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Factors Associated With Peripartum Virologic Suppression in Eastern Cape Province, South Africa: A Retrospective Cross-Sectional Analysis

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Background. This study describes the characteristics of pregnant women on antiretroviral therapy (ART) and the rate of peripartum virologic suppression in a large prevention of mother-to-child transmission cohort who delivered in some selected maternity centers in Eastern Cape Province, South Africa. In addition, the study examines the factors associated with virologic suppression in the cohort.

Methods. This multicenter, retrospective cross-sectional analysis included medical data of 1709 women with human immunodeficiency virus between September 2015 and May 2016 in Eastern Cape Province. The main outcome measure was the rate of peripartum virologic suppression, defined as viral load (VL) <1000 copies/mL and undetectable viremia (VL <20 copies/mL). Correlates of peripartum virologic suppression and undetectable viremia were examined by fitting logistic regression model analysis.

Results. Of 1463 women with available VL results, the overall rate of peripartum suppression was 82%, and undetectable viremia was 56.9%. Being aged 24 years or younger (adjusted odds ratio [AOR], 0.68 [95% confidence interval {CI}, .48–.94]), smoking during pregnancy (AOR, 0.50 [95% CI, .28–.90]), and starting ART in the first trimester were associated with lower odds of viral suppression (<1000 copies/mL). Women who had never defaulted ART had an increased odds of having an undetectable VL (AOR, 3.09 [95% CI, 2.12–4.49]) and virologic suppression (AOR, 3.88 [95% CI, 2.62–5.74]) compared to those who defaulted.

Conclusions. More than half of the women achieved undetectable VL, and 4 in 5 women achieved viral suppression at delivery in the region. Early antenatal booking, combined with enhanced adherence support for pregnant women on ART, would be crucial toward achieving the goal of elimination of mother-to-child transmission in the region.

Keywords. antiretroviral therapy; HIV; in utero transmission; mother-to-child transmission; South Africa.

South Africa has the largest human immunodeficiency virus (HIV) epidemic worldwide (7.7 million people living with HIV, including 260 000 children) [1]. The country has the largest treatment program globally, accounting for 20% of individuals receiving ART worldwide, and with 80% of the AIDS response funded by the government [1]. Also, the country has recorded significant successes in the key indicators of the elimination of mother-to-child transmission (EMTCT) [2]. More than 95% of pregnant women are accessing antenatal care services, including HIV testing [3, 4]. About 93% of HIV-infected pregnant women received ART, and 6-week infant diagnosis declined from 25%–30% in 2001 to 2.6% in 2014 [3, 4]. All HIV-infected pregnant women accessing antenatal clinics are initiated on ART regimens [5].

Despite the successes, there were 14 000 new pediatric infections in South Africa in 2018 [1]. In addition, the high prevalence of HIV infections of 25.8% among reproductive-age women (15–49 years) [1] and 30.7% among women who attended antenatal care in 2017 [6] suggest that the battle toward EMTCT is not over. As such, women at risk of nonsuppression of viral load (VL) during pregnancy and delivery while on ART should be identified for appropriate management at antenatal clinics. With the introduction of dolutegravir into the new prevention of mother-to-child transmission (PMTCT) guideline in 2019, which can be initiated in pregnant women after 7 weeks [7], a further reduction in pediatric HIV infections can be anticipated.

Local studies on PMTCT outcomes tend to evaluate the rate of MTCT of HIV [8–11] as the main indicator of the

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effectiveness of the program without assessing maternal viremia during delivery. Also, some of these studies are single-facility data with small samples [8, 10] and can rarely influence programmatic reengineering. In addition, Myer et al [8] provided interventions (adherence support) for the participants in their study in the Western Cape, a resource-rich province with the lowest HIV prevalence in the country. Therefore, the high level of peripartum virologic suppression reported in the study [9] is not generalizable to the entire country, suggesting a need for studies in resource-constrained settings of the country.

We addressed this gap by starting the East London Prospective Cohort Study [12], a longitudinal observational study involving 3 large maternity services serving a combined population of 1 674 637 people in the Amathole/Buffalo City districts of the Eastern Cape Province [13]. Amathole district has the highest intrauterine infection rate (346 HIV polymerase chain reaction–positive infants per 100 000 live births) in the country in 2016 [11]. Given the overwhelming evidence supporting viral suppression with ART as an effective strategy to significantly reduce mother-to-child transmission (MTCT) [14–20], this observational study examined the rate and factors associated with undetectable viremia and virologic suppression at delivery (peripartum) in women enrolled in the East London Prospective Cohort Study. This study also identified high-risk subpopulation of pregnant women with high VL who could be targeted for intensified interventions.

METHODS

Ethical Considerations

The Walter Sisulu University Ethics Committee approved the study protocol (reference number 098/2014). The Eastern Cape Department of Health and the clinical governance of each hospital gave permission for the implementation of the study. Each participant gave written informed consent for her voluntary participation in the study. Legal guardians completed consent forms for a few participants who were below the age of 16 years, who also gave their assent to be recruited into the study. Participants' privacy and confidentiality of medical information were protected during and after the study. The entire process followed the Helsinki Declaration and local institutional policies on human research.

Study Design and Settings

Drawing from the PMTCT data of women enrolled in the East London Prospective Cohort Study, the detailed methodology of the cohort study has been published elsewhere [12]. In brief, this is a longitudinal cohort of HIV-infected pregnant women who delivered in 3 of the largest maternity centers in the Amathole/Buffalo City districts of Eastern Cape Province between September 2015 and May 2016.

Routine ART Care for Pregnant Women With HIV

The national PMTCT guideline recommended a lifelong ART regimen for all HIV-infected pregnant and lactating women (Option B+), VL monitoring every 3 months till delivery, and infant testing at birth [5]. This guideline had been implemented across the region at the time of this study. As such, the findings of this study reflect the effectiveness of the implementation of this guideline in the region.

Participants and Procedures

A total of 1709 women were enrolled in the East London Prospective Cohort study [12]. Participants were recruited consecutively within 24 hours of vaginal delivery and 72 hours of cesarean delivery at the postnatal wards into the study database. Trained research assistants completed the interviewer-administered questionnaire (designed purposely for this study), which was captured and archived into the pediatric ART data management tool hosted on the Eastern Cape Department of Health server. All HIV-infected pregnant women who delivered in the study sites during the period were enrolled without any dissent.

Peripartum Viral Load Monitoring

The research nurses assigned to each study sites drew about 5 mL of venous blood from each parturient woman for VL. All VL assays were conducted by the National Health Laboratory Services according to standard protocols.

Main Outcome Measure

Peripartum virological suppression was defined as VL <1000 copies/mL and further categorized as undetectable (VL <20 copies/mL) and low-level viremia (VL 20–999 copies/mL), whereas high VL was defined as VL ≥1000 copies/mL. All parturient women with high VL results were treated as emergencies in accordance with the PMTCT guideline [5].

Covariates

Demographic, clinical, and lifestyle behavioral covariates were included in the study. Age, employment status, place of residence, marital status, parity, and level of education were the demographic covariates included, all self-reported by respondents. Age was measured as a continuous variable but recategorized for multivariable analysis. Respondents were grouped into employed and unemployed.

Lifestyle behavior covariates included cigarette smoking and alcohol use during the index pregnancy. Respondents self-reported their use of alcohol and tobacco smoking during pregnancy.

Clinical data, such as awareness of HIV serostatus at booking, gestational age at booking (categorized per trimester), duration on ART, and disclosure to partners, were obtained from interviews. Adherence to ART was measured by self-report, on-time

pharmacy refill, and history of default of ART, which was confirmed from the medical records. Details on adherence during the index pregnancy have been published elsewhere [21]. However, the history of default of ART showed internal consistency in predicting virologic suppression in this study.

Data Analysis

Data of HIV-infected women were analyzed using IBM SPSS version 24.0 software (IBM SPSS, Chicago, Illinois). The analysis was performed on all participants with VL results (n = 1463 [85.6%]). Descriptive statistics such as mean (standard deviation [SD]) and proportion were used to describe maternal sociodemographic characteristics and rates of peripartum viral suppression and undetectable VL. Peripartum virologic response to ART was categorized as suppressed (<1000 copies/mL), which is divided into undetectable VL (<20 copies/mL), low viremia (20–999 copies/mL), and high VL (≥1000 copies/mL). These were compared with maternal demographics, lifestyle, and clinical characteristics using the Pearson χ^2 test and Fisher exact test for bivariate analysis. We fitted the adjusted and unadjusted multinomial logistic regression models to identify the risk factors for undetectable VL and virologic suppression. In the unadjusted model (the baseline model), we examine the effect of each demographic, lifestyle behaviors, and clinical characteristics on undetectable VL and virologic suppression relative to high VL/probable virological failure. The adjusted multinomial regression model was used to examine the net effects of each variable while controlling for important covariates. All reported *P* values were based on a 2-sided test.

Sensitivity Analysis

Sensitivity analysis was performed by comparing the demographic characteristics of respondents with VL results (n = 1463 [85.6%]), and those without VL results (n = 262 [14.4%]) to assess the potential effect of missing data on our results. There was no statistically significant difference in the sociodemographic (age, marital status, place of residence, employment status, and smoking status) and clinical characteristics (awareness of HIV status at booking, disclosure to partner, and default of ART) of women with or without VL, suggesting that our results would not be significantly different had all respondents' VL results been included in our analysis. Also, some respondents did not report adherence to ART information; as such, we fitted logistic regression models by including and removing respondents without VL results. The missing data did not change our findings.

RESULTS

Baseline Characteristics of Participants

The ages of the participants ranged from 14 to 44 years with a mean of 29.6 (SD, 6.2) years. We compared the demographic characteristics of participants with peripartum VL results (n = 1463) and those without peripartum VL results (n = 246). A higher proportion of those with VL results attained grade 7–12 education in comparison to those without VL results (87.2% vs 82.5%, respectively). Similarly, a higher proportion of those with VL results reported quitting alcohol use during pregnancy in comparison to those without VL results (27.0% vs 14.6%, respectively). In addition, fewer women with VL results confirmed having defaulted ART in comparison to those without VL results (10.5% vs 17.1%, respectively). All other parameters showed no significant difference ($P > .05$). Among those with VL results (n = 1463), high proportions of the women were 25 years or older (77%), single (68.6%), had attained grade 7–12 education (87.2%), were unemployed (74.2%), had never smoked cigarettes (89.4%) nor consumed alcoholic beverages (59.2%), had 2 or more children (69.2%), and booked in the second trimester (72.5%) (Table 1).

HIV Serostatus Awareness at Booking, Timing, and Type of ART Regimen

The majority of the participants were aware of their HIV-positive serostatus at booking (80.8%); 79 women reported negative serostatus preconception, and 202 women never had an HIV test done prior to booking. The last 2 categories tested positive at booking and were initiated on ART on the same day.

Preconception ART occurred in 58.1% (n = 850) of the participants. Of those who initiated ART during the index pregnancy (n = 613), the majority began in the second trimester (n = 430), whereas 77 women were initiated in the third trimester. Most participants had >13 weeks on ART prior to delivery (85.5%; Table 1). The median duration since patients were diagnosed with HIV was 2 (range, 1999–2016) years.

Of the total participants (N = 1709), a large majority were using a first-line regimen (94.1%); second-line regimens (2.1%), and a few participants' ART regimens were not documented (9.7%). More than 80% of the women were using tenofovir-emtricitabine-efavirenz at the time of delivery (n = 1437), and the tenofovir-based regimen was used by 86.2% of participants (Table 2).

Peripartum Virologic Suppression Rate and Its Correlates

Of the participants with available VL results (n = 1463), the virological suppression rate was 82% (n = 1200). Undetectable VL occurred in 56.9% (n = 832) and low viremia in 25.2% (n = 369). High VL occurred in 17.9% of the mothers (n = 262).

In the Pearson χ^2 test (Table 3), age, marital status, employment status, smoking status and alcohol use during pregnancy, trimester of booking, preconception awareness of HIV serostatus, duration on ART, disclosure to partners, defaulted ART, and peripartum CD4 count were significantly associated with peripartum virologic response ($P < .05$).

To identify the factors associated with undetectable VL (<20 copies/mL), we fitted (unadjusted and adjusted) logistic

Table 1. Demographic Characteristics of the Participants (With and Without Viral Load)

Variables	Viral Load Data (n = 1463)	Missing Data on Viral Load (n = 246)	*P* Value
Age, y			
≤19	55 (3.8)	5 (2.1)	.571
20–24	280 (19.2)	51 (21.2)	
25–29	392 (26.8)	67 (27.8)	
30–34	383 (26.2)	69 (28.6)	
35–39	265 (18.2)	38 (15.8)	
≥40	85 (5.8)	11 (4.6)	
Marital status			
Married	274 (18.7)	38 (15.4)	.166
Single	1003 (68.6)	184 (74.8)	
Cohabiting	163 (11.1)	23 (9.3)	
Divorced/separated	23 (1.6)	1 (0.4)	
Area of residence			
Rural	492 (33.6)	93 (37.8)	.326
Semiurban	680 (46.5)	112 (45.5)	
Urban	291 (19.9)	41 (16.7)	
Level of education			
No formal education	4 (0.3)	1 (0.4)	<.001
Grade 1–6	83 (5.7)	32 (13.0)	
Grade 7–12	1276 (87.2)	203 (82.5)	
Tertiary education	100 (6.8)	10 (4.1)	
Employment status			
Unemployed	1085 (74.2)	192 (78.0)	.111
Employed	378 (25.8)	54 (22.0)	
Smoking status			
Smoked during pregnancy	81 (5.5)	19 (7.7)	.090
Quit smoking during pregnancy	74 (5.1)	6 (2.4)	
Never smoked	1308 (89.4)	221 (89.8)	
Alcohol use			
Drank during pregnancy	202 (13.8)	33 (13.4)	<.001
Stopped drinking during pregnancy	395 (27.0)	36 (14.6)	
Never drank	866 (59.2)	177 (72.0)	
Parity			
1	450 (30.8)	71 (28.9)	.821
2	520 (35.5)	95 (38.6)	
3	301 (20.6)	48 (19.5)	
≥4	192 (13.1)	32 (13.0)	
Gestational age at booking			
First trimester	176 (12.0)	34 (13.8)	.393
Second trimester	1061 (72.5)	168 (68.3)	
Third trimester	226 (15.4)	44 (17.9)	
Disclosed status to partner			
Yes	1089 (25.1)	66 (28.7)	.141
No	365 (74.9)	164 (71.3)	
Preconception HIV status at booking			
Positive	1182 (80.8)	201 (81.7)	.737
Negative	79 (5.4)	15 (6.1)	
Unknown	202 (13.8)	30 (12.2)	
Duration of ART			
Preconception ART (>40 wk)	850 (58.1)	148 (60.2)	.098
27–40 wk	86 (5.9)	17 (6.9)	
13–26 wk	430 (29.4)	57 (23.2)	
<13 wk	97 (6.6)	24 (9.8)	

Data are presented as no. (%) unless otherwise indicated.

Abbreviations: ART, antiretroviral therapy; HIV, human immunodeficiency virus.

Table 2. Current Antiretroviral Therapy at Time of Delivery

ART Type	Frequency	(%)
TDF/FTC/EFV	1437	(84.1)
TDF/3TC/NVP	13	(0.8)
TDF/3TC/LPV/RIT	17	(1.0)
TDF/3TC/ATZ/RIT	6	(0.4)
ZDV/3TC/NVP	7	(0.4)
ZDV/3TC/EFV	13	(0.8)
ZDV/3TC/LPV/RIT	6	(0.4)
ZDV/3TC/ATZ/RIT	2	(0.1)
ABC/3TC/EFV	7	(0.4)
ABC/3TC/NVP	1	(0.1)
ABC/3TC/LPV/RIT	1	(0.1)
ABC/3TC/ZDV/RIT	2	(0.1)
d4T/3TC/EFV	23	(1.3)
d4T/3TC/NVP	7	(0.4)
d4T/3TC/LPV/RIT	1	(0.1)
Not stated	166	(9.7)

Abbreviations: 3TC, lamivudine; ABC, abacavir; ART, antiretroviral therapy; ATZ, atazanavir; d4T, stavudine; EFV, efavirenz; FTC, emtricitabine; LPV, lopinavir; NVP, nevirapine; RIT, ritonavir; TDF, tenofovir disoproxil fumarate; ZDV, zidovudine.

regression models (Table 4). The inclusion of variables in the models was based on previous studies [8, 14–16]. In the unadjusted model, younger age, unemployment, cigarette and alcohol use during pregnancy, and shorter duration on ART were significantly associated with increased odds of detectable VL, whereas complete adherence to ART was associated with higher odds of undetectable VL. However, in the adjusted logistic regression, only being unemployed, a history of defaulting ART, and shorter duration on ART reached a statistically significant threshold. Being unemployed was significantly associated with a higher likelihood of having a detectable VL. Women who reported having never defaulted in using ART were 3 times more likely have an undetectable VL than those who had defaulted. Those who had been on ART for shorter durations were 51% more likely to have a detectable VL compared with those who had been on ART for longer durations.

Similarly, younger age, being unemployed, smoking during pregnancy, alcohol use during pregnancy, and shorter duration on ART were significantly associated with a higher odds of virologic suppression in the unadjusted model. While never defaulting in using ART was associated with a higher likelihood of viral suppression. However, in the adjusted model, only younger age (<25 years), smoking during pregnancy, and initiating ART during the first trimester (duration on ART of 27–40 weeks) were associated with a lower likelihood of having suppressed VL. Women who never defaulted in using ART were about 4 times more likely to have virologic suppression (Table 4).

We further examined the risk factors of undetectable VL (<20 copies/mL) and viral suppression (VL <1000 copies/mL) with the inclusion and exclusion of missing data on adherence to ART, the results and effect size remained the same (Table 5).

DISCUSSION

To achieve the Joint United Nations Programme on HIV/AIDS goal of EMTCT in South Africa [22], identification of women with nonsuppressed VL during pregnancy, delivery, and breastfeeding period for prompt interventions will be crucial. This policy direction has been introduced in the new PMTCT guideline of 2019 [7]. This multicenter study highlights very important results important for improving PMTCT indicators in the resource-constrained settings of Eastern Cape Province, South Africa.

The rates of peripartum viral suppression of 82% and undetectable VL of 56.9% are suboptimal to achieve the goal of EMTCT of HIV. High VL is a concern given that a high proportion of the women in this cohort initiated exclusive breastfeeding [23]. Nonsuppressed VL in pregnant women should be treated as an obstetric emergency by clinicians to achieve the goal of EMTCT in the region. In addition, this result also highlights the potential risk for ongoing transmission in the postpartum period. Evidence has shown unequivocally that viral suppression with ART is an effective strategy to significantly reduce HIV transmission at the population level [14–20]. Though VL <1000 copies/mL was considered virologic suppression according to the PMTCT guidelines [5, 7], undetectable VL should be the desired goal for all pregnant women. A randomized controlled trial conducted in many African countries [18] and a case-control study from France [20] reported MTCT at VL <1000 copies/mL. A previous South African study reported a higher peripartum virologic suppression of 91%; however, the investigators monitored the VLs and provided interventions for the participants [8]. As such, the report by Myer et al [8] pointed to the pragmatic approach needed at the facility level in our region in order to improve the peripartum virologic suppression rate and, consequently, improve PMTCT outcomes.

Our study found a significant association between sociobehavioral factors (being unemployed and defaulting in ART) and high peripartum VL. Unemployed women face several challenges due to socioeconomic hardships, such as lack of food security and transportation costs to attend clinics for ART. Adherence challenges were reported by a significant proportion of the participants in the study (reported elsewhere [21]) and thus offer a plausible explanation for this relationship. Previous studies have proven conclusively that near-perfect adherence is needed to ensure viral suppression [8, 19, 20]. Clinicians should, therefore, provide adherence support for pregnant women on ART, especially those with sociobehavioral challenges.

Younger age was associated with peripartum virologic nonsuppression. Women of younger ages were more likely to be associated with several sociobehavioral challenges such as smoking, alcohol use, nondisclosure to sexual partners leading to hiding of ART, and poor socioeconomic status [21]. All of these factors influence ART adherence. This finding

Table 3. Pearson χ^2 Statistics Showing the Correlates of Peripartum Virologic Response

Variable	Undetectable VL (n = 832)	Low Viremia (n = 369)	High VL (n = 262)	*P* Value
Age				
≤24 y	159 (47.3)	98 (29.2)	79 (23.6)	<.001
≥25 y	673 (59.7)	271 (24.0)	183 (16.3)	
Marital status				
Married	183 (66.8)	58 (21.2)	33 (12.0)	.004
Single	541 (53.9)	267 (26.6)	195 (19.4)	
Cohabiting	98 (60.1)	35 (21.5)	30 (18.4)	
Divorced/separated	10 (43.5)	9 (39.1)	4 (17.4)	
Area of residence				
Rural	280 (56.9)	110 (22.4)	102 (20.7)	.219
Semiurban	387 (56.9)	182 (26.8)	111 (16.3)	
Urban	167 (56.7)	77 (26.5)	49 (16.8)	
Education level				
No formal education	2 (50.0)	1 (25.0)	1 (25.0)	.116
Grade 1–6	55 (66.3)	12 (14.5)	16 (19.3)	
Grade 7–12	712 (55.8)	329 (25.8)	235 (18.4)	
Tertiary	63 (63.0)	27 (27.0)	10 (10.0)	
Employment status				
Unemployed	592 (54.6)	277 (25.5)	216 (19.9)	.001
Employed	240 (63.5)	92 (24.3)	46 (12.2)	
Smoking status				
Smoked during pregnancy	35 (43.2)	16 (19.8)	30 (37.0)	<.0001
Quit smoking during pregnancy	48 (64.9)	15 (20.3)	11 (14.9)	
Never smoked	749 (57.3)	338 (25.8)	221 (16.9)	
Alcohol use				
Drank during pregnancy	99 (49.0)	50 (24.8)	53 (26.2)	.018
Quit drinking during pregnancy	226 (57.2)	103 (26.1)	66 (16.7)	
Never drank alcohol	507 (58.5)	216 (24.9)	143 (16.5)	
Trimester at booking				
First	87 (49.4)	43 (24.4)	46 (26.1)	.011
Second	627 (59.1)	261 (24.6)	173 (16.3)	
Third	118 (52.2)	65 (28.8)	43 (19.0)	
Preconception awareness of HIV status				
Positive	688 (58.2)	275 (23.3)	219 (18.5)	.006
Negative	43 (54.4)	22 (27.8)	14 (17.7)	
Unknown	101 (50.0)	72 (35.6)	29 (14.3)	
Duration on ART				
Preconception ART (>40 wk)	519 (61.1)	183 (21.5)	148 (17.4)	<.001
27–40 wk	37 (43.0)	22 (25.6)	27 (31.4)	
13–26 wk	235 (54.7)	128 (29.8)	67 (15.6)	
<13 wk	41 (42.3)	36 (37.1)	20 (20.6)	
Disclosure to partner				
Yes	641 (58.9)	217 (24.9)	177 (16.3)	.010
No	185 (51.0)	97 (26.6)	82 (22.5)	
Defaulted ART				
No	731 (59.3)	318 (25.8)	183 (14.9)	<.001
Yes	51 (33.1)	39 (25.3)	64 (41.6)	
No response	50 (64.9)	12 (15.6)	15 (19.5)	
Peripartum CD4 count, cells/μL				
1–199	44 (27.2)	49 (30.2)	69 (42.6)	<.001
200–349	180 (50.8)	104 (29.4)	70 (19.8)	
350–499	209 (62.6)	78 (23.4)	47 (14.1)	
500–3200	362 (68.6)	116 (22.0)	50 (9.5)	
Not available	37 (43.5)	22 (25.9)	26 (30.6)	

Data are presented as no. (%) unless otherwise indicated.

Abbreviations: ART, antiretroviral therapy; HIV, human immunodeficiency virus; VL, viral load.

Table 4. Adjusted and Unadjusted Logistic Regression Model Showing Factors Associated With Undetectable Viral Load and Virologic Suppression

	Viral Load <20 Copies/mL (Undetectable)		Viral Load <1000 Copies/mL	
Variable	UOR (95% CI)	AOR (95% CI)	UOR (95% CI)	AOR (95% CI)
Age				
≤24 y	0.61 (.47–.77)**	0.72 (.42–1.22)	0.63 (.47–.85)**	0.68 (.48–.94)*
≥25 y (ref)	1	1	1	1
Employment status				
Unemployed	0.69 (.54–.88)*	0.76 (.59–.98)*	0.56 (.40–.79)*	0.71 (.49–1.02)
Employed (ref)	1	1	1	1
Area of residence				
Rural	1.01 (.75–1.35)	1.04 (.76–1.42)	0.77 (.53–1.13)	0.86 (.57–1.29)
Periurban	1.01 (.76–1.33)	1.03 (.77–1.37)	1.04 (.72–1.50)	1.14 (.77–1.68)
Urban	1	1	1	1
Smoking status				
Smoked during pregnancy	0.57 (.36–.89)*	0.72 (.42–1.22)	0.35 (.22–.56)**	0.50 (.28–.90)*
Quit smoking during pregnancy	1.38 (.84–2.25)	1.81 (1.06–3.07)*	1.16 (.60–2.25)	1.54 (.76–3.14)
Never smoked (ref)	1	1	1	1
Alcohol use				
Drank during pregnancy	0.68 (.50–.93)*	0.92 (.64–1.31)	0.56 (.39–.80)*	0.80 (.52–1.25)
Quit drinking during pregnancy	0.95 (.74–1.21)	1.05 (.80–1.37)	0.99 (.72–1.36)	1.09 (.76–1.56)
Never drank alcohol (ref)	1	1	1	1
Disclosure to partner				
No	0.73 (.57–.92)*	1.11 (.86–1.43)	1.49 (1.11–2.00)*	1.22 (.89–1.69)
Yes (ref)	1	1	1	1
History of defaulting ART				
Never defaulted ART	2.95 (2.07–4.20)**	3.09 (2.12–4.49)**	4.08 (2.85–5.8)**	3.88 (2.62–5.74)**
Unknown	3.74 (2.10–6.65)**	4.42 (2.36–8.27)**	2.94 (1.54–5.62)*	3.61 (1.73–7.52)
Defaulted ART (ref)	1	1	1	1
Duration on ART				
<13 wk	0.48 (.31–.72)**	0.51 (.32–.81)*	0.81 (.48–1.37)	0.83 (.46–1.51)
13–26 wk	0.77 (.61–.97)*	0.89 (.66–1.21)	1.14 (.83–1.57)	1.35 (.90–2.04)
27–40 wk	0.48 (.31–.75)*	0.51 (.31–.85)*	0.46 (.28–.75)*	0.53 (.30–.96)*
Preconception ART (>40 wk)	1	1	1	1

Abbreviations: AOR, adjusted odds ratio; ART, antiretroviral therapy; CI, confidence interval; ref, reference; UOR, unadjusted odds ratio.

*$P < .05$.

**$P < .01$.

corroborates previous reports that have shown strong correlation between younger ages and virologic failure [24–26].

Our study also demonstrated the importance of early initiation of ART to achieve viral suppression at delivery. Shorter duration on ART (<13 weeks) was associated with detectable viremia. This result corroborates previous studies showing an association between the timing of ART and viral suppression [8, 18, 27]. Therefore, appropriate strategies to ensure that all HIV-infected women commence ART in a timely manner and achieve suppression before delivery should be prioritized. In addition, longer duration of ART (27–40 weeks) was associated with high VL. While this result is unexpected, given the longer ART exposure in this group, women initiating ART in the first trimester are at risk of nausea and vomiting due to combined effects of ART and pregnancy. These reasons were reported by the study participants [21]. It is, therefore, important for clinicians to intensify surveillance for this high-risk subpopulation of pregnant women during the antenatal period for adherence support and other interventions.

The participants enrolled in this PMTCT cohort were drawn from the 3 tiers of hospital services (district, regional, and tertiary) in the country. As such, the study participants will closely resemble the types of pregnant women on ART at these levels of care in the rest of Eastern Cape Province. Therefore, the findings from this study could guide planning of PMTCT programs in the province. It should be noted that some of the women did not have VL results due to blood samples that had clotted or were insufficient, which were rejected from the laboratory. However, we compared the demographic and clinical profiles between the 2 groups of women with and without VL results in the study, and found no significant differences.

CONCLUSIONS

The study shows that more than half of the women in this study achieved an undetectable VL, and 4 in 5 women achieved viral suppression at delivery. Younger age, lifestyle behaviors, and adherence challenges were associated with undetectable VL and

Table 5. Adjusted logistic regression model showing factors associated with undetectable viral load and viral suppression (with inclusion and exclusion of missing cases)

	Undetectable Viral Load (VL <20 Copies/mL)		Viral Load <1000 Copies/mL	
Variable	AOR (Missing Cases Included)	AOR (Missing Cases Excluded)	AOR (Missing Cases Included)	AOR (Missing Cases Excluded)
Age (y)				
24 and below	0.72 (.42–1.22)	0.76 (.54–1.07)	0.68 (.48–.94)*	0.82 (.52–1.28)
25 and above (ref)	1	1	1	1
Employment status				
Unemployed	0.76 (.59–.98)*	0.62 (.44–.87)*	0.71 (.49–1.02)	0.54 (.32–.90)*
Employed (ref)	1	1	1	1
Area of residence				
Rural	1.04 (.76–1.42)	1.16 (.77–1.74)	0.86 (.57–1.29)	0.84 (.49–1.44)
Periurban	1.03 (.77–1.37)	1.13 (.78–1.65)	1.14 (.77–1.68)	1.11 (.66–1.88)
Urban	1	1	1	1
Smoking status				
Smoked during pregnancy	0.72 (.42–1.22)	0.84 (.41–1.72)	0.50 (.28–.90)*	0.63 (.27–1.47)
Quit smoking during pregnancy	1.81 (1.06–3.07)*	1.97 (.93–4.16)	1.54 (.76–3.14)	1.26 (.46–3.48)
Never smoked (ref)	1	1	1	1
Alcohol use				
Drank during pregnancy	0.92 (.64–1.31)	0.99 (.62–1.58)	0.80 (.52–1.25)	0.88 (.48–1.62)
Quit drinking during pregnancy	1.05 (.80–1.37)	0.98 (.68–1.40)	1.09 (.76–1.56)	1.20 (.73–1.99)
Never drank alcohol (ref)	1	1	1	1
Disclosure to partner				
No	1.11 (.86–1.43)	0.85 (.60–1.20)	1.22 (.89–1.69)	1.24 (.80–1.93)
Yes (ref)	1	1	1	1
History of defaulting ART				
Never defaulted ART	3.09 (2.12–4.49)**	3.25 (2.05–5.14)**	3.88 (2.62–5.74)**	3.19 (1.95–5.2)**
Unknown	4.42 (2.36–8.27)**	[a]	3.61 (1.73–7.52)	[b]
Defaulted ART (ref)	1	1	1	1
Duration on treatment				
Less than 13 weeks	0.51 (.32–.81)*	0.55 (.28–1.11)	0.83 (.46–1.51)	0.67 (.27–1.63)
13–26 weeks	0.89 (.66–1.21)	0.61 (.38–.97)*	1.35 (.90–2.04)	1.11 (.57–2.15)
27–40 weeks	0.51 (.31–.85)*	0.40 (.18–.90)*	0.53 (.30–.96)*	0.50 (.19–1.36)
At least over 41 weeks on ART (Preconception ART)	1	1	1	1

Data are presented as AOR (95% confidence interval).

Abbreviations: AOR, adjusted odds ratio; ART, antiretroviral therapy; CI, confidence interval; ref, reference.

[a]Seventy-seven missing cases.

[b]Four hundred ninety-five missing cases.

*$P < .05$.

**$P < .01$.

virological suppression. Programmatic reengineering aimed at addressing adherence challenges in the region should focus on women who are young, employed, have history of defaulting ART, and initiated ART in the first and last trimester of pregnancy. Long-term follow-up of the cohort will provide insights on viral suppression during the breastfeeding period.

Notes

Author contributions. O. V. A., C. L. O., B. I., A. O., D. T. G., G. A., J. L., N. S.-C., and A. I. A. conceptualized and designed the study. All authors were involved in the implementation of the project. A. I. A. conducted the data analysis. O. V. A., A. I. A., D. T. G., B. I., C. C., and C. L. O. drafted the manuscript. All authors gave intellectual input and approved the final version of the manuscript for submission.

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