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REVIEW

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Prevalence and factors associated with viral non-suppression in people living with HIV receiving antiretroviral therapy in sub-Saharan Africa: A systematic review and meta-analysis

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Abstract

Despite advances in HIV treatment, the burden of viral non-suppression (VNS) remains a treatment success concern, particularly in Sub-Saharan African (SSA) countries. We determined the prevalence and factors associated with VNS for people living with HIV (PLHIV) receiving antiretroviral therapy (ART). This review, registered with PROSPERO (CRD42023470234), conducted an extensive search for evidence, focusing on PLHIV living in SSA on ART from the year 2000 to 19th October 2023, across databases including PubMed/MEDLINE, Embase, Web of Science, and Scopus. A total of 2357 articles were screened, from which 32 studies met the criteria for the final analysis, involving 756,620 PLHIV of all ages. The pooled prevalance for VNS was found to be 20.0% (95% CI: 15.43%–25.52%, I^2 = 100%, p-value <0.01) Children and adolescents demonstrated the highest prevalence of VNS (viral load ≥1000 copies/mL) at 27.98% (95% CI: 21.91%–34.97%, I^2 = 94%, p-value <0.01). The study revealed various factors associated with increased odds (risk) of VNS, p-value <0.05. These factors encompassed socio-demographics such as sex, age, education level, and marital status. Additionally, aspects related to HIV care, such as the facility attended, HIV status disclosure and adherence exhibited higher odds of VNS. Suboptimal ART adherence, longer duration on ART, socio-economic factors, lack of family and social support, presence of co-morbidities, advanced WHO HIV clinical stage, ART regimens, lower CD4+ count, abnormal body mass index, history of treatment interruptions, and progression of HIV illness were associated with VNS. Furthermore, behavioural/psychological factors including depression, substance use, negative perceptions towards ART, experiences of abuse, alcohol use, stigma, and certain patterns of sexual behaviour were also identified as factors for VNS. The occurrence of two VNS to every ten PLHIV on ART poses a threat to the progress made towards reaching the third 95% UNAIDS target in SSA. Additionally, these findings highlight the intricate interplay of various factors, encompassing patient characteristics, behavioural patterns, sociocultural influences, and pharmacological factors, all

Abbreviations: AOR, adjusted odds ratio; ART, antiretroviral therapy; PLHIV, people living with HIV; SSA, sub-Saharan Africa; UNAIDS, Joint United Nations AIDS Control Programme; VNS, viral non-suppression.

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impacting VNS among PLHIV. Recognising its multifaceted nature, we recommend designing and implementing high impact interventions to effectively address VNS in SSA.

KEYWORDS
antiretroviral therapy, people living with HIV, prevalence, sub-Saharan Africa, systematic review and meta-analysis, viral non-suppression

1 | INTRODUCTION

In 2022, the estimated number of people living with HIV (PLHIV) globally was 39 million (33.1–45.7 million). Sub-Saharan Africa (SSA) bears a significant burden of the global HIV epidemic, with more than 25 million PLHIV in the region.[1] Approximately 29.8 million people, comprising 76% (65%–89%) of all PLHIV were accessing antiretroviral therapy (ART).[2] An ART uptake of 18.0%–98.9%, with a pooled estimate of 53% has been reported in SSA.[3] Despite substantial progress in expanding access to ART and improving healthcare infrastructure, achieving viral suppression among PLHIV remains a critical challenge.[4]

Viral non-suppression (VNS)[5] is characterised by elevated viral loads (e.g.,1000 copies/mL or above after being on ART for at least 6 months in most of SSA countries), posing serious public health and clinical concerns, including the risk of disease progression and onward transmission of the virus.[6] To advance the UNAIDS '95-95-95' targets,[7] where 95% of PLHIV know their status, 95% of those diagnosed receive sustained ART, and 95% of those on treatment achieve viral suppression, bringing us closer to ending the HIV epidemic in this region, it was important to conduct a comprehensive review of the factors associated with VNS in SSA.

As of 2022, substantial progress was observed in HIV diagnosis, treatment, and viral suppression rates globally.[2] Within the group accessing treatment, 93% achieved viral suppression. Remarkable progress was noted in specific SSA countries such as Botswana, Eswatini, Rwanda, the United Republic of Tanzania, and Zimbabwe, which successfully achieved the 95-95-95 targets by 2022. Despite significant progress in HIV treatment, the challenge of VNS continues to persist, particularly in SSA countries.[8] Furthermore, disparities persist as children and adolescents continue to lag behind the global target of 95% viral suppression when compared to the adult population. This underscores the need for further studies to investigate the multifaceted contributions to VNS[9].

In this review, we examined factors influencing VNS, ranging from socio-demographic characteristics, clinical and treatment, behavioural and psychosocial factors, to the impact of comorbid conditions such as tuberculosis.[10–16] Our objective was to estimate the prevalence and the factors associated with VNS among patients residing in SSA. A comprehensive understanding of the complex factors influencing VNS is essential for designing targeted measures that address specific challenges and vulnerabilities within populations. This encompasses the identification and analysis of demographic, socioeconomic, cultural, and behavioural factors that intricately impact viral suppression rates and disease outcomes.

2 | MATERIAL AND METHODS

2.1 | Study design and protocol registration

We formulated a systematic review protocol following the guidelines established by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Protocols[17] and officially registered it with the International Prospective Register of Systematic Reviews (PROSPERO) under registration number CRD42023470234. The review aimed at determining the factors associated with VNS among PLHIV living in SSA and are using ART.

2.2 | Study search and eligibility criteria

This review aimed to search for evidence in PubMed/MEDLINE, Embase, Web of Science, and Scopus, focusing on studies conducted in SSA. We included articles published from the year 2000 to 19th October 2023. The initial search strategy was developed for PubMed/MEDLINE using keywords and Medical Subject Headings terms. The keywords we used included 'viral suppression,' 'suppression,' 'ART,' 'people living with HIV,' and 'SSA countries' (Supporting Information S1). This search strategy was customised for other databases. This review considered both randomised and non-randomised studies, such as cross-sectional, cohort, and case-control studies, conducted among PLHIV on ART in SSA countries.

2.3 | Study screening and data extraction

The Covidence software[18] was used to manage the study selection process and eliminate duplicates. Two independent reviewers, IHM and GGN, conducted screening of titles, abstracts, and full-text articles to determine their inclusion in the review (Figure 1). In cases of disagreements, a third reviewer, GMB, was consulted for resolution. During the full screening stage, study information, such as the first author and publication year, the country of the study, study design, study population (e.g., children, adolescents, and adults), viral load threshold for VNS, factors and outcome measures, including odds

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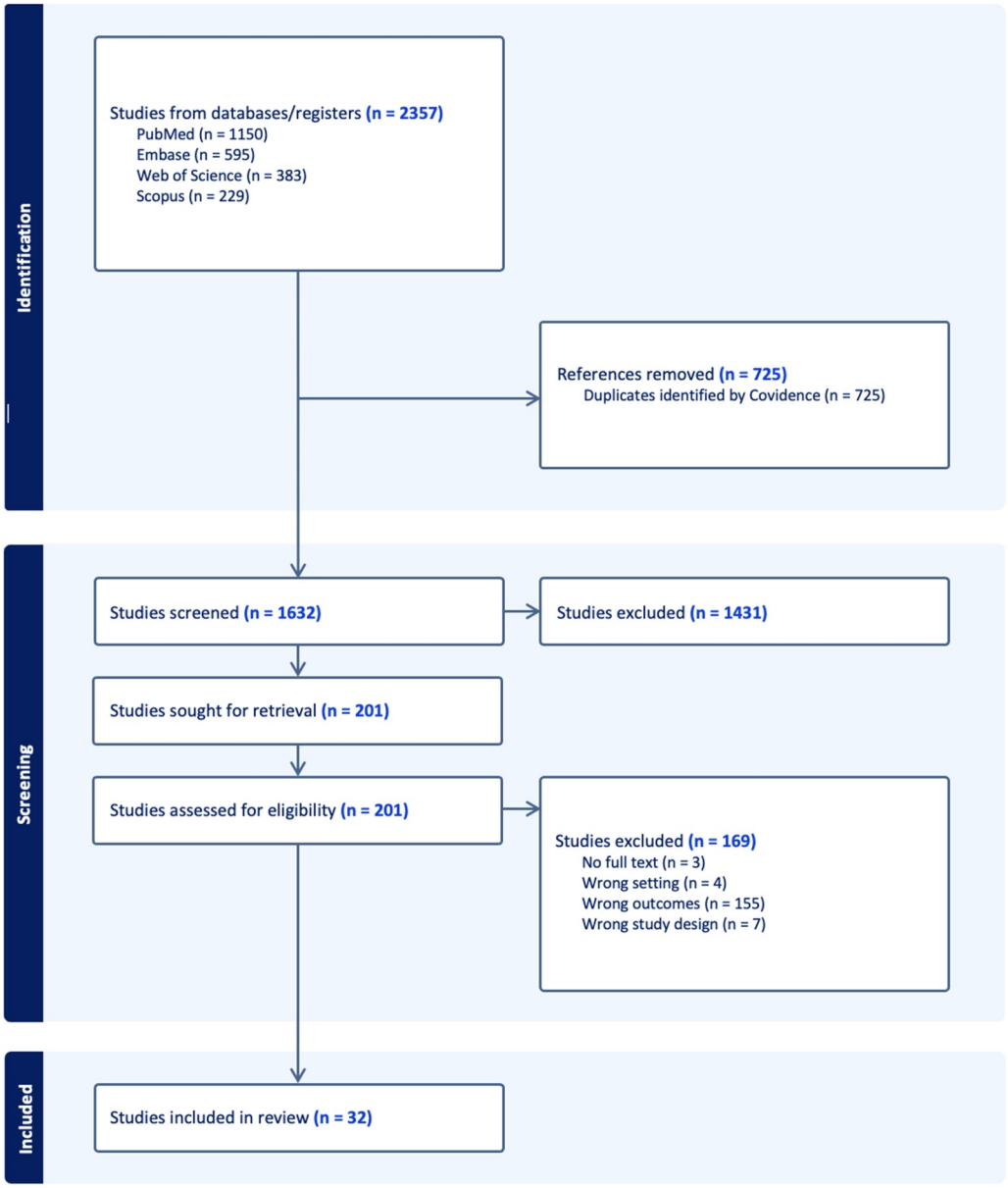


FIGURE 1 PRISMA flow chart describing the study screening process (Adapted from Covidence 2023).

ratios, relative risks, risk ratios, and prevalence ratios, were extracted from the primary articles and recorded in Excel spreadsheet 2015 (Microsoft Corporation). In this review, we focused on extracting information regarding the factors that were significantly associated with VNS at $p < 0.05$ after multi-variable analysis. The criteria for screening studies and the tool for data extraction were specifically designed by study authors.

2.4 | Assessment of study quality

2.4.1 | Publication bias

We assessed publication bias using a funnel plot.[19] In our analysis, if the funnel plot appeared skewed or funnel-shaped, with smaller studies predominantly reporting positive results positioned towards the top and larger studies distributed more evenly, it suggested the presence of potential publication bias. This asymmetry may indicate that smaller studies with positive results were more likely to be published, while studies with null or negative findings may be underrepresented or go unpublished (Supporting Information S2).

2.4.2 | Methodological quality (risk of bias)

Two authors (BJN & GGN) evaluated the methodological quality (risk of bias) of the included studies. We used the Newcastle-Ottawa Scale (NOS) tool to assess the quality of observational studies, including cross-sectional, cohort and case-control studies.[20] NOS

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was also used to assess the nested studies which were conducted as part of the clinical trials. The NOS tool considers factors such as selection of study groups, comparability between groups, and the ascertainment of the outcome of interest. The NOS quality instrument was scored by assigning a point for each answer marked with an asterisk below. A total of four points for selection, two points for comparability, and three points for outcomes comprised the potential scoring. The total score ranged from 0 to 9 (equivalent to 0%–100% of the total score), with studies scoring <50% (assigned high bias), 50%–74% (moderate bias), and ≥75% (low bias) (Supporting Information S3).

2.4.3 | Data synthesis and analysis

The narrative was written by the lead reviewer (IHM) and then checked independently by at least one other reviewer; a third reviewer adjudicated the disagreements. Furthermore, we assessed the degree of heterogeneity between the studies using the I^2 statistics where I^2 > 75% suggested greater heterogeneity.[21] We used a random effect model to estimate the pooled proportions for VNS (at a threshold of ≥1000 copies/mL) and adjusted odds ratio for factors associated with VNS (in this case we considered the threshold viral load reported by the primary study). We conducted subgroup analyses to categorise the study population into distinct groups, including children (<12 years old), adolescents (12–17 years), and adults (≥18 years). Furthermore, we conducted separate subgroup analyses specifically focusing on pregnant or postpartum women. Most of the studies encompassed overlapping age ranges, often reporting data on children and adolescents, adolescents and adults, and all age groups collectively. Given that most studies have used AOR to quantify the measure of effect, this study also adopted odds ratios to describe its findings. All statistics were performed using R software (version 4.3.2, R Core Team, 2023).

3 | RESULTS

3.1 | Characteristics of the reviewed studies

A total of 32 studies met the criteria for the final analysis, collectively involving 756,620 PLHIV that included children, adolescents, youth, adults, pregnant women, postpartum women and female sex workers. Of the included studies, 15 were cross-sectional, 10 were cohort, five were nested studies in clinical trials and two were case-control (Table 1). The majority (29/32) of the studies[10,22,23,25–43,45–47,49–52] used a viral load threshold of ≥1000 copies/mL to define VNS. Bhardwaj et al. (2023)[24] employed a viral load threshold of ≥50 copies/mL to examine factors associated with VNS among female sex workers aged 18 years and above. In contrast, Nyakato et al. (2022)[44] and Goldman et al. (2008)[29] utilised a viral load threshold of ≥400 copies/mL to Investigate factors associated with VNS among adults.

3.2 | The prevalence of viral non-suppression (≥1000 copies/mL)

This analysis found varying prevalence of VNS across different age groups. Specifically, children and adolescents exhibited the highest VNS prevalence at 27.98% (95% CI: 21.91%–34.97%, $I^2 = 94\%$, p-value <0.01). However, when the study included all age groups, the VNS prevalence was determined to be 8.61% (95% CI: 3.97%–17.68%, $I^2 = 100\%$, p-value = 0). Upon pooling the data to ascertain the overall prevalence of VNS across all study population, the pooled proportion for VNS was found to be 20.0% (95% CI: 15.43%–25.52%, $I^2 = 100\%$, p-value <0.01) Figure 2. We conducted a sensitivity analysis to determine whether the introduction of dolutegravir-based regimens in 2018 had an impact on the VNS rate. For this analysis, we included only studies published from 2019 onwards. The sensitivity analysis revealed an overall prevalence of. 21.4% (95% CI: 16.22%–27.70%, $I^2 = 100\%$, p-value <0.01) Supporting Information S4. In this regard, this finding is constrained by the fact that it pertains to studies published in 2019, although the data collection could have occurred prior to 2019.

3.3 | Factors associated with viral non-suppression

3.3.1 | Socio-demographics factors

The collective evidence from various studies[27,31,32,34,35,47,49] revealed a statistically significant association between male gender and an increased likelihood of experiencing VNS (AOR: >1, p-value <0.05) in the context of HIV. Younger age often exhibits a higher susceptibility to experiencing VNS[10,27,30,49,50] (AOR: >1, 95%, CI: <1 or >1, p-value <0.05). This heightened risk among younger individuals can stem from various factors, including lifestyle dynamics, such as social obligations or employment commitments, which may interfere with treatment adherence. Additionally, younger populations might face challenges in establishing consistent healthcare routines or managing the complexities of long-term medication regimens. Younger individuals managing HIV treatment often struggle with adherence due to factors such as lifestyle demands like education or work, social pressures, concerns about stigma and disclosure, mental health issues and limited health literacy. Several additional factors associated with increased odds of VNS included lower education levels,[30,34] being married or cohabitating status,[43] receiving care at smaller or medium-sized health facilities[49] or private clinics. Being treated at primary healthcare centers,[27] facing food insecurity,[26] lower household income,[46] residing in rural areas,[45] having a history of extensive external migration[46,50] and residence in HIV incidence hotspots[50] (Supporting Information S5).

3.3.2 | Clinical and treatment factors

Several studies[23,25,27–29,31,42,45,48] report that sub-optimal adherence, defined as falling below the 95% adherence level, is

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TABLE 1 Overall characteristics of the included studies and the methodological quality.

Author	Study country	Study design	Study population	Viral non-suppression threshold (copies/mL)	Proportion of viral non-suppression, *n* (%)	Total number of patients successful viral load tests (*N* = 756,620)	Risk of bias
Afrane 2021[22]	Ghana	Cross-sectional	Children aged 8 months to 15 years	>1000	96 (38.4)	250	Low
Alamneh 2023[23]	Ethiopia	Cross-sectional	Pregnant women	≥1000	90 (9.07)	992	Low
Bhardwaj 2023[24]	South Africa	Clinical trial (nested)	Female sex workers ≥18 years	>50	Not specified	1384	Low
Bitwale 2020[25]	Tanzania	Cross-sectional	Children and adolescents aged 1–19 years	≥1000	102 (34.0)	300	Low
Bulage 2017[10]	Uganda	Cross-sectional	All age groups from 0 years	≥1000 for plasma or ≥ 5000 for dry blood spots	10,805 (11)	100,678	Moderate
Chohan 2021[26]	Kenya	Clinical trial (nested)	Pregnant women	≥1000	57 (12.13)	470	Low
Desta 2020[27]	Ethiopia	Retrospective cross-sectional	Adolescents and adults–median age (IQR), 38 (31–45) years	>1000	5153 (26.39)	19,525	Low
Fokam 2021[28]	Cameroon	Cross-sectional	Adolescents with perinatal HIV aged 10–19 years	≥1000	Not specified	270	Low
Goldman 2008[29]	Zambia	Retrospective cohort	Adults	≥400	238 (26.0)	913	Moderate
Haas 2020[30]	Eswatini, Lesotho, Malawi, Zambia and Zimbabwe	Cross-sectional	Adults aged 15–59 years	≥1000	964 (10.49)	9200	Low
Hailu 2018[31]	Ethiopia	Retrospective cohort	Adolescents (aged 10–19) and adults (≥20 years)	≥1000	30 (11.54)	260	Low
Hakizayezu 2022[32]	Rwanda	Retrospective cross sectional	Adults ≥18 years	>1000	57 (8.95)	637	Moderate
Jackson 2022[33]	Zimbabwe and Malawi	Clinical trial (nested)	Children and adolescents, aged 6–19 years	≥1000	114 (36.42)	313	Low
Maena 2021[34]	Uganda	Retrospective cross sectional	Adolescents aged 13–19	>1000	178 (31.39)	567	Low
Makatini 2021[35]	South Africa	Retrospective cohort	Perinatally infected children aged <17 years	>1000	425 (25.62)	1659	Low
Mbe'bi Enone' 2023[36]	Cameroon	Prospective cohort	Children (0–9 years) and adolescents (10–19 years)	≥1000	228 (22.16)	1029	Moderate
Merrill 2021[37]	Zambia	Clinical trial (nested)	Adolescents and young adults, aged 15–24	≥1000	100 (36.76)	272	Low
Munyayi 2022[38]	Namibia	Retrospective cohort	Adolescents aged 10–19 years	≥1000	83 (12.0)	695	Low

(Continues)

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TABLE 1 (Continued)

Author	Study country	Study design	Study population	Viral non-suppression threshold (copies/mL)	Proportion of viral non-suppression, *n* (%)	Total number of patients successful viral load tests (*N* = 756,620)	Risk of bias
Nabukeera 2021[39]	Uganda	Retrospective cohort	Children aged 0–14 years	≥1000	69 (23.0)	300	Low
Nagata 2021[40]	Kenya	Clinical trial (nested)	Adults ≥18 years	≥1000	72 (10.06)	716	Low
Nanyeenya 2023[41]	Uganda	Retrospective cohort	All age	≥1000	1730 (9.73)	17,783	Low
Ndahimana 2016[42]	Rwanda	Retrospective cohort	Adults ≥18 years	≥1000	71 (12.26)	587	Low
Ngandu 2022[43]	South Africa	Cross-sectional	Pregnant and postpartum women	>1000	90 (14.71)	612	Low
Nyakato 2022[44]	South Africa	Retrospective cohort	Adolescents aged 15–19 years	≥400	424 (15.51)	2733	Low
Nyongesa 2022[45]	Kenya	Cross-sectional	Youths 18–24 years	≥1000	123 (32.0)	384	Low
Plymoth 2020[46]	Ethiopia	Case-control	Adolescents and adults aged ≥15 years	>1000	155 (50.49)	307	Low
Simms 2021[47]	Zimbabwe	Cross-sectional	Adolescents, aged 10–19 years	≥1000	292 (35.05)	833	Low
Sithole 2018[48]	Zimbabwe	Case control	Adolescents, aged 10–19 years	>1000	Not specified	102	Low
Tomescu 2023[49]	Nigeria	Cross-sectional	All age groups from 0 years	≥1000	35,549 (6.07)	585,632	Low
Tomita 2019[50]	South Africa	Cross-sectional	Women, aged ≥15 years	>1550	Not specified	5454	Low
Umar 2019[51]	Malawi	Cross-sectional	Youth aged 13–24 years	>1000	81 (39.0)	209	Low
van Liere 2021[52]	South Africa	Retrospective cohort	Children up to 14 years	≥1000	469 (30.18)	1554	Low

associated with viral VNS (AOR: >1, *p*-value <0.05). Lower drug concentrations in the body result from missed doses, weakening the ART medication to effectively suppress the virus. Sub-optimal adherence also heightens the risk of viral mutation, reducing the virus susceptibility to prescribed medication. Duration on ART was also associated with high odds of VNS (AOR: >1, *p*-value <0.05), especially 12 months after being on ART.[38,49,52] PLHIV with a history of or currently experiencing active tuberculosis (TB) infection demonstrated a higher likelihood of having VNS.[22,25] Additional contributing factors encompassed the WHO HIV clinical stage,[23,28,39] particularly stages III/IV, the treatment regimen specific line[10,28,34,41,43,48] and type of drugs contained in the regimen,[22,25,27,30] experiences of treatment interruptions,[32] high body mass index (BMI)[43] and the occurrence of drug-related side effects[33,39] (Supporting Information S5).

3.3.3 | Behavioural and psychological factors

The decision to not disclose one's HIV status[25,26,30,47,48] was found to be significantly linked with experiencing VNS among PLHIV who were on ART (AOR: >1, *p*-value <0.05). Commonly, PLHIV choose to hide their HIV-positive status due to the pervasive stigma that surrounds the condition. Stigmatisation can result in various forms of discrimination, including social exclusion, judgement, and even the fear of losing relationships, employment, or facing prejudice within their communities. On the other hand, stigmatisation was also reported to increase the chance of VNS.[51] Furthermore, depression, substance use, and experiences of physical or psychological abuse[37] have all been identified as factors associated with increased VNS risk. Depression can impact motivation and adherence to treatment, while substance use may lead to inconsistent medication adherence.

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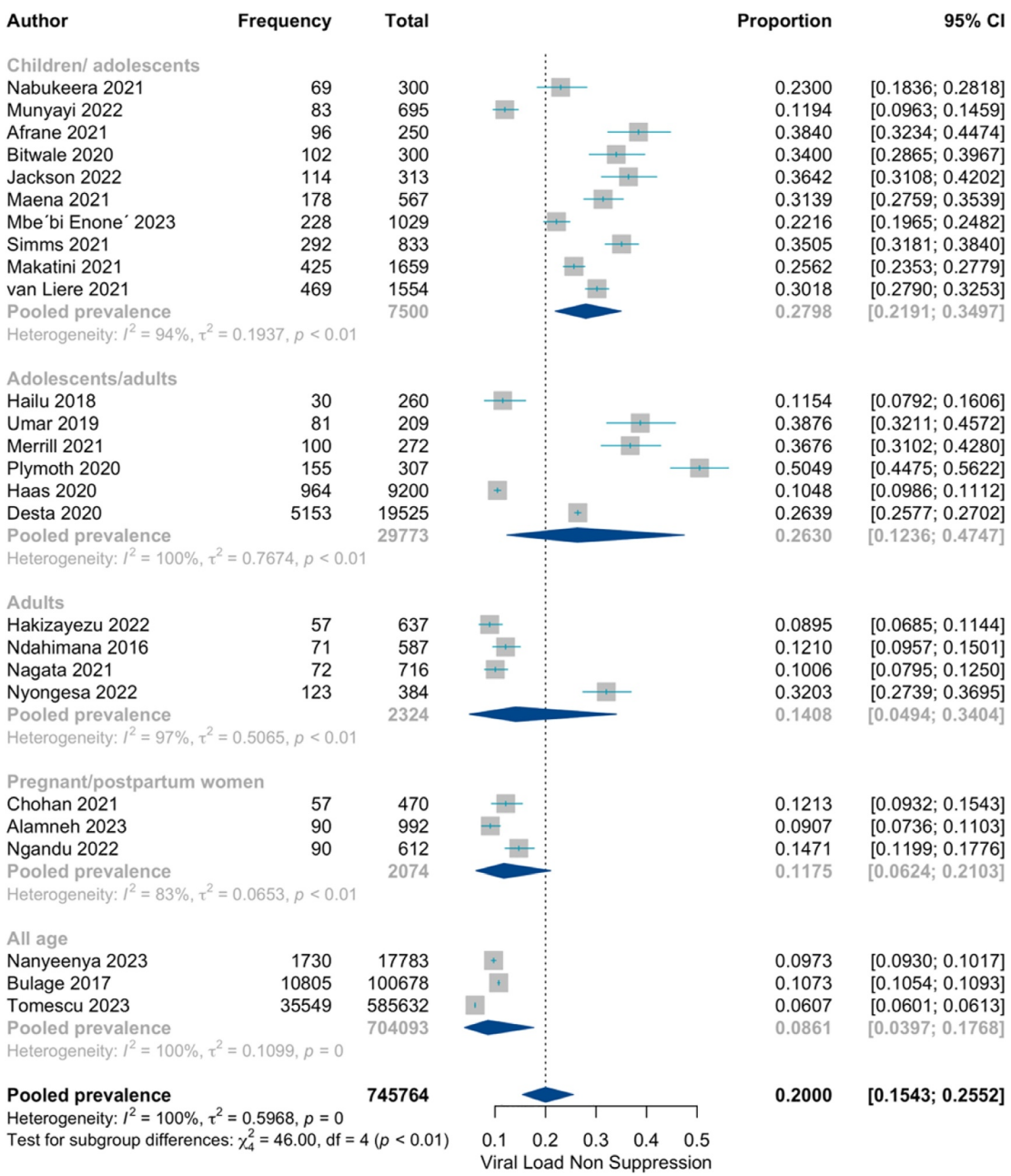


FIGURE 2 Pooled prevalence of viral non-suppression, defined as viral load ≥1000 copies/mL, across the study population.

Experiences of abuse, whether physical or psychological, can create stress and trauma that interfere with treatment adherence and overall health management. Additionally, alcohol use[48] has been linked to decreased adherence to medication regimens, potentially leadig to VNS in individuals with HIV (Supporting Information S5).

4 | DISCUSSIONS

The current study found an overall pooled VNS rate (≥1000 copies/mL) was 20.0% (95% CI: 15.43%–25.52%). Notably, children and adolescents exhibited the highest VNS rate at 27.98%. The slight discrepancies could arise due to temporal factors; the UNAIDS report covered global data for 2022, where approximately 71% (95% CI: 60%–83%) had suppressed their viral loads,[2] whereas our review synthesised data specifically from SSA countries, spanning from 2000 onwards. However, the meta-analysis included data from studies published from 2016 onwards. Furthermore, the transition of most SSA countries to Dolutegravir-based regimens from 2019[53] onwards could be a contributing factor to the lower reported VNS rates by UNAIDS.[2] Research evidence indicates that dolutegravir, an integrase strand transfer inhibitor, offers a higher genetic barrier compared to efavirenz, a non-nucleoside reverse transcriptase inhibitor.[54] Additionally, dolutegravir-based regimen are reported to

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be highly effective and tolerable as compared to efavirenz-based regimen.[14,16,55,56]

Being male was associated with increased odds of having VNS, suggesting potential gender-related disparities in VNS. The high rates of VNS among males compared to females in some contexts could be attributed to societal expectations around masculinity that often discourage men from seeking healthcare[57] or openly discussing health issues, potentially leading to delayed diagnosis or treatment initiation and adherence. Additionally, age categories exhibited significance where younger age were more likely to experience VNS. Younger individuals might face challenges related to treatment adherence due to lifestyle factors, social dynamics, or mental health issues. Additionally, older individuals might have coexisting health conditions or biological factors that could impact treatment response.[58]

The current study found that factors such as HIV status disclosure, socio-economic conditions, family and social support, and stigmatisation were significantly associated with VNS. The decision to disclose one's status[59] can impact treatment adherence and access to support networks, while socio-economic challenges like poverty and limited healthcare access can hinder consistent treatment.[15,60] Strong support systems, including family and social networks, positively influence mental health and adherence to medication, potentially aiding in achieving viral suppression. Conversely, stigmatisation surrounding HIV status remains a significant barrier, leading to isolation and reluctance to seek or adhere to treatment, ultimately affecting viral suppression rates.[61]

Various factors such as the HIV care facility, duration on ART, co-morbidities such as tuberculosis infection, advanced WHO HIV clinical stage, ART regimen, CD4+ count, BMI, history of treatment interruptions, and medication side effects had an elevated odds (greater than 1) with having VNS. A conducive care environment ensures privacy, confidentiality, and sensitivity to the unique needs of individuals, fostering trust and openness during healthcare interactions. Moreover, these facilities serve as hubs for multidisciplinary care, offering counselling, mental health support, and addressing co-existing health conditions. The quality of the care facility directly impacts an individual's experience and engagement in care, influencing treatment adherence and, consequently, viral suppression.[62]

We also found some psychological/behavioural factors such as depression/substance use, perceptions toward ART, experiences of physical/psychological abuse, alcohol use, and sexual behaviour significantly influence VNS among PLHIV. Mental health issues[63] and substance use can disrupt treatment adherence, while negative perceptions towards ART may hinder consistent medication intake, impacting viral suppression. Survivors of abuse might face trauma affecting overall health and treatment adherence, similar to excessive alcohol consumption,[64] which can impair medication adherence and health management. Moreover, sexual behaviours can influence the risk of exposure to HIV and other infections, impacting health status and treatment outcomes.

The findings from this review carry substantial implications across practice, policy, and future research in HIV care and treatment. Notably high rates (>10%) of VNS, especially among children and adolescents highlight the urgent need for tailored interventions targeting this vulnerable group. This may include specialised adherence support and educational programs. The identification of gender-related disparities, with males exhibiting increased odds of VNS, underscores the necessity for healthcare practices aimed at reducing gender-based barriers to access, addressing stigma, and promoting health-seeking behaviours among men. From a policy standpoint, continuous monitoring and evaluation of treatment outcomes, along with policies promoting confidentiality, stigma reduction, and improved access to mental health services, are crucial for enhancing HIV care delivery. Findings in this review could be limited within SSA, the conclusion might not be broadly applicable to the entire region or other populations with different socio-cultural or healthcare system characteristics. Additionally, the meta-analysis excluded studies in which information regarding viral suppression was not documented.

5 | CONCLUSIONS

The high prevalence of VNS in SSA presents a formidable challenge to achieving the third 95% target set by UNAIDS. Understanding the complex interplay of factors contributing to VNS is crucial in addressing the challenges faced by PLHIV in achieving optimal treatment outcomes. This review provides a landscape where various factors, including socio-demographic, clinical, and behavioural aspects, contribute to VNS. Recognising that no single factor acts alone in influencing treatment outcomes emphasises the need for multifaceted and tailored interventions. This entails shifting focus beyond medication adherence alone and adopting a holistic approach to address socio-economic barriers, behavioural elements, and clinical factors. Moreover, we advocate for the design and implementation of high-impact interventions to effectively tackle VNS as a complex problem. Future research should focus on longitudinal studies tracking the impact of evolving treatment regimens and socio-cultural dynamics on VNS rates. Additionally, exploring the intersectionality of factors such as age, gender, mental health, alcohol, and substance use, and their relation to the pharmacokinetics of ART, would be crucial to inform the development of targeted interventions and improve overall patient outcomes in HIV care.

AUTHOR CONTRIBUTIONS

Goodluck G. Nyondo & Idda H. Mosha participated in protocol development, study search and screening, data extraction and draughting of the manuscript. Belinda J. Njiro participated in data extraction and data analysis. Castory G. Munishi participated in data analysis. George M. Bwire participated in the design of the study, protocol review, data analysis and review of the manuscript. All authors have read and approved the final version of this manuscript.

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CONFLICT OF INTEREST STATEMENT

We declare no competing interests.

DATA AVAILABILITY STATEMENT

Data used to draw this conclusion are available from the corresponding author upon reasonable request.

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