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Associations between antenatal booking body mass index and postnatal placental weight: maternal health implications in HIV-positive and HIV-negative pregnant women in Uyo, Akwa Ibom state, Nigeria

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ABSTRACT

Introduction and aim. Maternal body mass index (BMI) and placental weight are important indicators of maternal-fetal health, and their relationship may be influenced by HIV status. This study examined the association between antenatal booking BMI and postnatal placental weight among HIV-positive and HIV-negative pregnant women in Uyo, Nigeria.

Material and methods. We conducted a retrospective comparative cross-sectional study based on medical records review of 143 women (48 HIV-positive, 95 HIV-negative) who attended antenatal care and delivered at the University of Uyo Teaching Hospital between December 2015 and May 2016. BMI was calculated from early pregnancy weight and height measured at the first antenatal visit; whole placental weight was measured post-delivery. Linear regression, adjusted for gestational age, evaluated associations between BMI, HIV status, and placental weight.

Results. Among 143 participants (48 HIV-positive, 95 HIV-negative), mean placental weight was significantly lower in HIV-positive women (602.94±174.92 g) compared with HIV-negative women (684.53±139.38 g; p=0.012). Gestational age was the strongest predictor of placental weight (p=0.009), while HIV infection was independently associated with lower placental weight (p=0.016). BMI was positively but not significantly associated with placental weight.

Conclusion. Antenatal BMI and postnatal placental weight are interrelated, with differing patterns by HIV status. These findings underscore the need to integrate routine nutritional assessment and targeted HIV care into antenatal programs to support healthy placental growth and improve pregnancy outcomes in high HIV-prevalence populations.

Keywords. antenatal care, body mass index, gestational age, HIV in pregnancy, placental weight, sub-Saharan Africa

Introduction

The co-occurrence of HIV infection and pregnancy presents significant challenges to maternal and fetal health globally.[1] HIV-positive pregnant women face unique pathophysiological and socio-demographic factors that can influence maternal health outcomes compared to their HIV-negative counterparts.[1–16] One crucial aspect of maternal health during pregnancy is body mass index (BMI), which reflects nutritional status and is linked to various pregnancy outcomes.[10,14–18] Although HIV infection alone may not directly increase obstetric risks, progression to AIDS and associated opportunistic infections during pregnancy can adversely affect outcomes.[2–8,13]

Research has consistently shown disparities in BMI and associated factors between HIV-positive and HIV-negative pregnant women.[11,19–31] Bengtson et al. found that both groups experienced weight gain postpartum, with HIV-negative women gaining more.[19] In another study, they found that pre-pregnancy obesity was common and did not vary by HIV status.[20] Bodkin et al. reported that, in relation to their body weights, HIV-positive pregnant women had lower hemoglobin, attended fewer antenatal appointments, and were more likely to present with certain conditions, such as abnormal vaginal discharge and intrauterine growth retardation.[11] Cruz et al. further highlighted the impact of maternal BMI on infant outcomes, with underweight mothers giving birth to smaller infants.[25] Likewise, Erasmus et al. found obesity prevalent in both HIV-positive and HIV-negative groups, with a significant link to hypertension during pregnancy.[31]

Placental weight serves as a proxy for fetal growth capacity and maternal-fetal nutrient exchange, making it a useful marker of placental function.[18] Variations in placental weight have been associated with adverse perinatal outcomes, including intrauterine growth restriction, preeclampsia, and preterm birth.[9,11,25] Given its predictive value, understanding determinants of placental weight in HIV-affected pregnancies may offer critical insights into maternal-fetal health interactions.[32–46]

However, the relationship between antenatal booking BMI and postnatal placental weight remains poorly understood in resource-limited settings. Uyo, Nigeria, an urban area in Akwa Ibom State with a mixed socio-economic profile and high HIV burden, offers a relevant context for this investigation. This study addresses that gap, emphasizing the relevance of such findings for localized maternal health interventions in sub-Saharan Africa. To our knowledge, this is the first study from Nigeria to examine the combined effects of maternal BMI and HIV status on placental weight, with statistical adjustment for gestational age. By focusing on a high HIV-burden urban population in Uyo, this work provides region-specific insights that may inform context-appropriate antenatal and nutritional interventions.

Aim

Therefore, this study aims to investigate the relationship between antenatal booking body mass index (BMI) and postnatal placental weight among HIV-positive and HIV-negative pregnant women receiving care at the University of Uyo Teaching Hospital (UUTH), Nigeria. Specifically, the study examines how HIV status influences BMI distribution and placental weight, while also assessing the role of key socio-demographic factors such as age, education, occupation, and gestational age. Considering the observed high burden of maternal obesity and the growing overlap between HIV infection and pregnancy, this study further explores whether HIV status modifies the association between maternal BMI and placental weight, accounting for potential confounders. By addressing these questions through a gestational age-adjusted analytical approach, the study seeks to generate context-relevant evidence that can inform precision-based antenatal care and maternal nutrition interventions in high-HIV-burden, resource-limited settings.

Material and methods

Study design and setting

We conducted a retrospective review of antenatal and delivery records over a defined six-month period, comparing two groups of women based on HIV status (HIV-positive and HIV-negative). This design allowed us to evaluate differences in maternal BMI and placental weight between groups at the University of Uyo Teaching Hospital (UUTH), Akwa Ibom State, Nigeria, a high HIV-prevalence urban center with diverse socio-economic profiles.

Study population and sampling

All pregnant women who received antenatal care and delivered at the University of Uyo Teaching Hospital (UUTH) between December 2015 and May 2016 were eligible. We included women with complete antenatal records containing booking weight, height, gestational age at delivery, HIV status, and placental weight. Women with missing key data (e.g., absent BMI measurement or unrecorded placental weight) were excluded. For each HIV-positive participant, one to two HIV-negative women delivering within the same time frame were selected for comparison.

Data collection

Booking BMI was calculated using weight (kg) and height (m) measured at first antenatal visit by trained midwives following hospital protocol, with women in light clothing and without shoes. Placental weight was measured by the midwives immediately after delivery, with membranes and cord trimmed at a standardized length before weighing using a calibrated digital scale. Data on antiretroviral therapy (ART) status (on ART prior to pregnancy, initiated during pregnancy, or ART-naïve) were extracted from antenatal records. Further data extracted from antenatal and delivery records included maternal age, education, occupation, marital status, blood pressure, HIV clinical stage (WHO criteria), gestational age. BMI was calculated as weight (kg)/height^2 (m^2).[20,47,48]

Data reliability

Extraction was conducted by trained staff using a standardized template, with cross-checks against antenatal and delivery logs to ensure accuracy.

Statistical analysis

Continuous variables (e.g., BMI, placental weight) were summarized as mean±standard deviation and compared between groups using independent-samples t-tests. Categorical variables (e.g., BMI categories, education level, ART status) were compared using Chi-square or Fisher's exact test as appropriate. Pearson's correlation was used to assess associations between normally distributed continuous variables, and Spearman's correlation for non-normally distributed variables. To identify predictors of placental weight, we performed multivariable linear regression including BMI, HIV status (binary), and gestational age (continuous) as covariates. Interaction terms (BMI × HIV status) were initially tested but retained only if statistically significant. Variables were chosen based on biological relevance and results of univariate analyses ($p < 0.10$). Statistical significance was set at $p < 0.05$.

Ethical considerations

Ethical approval for this study was granted by the UUTH Health Research Ethics Committee (UUTH/AD/S/96/VOL.XII/115). All patient data were anonymized prior to analysis; due to the retrospective nature of the study, individual consent was not required.

Results

BMI associations with socio-demographic factors

A total of 143 pregnant women were included in the study: 48 (33.6%) HIV-positive and 95 (66.4%) HIV-negative. The average age was 29.4±4.6 years. The majority of both HIV-positive (89.5%) and HIV-negative (88.0%) participants weighed more than 65 kg and had a height above the average reference range of 1.56 to 1.62 meters, accounting for 48.6% HIV-positive and 53.2% HIV-negative mothers (Fig. 1).[49] HIV-negative women had significantly higher rates of tertiary education (66.3%) compared to HIV-positive women (50.0%, $p<0.05$). The overall prevalence of obesity (BMI≥30 kg/m²) was 62.2%, with 64.5% in HIV-negative and 58.8% in HIV-positive groups; with a non-significant $p = 0.616$. Civil/public service was more common among HIV-positive women (40.0%), while HIV-negative women exhibited greater occupational diversity; with a significant p-value of 0.014. Obesity was also common among traders (24.2%) and civil/public servants (24%), though the association was not statistically significant ($p=0.594$). Marriage predominated in both groups (95.7% HIV-positive, 98.9% HIV-negative), again with obesity being most common; with a non-significant $p=0.542$ (Table 1).

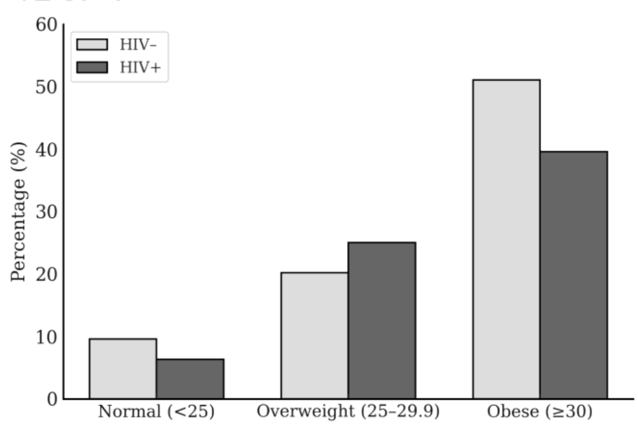

Fig. 1. Distribution of maternal BMI categories according to WHO classification (normal < 25 kg/m², overweight 25–29.9 kg/m², obese ≥ 30 kg/m²) among HIV-negative (n=95) and HIV-positive (n=48) pregnant women, data are shown as percentages (%)

Distribution/correlation of BMI and placental weight by HIV status

The mean BMI was slightly lower in HIV-positive women (31.65±6.47 kg/m²) compared to HIV-negative women (32.30±6.38 kg/m²); with a non-significant p-value of 0.627. Similarly, the mean placental weight was lower in HIV-positive (602.94±174.92 g) than in HIV-negative women (684.53±139.38 g); with a significant p =0.012 (Table 1). Most participants had placental weights above 540 g, especially in obese women (Fig. 2; see Table 1 for subgroup details). Also, across all placental weight categories, a weak positive correlation between BMI and placental weight was generally observed. In HIV-negative women, the positive association appeared slightly stronger, particularly in the normal and high placental weight groups. Conversely, among HIV-positive women, the correlation was less pronounced (Fig. 3). Overall, there is a weak positive correlation (r=0.17) between maternal body mass index (BMI) and placental weight. These patterns indicate that HIV status may influence how maternal BMI affects placental development, especially across different weight categories. Among HIV-positive mothers, most were in Stage 1 HIV (66.7%), followed by Stage 2 (27.1%), Stage 3 (2.1%), and Stage 4 (4.2%). Mean placental weight was highest in Stage 1 (604.69±174.76 g), followed by Stage 2 (569.23±177.41 g), Stage 3 (550.00 g; n=1), and Stage 4 (450.00±141.42 g; n=2). BMI was also highest in Stage 2 (32.55±12.28 kg/m²) and lowest in Stage 3 (28.91 kg/m²; n=1). Regarding ART status, 89.6% of HIV-positive mothers were on ART before pregnancy, with a mean placental weight of 593.02±177.14 g and mean BMI of 31.70±6.56 kg/m². Those not on ART before pregnancy (10.4%) had a lower mean placental weight (540.00±129.42 g) and mean BMI of 29.97 kg/m². These patterns suggest modest differences in placental weight and BMI across HIV stages and ART categories, though subgroup sizes, particularly for Stages 3 and 4, were small (Table 1).

Table 1. Maternal characteristics, BMI categories, and placental weight by HIV status[a]

Variable	HIV-negative (n=94)	HIV-positive (n=48)	p
Age (years), mean±SD	29.00±4.36	30.23±4.32	0.102
Tertiary education, n (%)	61 (64.9)	23 (47.9)	0.048[†]
Occupation – civil/public service, n (%)	28 (29.8)	10 (20.8)	0.238
BMI (kg/m²), mean±SD	32.46±6.50	31.65±6.47	0.521
BMI categories, n (%)			0.616
– Normal weight	9 (9.6)	3 (6.3)	
– Overweight	19 (20.2)	12 (25.0)	
– Obese	48 (51.1)	19 (39.6)	
Placental weight (g), mean±SD	678.83±137.58	587.50±172.44	0.004[‡]
Placental weight > 540 g, n (%)	82 (87.2)	31 (64.6)	0.006[‡]
HIV stage 1, n (%)	–	32 (66.7)	–

Mean placental weight (g) by HIV stage	–	Stage 1: 604.69±174.76 Stage 2: 569.23±177.41 Stage 3: 550.00 Stage 4: 450.00±141.42	0.632
Mean BMI (kg/m²) by HIV stage	–	Stage 1: 31.55±4.86 Stage 2: 32.55±12.28 Stage 3: 28.91 Stage 4: –	0.867
On ART before pregnancy, n (%)	–	43 (89.6)	–
Mean placental weight (g) by ART status	–	Yes: 593.02±177.14 No: 540.00±129.42	0.439
Mean BMI (kg/m²) by ART status	–	Yes: 31.70±6.56 No: 29.97	NA

[a] † – p<0.05, ‡ – p<0.01, NA – not applicable, Statistical comparison not possible due to insufficient sample size in the No ART group, BMI categories: normal weight (<25 kg/m²), overweight (25–29.9 kg/m²), obese (≥30 kg/m²), HIV stage defined per WHO clinical staging at antenatal booking, ART status reflects documented use before current pregnancy, p-values based on Chi-square tests (categorical) or independent-samples t-test (continuous)

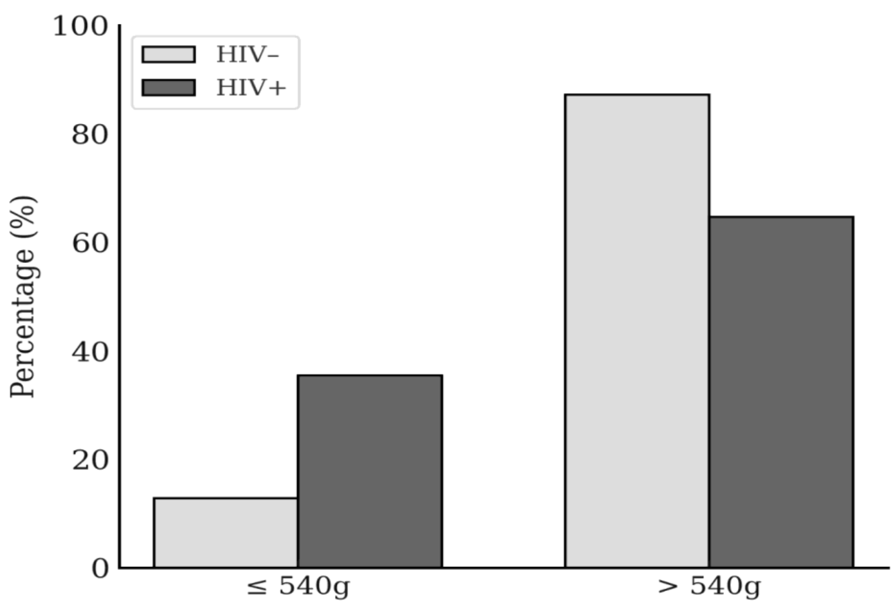

Fig. 2. Distribution of placental weight categories (≤ 540 g, > 540 g) among HIV-negative (n=95) and HIV-positive (n=48) pregnant women, data are presented as percentages (%), Chi-square p=0.006

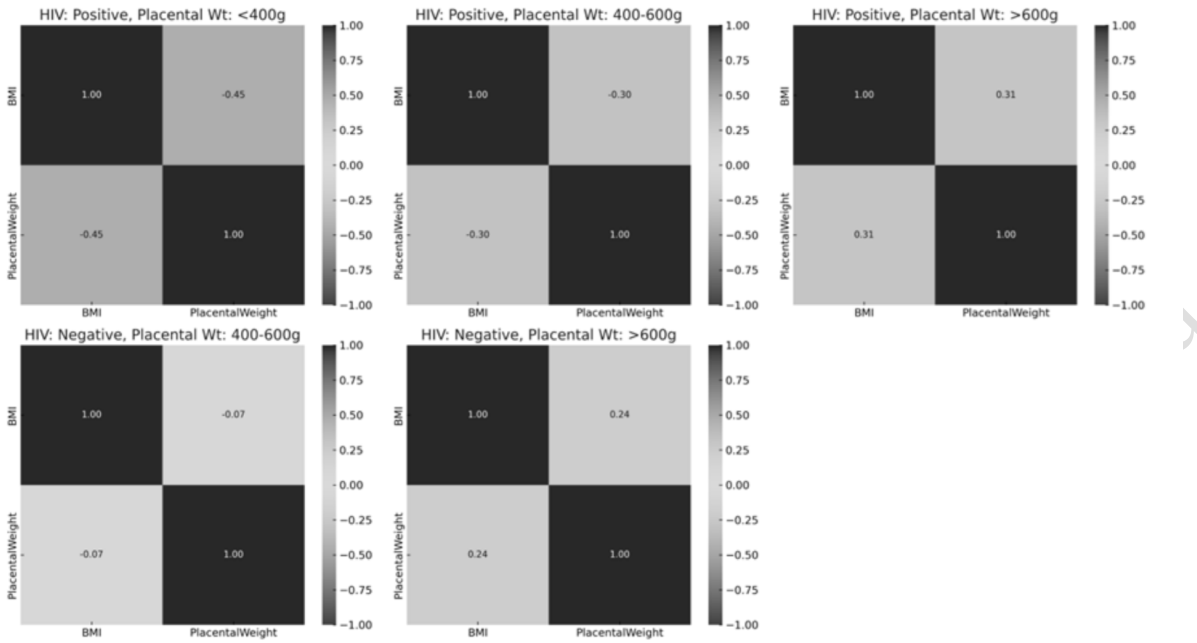

Fig. 3. Grouped correlation heatmaps showing Pearson's correlation coefficients between maternal BMI (kg/m^2) and placental weight (g), stratified by HIV status (HIV-positive: n=48; HIV-negative: n=95) and placental weight categories (<400 g, 400–600 g, >600 g), darker shades represent stronger positive correlations, whereas lighter shades represent weaker or negative correlations

Correlation of BMI with obstetrics/clinical variables

The relationship between maternal BMI and pregnancy loss indicators was examined separately for HIV-positive and HIV-negative women. In HIV-positive mothers, BMI demonstrated a weak inverse correlation with prior spontaneous miscarriage (r=-0.206, p=0.242), and a moderate inverse correlation with the number of induced abortions (Spearman's rho=-0.341, p=0.048), indicating that higher BMI may be associated with fewer reported induced abortions in this group. Among HIV-negative women, BMI showed a weak positive correlation with spontaneous miscarriage (r=0.210, p=0.069), which approached statistical significance, suggesting a possible trend towards increased miscarriage risk with higher BMI. The correlation between BMI and number of induced abortions in HIV-negative women was not statistically significant (Spearman's rho=0.145, p=0.212). These findings suggest differential associations between BMI and reproductive history based on HIV status, with significant implications for maternal risk profiling and antenatal care (Fig. 4). Furthermore, correlation analyses revealed a significant positive association between BMI and systolic blood pressure in HIV-negative women (r=0.591, p=0.020), but not in HIV-positive women (r=-0.111, p=0.859). Diastolic blood pressure in HIV-positive women showed a weak negative correlation with BMI (r=-0.584, p=0.302). Hence, no significant differences were observed in diastolic pressure (Fig. 5).

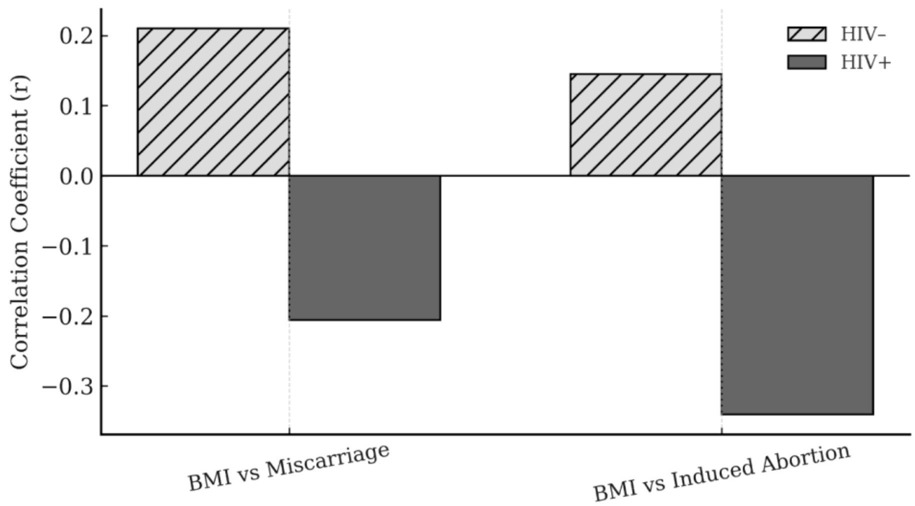

Fig. 4. Correlation coefficients (r) between maternal BMI (kg/m²) and pregnancy loss parameters (spontaneous miscarriage and induced abortion), stratified by HIV status (HIV-negative: n=95; HIV-positive: n=48), positive values represent direct associations, while negative values indicate inverse associations

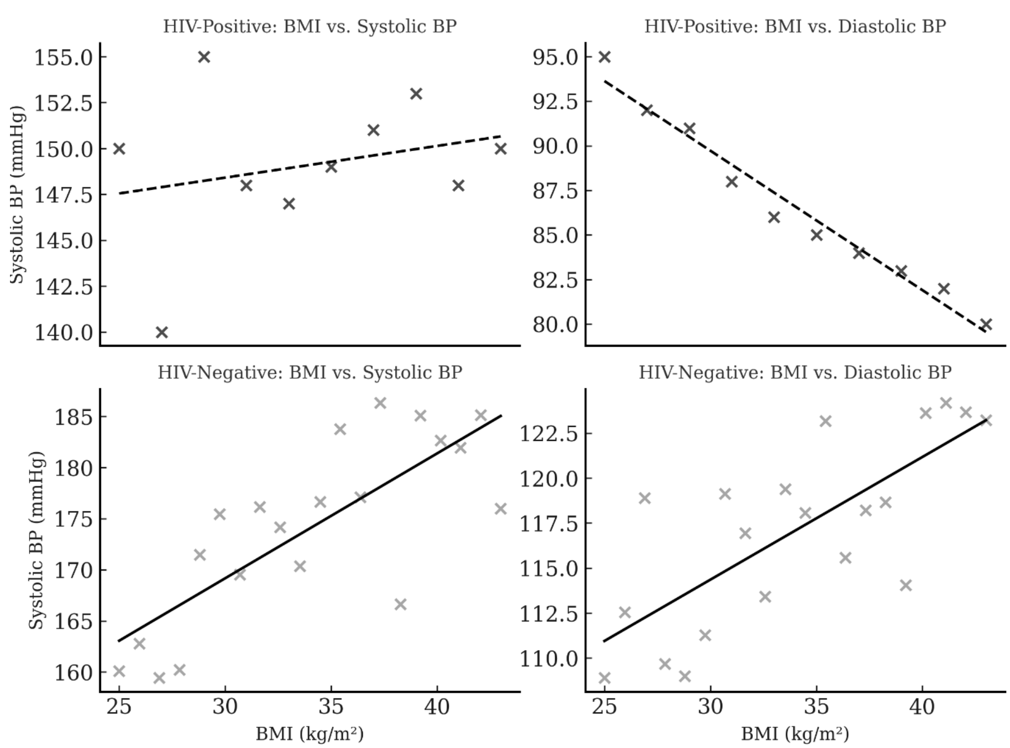

Fig. 5. Scatter plots showing the association between maternal BMI (kg/m²) and blood pressure (mmHg) stratified by HIV status (HIV-positive: n=48; HIV-negative: n=95), panels display systolic (left column)

and diastolic (right column) blood pressure, dashed regression lines represent HIV-positive participants, and solid lines represent HIV-negative participants

BMI, HIV status, and placental weight regression and subgroup analyses

To evaluate the independent associations between maternal BMI, HIV status, and placental weight, an ordinary least squares (OLS) regression was performed. The main regression model revealed that HIV-positive status was significantly associated with lower placental weight (β=-79.07, p=0.012), while maternal BMI showed a positive but non-significant association (β=3.90, p=0.087). The model explained approximately 8.6% of the variance in placental weight (R^2=0.086) (Table 2).

Subgroup analysis by HIV status showed differential effects. Among HIV-positive women, BMI was not a significant predictor of placental weight (β=4.71, p=0.325), while among HIV-negative women, a positive association between BMI and placental weight was observed but did not reach statistical significance (β=3.53, p=0.166). These findings suggest that the inverse association between HIV status and placental weight remains consistent regardless of maternal BMI, and that BMI may play a more prominent role in predicting placental weight among HIV-negative women (**Table 2**).

Furthermore, we performed a linear regression analysis to evaluate the independent contributions of maternal BMI and HIV status to postnatal placental weight, adjusting for gestational age (GA) at delivery. The model included BMI and GA as continuous variables, and HIV status as a binary variable. After adjusting for GA, gestational age emerged as a strong and statistically significant predictor of placental weight (p<0.001). HIV-positive status was independently associated with lower placental weight (β=-0.248, p=0.016), while BMI demonstrated a positive but non-significant association with placental weight (β=0.146, p=0.151). Notably, the interaction term between HIV status and BMI was not statistically significant, suggesting that HIV status did not modify the relationship between BMI and placental weight (Table 3). These findings highlight the importance of adjusting for gestational age in placental weight analyses and suggest that HIV infection may exert a modest but independent effect on placental development.

Table 2. Multivariable regression analysis and stratified subgroup models for the association between maternal BMI, HIV status, and placental weight[a]

Main regression analysis: effect of BMI and HIV status on placental weight					
Variable	Coefficient	Std. Error	t-Statistic	p	95% CI
Intercept	558.5193	75.07	7.44	0.0	409.687–707.352
BMI	3.9019	2.262	1.725	0.087	-0.582–8.386
HIV-positive	-79.0723	31.018	-2.549	0.012	-140.568–-17.577
Subgroup regression analysis: HIV-positive women					

Variable	Coefficient	Std. Error	t-Statistic	p	95% CI
Intercept	453.9805	151.971	2.987	0.005	144.427–763.534
BMI	4.7066	4.707	1.0	0.325	-4.882–14.295
Subgroup regression analysis: HIV-negative women					
Variable	Coefficient	Std. Error	t-Statistic	p	95% CI
Intercept	570.4459	83.092	6.865	0.0	404.843–736.049
BMI	3.5326	2.525	1.399	0.166	-1.499–8.565

[a] standard errors assume that the covariance matrix of the errors is correctly specified

Table 3. A table illustrating a linear regression model assessing the relationship between maternal BMI, HIV status, and GA on placental weight

Unstandardized regression coefficients from the gestational age-adjusted linear regression model analysis predicting placental weight				
Variable	Coefficient	Std. Error	t-Statistic	p
Intercept	-235.55	306.57	-0.768	0.444
BMI	3.641	2.266	1.607	0.111
HIV-positive	-67.44	33.002	-2.043	0.044
Gestational age (GA)	20.759	7.783	2.667	0.009

Standardized β coefficients from the regression model, adjusting for gestational age and HIV status		
Predictor	Standardized β	p
BMI	0.146	0.151
HIV-positive	-0.248	0.016
GA (in weeks)	0.497	<0.001

Discussion

This study aimed to investigate the association between antenatal booking body mass index (BMI) and postnatal placental weight among HIV-positive and HIV-negative pregnant women receiving care at the University of Uyo Teaching Hospital, Nigeria. Our key findings affirm that HIV status, BMI, and placental weight are interrelated, with significant implications for maternal and fetal outcomes. Through stratified analysis and regression modeling, this study elucidates the differential impact of HIV status on nutritional and placental health, and how socio-demographic and clinical factors interplay in this context. The novelty of our study lies in being, to our knowledge, the first Nigerian investigation to jointly assess maternal BMI, HIV status, and placental weight while adjusting for gestational age. This approach provides a more robust understanding of how HIV modifies placental growth independent of gestational length, addressing a critical evidence gap in sub-Saharan Africa.

HIV-positive and HIV-negative pregnant women differed in BMI, placental weight, educational attainment, and occupation. Consistent with earlier studies by Bodkin et al., Isah et al., and Ladner et al., our results reveal that HIV-positive pregnant women tended to have lower mean BMI (31.65±6.47 kg/m²) and placental weight (602.94±174.92 g) than their HIV-negative counterparts (32.46±6.50 kg/m² and 684.53±139.38 g, respectively).[11,36,37] GA-adjusted regression analysis confirmed HIV status as a statistically significant predictor of placental weight, while BMI showed a positive but non-significant association. Subgroup regression revealed that BMI had a significant effect on placental weight among HIV-negative women, but not among HIV-positive women.

These results support findings by Bengtson et al. and Erasmus et al., who observed that HIV-positive status is frequently accompanied by metabolic dysregulation, suboptimal nutritional states, and altered placental physiology.[19,31] The lower placental weight in HIV-positive pregnancies may be suggestive of compromised placental development. However, since our study did not assess birth outcomes directly, this hypothesis warrants further investigation.

BMI distribution also correlated with educational and occupational status. HIV-negative women had a higher proportion of tertiary education (66.3%) compared to HIV-positive women (50%). They were also more likely to be employed in civil/public service roles, whereas HIV-positive women were predominantly traders. These patterns reflect socio-economic disparities that may influence nutritional status and health outcomes, echoing trends reported by Bengtson et al., Erasmus et al., and Trindade et al., in their studies.[3,19,31,34]

Blood pressure patterns varied across HIV status. A statistically significant positive correlation was observed between systolic blood pressure and BMI in HIV-negative women ($r=0.591$, p-value=0.020), while no such correlation was found in HIV-positive women. This may reflect early differences in cardiovascular regulation, though our blood pressure data alone cannot confirm broader cardiovascular risk.

Our analysis demonstrated a weak overall correlation between BMI and placental weight, but subgroup and regression analyses clarified a more complex relationship moderated by HIV status and gestational age. Several studies have associated maternal HIV with poor placental morphology and function, contributing to adverse perinatal outcomes such as intrauterine growth restriction and low birth weight.[7,11,17,18,25,34,39,50] While we did not assess such outcomes, our findings emphasize the need for further research in this area.

These findings support multifaceted interventions, such as targeted nutrition programs, specialized antenatal clinics, integrated care services, and educational outreach, to address both biomedical and social determinants of health in HIV-positive pregnancies.[10,40–43,50] Training healthcare providers to recognize and mitigate HIV-related nutritional and cardiovascular risks is also vital. By examining BMI–placental weight relationships stratified by HIV status and controlling for gestational age, our study contributes new evidence that can guide region-specific antenatal nutritional and HIV care programs.

Study limitations

This study's cross-sectional design limits causal inference. Reliance on medical records constrained the inclusion of variables such as gestational weight gain, anemia, and detailed obstetric outcomes. Additionally, qualitative data that could contextualize socio-demographic differences were absent. Future longitudinal and mixed-methods studies should assess temporal nutritional trajectories and explore mechanisms linking HIV to placental pathophysiology.

Conclusion

This study provides critical insights into how antenatal BMI and placental weight vary with HIV status among pregnant women in Uyo, Nigeria. After adjusting for gestational age, HIV status remained significantly associated with lower placental weight. BMI demonstrated a positive but non-significant association. These findings underscore the need for further research into placental health and maternal nutrition in HIV-affected pregnancies. Tailored antenatal interventions that address nutritional, educational, and socio-economic disparities may improve maternal and fetal outcomes, particularly in resource-limited settings.

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Declarations

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Author contributions

Conceptualization, U.B.E., O.O.A. and N.M.U.; Methodology, U.B.E.; Software, U.B.E. and O.O.A.; Validation, U.B.E., M.W.R., I.J.K., C.O.N., N.M.U., O.O.A, E.O.E., E.D.E. and I.O.C.; Formal Analysis, U.B.E. and O.O.A.; Investigation, U.B.E., O.O.A. and N.M.U.; Resources, U.B.E., M.W.R., I.J.K., C.O.N., N.M.U., O.O.A, E.O.E., E.D.E., I.E.A. and I.C.O.; Data Curation, U.B.E. and O.O.A.; Writing – Original Draft Preparation, U.B.E., M.W.R., I.J.K., C.O.N., N.M.U., O.O.A, E.O.E., E.D.E., I.E.A. and I.C.O.; Writing – Review & Editing, U.B.E., M.W.R., I.J.K., C.O.N., N.M.U., O.O.A, E.O.E., E.D.E., I.E.A. and I.C.O.; Visualization, U.B.E. and O.O.A.; Supervision, U.B.E.; Project Administration, U.B.E.; Funding Acquisition, U.B.E., M.W.R., I.J.K., C.O.N., N.M.U., O.O.A, E.O.E., E.D.E., I.E.A. and I.C.O.

Conflicts of interest

The author(s) declare no competing interests.

Data availability

All data generated or analyzed during this study are included in this published article.

Ethics approval

This study was conducted in accordance with the Declaration of Helsinki, and its ethical approval was granted by the UUTH Health Research Ethics Committee (UUTH/AD/S/96/VOL.XII/115).

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