|                                  |          | Viral Suppressed | Censored                   |                                |         |
| Sex                              | Male     | 58             | 81                          | 1                              | 1       |
|                                  | Female   | 121            | 86                          | 1.54(1.12, 2.10)               | 1.50(1.05, 2.15) | 0.023* |
| Baseline viral load (RNA copies/mL) | ≤ 5000   | 80             | 51                          | 1                              | 1       |
|                                  | 5001–49,999 | 63           | 76                          | 0.57(0.41, 0.79)               | 0.84(0.58, 1.21) | 0.35   |
|                                  | ≥ 50,000 | 36             | 40                          | 0.45(0.30, 0.68)               | 0.81(0.52, 1.26) | 0.36   |
| WHO clinical staging             | Stage I  | 163            | 142                         | 1                              | 1       |
|                                  | Stage II | 12             | 9                           | 0.64(0.52, 0.94)               | 0.80(0.42, 1.21) | 0.5    |
|                                  | Stage III & IV | 4         | 16                          | 0.45(0.16, 0.88)               | 0.71(0.25, 2.00) | 0.52   |
| CD4 count                        | ≤ 200    | 28             | 66                          | 1                              | 1       |
|                                  | 201–349  | 49             | 46                          | 2.03(1.27, 3.23)               | 1.62(0.98, 2.66) | 0.055  |
|                                  | ≥350     | 92             | 50                          | 2.19(1.43, 3.35)               | 1.98(1.12, 3.51) | 0.018* |
| Presence of recurrent OIs        | Yes      | 20             | 47                          | 1                              | 1       |
|                                  | No       | 179            | 120                         | 2.14(1.34, 3.41)               | 1.85(1.06, 3.24) | 0.029* |
| Current ART regimen              | EFV based | 104           | 97                          | 1                              | 1       |
|                                  | NVP based | 39            | 64                          | 0.36(0.34–0.92)                | 0.77(0.52, 1.16) | 0.21   |
|                                  | DTG based | 36            | 6                           | 2.10(1.12–3.32)                | 1.28(0.85, 1.92) | 0.23   |
| Duration of ART (months)         | ≤ 59 months | 47           | 39                          | 1                              | 1       |
|                                  | > 59 months | 132         | 128                         | 0.54(0.42, 0.89)               | 0.96(0.66, 1.39) | 0.85   |
| INH treatment status             | Treatment not taken | 23         | 36                          | 1                              | 1       |
|                                  | Treatment taken | 156       | 131                         | 1.30(1.04, 2.02)               | 1.06(0.65, 1.70) | 0.81   |
| Last adherence level             | Good     | 178            | 159                         | 1                              | 1       |
|                                  | Poor     | 8              | 8                           | 0.11(0.01, 0.83)               | 0.01(0.01, 1.07) | 0.059  |

Notes: *P-value < 0.05 (statistically significant association) 1, reference category.
clients with compromised immunity are more vulnerable to different opportunistic infections that sustain a vicious cycle of immunity and viral replication.

The hazard of viral load suppression after EAC was 1.85 times greater among participants who had no recurrent OI than those who had. The findings of this study were
supported by the studies conducted in South Africa and Uganda. This could be explained in two forms, first a large number of the study participant was put on cotrimoxazole and isoniazid prophylaxis that might prevent the occurrence opportunistic infections like TB. Secondly, it could be due to the fact that those patients who had developed recurrent OI were treated while on EAC.

The findings of this study using multivariate Cox modeling showed that baseline viral load count was not a significant predictor of viral load suppression as in most studies. This might be because poor adherence was associated with high viral load and modified by intensive adherence support.

Factors associated with psychosocial, mental, and behavioral of the study participants were not a significant predictor of viral load suppression. This contrast might be associated with the diagnosis procedure as well as the skill of profession.

**Conclusion**
The study showed that the overall incidence density rate of viral suppression was 11.17 per 100 person-months of observation. The highest incidence of viral load suppression was observed after completion of the first 3 months of enhanced adherence counseling. Being female, a CD4 count of greater than or equal to 350 cells/mm$^3$ and no history of recurrent OI were associated with a higher rate of viral load suppression upon initiation of treatment. As a result, ART case managers, adherence counselors, and the multidisciplinary team in both hospitals and health centers should focus on patients with a low current CD4 count in order to improve management of recurrent OI.

**Abbreviation**
AIDS, acquired immune deficiency syndrome; ART, antiretroviral therapy; ARV, antiretroviral; CI, confidence interval; HIV, human immunodeficiency virus; PLWHA, people living with HIV/AIDS; WHO, World Health Organization; USAID, United States Aid for International Development; AHR, adjusted hazard ratio; EAC, enhanced adherence counseling; OI, opportunistic infections; MRN, medical record number; EFV, efavirenz; NVP, nevirapine; DTG, dolutegravir.

**Data Sharing Statement**
All the data supporting the study findings are within the manuscript. Additional detailed information and raw data are available from the corresponding author on reasonable request.

**Ethical Approval and Consent to Participate**
Ethical clearance was obtained from the ethical review committee of college of Health science, Debre Markos University, with the approval number of HSC/R/C/Scr/Co/105/11/13 dated on 13 October 2020. Study participants’ informed consent was waived by the review board as the data source of the patient’s medical record numbers (MRN) that were anonymously registered using codes without personal identifiers such as names of patients. Supporting letter was obtained from the West Gojjam zonal health department office and permission letters were obtained from each hospital administration and head of the health center. The data were collected by keeping confidentiality while reviewing the card of the patient. All methods were performed in accordance with the relevant regulations and guidelines. This study was conducted in accordance with the Declaration of Helsinki.

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**Author Contributions**
All authors made a substantial contribution to the conception and design, acquisition of data, or analysis and interpretation of data. They took part in drafting the article and revising it critically for important intellectual content; agreed to submit to the current journal, gave final approval of the version to be published; and agreed to be accountable for all aspects of the work.

**Disclosure**
Gezahegn Terefe Atnafu is principal investigator. The authors report no conflicts of interest in this work.

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