Barriers to early infant diagnosis of HIV in the Wa Municipality and Lawra District of Upper West Region, Ghana

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SUMMARY

Objective: We identified socio-demographic, health system and psycho-social barriers to Early Infant Diagnosis (EID) of HIV in the Upper West Region of Ghana.
Design: An unmatched case control study of 96 cases and 96 controls was conducted in the ART centers in Lawra district and Wa Municipality between December 2014 and April 2015.
Setting: A public health facility
Participants: We defined a case as an HIV positive mother with an exposed infant who received EID service between January 2011 and December 2014. A control was defined as HIV Positive Mother with an exposed infant who did not receive EID services between January 2011 and December 2014.
Main outcome: EID by dry blood spot Deoxyribonucleic acid Polymerase chain reaction.
Results: A total of 192 mother-infant pairs were assessed. The mean age of infants at testing for cases was 17.3 ± 14.9 weeks. Mother-to-child-transmission-rate was 2.3%. Factors associated with EID testing included: mother being formally employed (cOR=2.0: 95%CI:1.1-3.8), maternal formal education (cOR=2.0, 95%CI: 1.1-3.6) and maternal independent source of income (cOR 2.2, 95%CI 1.2-4.1). After adjusting for confounders, maternal independent income source was associated with EID testing (aOR 2.2, 95%CI 1.2-4.1). Median turn-around time of EID result was 11 weeks (IQR 4-27weeks).
Conclusion: Women need to be empowered to gain an independent source of income. This can help maximize the benefits of e-MTCT and increase EID in the Upper West Region of Ghana.

Keywords: Barriers, HIV, early infant diagnosis, DNA-PCR, Ghana
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INTRODUCTION

An estimated 35.3 million people are living with HIV globally with approximately 70% of all infections believed to occur in Africa.[1,2] Transmission of HIV is mainly through sex, however, among children and infants less than 14 years, 90% of infections are transmitted from mother to the child. It is estimated that 14% of all new HIV infections that occur daily are among infants. Evidence from the Children living with HIV Early antiretroviral therapy (CHER) study of South Africa and others suggest that with effective elimination of mother to child transmission programs (e-MTCT), new infections among exposed infants could be reduced from 40% to less than 5%.[3-5] Based on evidence that early detection and treatment initiation improves the success of treatment and chances of survival, the World Health Organization (WHO) recommended the use of a virologic test to diagnose HIV in all HIV exposed infants at exactly six weeks after birth or the earliest opportunity there-after.[6] Despite this recommendation, it is estimated that over 85% of HIV exposed infants globally are still not covered by EID services. [7] In addition, some of those who get enrolled in early infant diagnosis are lost to follow up along the cascade.[8] Among the factors that have been observed to present challenges in early infant diagnosis of HIV, are lack of effective diagnostic tools and laboratory support, late return of results[9], late or non-reporting of mothers, loss to follow up, lack of husband support or independent maternal income source, as well challenges with disclosure of HIV status.[3,10,11]

Ghana is among the few countries in Africa that made significant progress in the fight against HIV, showing the greatest decline in new HIV infections among global plan priority countries by 76% between 2003 and 2009.[12] The country also further reduced all new HIV infections by 50% between 2009 and 2013[1], however, challenges remain with the identification and testing of infants. A review of data from Ghana's National AIDS Control Program(NACP) indicates that over 80% of infants born to HIV positive mothers in Ghana are not tested by dry blood spot DNA PCR.[13]

Out of over 27,000 eligible HIV exposed infants who were expected to be tested for early diagnosis in 2011 and 2012, only about 400 were tested within the same period.[13] At the end of 2013, EID coverage for Ghana was 30% and coverage for the Upper West Region from summary data at the regional HIV surveillance office is estimated at 28%.[14] Ghana's aim of achieving zero new infections among infants will be very unlikely if over 85% of exposed infants still have an unmet need for EID. This study, therefore, sought to identify the socio-demographic, health system, and psychosocial factors that serve as barriers to early infant diagnosis of exposed infants, as well as timeliness of EID and mother to child transmission rates of HIV in the Upper West Region of Ghana.

METHODS
Study Design
We conducted a 1:1 unmatched case control study among HIV exposed infants between December 2014 and April 2015 in two ART centers at the Lawra and Wa districts. Study samples of 96 cases and 96 controls were selected. We reviewed records to identify all infants who were eligible for EID between January 2011 and December 2014. We used the term "early infant diagnosis because the period of observation for each child case or control was when the child was 6 weeks to 18 months. The inclusion criteria for this study were all HIV positive mother with infants/children who were eligible for EID between January 2011 and December 2014 living within the study area. We defined a case as any HIV positive mother with exposed infant who was eligible for EID (aged between 6 weeks and 18 months) and living within the study area between 2011 - 2014 from whom a dry blood spot (DBS) was collected for DNA-PCR. A control was defined as an HIV positive mother with exposed infant/child above 18 months living within the study area, between January 2011 and December 2014 from whom a dry blood spot was not collected for DNA-PCR when the child was 6 weeks to 18 months. A control was only selected if the child had exceeded the 18 months and EID samples had not been taken based on the records reviewed.

Study area/setting
The study was conducted in two districts of the Upper West region of Ghana, (Wa Municipalility and Lawra District). The ART centers in Wa and Lawra form part of the 94 PMTCT and 5 ART centers that provide EID services in the Upper West Region.[15] Out of about 670 HIV positive pregnant women reported in the region between January 2011 and December 2014, the two selected Districts contributed almost half (337) of the total, with 243 from Wa Municipality and 94 from Lawra District

Sample size and sampling
The sample size was calculated using StatCalc of Epi Info 7 based on the statistical power of 80%, 95% confidence interval, and an expected odds ratio of 2.5 to determine any significant effect of exposure. The proportion HEI (HIV exposed infants) receiving PMTCT intervention who were screened for EID using dried blood spot for PCR was 19.5%.[15] The ratio of cases to controls was 1: 1 (96 cases and 96 controls).

Selection of participants
A review of early infant diagnosis (EID) registers was first conducted at the Lawra and Wa ART centres to obtain a list of all infants from whom Dry Blood Spots (DBS) were supposed to have been collected for EID between January 2011 and December 2014. This period was selected to include enough HIV exposed infants to meet the minimum sample size.

From this list, cases and controls were selected. Cases and Controls were then contacted by reaching out to all resident HIV positive women reporting to the two ART centers for services. Women were approached to confirm those who had an infant/child who was eligible for Early infant diagnosis between January 2011 and December 2014 and whose names were captured on the list generated. Infants/children who had DBS collected for EID while they were eligible were identified as cases and those from whom no DBS was collected while there were eligible within the period were identified as controls. Records of eligible cases and controls were confirmed from the hospital records available. Calls were also placed to mothers who were on the list but did not show up at the ART centres. Interviews were conducted by the ART data manager, two HIV peer educators from Wa ART center and one HIV peer educator from Lawra ART centre who were trained on how to interview HIV positive mothers using a structured questionnaire. The data manager and peer educators were selected as interviewers because ART clients were more comfortable talking to them. The study was then explained to the HIV positive mothers and those who agreed to participate were asked to complete a written informed consent form.

The consenting women were subsequently interviewed using a structured questionnaire. All cases were cross-checked from the list of infants from whom DBS were collected for EID from the EID registers.

Variables measured
The outcome (dependent) variable for this study was testing for EID by DNA PCR. The independent variables measured were socio-demographic characteristics of the mother (age, sex, place of residence, maternal occupation, marital status, maternal employment status, maternal independent source of income as well as number of children/family size) place of delivery, and distance from home to the clinic. Data was collected using a structured questionnaire administered to mothers. Mothers were also interviewed to collect information on health system factors such as access to infant HIV testing information, the timing of information, PMTCT interventions received by both mother and child. Information about DNA PCR result, Turnaround time (TAT) of result and type of result (positive or negative) were collected. Finally, information was collected on psychosocial factors such as disclosure of HIV status, membership to support groups and reasons for testing or not testing infants.

Ethical Considerations
Ethical approval for this work was obtained from the Ghana Health Service Ethics Review Committee (GHS-ERC). Permission was obtained from the district health directorates, heads of the facilities and heads of the ART centers before the study began. Written informed consent was obtained from all HIV positive mothers with infant/children who were included in this research after the interviewer had been fully explained to them and all their concerns addressed.

Statistical Analysis
Data was entered into Epi-Info 7, and cleaned by running frequencies to determine missing values. The data was then exported into STATA version 13 for further recoding and analysis. Continuous variables were summarized as means with standard deviations or medians with interquartile ranges and categorical variables were summarized as frequencies and percentages.

Percentages of cases (infants, who tested for HIV by PCR), received EID result and outcome of result were also calculated. The results were presented in tables. Simple logistic regression was performed between being tested for EID and the demographic, psychosocial and health system factors assessed to determine the associations. The odds ratios and 95% confidence intervals were reported. Adjusted odds ratios were also calculated for all variables that were significantly associated with being tested for EID with a p-value <0.05.

Potential confounders such as maternal age, level of formal education and occupation were included in the final model that adjusted for significant factors. The final regression model included time of accessing EID information, maternal independent income, and place of residence which were significant at crude analysis as well as maternal age, and maternal level of education which were potential confounders.

RESULTS
Demographic characteristics of HIV positive Mothers and their exposed infants in the Case Control Study
A total of 192 HIV positive mothers with exposed infants including 96 cases and 96 controls were selected for this study. The mean age of HIV positive mothers was 29.6 ± 5.3 years. Majority of mothers (64.3 %) included in this study were aged 25 to 29 years. Exposed infant ages at the time of data collection ranged from 6 weeks to 205 weeks with a mean of 53.4 ± 33.1 weeks. The mean age of infants at the time of testing (DBS collection) for cases was 17.3 ± 14.9 SD weeks. The mean age of infants at time of testing for controls was calculated from ages recorded at the time of DBS collection. Out of 192 infants /children, 107(56%) were males and 85(44%) were females. (Table 1).

Table 1 Demographic characteristics of HIV positive mother-baby pairs Reporting to selected ART centres, Upper West Region, 2011-2014

Characteristic	Cases 96 (%)	Controls 96 (%)	Total=192 (%)
Sex of HIV Exposed Infant			
Males	52(54.2)	55(57.3)	107 (55.7)
Females	44(45.8)	41(42.7)	85 (44.5)
Maternal age groups (Years)*			
20-24	11(12.9)	17 (20.2)	28 (16.6)
25-29	55(64.7)	52(61.9)	107 (63.3)
30-34	17 (20.0)	11 (13.1)	28 (16.6)
35-49	2(2.6)	2 (2.4)	4(2.4)
40-44	0	2 (2.4)	
Place of Delivery			
Health facility	90 (93.7)	85 (88.5)	175 (91.1)
Home	6 (6.3)	11 (11.5)	17 (8.9)
Employment Status of Mothers			
Self employed	43(44.8)	29(30.2)	72(37.5)
Public employed	4 (4.2)	4(4.2)	8 (4.2)
Unemployed	49 (51.0)	63 (65.6)	112 (58.3)
Maternal independent income source			
Have income source	47(49.0)	33(34.4)	80 (41.7)
No income source	49 (51.0)	64 (66.7)	112 (58.3)
Mother Baby pair Residence			
Urban	64 (66.7)	49 (51.0)	113 (58.9)
Rural	32 (33.3)	47 (49.0)	79 (41.1)

* missing variables

Socio-demographic factors and follow up for early infant diagnosis of HIV
Females had 10% higher odds of their EID test done compared to their male counterparts (cOR: 1.1; 95%CI:0.6-2.0). This was however not significant after adjusting for confounders. None of the other socio-demographic variables was found to be associated with EID testing (table 2).

Table 2 Association of selected demographic factors and follow up for early infant diagnosis of HIV, Upper West Region, December 2011- 2014

Characteristic	Cases 96	Controls 96	OR (95%CI)	P-value	aOR(95%CI)	P-value
Sex of HEI						
Females	44	41	**1.1(0.6-2.0)**	**0.001**	1.2(0.6-2.4)	0.51
Males	52	55	1.0		1	
Maternal age groups						
20-24	11	17	1			
25-29	55	52	1.6(0.7-3.8)	0.26	1.6(0.7-3.9)	0.30
30-34	17	11	2.4(0.8-7.0)	0.11	2.3(0.8-7.1)	0.14
35-49	2	2	1.5(0.2-12.6)	0.69	1.6(0.2-13.9)	0.75
40-44	0	24	(omitted)		Omitted	
Employment Status of Mothers						
Self employed	43	29	1.4 (0.3-6.4)	0.43	1.3(0.25-6.9)	0.74
Unemployed	49	63	0.7(0.2-3.2)	0.49	0.7(0.3-4.8)	0.71
Public/formal	4	4	1.0		1	
Marital status						
Married	73	78	1.0		1	
Single	5	6	0.9(0.3-3.0)	0.55	1.2(0.3-4.8)	0.76
Cohabiting	5	5	1.1(0.3-3.8)	0.59	3.6(0.4-34.4)	0.27
Divorced	4	2	2.1(0.4-12.0)	0.32	1.0(0.3-3.8)	0.97
Widow	9	5	1.9(0.6-6.0)	0.19	1.5(0.3-9.1)	0.63

Babies born to HIV positive mothers with an independent source of income were two times more likely to have their children take EID compared to those with mothers without an independent source of income (cOR)=2.0, 95% CI: 1.2-4.1). The odds of a mother-baby pair living in a rural area taking EID was 50% lower compared to those living in urban areas (cOR=0.5, 95% CI: 0.3-0.9).

Infants/children of mothers with formal education had two times higher odds of taking EID testing compared with those mothers who were not educated (cOR=2.0 ,95% CI: 1.1-3.8). However, only maternal independent source of income was significantly associated with EID after adjusting for confounders. (Table 3).

Table 3 Association of selected factors and follow up for early infant diagnosis of HIV in Wa Municipal and Lawra Districts, Upper West Region-Ghana.

Variable	Cases	Controls	cOR (95%CI)	P-value	aOR (95%CI)	p-value
Distance of Residence to EID Clinic						
≤10km	13	21	0.6(0.3-1.2)	0.134	0.9(0.3-2.0)	0.82
>10km	83	75	1.0			
Place of delivery						
Home	6	11	0.5 (0.2-1.5)	0.21	0.5(0.2-1.5)	0.22
Health Facility	83	85	1.0			
Setting of Residence^						
Rural	32	47	**0.5(0.3-0.9)**	**0.03**	0.7(0.3-1.5)	0.33
Urban	64	49	1.0			
Maternal formal Education^						
Mother educated	48	32	**2.0(1.1-3.8)**	**0.01**	5108302 (0)	0.1
Mother not educated	48	64	1.0			
Level of formal education						
No education	48	62	0.5(0.1-1.9)	0.33	5124469 (0)	0.1
Primary	24	13	1.2(0.3-5.3)	0.78	3.0(0.6-14.0)	
Secondary	18	17	0.7(0.2-2.9)	0.63	1.3(0.28-5.6)	
College/university	6	4	Ref			
Maternal independent income source^						
Have income source	47	33	**2.2 (1.2-4.1)**	**0.01**	**2.1(1.1-4.0)**	**0.02**
Have no income source	49	64	1.0			
Mother heard of EID^						
Heard of testing	95	89	7.4(0.9-61.9)	0.06	7.5(0.9-64.8)	0.07
Not heard of testing	1	7	1.0			

DNA PCR results, Turnaround Time, Timeliness of testing and MTCT

Out of 96 cases, 49.0% were tested within two months (8 weeks) after delivery, while 51.0% were tested between 9 weeks and 18 months after delivery. DNA PCR results for 47.3% of children tested had been received at the time of data collection while the results of 52.7% were pending. The median age of infants at the time of testing was 10 weeks (IQR 6-26 weeks). About 30 % of DNA PCR results were received within 4 weeks after the collection of DBS. The median Turnaround Time (TAT) of DNA PCR results was 11 weeks (IQR 4-27 weeks). One out of 44 DNA PCR result received, was HIV positive (2.3%) and 97.7% were HIV negative. A majority of mothers (68%) tested their infants because they were eager to know the child's HIV status, while 30.2% tested their infant because they were counselled by a healthcare worker.

The commonest reason given by women for not testing their infants was because health workers did not collect DBS samples for PCR testing. Out of 92 controls (mothers with infants not tested), 58 (62.8%) were not tested because mothers made one or more visits to EID sites but blood samples were not collected due to a shortage of laboratory reagents at the testing laboratories. About 17.2% of mothers did not test their infant because they did not know the exact time to test or were waiting to be prompted by PMTCT nurses. Other reasons for not testing were fear (4.3%), the child looks healthy (4.3%), long distance to testing facility (2.2%), transportation challenges (1%), and other reasons including mother falling sick at the time of testing/mother travelled (8.6%).

Health System Factors and follow up for early infant diagnosis

A total of 45.8% (44/96) of the infants were tested within the first two months after delivery as recommended by WHO. Mothers receiving EID information from health care workers was not significantly associated with doing EID, (Table 3). About 95% of mothers with exposed

infants ever heard of HIV testing and the main source of EID information for mothers was from healthcare workers (mainly ANC/PMTCT/ART nurses), 95.8 (184/192). Out of those mothers who heard about infant HIV testing, 70.1% (129/184/) heard of testing before pregnancy and 23.9 % (44/184) heard of testing during pregnancy/labour. An infant born to a mother who heard of testing after delivery had seven times odds of doing the test for their child, (cOR=7.4 ,95% CI 0.9.5-61.9) compared to mothers who didn't hear about testing after delivery.

Psychosocial Factors and follow up for early infant in diagnosis

Psychological factors such as Disclosure of Maternal HIV status and Mother's membership to a PLHIV (People living with Human Immunodeficiency Virus) association or support group were not significantly associated with follow up for EID testing.

Out of the 96 HIV positive mothers whose children were tested by DNA PCR 68.8% (66/96), tested because they were eager to know the HIV status of their infants.

DISCUSSION

In this hospital-based unmatched case control study to assess barriers to early infant diagnosis, we found that mothers' independent source of income was the main barrier to EID testing. Other barriers identified were having a rural residence, maternal employment, mothers' education, having information about infant HIV testing. The role of poverty as a barrier to early infant diagnosis was prominent in our study such that a greater proportion of unemployed mothers or those without an independent source of income did not have their infants tested. This is also evident in the fact that women who were traders were more likely to get their infants tested. This observation was probably because mothers engaged in trade could afford a few more extra visits to the testing facility. Similar observations have been made in Kenya where poverty and lack of social support were reported as important barriers to early infant diagnosis.[16]

This low EID uptake was possibly compounded by frequent and long-standing stock-outs of laboratory reagent which would have compelled mothers to make several visits to testing sites. Even though young maternal age was found to be associated with poor EID testing in rural areas of Kenya, maternal age was not associated with EID testing in this study.[16, 17]

Besides formal education, all HIV positive women need to be educated on the need for PMTCT and testing of their infants. However, this education must be timely enough to make the necessary impact. Nurses at points of patient care especially Out Patients Departments (OPDs) and ante-natal care (ANC) clinics should be trained to identify exposed infants and educate women on EID at the facility level, peer educators could be trained on EID so they can educate mothers on the benefits of EID testing and possible e-MTCT. Incorporating EID information in child health records and monitoring it during routine childhood immunization schedules could improve EID coverage in the Country.

The results also suggest that test results of most of the dry blood spots collected and transported for testing are not received at all or come late. Tailor-made EID services using point of care devices and SMS result transfer would be necessary to improve early infant diagnosis coverage in rural communities. This late or non-return of result has been attributed to frequent stock out of reagents at testing laboratories. Contrary to expectations that most mothers may not test their babies because of fear of stigmatization, the study found that there was rather a strong desire by most mothers (up to 60%) to test and know the status of their babies.

Over 60% of mothers who tested their babies did so because they were eager to know the results of their child. This finding agrees with findings of a survey conducted in a similar setting in Zimbabwe where about 92% of parents with HIV exposed infants said they will be happy to know the test result of their infants.[18] This finding is the converse of what is being suggested in some studies, that mothers may not test their babies since such an act may be tantamount to declaring their own status and also because of the fear of blame that they transferred the infection to their babies.[19] In our study, two in every three of the mothers were eager to know the result of their infants through testing by DNA PCR.

This suggests that the relief that mothers get from knowing the true status of their infant especially when the infant tests negative far outweighs the fear of testing. This could also be due to the fact that more mothers are now well informed about MTCT. There are several documented health system challenges, including a shortage of commodities, sample collections, and transportation challenges,[16,20] late reporting of mothers with infants to health facilities,[3,11], poor data collection methods, late return of results and loss to follow up[8] that influence early infant testing. Other well-known factors include poor coordination between different levels of the health system and lack of integration of EID into other Maternal and Child Health services.[21]

This study demonstrates some of these challenges and strengths of the health care system in the Upper West Region of Ghana. An interview with health workers in the Region showed that personnel have been trained, EID services are well integrated into maternal and child health services in health facilities' and there are enhanced referrals (personal communication with PMTCT nurses at Wa Regional Hospital). Despite these achievements, poor turnaround time of DNA PCR results, stock-outs and late reporting by mothers were key health system challenges observed in the current study just as has been observed in other places with similar settings.[16,17] Decentralization of EID testing by DNA PCR testing, provision of appropri-

ate reagent, and training of laboratory staff could eliminate the challenge of long waiting and non-testing of exposed infants.

Arguably, the poor turnaround time (TAT) of DNA PCR results or even non-return of results of infants tested was also a disincentive for mothers to test their infants. While the average TAT for DNA PCR results is around two weeks with over eighty percent of results returning in Thailand[6,22] self-reported median TAT in this study was eleven weeks. Even in other African countries with similar resource challenges, better turnaround times of DNA PCR results have been reported (9-21 days).[15] In Tanzania, Malawi and Botswana,[23,24] Hassan and others observed that the availability of result on caregiver or mother's return visit dates was very important in determining adherence to scheduled follow up visits.[16] Empowerment of women so that they can have an independent source of income is therefore a way to improve EID testing.

Time of testing and treatment initiation are critical determinants of treatment outcome. In this study, more than half of mothers who tested their infant did so after the WHO recommended a testing time of "two months after delivery". Likewise, over 60% of mothers reported that they lost the opportunity to test their infants because of the shortage of laboratory reagents and associated no return of DNA PCR results. This suggests that many more mothers could have been disappointed after several visits and lost confidence in the health system.

Reagent and logistic shortages remain a major hindrance to early infant diagnosis of HIV because reagent have a very short shelf life of 6-9 months and manufacturers will only produce to meet the request of users.[20] The high cost of DNA PCR test coupled with the short shelf life of reagent has been reported as a major barrier to testing in other studies.[16, 20] As part of efforts to solve this problem, bundle EID commodities were introduced with single test EID packs which contain everything that is needed to collect a dry blood spot.[20] Several researchers have proposed the integration of EID services into immunisation services since most countries with early infant diagnosis challenges have already achieved high immunization coverage levels.[20,25,26] This could improve and maximize health gains for HIV exposed infants in Ghana since the country has high childhood immunization coverage. Ghana had a high coverage of most infant immunisations (over 80% of infants receiving all immunisations, 94% for DPT,96% for 3 doses of polio) in 2008.[26]

This high immunization coverage does not correspond with the rather lower EID coverage observed in this study, i.e, almost less than 30% in this study and exactly 30% for the whole country as of December 2013.[27]

This suggests that most mothers could turn up for immunisation services but do not go for EID, possibly due to fear of stigmatization. Implementing PITC with opt-outs at child immunisation centres using HIV RDT could help in the identification of infants at risk. Another reason why most women access immunisation service but do not go for EID could be attributed to their low knowledge of HIV prevention. The 2014 Ghana Demographic and Health Survey (GDHS) reports that only 10% of women in the Upper West Region have comprehensive knowledge about HIV prevention.[28]

Health workers especially ANC and PMCT nurses need to pay particular attention to counselling of mothers given that up to 16% of mothers who did not test their babies were waiting to be prompted by nurses before they do so. Poor communication between facilities collecting and transporting DBS and the laboratories that test these samples is a well-documented challenge also found in this study.[21] We found that over 50% of those who got tested did not receive any result or an explanation for the delay in receiving results. Some results have been pending for over three years with PMTCT nurses settling on antibody testing once the infant has attained 18 months. We observed that standard paper mails and occasionally telephone calls are used to send EID results in the region. Using short message sending (SMS) and electronic mails appear to be more innovative ways to improve coordination and reduce loss to follow up.[21]

In countries like Kenya, Nigeria, and South Africa, the use of SMS and remote data printing has simplified EID result dissemination and improved turnaround times.[24,29] Adoption of such a service in Ghana would allow health workers to make inquiries about outstanding results and allow laboratories to request a new sample where the sample is lost or is inadequate for testing. Efforts towards progress need to be coordinated at all levels of the health system to ensure the collection of accurate EID data at all times. A clear difference exists in the proportion of HIV exposed infants testing positive by DNA PCR at the national and local levels. Both reviewed data and self-reported HIV results suggest a low HIV prevalence among exposed infants in the region. Only 2.7 % of infant results were positive from reviewed records and 2.3% of positive exposed infant PCR results were reported by mothers in the case control study. This suggests a lower prevalence than the national rate of 7% reported in 2012.[28] This success story of the low rate of transmission could be attributed to the effectiveness of PMTCT/ e-MTCT (elimination of mother to child transmission) program in the region.

Limitations
Due to the low numbers of exposed infants, the age range of infants included in the study was increased from six

weeks - 18 months to all infants who were eligible for EID within the past four years. This was to help meet the minimum sample size. It is, therefore, possible that there could be recall bias on the part of mothers with older children who had to remember events when their children were younger. To reduce this bias, interviewers helped mother to remember major events that took place after the birth of their children. Mothers were not able to accurately estimate the distance from their homes to the health centre. We therefore determined the nearest 10 km community on all major routes to the two testing sites using google maps and also directly asked the study participant to estimate the distance.

CONCLUSION
The main barrier to EID was mothers' lack of independent source of income. Other barriers identified include; mothers' employment, mothers' education, place of residence and receiving adequate and timely EID information. Health systems challenges also were found to be one of the main barriers to early infant diagnosis in the Upper West region of Ghana. Late delivery of information on early infant diagnosis to mothers, stock-out of reagents, and prolonged turnaround time of DNA PCR results were also barriers.

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