Corrigendum: Determinants of HIV Positive Status at First PCR Test among Infants Seeking Early Infant Diagnosis (EID) Services in Selected Hospitals in Nairobi County, Kenya

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Summary

INTRODUCTION

Early Infant Diagnosis (EID) is the practice of testing infants for HIV within the first 4–6 weeks of life or at the earliest opportunity possible so as to promptly link HIV-infected infants to healthcare and treatment. In the absence of timely HIV testing and Antiretroviral Therapy (ART) initiation, one-third of infants living with HIV die before their first birthday and more than half die before 2 years. Worldwide, Mother-to-Child Transmission (MTCT) rates accounted for 8.9% of all HIV infections by the end of 2015, with Sub-Saharan Africa accounting for 12% of these infections. In Kenya, MTCT infection rates were at 14%, accounting for 7% of all new infant infections globally by the end of 2018.

OBJECTIVES

The objective of this study was to establish the determinants of HIV positive status at first PCR test among infants seeking EID services in selected hospitals in Nairobi County, Kenya.

MATERIALS AND METHODS

A longitudinal cohort study employing a mixed-method approach was used. Quantitative data was collected from pairs of 163 mother-infant pairs using interviewer administered, pre-tested, and semi-structured questionnaires while qualitative data was collected using Focus Group Discussion (FGDs) guides, it was coded, cleaned and analyzed using STATA *Version 14*. Quantitative data was analyzed using Fisher's exact test (p= 0.05) and Poisson Regression (p= 0.05) at bivariate and multivariable levels respectively. Thematic analysis was undertaken for qualitative data.

RESULTS

The findings from the adjusted parsimonious model revealed that, three variables influenced the infant HIV status at first PCR test. The study participants who had been administered with ART during pregnancy had a lower risk (RR= 0.06) of getting HIV positive infants relative to those who hadn't received ARVs during pregnancy (95% CI 0.014, 0.213 p= 0.000). Respondents who had been initiated on ART during the first trimester had lower risk (RR= 0.1) of getting an

HIV positive infant than respondents who were administered with ARVs in the third trimester (95% CI 0.014, 0.021, p= 0.001). Respondents on first-line ART regimen had a lower risk (RR= 0.04) of getting HIV infected infants compared to those who were on the second line ART regimen (95% CI 0.012, 0.114, p= 0.000), confirming all the three significant variables as protective factors.

CONCLUSION

The study corroborated that, first line ART regimen administered before pregnancy or during the first trimester of pregnancy was effective in lowering the risk of getting an HIV positive infant. Pediatric HIV infection and disease progression is quite rapid without prompt care and treatment.

Keywords: Early Infant Diagnosis, Pediatric, HIV, Maternal

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Introduction

Globally, HIV/AIDs infection continues to be a public health concern with an estimated 36.7 million people living with it by the end of 2015 [1].

Despite being a preventable disease, it continues to cause morbidity and mortality amongst populations. Prevention strategies that are effective in reducing the disease burden among infants include Prevention of Mother- to- Child Transmission (PMTCT) and Early Infant Diagnosis (EID) which is the practice of testing infants for HIV within the first 4–6 weeks of life or at the earliest opportunity possible [2].

Without proper and prompt interventions, half of the infants infected with HIV do die before their second birthday. MTCT of HIV accounted for 8.9% of all HIV infections worldwide by the end of 2015. Sub-Saharan Africa accounted for 12% MTCT, while Kenya accounted for 7% of all new infant HIV infections globally, with 13,000 new infant infections occurring annually [3 - 4].

HIV-positive mothers can transmit the virus to their children during pregnancy, labor, delivery, or during the breastfeeding period. In the absence of any intervention, transmission rates would range from 15% to 45%. This rate can be reduced to below 5% with effective interventions during the critical periods of pregnancy, labor, delivery, and breastfeeding [4].

Although there has been a reduction in MTCT rates in Kenya from 17% in 2010 to 14% by the end of 2015, MTCT rates of HIV in Kenya remained higher than the global target which was to reduce MTCT rates to 5% or less among breastfeeding women and to less than 2% or less among non-breastfeeding women by the end of 2015 [5].

Furthermore, a low number of infants were retained throughout the EID program due to a high rate of Loss-To-Follow-Up (LTFU) of up to 54% by the end of the EID program. These factors greatly undermined the efforts to reduce the MTCT rates that stood at 14% in Kenya by the end of 2014 [6,7].

This study focused on assessing the determinants of HIV positive status at first PCR (Polymerase Chain Reaction) test among infants seeking EID services. This would in-turn help in informing ways to strengthen EID services ultimately reducing pediatric HIV infection in Kenya.

Materials and Methods

Study design

A longitudinal cohort study employing mixed-methods approach was used where both qualitative and quantitative data was collected and analyzed.

Study site

The study was carried out in Mathare North Health Center, Mbagathi District Hospital and Kibera South Health Center in Nairobi County Kenya, within the catchment area of Kibra and Mathare informal settlements.

Study population

The study participants were infants recruited at 4 -6 weeks age of infants, attending the Comprehensive Care Clinic (CCC) at the selected healthcare facilities. Mothers not willing to participate in the study, or were too sick to respond to the questions and were not the biological mothers to the infants were excluded from the study.

Sampling and sample size determination

The sample size was determined using Conchran's (Cochran, 1977) method and 166 respondents were selected with 163 (98.2%) respondents participating in the study. Simple random sampling technique was used to select the study participants. A total of six (6) FGDs with 5 - 6 participants were conducted to attain theme saturation. Respondents selected were grouped based on age categories as follows; ≤ 21, 22 - 35 and 36-49 years.

Data collection tools

A pre-tested, semi-structured interviewer administered questionnaire and a Focus Group Discussion (FGD) guide were used. A data abstraction tool was also used to collect health information data from Maternal and Child Health (MCH) booklets and mothers' CCC follow-up files. In addition, anthropometry instruments (for measuring weight and height) and laboratory equipment (for carrying out Polymerase Chain Reaction (PCR) tests and determining Viral Load counts) were used. In addition, a Key Informant Interview (KII) guide was used to collect information from key healthcare workers delivering EID services in each of the selected facilities.

Data analysis

Data entry, cleaning, coding, and analysis were done using STATA Version 14. Descriptive statistics was used to summarize the data. Fisher's exact test and Poisson was used to analyze the data at bivariable and multivariable levels, respectively.

The study outcome was to determine the HIV positive status of the infants at first PCR test, which is usually done at 6 weeks. This was undertaken by categorizing the infants into two groups i.e. HIV positive and HIV negative infants. The overall HIV positivity rate among the infants was (4.3%) and since this proportion was very small, the outcome was assumed to represent a count of the number of cases in the group. To relate the count of the cases to predictors (Socio-demographic and maternal factors), a Poison regression model was assumed in the form:

$$E\,\underline{n}^{y} = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots \beta_K X_K \ldots (1)$$

Where, the term on the left of the equation was the log of the expected value of counts of HIV positive status, which was modeled as a linear combination of the predictors (on the right of the equal sign). The model related the log of the expected value of counts of HIV positive infants and a linear combination of predictors in the bivariable analysis at a significance level of $P \leq 0.1$.
The model was subsequently extended to control for other predictors by including all significant variables at the bivariable step in the multivariable analyses at a significance level of $P<0.05$ as follows:

$$E\,\underline{n}^{y} = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_K X_K \ldots (2)$$

Where, K was The Number of Predictors Multivariable modeling was carried out using a backward elimination strategy and involved checking for confounding and relevant interaction terms. During modeling, the statistical significance of the contribution of individual predictors (in bivariable analyses) or groups of predictors (in multivariable analyses) to the model was tested using the likelihood ratio test and the Bayesian predictors of best model selection.

The models were assessed for overall fit using $\chi 2$ goodness-of-fit tests computed as the sum of the squared deviance or Pearson residuals. The values of the two test statistics were compared to assess a lack of fit. As with all overall goodness-of-fit statistics, a $P>0.05$ (non-significant) indicates that the model fits the data well.

Qualitative data was entered using the NVIVO software, which was then presented thematically by describing emerging themes obtained from the HIV positive mothers.

Ethics statement

The researcher sought ethical approval to conduct the study from the Kenya Medical Research Institute (KEMRI) Scientific Ethics Review Unit (SERU) KEMRI/SERU/CPHR/002/3525.

Permission was also sought from Nairobi County Ministry of Health and the Medical Superintendent of the facilities where the study was conducted. Risks, benefits, confidentiality, and voluntary participation were clearly explained. Written and informed consent was obtained and duly signed by the study participants.

Results

Socio-demographic and socio-economic characteristics of the study participants

The median age of participants was 29.6 years. Approximately, (55.8%) of the participants had at most primary level of education. Majority of the participants were married (85.28%). Approximately seventy (73.01%) of the participants had 2-5 persons living in their households and close to two thirds (65.64%) had informal employment. In this study majority (57.67%) earned between Kenya Shillings (Ksh.) 6,001-12,000.00) per month. (Table 1).

Table 1: Maternal Socio-Demographic and Socio-Economic Characteristics

Characteristics of the study participants	Frequency (n=163)	Percentage (%)
Age in years		
≤21	**32**	**19.6**
22-35	**75**	**46.0**
36-49	**56**	**34.4**
Highest Level of Education		
≤Primary	**91**	**55.8**
≥Secondary	**72**	**44.2**
Number of persons living in the household		
2-5	**119**	**73.0**
6-8	**44**	**27.0**
Respondent marital status		
Single	**24**	**14.7**
Married	**139**	**85.3**
Employment status		
Formal	**27**	**16.6**
Informal	**107**	**65.6**
Unemployed	**29**	**17.8**
House-hold income (Ksh)		
≤6000	**32**	**19.6**
6001-12000	**94**	**57.7**
≥ 12001	**37**	**22.7**

The overall HIV prevalence of the infants at recruitment was (4.3%) of the 163 infants that were included in the study. The HIV prevalence of the infants as per the maternal socio-economic and socio-demographic factors of the mothers' was as shown in Table 2 below:

Table 2: Prevalence of Infant HIV Status at Recruitment

Characteristics (n=163)	**HIV status among infants at first PCR test**	
	HIV Negative n (%)	**HIV Positive n (%) n (%)**
Age in years		
≤21	29 (90.6)	3 (9.4)
22-35	72 (96.0)	3(4.0)
36-49	55 (98.2)	1 (1.8)
Highest Level of Education		
≤Primary	86 (94.5)	5 (5.5)
≥Secondary	70 (97.2)	2 (2.8)
Number of persons living in the household		
2-5	114 (95.8)	5 (4.2)
6-8	42 (95.4)	2 (4.6)
Respondent marital status		
Single	23 (95.8)	1 (4.2)
Married	113 (95.7)	6 (4.3)
Employment status		
Formal	26 (96.3)	1 (3.7)
Informal	106 (99.1)	1 (0.9)
Unemployed	24 (82.8)	5 (17.2)
Monthly house-hold income (Ksh)		
≤6000	27 (84.4)	5 (15.6)
6001-12000	93 (98.9)	1 (1.1)
≥ 12001	36 (97.3)	1 (2.7)

Socio-demographic and socio-economic factors associated with infant HIV positive status

Employment status (p= 0.002) and household income (p= 0.004) were significantly associated with infant HIV status. Most (17.2%) of the HIV positive infants were from unemployed mothers and with the lowest household income (15.6%). (Table 3).

Table 3: Socio-Demographic and Socio-Economic Factors Associated with Infant HIV Positive Status

Characteristics (n=163)	HIV negative infants n (%)	HIV positive infants n (%)	Fishers Exact Test P-value
Age in years			
≤21	**29 (90.6)**	**3 (9.4)**	**0.224**
22-35	**72 (96.0)**	**3 (4.0)**	
36-49	**55 (98.2)**	**1 (1.8)**	
Highest Level Education			
≤Primary	**86 (94.5)**	**5 (5.5)**	**0.466**
≥Secondary	**70 (97.2)**	**2 (2.8)**	
Number of persons living in the household			
2-5	**114 (95.8)**	**5 (4.2)**	**1.000**
6-8	**42 (95.5)**	**2 (4.5)**	
Respondent marital status			
Single	**23 (95.8)**	**1 (4.2)**	**1.000**
Married	**133 (95.7)**	**6 (4.3)**	
Employment status			
Formal	**26 (96.3)**	**1 (3.7)**	**0.002**
Informal	**106 (99)**	**1 (1)**	
Unemployed	**24 (82.8)**	**5 (17.2)**	
Monthly household income			
≤6000	**27 (84.4)**	**5 (15.6)**	**0.004**
6001-12000	**93 (98.9)**	**1 (1.2)**	
≥12001	**36 (97.3)**	**1 (2.7)**	

Maternal characteristics during PMTCT associated with infant HIV positive status

Increasing infant HIV positivity (10.3%) was observed in mothers that had ≤ two years since HIV diagnosis from the time of study inception than mothers who had been diagnosed more than two years, at the time of study inception. The respondents that had not been initiated on ART during pregnancy and the respondents that had delayed ART initiation (i.e. given ART in the third trimester) also experienced highest infant positivity at (27.3%) and (50.0), respectively (Table 4).

Table 4*: *Association between Infant HIV Positive Status and Maternal Characteristics during PMTCT

Characteristics (n=163)	HIV Negative infants' n (%)	HIV Positive infant's n (%)	Fishers Exact P-value
Year Confirmed Positive			
1997 - 2015 (> 2years prior to study)	**104 (99.0)**	**1 (1.0)**	**0.009**
2016 - 2017 (≤ 2years prior to study)	**52 (89.7)**	**6 (10.3)**	
Mode of Delivery			
CS	**18 (94.7)**	**1 (5.3)**	**0.587**
SVD	**138 (95.8)**	**6 (4.2)**	
Given any ART			
No	**2 (50.0)**	**2 (50.0)**	**0.009**
Yes	**154 (96.9)**	**5 (3.1)**	
Stage ARTs administered during pregnancy			
First Trimester	**124 (98.4)**	**2 (1.6)**	**0.002**
Second Trimester	**24 (92.3)**	**2 (7.7)**	
Third Trimester	**8 (72.3)**	**3 (27.3)**	
Gestation of pregnancy at 1st PMTCT / ANC visit for this pregnancy			
First Trimester	**29 (96.7)**	**1 (3.3)**	**0.881**
Second Trimester	**75 (96.2)**	**3 (3.8)**	
Third Trimester	**52 (94.6)**	**3 (4.6)**	
No of PMTCT Visits			
<=1	**10 (90.9)**	**1 (9.1)**	**0.000**
2	**15 (75.0)**	**5 (25.0)**	
>=3	**131 (99.2)**	**1 (0.8)**	

Association between infant HIV positive status and partner disclosure of HIV status

Mothers who had not disclosed their HIV status to their partners and neither knew their partner's HIV status experienced more HIV positivity in their infants (13.3%) and (10%), respectively (Table 5) below.

Table 5: Association between Infant HIV Status and Partner Disclosure of HIV Positive Status

Characteristics (n=163)	HIV Negative infants n (%)	HIV Positive infants n (%)	Fishers p-value
Have a partner			
No	16 (94.1)	1 (5.9)	0.545
Yes	140 (95.9)	6 (4.1)	
Disclosed your HIV Status			
No	13 (86.7)	2 (13.3)	0.116
Yes	127 (97.0)	4 (3.0)	
Know Partner HIV status			
No	36 (90.0)	4 (10.0)	0.048
Yes	104 (98.1)	2 (1.9)	
Spouse HIV Status			
Negative	42 (97.7)	1 (2.3)	1.00
Positive	62 (98.4)	1 (1.6)	

Association between infant HIV positive status and maternal characteristics at recruitment

A mother who had poor ART adherence and high viral loads experienced more HIV positivity in their infants (26.7%) and (21.7%), respectively. Similarly, respondents who were on the second line ART regimen and in stage II of HIV infection also experienced the highest HIV positivity in their infants (45.4%) and (13.8%) respectively (Table 6).

Table 6: Association between Infant HIV Status and Maternal Characteristics at Recruitment

Characteristics (n=163)	HIV Negative infants n (%)	HIV Positive infants n (%)	Fishers p-value
ART adherence - (Morisky Score)			
Good	95 (99.0)	1 (1.0)	0.001
Inadequate	50 (96.2)	2 (3.8)	
Poor	11 (73.3)	4 (26.7)	
Maternal HIV Staging			
I	131 (97.8)	3 (2.2)	0.020
II	25 (86.2)	4 (13.8)	
ART Regimen			
First Line	150 (98.7)	2 (1.3)	0.000
Second Line	6 (54.6)	5 (45.4)	
Viral Load			
Undetectable Viral Load	119 (99.2)	1 (0.8)	0.000
Low Viral Load	19 (95.0)	1 (5.0)	
High Viral Load	18 (78.3)	5 (21.7)	
Maternal BMI			
Underweight	8 (88.9)	1 (11.1)	0.376
Normal	83 (95.4)	4 (4.6)	
Overweight	49 (98.0)	1 (2.0)	
Obese	16 (94.1)	1 (5.9)	

Significant variables in the multivariable (P <0.05) Model assessing the relationship between the log of expected counts of HIV positive infants and the associated risk factors:

In the overall parsimonious model, (p= 0.000) which was arrived at in a backward stepwise method, three variables discussed next did best explain and most influenced the infant HIV positive status at first PCR test.

ART being given during pregnancy was a protective factor whereby participants who had been administered with it during pregnancy had a lower risk (RR=0.06) of getting HIV positive infants relative to those who had not received ART during pregnancy (95% CI 0.014, 0.213 p= 0.000). Additionally, respondents who had been initiated on ART in the first trimester experienced lower risk (RR=0.1) of getting a HIV positive infant than mothers who had been administered with ARVs in the third trimester (95% CI 0.014, 0.021, p= 0.001).

Therefore, administering ARVs as early as in the first trimester or sooner was a protective measure in reducing the risk of HIV transmission to the infant. Likewise, respondents who were on the first-line ART regimen experienced a lower risk (RR= 0.04) of getting HIV infected infants compared to participants who were on the second line ART regimen (95% CI 0.012, 0.114, p=0.000) (Table 7).

Table 7: Parsimonious Multivariable (P <0.05) Model for The Log of Expected Counts of HIV Positive Infants

Infant HIV status at Recruitment	ARR	Robust Std. Err.	z	P>z	95% C.I Lower	95% C.I Upper	LR Chi2(4)	Prob > Chi2
Given ART during pregnancy							47.55	0.000
No *(Reference)*	1.00							
Yes	0.06	0.04	-4.18	0.000	0.014	0.213		
Stage ART first administered in Pregnancy								
Third Trimester *(Reference)*	1.00							
First Trimester	0.10	0.10	-2.22	0.026	0.012	0.760		
Second Trimester	0.69	0.43	0.60	0.549	0.201	2.352		
ART regimen								
Second-line *(Reference)*	1.00							
First-line	0.04	0.02	-5.81	0.000	0.012	0.114		
_cons	18.37	11.59	4.62	0.003	5.34	63.23		

Table 8: Model Summary

Model	Deviance G.O.F	Persons G.O.F	Log-Likelihood	AIC	BIC
	13.805 (1.000)	28.873 (1.000)	-13.902	37.805	53.274

Spearman test of correlation

Test of *Ho*: Giving ARVs during pregnancy, Stage. ARVs were administered in pregnancy and Mothers' ARV regimens were correlated, hence we reject the null hypothesis (Table 9). Therefore, the variables in the model shown in (Table 7) are not correlated. Hence, it is a good model to explain the outcome variable of infant HIV status.

Table 9: Spearman Correlation Coefficient Test

Explanatory variables	Given ARVs during pregnancy	Stage ARVs were administered in pregnancy	Mothers ARV regimen
Given ARVs during pregnancy	1.000		
Stage ARVs were administered in pregnancy	-0.0236	1.000	
Mothers ARV regimen	-0.1154	0.098	1.000

Discussion

The study provided a detailed quantitative and qualitative assessment of factors that influence infant HIV positive status at first PCR test. The mean HIV positivity rate at 6 weeks for the respondents was 4.3% (CI 1.149 - 7.440), similar to findings in four government hospitals with the same group of targeted ages in Kenya.

This figure of 4.3% was below the national MTCT rates that stood at 14.3% and also met the national and global target of reducing the MTCT rates to below 5%; equally this was comparable to findings in Malawi that had a prevalence of (4.1%) [8,9,10].

The low prevalence rate in Malawi was achieved through vigorous PMTCT interventions to enhance adherence and retention throughout the cascade of care [10]. Approximately 52.7% of the infants had a PCR test before 6 weeks of age and were regarded as having timely initiation into EID [10].

This was much higher than what was seen in a study conducted in Ethiopia where the initiation rate was 41% [11]. At bivariable level, timely initiation into EID was positively associated with infants HIV status at 6 weeks (p=0.03).

However at multivariable level it was not significantly associated with infant HIV status at first PCR test (p= 0.08). In a Libyan study, infants had a timelier PCR testing with 73% of the respondents recruited between 4 - 6 weeks. This high rate of timely PCR testing was attributed to mothers knowing their HIV status before pregnancy and good maternal ART adherence postpartum [12].

Demographic characteristics

Demographic characteristics that influenced infant HIV status at recruitment included household income (p=0.002) and maternal employment status (p= 0.004) which were consistent with a study conducted in Kenya [2].

At multivariables level participants who had informal employment had a lower risk of getting HIV positive infants relative to respondents who were unemployed. Similarly, respondents with higher income were at lower risks of getting HIV positive babies compared to those that had very little income of less or equal to Ksh. 6000/=. Improvement of household economic status through income-generating activities

could help reduce sero-positivity in infants by eliminating other competing priority interests. This was further supported by FGDs that were conducted where the respondents indicated that economic constraints were a big challenge towards access to service delivery:

P3: "My husband will not give me a coin
to come for my appointments despite
the fact that I am unemployed.
I am forced to save from
the little money he leaves for food.
Sometimes I call the healthcare providers in EID in advance and tell them that they will have to give me transport back home
since I only have money for one way trip. They usually help but you cannot borrow each time"(FGD5).

P3: "Sometimes getting bus fare
is an uphill task,
I am forced to borrow KSh 100
from friends so as to be able
to attend my scheduled clinics, you cannot borrow every time it is a big challenge" (FGD2)

A Key Informant Interview (KII) also conducted on health workers managing the EID clinics also revealed economic challenges as a barrier to access service delivery which could lead to poor ART adherence and increase the risk of HIV transmission to infants:

"Sometimes respondents miss their appointments
and when we call them
as part of clinic defaulter tracing
they complain of, lack of money for transport,
they will come once they get money.
That was dangerous since the mothers might not be having enough drugs
and might end up with poor drug adherence"
(Nurse, KII 2)

The maternal level of education did not influence the infant HIV status despite most of the participants having a primary level of education and below. These findings were similar to those from Zambia [3,13,11].

All HIV positive respondents who did not receive ART during pregnancy got HIV positive babies. This denoted a high rate of vertical transmission in these infants. Similar findings were observed in these studies conducted in Kenya [14, 8]. It is important to increase ART coverage during PMTCT to reduce the chances of vertical transmission.

Gestation at first Prevention of Mother- to-Child Transmission (PMTCT) visit did not influence infant HIV status, a finding similar to that of [8] despite respondents who attended many ANC visits(>=3) had a lesser risk (0.03) of getting HIV infected babies relative to mothers who had attended lesser clinics, with similar observations in another study conducted in Kenya [11].

ANC attendance improves maternal knowledge on importance of PMTCT attendance and consequently improves ART adherence and maternal health which cascades to improve HIV exposed infant health outcomes [13].

Partner disclosure is pertinent in ensuring maternal adherence to PMTCT clinics and provides a facilitated environment for HIV testing where issues of blame, discordance, and future care options are discussed [12]. Mothers who fail to disclose to their partners due to fear, stigma or denials are much more likely to default care putting their babies at most risk of HIV infection [15].

There was a significant link between partner disclosure and infant HIV status at the bivariate level. Nonetheless, at multivariate level partner disclosure status was not significant despite the fact that, in the FGD conducted by the researcher, respondents cited disclosure as a barrier to proper ART adherence like so:

"I am married as a second wife,
my husband's other wife and I have never met. I have not disclosed my status to my husband, and
he does not know my status either.
I find it difficult to disclose to him my status,
with time I will.
He gives me very little financial support
and at times I go hungry
with my other children" P2:

P4: "Long ago when I used to visit my rural home,
since I have not disclosed my status to anyone,
I used to remove my tablets from the medicine bottle,
put in a paper and hide under my mattress,
my viral load went very high and I had to disclose to the healthcare workers that I was removing my medicine from

the dispensing bottle.
I was discouraged from doing this, now I don't go to my rural home anymore" (FGD4).

Disclosure was seen as an enabler of good adherence if proper disclosure strategies were put in place:

P2: "I disclosed my status to my nuclear family members and they were very supportive, they even remind me to take my medicine, the nurse assisted in the disclosure"(FGD2).

Disclosure status in this study was high (89.8%) among HIV positive respondents. A finding similar to that of [12] in a Zambian study. A pooled estimate study in sub-Saharan Africa among postpartum and pregnant women however showed much lower levels of disclosure (63.9% CI 56.7% - 71.1%) [16].

Majority of the participants had partners with (59.81%) of the partners being concordant and (40.19%) being discordant partners. The seroconcordant status findings were similar to those of HIV positive respondents in the Zambian study [12]. Unlike the discordant status, they differed and the authors found only 28% serodiscordance among the participants' partners.

Interventions to encourage and support women in safely disclosing their status were seen to be an urgent area to be addressed to enhance maternal adherence.

Approximately 58.9% of the participants had good ART adherence post-postpartum. A finding that differed with a study in Libya where respondents reported very high adherence (81%) [13]. However, only 56% of the participants were on lifelong ART in the Libyan study whereas in the current study (97.6%) nearly all the participants were on lifelong ART. Good ART adherence was key in ensuring viral suppression and ensuring that vertical transmission rates were kept below 5% in breastfeeding mothers and below 2% in non- breastfeeding mothers [4].

A systematic review also highlighted that, maternal ART adherence reduced the odds of HIV infection to the infants. Routine viral load monitoring was carried out at 6 months, 12 months for newly diagnosed HIV positive patients then thereafter every 12 months if the patient was virologically suppressed i.e. viral load count of <100 copies [4]. Undetectable viral load was a protective factor and was associated with a lower risk (RR 0.04) of infant HIV transmission in comparison to respondents that had high viral load counts [17].

Viral load was used to detect treatment failure and decision making, whether to change ART regimen or enhance adherence through counseling. That pointed to a re-evaluation of the respondents in high viral load category for enhanced adherence counseling or change of ART regimen to reduce the risk of HIV infection to the infants. This was specifically important, to initiate HIV exposed infants to the optimal prophylaxis in cases of respondents with high viral load and were breastfeeding [18].

In the United Kingdom, the link between MTCT was well established whereby the risk of transmission from a pregnant mother on antiretroviral treatment and had achieved viral suppression (undetectable viral load) to her infant was 0.1%. Although the risk of MTCT was greatest for pregnant respondents with high viral load, transmission could still occur whether maternal viral load was very low (<50 copies) or even undetectable [19].

Proper PMTCT strategies ensured that respondents did not progress from the first to the second stage of HIV infections by keeping the viral load suppressed through proper ART adherence. In this study, respondents who were in the second stage of HIV infections experienced more positivity (2.45%) in their infants compared to those respondents in the first stage who experienced (1.8%) infant HIV positivity at bivariate level.

In the multivariate level, respondents in stage two of HIV infection had a higher risk (RR= 6.2) of getting HIV positive infants compared to those in the first stage. Most HIV patients were usually switched to second-line ART regimen due to treatment failure caused by several reasons such as poor drug adherence and drug resistance. These were the two leading reasons why HIV positive respondents were usually switched on second-line ART regimen. Treatment failure lead to an increase in maternal vial load, which could in turn, increase the risk of HIV transmission to the infant [14]. There was usually a period of high viremia (due to treatment failure or poor adherence) between being switched from first to second line ART

regimens which exposed the infant to a very high risk of HIV transmission. That also explained why most infant HIV positivity was observed in respondents on the second line regimen of ART.

Limitations

This study had several limitations. Exposure history was from the respondent's' self-report and not all the history given could be corroborated from the maternal CCC file, IMCI booklet or appointment booklets. Despite the inability to corroborate the respondent's self-report, the questionnaire was structured to counter-check the responses asked in a different format within the same script.

Secondly, given the phrasing of the questionnaire, it was difficult to determine if the respondents were adherent to ARVs throughout the pregnancy period. That is, the time of cessation and non-adherence. Adherence however, was also determined by observation of the participant's serial viral loads from pregnancy up to one year postpartum.

Due to the small sample size selected, the MTCT rates of 4.3% obtained in the study might have been an underestimation of the true MTCT rates.

Conclusion

Contrary to adults' HIV infections, pediatric HIV infection and disease progression is quite rapid and without prompt treatment, half of the infants might not survive their second birthday. This then necessitates rigorous interventions to ensure that infants are identified on time and retained in the EID cascade of care to ensure optimal infant health outcomes.

This study, therefore, identified three main factors that promote optimal infant health outcomes as they go through the EID process and these included ensuring mothers are initiated on ARVs on or before the first trimester of pregnancy and ensuring proper ART adherence so that the mother remains in the first-line ART regimen of care for as long as possible.

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Competing interests

The authors declare no competing interests.

Authors' contributions

Elizabeth Mueke Kiilu development of the concept and manuscript, Prof. Simon Karanja, Prof. Gideon Kikuvi and Dr. Peter Wanzala critically reviewing of the document from its conception, up to manuscript submission and the final approval and Dr. John Gachohi, data analysis and review. All authors read and agreed to the final version of this manuscript and equally contributed to its contents and the management of the case.

References

1. **UNAIDS.** (2016). On the fast track to an AIDS-free generation. Geneva: *UN AIDS*.
2. **NASCOP.** (2014). Guidelines for Prevention of Mother to Child Transmission (PMTCT) of HIV/ AIDS in Kenya. MOH. Nairobi: *MOH. Retrieved* from http://www.nascop.or.ke.
3. **Ciaranello, A. L., Park, J.-E., Ramirez-Avila, L., Freedberg, K. A., Walensky, R. P., & Leroy, V.** (2011, September 17). Early infant HIV-1 diagnosis programs in resource-limited settings: opportunities for improved outcomes and more cost-effective interventions. BioMed Central. doi:10.1186/1741-7015-9-59
4. **UN AIDS.** (2015). 2015 Progress Report on the Global Plan. UN AIDS. Retrieved July 11, 2019, from https://www.unaids.org/sites/default/files/ media_asset/JC2774_2015*ProgressReport_ GlobalPlan_en.pdf*
5. **Sirengo, M., Muthoni, L., Kellogg, T., Kim, A., Katana, A., Mwanyumba, S., . . . Rutherford, G.** (2014). Mother-to-child transmission of HIV in Kenya: results from a nationally representative study. *PMC. doi*:10.1097/QAI.0000000000000115
6. **Ngugi, E. W., Kim, A. A., Nyoka, R., Ng'ang'a, L., Mukui, I., Bernadette Ng'eno,**

B., & Rutherford, G. W. (2014). Contraceptive Practices and Fertility Desires Among HIV-Infected and Uninfected Women in Kenya: Results From a Nationally Representative Study. *National Center for Biotechnology Information (S*75–S81). doi:10.1097/QAI.0000000000000107

7. **World Health Organization.** (2014). Rapid Advice: Use of antiretroviral drugs for treating pregnant women and preventing HIV infection in infants. *Geneva: WHO.*

8. **Finocchario-Kessler, S., Gautney, B. J., Clark, K. F., Okoth, V., Goggin, K., & Khamadi, S.** (2015). Progress Toward Eliminating Mother to Child Transmission of HIV in Kenya: *Review of Treatment Guideline Uptake and Pediatric Transmission at Four Government Hospitals Between 2010 and 2012. Springer,* 20, 2602-2611. doi:10.1007/s10461-015-1071-5

9. **National AIDS Control Council, National AIDS** and **STI Control Program**. (2015). Kenya AIDS response progress report 2014: Progress towards zero. Ministry of Health. Nairobi: Government of Kenya. *Retrieved July* 11, 2019, from http://www.unaids.org/sites/default/files/country/documents/KEN_narrative_report_2014.pdf

10. **Kim, M. H., Ahmed, S., Preidis, G. A., Abrams, E. J., Hosseinipour, M. C., Giordano, T. P., & Chiao, E. Y.** (2013). Low Rates of Mother-to-Child HIV Transmission in a Routine Programmatic Setting in Lilongwe, Malawi. 5(8). *Retrieved July 11, 2019,* from https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0064979

11. **Kebede, B., Gebeyehu, A., Jain, S., Sun, S., & Haubrich, R.** (2014). Delay in Early Infant Diagnosis and High Loss to Follow-Up among Infant Born to HIV-Infected Women in Ethiopia. *World Journal of AIDS,* 4, 402-412. Retrieved July 2019, 2019, from http://file.scirp.org/pdf/WJA_2014112613555031.pdf

12. **Hampanda, K. M., Nimz, A. M., & Abuogi, L. L.** (2017). Barriers to uptake of early infant HIV testing in Zambia: the role of intimate partner violence and HIV status disclosure within couples. *AIDS Research and Therapy,* 17. doi:10.1186/ s12981-017-0142-2

13. **Makau, G., Okwara, F., & Oyore, J.** (2015). Determinants of early infant diagnosis and treatment of HIV among exposed infants. *East and Central Africa Medical Journal,* 2, 74-79. Retrieved March 18, 2019, from https://irlibrary.ku.ac.ke/bitstream/handle/123456789/13978/Determinants%20of%20early%20infant%20diagnosis.....pdf?sequence=1&isAllowed=y

14. **Ashiono, E., Achwoka, D., Chabikuli, O. N., Mutugi, J., Joel, R., & Wafula, A. (n.d.).** Vertical HIV transmission in perinatally exposed infants in South-Rift region of Kenya: Kenya: a retrospective cross-sectional study. *BMC,* 17(207). doi:10.1186/s12889-017-4124-z

15. **Turan, J. M., Bukusi, E. A., Onono, M., Holzemer, W. L., Miller, S., & Cohen, C. R.** (2011). HIV/AIDS stigma and refusal of HIV testing among pregnant women in rural Kenya: results from the MAMAS Study. *AIDS and Behavior,* 15(6), Retrieved March 18, 2019, from https://www.ncbi.nlm.nih.gov/pubmed/20827573.1111–1120. doi:10.1007/s10461-010-9798-5

16. **Tam, M., Amzel, A., & Phelps, B. R.** (2015). Disclosure of HIV serostatus among pregnant and postpartum women in sub-Saharan Africa: a systematic review. *AIDS Care,* 27(2), 436-450. doi:doi.org/10.1080/09540121.2014.997662

17. **Vrazo, A. C., Firth, J., Amzel, A., Sedillo, R., Ryan, J., & Phelps, B. R.** (2018). Interventions to significantly improve service uptake and retention of HIV-positive pregnant women and HIV-exposed infants along with the prevention of mother-to-child transmission continuum of care: a systematic review. *Tropical Medicine and International Health,* 23(**2**), 136–148. doi:10.1111/ tmi.13014

18. **Sullivan, D., & Kottutt, J. (2018).** *USAID.* Retrieved July 13, 2019, from https://aidsfree.usaid.gov/sites/default/files/2018-11/2018.6.13_vl-eid-webinar_sullivan-kottutt.pdf

19. **NAM Publications.** (2019). HIV *& AIDS - Sharing knowledge, changing lives.* Retrieved July 13, 2019, from aidsmap: http://www.aidsmap. com/Transmission-from-mother-to - child/ page/1746452/