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Sociodemographic and obstetric determinants of HIV infection among pregnant women in Cameroon: A contribution toward the elimination of vertical transmission in low- and middle-income countries

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Abstract

Background: The risk of HIV transmission during pregnancy remains a concern in Cameroon. Recent estimates suggest a national HIV prevalence of approximately 4.5%, increasing the likelihood of vertical transmission.

Objective: To estimate HIV seroprevalence and identify sociodemographic and obstetric determinants of HIV infection among pregnant women attending antenatal care in Cameroon.

Methods: A cross-sectional study was conducted from September 2022 to June 2023 among pregnant women aged 15 years and above in 324 health facilities across eight regions. Consecutive voluntary sampling was used until the site-specific sample size was reached. Facilities were purposively selected based on monthly ANC attendance >30. HIV screening followed the national algorithm. Multivariable Complementary Log-Log regression was used to identify factors associated with HIV infection, and adjusted prevalence ratios (aPRs) with 95% confidence intervals (CIs) were reported. Data were analysed using Excel and SPSS 27.

Results: Among 10,669 pregnant women (median age: 25 years), HIV prevalence was 2.6%. Younger women (<25 years) were more likely to be HIV-positive (aPR = 1.20; 95% CI: 1.07–1.34). HIV positivity was lower among single (aPR = 0.80) and cohabiting women (aPR = 0.89) compared with married women. Women with primary (aPR = 0.82) or secondary education (aPR = 0.86) had lower HIV positivity than those with higher education. First-trimester ANC attendance was also associated with reduced HIV positivity (aPR = 0.88). Compared with Yaoundé, women in five other regions showed significantly lower HIV positivity (aPRs: 0.75–0.79).

Conclusion: HIV prevalence among pregnant women in Cameroon is relatively low but remains unevenly distributed across regions and sociodemographic groups, with higher prevalence observed among married women and lower prevalence among women initiating antenatal care in the first trimester. Strengthening antenatal care as a platform for early HIV prevention, including timely counselling and partner testing, may help reduce these disparities and support progress toward eliminating mother-to-child transmission of HIV.

Clinical trial number: not applicable

Keywords: HIV infection, Mother-to-Child Transmission, pregnancy, prenatal care, HIV seroprevalence, risk factors, Cameroon

Background

HIV infection remains prevalent among pregnant women and continues to pose a major public health challenge across many low- and middle-income countries (LMICs). In 2023, an estimated 1.2 million (950,000–1.4 million) pregnant women worldwide were living with HIV, of whom approximately 84% (72–>98%) received antiretroviral therapy for the prevention of mother-to-child transmission (PMTCT) [1]. Sub-Saharan Africa accounts for two-thirds of these infections, with prevalence ranging from 5% to 42% across countries [2,3].

Pregnant women living with HIV face a high risk of transmitting the virus to their infants during pregnancy, labour, delivery, or breastfeeding [4]. In the absence of any intervention, between 20% and 45% of infants may acquire HIV, with an estimated risk of 5–10% during pregnancy, 0–20% during labour and delivery, and 5–20% during breastfeeding [3–8]. Without treatment, half of all HIV-infected children die before their second birthday, reinforcing the urgency of eliminating vertical HIV transmission in high-priority countries such as Cameroon [3].

Although Cameroon has achieved substantial progress—reducing HIV prevalence in the general population from 5.5% in 2005 [9] to 2.7% in 2018 [10], the burden remains high among specific groups, including pregnant women. HIV prevalence among pregnant women declined from 7.6% in 2009 to 4.26% in 2019, yet some regions continue to show elevated levels (e.g. 8.46% in the South Region), highlighting the need for continued surveillance to guide targeted interventions [11]. HIV prevalence in this population remains similar in urban and rural areas, ranging from 5.58% to 5.87% in national HIV Sentinel Surveillance (HSS) reports [12].

Multiple factors have been associated with HIV infection among pregnant women in Cameroon, including marital status, multiparity, age, and region of residence [12]. However, given ongoing demographic and behavioural shifts, updated evidence is essential for strategic public health action. This study aligns with global and national goals to eliminate vertical HIV transmission. At the international level, it supports the UNAIDS target of achieving zero new paediatric HIV infections by 2030, within the Global Alliance to end AIDS in children [13]. It also reflects the WHO "triple elimination initiative," which promotes the simultaneous elimination of mother-to-child transmission of HIV, syphilis, and hepatitis B through integrated ANC services [14]. Nationally, Cameroon has committed to these objectives through its PMTCT programme, emphasizing the need for up-to-date, high-quality epidemiological data to inform region-specific interventions and advance progress toward eMTCT.

Methods and materials

Study design and setting

A cross-sectional study was conducted between September 2022 and June 2023 across eight regions of Cameroon: Adamaoua, East, Far North, North, West, South, Centre, and Littoral. Within the Centre and Littoral regions, the major urban centres of Yaoundé and Douala were specifically included because of their high population density and the representativeness of their demographic and health profiles. These cities are considered comparable to other regions in terms of healthcare access, socioeconomic diversity, and HIV epidemiological patterns.

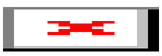
Study population

The study population comprised pregnant women aged 15 years and above who provided informed consent and were attending antenatal or maternity care services. Eligible participants were those with unknown HIV status or those who had been documented as HIV-negative for at least three months prior to enrolment. Pregnant women presenting with acute illnesses (e.g., febrile conditions, respiratory infections, or any medical condition requiring immediate intervention) were excluded from participation.

Sample size and sampling

Sample size

The sample size was calculated using the WHO expert formula (Adequacy of sample size in health surveys) and taking into account the estimated HIV prevalence of pregnant women [15] :



With:

- P= anticipated pregnant women prevalence of HIV infection at 2.13% [16,17];
- Ɛ= relative accuracy set in advance at 4%
- $Z^2_{1-\alpha/2}$= number of standard errors of the mean (1.96);

Accordingly, the minimal required sample size was estimated at 9,604 pregnant women. However, because data collection involved 324 high-volume ANC facilities, all eligible and consenting women attending during the study period were enrolled, resulting in a final sample of 10,687 women. This 11.3% increase over the minimum requirement does not introduce bias; instead, the larger sample reduces standard errors and narrows confidence intervals, thereby improving the precision and stability of the estimations[18–20] without altering the direction or magnitude of the associations.

Sampling

Purposive sampling was used to select 324 health facilities out of 4679 (6.92%). Health facilities were selected based on their prenatal care service volume (>30 new prenatal care clients per month), referred to as ‘prenatal care weight’, which corresponds to the average number of pregnant women attending first prenatal care visits per month. Criterion sampling appears to be used most commonly in implementation research [21].

Selected facilities included a range of service levels, including integrated health centres, district hospitals, and regional referral hospitals, in both urban and rural areas.

In each selected health facility, voluntary sampling [22,23] was used to recruit pregnant women until the minimum size requirement was exceeded. While the selection was not probabilistic, the wide regional distribution and inclusion of high-volume facilities across various levels of the health system ensured operational representativeness for pregnant women attending antenatal care services.

Data collection and HIV testing procedure

Two HIV tests were used according to national guidelines (national HIV screening algorithm): Determine (Abbott Laboratories, IL, USA) and Oraquick.

The data were collected using a dedicated paper-based register specifically designed for this study. This register was developed to ensure standardized recording of key information, including sociodemographic characteristics, obstetric history, and HIV testing results, across all 324 participating health facilities. The tool was designed to meet the operational requirements of this research. Given the multi-week duration (12 weeks) of the data collection phase, a register format was chosen over loose questionnaires to minimize the risk of data loss, improve organization, and ensure traceability. Trained midwives and nurses completed the register during routine ANC visits for all eligible and consenting pregnant women. They were trained for 03 days in the use of Determine and Oraquick for HIV screening and in the study methodology. Testing took place at the entry point (prenatal care and maternity clinics) of the health facilities selected for the study.

When a pregnant women arrived at the prenatal care or maternity ward, the site's trained provider introduced himself to her, checked her eligibility, sent her the information leaflet and asked for her informed consent. Once the participants had provided informed consent, pre-test counselling was conducted, after which HIV testing of pregnant women was performed in accordance with the national algorithm (Figure 1).

Pregnant women who tested positive by the national HIV screening algorithm were managed by the aforementioned health facility in accordance with the guidelines for HIV management in Cameroon. Women who tested HIV-negative received standard post-test counselling and were referred to routine prevention services, including health education, as recommended by national guidelines. Among the 10,683 participants, 14 (0.1%) had indeterminate HIV results. These cases were managed in accordance with the Cameroonian national HIV screening algorithm, which recommends retesting three weeks after the initial indeterminate result. These participants were excluded from prevalence and regression analyses to avoid misclassification bias.

Variables of study

The main outcome was HIV seroprevalence. HIV seroprevalence was defined as the proportion of pregnant women who tested positive by the HIV screening algorithm.

Independent variables included region, age group, marital status, gestational age, history of abortion, and number of previous pregnancies.

In this operational survey, although a specific data-collection register was designed for the study, data were collected by routine ANC staff. To avoid disrupting service delivery and to minimise staff workload, the register was intentionally aligned with the sociodemographic and obstetric variables that are systematically and uniformly documented in national

ANC registers. This approach ensured feasibility, consistency, and data completeness across the 324 participating facilities and maintained comparability with previous HIV Sentinel Surveillance rounds. Variables such as religion, household economic status, age of sexual debut, partner characteristics, and other behavioural factors were not included because they are not routinely collected in ANC settings and would have introduced substantial missing data and measurement heterogeneity. Restricting the analysis to consistently available variables therefore preserved internal validity and analytical reliability.

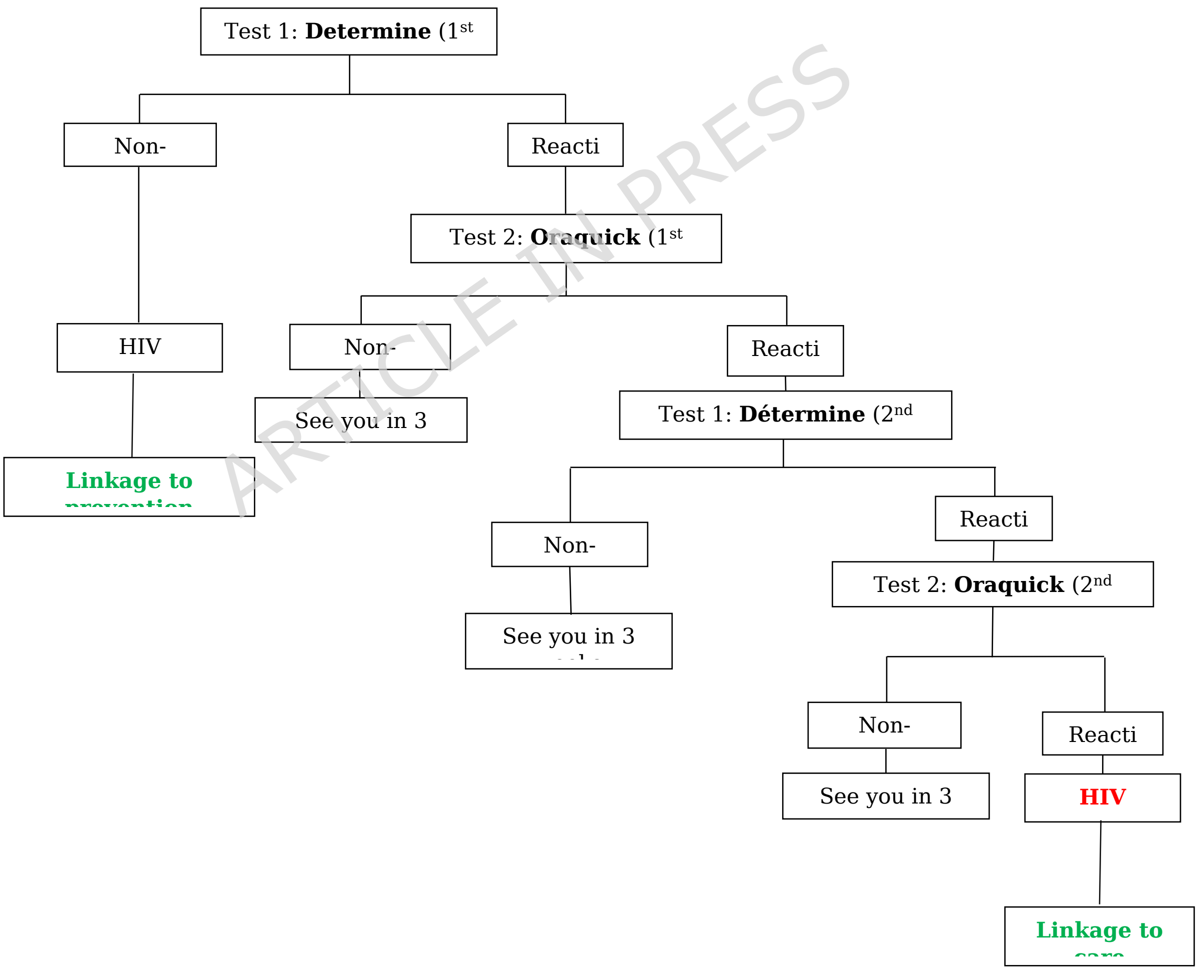


Figure 1. HIV screening algorithm used in the study

Data management and analysis

Data were collected on a specific register developed for the purpose of the study. In addition, data quality assurance measures were implemented throughout the study, including daily verification of registers by site supervisors, weekly data reviews, and centralized consistency checks prior to data entry. Data were first entered using CS Pro version 7.7.3 for its suitability in handling large-scale survey data and then exported to Excel for initial cleaning. Final statistical analyses were conducted using SPSS version 27. Continuous variables were described using the median with the interquartile range (IQR) because the data were not normally distributed, as confirmed by visual inspection and distribution tests. Categorical variables were described using proportions. The association of independent variables with primary outcome (Positive HIV infection) was assessed in univariate and multivariable analysis using binomial regression with Complementary Log-Log link (Clog-Log regression). The Clog-Log regression is the best way to deal with imbalanced data (extremely skewed) [24–27]. The final multivariable model was built using independent variables with a significance level set at $p < 0.2$. We have reported adjusted prevalence ratio (aPR), and the 95 % confidence intervals (95%CI). Multicollinearity among the predictor variables included in the final complementary log-log regression model was evaluated using variance inflation factors [28,29]. No evidence of high collinearity was found (Supplementary file 7). The outliers, the influential cases were also examined (File 7. Checking bias of Complementary Log Log regression). In the absence of a continuous predictor in the model, the linearity of the logit has not been verified. All tests were two-sided, with $p < 0.05$ indicating statistical significance.

Ethical consideration

In accordance with Cameroonian law, the legal age for marriage is 18 years for both males and females, as stipulated in the Family and Persons Code (Law No. 2016/007 of July 12, 2016). However, under Cameroonian civil law, a pregnant minor is considered an emancipated minor, thereby legally capable of giving informed consent for herself, including participation in research involving minimal risk such as this epidemiological study. Accordingly, written informed consent was obtained directly from all participants aged 15 years and above, including emancipated minors.

For participants who were illiterate, the informed consent process was conducted orally in the participant's preferred language in the presence of an impartial witness. Consent forms were read aloud in full, and participants indicated their agreement by affixing a thumbprint, countersigned by the witness, as per the principles of the Declaration of Helsinki and national ethics guidelines.

Although the names of participants were temporarily collected on field registers for follow-up and linkage to care, all data used for analysis were anonymized prior to entry. Unique study identification codes replaced personal identifiers. Only authorized personnel had access to identifiable data, which were stored securely in accordance with data protection standards and confidentiality protocols approved by the National Ethics Committee."

Results

Sociodemographic characteristics of pregnant women

Of 10,669 pregnant women tested, the median age was 25 (21 - 30) and the age group least represented was 35 and over (10.7%). 39.7% had secondary education, 57.9% were married (Table 1).

Table 1. Sociodemographic characteristics of pregnant women attending antenatal care in 324 health facilities across 8 regions of Cameroon, 2022 –2023 (N = 10,669)

Variables	Frequency	Percentage (%)
Region		
Adamaoua	740	6.9
East	836	7.8
Far North	2089	19.6
North	2054	19.3
West	110	1.0
South	732	6.9
Yaoundé	2173	20.4
Douala	1935	18.1
Age		
Median (IQR)	25 years (21 – 30)	
Under 25 years	4782	44.8
25 - 35 years old	4744	44.5
35 years old and above	1143	10.7
Educational level		
Never schooled	2149	20.1
Primary	2905	27.2
Secondary	4231	39.7
Superior	1384	13.0
Marital status		
Bachelor	2132	20.0
Cohabitation	2357	22.1
Married	6180	57.9

Among pregnant women, 29.4% were nulliparous, 45.3% of pregnant women were in the 3rd trimester of pregnancy and 15.7% of pregnant women had declared that they had already had at least one abortion (Table 2).

Table 2. Obstetric characteristics of pregnant women attending antenatal care in 324 health facilities across 8 regions of Cameroon, 2022 –2023

Variables	**frequency**	**Percentage (%)**
Number of pregnancies N=10,387		
Nulliparous	3026	29.4
Primiparous	2350	22.6
Pauciparous	3059	29.5
Multiparous	1293	12.4
Large multiparous	659	6.3
Gestational age (in weeks of amenorrhea) (n=10,669)	24 weeks (16 – 32)	
1st trimester of pregnancy	1451	13.6
2nd trimester of pregnancy	4383	41.1
3rd trimester of pregnancy	4835	45.3
History of abortion (n=10,669)		
No abortion	8998	84.3
01 abortion	1105	10.4
02 abortions and more	566	5.3

Seroprevalence of HIV infection among pregnant women

Overall, HIV seroprevalence among pregnant women was 2.6% (95% CI: 2.33 - 2.93) (Table 3).

Table 3. Seroprevalence of HIV infection among pregnant women attending antenatal care in 324 health facilities across 8 regions of Cameroon, September 2022 –2023 (n = 10,669)

HIV diagnosis using the national algorithm	**Frequency**	**Percentage (%)**	**95% CI**
	Frequency	**Percentage (%)**	**95% CI**
Negative	10 390	97.4	97.1 – 97.7
Positive	279	2.6	2.33 - 2.93

Factors associated with HIV seroprevalence among pregnant women

Table 4 presents factors associated with HIV diagnosis among pregnant women based on univariate and multivariable analyses. Geographically, women residing in the Adamaoua, East, Far North, North and South regions were significantly less likely to be diagnosed with HIV compared to those in Yaoundé, after adjustment, with adjusted prevalence ratios (aPR) ranging from 0.75 to 0.79 ($p<0.01$). Younger age, particularly being under 25 years old, was associated with a significantly higher likelihood of HIV infection (aPR = 1.20; 95% CI: 1.07–1.34; $p = 0.002$), highlighting the increased vulnerability of this age group. Regarding marital status, women in cohabiting relationships or who were single (bachelor) had significantly lower HIV prevalence compared to married women (aPR = 0.89 and 0.80, respectively). Educational attainment also played a protective role, with women who had only primary education aPR=0.82; $p=0.009$) or secondary education (aPR = 0.86; $p = 0.024$) being significantly associated with lower HIV prevalence, while no significant protective effect was observed for women who were never schooled comparing with those who had undergone university education. First-trimester pregnancy was significantly associated with a lower prevalence of HIV (aPR = 0.88; $p = 0.016$). In contrast, abortion history was not statistically associated with HIV diagnosis in the multivariable model. These findings underscore the importance of tailoring HIV prevention strategies based on age, marital status, education level, and geographic location (Table 4).

Discussion

In this large national sample of over 10,000 pregnant women, we found an overall HIV prevalence of 2.6%. These observed HIV seroprevalence among pregnant women in Cameroon indicates a low but still persistent burden of HIV infection in antenatal populations. Also, HIV prevalence among pregnant women is one of the indicators of HIV prevalence among general population, as they represent the sexually active population [30]. This result of seroprevalence are similar to the last national HIV prevalence rate (2.7%) conducted in 2018 [10] but is significantly lower compared to the 2016 Cameroonian HSS with 5.75% among pregnant women [12], including the results of other studies in Cameroon which reported HIV prevalences (up to 6%) among pregnant women [31–33].

Table 4. Sociodemographic, Obstetrical Factors Associated with HIV Diagnosis Among Pregnant Women attending ANC: Univariate and Multivariable Analyses (N = 10,669)

	HIV diagnosis		Univariable analysis		Multivariate analysis (N2=10669)	
	N	***n (%)***	**P**	**cPR(95% CI)**	**P**	**aPR (95% CI)**
Region (N=10669)						
Adamaoua	740	17(2.3)	0.142	0.89 (0.77-1.04)	**0.006****	**0.78 (0.66-0.93)**
East	836	74(8.9)	<0.001	0.57 (0.51- 0.65)	**0.001****	**0.55 (0.48-0.63)**
Far North	2089	47(2.2)	0.060	0.90 (0.80-1.00)	**<0.001****	**0.79 (0.68-0.90)**
North	2054	49(2.4)	0.031	0.89 (0.79-0.99)	**<0.001****	**0.78 (0.68-0.90)**
West	110	3(2.7)	0.334	0.85 (0.62-1.18)	0.164	0.79 (0.56-1.10)
South	732	29(4.0)	<0.001	0.76 (0.67-0.88)	**<0.001****	**0.75 (0.65-0.87)**
Douala	1935	28(1.4)	0.946	1.00 (0.89-1.13)	0.958	1.00 (0.88-1.13)
Yaounde	2173	32(1.5)		1		1
Age (N=10669)						
Under 25 years old	4782	113(2.4)	0.071	1.10 (0.99-1.22)	**0.002****	**1.20 (1.07-1.34)**
25 - 34 years old	4744	128(2.7)	0.259	1.06 (0.96-1.18)	0.190	1.08 (0.96-1.20)
35 years old and above	1143	38(3.3)		1		1
Marital status (N=10669)						
Bachelor	2132	69(3.2)	0.007	0.89 (0.83-0.97)	**<0.001****	**0.80 (0.72-0.89)**
Cohabitation	2357	76(3.2)	0.006	0.90 (0.83-0.97)	**0.024***	**0.89 (0.81-0.98)**
Married	6180	134(.2)		1		1
Parity (N=10387)						
Nulliparous	3026	71(2.3)	0.901	1.01 (0.87-1.16)		
Primiparous	2350	58(2.5)	0.953	0.99 (0.83-1.10)		
Pauciparous	3059	87(2.8)	0.550	0.96 (0.83-1.10)		
Multiparous	1293	35(2.7)	0.714	0.97 (0.83-1.14)		
Large multiparous	659	16(2.4)		1		
Educational level (N=10669)						
Never schooled	2149	54(2.5)	0.004	0.83 (0.72-0.94)	0.057	0.86 (0.73-1.00)

Primary	2905	93(3.2)	<0.001	0.77 (0.68-0.87)	**0.009****	**0.82 (0.71-0.95)**
Secondary	4231	116(2.7)	<0.001	0.80 (0.71-0.91)	**0.024***	**0.86 (0.75-0.98)**
Supérior	1384	16(1.2)		1		1
Gestational age (N=10669)						
1st trimester of pregnancy	1451	46(3.2)	0.067	0.91 (0.83-1.00)	**0.016***	**0.88 (0.80-0.98)**
2nd trimester of pregnancy	4383	122(2.8)	0.137	0.95 (0.89-1.02)	0.151	0.95 (0.88-1.02)
3rd trimester of pregnancy	4835	111(2.3)		1		1
History of abortion (N=10669)						
No abortion	8998	226(2.5)	0.059	1.13(0.99-1.30)	0.051	1.15 (1.00-1.33)
01 abortion	1105	31(2.8)	0.239	1.10 (0.94-1.29)	0.433	1.07 (0.90-1.27)
02 abortions and more	566	22(3.9)		1		1

1: reference category; **P:** significance; ***:** significant at 5%; ****:** significant at 1%; **cPR**: crude Prevalence Ratio; **aPR:** adjusted Prevalence Ratio; **N:** number of subjects included in univariate analysis; N**2:** number of subjects included in multivariable analysis

Although our study design is similar to national HSS exercises conducted in ANC settings, this study was an independent, cross-sectional survey designed to assess the prevalence, sociodemographic and obstetrical determinants of HIV infection among pregnant women. It was not conducted within the fixed existing network of sentinel surveillance sites. Only 6.48% (21 out of 324) of the HHS collection sites were represented within our sample of health facilities. Although our study sites were not part of the national HSS network, we compare selected findings with data from sentinel studies for national context. This prevalence is meaningful as it places Cameroon below the commonly cited 5% threshold used in policy frameworks to identify generalized epidemics among pregnant women. It also reflects a further decline from previous sentinel survey [12], suggesting that Cameroon is making tangible progress in the context of the eMTCT initiative. This declining prevalence is the result of progress and strategies implemented by Cameroon in recent years to strengthen HIV prevention among women, who are disproportionately affected by HIV. These include the integration of reproductive health and maternal, newborn, child and adolescent health services/HIV/PMTCT, decentralisation of services and delegation of tasks, family-based HIV testing, implementation of option B+, contact tracing, implementation of Users Fees and HIV self-testing for partners of pregnant women [34].

Unlike the findings from the 2016 HSS survey in Cameroon, which identified multiparity as a significant factor associated with higher HIV prevalence among pregnant women [12], our study did not observe a significant association between parity and HIV status in the univariate analysis. This divergence may reflect differences in sample composition, temporal shifts in reproductive behaviours, or improved access to HIV prevention services across parity groups in recent years. It also suggests that the influence of parity on HIV risk may not be consistent across settings or over time and highlights the importance of continuously re-evaluating epidemiological patterns as service coverage and population dynamics evolve.

Evidence on HIV infection and its predictors among pregnant women is key to ensuring an HIV free new generation of children beyond 2030. Most importantly, LMICs like Cameroon require such epidemiological surveillance to set-up priority interventions with impact at country-level.

The multivariable analysis identified several sociodemographic and obstetric characteristics significantly associated with HIV infection among pregnant women attending antenatal care services in Cameroon. Several methodological limitations in the HSS and other cross sectional reviewed studies hinder direct comparability with our findings, particularly in settings where HIV prevalence is below 5% or even 1%. Most of these studies applied multivariable logistic regression without adjusting for the rarity of the outcome, which leads to overestimation of effect sizes due to the inflation of odds ratios when the event is uncommon and extremely skewed [24–26,35,36]. Beyond the overestimation of effect size, the direction of the association may also be distorted, particularly when the outcome of interest has a prevalence below 5%, as illustrated in our supplemental file (Supplementary files 8) presenting the logistic regression model applied to our study data. This is particularly problematic in studies in India [30,37,38], in Angola [39], in Brazil [40,41], in China [42], where HIV prevalence were well raging between 0.24% to 3%, yet odds ratios were used and interpreted as risk estimates. Additionally, many studies lacked verification of key model assumptions—such as absence of multicollinearity, assessment of influential points, or proper variable selection strategies—further limiting the robustness and generalizability of their results. In contrast, our study employed complementary log-log regression, a method more suited to rare event imbalanced data, allowing for direct estimation of adjusted prevalence ratios (aPR) and improved interpretability. As such, methodological disparities—especially the inappropriate use of logistic regression in low-prevalence contexts—render comparisons with our prevalence ratios problematic and potentially misleading.

The spatial distribution of HIV among pregnant women shows regional disparities varying from 2.2% in the Far North to 8.9% in the East and similarly low prevalence in the country major cities of Yaoundé (1.5%) and Douala (1.4%) [10]. In other Cameroonians studies, regional variations from 0.7% in the Far North to 11.8% in the South, as well varying trends between urban and rural settings [12,33]. These regional and urban disparities show that prevention activities and priority interventions achieved the expected goals more easily in the major cities, likely due to accessibility to several channels and means of information and communication. In addition, the educational level and the presence of community-based organisations in these major cities also contribute to strengthening HIV prevention, raising awareness and involving pregnant women and their partners in healthy behavioural factors. Henceforth, these results suggest strengthening strategies through targeted and differentiated priority HIV prevention interventions in regions, also supported by previous the Demographic and Health Survey [10].

The finding that pregnant women under 25 years of age had a higher risk of HIV infection (aPR = 1.20; 95% CI: 1.07–1.34) is particularly meaningful, as it suggests a shift in the age profile of HIV vulnerability among women of reproductive age. While earlier literature in Cameroon [12,32,33] and at international level [39] frequently associated HIV infection with increasing age, this finding implies that younger women—possibly engaging in early sexual debut, having limited access to reproductive health information, or facing power imbalances in relationships—are now increasingly at risk. These dynamics may reflect changing patterns in sexual behaviour and partner characteristics among adolescents and young adults in Cameroon.

The reason behind this increased vulnerability may lie in the interplay of behavioural and structural factors. Young women may be more susceptible to coercive or transactional sex, may lack negotiating power for condom use, or may be partnered with older men who themselves are at higher risk of HIV exposure. Moreover, age-disparate relationships, which are still common in several Cameroonian communities, have been repeatedly identified as drivers of HIV transmission among adolescent girls and young women [43]. This divergence may reflect contextual differences in epidemic maturity and sexual networks. It may also be explained by the use of different statistical models (e.g., odds ratios vs. prevalence ratios), or varying access to ANC services by age group. Public health implications include the necessity to reposition adolescents and young pregnant women at the centre of HIV prevention strategies. Tailored interventions such as youth-friendly health services, age-appropriate sexuality education, and adolescent-specific PrEP access should be scaled up. Community outreach to delay age of sexual debut and empower young women with decision-making autonomy are essential for reversing this trend.

Marital status also emerged as a significant factor, with women who were single (aPR = 0.80; 95% CI: 0.72–0.89) or cohabiting (aPR = 0.89; 95% CI: 0.81–0.98) showing significantly lower HIV prevalence than their married counterparts. This is meaningful because it challenges common assumptions that formal marital unions are inherently protective against HIV. Instead, it suggests that some married women may face greater exposure to HIV through unfaithful or high-risk partners, compounded by limited power to negotiate safe sex or access testing services within the marital framework. The underlying reason for this finding may relate to the power asymmetrical and gender norms often present in marriage. In many Cameroonian settings, cultural expectations may discourage women from questioning their husband's sexual behaviour or insisting on condom use. These factors, combined with potential delays in health-seeking or denial of risk, may account for the higher burden in married women. Although older study conducted in two sub-Saharan African cities (Ndola and Kisumu) found that HIV was more prevalent among those who were currently or previously married than among those who were single [44], contrastingly, recent studies, including a Cameroonian HSS, found single women to be at higher risk, often due to multiple partnerships or economic vulnerability [12,42,45]. This discrepancy underlines the importance of context in interpreting the relationship between marital status and HIV risk. Marital institutions do not universally guarantee protection and may, in some contexts, represent an overlooked risk environment. This insight has several implications for public health. Interventions must address the risks within marital relationships by encouraging couple testing, improving spousal communication, and integrating HIV prevention into family counselling platforms. Furthermore, the implementation of HIV self-testing kits and community-based partner notification could improve detection among partners of pregnant women.

Education level was also significantly associated with HIV status, with women having only primary (aPR = 0.82; 95% CI: 0.71–0.95) or secondary education (aPR = 0.86; 95% CI: 0.75–0.98) exhibiting lower HIV prevalence compared to those with higher (university) education. Although seemingly paradoxical, this finding is meaningful as it reaffirms that education, particularly basic literacy and secondary schooling, confers protection against HIV, likely by increasing awareness, enabling healthier decision-making, and enhancing access to care. One plausible reason for the lack of a protective association in women with university-level education may be related to small sample size for this category or the influence of socioeconomic and behavioural heterogeneity within that group. Moreover, tertiary education may be more accessible to urban women, who could face urban-specific risk environments such as anonymity in partnerships, sexual networking via digital platforms, or competing priorities delaying ANC engagement. In contrast, many prior studies have reported a clear gradient of decreasing HIV prevalence among pregnant women with increasing education [37,45] while the Cameroonian HSS did not find any association [12]. The absence of a strong protective effect for higher education in this dataset invites further research into the qualitative differences in sexual behaviour, relationship dynamics, and service use patterns among educated women. Note that, in some studies, none of the sociodemographic variables—such as age, education, or area of residence—were significantly associated with HIV infection at the 5% level [39]. From a policy perspective, it remains essential to promote universal primary and secondary education for girls, particularly in rural and underserved areas. Complementary strategies could include school-based HIV prevention programs, sexual health life-skills curricula, and reinforcement of safe behavioural norms across all education levels.

First-trimester antenatal care (ANC) attendance was independently associated with a lower prevalence of HIV infection compared with attendance in later trimesters. This association should be interpreted cautiously and is unlikely to reflect a direct protective effect of early ANC initiation per se. Rather, it most plausibly represents a marker of favourable health-seeking behaviour. Women who initiate ANC early are more likely to be proactive in managing their health, to have planned or wanted pregnancies, and to engage more consistently with preventive health services, including HIV testing and counselling.

Early ANC attendance has been widely recognised as a proxy for higher health literacy, greater autonomy in healthcare decision-making, and stronger linkage to health systems, particularly in low- and middle-income countries (LMICs) [46,47]. Women who seek care early may also maintain lower baseline risk profiles, including safer sexual practices or more stable partner dynamics, which are not fully captured in routine ANC data. Consequently, the observed association likely reflects underlying behavioural and social determinants rather than a causal relationship between ANC timing and HIV acquisition.

In addition, differential patterns of care-seeking may contribute to this finding. Women with higher perceived HIV risk or prior exposure may delay ANC attendance due to fear of diagnosis, stigma, or denial, a phenomenon documented in several sub-Saharan African settings [48]. Such delayed engagement could lead to an apparent concentration of HIV-positive diagnoses among women presenting later in pregnancy, without implying increased biological risk during later trimesters.

From a programmatic perspective, these findings reinforce the importance of early ANC attendance as a critical entry point for HIV prevention and linkage to care, rather than as an independent protective factor. Early ANC provides timely opportunities for HIV testing, partner testing, counselling, and initiation of prevention interventions, including pre-exposure prophylaxis (PrEP) for HIV-negative women at substantial risk [49]. However, given the cross-sectional design of this study, residual confounding and reverse causality cannot be excluded, and longitudinal studies are needed to better disentangle behavioural pathways from programmatic effects.

Overall, the association between early ANC attendance and lower HIV prevalence should be interpreted as an indicator of good health-seeking behaviour and effective engagement with preventive services, underscoring the need to promote early and equitable access to ANC as part of comprehensive HIV prevention strategies.

In contrast to our findings, where the history of abortion was not significantly associated with HIV seropositivity in the multivariable model, some studies have reported a different pattern. For instance, Omatola et al., [50] found that while age, marital status, trimester, and educational or occupational status were not significantly related to HIV prevalence, a history of abortion or miscarriage, intravenous drug use, and prior sexually transmitted infections were significantly associated with increased HIV seropositivity. This discrepancy may reflect differences in study populations, behavioural risk profiles, or contextual exposures such as sexual violence, unsafe abortion practices, or access to reproductive health services. In our study, although not statistically significant, women with no history of abortion demonstrated a trend toward lower HIV prevalence—approximately a 50% reduction—compared to those with a history of multiple abortions. This suggests a potential underlying vulnerability among women with adverse reproductive histories, which warrants further investigation through longitudinal studies.

In sum, these findings confirm the heterogeneity of HIV risk among pregnant women in Cameroon and highlight the need for precision public health approaches. Age, marital status, education, region, and ANC timing are not mere background characteristics—they are actionable determinants around which differentiated interventions can be structured to close the remaining gaps toward eMTCT.

Limitation of the study

Despite its large sample size, this study has several limitations that should be considered when interpreting the findings. First, data were collected exclusively in health facilities, which limits the generalizability of the results to all pregnant women in the general population. In addition, participation was voluntary, which may have introduced selection bias, as women who were more health-conscious or more confident about their HIV status may have been more likely to participate. Social desirability bias may also have affected self-reported variables, such as marital status or history of abortion. However, this risk was mitigated by having trained midwives—rather than external study investigators—collect data during routine antenatal care visits, thereby fostering a climate of confidentiality and neutrality.

Second, although the proportion of indeterminate HIV test results was extremely low (0.1%) and unlikely to introduce meaningful bias, their exclusion from the analyses may theoretically have influenced prevalence estimates. Nevertheless, all indeterminate cases were managed according to national re-testing protocols to ensure accurate case classification.

Third, while the study aimed to identify determinants of HIV infection among pregnant women, the analysis was restricted to sociodemographic and obstetric variables that are routinely documented in antenatal care registers. Important clinical, socioeconomic, and behavioural factors—such as history of sexually transmitted infections, partner characteristics, condom use, or age at sexual debut—were not available and could not be included, potentially resulting in the omission of additional relevant predictors. Furthermore, although regional differences were accounted for in the analysis, future studies with greater regional power or mixed-methods designs are needed to better explore the contextual factors underlying these geographic variations.

Finally, although a minimum sample size was calculated a priori, the final number of participants exceeded this estimate because all eligible pregnant women attending selected high-volume antenatal care facilities during the study period were enrolled for operational reasons. This discrepancy between the calculated and achieved sample sizes reflects programmatic and field implementation constraints rather than a deliberate statistical decision and should therefore be considered a methodological limitation. While the larger sample is unlikely to compromise the internal validity of the analyses, it may affect the strict interpretability of inferential assumptions and should be taken into account when interpreting the results.

Conclusion

In this large cross-sectional study of pregnant women attending antenatal care in Cameroon, HIV seroprevalence was relatively low (2.6%), yet important sociodemographic and geographic disparities persist. Younger women, particularly those under 25 years of age, were at higher risk of HIV infection, highlighting a shift in vulnerability toward younger age groups. In contrast, women residing outside Yaoundé, those who were single or cohabiting, and women with primary or secondary education exhibited a significantly lower prevalence of HIV. Early initiation of antenatal care during the first trimester was also associated with reduced HIV prevalence, likely reflecting favorable health-seeking behaviors.

These findings emphasize that, despite overall progress in reducing HIV burden among pregnant women, prevention efforts must remain differentiated and targeted. Tailoring interventions by age, marital status, educational level, and geographic context is essential to further reduce maternal HIV infection and to strengthen progress toward the elimination of mother-to-child transmission of HIV in Cameroon and similar low- and middle-income settings.

List of abbreviations

ANC: antenatal care

aPR: adjusted Prevalence-ratio

CI: Confidence Interval

CIRCB: Chantal Biya International Reference Centre

cPR: crude Prevalence-Ratio

eMTCT: Elimination of mother-to-child transmission

HIV: Human Immunodeficiency Virus

HSS: HIV Sentinel Surveillance

IQR: Interquartile Range

LMIC: Low-and middle-income countries

NACC: National AIDS Control Committee

PETVISIDAME: Project to eliminate mother-to-child transmission of HIV

PMTCT: Prevention of mother-to-child transmission

STI: Sexual Transmitted Infection

UNICEF: United Nations Children's Fund

WHO: World Health Organization

Ethics approval and consent to participate

This study was conducted in accordance with the principles of the Declaration of Helsinki and national regulations. Ethical approval was obtained from the National Ethics Committee for Human Health Research (reference number N°2022/08/1478/CE/CNERSH/SP/2022) and an Administrative Research Authorization (reference number N° 631-26-22/2022) was obtained. Written informed consent was obtained from study participants. Confidentiality was ensured by codes and restricting access to data.

Informed consent

Informed consent was also from each participant and Helsinki Declaration rules were followed. Informed consent was obtained from the legal guardians of the participants who were illiterate.

Consent for publication

Not applicable.

Availability of data and materials

All relevant data are within the manuscript and its Supporting Information files.

Competing interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Authors' contributions

JN, JPYAN, **FAN** conceptualized the study, designed the methodology, oversaw data collection, analysed the data, drafted the manuscript, contributed to interpretation of the results, critically reviewed the manuscript, and approved the final version for submission.

JF and **AK** contributed to conceptualize the study, designed the methodology, drafted the manuscript, contributed to interpretation of the results, critically reviewed the manuscript, and approved the final version for submission.

RKD, JDA, MGB, GN, HLS, CDY: contributed to analyse the data, drafted the manuscript, contributed to interpretation of the results, critically reviewed the manuscript, and approved the final version for submission.

CNB: contributed to conceptualize the study, designed the methodology and funding acquisition.

RT, **TANP, CTM and FNT** contributed to conceptualize the study, designed the methodology and critically reviewed the manuscript, and approved the final version for submission.

NYW contributed to design the methodology and critically reviewed the manuscript, and approved the final version for submission.

ARDN: contributed to conceptualize the study, designed the methodology, investigation and critically reviewed the manuscript, and approved the final version for submission.

DOM, MRM, MMD, NI contributed to critically reviewed the manuscript and approved the final version for submission.

NM: contributed to conceptualize the study, critically reviewed the manuscript, approved the final version for submission and funding acquisition

LMO, CM, PT, VC, CFP, GC, NN, **DK** and **GEHE** contributed to design the methodology, drafted the manuscript, contributed to interpretation of the results, critically reviewed the manuscript, and approved the final version for submission.

BK and **CM:** contributed to conceptualize the study, designed the methodology, drafted the manuscript, contributed to interpretation of the results, critically reviewed the manuscript, and approved the final version for submission and funding acquisition.

AN, SCB, CN, JA, and **ACZKB:** contributed to conceptualize the study, designed the methodology, drafted the manuscript, contributed to interpretation of the results, critically reviewed the manuscript, and approved the final version for submission, study administration.

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Additional information

File 1. Ethical Approval_ french original version (.pdf)

File 2. Ethical approval english version (.docx)

File 3. Research Administrative Autorization_french original version (.pdf)

File 4. Research Administrative Autorization_english version (.docx)

File 5. Row data. Database_HIV_Pregnancy_Cameroun. (.xlsx)

File 6. Data collection sheet (.xlsx)

File 7. Checking bias of Clog-Log regression (.docx)

File 8. Logistic regression model applied to our data (.docx)

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