Virological suppression rate and its predictors among HIV/AIDS patients on antiretroviral therapy before and during the COVID-19 pandemic in Ethiopia: Systematic review and meta-analysis

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Abstract

Background

Achieving viral load suppression is crucial for the prevention of complications and deaths related to HIV infection. Ethiopia has embraced the worldwide 90-90-90 target, but there is no national representative information regarding virological suppression. Therefore, this review aims to determine the pooled virological suppression rate and identify the pooled effect of contributing factors of viral suppression for HIV-positive patients on antiretroviral therapy in Ethiopia.

Method

We systematically searched websites and databases, including online repositories, to obtain primary studies. We assessed the quality of the included articles using the Newcastle—Ottawa Scale appraisal checklist by two reviewers. Publication bias was checked using Egger's regression test, the heterogeneity of the studies was assessed using I^2 statistics and Q statistics, and sensitivity analysis was performed to identify any outlier results in the included studies. The Der Simonian Laird random-effects model was used to estimate the overall proportion of viral suppression, and STATA 17 statistical software was used for all types of analysis.

Result

A total of 21 eligible articles were used for this quantitative synthesis. The overall pooled virological suppression was 71% (95% CI: 64%, 77%). The pooled effects of poor adherence to ART (AOR = 0.33; 95% CI: 0.28, 0.40), body mass index (18.5–24.9 kg/m2) (AOR = 1.8; 95% CI: 1.37, 2.36), disclosure AOR = 1.41; 95% CI: 1.05, 1.89), absence of opportunistic infection (AOR = 1.68; 95% CI: 1.43, 1.97), and high baseline viral load (AOR = 0.65; 95% CI: 0.52, 0.81) were identified as significant predictors of viral suppression.

Conclusion

The overall pooled percentage of virological suppression was low compared with the global target of viral suppression. Poor adherence, normal body mass index, disclosure, absence of opportunistic infection and high viral load were contributing factors of viral suppression in Ethiopia. Responsible stakeholders should maximize their effort to achieve the global target of virological suppression by addressing significant predictors.

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Introduction

The world has experienced a series of crises that have had a severe impact on individuals living with and affected by human immunodeficiency virus (HIV) in the past two years, particularly during the COVID-19 era (1). These crises have not only hindered the global response to the acquired immunodeficiency syndrome (AIDS) pandemic but also exacerbated existing socioeconomic inequalities within and between countries, particularly in Sub-Saharan Africa (1, 2, 3). The COVID-19 pandemic has caused significant disruptions to essential HIV treatment and prevention services, derailing the progress made in the HIV response (1, 4).

It is our collective responsibility to put an end to the AIDS epidemic, honoring the memory of the 39 million individuals who have lost their lives to this disease (2, 5). The Joint United Nations Program on HIV/AIDS (UNAIDS) has set a global target known as the 90-90-90 goal, aiming to achieve by 2020 that 90% of all people living with HIV are aware of their HIV status, 90% receive consistent antiretroviral therapy, and 90% of those on treatment achieve viral suppression (5). However, the current reality is that only three-quarters of people living with HIV have access to antiretroviral treatment, and merely 52% of children living with HIV have access to life-saving medication (1). Shockingly, approximately 10 million adult individuals still lack access to treatment, and the gap in HIV treatment coverage between children and adults is widening instead of narrowing (1, 6).

Ethiopia has embraced the worldwide 90-90-90 target as a crucial component of its efforts to eliminate HIV/AIDS epidemics by 2030. The country has been collaborating with numerous partners and stakeholders to enhance disease detection, viral load testing, and adherence to antiretroviral therapy (7, 8, 9). Consequently, the national prevalence of HIV infection among individuals aged 15–49 has decreased to 0.9%, although variations persist based on gender, location, and specific population groups, with higher rates among women and in urban areas (10)

Achieving viral load suppression (VLS) is crucial for the effective treatment and prevention of complications and deaths related to HIV infection (6, 11). The World Health Organization (WHO) advises regular viral load testing as the preferred method for monitoring and confirming treatment failure (12). Virological suppression is defined as when the viral load count drops below 1000 copies/milliliter of blood or becomes undetectable after a sufficient duration of antiretroviral therapy (ART) (12).

A longitudinal analysis conducted across multiple countries in Sub-Saharan Africa revealed that the rates of virological suppression range from 90–93% (13). In Rwanda, the rate is 83% (14), while in Cameroon, it is 79.4% (15); in Nigeria, it is 80.2% (16); and in Tanzania, it is 94% (17). In Ethiopia, the virological suppression rates vary, with Hawassa reporting 40.9% (18), West Gojjam reporting 51.73% (19), North Shewa zone reporting 72% (20) and Debre Markos reporting 92% (21). These variations in the reports highlight the need for nationally representative data on virological suppression in Ethiopia. It is crucial to continue concerted efforts to address the uneven distribution of HIV infection and work toward achieving global targets uniformly within the remaining timeframe (9).

In order to facilitate the establishment of a bold future goal, it is essential to analyze the pooled prevalence of virological suppression and the factors that contribute to it within the Ethiopian context. Therefore, the objective of this review is to determine the overall national rate of virological suppression and analyze the contextual predictors of virological suppression using internationally recognized frameworks of key performance indicators. The findings of this study will provide valuable insights for healthcare providers and assist the country in sustaining the achievements of virological suppression while addressing areas of improvement to achieve the goal of ending AIDS by 2030.

Methods

Reporting

We strictly followed the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) guidelines (22) with a supplementary file-research checklist (Table S 1). The protocol is registered in the Prospero database with a registration number of CRD42023434248. Available at: https://www.crd.york.ac.uk/prospero/#recordDetails

Inclusion and exclusion criteria

The articles selected for this systematic review and meta-analysis consisted of cohort, case—control, and cross-sectional studies. Those studies reported the proportion of viral suppression at various time intervals and included adjusted effect measures of factors associated with virological suppression. Additionally, the studies had to be conducted in Ethiopia and written in English. Studies that lacked full-text access and requiring subscription, qualitative studies, and conference proceedings without full-text reports were excluded from the analysis.

Search strategy

Web site searches (Google, Google Scholar and registries) and database searches (PubMed, Science Direct and Hinari (research4life)) were searched to find research articles. The search strategy used in PubMed was [((virological) OR (viral)) AND ((suppression) OR (re-suppression)) AND ((predictors) OR (factors) OR (determinants)) AND ((HIV) OR (AIDS)) AND (("antiretroviral therapy") OR (ART) OR (HAART)) AND (Ethiopia)]; similar search terms were used for Hinari. In addition, the Ethiopian Universities online repository library (University of Gondar, Addis Ababa University, Hawassa University and Bahirdar University) was searched. Endnote 20 reference manager software was used to manage duplicated references and for citation in the manuscript.

Outcome measurement/ascertainment

Virological suppression is considered when viral load copies become less than 1000 copies/ml blood after initiation of ART (12).

Data extraction process

Data from each study were independently extracted by two reviewers (AM and HY) and crosschecked by both reviewers. Any discrepancies were resolved through revision. The extracted data included the first author and year of publication, sample size, number of individuals with the outcome of interest, study design, study population with sample size, geographical location, funding information, and response rate.

Quality assessment

Two authors (AM, YT) independently evaluated the quality of the articles using the Newcastle—Ottawa Scale, which is a tool for assessing the quality of cross-sectional, case—control, and cohort studies (23). The criteria for cross-sectional studies consisted of three sections. The first section focused on selection and was rated on a scale of up to five stars. The second section assessed the comparability of the study and was rated on a scale of up to two stars. The third section emphasized the outcome and was rated on a scale of up to three stars. For case-control studies, the criteria included selection, which was evaluated with a maximum of four stars, comparability, assessed with a maximum of two stars, and exposure, graded with a maximum of four stars. Cohort studies had criteria that included selection, graded with up to six stars, comparability, graded with up to two stars, and outcome, graded with up to five stars. In cases where there was disagreement between the two assessors, the process was repeated and resolved with the involvement of a third reviewer (MM). Cross-sectional scored 6 and above, case-control studies scored 7 and above and cohort studies scored 9 and above quality assessment criteria were included to review (Table S 2).

Statistical analysis and Data synthesis

Publication bias was assessed using the funnel plot and Egger's test for a more objective evaluation. The heterogeneity of the studies was assessed using I^2 and Q statistics, and sensitivity analysis was performed to identify any outlier results in the included studies. The Der Simonian Laird random-effects model was used to estimate the overall proportion of viral suppression. Subgroup analysis was conducted based on the geographical location of the study, type of antiretroviral therapy regimen, sample size, study population by age, and study design to examine variations in outcomes. STATA 17 statistical software was used for analysis.

Result

A comprehensive search of databases and websites, including Google Scholar (n = 846), PubMed (n = 111), Hinari research4life (n = 96), Ethiopian university online repositories (Hawassa University n = 1, Bahirdar University n = 1, and Addis Ababa University n = 1), and other sources (n = 1), yielded a total of 1081 articles. After removing 104 duplicate articles, 977 articles remained. Among these, 848 articles were excluded based on a lack of matching titles and abstracts. Additionally, 108 articles were excluded after a full-text review due to differences in outcome variable measurement (n = 10), duplication (n = 4), and studies conducted outside Ethiopia (n = 94). Finally, a total of 21 articles were included for quantitative review (Fig. 1)for detail.

Characteristics of the included studies in Ethiopia

The study found through database searching was performed between 2011 and 2022. Regarding the study area/region, seven studies were conducted in the Amhara region(19, 24, 25, 26, 27, 28, 29), six studies in the Oromia region (20, 30, 31, 32, 33, 34), five studies in the South Nation and Nationalities and Peoples of Ethiopia (SNNPE) region(18, 35, 36, 37, 38), one study in the Tigray region (39) and two studies in the Addis Abeba city administration(40, 41).

By study design, ten studies were conducted using a cross-sectional study design (18, 24, 27, 31, 32, 33, 34, 36, 38, 39), two studies were conducted using a case control study design(30, 40), eight studies were conducted using a retrospective cohort stud (19, 20, 25, 26, 28, 29, 35, 41) and one study was conducted using a prospective cohort study (37). Nine studies were conducted on first-line ART patients (20, 25, 30, 32, 33, 35, 36, 37, 41), nine studies were conducted on both first- and second-line ART patients (18, 19, 24, 27, 28, 31, 34, 38, 39, 40), and two were conducted on second-line ART patients (26, 29). The minimum sample size was 152 taken in the study in Arba Minch (37), and the maximum sample size was 19,525 used in the study in the Tigray region (39) for detail (Table 1).

Table 1
Characteristics of the included studies in the systematic review and meta-analysis in Ethiopia

Author name/Publication year	study period	study region/area	study setting	Population	ART regimen	sample size	response rate	study design	funding source
Ali JH et al/2019(20)	2011–2013	Oromia	Health center	Adult	first line ART	243	100%	retrospective cohort	Saint Paul's Hospital, Ethiopia
Anito AA et al/2022 (18)	May to June,2021	SNNPE	Hospital	all ART patients	all ART regimen	342	100%	cross-sectional	not reported
Atnafu GT et al/2022(19)	2016–2020	Amhara	All health facility	Adult	all ART regimen	347	100%	retrospective cohort	not reported
Berihun H et al/2023(24)	March to June 2022	Amhara	APHI	Children	all ART regimen	522	100%	cross-sectional	not reported
Diress G et al/2020(25)	March to May,2019	Amhara	Hospital	All ART patients	first line ART	235	100%	retrospective cohort	Woldia University, Ethiopia
Erjino E et al/2023(35)	2016–2021	SNNPE	Hospital	Adult	first line ART	297	100%	retrospective cohort	not reported
Fenta DA/2021(36)	July to Dec, 2019	SNNPE	Hospital	Children	first ART	273	100%	cross-sectional	Hawassa University, Ethiopia
Kolako E/2019(38)	March, 2019	SNNPE	Hospital	Adult	all ART regimen	367	98%	cross-sectional	not reported
Melku M et al/2020(27)	Feb to April 2018	Amhara	Hospital	Adult	all ART regimen	323	100%	cross-sectional	not reported
Minyichil B/2022(28)	2017–2021	Amhara	All health facility	All ART patients	all ART regimen	546	96%	retrospective cohort	not reported
Sado AG et al/2022(31)	June Nov, 2019	Oromia	Hospital	Adult	all ART regimen	430	100%	cross-sectional	not reported
Sorsa A/2018(32)	May-August 2017	Oromia	Hospital	Children	first line ART	183	100%	cross-sectional	Self
Waju B et al/2021(33)	March, 2019	Oromia	All health facility	Adult	first line	669	100%	cross-sectional	not reported
Wedajo S et al/2021(29)	2016–2019	Amhara	Hospital	Adult	second line ART	642	100%	retrospective cohort	Bahir Dar University, Ethiopia
Melak D et al/2023(29)	2018–2022	Amhara	Hospital	Adult	second line ART	364	100%	retrospective cohort	Wollo University, Ethiopia
Desta AA et al/2020(39)	2015–2019	Tigray	THRI	All ART patients	all ART regimen	19,525	100%	cross-sectional	not reported
Hussen S et al/2019(37)	2017–2018	SNNPE	Hospital	Adult	first line	152	100%	prospective Cohort	Arba Minch University. Ethiopia
Dires YM et al/2021(40)	2021	Addis Abeba	hospital	Youth	all ART regimen	192	100%	case control	Addis Ababa University, Ethiopia.
Sosna M/2021(41)	2018–2019	Addis Abeba	all health facility	Adult	first line	356	93%	retrospective cohort	not reported

Author name/Publication year	study period	study region/area	study setting	Population	ART regimen	sample size	response rate	study design	funding source
Haile B et al/2021(34)	August-October, 2020	Oromia	all health facility	Adult	all ART regimen	424	100%	Cross-sectional	Not reported
Jaleta.F et al/2022(30)	2015–2020	Oromia	All health facility	Adult	first line	347	100%	Case control	Oromia regional Health Bureau (ORHB)

Publication bias

The figure below (Fig. 2) indicates the funnel plot for HIV viral load suppression, which indicates symmetries. Egger's test showed no small-study effects with a P value of 0.747.

Meta-analysis of the proportion of virological suppression in Ethiopia

Virological suppression rate (suppressed "<1000 copies/ml" of blood or unsuppressed "≥1000 copies/ml" of blood) according to the Ethiopian context. To determine the pooled proportion of viral suppression, 19 studies were included with a total sample size of 26,240 participants. By definition, the pooled prevalence of virological suppression in the Ethiopian context was 71% (95% CI: 64%, 77%) (I^2 = 98.77, Q statistics p-value ≤ 0.01) (Fig. 3).

Subgroup analysis of virological suppression in Ethiopia

Subgroup analysis was employed by region (Fig. 4), study population, study design and ART regimen. The virological suppression rate was 62% in the Oromia region, 72% in the SNNPE region, 70% in the Amhara region and 74% in other regions (Tigray and Adis Ababa). By study population; the pooled virological suppression rate among adults was found to 73% (95%CI: (61, 85)); whereas in children it was 74% (95% CI: 70, 78). By ART regimen the pooled virological suppression rate for patients on first line ART was78% (95%CI: (73, 82)); Where as in second line ART it was 82% (79, 84)) (Table 2).

Table 2
Subgroup analysis of the HIV virological suppression percentage by region, study population, study design and ART regimen type in Ethiopia

Sub group analysis	Number of studies	Pooled Percentage of VLS**	95% CI of P	Heterogeneity I^2 (p value)
By region				
Oromia	5	67	39, 95	99.6%%
SNNPE	5	72	56, 87	98.01%
Amhara	7	70	62, 79	96.89%
Other*	2	74	73, 74	0.0%
By Study population				
Adults	12	73	61, 85	99.11%
All ART patient	4	60	45, 75	98.56%
Children	3	74	70, 78	0.0%
By study design				
Cohort study	9	73	65, 81	96.60%
Cross-sectional study	10	68	57, 79	99.25%
By ART regimen				
First line	8	78	73, 82	84.86%
first and second line	8	62	50, 75	99.38%
Second line	2	82	79, 84	0.0%
Overall pooled Percentage	19	71	64,77	98.8%/ 0.839

*Addis Ababa and Tigray region, **viral load suppression

Trend of virological suppression in Ethiopia over time (2018–2023*)*

The cumulative proportion of virological suppression in Ethiopia was higher from 2018 to 2020 but constantly decreased from 2020 to 2023 (Fig. 5).

Systematic review of factors associated with virological suppression in Ethiopia

Different factors, such as sociodemographic, clinical and treatment-related factors, contribute to virological suppression.

Sociodemographic factors associated with virological suppression

Based on the primary study report, being female was positively associated with virological suppression (AHR = 1.50; 95% CI: 1.05–2.15) (19), the study (25) (95% CI ARR = 1.18 (1.017–1.192), the study (36) (95% CI AOR: 1.9 (1.04–3.48) and the study (95% CI AHR:1.31(1.01,1.69). Another study also revealed a similar finding, in which male sex had a positive association with viral non-suppression (AOR = 1.27; 95% CI: 1.18, 1.37)(39). Different age categories also showed an association with viral non-suppression, with an age category between 15–19 years (AOR = 4.86 95% CI: 3.86, 6.12), 20–24 years (AOR = 96; 95% CI: 1.57, 2.45) 25–29 years (AOR = 1.79; 95% CI: 1.55, 2.08) 30–34 years (AOR = 1.46; 95% CI: 1.29, 1.65), 35–39 years (AOR = 1.43; 95% CI: 1.27, 1.61), 40–44 years (AOR = 1.22; 95% CI: 1.08, 1.39), 45–49 years (AOR = 1.22; 95% CI: 1.06, 1.40) were positively associated with viral non-suppression compared with older age groups 50 + years(39). The primary study, having formal education in primary (95% CI ARR = 1.38 (1.032–1.841) and secondary and above (95% CI ARR = 1.65 (1.253–2.164) were positively associated with viral suppression (25).

Clinical factors associated with virological suppression

In the primary study, malnourished patients were less likely to have viral suppression (95% CI AOR = 0.565 (0.329–0.971) (18), BMI (18.5–24.9 kg/m2) was more likely to have virological re-suppression (95% CI AHR = 1.42(1.03,1.95 (26). Poor adherence (95% CI AOR: 0.504 (0.287–

0.886) (18) and one study (39) showed that poor adherence was more likely to non-suppression (95% CI AOR = 2.56 (1.97, 3.33). CD4 count < 200 cells/mm3 (95% CI AOR = 0.149 (0.071–0.314)) (18) and CD4 count > 350 cells/mm3 (95% CI AHR = 1.98 (1.12, 3.51)) (19) showed a positive association with viral suppression. The presence of opportunistic infection (95% CI AHR = 1.85 (1.06, 3.24) showed a positive association with viral non-suppression (19).

Treatment-related predictors of virological suppression

NVP-based (95% CI AOR = 0.125 (0.034–0.464)) and EFV-based (95% CI AOR = 0.223 (0.063–0.795)) ART regimens were less likely to suppress viral load than PI-based regimens(18). Another study showed that patients on second-line regimens were more likely to have virological suppression than those on first-line regimens (95% CI AOR = 8.98 (2.64,30.58)(34). The use of CPT (95% CI AHR = 1.997 (1.108,3.600) (37) and (95% CI AOR = 2.6(1.23–5.48) (30)) and IPT use (95% CI AHR = 3.085(1.721,5.529) were more likely to have virological suppression (37) compared with nonusers.

Meta-analysis of factors associated with virological suppression in Ethiopia

The pooled effect of patient adherence to ART showed that patients with poor adherence were 0.33 times less likely to have virological suppression (AOR = 0.33; 95% CI: 0.28, 0.40) (Fig. 6). The pooled effect of BMI (18.5–24.9 kg/m^2) showed a positive association with virological suppression (AOR = 1.8; 95% CI: 1.37, 2.36) (Fig. 7). The pooled effect of CD4 count ≥ 200 cells/mm3 had 1.64 times higher virological suppression compared with CD4 < 200 cells/mm3 (AOR = 1.64; 95% CI: 1.34, 2.01) (Fig. 8).

Patients having disclosure of HIV status had 1.41 times more likely to have virological suppression (AOR = 1.41; 95%CI:1.05,1.89) (Fig. 9). Opportunistic infection also determines the virological suppression; absence of opportunistic infection increases the virologic suppression by 1.68-fold as compared with patients having opportunistic infection (AOR = 1.68; 95%CI: 1.43, 1.97) (Fig. 10). Base line viral load count had showed significant association with viral suppression; viral load count ≥ 10,000 copies/ml of blood had 35% lower virologic suppression as compared with its counter parts (AOR = 0.65;95%CI: 0.52, 0.81) (Fig. 11). In this study the pooled effect of WHO stage does not show significant association with virological suppression (Fig. 12). Summary of findings found in (Table 3).

Table 3
Summary of pooled effect of factors associated with virological suppression in Ethiopia

Variables	Number of studies	AOR	95% CI of AOR	Heterogeneity I^2 (p value)
Poor adherence	10	0.33	0.28, 0.40	87.3%% (0.000)
BMI (18.5–24.9 kg/m2)	4	1.80	1.37, 2.36	81.5% (0.001)
CD4count > = 200 cells/mm3 at baseline	6	1.64	1.34, 2.01	23.8% (0.255)
CD4count > = 350 cells/mm3 at baseline	2	1.27	0.93, 1.74	69.5% (0.07)
CD4count > = 500 cells/mm3 at baseline	6	0.971	0.86, 1.10	91.3% (0.000)
Having disclosure of HIV status	3	1.41	1.05, 1.89	0.00% (0.42)
Absence of opportunistic Infection	6	1.68	1.43, 1.97	0.00% (0.718)
Viral load > = 10,000copies at baseline	5	0.65	0.52, 0.81	72.5% (0.006)
WHO stage III/IV	7	0.98	0.86, 1.13	70.9% (0.002)

Discussion

The objective of this systematic review and meta-analysis was to determine the pooled proportion of virological suppression and investigate the pooled impact of factors contributing to virological suppression in Ethiopia. Based on the analysis of data from 19 primary studies conducted in Ethiopia, the pooled prevalence of virological suppression was 71% (95% CI: 64%, 77%). This estimate is lower compared to the global target for virological suppression in controlled patients (5), multicounty longitudinal cohort analysis studies and meta-analysis of virological success rates in Sub-Saharan Africa (13, 42) and a randomized control trial in Botswana (43). The variation in measurement of virologic suppression in different contexts may explain this discrepancy. The low rate of virological suppression in Ethiopia could also be attributed to an increased rate of treatment failure, as indicated by a recent meta-analysis study in Ethiopia (44), as well as the impact of the COVID-19 pandemic on HIV care and treatment. However, the findings of this study align with the nationwide estimate of virological suppression in Cameroon (45). It is worth noting that the review finding is higher than the results reported in some specific studies conducted in certain regions of Ethiopia (18) (19).

The cumulative meta-analysis conducted in this study indicates a decline in the cumulative rate of virological suppression from 2020 to 2022. This decrease can be attributed to various challenges faced in Ethiopia. One of the significant challenges mentioned is the COVID-19 pandemic, which has had a profound impact on all aspects of HIV service delivery. This includes difficulties in scheduling appointments for medication refills, clinical and laboratory follow-ups for routine viral load testing, and an increase in the number of individuals lost to ART follow-up (46, 47). Additionally, healthcare facilities have prioritized the response to COVID-19, leading to a disruption in routine HIV services (48), and the COVID-19 pandemic has had a detrimental effect on HIV treatment and prevention services globally (1, 4).

Based on this review, it suggests that Ethiopia has not yet reached the global target of achieving virological suppression in 90% of patients on ART. In order to enhance the likelihood of achieving positive virological outcomes, it is necessary to address various factors and challenges. This systematic review and meta-analysis found that factors such as patient adherence to ART, body mass index, baseline CD4 count, disclosure, opportunistic infections, and baseline viral load count had a significant pooled impact on virological suppression in Ethiopia. By focusing on these factors, improvements can be made to enhance virological suppression rates in the country.

According to this review, it was discovered that low patient adherence to ART had a notable negative impact on virological suppression in Ethiopia. This finding aligns with another meta-analysis study that demonstrated a correlation between higher adherence rates and increased levels of viral suppression (18, 49), which suggests that it is crucial to identify and address barriers to adherence to enhance virological suppression.

Nutritional status, as indicated by BMI and baseline CD4 count, was identified as another contributing factor to viral suppression in Ethiopia. Patients with a normal BMI (18.5-24.9kg/m^2), according to the WHO classification, were more likely to achieve viral load suppression, which is in line with the findings of primary studies (18), this is because BMI has a predictive impact on immune recovery, which is crucial for controlling viral replication. Additionally, the baseline CD4 count of patients was found to determine virological suppression, which is consistent with previous studies (19, 20). CD4 count plays a vital role in immune function, protecting the body against opportunistic infections and the multiplication of the virus.

Disclosure of HIV status was an important contributing factor of viral suppression in this review, and this finding was supported by other studies (31, 33, 37); this is because disclosure improves adherence to ART (50). This implies that encouraging supportive social environments for disclosure can enhance the viral suppression rate.

The presence of opportunistic infections plays a significant role in determining the virological suppression of patients receiving ART. Patients without any opportunistic infections are more likely to achieve virological suppression, which is supported by studies (19, 35). Initiating ART can help prevent many opportunistic infections, but in Ethiopia, the late presentation of patients to care and treatment leads to a high incidence of opportunistic infections and non-suppression of the virus. This finding suggests that preventing and managing common opportunistic infections can improve viral suppression in Ethiopia. Additionally, a high baseline viral load copy reduces the rate of viral suppression in Ethiopia, which is consistent with studies (25, 26, 35) because a high viral load indicates disease progression and adherence issues, resulting in lower viral suppression. Furthermore, limited appropriate action is taken based on viral load results in various resource-poor settings (51).

Conclusion

In this study, the pooled percentage of virological suppression in Ethiopia was still low compared with the global target of viral suppression. Adherence to ART, body mass index, baseline CD4 count, disclosure, opportunistic infection and baseline viral load count was identified as significant contributing factors to virological suppression. The current study recommends that responsible stakeholders in HIV programs should maximize their effort to achieve the global target of virological suppression by addressing significant predictors. Appropriate action on viral load test results should be taken to track progress toward ending HIV public health threats. Although sufficient primary studies were utilized to determine the pooled virological suppression rate, there was a lack of representation from certain regions of Ethiopia. As a result, it is necessary for researchers to conduct additional studies in these regions that were not included in the systematic review and meta-analysis of the current study.

Abbreviations

AHR: Adjusted Hazard Ratio; AIDS: Acquired Immunodeficiency Syndrome; AOR: Adjusted Odds Ratio; APHI: Amhara Public Health Institute; ART: Antiretroviral Therapy; BMI: Body Mass Index; CD4: Cluster of Differentiation; HIV: Human Immunodeficiency Virus; PRISMA: Preferred

Reporting Item for Systematic Review and Meta-Analysis; SNNPE: South Nation, Nationalities and Peoples of Ethiopia; THRI: Tigray Health Research Institute; UNAIDS: The Joint United Nations Program On HIV/AIDS; VLS: Viral Load Suppression; WHO: World Health Organization

Declarations

Ethics approval and consent to participate

No primary data were used; thus, ethical approval is not applicable

Consent for publication

consent of publication "Not applicable"

Availability of data and materials

The datasets used and analyzed during the current study are available from the corresponding author and can be taken upon justifiable request

Competing interests

All authors declare that they have no conflict of interest

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Authorship

All authors review and put their substantial effort to this study. DM and FD: conceptualization and design of the study; FY, AH and ZA: searching the databases; MM, AM, YT: quality appraisal of the included primary studies; NC, AA and HY: data extraction; DM, AE, BW, AM: analysis, interpretation of the data and write the first draft of the research; DM, FD, ZA and EA: write final draft of the research; NK, TB and DM: editing and approval of the final research before submission.

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Not applicable

Authors' information

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Figures

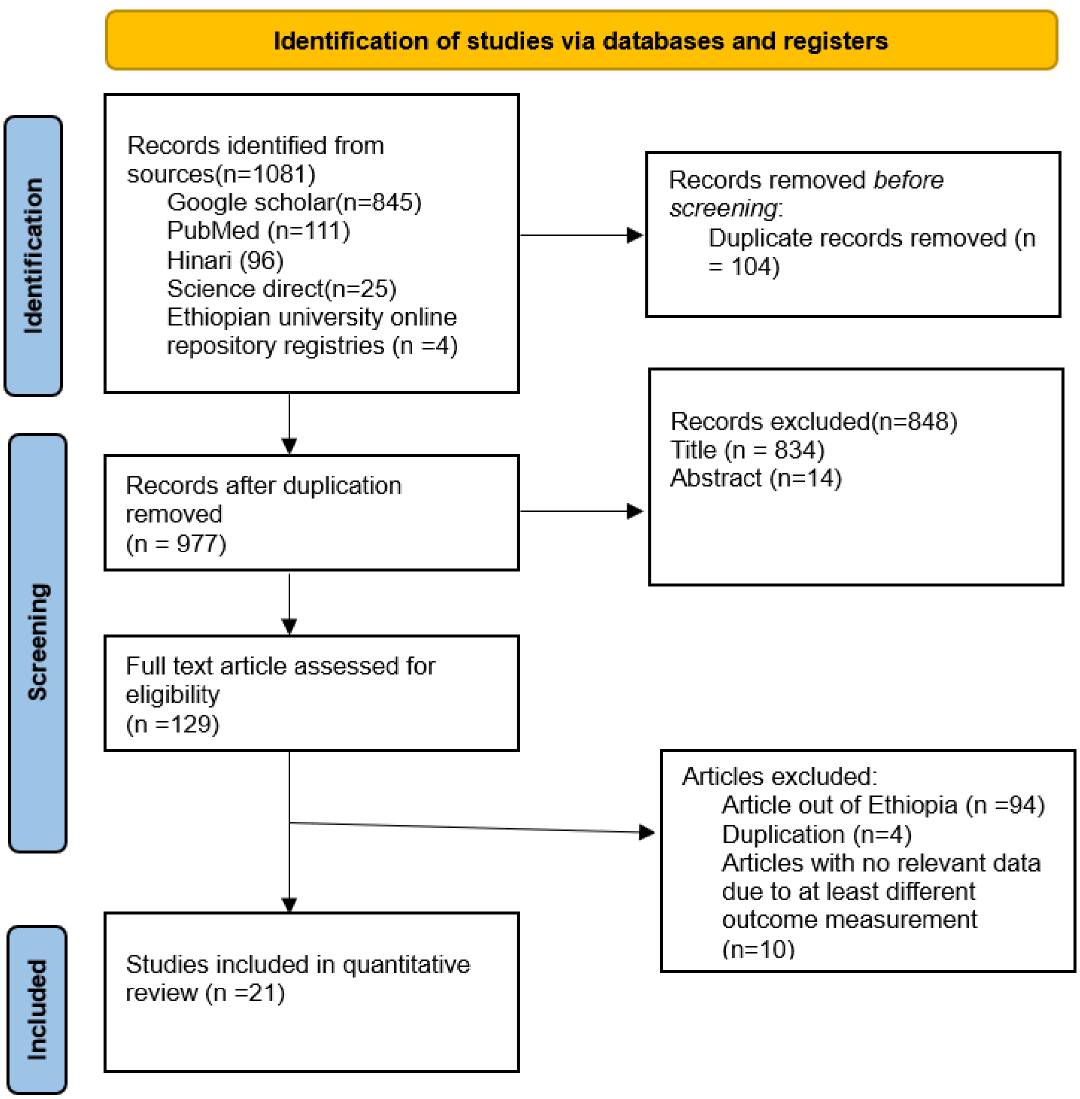

Figure 1

PRISMA flow-chart diagram describing the screening and selection of studies for systematic review and meta-analysis in Ethiopia.

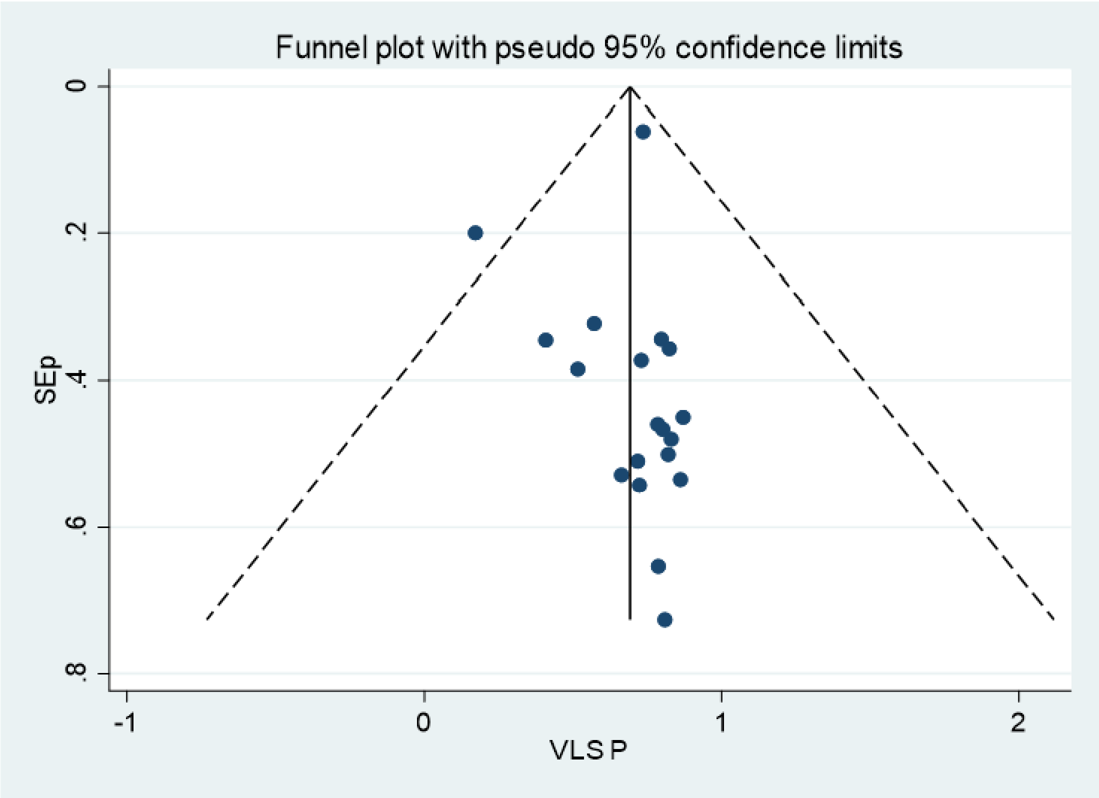

Figure 2

Funnel plot, in which the vertical line indicates the effect size, whereas the diagonal line indicates the precision of individual studies with a 95% confidence limit

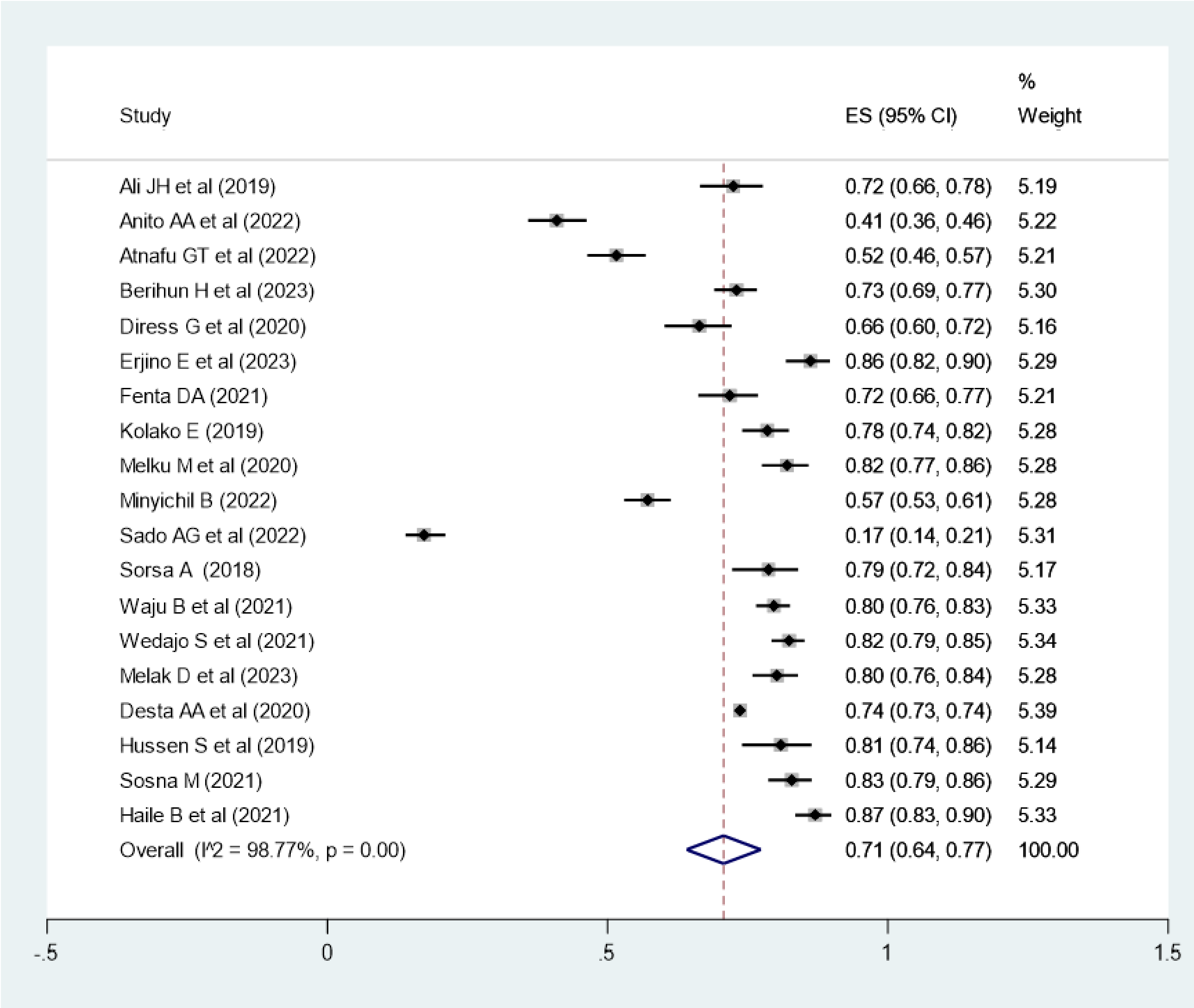

Figure 3

Forest plot of the proportion of virological suppression in Ethiopia and its 95% CI. The midpoint of each line illustrates the estimated proportion of VL in each study. The diamond shows the pooled proportion.

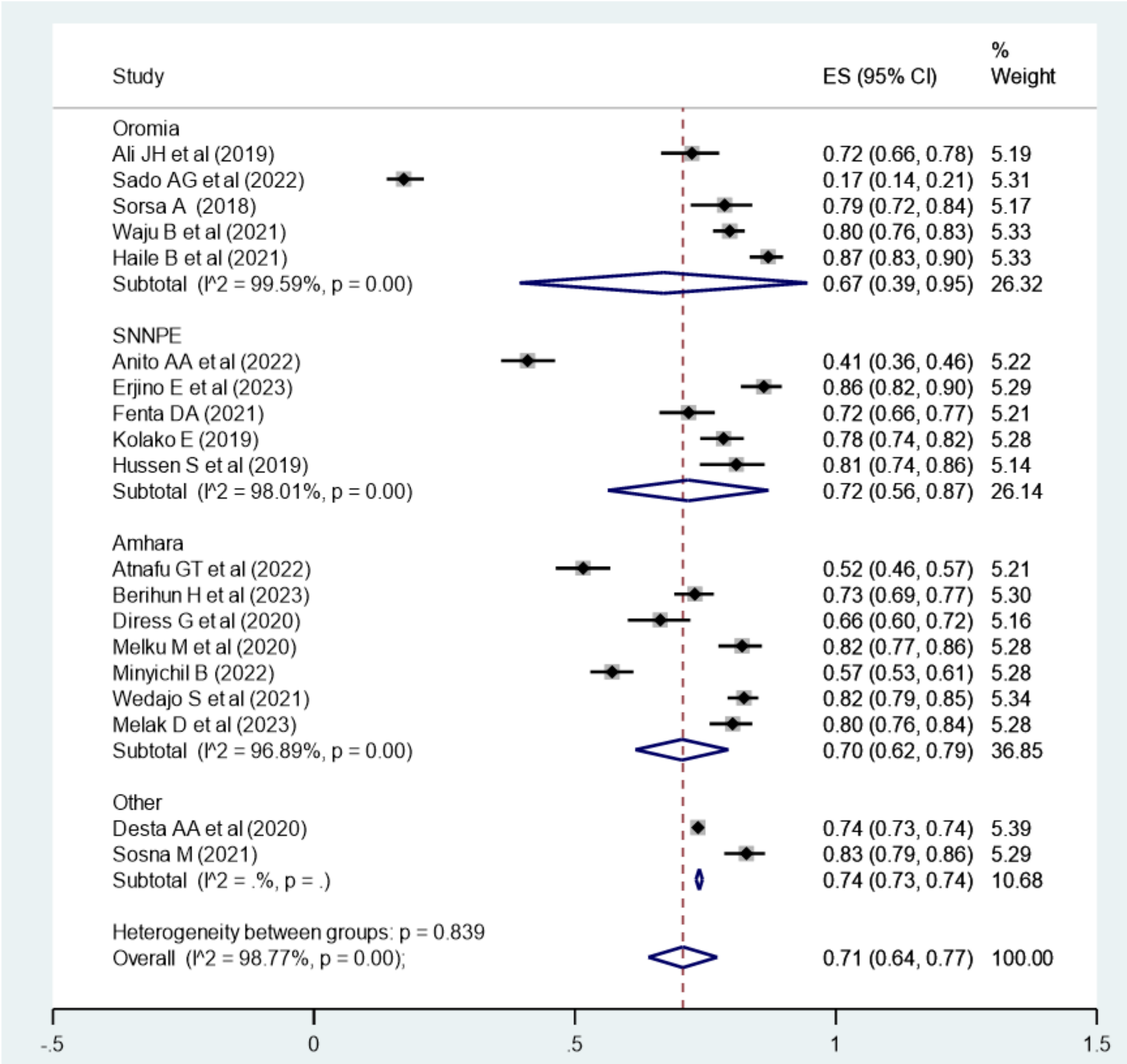

Figure 4

Subgroup analysis by region of Ethiopia to determine the pooled proportion of virological suppression in each region. The midpoint of each line illustrates the estimated proportion of VL in each study. The diamond shows the pooled proportion.

*Other- Addis Ababa and Tigray region, SNNPE- south nation, nationalities and peoples of Ethiopia

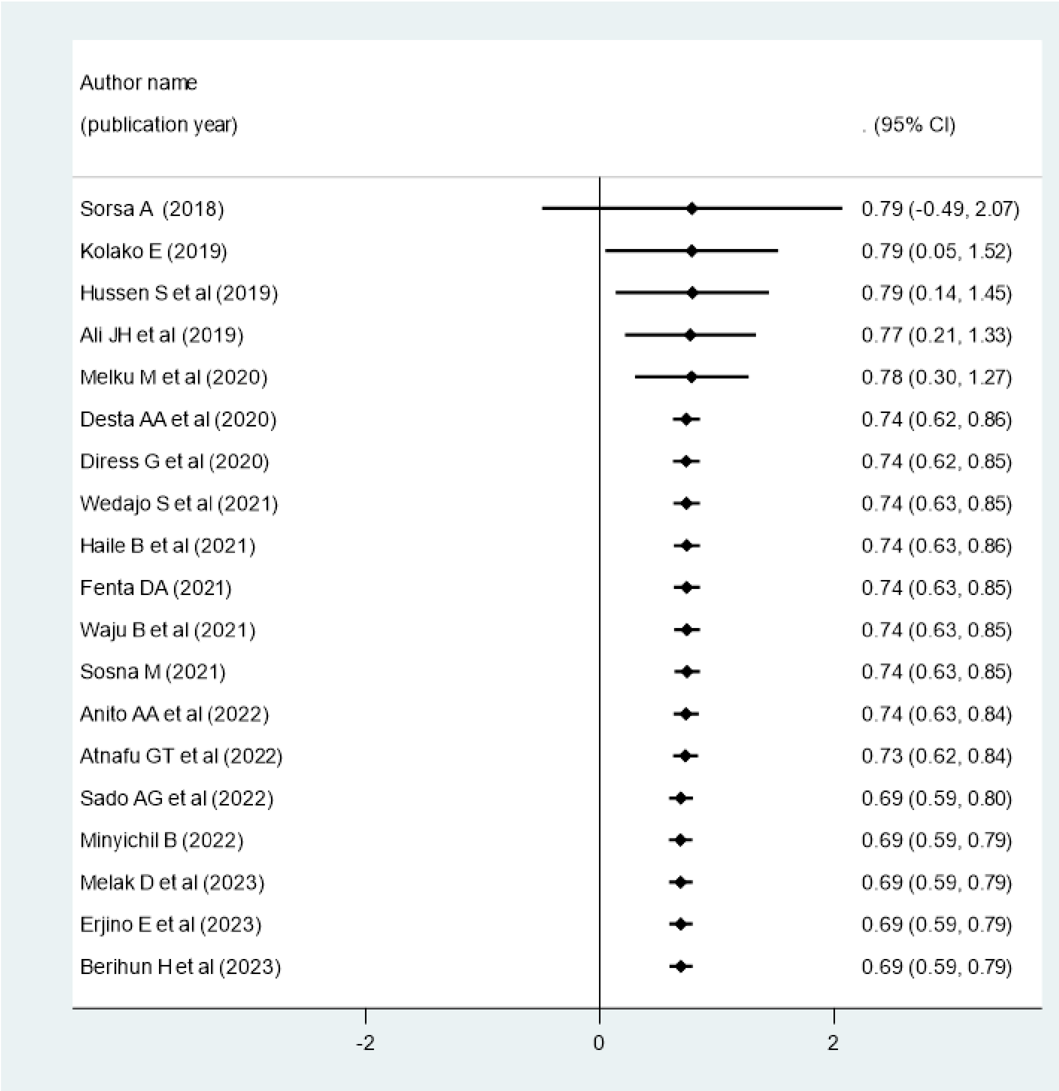

Figure 5

Forest plot for the cumulative proportion of virological suppression in Ethiopia over time (2018-2023)

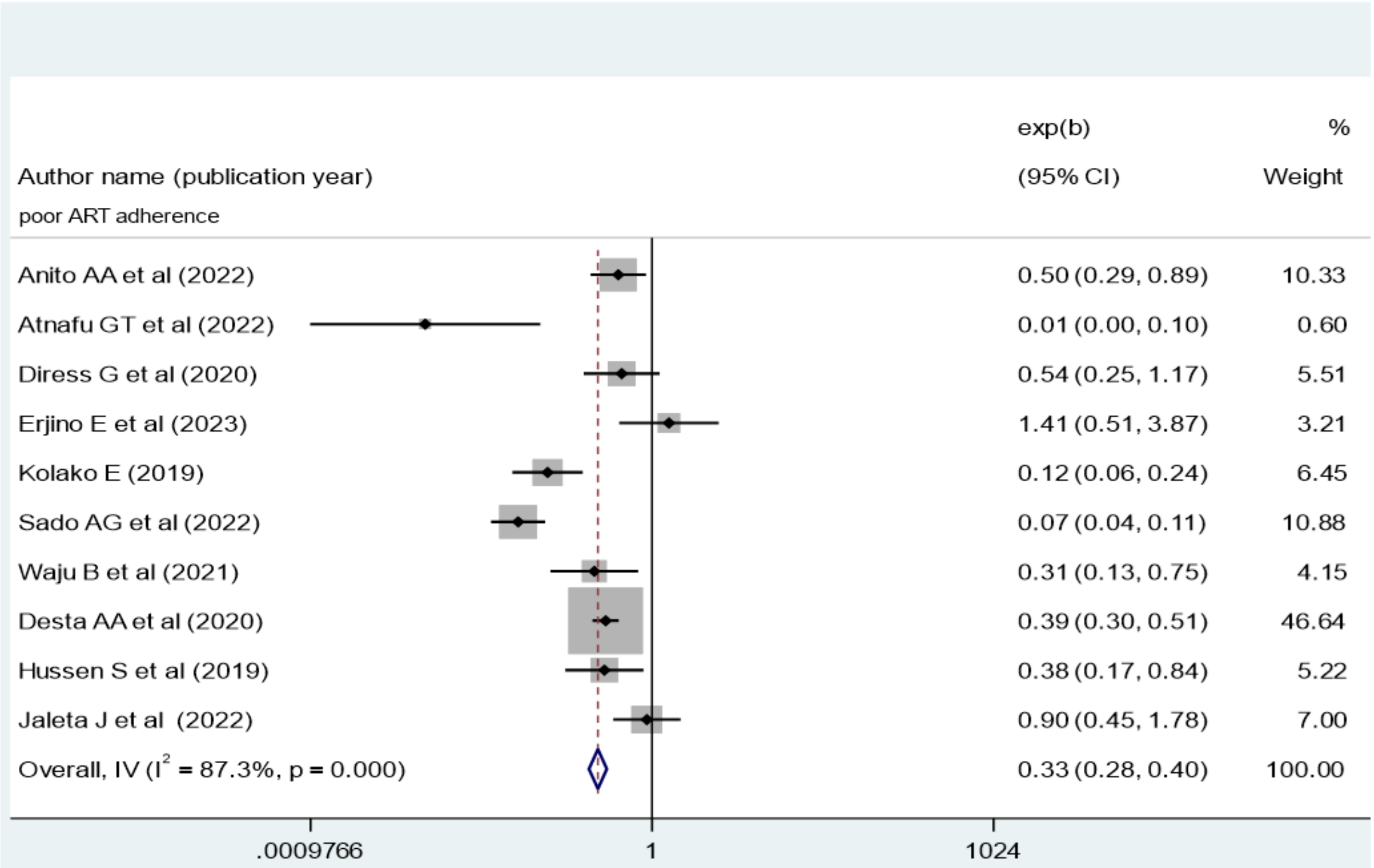

Figure 6

Forest plot of the adjusted odds ratios with corresponding 95% CIs of studies on the association of poor ART adherence and virological suppression in Ethiopia.

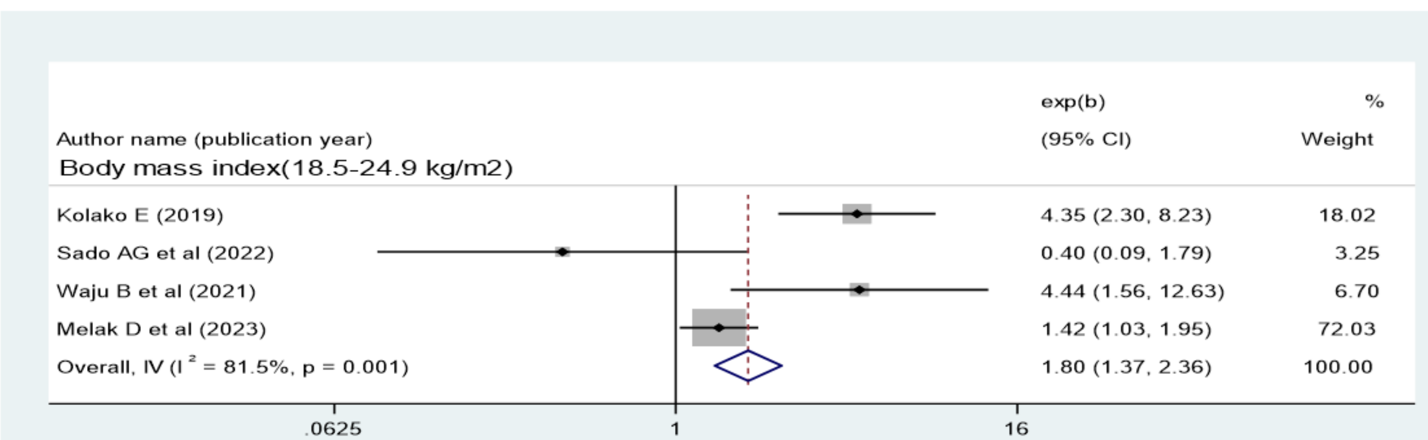

Figure 7

Forest plot of the adjusted odds ratios with corresponding 95% CIs of studies on the association of body mass index and virological suppression.

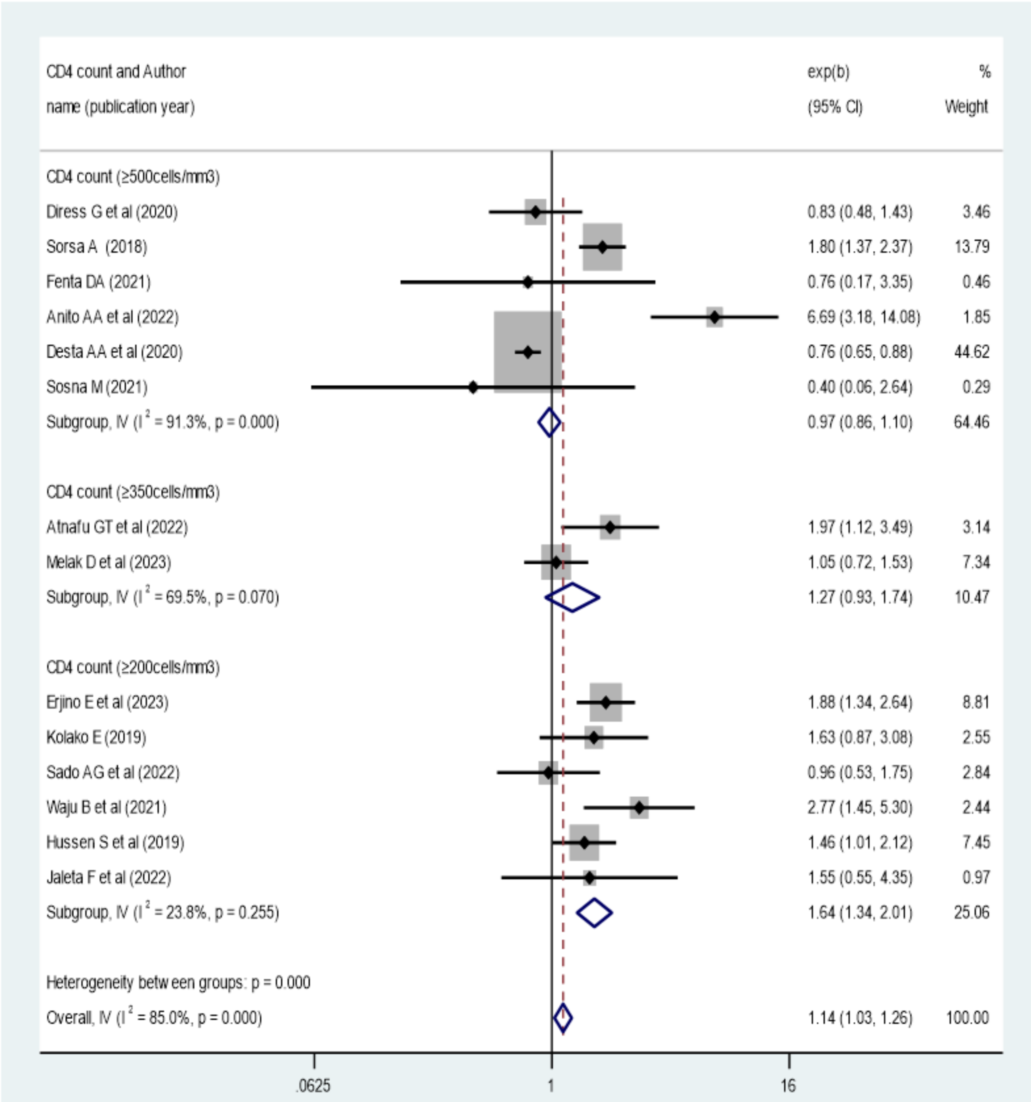

Figure 8

Forest plot of the adjusted odds ratios with corresponding 95% CIs of studies on the association of CD4 count and virological suppression.

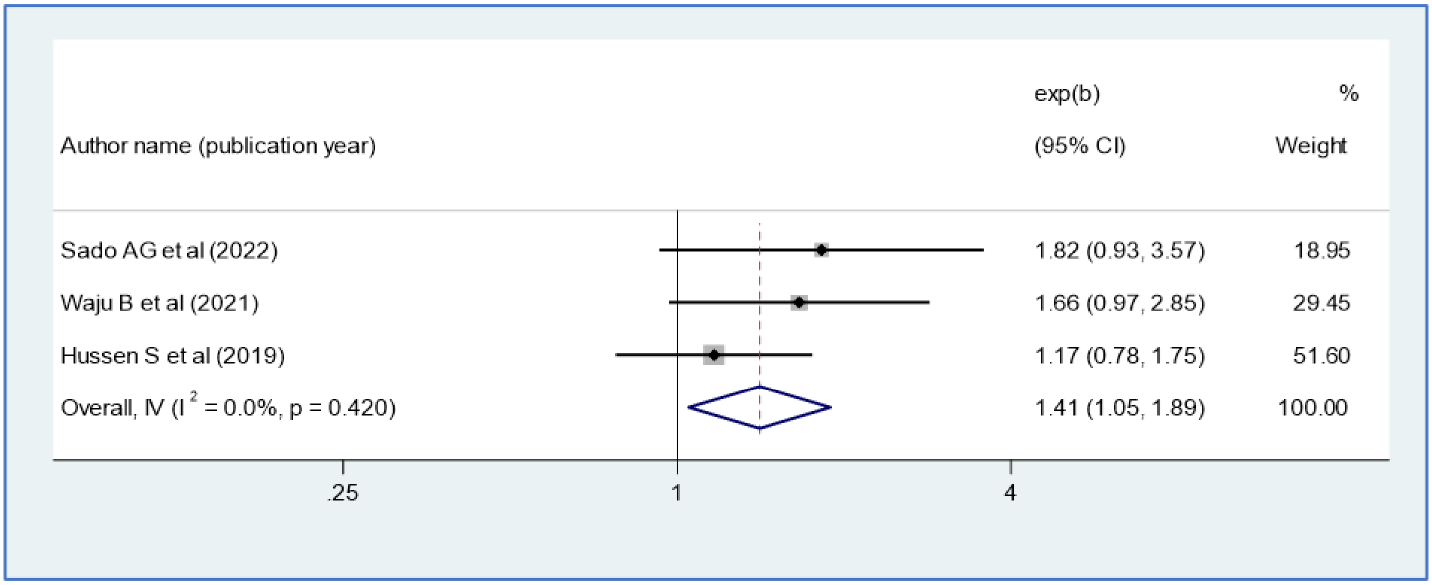

Figure 9

Forest plot of the adjusted odds ratios with corresponding 95% CIs of studies on the association of disclosure of HIV status and virological suppression.

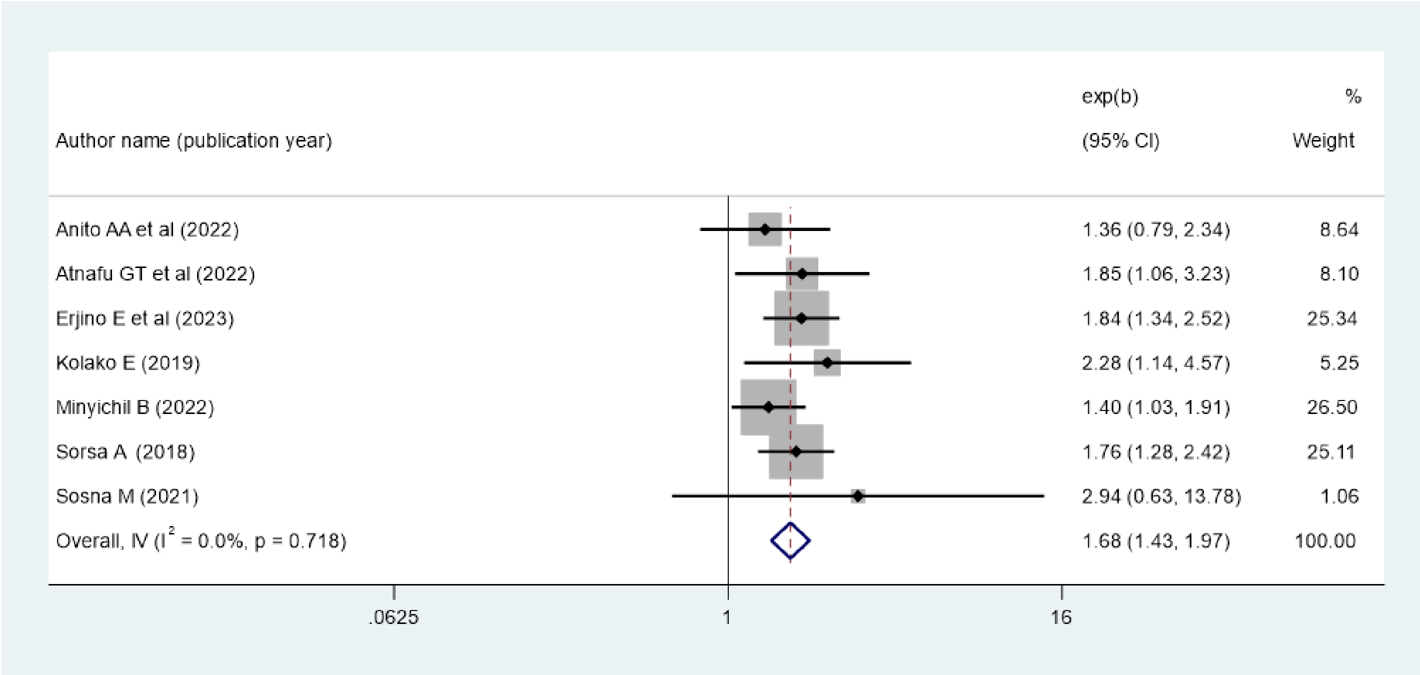

Figure 10

Forest plot of the adjusted odds ratios with corresponding 95% CIs of studies on the association of absence opportunistic infection and virological suppression.

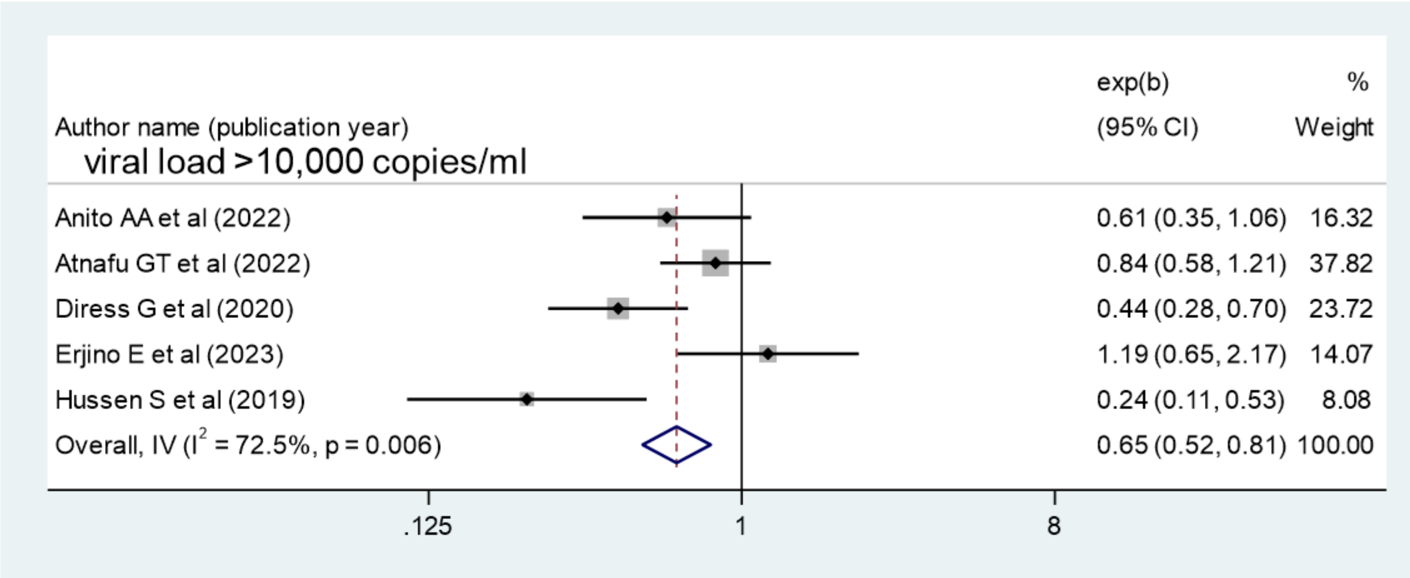

Figure 11

Forest plot of the adjusted odds ratios with corresponding 95% CIs of studies on the association of baseline viral load ≥10,000 copies/ml and virological suppression.

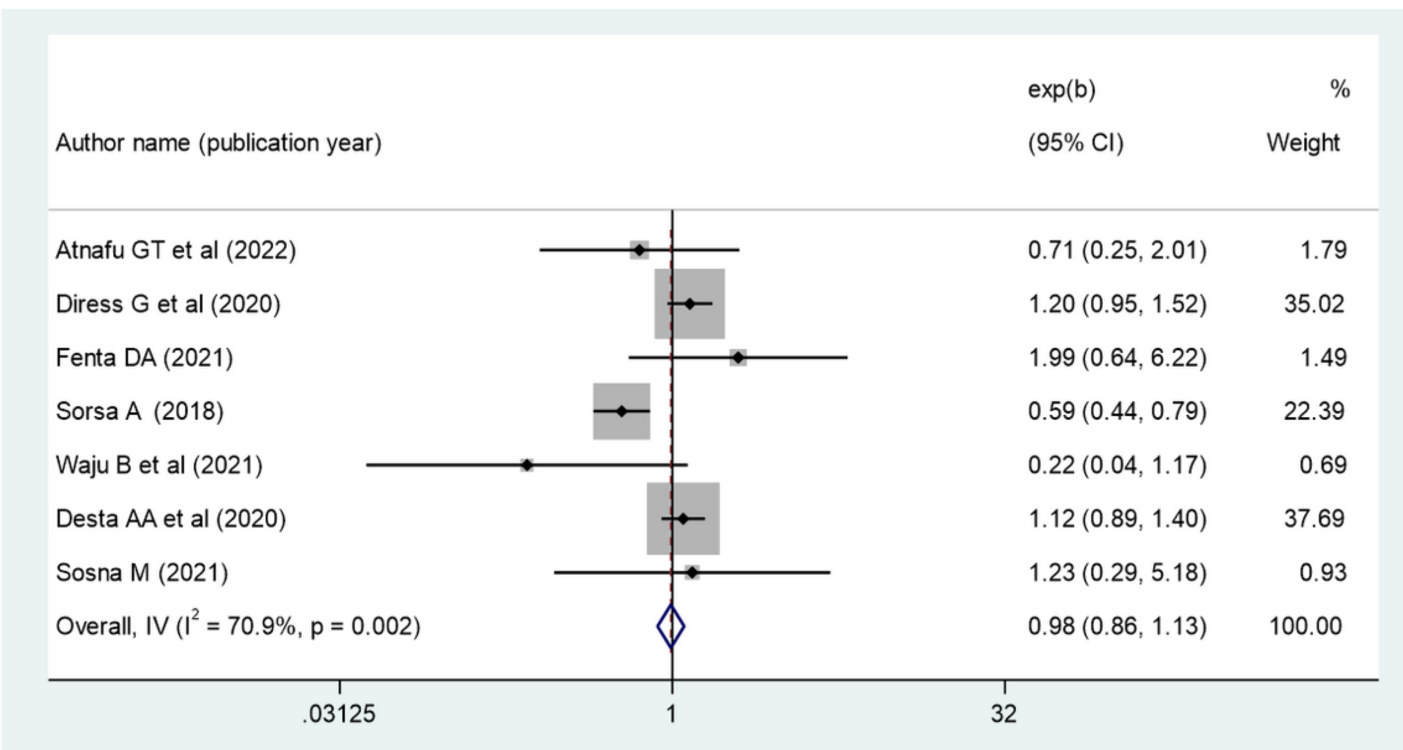

Figure 12

Forest plot of the adjusted odds ratios with corresponding 95% CIs of studies on the association of WHO stage III/IV and virological suppression.

Supplementary Files

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