AIDS, Publish Ahead of Print

DOI: 10.1097/QAD.0000000000003459

Prevalence and risk factors of unsuppressed viral load among pregnant and breastfeeding women in sub-Saharan Africa: analysis from population-based surveys

Short title: Viral suppression in pregnancy/breastfeeding

Leah A SCHRUBBE[1], Heidi STÖCKL[2], Abigail M HATCHER[3], Milly MARSTON[1], Salome KUCHUKHIDZE[4], Clara CALVERT[1,5]

[1]Faculty of Epidemiology and Population Health, London School of Hygiene & Tropical Medicine (LSHTM), London, UK

[2]Institute for Medical Information Processing, Biometry and Epidemiology, Ludwig-Maximilians-University, Munich, Germany

[3]Department of Health Behavior, University of North Carolina at Chapel Hill, Chapel Hill, USA

[4]Department of Epidemiology, Biostatistics, and Occupational Health, McGill University, Montreal, Canada

[5]Centre for Global Health, Usher Institute, University of Edinburgh, Edinburgh, UK

Corresponding Author: Leah Schrubbe, LSHTM, leah.schrubbe@lshtm.ac.uk

Funding: none

ABSTRACT

Objective: To examine the prevalence of viral suppression and risk factors for unsuppressed viral load among pregnant and breastfeeding women living with HIV (WLH).

Design: Pooled analysis among pregnant and breastfeeding WLH from Population-Based HIV Impact Assessment (PHIA) cross-sectional surveys from 10 sub-Saharan African countries.

Methods: Questionnaires included sociodemographic, relationship-related, and HIV-related items, while blood tests examined HIV serostatus and viral load (data collected 2015-2018).

The weighted prevalence of viral suppression was calculated. Logistic regression was used to examine risk factors for unsuppressed viral load (≥1000 copies/mL).

Results: Of 1685 pregnant or breastfeeding WLH with viral load results, 63.8% (95% CI:60.8-66.7%) were virally suppressed at the study visit. Among all included women, adolescence (aOR: 4.85, 95% CI:2.58-9.14, p<0.001) and non-disclosure of HIV status to partner (aOR: 1.48, 95% CI:1.02-2.14, p=0.04) were associated with unsuppressed viral load. Among only partnered women, adolescence (aOR: 7.95, 95% CI:3.32-19.06, p<0.001), and lack of paid employment (aOR: 0.67, 95% CI:0.47-0.94, p=0.02) were associated with unsuppressed viral load. Examining only women on ART, non-disclosure of HIV status to partner (aOR: 1.85, 95% CI:1.19-2.88, p=0.006) was associated with unsuppressed viral load.

Conclusion: Viral suppression among pregnant and breastfeeding WLH in sub-Saharan Africa remains suboptimal. Relationship dynamics around non-disclosure of HIV-positive status to partners was an important risk factor for unsuppressed viral load. Improving HIV care via sensitive discussions around partner dynamics in pregnant and breastfeeding women could improve maternal HIV outcomes and prevention of mother-to-child transmission of HIV (PMTCT).

KEYWORDS: HIV; Viral load; Sustained Virologic Response; Infectious Disease Transmission, Vertical; Maternal Health; Pregnancy; Breastfeeding

INTRODUCTION

Mother-to-child transmission (MTCT) rates of HIV range from 15-45% globally without intervention [1] but, with sustained antiretroviral therapy (ART) adherence and resulting viral load suppression, MTCT can virtually be eliminated [1–3]. Option B+, a policy providing lifelong ART for all pregnant and breastfeeding women living with HIV (WLH), was recommended by the World Health Organization (WHO) in 2013 [4]. However, despite tremendous progress in the prevention of MTCT (PMTCT) of HIV in sub-Saharan Africa, women still face challenges in ART uptake, ART adherence, and achieving viral suppression [5].

Existing estimates of ART uptake, retention in HIV care, ART adherence, and viral suppression among pregnant and postpartum women in sub-Saharan Africa are suboptimal. The Joint United Nations Programme on HIV/AIDS (UNAIDS) estimates 95% of pregnant women from Eastern and Southern Africa received ART for PMTCT, and the MTCT rate in this region was 8% in 2019 [6]. In Western and Central Africa, 58% of pregnant women received ART for PMTCT, and the MTCT rate was 20% [6]. Retention in HIV care during pregnancy and postpartum in African settings with Option B+ was 72.9% at 6 months follow-up using data from 2012-2017 [7]. A pooled meta-analysis from 1986-2011 suggests 76.1% of pregnant women in low- and middle-income countries had optimal (≥80%) ART

adherence [8]. Existing evidence on barriers to optimal ART adherence for PMTCT include sociodemographic factors such as young age and low education [9,10]. Additional barriers include relationship dynamics such as power and control, and partner non-disclosure [9–14]. Population-based estimates of prevalence and determinants of viral suppression in pregnant and breastfeeding WLH in sub-Saharan Africa after Option B+ implementation is lacking. Yet these data are critical in informing progress towards UNAIDS 2025 AIDS targets [15] and Sustainable Development Goal target 3.3 to end AIDS by 2030 [16].

The aim of this paper is to examine the prevalence of viral suppression and risk factors for unsuppressed viral load among pregnant and breastfeeding WLH using the Population-Based HIV Impact Assessment (PHIA) surveys from 10 sub-Saharan African countries.

METHODS

Survey design

The PHIA surveys are nationally representative, household-based, cross-sectional surveys designed to measure the HIV epidemic [17]. PHIA used a stratified multistage sampling design. Data collection included household interviews, individual interviews, and laboratory testing. Individual interviews included adult women and men, generally aged 15+ and young adolescents aged 10-14 years. One adult woman from each household was randomly selected to the violence module. Data collection took place between 2015-2018 in the countries included in this analysis (all available PHIA datasets in sub-Saharan African countries with the required data): Cameroon, Cote D'Ivoire, Ethiopia, Eswatini, Lesotho, Malawi, Namibia, Uganda, Zambia, and Zimbabwe. Supplementary Digital Content, Table S1, http://links.lww.com/QAD/C760 displays a breakdown of the number of women included from each country.

Trained staff collected questionnaire data including sociodemographics, relationship dynamics, and HIV care and treatment, from participants using tablets, and collected blood samples which were transported for laboratory processing. Blood testing included HIV serostatus, and for those seropositive, recency of HIV infection, HIV RNA viral load, and selected antiretroviral (ARV) drug presence. HIV-1 serostatus testing was conducted using country-specific algorithms that generally included a combination of home-based rapid HIV testing and confirmatory laboratory-based testing. Recency of HIV infection was determined by a combination algorithm of Limiting Antigen Enzyme Immunoassay (LAg-Avidity EIA), viral load, and ARV results. The LAg-Avidity EIA threshold corresponded to a mean duration since seroconversion between 130 and 153 days depending on HIV subtype. HIV viral load (HIV RNA copies/mL) was measured (assay varied by country) on plasma samples or dried blood spot (DBS) for those with insufficient plasma volume. ARV drug presence was conducted on DBS specimens using high-resolution liquid chromatography with tandem mass spectrometry. This highly specific and sensitive assay was set with a limit of detection of 0.02 μg/mL for each drug. Details of PHIA methods can be found in final reports online [18].

Study population

Pregnant and breastfeeding WLH aged 15-49 were included in this analysis. Women self-reported pregnancy and breastfeeding status. HIV-positive serostatus was based on laboratory testing.

Outcome

Based on WHO guidelines, viral load suppression was defined as <1000 copies/mL and unsuppressed viral load as ≥1000 copies/mL [19].

Exposures

Both awareness of HIV-positive status and ART status were based on a combination of self-report and ARV detection through blood testing. ART duration was based on self-reported ART start date. Self-reported optimal ART adherence was defined as no missed days in the past 30 days [14,20,21]. ART status, duration, and adherence questions were only asked of those aware of their HIV-positive status. Women who had ever tested for HIV were asked if they tested positive before pregnancy and the result of their last HIV test during pregnancy.

Paid work in the last 12 months included work for which a paycheck, cash, or goods was received as payment. An asset-based wealth index was categorized into wealth index scores and then into quintiles [22]. Healthcare power and financial power were based on questionnaire responses on who usually made decisions about their healthcare and decided how the money they received was spent; these questions were only asked of women whose self-reported marital status was currently married or living together. Partner disclosure included disclosure to a spouse or sex partner and was only asked of those aware of their HIV-positive status. A variable for region was created based on the United Nations subregions for Africa [23], with Western and Central Africa grouped together due to data sparsity. A variable for lifetime sexual violence was created by categorizing women as "yes" if they self-reported ever having experienced sexual violence or "no" if they never experienced sexual violence. Supplemental Digital Content, Table S2, http://links.lww.com/QAD/C761 presents sexual violence measures available in each country. In this sample, 533 women were not randomly selected to the violence module, seven women randomly selected to the violence module were missing data, and 1149 randomly selected women had available violence data. For the sexual violence variable, unavailable values were coded as "unknown" for regression models to avoid participants being dropped. Sexual violence was explored to examine whether the distribution of the outcome or distribution of sociodemographic variables differed between those selected and those not selected for the violence module (Supplemental Digital Content, Table S3, http://links.lww.com/QAD/C762).

Statistical analysis

The complex multistage cluster sample design was accounted for with sampling weights for blood testing. Weighting accounted for selection probability and non-response. Jackknife variance estimation was used for this pooled multi-country cross-sectional secondary analysis. Weights were denormalized accounting for differential country population size.

Missing data was explored for patterns of nonresponse. Given low levels of missing data, they were reported in descriptive analyses but cases with missing data were dropped from regression models. An unweighted number of participants and weighted proportions were calculated. The weighted prevalence of suppressed and unsuppressed viral load was calculated (among all women regardless of whether they were aware of their HIV-positive status), overall and by country.

We used a Wald chi-squared test to examine the association between region and awareness of HIV status. We used a Wald chi-squared test to evaluate the difference in the proportion of those virally suppressed between women who tested HIV-positive during pregnancy versus those who knew they were HIV-positive prior to pregnancy.

We used logistic regression for bivariate analyses to identify any crude associations between covariates of interest and unsuppressed viral load. For our primary analysis among all pregnant and breastfeeding WLH, we undertook a risk factor analysis, using multivariable logistic regression. Guided by a conceptual framework (Supplemental Digital Content, Figure S4, http://links.lww.com/QAD/C758), starting with the most distal level of risk factors (sociodemographic), variables were added to the model one at a time, starting with a priori variables, then the variable with the lowest p-value from bivariate analysis. Tested variables remaining independently associated with the outcome at $p<0.05$ from a Wald test were retained in the model. This procedure was repeated at each subsequent hierarchical level (relationship-related, then HIV-related) with adjustment for the independent risk factors from more distal levels. A priori variables included age [9,10], region, education [10], and partner disclosure [9,10,13]. Adjusted associations between risk factors and unsuppressed viral load continued in this way until all variables were examined. Due to the partner disclosure variable only applying to women aware of their HIV status, the relationship-related and HIV-related variable results in this primary model were restricted to women aware of their HIV-positive status. Region as well as pregnant versus breastfeeding status were investigated as effect modifiers of the association between the independent risk factors and unsuppressed viral load. In secondary analyses, we adopted the same approach among only partnered women in one model, and among only women on ART in another model.

In sensitivity analysis, we examined the association between ART status and unsuppressed viral load in the primary model using a self-report only measure of ART status. We also examined the primary model using a viral suppression definition of <400 copies/mL.

Statistical analyses were done using R version 4.0.2 (2020, R Foundation for Statistical Computing, Vienna, Austria).

Ethical approval

Local institutional review boards (IRB) and the IRB at the Centers for Disease Control and Prevention, Columbia University Medical Center, and Westat approved the PHIA surveys. The Research Ethics Committee at the London School of Hygiene and Tropical Medicine provided ethical approval for this secondary analysis.

RESULTS

Characteristics of study population

A total of 1689 pregnant or breastfeeding WLH (551 pregnant, 1129 breastfeeding, and nine both pregnant and breastfeeding) were included. Their mean age was 29. Most women were unemployed (n=1186, 67.4%), and lacked formal education or had only attended primary school (n=930, 62.7%). More than half of women (n=798, 62.2%) had disclosed their HIV-positive status to their partner. Participant characteristics are presented in Table 1, with breakdowns by region in Supplemental Digital Content, Table S5, http://links.lww.com/QAD/C763.

Most women were aware of their HIV-positive status prior to the survey (n=1373, 74.9%), though new diagnoses were made at the time of the survey for 316 women. The proportion of women who were aware of their HIV-positive status ranged from 52.2%-89.6% across regions ($p<0.001$). Few were recently infected (n=36, 2.9%). Of the total sample, 1299 women (69.7%) were on ART. Of women on ART, 600 (55%) had been on ART for ≥24 months, and 936 (79.4%) had optimal self-reported ART adherence.

Prevalence of viral load suppression

Among 1685 pregnant and breastfeeding women with available viral load results, the prevalence of viral suppression at the time of the study visit was 63.8% (95% CI: 60.8-66.7%). There were differences in viral suppression by country ($p<0.001$), ranging from 37.9% in Cote d'Ivoire to 88.2% in Ethiopia (Figure 1; Supplemental Digital Content, Table S6, http://links.lww.com/QAD/C764). Viral suppression prevalence also differed by region ($p<0.001$); Western/Central Africa had the lowest prevalence (40.1%), Eastern Africa's prevalence was in the middle (66.2%), and Southern Africa had the highest prevalence (76.2%).

A higher proportion of breastfeeding women were virally suppressed compared to pregnant women (66.0% vs. 59.9%; $p=0.04$). There was no evidence of a difference in the proportion of those virally suppressed between women who tested HIV-positive during pregnancy versus those who knew they were HIV-positive prior to pregnancy (79.2% vs. 83.3%; $p=0.30$).

95-95-95 targets

Among pregnant and breastfeeding WLH, 74.9% were aware of their HIV-positive status, 93.0% of those aware were on ART, and 86.9% of those on ART were virally suppressed (Supplemental Digital Content, Figure S7, http://links.lww.com/QAD/C759).

Risk factors associated with unsuppressed viral load

In crude analyses, there was evidence ($p<0.05$) of higher odds of unsuppressed viral load (≥1000 copies/mL) among women who were adolescent, lacked education, unmarried, from Western/Central Africa, lacked sole healthcare decision-making power, had not disclosed HIV to partner, were unaware of HIV-positive status prior to PHIA survey, and not on ART (Table 1).

Table 2 presents results of the primary multivariable model including all women. After adjusting for region and education, there was very strong evidence ($p<0.001$) for an association with age, with women 15-19 having 4.85 times the odds of unsuppressed viral load compared to women 35-39 (95% CI: 2.58-9.14). After adjusting for age, region, and education, there was good evidence ($p=0.04$) for an association with partner disclosure, with women who had not disclosed their HIV-positive status to their partner having 1.48 times the odds of unsuppressed viral load compared to women who had disclosed (95% CI: 1.02-2.14). After adjusting for age, region, education, and partner disclosure, there was very strong evidence ($p<0.001$) for an association with ART status, with women not on ART having 49.09 times the odds of unsuppressed viral load compared to women on ART (95% CI: 13.78-174.86). Supplemental Digital Content, Table S8, http://links.lww.com/QAD/C765 displays other variables tested that were not identified as independent risk factors.

Table 3 displays results of the multivariable model that included only partnered women. After adjusting for region, education, and employment, there was very strong evidence ($p<0.001$) for an association with age, with women 15-19 having 7.95 times the odds of unsuppressed viral load compared to women 35-39 (95% CI: 3.32-19.06). After adjusting for age, region, and education, there was good evidence ($p=0.02$) for an association with employment, with women who had not reported paid work in the past 12 months having 33% less odds of unsuppressed viral load compared to women who had worked (95% CI: 0.47-0.94). After adjusting for age, region, education, and employment, there was weak evidence ($p=0.09$) for an association with partner disclosure, with women who had not disclosed having 1.48 times the odds of unsuppressed viral load compared to women who had disclosed their HIV-positive status (95% CI: 0.94-2.35). After adjusting for age, region, education, employment, and partner disclosure, there was very strong evidence ($p<0.001$) for an association with ART status, with women not on ART having 66.79 times the odds of unsuppressed viral load compared to women on ART (95% CI: 12.08-369.11). Supplemental Digital Content, Table S9, http://links.lww.com/QAD/C766 displays other variables tested that were not identified as independent risk factors.

In secondary analysis, only including pregnant and breastfeeding WLH on ART (Table 4), after adjusting for age, region, and education, there was strong evidence (p=0.006) for an association between partner disclosure and unsuppressed viral load. Women who had not disclosed had almost 2 times the odds of unsuppressed viral load compared to women who had disclosed their HIV-positive status (aOR: 1.85, 95% CI: 1.19-2.88). Supplemental Digital Content, Table S10, http://links.lww.com/QAD/C767 displays other variables tested that were not identified as independent risk factors.

There was no evidence that region nor pregnant versus breastfeeding status were effect modifiers for any independent risk factors tested in any models.

Sensitivity analyses

Using a self-reported only measure for ART status in the primary multivariable model (Supplemental Digital Content, Table S11, http://links.lww.com/QAD/C768), the effect size was lower (aOR: 25.16, 95% CI: 11.45-55.30, p<0.001). A multivariable model using a cutoff of >400 copies/mL for unsuppressed viral load produced similar results as the primary model (Supplemental Digital Content, Table S12, http://links.lww.com/QAD/C769).

DISCUSSION

Nationally representative data pooled from ten sub-Saharan African countries showed suboptimal viral load suppression among pregnant and breastfeeding WLH (63.8%, 95% CI: 60.8-66.7%), which varied by country and region. Differences among countries and regions could be due to cultural, political, and/or policy factors or considerations such as healthcare systems or education [24]. Variations could also be influenced by differences in the proportion of those aware of their HIV-positive status - ranging from 52.2%-89.6% among regions.

Among pregnant and breastfeeding WLH, our results showed 75% were aware of their HIV-positive status, 93% of those aware were on ART, and 87% of those on ART were virally suppressed. Although the proportions of women on ART and viral suppression are approaching 95% UNAIDS targets, the proportion of women aware of their HIV-positive status is considerably below the target. This deficit, presumably from lack of access to, lack of uptake of, or incomplete HIV testing services, contributes to the poor overall viral suppression rate (63.8%). These results highlight the continued need to prioritize these populations and suggest additional interventions are needed to achieve UNAIDS targets to end AIDS [15].

Data on viral suppression (≤1000 copies/mL) among pregnant and breastfeeding women in sub-Saharan Africa are scarce, but available estimates range from 62-92.7% [5,9,25–28]. These estimates tend to be higher than in our population-based analysis, as they rely on facility-based data either at a national level [27,28] or at the clinic level [9,25–28] and some included only women aware of their HIV-positive status [9,25–27]. In a comprehensive

review including studies from 2003-2017, the viral suppression rate during pregnancy or postpartum in various sub-Saharan African settings ranged from 82-91% [5]. However, studies included were mostly clinic-based data from single cities.

Women who were younger, had not disclosed their HIV status to their partner, and were not on ART had higher odds of unsuppressed viral load in this study, which is consistent with published studies from sub-Saharan Africa which used ART adherence as the outcome. A 2014 systematic review in pregnant sub-Saharan African WLH found social determinants associated with poor ART adherence for PMTCT included young age and lack of partner disclosure [10]. A 2018 systematic review in pregnant WLH receiving ART in sub-Saharan Africa found lack of partner disclosure was a barrier to ART adherence [13]. Other factors shown to influence ART adherence and viral suppression include depression, alcohol use, low education, HIV stigma, lack of male involvement in PMTCT, fear of partner's reaction to disclosure (including violence), intimate partner violence, and few antenatal care visits [8,10,29,30].

Young women are often identified as a particularly vulnerable group. Compared to adult women, adolescent women have been shown to have lower relationship power and be at increased risk for postpartum HIV acquisition in South Africa [31]. Among adolescent women in South Africa, intimate partner violence has been shown to be associated with reduced viral suppression [32]. Tailored strategies for addressing gender inequality and ensuring access to HIV services among this age group is critical for improving adolescent women's health [33].

Non-disclosure of women's HIV-positive status may hinder ART adherence and viral suppression through lack of partner support (e.g., medication reminders, financial support for care/treatment), the consequences of hiding HIV treatment from partners (harder to take ART consistently), lack of access to care since partners may have sole or partial decision-making power in women's healthcare, or a combination of factors. Although lack of partner disclosure and lack of male involvement may be barriers to successful HIV treatment [9,10,14,34], universal male involvement in PMTCT should be considered with caution [11]. WLH often report gender power imbalances and intimate partner violence in relationships; dynamics tied to partner disclosure and the fear and/or consequences of disclosure (including violence) [12,35–37]. Qualitative research from various sub-Saharan African settings has shown in some relationships, male partners' control of pregnant and postpartum women's healthcare can limit women's engagement in PMTCT through barring access to clinics or medications [11,12].

Among only partnered women, we found unemployed women had lower odds of unsuppressed viral load. This result is contrary to findings in the literature; a systematic review and meta-analysis found employed individuals were more likely to adhere to ART than unemployed individuals [38]. However, it is possible unemployed partnered pregnant/breastfeeding women may have better HIV outcomes than employed partnered pregnant/breastfeeding women because they have more time to focus on their HIV care, they

experience less partner violence because their husbands are not threatened by their work outside the home [39], or this result may be due to chance.

The strengths of this study include the population-based design of PHIA surveys, large sample size, and inclusion of social/behavioral and clinical factors. HIV status awareness and ART status were classified based on both self-report and laboratory testing, potentially reducing the risk of social desirability bias. However, other self-reported data such as sexual violence could have been subject to social desirability bias. While pooling data from multiple countries has benefits for increasing sample size and producing regional estimates, there are limitations to interpretation. The cross-sectional nature of the data means we cannot rule out reverse causality. In addition, the violence module's question wording, answer choices, and types of violence included varied among countries. As not all violence measures were included in all countries, violence prevalence was likely underestimated, and this may have affected the results related to sexual violence. No data were collected on month of pregnancy in six out of ten countries, postpartum duration of breastfeeding in eight countries, or date of first HIV positive test result if tested positive during pregnancy in seven countries. Lastly, because all women with recent HIV diagnoses had unsuppressed viral load, recency of HIV infection could not be analyzed in logistic regression models.

Conclusions

Viral suppression rates among pregnant and breastfeeding women in sub-Saharan Africa remain suboptimal. Our results showed relationship dynamics around HIV status disclosure to partners was an important risk factor for unsuppressed viral load. To reach elimination of MTCT, further consideration of gender equality and women's empowerment programs, HIV testing services, access to PMTCT services, and viral load monitoring is needed. Our findings highlight the ongoing need to improve HIV care and treatment in pregnant and breastfeeding women for PMTCT and maternal health.

ACKNOWLEDGEMENTS

We are grateful to the organizations and entities involved with the original PHIA surveys (the Ministry of Health in each participating country, the U.S. Centers for Disease Control and Prevention (CDC), the U.S. President's Emergency Plan for AIDS Relief (PEPFAR), and ICAP at Columbia University), PHIA survey staff in each participating country, and the individuals who participated in the surveys.

Funding: None.

Authors' contributions: LS, HS, AH, and CC conceptualized the analysis and study design. LS drafted the original manuscript draft. All authors assisted with data interpretation and manuscript editing. All authors read and approved the final article.

Conflicts of interest: There are no conflicts of interest.

REFERENCES

1 World Health Organization. Global HIV Programme: Mother-to-child transmission of HIV. Available at: https://www.who.int/teams/global-hiv-hepatitis-and-stis-programmes/hiv/prevention/mother-to-child-transmission-of-hiv. [Accessed 15 March 2022].

2 Mandelbrot L, Tubiana R, Le Chenadec J, Dollfus C, Faye A, Pannier E, *et al.* **No Perinatal HIV-1 Transmission From Women With Effective Antiretroviral Therapy Starting Before Conception**. *Clinical Infectious Diseases* 2015; **61**:1715–25.

3 Myer L, Phillips TK, Mcintyre JA, Hsiao N-Y, Petro G, Zerbe A, *et al.* **HIV viraemia and mother-to-child transmission risk after antiretroviral therapy initiation in pregnancy in Cape Town, South Africa**. *HIV Med* 2017; **18**:80–88.

4 Kalua T, Tippett Barr BA, van Oosterhout JJ, Mbori-Ngacha D, Schouten EJ, Gupta S, *et al.* **Lessons learned from option B+ in the evolution toward test and start from Malawi, Cameroon, and the United Republic of Tanzania**. *J Acquir Immune Defic Syndr (1988)* 2017; **75**:S43–S50.

5 Abuogi LL, Humphrey JM, Mpody C, Yotebieng M, Murnane PM, Clouse K, *et al.* **Achieving UNAIDS 90-90-90 targets for pregnant and postpartum women in sub-Saharan Africa: progress, gaps and research needs**. *J Virus Erad* 2018; **4**:33–39.

6 UNAIDS. UNAIDS data 2020. UNAIDS; 2020.

7 Knettel BA, Cichowitz C, Ngocho JS, Knippler ET, Chumba LN, Mmbaga BT, *et al.* **Retention in HIV Care During Pregnancy and the Postpartum Period in the Option B+ Era: Systematic Review and Meta-Analysis of Studies in Africa**. *J Acquir Immune Defic Syndr (1988)* 2018; **77**:427–438.

8 Nachega JB, Uthman OA, Anderson J, Peltzer K, Wampold S, Cotton MF, *et al.* **Adherence to antiretroviral therapy during and after pregnancy in low-income, middle-income, and high-income countries: A systematic review and meta-analysis**. *AIDS* 2012; **26**:2039–2052.

9 Yotebieng M, Mpody C, Ravelomanana NLR, Tabala M, Malongo F, Kawende B, *et al.* **HIV viral suppression among pregnant and breastfeeding women in routine care in the Kinshasa province: a baseline evaluation of participants in CQI-PMTCT study**. *J Int AIDS Soc* 2019; **22**:e25376.

10 Colombini M, Stöckl H, Watts C, Zimmerman C, Agamasu E, Mayhew SH. **Factors affecting adherence to short-course ARV prophylaxis for preventing mother-to-**

child transmission of HIV in sub-Saharan Africa: a review and lessons for future elimination. *AIDS Care* 2014; **26**:914–926.

11 Hampanda KM, Mweemba O, Ahmed Y, Hatcher A, Turan JM, Darbes L, *et al.* **Support or control? Qualitative interviews with Zambian women on male partner involvement in HIV care during and after pregnancy**. *PLoS One* 2020; **15**:e0238097.

12 Hatcher AM, Stöckl H, Christofides N, Woollett N, Pallitto CC, Garcia-Moreno C, *et al.* **Mechanisms linking intimate partner violence and prevention of mother-to-child transmission of HIV: A qualitative study in South Africa**. *Soc Sci Med* 2016; **168**:130–139.

13 Omonaiye O, Kusljic S, Nicholson P, Manias E. **Medication adherence in pregnant women with human immunodeficiency virus receiving antiretroviral therapy in sub-Saharan Africa: A systematic review**. *BMC Public Health* 2018; **18**:805.

14 Adeniyi OV, Ajayi AI, Ter Goon D, Owolabi EO, Eboh A, Lambert J. **Factors affecting adherence to antiretroviral therapy among pregnant women in the Eastern Cape, South Africa**. *BMC Infect Dis* 2018; **18**:175.

15 UNAIDS. 2025 AIDS TARGETS - UNAIDS. Available at: https://aidstargets2025.unaids.org/. [Accessed 6 January 2022].

16 UNAIDS. The AIDS response in the 2030 agenda for sustainable development: joint work, shared gains | UNAIDS. Available at: https://www.unaids.org/en/AIDS_SDGs. [Accessed 6 January 2022].

17 ICAP at Columbia University. About - PHIA Project. Available at: https://phia.icap.columbia.edu/about/. [Accessed 8 April 2021].

18 ICAP at Columbia University. Resources - PHIA Project. Available at: https://phia.icap.columbia.edu/resources/. [Accessed 9 August 2022].

19 World Health Organization. Consolidated guidelines on the use of antiretroviral drugs for treating and preventing HIV infection: recommendations for a public health approach – 2nd ed. Geneva, Switzerland: World Health Organization; 2016.

20 Ayuo P, Musick B, Liu H, Braitstein P, Nyandiko W, Otieno-Nyunya B, *et al.* **Frequency and factors associated with adherence to and completion of combination antiretroviral therapy for prevention of mother to child transmission in western Kenya**. *J Int AIDS Soc* 2013; **16**. doi:10.7448/IAS.16.1.17994

21 Kesho Bora Study Group, de Vincenzi I. **Triple antiretroviral compared with zidovudine and single-dose nevirapine prophylaxis during pregnancy and breastfeeding for prevention of mother-to-child transmission of HIV-1 (Kesho Bora study): a randomised controlled trial**. *Lancet Infect Dis* 2011; **11**:171–180.

22 Rutstein SO, Johnson K. The DHS Wealth Index. Calverton, Maryland: ORC Macro; 2004.

23 WorldAtlas. Regions Of Africa - WorldAtlas. Available at: https://www.worldatlas.com/geography/regions-of-africa.html. [Accessed 8 February 2022].

24 Chipanta D, Amo-Agyei S, Giovenco D, Estill J, Keiser O. **Socioeconomic inequalities in the 90–90–90 target, among people living with HIV in 12 sub-Saharan African countries — Implications for achieving the 95–95–95 target — Analysis of population-based surveys**. *EClinicalMedicine* 2022; **53**. doi:10.1016/j.eclinm.2022.101652

25 Atanga PN, Ndetan HT, Fon PN, Meriki HD, Muffih TP, Achidi EA, *et al.* **Using a composite adherence tool to assess ART response and risk factors of poor adherence in pregnant and breastfeeding HIV-positive Cameroonian women at 6 and 12 months after initiating option B+**. *BMC Pregnancy Childbirth* 2018; **18**:418.

26 Moyo F, Haeri Mazanderani A, Murray T, Technau KG, Carmona S, Kufa T, *et al.* **Characterizing Viral Load Burden Among HIV-Infected Women Around the Time of Delivery: Findings From Four Tertiary Obstetric Units in Gauteng, South Africa**. *J Acquir Immune Defic Syndr* 2020; **83**:390–396.

27 Landes M, Lettow M van, Nkhoma E, Barr BT, Truwah Z, Shouten E, *et al.* **Low detectable postpartum viral load is associated with HIV transmission in Malawi's prevention of mother-to-child transmission programme**. *J Int AIDS Soc* 2019; **22**:e25290.

28 Woldesenbet SA, Kufa T, Barron P, Chirombo BC, Cheyip M, Ayalew K, *et al.* **Viral suppression and factors associated with failure to achieve viral suppression among pregnant women in South Africa**. *AIDS* 2020; **34**:589–597.

29 Biomndo BC, Bergmann A, Lahmann N, Atwoli L. **Intimate partner violence is a barrier to antiretroviral therapy adherence among HIV-positive women: Evidence from government facilities in Kenya**. *PLoS One* 2021; **16**:e0249813.

30 Hatcher AM, Brittain K, Phillips TK, Zerbe A, Abrams EJ, Myer L. **Longitudinal association between intimate partner violence and viral suppression during pregnancy and postpartum in South African women.** *AIDS* 2021; **35**:791–799.

31 Groves AK, Gebrekristos LT, McNaughton Reyes L, Moodley D, Maman S. **Describing relationship characteristics and postpartum HIV risk among adolescent, young adult and adult women in South Africa**. *The Journal of adolescent health* 2020; **67**:123–126.

32 Gibbs A, Reddy T, Closson K, Cawood C, Khanyile D, Hatcher A. **Intimate Partner Violence and the HIV Care and Treatment Cascade Among Adolescent Girls and Young Women in DREAMS, South Africa**. *J Acquir Immune Defic Syndr (1988)* 2022; **89**:136–142.

33 UNAIDS. Women and HIV — A spotlight on adolescent girls and young women. Geneva: ; 2019.

34 Buregyeya E, Naigino R, Mukose A, Makumbi F, Esiru G, Arinaitwe J, *et al.* **Facilitators and barriers to uptake and adherence to lifelong antiretroviral therapy among HIV infected pregnant women in Uganda: A qualitative study**. *BMC Pregnancy Childbirth* 2017; **17**:94.

35 Mulrenan C, Colombini M, Howard N, Kikuvi J, Mayhew SH. **Exploring risk of experiencing intimate partner violence after HIV infection: a qualitative study among women with HIV attending postnatal services in Swaziland**. *BMJ Open* 2015; **5**:e006907.

36 Visser MJ, Neufeld S, De Villiers A, Makin JD, Forsyth BWC. **To tell or not to tell: South African women's disclosure of HIV status during pregnancy**. *AIDS Care* 2008; **20**:1138–1145.

37 Meskele M, Khuzwayo N, Taylor M. **Mapping the evidence of intimate partner violence among women living with HIV/AIDS in sub-Saharan Africa: a scoping review**. *BMJ Open* 2021; **11**:e041326.

38 Nachega JB, Uthman OA, Peltzer K, Richardson LA, Mills EJ, Amekudzi K, *et al.* **Association between antiretroviral therapy adherence and employment status: systematic review and meta-analysis**. *Bull World Health Organ* 2015; **93**:29.

39 Stöckl H, Hassan A, Ranganathan M, M. Hatcher A. **Economic empowerment and intimate partner violence: a secondary data analysis of the cross-sectional Demographic Health Surveys in Sub-Saharan Africa**. *BMC Womens Health* 2021; **21**:1–13.

Figure 1. Prevalence of viral load suppression among pregnant and breastfeeding women living with HIV (N=1685), by country (2015-2018)

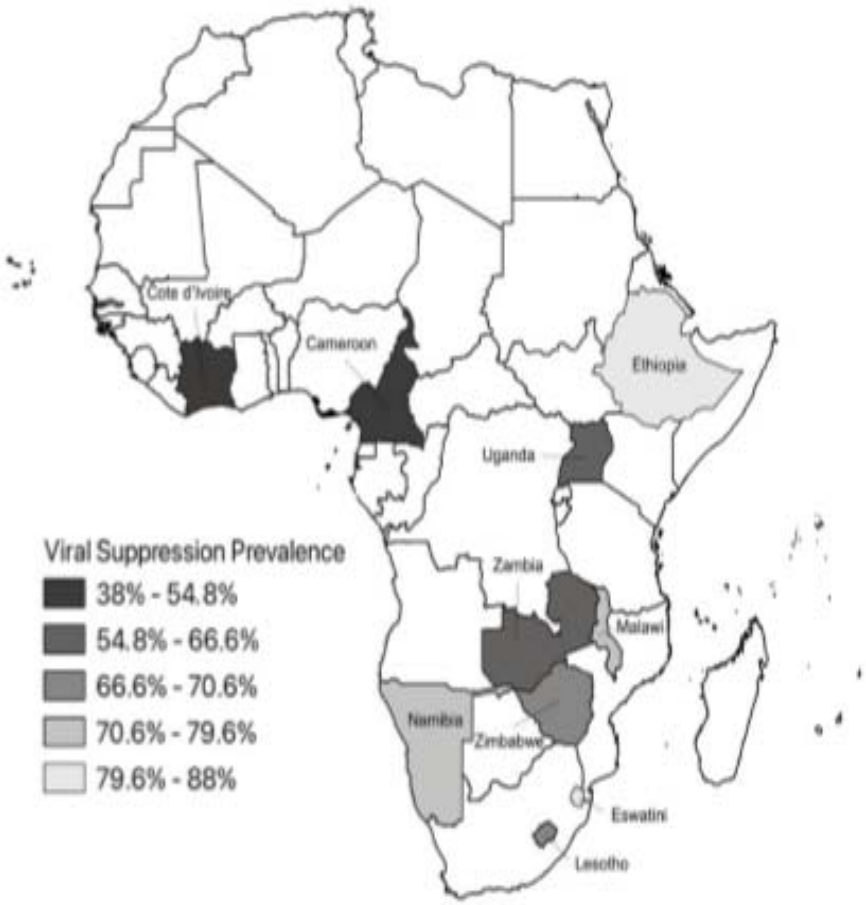

Table 1. Sample characteristics and unadjusted association of risk factors with unsuppressed viral load among pregnant and breastfeeding women living with HIV (N=1689)*

	All (n=1689) no. (%)[b]	Number with suppressed viral load (<1000 copies/mL) (n=1167) no. (%)[b]	Number with unsuppressed viral load (≥1000 copies/mL) (n=518) no. (%)[b]	Crude OR (95% CI)	P-value[a]
Sociodemographic					
Age (years)					<0.001
15-19	94 (6.9%)	43 (39.9%)	51 (60.1%)	4.55 (2.46-8.42)	
20-24	316 (18.4%)	183 (54.7%)	133 (45.3%)	2.50 (1.63-3.83)	
25-29	436 (26.8%)	293 (59.5%)	141 (40.5%)	2.05 (1.39-3.02)	
30-34	444 (26.2%)	328 (72.1%)	114 (27.9%)	1.17 (0.79-1.72)	
35-39	302 (16.8%)	242 (75.1%)	60 (24.9%)	1	
□40	97 (5.0%)	78 (70.6%)	19 (29.4%)	1.26 (0.64-2.49)	
Highest level of education attended					0.05
None	145 (12.2%)	89 (55.5%)	56 (44.5%)	1.64 (1.12-2.41)	
Primary education	785 (50.5%)	532 (64.1%)	251 (35.9%)	1.15 (0.88-1.51)	
Secondary education	661 (32.6%)	476 (67.2%)	183 (32.8%)	1	
Post-secondary education	96 (4.8%)	68 (56.4%)	28 (43.6%)	1.59 (0.87-2.91)	
Missing	2	2	0		
Paid work in last 12 months					0.2
Yes	503 (32.6%)	334 (60.9%)	168 (39.1%)	1	
No	1186 (67.4%)	833 (65.2%)	350 (34.8%)	0.83 (0.63-1.10)	
Wealth quintile					0.9
Lowest	440 (20.6%)	301 (61.6%)	138 (38.4%)	1.12 (0.74-1.69)	
Second	346 (19.9%)	242 (64.6%)	103 (35.4%)	0.99 (0.65-1.50)	
Middle	326 (21.4%)	230 (64.7%)	95 (35.3%)	0.98 (0.64-1.50)	
Fourth	338 (23.8%)	225 (63.7%)	112 (36.3%)	1.02 (0.67-1.56)	
Highest	238 (14.3%)	168 (64.2%)	70 (35.8%)	1	
Missing	1	1	0		
Marital status					0.05
Married/Living together	1179 (74.2%)	825 (65.5%)	351 (34.5%)	1	
Divorced/Separated/ Widowed	236 (17.6%)	158 (60.8%)	78 (39.2%)	1.22 (0.88-1.69)	
Never married/lived together	269 (8.2%)	180 (54.3%)	88 (45.7%)	1.60 (1.07-2.37)	
Missing	5	4	1		
Urban/Rural Residence					0.5
Urban	628 (37.2%)	427 (62.4%)	200 (37.6%)	1	
Rural	1061 (62.8%)	740 (64.6%)	318 (35.4%)	0.91 (0.70-1.18)	
Region					<0.001

Southern Africa	558 (7.3%)	429 (76.2%)	129 (23.8%)	1	
Western/Central Africa	110 (12.1%)	41 (40.1%)	69 (59.9%)	4.78 (3.18-7.19)	
Eastern Africa	1021 (80.6%)	697 (66.2%)	320 (33.8%)	1.63 (1.25-2.13)	
Relationship-related					
Healthcare power[c]					<0.001
Self	392 (33.6%)	273 (66.4%)	117 (33.6%)	1	
Spouse/partner or someone else	243 (24.2%)	149 (53.2%)	94 (46.8%)	1.74 (1.23-2.48)	
Both self and spouse/partner	541 (42.1%)	402 (72.4%)	138 (27.6%)	0.76 (0.53-1.09)	
N/A, not currently married/living together or Missing[d]	513	343	169		
Financial power[c]					0.3
Self	236 (20.9%)	165 (63.4%)	71 (36.6%)	1	
Spouse/partner or someone else	298 (30.1%)	190 (62.5%)	108 (37.5%)	1.04 (0.69-1.56)	
Both self and spouse/partner	643 (49.0%)	470 (68.6%)	170 (31.4%)	0.79 (0.54-1.17)	
N/A, not currently married/living together or Missing[d]	512	342	169		
Disclosed HIV+ status to partner					0.005
Yes	798 (62.2%)	677 (84.1%)	120 (15.9%)	1	
No	496 (37.8%)	382 (76.2%)	113 (23.8%)	1.65 (1.16-2.35)	
N/A, unaware of HIV+ status/Missing[d]	395	108	285		
Lifetime sexual violence					0.2
Yes	133 (7.0%)	97 (71.5%)	36 (28.5%)	0.73 (0.46-1.16)	
No	1016 (56.4%)	706 (64.7%)	307 (35.3%)	1	
Unknown (Not selected for violence module/Missing[d])	540 (36.6%)	364 (60.9%)	175 (39.1%)	1.17 (0.90-1.54)	
HIV-related					
Felt needed to hide HIV+ status at healthcare facility in past 12 months					0.5
Yes	162 (14.5%)	136 (83.3%)	26 (16.7%)	0.85 (0.52-1.40)	
No	1121 (85.5%)	914 (81.0%)	205 (19.0%)	1	
N/A, unaware of HIV+ status/Missing[d]	406	117	287		
Aware of HIV+ status[e]					<0.001
Yes	1373 (74.9%)	1132 (81.6%)	241 (18.4%)	1	
No	311 (25.1%)	33 (10.0%)	276 (90.0%)	39.88 (26.01-61.15)	
Missing	5	2	1		
Recency of HIV infection[f]					-
Recent	36 (2.9%)	0 (0.0%)	36 (100%)	-	
Long-term	1653 (97.1%)	1167 (65.7%)	482 (34.3%)	-	

On ART[e]					<0.001
Yes	1299 (69.7%)	1125 (86.9%)	174 (13.1%)	1	
No[g]	385 (30.3%)	40 (10.3%)	343 (89.7%)	57.84 (37.74-88.63)	
Missing	5	2	1		
ART duration					0.9
<12 months	315 (26.8%)	260 (85.4%)	55 (14.6%)	1.10 (0.69-1.77)	
12-23 months	225 (18.1%)	199 (87.4%)	26 (12.6%)	0.93 (0.51-1.70)	
≥24 months	600 (55.0%)	521 (86.6%)	77 (13.4%)	1	
Not on ART[g]/Missing[d]	549	187	360		
ART adherence (in past month)					0.1
No missed days	936 (79.4%)	817 (87.4%)	118 (12.6%)	1	
Missed days	231 (20.6%)	189 (82.7%)	41 (17.3%)	1.46 (0.90-2.36)	
Not on ART[g]/Missing[d]	522	161	359		

ART=antiretroviral therapy. CI=confidence interval. HIV=human immunodeficiency virus. OR=odds ratio.

*Unweighted number of participants and weighted percentages and p-values are reported. Percentages might not total 100% due to rounding.

[a]Wald test p-value

[b]Missing values and not applicable values not included in %. Viral load unavailable in n=4 participants.

[c]Question only asked of those with marital status of currently married or living together

[d]Missing data in these variables is <10% of total

[e]Includes self-report and ARV detection through blood testing

[f]Unable to use in regression analyses due to 0 observations in the recent infection and virally suppressed category

[g]Includes those unaware of HIV+ status

Table 2. Adjusted association of risk factors with unsuppressed viral load among pregnant and breastfeeding women living with HIV (N=1685)*

	Crude OR (95% CI)	P-value[a]	aOR (95% CI)	P-value[a]
Sociodemographic				
Age (years)		<0.001		<0.001
15-19	4.55 (2.46-8.42)		4.85 (2.58-9.14)	
20-24	2.50 (1.63-3.83)		2.71 (1.75-4.19)	
25-29	2.05 (1.39-3.02)		2.02 (1.36-3.00)	
30-34	1.17 (0.79-1.72)		1.18 (0.79-1.77)	
35-39	1		1	
□40	1.26 (0.64-2.49)		1.14 (0.58-2.22)	
Region		<0.001		<0.001
Southern Africa	1		1	
Western/Central Africa	4.78 (3.18-7.19)		4.78 (3.04-7.53)	
Eastern Africa	1.63 (1.25-2.13)		1.60 (1.21-2.12)	
Highest level of education attended		0.05		0.8
None	1.64 (1.12-2.41)		1.17 (0.72-1.91)	
Primary education	1.15 (0.88-1.51)		1.06 (0.80-1.41)	
Secondary education	1		1	
Post-secondary education	1.59 (0.87-2.91)		1.30 (0.69-2.47)	
Relationship-related				
Disclosed HIV+ status to partner		0.005		0.04
Yes	1		1	
No	1.65 (1.16-2.35)		1.48 (1.02-2.14)	
HIV-related				
On ART[b]		<0.001		<0.001
Yes	1		1	
No	50.44 (16.10-157.99)		49.09 (13.78-174.86)	

ART=antiretroviral therapy. aOR=adjusted odds ratio. CI=confidence interval. HIV=human immunodeficiency virus.

*Final model of all variables in the table together included n=1289 participants. Each variable was adjusted for all other shown covariates in the hierarchal level (sociodemographic, relationship-related, HIV-related) and level(s) prior. Due to the partner disclosure variable only applying to women aware of their HIV status, the relationship-related and HIV-related variable results shown are restricted to women aware of their HIV+ status. Age, region, education, and partner disclosure were included a priori.

[a]Wald test p-value

[b]Includes self-report and ARV detection through blood testing

Table 3. Adjusted association of risk factors with unsuppressed viral load among pregnant and breastfeeding partnered women living with HIV (N=1176)*

	Crude OR (95% CI)	P-value[a]	aOR (95% CI)	P-value[a]
Sociodemographic				
Age (years)		<0.001		<0.001
15-19	6.92 (2.94-16.28)		7.95 (3.32-19.06)	
20-24	2.29 (1.39-3.78)		2.84 (1.69-4.75)	
25-29	1.89 (1.22-2.92)		2.01 (1.28-3.15)	
30-34	1.05 (0.67-1.65)		1.17 (0.73-1.88)	
35-39	1		1	
□40	0.90 (0.39-2.07)		0.93 (0.37-2.33)	
Region		<0.001		<0.001
Southern Africa	1		1	
Western/Central Africa	4.40 (2.67-7.26)		3.79 (2.15-6.68)	
Eastern Africa	1.73 (1.22-2.46)		1.59 (1.11-2.29)	
Highest level of education attended		0.05		0.7
None	1.79 (1.17-2.73)		1.34 (0.79-2.29)	
Primary education	1.11 (0.80-1.54)		1.04 (0.74-1.47)	
Secondary education	1		1	
Post-secondary education	1.35 (0.66-2.73)		1.17 (0.54-2.55)	
Paid work in last 12 months		0.04		0.02
Yes	1		1	
No	0.71 (0.51-0.98)		0.67 (0.47-0.94)	
Relationship-related				
Disclosed HIV+ status to partner		0.02		0.09
Yes	1		1	
No	1.65 (1.10-2.49)		1.48 (0.94-2.35)	
HIV-related				
On ART[b]		<0.001		<0.001
Yes	1		1	
No	70.21 (14.39-342.43)		66.79 (12.08-369.11)	

ART=antiretroviral therapy. aOR=adjusted odds ratio. CI=confidence interval. HIV=human immunodeficiency virus.

*This model is only in women with a self-reported marital status of currently married or living together. Among partnered women, viral load unavailable in n=3 participants. Final model of all variables in the table together included n=889 participants. Each variable was adjusted for all other shown covariates in the hierarchal level (sociodemographic, relationship-related, HIV-related) and level(s) prior. Due to the partner disclosure variable only applying to women aware of their HIV status, the relationship-related and HIV-related variable results shown are restricted to women aware of their HIV+ status. Age, region, education, and partner disclosure were included a priori.

[a]Wald test p-value

[b]Includes self-report and ARV detection through blood testing

Table 4. Adjusted association of risk factors with unsuppressed viral load among HIV+ pregnant and breastfeeding women on ART (N=1299)*

	Crude OR (95% CI)	P-value[a]	aOR (95% CI)	P-value[a]
Sociodemographic				
Age (years)		0.6		0.6
15-19	1.90 (0.70-5.15)		1.92 (0.71-5.21)	
20-24	1.59 (0.82-3.10)		1.61 (0.83-3.12)	
25-29	1.29 (0.69-2.40)		1.23 (0.66-2.29)	
30-34	1.03 (0.57-1.87)		0.98 (0.54-1.77)	
35-39	1		1	
□40	1.47 (0.52-4.18)		1.36 (0.49-3.76)	
Region		0.1		0.08
Southern Africa	1		1	
Western/Central Africa	1.77 (0.96-3.26)		1.94 (1.01-3.73)	
Eastern Africa	0.92 (0.63-1.35)		0.95 (0.64-1.41)	
Highest level of education attended		0.4		0.3
None	0.90 (0.40-2.03)		0.78 (0.32-1.90)	
Primary education	1.25 (0.81-1.91)		1.24 (0.79-1.93)	
Secondary education	1		1	
Post-secondary education	1.98 (0.83-4.70)		1.76 (0.75-4.13)	
Relationship-related				
Disclosed HIV+ status to partner		0.001		0.006
Yes	1		1	
No	1.98 (1.30-3.00)		1.85 (1.19-2.88)	

ART=antiretroviral therapy. aOR=adjusted odds ratio. CI=confidence interval. HIV=human immunodeficiency virus.

*Each variable was adjusted for all other shown covariates in the hierarchal level (sociodemographic, relationship-related) and level(s) prior. Final model included n=1216 participants. Age, region, education, and partner disclosure were included a priori.

[a]Wald test p-value