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The Role of Maternal, Health System, and Psychosocial Factors in Prevention of Mother-to-Child Transmission Failure in the Era of Programmatic Scale Up in Western Kenya: A Case Control Study

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Abstract

The aim of this study was to identify factors associated with prevention of mother-to-child transmission (PMTCT) in an area of Kenya with widely accessible free PMTCT services. A matched case-control study was conducted at 31 public facilities in western Kenya. HIV-infected mothers with infants aged 6 weeks to 6 months were interviewed and medical charts were reviewed. Cases were mothers of infants with a definitive diagnosis of HIV. Controls were mothers of infants testing HIV negative. Cases and controls were matched in a 1:3 ratio on socio-demographic factors. Fifty cases and 135 controls were enrolled. Conditional (matched) logistic regression analysis was conducted. Odds of being a case were higher for women who first learned their HIV status during pregnancy [OR:2.85, 95%CI:1.41–5.78], did not adhere to antiretroviral therapy (ART) [OR:3.35, 95%CI:1.48–7.58], or had a home delivery [OR:2.42, 95%CI:1.01–5.80]. Based on medical record review, cases had higher odds of their provider not following guidelines for prescription of ART for mothers [OR:8.61, 95%CI:2.83–26.15] and infants [OR:9.72, 95%CI:2.75–34.37]. Stigma from the community [OR:0.37, 95% CI:0.14–1.02] or facility [OR:0.38, 95%CI:0.04–3.41], did not increase the odds of MTCT. Poor adherence to PMTCT guidelines and recommendations by both infected women and health care providers hamper efforts to attain elimination of MTCT.

Introduction

When accessible and implemented optimally, antiretroviral therapy (ART) for the prevention of mother-to-child transmission (PMTCT) represents one of the greatest achievements to date in HIV prevention with the potential to eliminate vertical HIV transmission.[1] New HIV infections among infants have already become virtually non-existent in high-income countries, with the number of new infections among infants falling by 93% between 1992 and 2005.[2] In low- and middle-income countries where PMTCT services have been scaled up, more than 620,000 new HIV infections among infants were averted between 2001 and 2012.[3] In Botswana, for example, the percentage of infants who are born HIV-positive to mothers living with HIV has declined from 21% in 2003 to 4% in 2010.[4] Despite the strides in virtual elimination of new HIV infections in infants, preventable transmissions continue to occur.[5,6] In order to reach the global target of reducing by at least 90% the number of new infections among infants by 2015 (using a 2009 baseline), governments and other program implementers will need to critically appraise barriers and facilitators to uptake of PMTCT services, even as they accelerate scale up.

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The PMTCT ''cascade'' identifies the sequence of steps needed to deliver PMTCT interventions to HIV-infected women and their infants.[7,8] Each aspect of the package is important, and a deficiency in any of the interventions compromises overall effectiveness, thereby resulting in increased risk for MTCT.[9,10] Modeling studies estimate that each step of the cascade needs to be delivered with greater than 90% reliability in order to reduce the number of infants who become infected with HIV.[11] Unfortunately only 15–30% of eligible women complete this cascade.

When an infant is diagnosed with HIV, it can be considered to be a ''PMTCT failure.'' A fundamental need exists to put every case of PMTCT failure into context.[12,13] Social factors, such as HIV-related stigma and discrimination, have been associated with failure to take ARV as prescribed, clinic non-attendance, and refusal of HIV testing.[14–16] Structural and economic factors such as distance from and cost of transport to the health facility can limit women's ability to follow the steps required by PMTCT protocols. Failures in the health service delivery system including faulty patient management, long waiting times, and frequent drug stock outs, decrease service quality and patient satisfaction. Furthermore, individual health status factors such as low CD4 counts, wasting, and low weight gain during pregnancy, have been associated with increased vertical transmission. This interface between individuals, communities, and systems fundamentally affects the degree to which a pregnant HIV-infected woman and her infant are able to benefit from prevention and treatment interventions, and the extent to which health care workers and program implementers respond and provide these interventions.[17]

According to the Kenya AIDS Indicator Survey completed in 2012, among all women who were HIV-infected, at the most recent birth, 71.2% reported they received maternal PMTCT during their pregnancy, 67.1% at delivery, and 82.6% while breastfeeding.[18] Despite this relatively high coverage, an evaluation of all dried blood spot samples collected from infants from all over the country showed an HIV-exposed infant sero-positivity of 8.3%.[19] Within this Kenyan context, where PMTCT services are available for free in public facilities and the government's increasing attention to the elimination of MTCT, we investigated factors associated with PMTCT failure among women accessing these services. Specifically we evaluated the individual, socio-cultural, health system, and operational barriers that contribute to PMTCT failure in Western Kenya.

Methods

Study design

We conducted a matched case-control study at 31 Ministry of Health facilities in Western Kenya. PMTCT failure is an important clinical and public health event. However, a cohort approach would require large populations and prohibitive expense and follow-up time, and may not contribute sufficient data on stigma or structural causes of PMTCT failure. The case control design was facilitated by the availability of a case-ascertainment system in our study setting that included: (1) facility-based HIV registers, (2) hospital and laboratory-based surveillance systems, and (3) availability of locator information and systems for tracing all HIV-positive pregnant mothers and their infants.

Setting

Western Kenya, and specifically Migori, Kisumu, and Homabay Counties where this study was conducted, has characteristics that make it a priority area for doing a PMTCT failure study audit: (1) high HIV prevalence among pregnant women, and (2) relatively high rates of mother-to-child transmission of HIV despite an existing PMTCT program (approximately 10.7%).

Cases and controls

Cases were defined as HIV-infected mothers of infants aged 6 weeks to 6 months with a definitive diagnosis of HIV in the infant. Controls were defined as HIV-infected mothers of infants aged 6 weeks to 6 months with an HIV-negative test result in the infant. Participants were enrolled as infant HIV diagnosis became known between November 2012 and June 2013. Participants had to also meet the following inclusion criteria to participate in the study: (1) have attended antenatal clinic at least once and tested HIV-positive during the antenatal clinic visit at any of the 31 participating health facilities, (2) have an infant with a definitive diagnosis (HIV-positive or HIV-negative) via PCR aged between 6 weeks to 6 months, (3) aged at least 18 years, and (4) able and willing to give written informed consent.

Matching. Cases and controls were matched in a 1:3 ratio on age, level of education (primary, secondary, or tertiary), type of health facility (whether providing integrated ANC/HIV services or standard referral), and age of infant at time of the infant HIV test (± 1 month). Matching on these factors increased the comparability of the cases to the controls with regard to potential confounding factors.

Study procedures

Participants completed an interviewer-administered questionnaire. Topics (explanatory variables) that were covered in the structured questionnaires included: (1) knowledge and attitudes about the benefits of PMTCT interventions, (2) disclosure to close persons, including male partner, mother, father, sister, mother-in-law, etc., (3) accessibility of a healthcare facility from the woman's home in terms of distance, time, and cost, (4) perceptions of health care facility ability to offer quality and confidential diagnosis and care, (5) information provided by the health care providers during the clinic visits, (6) cultural and religious beliefs and traditions in health seeking behaviors, and (7) perception of outcomes for HIV-infected infants. The questionnaire also explored perceptions of HIV-related stigma from the community and perceived and experienced stigma from the male partner and family, as well as any incidences of intimate partner violence. To measure stigma, we used validated stigma and discrimination scales translated into the local languages that have been used in this setting before and found to have good reliability.[15,16]

Supplementary data were also gathered at the health facility through a review of multiple medical registers and charts of the cases and controls enrolled in the study. A standard abstraction tool was used to collect the information. The registers reviewed included maternal HIV clinic records, prenatal, labor and delivery records, pediatric records,

laboratory reports and home visit records, bearing in mind missed opportunities or time lapses. This review also included evaluation of guideline compliance by providers based on what was documented in the record of the medical care received by the participant. Specifically we looked at the following five components of the guidelines: (1) timely provision of HAART to eligible women [i.e., within one week of eligibility], (2) giving the right combination of ARVs to the mothers, (3) giving mothers AZT and NVP syrup to baby for 6 weeks at first contact for the baby, (4) tracing of defaulters within 3 days of missed appointment and early infant diagnosis of infants by 6 weeks. For medical record review, we used different data collectors than those who conducted the interviews, in order to prevent bias. These data collectors were nonclinical staff based at the health facility where the mother had first attended antenatal care. The data collectors were not blinded to whether the records were for a case or a control.

Collectively the questionnaire and the chart audits collected information on: (1) socio-demographic factors such as age, education, ethnicity, income, religion, residence, and marital status, (2) survival status of infant, (3) age, date, and result of infant HIV test (PCR), (4) woman's enrollment and retention in HIV care, and (5) uptake and utilization of PMTCT interventions such as use of ARVs for the mother, prophylactic ARVs for the infant, infant feeding practices, uptake of infant testing, and infant enrolment in HIV care.

Statistical methods

Estimates of the attainable sample size for this study were based on historical data from the Family AIDS Care and Education Services (FACES) PMTCT program, which indicated an MTCT rate of 10.7%. The estimated sample size was 200 with a case: control ratio of 1:3. With this sample size we would have greater than 80% power to detect a minimum odds ratio of 3 for impact of maternal, health facility stigma, and other contextual factors on PMTCT failure. Power calculations used the attainable numbers of cases based on FACES program data[20] estimated prevalence of stigma from previous studies on the effects of socio-cultural factors such as stigma and negative male partner reactions on uptake of labor and delivery services (28–46%).[15,16] We estimated that 90% of HIV-positive women would agree to participate in the study and anticipated that 20% of women would not be traceable due to missing information on the locator form or out-migration.

Variables including infant's age at time of blood collection for HIV testing, mother's age, distance from health facility, and number of health facility visits were summarized, using means (±SD) or medians (IQR) as appropriate. We collapsed the responses of whether a client had been stigmatized once or twice, several times, or most of the time into the 'yes' category for stigma if she mentioned it in any of the questions. The violence was considered as experienced if she answered 'yes' to 'During this last pregnancy, after testing positive was there ever a time when you were slapped, hit or beaten by (any of) your partner(s) while you were pregnant?' as having received a form of violence.

As the study design was matched, we used conditional (matched) logistic regression analysis to assess maternal, facility, and infant factors associated with MTCT reporting the odds ratios (OR) and respective 95% confidence intervals (CI). All analyses were done using STATA version 12.1 (StataCorp, Texas, USA).

Results

Socio-demographic characteristics

Fifty cases and 135 controls were enrolled in the study across 31 health facilities. As shown in Table 1, the difference in mean age of mothers between cases and controls, 26.1 years (SD = 5.6) vs. 26.0 years (SD = 5.1), respectively, was not statistically significant. The proportions of women with primary level education and mean age of the infants at time of the blood sample for PCR were similar between cases and controls' demonstrating that matching was successful (Table 1).

Maternal and infant factors

The odds of being a case were higher if a woman first learned of her HIV status during pregnancy [OR = 2.85, 95%CI 1.41–5.78], did not adhere to ART for her own health or for PMTCT [OR = 3.35, 95%CI 1.48–7.58], had a home delivery [OR = 2.42, 95%CI 1.01–5.80], or if the infant did not receive any ART prophylaxis (mother's report) even when it was dispensed [OR = 3.92, 95%CI 1.13–13.59] (Table 2).

Health facility related factors

Not receiving HIV education [OR = 3.57, 95%CI 1.36–9.33], HIV counseling [OR = 3.95, 95%CI 1.28–12.21], not being encouraged to involve their male partner [OR = 3.87, 95%CI 1.25–11.99], and not receiving assistance with HIV disclosure [OR = 5.63 95%CI 1.99–15.9] were strongly associated with being a case (PMTCT failure), as compared to being a control. Cases also had higher odds of reporting that providers did not give them ART medications at first contact in the clinic [OR = 2.97, 95% CI 1.38–6.31]. In addition, examination of the medical record data indicated that cases were much more likely to have health care providers who did not follow the PMTCT guidelines for prescription of ART for mothers [OR = 8.61, 95%CI 2.83–26.15] and infants [OR = 9.72, 95%CI 2.75–34.37]. Other health facility level

Table 1. Socio-Demographic Characteristics of Cases and Controls

Characteristics[a]	*Control n (%)* (n = *135*)	*Case n (%)* (n = *50*)
Mothers age, mean years (SD)	26 (5.1)	26.1 (5.6)
Infants age (months) at PCR, mean (SD)	3.9 (1.1)	3.9 (1.2)
Mothers education		
Primary	97 (74.6)	39 (76.5)
Secondary	28 (21.5)	10 (19.6)
College/university	5 (3.9)	2 (3.9)
Marital status		
Married	110 (83.3)	35 (67.3)
Separate	4 (3)	4 (7.7)
Single	10 (7.6)	10 (19.2)
Widowed	8 (6)	3 (5.8)

[a]No significant difference between the cases and controls in terms of all the demographic characteristics.

Table 2. Maternal and Infant Factors Associated with PMTCT Failure [Odds Ratio (OR) and 95% Confidence Interval (CI) Having a Case of PMTCT Failure]

Maternal and infant factors	*Control* (n = *133*)	*Case* (n = *52*)	*OR (95% CI)*
Attended ANC	126 (96.9)	45 (88.2)	3.09 (0.68–14.14)
No. of times attended ANC			
One visit	2 (1.6)	7 (15.2)	Ref
Two visits	10 (7.8)	10 (21.7)	0.3 (0.05–1.8)
Three visits	34 (26.4)	8 (17.4)	0.09 (0.02–0.54)
Four plus visits	83 (64.3)	21(45.7)	0.08 (0.02–0.43)
First learned of HIV status during pregnancy			
Before pregnancy	87 (66.4)	20 (38.5)	Ref
After pregnancy	44 (33.6)	32 (61.5)	2.85 (1.41–5.78)
Missed pills during pregnancy			
No/didn't take drugs	110 (85.3)	30 (61.2)	Ref
Yes	19 (14.7)	19 (38.8)	3.35 (1.48–7.58)
Presently enrolled for HIV treatment			
Yes	129 (97.7)	47 (95.9)	Ref
No	3 (2.3)	2 (4.1)	2.07 (0.28–15.43)
Received ARV for baby			
Yes	126 (96.2)	34 (70.8)	Ref
No	5 (3.8)	14 (29.2)	9.72 (2.75–34.37)
Baby missed drugs			
No/didn't take drugs	121 (93.1)	38 (77.6)	Ref
Yes	9 (6.9)	11 (22.5)	3.92 (1.13–13.59)
Delivery place of last child			
Hospital	100 (77.5)	29 (59.2)	Ref
TBA	7 (5.4)	2 (4.1)	1.63 (0.3–8.83)
Home	22 (17.1)	18 (36.7)	2.42 (1.01–5.8)
Child breastfeeding			
Yes	126 (96.9)	49 (98)	Ref
No	4 (3.1)	1 (2)	1.17 (0.1–13.31)
Age (weeks) at introduction of other foods, median age (IQR)	12 (8–16)	12 (8–12)	0.9 (0.76–1.06)

n may be different for some variables.

factors, such as cost of services, were not associated with PMTCT failure (Table 3).

Psychosocial factors

Cases had higher odds of reporting that they felt they had not done everything to avoid MTCT [OR 6.67, 95% CI 2.04–20]. The odds of MTCT were also increased if the mother reported that she lacked any social support [OR 2.83, 95% CI 1.12–7.15]. Reports of stigma experienced from the community [OR 0.37, 95% CI 0.14–1.02] or facility [OR 0.38, 95% CI 0.04–3.41], or reported intimate partner violence [OR 1.23, 95%CI 0.39–3.88] were not statistically related to being a case or a control (Table 4). However, in bivariate analysis comparing women with known HIV status at time of pregnancy versus those women who learned their HIV status for the first time during pregnancy, women with known HIV status had statistically significant higher rates of disclosure to family members ($p < 0.001$), community ($p < 0.003$), and tended to have a support structure ($p < 0.04$) when compared to women who learned their HIV status for the first time in pregnancy. In multivariate analysis of these two groups, becoming aware of one's HIV status for the first time during pregnancy was associated with MTCT even after controlling for disclosure to family or partner, violence from partner, or enrolment into HIV care [adjusted OR 2.22, 95%CI 1.01–4.87].

Discussion

This study aimed to identify individual, socio-cultural, and health system factors that contribute to PMTCT failure in Kenya. We found that women who become aware of their HIV status for the first time during the course of the pregnancy had increased odds of MTCT. These newly diagnosed women likely represent a vulnerable group who are yet to come to terms with their HIV-positive diagnosis and overcome barriers such as stigma and lack of disclosure.[21] They may also have additional challenges to taking the ART medications as prescribed, especially if health care workers manage them in the same way that they manage women who were diagnosed with HIV before pregnancy.[22] Increased counseling may provide these women with the psychosocial support required to navigate these barriers and equip them with information about ART and the need for adherence.

Not surprisingly, non-adherence to maternal ART for prophylaxis, as well as not providing prophylaxis to the infant, increased the odds of MTCT. Non-adherence is probably the most challenging issue for both short course and lifelong therapy within the PMTCT program. Optimal drug

Table 3. Health Facility Factors Associated with PMTCT Failure

Facility factors	*Control* n *(%)* (n = *133)*	*Case* n *(%)* (n = *52)*	*OR (95% CI)*
HIV Education at ANC			
Yes	117 (91.4)	34 (73.9)	Ref
No	11 (8.6)	12 (26.1)	3.57 (1.36–9.33)
HIV counseling at ANC			
Yes	125 (96.2)	39 (83)	Ref
No	5 (3.9)	8 (17)	3.95 (1.28–12.21)
Asked to bring partner			
Yes	124 (94.7)	42 (84)	Ref
No	7 (5.3)	8 (16)	3.87 (1.25–11.99)
Assistance with disclosure to partner			
Yes	123 (93.2)	34 (68)	Ref
No	9 (6.8)	16 (32)	5.63 (1.99–15.9)
Use of ARV in pregnancy			
Yes	122 (93.9)	30 (63.8)	Ref
No	8 (6.2)	17 (36.2)	8.62 (2.84–26.15)
Received ARV for baby			
Yes	126 (96.2)	34 (70.8)	Ref
No	5 (3.8)	14 (29.2)	9.72 (2.75–34.37)
When given drugs			
1stANC/on drugs	87 (66.4)	18 (40.0)	Ref
Subsequent/NA	44 (33.6)	27 (60.0)	2.97 (1.39–6.37)
Satisfied with health worker explanation			
Yes	125 (98.4)	31 (79.5)	Ref
No	2 (1.6)	8 (20.5)	N/A
Health community visit			
Yes	27 (20.9)	4 (8.2)	Ref
No	102 (79.1)	45 (91.8)	2.53 (0.81–7.94)
Means of transport			
Walking	9 (6.8)	5 (9.8)	Ref
Bicycle	18 (13.6)	7 (13.7)	0.64 (0.13–3.25)
Motorcycle	85 (64.4)	32 (62.8)	0.63 (0.17–2.33)
Matatu/bus	20 (15.2)	7 (13.7)	0.71 (0.14–3.77)
Payment at hospital			
Yes	1 (5)	0 (0)	Ref
No	19 (95)	6 (100)	N/A
Distance from health facility median (IQR)	88 (5–88)	88 (6–88)	1.01 (1–1.02)
Number of health facility visits median (IQR)	1.5 (1–2.5)	2.5 (1.5–3)	0.71 (0.04–11.79)

n may be different for some variables; N/A, no odds ratio computed due to all positive or all negative group outcomes.

adherence is necessary to lower viral load,[23] and thus reduce risk of MTCT among HIV infected women.[24–26] Multiple personal, socio-cultural, and economic reasons are cited for non-adherence among pregnant women in the literature. These include forgetfulness, losing tablets, stigma and lack of disclosure, food insecurity, cultural factors, lack of accurate health information, lack of social support, medication side effects, and overcrowded health systems.[27–32] Consistent with other literature, home delivery, as compared to delivery in a health facility, increased the odds of MTCT. Home delivery puts an infant to a higher risk of HIV transmission[33] and increases chances of a woman not taking her tablets in labor or giving their infants prophylaxis.[34]

Weaknesses within the health system were associated with increased odds of MTCT. It appears that optimizing provider–patient relations can improve uptake of PMTCT services and maternal and infant health outcomes.[17,35] This will involve tackling unclear expectations, skill deficits, resource and/or equipment shortages that often underlie negative patient–provider interactions and hamper access to and retention in PMTCT services.[36–38] Whatever strategies that are employed, they must strive to improve the productivity, competence, and responsiveness of health care workers.[36] Health system capacity can be strengthened by ensuring autonomy over resources at lower levels; linking performance management interventions to facility-wide human resources management; and developing accountability systems to ensure that health workers and managers are responsible for their performance.[39,40]

In addition, health systems should aim not only to provide knowledge to women but also to cultivate a supportive relationship that enables the women to apply the new knowledge to their daily lives, and come up with solutions to challenges to healthy daily routines.[36,41] This can only happen if patient–provider communication is improved at every stage of the continuum of care.[42] For example, it may include being an encourager during the testing stage, providing

Table 4. Comparison of Knowledge, Attitudes, and Perceived Benefits of PMTCT, Disclosure, Stigma, and Violence by Cases and Controls

Community knowledge, attitudes, and benefits of PMTCT	*Control* n *(%)* (n = *133*)	*Case* n *(%)* (n = *52*)	*OR (95% CI)*
I felt I had done everything to avoid transmitting the virus to my infant			
No	4 (3.1)	11 (21.6)	6.67 (2.04–20)
Yes	126 (96.9)	40 (78.4)	Ref
If my child tested positive, people would find out about my HIV status			
No	24 (18.3)	10 (19.6)	Ref
Yes	107 (81.7)	41 (80.4)	1.03 (0.45–2.36)
I didn't think knowing the HIV status of my child would do any good			
Yes	26 (19.9)	17 (33.3)	2.20 (1.01–4.76)
No	105 (80.2)	34 (66.7)	Ref
There is someone I could talk to about important decisions in my life			
Yes	118 (89.4)	42 (80.8)	Ref
No	14 (10.6)	10 (19.2)	2.35 (0.86–6.39)
There are people I can depend on to help me if I really need it			
Yes	122 (92.4)	48 (92.3)	Ref
No	10 (7.6)	4 (7.7)	1.22 (0.35–4.24)
If sick and needed someone to take me to the doctor I would have trouble finding someone			
Yes	27 (20.6)	9 (17.3)	1.18 (0.47–2.90)
No	104 (79.4)	43 (82.7)	Ref
If in need of money, would find trouble finding help			
Yes	109 (82.6)	37 (71.2)	Ref
No	23 (17.4)	15 (28.9)	2.83 (1.12–7.15)
If I needed a place to stay, there is someone who would welcome me into their home			
Yes	119 (90.2)	43 (82.7)	Ref
No	13 (9.9)	9 (17.3)	1.88 (0.67–5.24)
Disclosure to family			
No	4 (3)	4 (7.7)	Ref
Yes	129 (97)	48 (92.3)	0.36 (0.07–1.82)
Disclosure to community			
No	67 (50.4)	31 (59.6)	Ref
Yes	66 (49.6)	21 (40.4)	0.57 (0.25–1.3)
Violence			
No	113 (90.4)	44 (86.3)	Ref
Yes	12 (9.6)	7 (13.7)	1.23 (0.39–3.88)
Stigma from community			
No	97 (72.9)	46 (88.5)	1
Yes	36 (27.1)	6 (11.5)	0.37 (0.14–1.02)
Stigma from Facility			
No	127 (95.5)	51 (98.1)	1
Yes	6 (4.5)	1 (1.9)	0.38 (0.04–3.41)

n may be different for some variables.

knowledge and reassurance during the early stages of care, and becoming a partner in health as care becomes more established.[35] Strategies may also include patient-selected community-based treatment supporters to improve understanding of HIV and PMTCT particularly for newly diagnosed women.[21,39] Home visits by trained nurses or community health workers can be introduced to circumvent challenges such as expensive transport, long waiting lines, and discordant mother-infant clinic appointments,[36] and by extension enhance maternal and child outcomes.[39,41]

Our finding that stigma and other psychosocial factors did not increase the odds of MTCT differs from prior studies in the region that have found that fears of HIV-related stigma and discrimination negatively impact service uptake and adherence at each step of the PMTCT cascade.[8,43] Our results are, however, in keeping with those of another study done in Kenya, which showed that health systems factors were more important than stigma in predicting PMTCT failure.[44] One of the reasons for these mixed results may be that the majority of the studies have looked at missed opportunities and stigma along the PMTCT cascade as two parallel rather than intersecting determinants of MTCT. It is also possible that these studies have not distinguished between women who are newly diagnosed in pregnancy versus the known positive. Our study revealed significant differences in rates of disclosure and feelings of social support among women who are newly diagnosed in pregnancy versus those who knew about their HIV-positive status prior to pregnancy. While health system factors will affect all women, it is possible that disclosure and other psychosocial factors may play a bigger role

for women newly diagnosed as HIV-positive in pregnancy, than in women who were diagnosed with HIV prior to pregnancy and amplify the health system deficiencies.

There were a few important limitations to this study. Due to the time elapsed since the antenatal period and time of diagnosis, women may not have been able to accurately recall information on drugs taken or given to their infants. To minimize this, we limited the timing of study recruitment to 6 weeks to 6 months after the birth and corroborated reports with medical and other clinical records at the health facility. We did not match participants by maternal CD4 counts; however, the mean CD4s pooled by case and control did not differ. It is also possible that because infant HIV status was measured at variable time periods after the birth, some later infant HIV infections (e.g., through breastfeeding) may have been missed. However, analysis was done on matched cases and controls at the time of infant HIV testing.

Additionally while the results from this study are likely to be representative of the situation in Western Kenya, it is unclear how generalizable they will be to other regions of Kenya or sub-Saharan Africa. Nonetheless, combined with information about the study setting, the results will be useful to policy makers and program planners throughout the region as they develop services to improve the PMTCT services. The main strength of our study is that we used mothers' self reports and corroborated the information with routine data from health facilities within a non-research set up, reflecting routine health care practice, rather than using data from research clinics where quality of care may be better.

In conclusion, PMTCT failure in this setting was associated with several potentially modifiable risk factors, and thus findings of this study can be used to improve PMTCT service delivery in this and similar contexts. Health care workers need to pay particular attention to pregnant women who learn their HIV status for the first time during pregnancy and routinely provide simple recommended interventions such as HIV education and counseling, encouraging male involvement, and facilitating safe disclosure of HIV status. Targeted efforts to improve adherence to recommended PMTCT guidelines by health care providers to all eligible mothers are needed.

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Author Disclosure Statement

The authors have declared that no competing interests exist.

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