



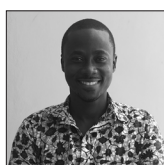
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ORIGINAL ARTICLE INFANT HEALTH

Prevalence and Predictors of Mother-to-Child Transmission of Human Immunodeficiency Virus (HIV) among HIV-exposed Infants

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ABSTRACT

Background and Objective: There is a global effort to eliminate new human immunodeficiency virus (HIV) infections among children. However, mother-to-child transmission (MTCT) of HIV, which accounts for nearly all pediatric infections, remains disproportionately high in Africa, including Ghana. This study aims to determine the prevalence and identify the key predictors of MTCT of HIV among HIV-exposed infants in the Ashanti Region of Ghana.

Methods: A retrospective cohort analysis of routine follow-up records of HIV-infected mothers and their exposed infants was conducted between August 2023 and June 2024 in four hospitals. A convenient consecutive sampling technique was employed to include exposed infants who were at least 18 months old, had ceased breastfeeding, and had definite HIV test results. A structured form was used to collect sociodemographic, clinical, and treatment data of mother-infant pairs. The data were entered into an Excel sheet and exported to STATA version 17.0 for analysis. Bivariate and multivariate logistic regression models were used to determine key predictors of MTCT.

Results: Out of the 220 records reviewed, 24 infants tested positive for HIV, giving an overall prevalence of 10.9%. The prevalence was 17.5% (21/120) among participants living in rural communities, compared to 0.03% (3/100) in urbanized areas. Maternal viral load ≥ 1000 copies/mL (adjusted odds ratio [aOR]: 13.13; 95% confidence interval [CI]: 2.75–62.69), no antiretroviral (ARV) prophylaxis in infant (aOR: 11.05; 95% CI: 2.18–55.91), and mixed feeding during the first 6 months of life of the infant (aOR: 5.65; 95% CI: 1.34–23.87) were the main predictors of MTCT of HIV.

Conclusion and Global Health Implications: The prevalence of MTCT of HIV is high, especially in rural settings. Eliminating MTCT will require effective maternal viral suppression through optimal ART adherence, ensuring prompt ARV prophylaxis for infants at birth and promoting safer feeding practices during the infant's first 6 months of life.

Keywords: Ghana, HIV Infections, HIV-exposed Infants, Infant Health, Mother-to-child transmission, Predictors, Prevalence

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INTRODUCTION

The primary mode by which infants contract the human immunodeficiency virus (HIV) is through the mother-to-child transmission (MTCT) route.^[1] It is responsible for more than 90% of pediatric HIV infections and remains disproportionately high in Africa.^[2]

The passage of the virus from an infected mother to the baby occurs during gestation, delivery, or breastfeeding.^[3] If no intervention is applied, the transmission risk is estimated at 15–45%.^[1] The primary intervention to prevent MTCT of HIV involves the use of antiretroviral therapy (ART) to achieve viral suppression before conception, during gestation, and throughout lactation, complemented by infant antiretroviral (ARV) prophylaxis initiated immediately after birth.^[4] Since 2011, global efforts have led to increased access to ART and other preventive services.^[5] Between 2010 and 2022, these efforts contributed to a 58% reduction in new HIV infections among children.^[6] However, there has been a stagnation in the progress toward the elimination of MTCT of HIV, with a significant proportion of infections occurring during the breastfeeding period.^[7]

MTCT is the second most common mode of HIV transmission in Ghana, following sexual transmission, and is responsible for nearly all cases among children below 15 years of age.^[8] At 13%, Ghana ranks among the countries with the highest MTCT rate.^[6] Following Ghana's adoption of the World Health Organization (WHO)'s "Treat All" policy, there has been a scale-up of interventions aimed at eliminating new HIV infections among children. Key among these strategies include HIV testing of every pregnant woman and the rapid start of ART in all populations who test positive, including pregnant women. Additional measures include providing ARV prophylaxis for all infants born to HIV-infected mothers, promoting safer infant feeding practices, and ensuring prompt HIV testing and treatment among infants.^[9] Even though the country has made substantial progress in lowering the MTCT of HIV, it is still far from its target of <5%.^[10] However, a limited number of studies have been conducted in this area in Ghana, and those that do exist have mostly taken place in tertiary hospitals in urban centers, where access to HIV services is relatively high.

Identifying the key factors that contribute to vertical transmission is critical for informing the design of context-specific interventions to eliminate pediatric HIV infections. The study aims to assess the prevalence and predictors of MTCT of HIV among HIV-exposed infants in the urban and periurban areas of the Ashanti region of Ghana.

METHODS

Study Design and Participants

The study is a retrospective cohort study. It included all eligible HIV-infected mothers and their at-risk infants who registered at the HIV treatment centers between 2016 and 2022. We used a structured data collection form to extract secondary data from routine follow-up records of these mothers and their exposed infants. The data were collected between August 2023 and June 2024. The data collected include the mother's sociodemographic characteristics, clinical details, obstetric history, and the exposed infant's demographic and clinical data. In addition, we collected results of HIV laboratory investigations and details of treatment provided to both the mother and the exposed infant.

Study Setting

The research was carried out in four public hospitals across the Ashanti region of Ghana, which is situated in the middle belt of the country and comprises 43 districts. It is the most populous region in Ghana. Two of the hospitals, Effiduase District Hospital and Juaben Government Hospital (JGH), located in periurban areas, primarily serve patients from surrounding rural communities within the Sekyere East and Juaben Municipal districts, respectively. The other two hospitals, Kumasi South Hospital (KSH) and Kwame Nkrumah University of Science and Technology Hospital (KNUSTH), are situated in the urban areas and cater for patients mainly within the Kumasi metropolis.

Inclusion and Exclusion Criteria

The study utilized data from HIV-infected mothers and their at-risk infants aged 18 months or older who had undergone confirmatory HIV testing following the cessation of breastfeeding. If a rapid antibody test was used for the confirmation, it should have been done at least 6 weeks following the discontinuation of breastfeeding. Data of HIV-infected mothers with missing key variables, HIV-exposed infants still breastfeeding, those without confirmatory HIV testing after breastfeeding cessation, and those with indeterminate test results were not included.

Sample Size Calculation

The sample size ($n = 220$) was calculated using the single population proportion formula, with a 95% confidence interval, a 5% margin of error, and an expected 13% MTCT rate of HIV among exposed infants, based on the 2022 WHO prevalence estimates.^[6]

Data Analysis

We analyzed the data using STATA version 17 (StataCorp. [2021]. Stata Statistical Software: Release 17. College Station, TX: StataCorp LLC) after cleaning. The data were reported in accordance with the STROBE reporting guideline. We expressed categorical variables as counts and percentages, whereas continuous variables were expressed as mean and standard deviation. Associations between variables and the HIV outcome of the exposed infant were analyzed using Fisher's exact test. We used bivariate and multivariate logistic regression analysis to determine the predictors of HIV infection among the exposed infants. All variables showing a *p*-value below 0.05 in the bivariate analysis were subsequently included in the multivariate analysis. Those that maintained a *p*-value below 0.05 in the multivariate model were identified as the key determinants of MTCT of HIV.

RESULTS

Sociodemographic, Clinical, and Obstetric Characteristics of the HIV-Infected Mothers

We reviewed and included data from 220 mother-infant pairs, comprising 73 records from KSH, 52 records from KH, 39 records from EGH, and 56 records from JGH. The sociodemographic, clinical, and obstetric characteristics of the mothers are summarized in Table 1. The mothers had a mean age of 33 years (± 6.7). More than half (54.5%) lived in rural areas. Regarding marital status, the majority (62.3%) were married, 17.7% were single, 14.5% were cohabitating, and 5.5% were divorced or separated. Most of the mothers (85.9%) had some level of formal education. The majority (82.3%) identified as Christian. Among the 220 mothers, only 32 (14.5%) were unemployed.

Routine clinical and obstetric data of the mothers at both baseline and follow-ups were collected. Out of the 220 mothers, 123 (56%) were diagnosed with HIV after pregnancy, and the remaining, i.e., 97 were known HIV patients on ART who became pregnant. At diagnosis, 211 (95.9%) were at WHO HIV clinical stage I or II (mild stage), and 9 (4.1%) were at stage III (advanced stage). At baseline, only 17 (7.7%) had opportunistic infections, including respiratory tract infections, abscesses, oral candidiasis and ulcers, severe weight loss, herpes zoster, and other skin rashes. After 6 months of ART, viral load test results for 218 mothers showed that 183 (84%) achieved viral suppression, defined as achieving a viral load of 1000 copies of virus per milliliter of blood, while the remaining 16% had viral loads exceeding this threshold. Nearly all mothers (97.3%) delivered in a health facility, with the majority (85%) having vaginal deliveries while 33 (15%) delivered through cesarean section.

Characteristics of the HIV-exposed Infants and the Prevalence of MTCT of HIV

Among the exposed infants, 51% were males and 49% were females. Most infants (58%) had a birth weight between 2 and 3 kg, while 32% weighed 3.1–4 kg. A smaller proportion weighed <2 kg (3%) or more than 4 kg (7%). At birth, 199 infants (90%) received ARV prophylaxis, while 21 (10%) did not. During the first 6 months of life, 164 infants (74%) were exclusively breastfed, 6 (3%) were fed with only infant formula, and 50 (23%) received both breast milk and other foods. These results are presented in Table 2.

Out of the 220 HIV-exposed infants, 24 tested positive for HIV, giving an overall prevalence of 10.91%. The prevalence was 17.5% (21/120) among participants living in rural communities and 0.03% (3/100) among those in urbanized areas.

Predictors of MTCT of HIV

The bivariate analysis identified statistically significant associations between MTCT of HIV and several factors. In the multivariate logistic regression model, three factors emerged as the main determinants of MTCT of HIV. They are maternal viral load >1000 copies/mL at 6 months post-ART initiation (adjusted odds ratio [aOR]: 13.13; 95% confidence interval [CI]: 2.75–62.69); ARV prophylaxis not given in the infant (aOR: 11.05; 95% CI: 2.18–55.91); and mixed feeding (breastfeeding combined with other feeds) during the infant's first 6 months of life (aOR: 5.65; 95% CI: 1.34–23.87) [Table 3].

DISCUSSION

The prevalence of HIV infection among the infants studied was 10.91%, marginally lower than the national estimate of 13% reported in the 2022 WHO statistics.^[6] The observed difference may reflect a modest improvement in the transmission rate or regional variations, as the study was conducted only within the Ashanti region of Ghana. Notably, the prevalence of HIV infection was significantly higher among infants from rural communities (17.5%, 21/120) compared to those from urbanized areas (0.03%, 3/100). This disparity underscores the impact of inequities in access to and adherence to prevention of MTCT (PMTCT) services. Similar findings have been reported in Southern and Eastern Ethiopia.^[11,12] Factors attributed to this elevated risk include limited access to comprehensive PMTCT interventions, delayed enrollment into care, and mixed feeding practices during early infancy.

The observed prevalence is higher than the WHO global target of <5% in breastfeeding populations.^[13] While Ghana has made some progress, our findings suggest that achieving

Table 1: Sociodemographic, clinical, and obstetric characteristics of HIV-infected mothers and HIV outcome of their exposed infants (n=220).

Variables	Frequency (n, %)	HIV test results of infants		P-value
		Negative (n, %)	Positive (n, %)	
Age				
15–24	25 (11.4)	22 (88)	3 (12)	N/A
25–34	113 (51.4)	104 (92)	9 (8)	
≥35	82 (37.3)	70 (85.4)	12 (14.6)	
Residence				
Urban	100 (45.5)	97 (97)	3 (3)	<0.001
Rural	120 (54.5)	99 (82.5)	21 (17.5)	
Marital status				
Married	137 (62.3)	133 (97.1)	4 (2.9)	N/A
Divorced/Separated	12 (5.5)	7 (58.3)	5 (41.7)	
Single	39 (17.7)	34 (87.2)	5 (12.8)	
Cohabitating	32 (14.5)	22 (68.8)	10 (31.2)	
Education				
Educated	189 (85.9)	167 (88.4)	22 (11.6)	0.308
Not educated	31 (14.1)	29 (93.5)	2 (6.5)	
Religion				
Christian	183 (83.2)	160 (87.4)	23 (12.6)	N/A
Muslim	35 (15.9)	34 (97.1)	1 (2.9)	
Other	2 (0.9)	2 (100)	0 (0)	
Occupational status				
Employed	188 (85.5)	167 (88.8)	21 (11.2)	0.526
Unemployed	32 (14.5)	29 (90.6)	3 (9.4)	
Time of HIV diagnosis				
Before pregnancy	97 (44.1)	95 (97.9)	2 (2.1)	<0.001*
After pregnancy	123 (55.9)	101 (82.1)	22 (17.9)	
WHO HIV clinical stage at diagnosis				
Mild	211 (95.9)	188 (89.1)	23 (10.9)	0.654
Advanced	9 (4.1)	8 (88.9)	1 (11.1)	
Presence of opportunistic infections at diagnosis				
Absent	203 (92.3)	184 (90.6)	19 (9.4)	0.025*
Present	17 (7.7)	12 (70.6)	5 (29.4)	
Time of starting ART				
Before pregnancy	96 (43.6)	94 (97.9)	2 (2.1)	<0.001*
After pregnancy	124 (56.4)	102 (82.3)	22 (17.7)	
Disclosure to the male partner				
Yes	138 (64.8)	126 (91.3)	12 (8.7)	0.134
No	75 (35.2)	64 (85.3)	11 (5.2)	
Viral load 6 months after ART initiation				
Suppressed (<1000 copies/mL)	183 (83.9)	175 (80.3)	8 (14.7)	<0.001*
Not suppressed (≥1000 copies/mL)	35 (16.1)	19 (54.3)	16 (45.7)	

(Contd...)

Table 1: (Continued).

Variables	Frequency (n, %)	HIV test results of infants		P-value
		Negative (n, %)	Positive (n, %)	
Parity				
1–2	96 (44.2)	85 (88.5)	11 (11.5)	N/A
3–5	118 (54.4)	105 (89)	13 (11)	
>5	3 (1.4)	3 (100)	0 (0)	
Place of delivery				
Health facility	214 (97.3)	192 (87.9)	22 (12.1)	0.130
Home	6 (2.7)	4 (66.7)	2 (33.3)	
Mode of delivery				
Vaginal delivery	187 (85)	165 (88.2)	22 (11.8)	0.264
Cesarean section	33 (15)	31 (93.9)	2 (6.1)	
Postnatal follow-up				
Yes	208 (97.7)	186 (89.4)	22 (10.6)	0.438
No	5 (2.3)	4 (80)	1 (20)	
P-value represents Fisher’s exact test. *P<0.05. HIV: Human immunodeficiency virus, WHO: World Health Organization, ART: Antiretroviral therapy, N/A: Not applicable.				

Table 2: Characteristics of HIV-exposed infants (n=220).

Variables	Frequency (n, %)	HIV test results of infants		P-value
		Negative (n, %)	Positive (n, %)	
Sex of baby				
Male	110 (50.9)	95 (86.4)	15 (13.6)	0.162
Female	106 (49.1)	97 (91.5)	9 (8.5)	
Birth weight				
<2 kg	5 (2.7)	3 (60)	2 (40)	N/A
2–3 kg	108 (57.8)	97 (89.8)	11 (10.2)	
3.1–4 kg	61 (32.6)	59 (96.7)	2 (3.3)	
>4 kg	13 (7)	11 (84.6)	2 (15.4)	
Antiretroviral prophylaxis given				
Yes	199 (90.5)	190 (95.5)	9 (4.5)	<0.001*
No	21 (9.5)	6 (28.6)	15 (71.4)	
Type of antiretroviral prophylaxis given				
Zidovudine+Nevirapine	144 (73.5)	136 (94.4)	8 (5.6)	N/A
Zidovudine only	28 (14.3)	27 (96.4)	1 (3.6)	
Nevirapine only	24 (12.2)	24 (100)	0 (0)	
Feeding options for the first 6 months of life				
Exclusive breastfeeding	164 (74.6)	157 (95.7)	7 (4.3)	N/A
Infant feeds only	6 (2.7)	6 (100)	0 (0)	
Mixture	50 (22.7)	33 (66)	17 (34)	
Feeding options after 6 months of life				
Exclusive breastfeeding	10 (4.5)	10 (100)	0 (0)	N/A
Infant feeds only	10 (4.5)	8 (80)	2 (20)	
Mixture	200 (91)	178 (89)	22 (11)	
P-value represents Fisher’s exact test. *P<0.05. HIV: Human immunodeficiency virus, WHO: World Health Organization, N/A: Not applicable.				

Table 3: Bivariate and multivariate analysis of predictors of MTCT of HIV.

Variables	cOR (95% CI)	p-value	aOR (95% CI)	P-value
Age				
15–24	1			
25–34	0.63 (0.16–2.54)	0.520		
≥35	1.26 (0.32–4.86)	0.740		
Residence				
Urban	1		1	
Rural	6.86 (1.98–23.74)	0.002*	3.17 (0.49–20.37)	0.223
Marital status				
Married	1		1	
Divorced/Separated	23.75 (5.20–108.44)	<0.001*	1.74 (0.16–18.73)	0.646
Single	4.89 (1.25–19.20)	0.023*	1.55 (0.26–9.45)	0.633
Cohabiting	15.11 (4.36–52.45)	<0.001*	4.98 (0.86–28.76)	0.073
Education				
Educated	1			
Not educated	0.52 (0.12–2.35)	0.398		
WHO clinical stage at diagnosis				
Mild	1			
Advanced	1.02 (0.12–8.54)	0.984		
Presence of opportunistic infections at diagnosis				
Absent	1		1	
Present	4.04 (1.28–12.68)	0.017*	1.48 (0.10–22.18)	0.778
Time of starting ART				
Before pregnancy	1		1	
After pregnancy	10.14 (2.32–44.28)	0.002*	5.79 (0.50–66.92)	0.159
Viral load 6 months after ART initiation				
Suppressed (<1000 copies/mL)	1		1	
Not suppressed (≥1000 copies/mL)	18.42 (6.97–48.68)	<0.001*	13.13 (2.75–62.69)	0.001*
Place of delivery				
Health facility	1			
Home	4.36 (0.76–25.20)	0.100		
Mode of delivery				
Vaginal delivery	1			
Cesarean section	0.48 (0.11–2.16)	0.342		
Antiretroviral prophylaxis given				
Yes	1		1	
No	52.78 (16.56–168.20)	<0.001*	11.05 (2.18–55.91)	0.004*
Feeding options for the first 6 months of life				
Exclusive breastfeeding	1		1	
Infant feeds only	1		1	
Mixture	11.55 (4.44–30.08)	<0.001*	5.65 (1.34–23.87)	0.019*

* $P < 0.05$. MTCT: Mother-to-child transmission, HIV: Human immunodeficiency virus, aOR: Adjusted odds ratio, cOR: Crude odds ratio, CI: Confidence interval, WHO: World Health Organization.

this milestone remains a challenge. Similar challenges are evident across sub-Saharan Africa, where MTCT rates range

from 2% to over 15%, depending on the effectiveness and coverage of PMTCT interventions.^[14]

Regarding the key determinants of MTCT of HIV, maternal viral load ≥ 1000 HIV copies/mL at 6 months post-ART initiation increased the odds of MTCT of HIV by thirteen-fold compared to mothers with viral suppression (< 1000 copies/mL). Several studies have reported that maintaining viral suppression can lower transmission rates to below 1%, even in resource-limited settings.^[15-18] A study with a large sample size conducted in Malawi showed that maternal viral suppression is the most significant factor associated with the MTCT of HIV.^[15] The transmission rate has been shown to decrease to approximately 0.5% among women with viral loads below this threshold, in contrast to rates as high as 7.5% among those with viral loads exceeding 10,000 copies/mL.^[15,17]

Additionally, infants who were not given ARV prophylaxis had a markedly elevated risk of MTCT, with an 11.05-fold increase compared to those who received prophylaxis. This aligns with evidence from studies in Ethiopia,^[19] Nigeria,^[20] and Malawi.^[21] It is also consistent with global guidelines^[22] and evidence from other recommendations,^[7,23] which shows that the timely provision of ARV prophylaxis considerably reduces the risk of postnatal transmission, particularly when maternal ART is not optimally managed. Ensuring access and strengthening adherence to prophylactic regimens remain a critical component of PMTCT programs.

Another key predictor of MTCT was mixed feeding practices during the first 6 months of infancy. It was associated with a 5.65-fold increase in the odds of MTCT compared to exclusive breastfeeding. Similar findings have been reported in studies from Ethiopia,^[24,25] South Africa,^[26] and Lesotho,^[27] highlighting that mixed feeding remains a challenge in many African countries despite educational interventions. Mixed feeding introduces a significant risk of HIV transmission due to the potential for intestinal inflammation and mucosal barrier disruption caused by non-human milk or complementary feeds.^[28] WHO guidelines^[29] strongly recommend exclusive breastfeeding during the initial 6 months of an infant's life, accompanied by maternal ART to achieve viral suppression, as the safest infant feeding strategy in resource-limited settings.

In our study, infants born to mothers with advanced WHO clinical stages at baseline were not at higher risk of HIV infection. This contrasts with findings from Southern Ethiopia.^[30] The difference may be attributed to the low proportion ($< 5\%$) of mothers with advanced HIV stage at baseline in our study. It could also be attributed to the prompt initiation of ART, which is effective in achieving viral suppression and improving maternal clinical status before conception or delivery.

Other potential risk factors, such as the mode of delivery, the delivery settings, and the infant's sex, were not significantly associated with MTCT in this study. Similar findings have

been reported in studies from Nigeria^[16] and Mozambique,^[18] suggesting that these factors may play a less critical role in MTCT when robust PMTCT programs are implemented.

Limitations of the study

Since the study utilized secondary data, missing or inconsistent entries posed challenges to the quality and comprehensiveness of the dataset. To address this, data with missing values for key variables were excluded. While this approach ensured the validity of the results, it inadvertently reduced the sample size, affecting the power of the study and the precision of the estimates.

Availability of Data and Materials

The dataset used in this manuscript can be made available by the corresponding authors upon reasonable request.

CONCLUSION AND GLOBAL HEALTH IMPLICATIONS

The high prevalence of MTCT of HIV underscores challenges in eliminating MTCT in Ghana. To achieve substantial reductions, strategies should be implemented to improve maternal adherence to ART, ensure timely administration of ARV prophylaxis to infants, and promote exclusive breastfeeding practices during the critical early months of life. Additionally, enhancing access to PMTCT services in rural communities is essential to address disparities in healthcare delivery.

Key Messages

- 1) The elimination of MTCT of HIV in Ghana faces several challenges, including high viral loads among HIV-infected pregnant women due to suboptimal ART adherence, inadequate provision of ARV prophylaxis for HIV-exposed infants, and the practice of mixed feeding during the first 6 months of the infant's life.
- 2) High viral load due to suboptimal ART adherence is strongly associated with MTCT.
- 3) Lack of ARV prophylaxis and mixed feeding in early infancy play important roles in HIV MTCT risk.
- 4) Interventions should be targeted at improving ART adherence throughout pregnancy and the postpartum period, ensuring the provision of adequate ARV prophylaxis immediately after birth, and promoting exclusive breastfeeding during the first 6 months of the infant's life to reduce MTCT rates.

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COMPLIANCE WITH ETHICAL STANDARDS

Conflicts of Interest: The authors declare no competing interests. **Financial Disclosure:** Nothing to declare. **Funding/Support:** There was no funding for this study. **Ethics Approval:** The research/study was approved by the Institutional Review Board at The Committee on Human Research, Publication, and Ethics, School of Medicine and Dentistry, number CHRPE/AP/731/22, dated November 01, 2022. **Declaration of Patient Consent:** The authors certify they have obtained all appropriate patient consent. **Use of Artificial Intelligence (AI)-Assisted Technology for Manuscript Preparation:** The authors confirm that there was no use of artificial intelligence (AI)-assisted technology for assisting in the writing or editing of the manuscript, and no images were manipulated using AI. **Disclaimer:** None.

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