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Does knowledge impact adherence?: correlation between HIV-infected pregnant women's knowledge of WHO-recommended PMTCT guidelines and their adherence to the PMTCT program in India

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ABSTRACT

WHO's 2013 PMTCT guidelines recommended lifelong antiretroviral therapy (ART) for HIV-infected pregnant and breastfeeding women, exclusive breastfeeding (EBF), nevirapine prophylaxis (NVP) and early infant diagnosis (EID) for HIV-exposed-breastfed infants. We examined the association between knowledge and adherence to these guidelines among 550 HIV-infected pregnant women in Maharashtra, India. Knowledge of PMTCT guidelines was assessed using a structured-questionnaire during enrollment. Adherence to ART, NVP, and EBF was assessed using structured questionnaires during post-partum home visits at 2 weeks, 2, and 6 months respectively. EID adherence at 6 weeks was assessed by weekly infants' HIV testing clinical record review. We used Fisher's exact test to assess the association between correct knowledge and subsequent adherence and logistic regression to estimate the odds ratios. The results showed that women's correct responses to specific questions of each PMTCT guideline correlated with subsequent adherence. For instance, awareness of duration and place to obtain ART was associated with a higher likelihood of taking ART at delivery (aOR = 1.93, $p = 0.02$ and aOR = 3.91, $p < 0.01$ respectively). Similarly, women knowing only breastmilk should be given to infants for 6 months showed highest adherence to EBF (aOR = 2.59, $p = 0.02$). Women who correctly knew the reason for infant NVP administration were more adherent to it at 6 weeks (aOR = 1.77; $p = 0.03$). Women aware of mother-to-child HIV transmission during delivery had highest adherence to EID at 6 weeks (aOR 3.58, $p = 0.01$). Gaps were identified in women's detailed knowledge of and adherence to each PMTCT guideline. Suboptimal adherence to ART (n = 389, 71%), EBF (n = 179, 33%), NVP (n = 428, 78%), and EID at 6 weeks (n = 369, 67%) was found. Our study suggests providing a comprehensive knowledge of each guideline through the PMTCT program's education strategies can enhance adherence among HIV-infected women.

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Introduction

Mother-to-child transmission (MTCT) of HIV is a significant contributor to new infections among children (WHO, 2017). Access to the prevention of mother-to-child-transmission (PMTCT) programs for pregnant mothers expanded from <50% in 2010 to >80% in 2022 (UNAIDS, 2020; UNICEF, 2019; WHO, 2023), which was associated with a reduction in the global estimate of MTCT from 23% to 11% during that same period (UNICEF, 2019). In 2013, World Health Organization (WHO) PMTCT guidelines incorporated four specific recommendations: (1) Lifelong antiretroviral therapy (ART) for all HIV-infected pregnant and breast-feeding women, regardless of CD4 count or clinical stage (2) Promotion of exclusive breastfeeding (EBF) (3) Nevirapine-prophylaxis (NVP) for 6–12 weeks to HIV-exposed, breastfed infants (4). Engagement and retention of women and infants in postpartum HIV care to facilitate early infant diagnosis (EID) (National AIDS Control Organization., 2013; WHO, 2013; WHO, 2017).

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India has had a national PMTCT program since 2002 which incorporated the updated 2013 WHO guidelines in 2014 (National AIDS Control Organization, 2013; National AIDS Control Organization, 2024). By 2022, the National AIDS Control Organization (NACO) had established more than 34,000 Integrated Testing and Counseling Centers (ICTC) throughout the country, which provide free HIV counseling and testing services and link HIV-infected individuals, including pregnant women and children, to treatment and care centers (National AIDS Control Organization, 2022). Despite this expansion of services, the HIV MTCT rate in India was estimated to be 24% in 2021 (National AIDS Control Organisation & ICMR, 2022), more than twice the global average of 11% (UNAIDS, 2020). In addition, the number of new infections among children in India increased from 3700 to 5000 between 2017 and 2021(National AIDS Control Organisation & ICMR, 2018; National AIDS Control Organisation & ICMR, 2022), contributing to an estimate of >69,000 Indian children with HIV in India and 8% of the new infections in 2021 (National AIDS Control Organisation & ICMR, 2022).

Studies from sub-Saharan Africa (SSA) suggest that poor adherence to maternal ART (Abdisa & Tenaw, 2021; Fedlu et al., 2020) and EBF guidelines (Ndubuka et al., 2013) is associated with poor maternal general knowledge of PMTCT guidelines. Studies from SSA also demonstrate that a woman's general knowledge of HIV and interventions to prevent MTCT correlate with the uptake of PMTCT services (Alemu et al., 2017; Asefa & Beyene, 2013; Igwegbe & Ilika, 2005; Lamina, 2012; Teshale et al., 2021). However, it remains unclear whether an HIV-infected pregnant woman's specific knowledge about the four key components of the 2013 WHO-recommended updated PMTCT guidelines correlates with adherence to these guidelines.

Data from India on maternal knowledge of PMTCT guidelines are limited. Studies conducted prior to the 2014 implementation of the updated WHO PMTCT recommendations, found inadequate knowledge about the prior PMTCT guidelines (Kumar et al., 2020; Panditrao et al., 2015; Rastogi et al., 2012; Sagili et al., 2015). To date, there are no data from India documenting maternal knowledge about the revised WHO PMTCT guidelines and no studies have assessed the association of maternal knowledge about specific PMTCT guidelines with adherence to the PMTCT recommendations. Therefore, to inform and improve maternal education programs and strategies to reduce MTCT of HIV in India, the country with the second largest HIV burden (Kumar et al., 2023; National AIDS Control Organization & ICMR-National Institute of Medical Statistics, 2022), the association of maternal knowledge with adherence to specific PMTCT guidelines was assessed among HIV-infected pregnant Indian women.

Methods

Study setting and participants

This study was conducted as part of the "Community-Home Based India Prevention of Mother to Child Transmission of HIV(COMBIND) study" in 4 districts in the state of Maharashtra, India (Pune, Thane, Satara, and Sangli). COMBIND was a cluster randomized trial to assess the effectiveness of integrated behavioral and mobile technology interventions to improve uptake of the four key PMTCT guidelines among HIV-infected pregnant and post-partum women. Full details of the study are published elsewhere (Suryavanshi et al., 2020). Between March 2015 and May 2017, 550 consenting HIV-infected pregnant women, aged >18 years, and registered in the ICTC were enrolled in the study. HIV-infected pregnant women below 18 years and women who refused to give consent were excluded from the study.

Data collection

Eligible and consenting participants were enrolled in one of 119 ICTCs in the 4 participating districts, by study staff (interviewers). Study data were collected using a tablet-based mHealth application (emocha Mobile Health, Baltimore, MD, USA). Data were captured on Smart Forms, encrypted, and wirelessly synced to a secure server. Participants were administered structured questionnaires at enrollment in the ICTCs that were completed by an interviewer, to assess their baseline knowledge about the PMTCT guidelines. Additionally, these women were administered structured questionnaires during post-partum home visits conducted by the interviewers at 2 weeks (to assess the adherence to maternal ART at delivery), at 2 months (to assess the adherence of infant NVP at 6 weeks), and at 6 months post-partum (to assess the adherence to EBF). Both structured questionnaires for assessing knowledge and adherence were translated into the local languages, Marathi and Hindi, before being administered to the study participants. The interviewers abstracted data on adherence to EID at 6 weeks through weekly reviews of infant HIV testing records in the ICTCs.

Assessment of HIV-infected pregnant women's knowledge about PMTCT guidelines

Structured questionnaires administered by the COMBIND study staff (interviewers) to pregnant women with HIV (WHIV) at their study enrollment visit contained a total of 17 knowledge questions (see Data Supplement file A). The interviewers read each question and respective responses to the HIV-infected pregnant women. The responses selected by the participants were entered into the study database. The knowledge questionnaire was focused on the 4 components of the WHO-recommended PMTCT guidelines and pretested for understanding among 50 women attending the antenatal care clinic at Byaramjee Jeejeebhoy Government Medical College in Pune, India. Five questions were related to knowledge about the PMTCT recommendation for lifelong ART for pregnant/breastfeeding WHIVs. Five questions were related to knowledge about the EBF recommendation, and two questions were related to the NVP recommendation for breastfed infants. Knowledge about the recommendation for EID was assessed by asking five questions. For 15 knowledge questions, there was 1 correct answer. For the other 2 questions, either of the two possible answers were counted as correct.

Assessment of HIV-infected pregnant women's adherence to PMTCT guidelines

During home visits by the interviewers conducted at 2 weeks post-partum, study participants were also administered a structured questionnaire (see Data supplement file B) that assessed adherence to the PMTCT maternal ART recommendation, defined as women who self-reported that they have taken ART in the hospital during or immediately after delivery. During a home visit conducted by study staff at 2 months post-partum, adherence to the recommendation for 6 weeks of infant NVP was assessed by administration of a structured questionnaire. Women who self-reported that they "never missed" administering any doses of infant NVP for at least 6 weeks (±1 month window period) post-partum were considered adherent to the PMTCT infant NVP guidelines. Women whose infants had been screened for HIV at 6 weeks (±1 month window period) were considered adherent to the EID guideline if an HIV test conducted for their infant was also identified through a review of the ICTC's clinical records by study staff. Adherence to EBF was assessed during home visits conducted by the interviewers administering a structured questionnaire at 6 months post-partum. Women who self-reported that they exclusively breastfed their infants without any additional food for 6 months (±1 month window period) were considered adherent to the EBF guidelines. The outcome data on adherence to the 4 PMTCT guidelines were entered into a structured e-CRF and then entered into the study database.

Data analysis

Data were analyzed using STATA version 14.2 (copyright 1985–2015 Stata Corp 4905 Lakeway Drive, TX, USA). Baseline data on characteristics was summarized using frequencies and percentages and compared using Fisher's exact test. Knowledge responses were summarized using frequencies and percentages. Fisher's exact test was used to assess the association between correct knowledge and subsequent adherence and logistic regression was used to estimate the odds ratios. Since study participants were enrolled in a cluster-randomized clinical trial to evaluate the impact of a mobile health education intervention, a multivariable analysis of the association between correct knowledge responses and adherence outcomes was applied that included randomization assignment.

Ethics approval

The study was reviewed and approved by the NACO research committee, the Lakshya Trust IRB, the Johns Hopkins University School of Medicine Institute Review Board (IRB), and the science office of the US Center for Disease Control and Prevention.

Results

Participant characteristics

A total of 550 HIV-infected pregnant women were enrolled with a median age of 25 years (IQR 22–28). Four-hundred thirty-nine (80%) of the 550 enrolled women were from predominantly urban districts (Thane and Pune) and 111 (20%) were from the peri-urban districts (Satara and Sangli). Four-hundred and eight (74%) had received at least 5 years of formal education. Two-hundred-seventeen (39%) were primigravida, 460 (84%) were unemployed and 544 (99%) had disclosed their HIV status to their family members (Table 1).

Maternal ART guidelines

As shown in Table 2, 458 (83%) and 516 (94%) of the pregnant participants correctly answered questions regarding the recommended maternal ART duration and place to obtain maternal ART, respectively. Three

Table 1. Socio-demographic characteristics of the study participants.

Characteristics	Pregnant (n = 550)
District	
Pune	226 (41%)
Sangli	46 (8%)
Satara	65 (12%)
Thane	213 (39%)
Age, Median (Inter-Quartile Range)	25 (22–28)
Marital Status	
Married	543 (99%)
Other	7 (1%)
Religion	
Hindu	451 (82%)
Muslim	56 (10%)
Other	43 (8%)
Mother Tongue	
Hindi	141 (26%)
Marathi	358 (65%)
Other	51 (9%)
Family Type	
Joint	254 (46%)
Nuclear	296 (54%)
Years of Education	
None	101 (18%)
1–4	41 (8%)
5–10	266 (48%)
11–12	92 (17%)
> 12	50 (9%)
Occupation	
Yes	90 (16%)
No	460 (84%)
First Pregnancy	
No	333 (61%)
Yes	217 (39%)
Children	
No	303 (55%)
Yes	247 (45%)
Family knows about HIV Status	
No	6 (1%)
Yes	544 (99%)

hundred eighty-nine (71%) pregnant mothers were subsequently documented to be taking ART at the time of delivery. When controlled for their randomization assignment to either the SOC or COMBIND intervention, correctly answering either of these two questions was independently associated with a higher likelihood that she was subsequently taking ART at the time of delivery. Additionally, the aOR for knowing where to get ART (aOR: 3.91, p-value = 0.001) was twice the aOR for knowing that ART was lifelong (aOR: 1.93, p-value = 0.02). The proportion of pregnant women with correct answers to 3 other maternal ART knowledge questions ranged between 51-98%, but correct responses to these knowledge questions were not statistically significant with an increased likelihood of maternal ART taken at the time of delivery.

Exclusive breastfeeding guideline

One hundred seventy-nine pregnant mothers (33%) reported that they practiced EBF for at least 6 months. As shown in Table 3, the correct answer to the question about what additional food should be given to a breastfed infant was reported by 322 (59%) of pregnant participants. Two hundred forty-two (44%) and 284 (52%) of pregnant participants correctly answered questions about what it means to exclusively breastfeed and how long to provide EBF, respectively. When participants enrolled in the study during their pregnancy were later interviewed about their breastfeeding practices at 6 months post-partum, those that had correctly answered any of these three questions prior to delivery were more likely to report exclusively breastfeeding their infants for the prior 6 months. Compared to mothers who answered incorrectly, pregnant mothers who knew that only breast milk should be given to infants for the first 6 months were almost 2.5 times more likely to practice EBF after delivery (aOR 2.59; $p = 0.02$). A correct response to the remaining knowledge questions was not statistically significant with an increased likelihood of subsequent EBF.

Infant NVP guideline

Four hundred twenty-eight (78%) of the infants born to pregnant mothers received daily infant NVP doses from birth till at least 6 weeks. As shown in Table 4, 264 (48%) of the mothers correctly answered the question about why infant NVP is given to infants born to HIV-positive mothers, and, compared to mothers who answered incorrectly, their infants were almost twice as likely to subsequently receive NVP (AOR 1.77; $p = 0.03$). Only 141 (26%) of the mothers knew how long infant NVP should be prescribed, and a correct response was not independently associated with subsequent use of infant NVP prophylaxis.

Infant HIV testing (EID) guideline

As shown in Table 5, 514 (93%) of mothers responded "Yes" when asked if babies born with HIV-.

positive mothers should be tested. Three hundred and sixty-nine (67%) WHIVs reported that their infants were HIV tested at 6 weeks of age which was verified from the weekly clinical records review by the study staff. However, correctly answering this question during their pregnancy interview was not independently associated with the likelihood of subsequent infant HIV testing at 6 weeks. In addition, correctly answering questions about why or where infants should be HIV tested were also not associated with subsequent infant testing at 6 weeks of age. In contrast, correctly answering that infants should be tested at 12 and 18 months was associated with the

Table 2. Association of Correct Knowledge about Maternal Anti-Retroviral Therapy (ART) Guidelines among Pregnant Women with their Use of ART at Delivery[1].

Knowledge Questions	Pregnant n (%) Total = 550	SOC[2] Odds Ratio (*p*-value) N = 240	COMBIND[3] Odds Ratio (*p*-value) N = 310	Unadjusted Odds Ratio (*p*-value)	Adjusted Odds Ratio (*p*-value)
1. Should pregnant and Breastfeeding women take ART?					
Correct response: Yes	538 (98%)	0[4]	6.61 (0.01)	2.55 (0.14)	2.58 (0.14)
2. As per the PMTCT guidelines, when should an HIV-positive woman start ART?					
Correct response: At the time of diagnosis regardless of trimester	348 (63%)	1.61 (0.18)	1.40 (0.29)	1.49 (0.09)	1.49 (0.09)
3. How long should a woman be provided ART after detecting she is HIV positive during her pregnancy or delivery?					
Correct response: Lifetime	458 (83%)	1.19 (0.70)	2.76 (0.01)	1.94 (0.02)	1.93 (0.02)
4. Why is ART given to pregnant and breastfeeding mothers who are diagnosed as HIV positive?					
Correct Responses					
-Reduce the risk of HIV transmission to Infant	282 (51%)	0.83 (0.60)	1.41 (0.27)	1.52 (0.25)	1.12 (0.64))
-For Women's health?	281 (51%)	1.18 (0.65)	1.04 (0.90)	1.55 (0.36)	1.10 (0.69
5. Where do you get HIV medicines?					
Correct response: ART Center	516 (94%)	4.46 (0.02)	3.60 (0.01)	3.86 (0.001)	3.91(0.00)

[1]Participants interviewed at 2 weeks post-partum. Adherence to PMTCT maternal ART guidelines was defined as WHIV who self-reported receiving ART during or immediately after delivery.
[2]SOC Arm: Standard of Care Arm. Women who were in the control group of the COMBIND intervention study.
[3]COMBIND Arm: Pregnant and post-partum WHIV who were enrolled in the COMBIND study and received COMBIND intervention i.e., integrated behavioral and mobile technology intervention to improve uptake of four key components of PMTCT guidelines.
[4]No women in the SOC arm answered this question incorrectly.
The multivariable model was adjusted for the randomized treatment arm, i.e., COMBIND or SOC.

likelihood of a subsequent infant HIV test at 6 weeks (aOR 2.26; p value = 0.05 and aOR 1.96; p value = 0.05, respectively). Interestingly, correctly answering that infants should be tested earlier at 6 weeks and 6 months of age was not associated with subsequent infant testing. Finally, correctly answering that HIV is transmitted from mothers to infants during delivery was also independently associated with a subsequent infant HIV test (aOR 3.58; p-value = 0.01).

Discussion

Our study is the first to establish an association between a pregnant WHIV's correct answer to specific PMTCT knowledge questions and subsequent uptake of the related PMTCT recommendation. In general, most women in our study knew about the need to take lifelong ART. However, findings show that those who were aware of "where to obtain ART" had

Table 3. Association of Correct Knowledge about Exclusive Breastfeeding (EBF) Guidelines among Pregnant women with subsequent EBF practice[1].

Knowledge Questions	Pregnant n (%) Total = 550	SOC[2] Odds Ratio (*p*-value) N = 240	COMBIND[3] Odds Ratio (*p*-value) N = 310	Unadjusted Odds Ratio (*p*-value)	Adjusted Odds Ratio (*p*-value)
1. What additional food you will give to your baby if you decide to breastfeed your baby?					
Correct response: Only breastmilk for the first 6 months	322 (59%)	1.32 (0.38)	1.95 (0.02)	1.65 (0.02)	2.59 (0.02)
2. What does it mean to exclusively breastfeed an infant?					
Correct response: Give only breast milk	242 (44%)	1.37 (0.31)	1.32 (0.32)	1.31 (0.20)	1.34 (0.16)
3. How long should a woman exclusively breastfeed her baby?					
Correct response: For first 6 months	284 (52%)	1.96 (0.03)	1.59 (0.09)	1.75 (0.01)	1.74 (0.01)
4. How long should the mother continue breastfeeding her baby (non-exclusive)?					
Correct response: Until the baby is 1 year old	120 (22%)	1.55 (0.29)	1.97 (0.03)	1.84 (0.02)	1.80 (0.02)

[1]Participants were interviewed at their homes at 6 months post-partum. Women who exclusively breastfed their infants for 6 months were considered adherent.
[2]SOC Arm: Standard of Care Arm. Women who were in the control group of the COMBIND intervention study.
[3]COMBIND Arm: Pregnant and post-partum WHIV who were enrolled in the COMBIND study and received COMBIND intervention i.e., integrated behavioral and mobile technology intervention to improve uptake of four key components of PMTCT guidelines
The multivariable model was adjusted for the randomized treatment arm, i.e., COMBIND or SOC.

Table 4. Association of Correct Knowledge about Infant Nevirapine-prophylaxis (NVP) Guidelines among Pregnant Women and Subsequent Post-partum Infant NVP Use[1].

Knowledge Questions	Pregnant n (%) Total = 550	SOC[2] Odds Ratio (*p*-value) N = 240	COMBIND[3] Odds Ratio (*p*-value) N = 310	Unadjusted Odds Ratio (*p*-value)	Adjusted Odds Ratio (*p*-value)
1. How long should HIV medicines be given to the baby born to an HIV-positive woman?					
Correct response: From birth until 6 weeks	141 (26%)	2.74 (0.07)	1.04 (0.92)	1.50 (0.19)	1.49 (0.20)
2. Do you know why HIV medicine is given to a baby born to an HIV-positive mother?					
Correct response: To prevent HIV transmission from mother to baby	264 (48%)	1.45 (0.30)	2.08 (0.04)	1.76 (0.03)	1.77 (0.03)

[1]Participants interviewed at 2 months post-partum home visit who self-reported that their infants were given a daily dose of liquid NVP for at least 6 weeks were classified as adherent to this recommendation.
[2]SOC Arm: Standard of Care Arm. Women who were in the control group of the COMBIND intervention study.
[3]COMBIND Arm: HIV-infected pregnant and post-partum women who were enrolled in the COMBIND study and received COMBIND intervention i.e., integrated behavioral and mobile technology intervention to improve uptake of four key components of PMTCT guidelines
The multivariable model was adjusted for the randomized treatment arm, i.e., COMBIND or SOC.

the highest likelihood to take ART at delivery, compared to those women who correctly answered to other 4 knowledge questions on maternal ART. The adherence to maternal ART at the time of delivery was much lower than in other studies conducted in Ethiopia which measured HIV-infected pregnant and lactating women's one-month's ART adherence (Ebuy et al., 2015; Fedlu et al., 2020). Both studies found that higher adherence to ART medicines is attributed to women receiving counseling on the importance and effects of maternal ART and having knowledge about the purpose of taking ART medication. One of these Ethiopian studies showed women with a longer duration on ART had better adherence to ART medicines than those who were put on ART after pregnancy (Fedlu et al., 2020). In contrast to this study, our data did not correlate the duration on ART with adherence to maternal ART among HIV-infected pregnant women. Maternal ART knowledge was assessed during pregnancy, and mothers had already started taking ART at the time of assessment. Therefore, they were more likely to

Table 5. Association of Correct Knowledge about Early Infant Diagnosis (EID) Guidelines among Pregnant Women with Subsequent Post-partum Infant HIV Testing[1].

Knowledge Questions	Pregnant n (%) Total = 550	SOC[2] Odds Ratio (*p*-value) N = 240	COMBIND[3]Odds Ratio (*p*-value) N = 310	Unadjusted Odds Ratio (*p*-value)	Adjusted Odds Ratio (*p*-value)
1. Should babies born to HIV-positive women be tested for HIV?					
Correct response: Yes	514 (93%)	0.51 (0.39)	1.49 (0.47)	0.98 (0.96)	0.98 (0.96)
2. Why should a baby born to an HIV-positive woman get tested for HIV?					
Correct Response: If positive, HIV treatment to infant	179 (33%)	0.67 (0.42)	1.72 (0.19)	1.13 (0.70)	1.11 (0.75)
3. Where should babies born to HIV-positive women be tested?					
Correct response: ICTC	381 (69%)	1.13 (0.72)	1.11 (0.75)	1.14 (0.59)	1.12 (0.63)
4. When should babies born to HIV-positive women be tested for HIV?					
Correct responses:					
6 Weeks (EID)	181 (33%)	2.42 (0.18)	0.93 (0.88)	1.37 (0.42)	1.38 (0.41)
6 Months	235 (43%)	0.91 (0.84)	0.94 (0.89)	0.92 (0.80)	0.93 (0.82)
12 Months	174 (32%)	1.18 (0.79)	3.80 (0.04)	2.34 (0.05)	2.29 (0.05)
18 Months	227 (41%)	1.45 (0.44)	2.55 (0.05)	1.97 (0.05)	1.96 (0.05)
5. When is HIV transmitted from mother to baby?					
Correct responses:					
Pregnancy	96 (17%)	1.79 (0.15)	0.75 (0.43)	1.10 (0.71)	1.13 (0.65)
Delivery	115 (21%)	4.80 (0.04)	2.86 (0.10)	3.56 (0.01)	3.58 (0.01)
Breastfeeding	166 (30%)	1.96 (0.41)	2.28 (0.29)	2.14 (0.17)	2.13 (0.17)

[1]Participants whose infants were tested for EID at 6 weeks. A weekly ICTC clinical record confirmed this. These participants were classified as adherent to EID guidelines.
[2]SOC Arm: Standard of Care Arm. Women who were in the control group of the COMBIND intervention study.
[3]COMBIND Arm: Pregnant and post-partum WHIV who were enrolled in the COMBIND study and received COMBIND intervention i.e., integrated behavioral and mobile technology intervention to improve uptake of four key components of PMTCT guidelines.
The multivariable model was adjusted for the randomized treatment arm, i.e., COMBIND or SOC.

know where to obtain and why it was important to take ART medicines. Consequently, having accurate knowledge about maternal ART could be associated with already being on ART at that time. Therefore, the outcome assessment of adherence to maternal ART may be biased due to this factor.

Overall, knowledge of EBF practices was low among the women in our study on all questions but the highest association with adherence was found to be among women who knew that for the first six months, only breastmilk is appropriate for the baby (aOR 2.59, *p*-value 0.02). Therefore, during pregnancy, a WHIV should be provided with correct knowledge about the feeding practices for the first 6 months of the babies born to an HIV-infected woman. This is crucial for enhancing adherence to EBF guidelines among them. Studies from Kenya and Tanzania suggest higher adherence rates to EBF practices among HIV-infected women from the PMTCT program (Okanda et al., 2014; Philemon et al., 2022) contrary to our study. However, neither study assessed women's knowledge of EBF and its association with adherence to EBF practices. Our study showed that mothers who knew the definition and recommended duration of EBF were more likely to practice EBF for their infants. Studies have shown that EBF for 6 months reduces the risk of HIV MTCT (Coovadia & Kindra, 2008; Mofenson, 2010). It is therefore imperative that in pregnancy all HIV-infected women be provided information about the importance and duration of EBF which may improve adherence to EBF and avert the risk of HIV MTCT. Alongside, during pregnancy, all HIV-infected women should be thoroughly counseled about the importance of taking lifelong ART medications which could further increase their adherence to maternal ART.

Knowledge of NVP guidelines was also found to be low, though the lack of awareness of these guidelines did not correlate with adherence to infant NVP administration. Seventy-eight percent of study participants were found to adhere to daily infant NVP administration. This may be attributed to the involvement of HIV outreach workers who were recruited and assigned to ensure that babies born to HIV-infected women receive daily NVP as part of the national HIV prevention and intervention program. (National AIDS Control Organization, Department of AIDS Control Operational Guidelines for Care & Support Centres, New Delhi, India, 2013). However, adherence to infant NVP up to 6 weeks was lower in our study as compared to a study conducted in Uganda among HIV-infected women and their infants. Unlike our study, the Uganda study showed that higher adherence to infant NVP for 6 weeks was associated with factors such as the mother's years of education, and spouse involvement during delivery (Napyo et al., 2020).

Women's adherence to their infant's HIV testing (EID) at 6 weeks and their knowledge that a baby born to an HIV-positive mother should be tested for HIV at 6 weeks of age was found to be low in our study. Interestingly, WHIV's knowledge about the infant's HIV testing at 6 weeks did not correlate with their adherence to EID at 6 weeks. This finding in our study resonates with a cluster-randomized intervention trial in Kenya that provided regular peer counseling to the intervention arm to enhance HIV-infected women's knowledge and subsequent retention of PMTCT cascade care. This study showed that despite regular interventions to enhance knowledge of PMTCT, women's adherence to EID for their infants was similar among the intervention and standard of care arm. However, altogether >97% of women adhered to EID at 6, 24, and 48 weeks for their infants from both arms in the Kenya study which is much higher than our data (Larson et al., 2023). Our data shows that HIV-infected pregnant women's correct knowledge about the potential risk of HIV MTCT during delivery is correlated with their adherence to the infant's EID at 6 weeks. It would be beneficial to include detailed information on how HIV can be transmitted from mother to child during delivery and breastfeeding in the existing counseling programs provided by the ICTCs (National AIDS Control Organization, 2013). Providing this information during pregnancy could potentially improve HIV-infected women's adherence to the EID at 6 weeks post-partum for their infants.

Our data analyses did not control for prior pregnancies while correlating knowledge of PMTCT guidelines with subsequent adherence as the median knowledge score of both primigravida and multigravida was 12, with an Interquartile range of 9–16 for the primigravida, and 9–15 for multigravida women. The *p*-value for the median difference was 0.99 suggesting no statistical difference between the baseline knowledge of PMTCT guidelines among primigravida and multigravida women.

Several key findings from our study can inform efforts to improve the uptake of PMTCT guidelines and reduce the number of infants born with HIV in India. Most importantly, our study has found that if a pregnant mother correctly understands specific facts and can correctly answer very specific questions, the subsequent uptake of the recommendations is

higher. Secondly, the correct answer to some of the knowledge questions did not correlate with a significant increase in subsequent uptake of the guidelines. These findings suggest that focusing counseling and education efforts on the specific facts associated with increased adherence should be prioritized by PMTCT programs in India. Perhaps only elemental knowledge is not enough to increase adherence. Instead, providing detailed and ongoing counseling and educational efforts from the moment an HIV-infected woman registers with the national AIDS care program is likely to enhance adherence to PMTCT guidelines during both the antepartum and postpartum periods. However, increasing knowledge is only one component of a multicomponent approach to enhance adherence to the PMTCT program, as there would be perhaps multiple barriers to adherence like social stigma, geographical inaccessibility, etc. which should also be considered while augmenting the national PMTCT program. However, this study has not explored the barriers or other factors that might influence the adherence to the PMTCT guidelines among the study participants.

UNAIDS "Start Free, Stay Free, AIDS Free framework" aims to reduce the MTCT rates to 5 percent for the "focus countries' including India (UNAIDS, 2021). India's MTCT is yet over 24 percent even after 9 years of the successful rollout of WHO-recommended PMTCT guidelines (National AIDS Control Organisation & ICMR-National Institute of Medical Statistics, 2022). However, in most of the "focus countries', after implementing the PMTCT guidelines, the MTCT rate has gone below or close to 5 percent (UNAIDS, 2023). A higher adherence to PMTCT can effectively lead to a significant reduction in MTCT of HIV (WHO, 2010). The study results can shed light on HIV-infected women's knowledge gap of WHO's PMTCT guidelines and its impact on adherence.

Limitations and strengths of the study

Our study explored the association between a pregnant WHIV's correct knowledge of 4 specific WHO-recommended PMTCT guidelines and the subsequent adherence to those PMTCT recommendations during their postpartum period, addressing a gap where such studies are limited. Thus, the findings of this study may be utilized as a reference for other research on this subject, and these results could establish a baseline for enhancing the implementation of the PMTCT program. However, there are some potential limitations in our study. Our data analyses did not control for prior pregnancies while correlating knowledge of PMTCT guidelines with subsequent adherence as there were no differences found in baseline knowledge of PMTCT guidelines among multigravida and primigravida women. The assessment of adherence to Maternal ART may have a potential bias as women enrolled in our study were already on ART, which may influence their knowledge of Maternal ART. However, the COMBIND study enrolled HIV-infected women after their enrollment in the ART/PMTCT program Additionally, the outcome definition of maternal ART adherence was ART given at delivery, which may not accurately measure study participant's adherence to lifelong ART guidelines and the knowledge questionnaire is new, which may not accurately assess all knowledge. Furthermore, this study tried to assess knowledge of and adherence to PMTCT guidelines using self-reported questionnaires, which may be subjected to recall and social desirability biases. However, adherence to EID at 6 weeks was assessed by weekly infants' HIV testing clinical record review which is an objective indicator of adherence to EID.

Conclusions

Our study found that HIV-infected pregnant women who correctly answered specific PMTCT knowledge questions were more likely to adhere to related PMTCT recommendations. Notably, knowledge of certain aspects, such as where to obtain HIV medications, was significantly correlated with increased adherence. However, awareness of exclusive breastfeeding (EBF) practices and nevirapine (NVP) guidelines was low, with limited association with adherence. Improving knowledge on specific aspects of PMTCT, such as the duration and significance of EBF and infant NVP administration, could enhance adherence and potentially reduce mother-to-child transmission (MTCT) risk. The findings underscore the importance of targeted education and counseling efforts to improve PMTCT guideline adherence among pregnant women living with HIV in India. These insights can inform policymakers in developing interventions aimed at enhancing PMTCT guideline knowledge and adherence to mitigate the risk of HIV MTCT.

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Authors' contributions

NS, RCB, VM, NG, and AK conceived the COMBIND study. NS, VM, JMW, RCB, AK, SK, and AS prepared smart data collection forms. NS, AK, and JMW programmed the forms in eMOCHA software. NG, NS, SB, AK, and RCB performed data analyses and data interpretation. SB, AK, NS, and NG drafted the initial manuscript. RCB, AG, NS, NG, VM, JMW, AS, SK, and PD critically reviewed the manuscript and provided inputs. All authors approved the manuscript.

Data availability statement

The data required for this paper are presented in the manuscript. The datasets generated during and/or analyzed during the COMBIND study are not available publicly to ensure confidentiality as they deal with HIV status and other sensitive information of the study participants. The data that support the findings of this study are available from the corresponding author, [SB], upon reasonable request.

Disclaimer

This paper represents the opinions of the authors and does not necessarily represent the official views of the US Centers for Disease Control and Prevention

Disclosure statement

No potential conflict of interest was reported by the author(s).

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References

Abdisa, S., & Tenaw, Z. (2021). Level of adherence to option B plus PMTCT and associated factors among HIV-positive pregnant and lactating women in public health facilities of Hawassa city, Southern Ethiopia. *PLoS One*, *16*(8), e0255808. https://doi.org/10.1371/journal.pone.0255808

Alemu, Y. M., Ambaw, F., & Wilder-Smith, A. (2017). Utilization of HIV testing services among pregnant mothers in low-income primary care settings in northern Ethiopia: A cross-sectional study. *BMC Pregnancy and Childbirth*, *17*(1), 199. https://doi.org/10.1186/s12884-017-1389-2

Asefa, A., & Beyene, H. (2013). Awareness and knowledge on timing of mother-to-child transmission of HIV among antenatal care attending women in southern Ethiopia: A cross-sectional study. *Reproductive Health*, *10*, 66. https://doi.org/10.1186/1742-4755-10-66

Coovadia, H., & Kindra, G. (2008). Breastfeeding to prevent HIV transmission in infants: Balancing pros and cons. *Current Opinion in Infectious Diseases*, *21*(1), 11–15. https://doi.org/10.1097/QCO.0b013e3282f40689

Ebuy, H., Yebyo, H., & Alemayehu, M. (2015). Level of adherence and predictors of adherence to the option B+ PMTCT programme in tigray, northern Ethiopia. *International Journal of Infectious Diseases: IJID: Official Publication of the International Society for Infectious Diseases*, *33*, 123–129. https://doi.org/10.1016/j.ijid.2014.12.026

Fedlu, A., Alie, B., Siraj Mohammed, A., Adem, F., & Hassen, A. (2020). Adherence to antiretroviral treatment for prevention of mother-to-child transmission of HIV in eastern Ethiopia: A cross-sectional study. *HIV/AIDS (Auckland, N.Z.)*, *12*, 725–733. https://doi.org/10.2147/HIV.S274012

Igwegbe, A. O., & Ilika, A. L. (2005). Knowledge and perceptions of HIV/AIDS and mother-to-child transmission among antenatal mothers at nnamdi azikiwe university teaching hospital, nnewi. *Nigerian Journal of Clinical Practice*, *8*(2), 97–101.

Kumar, P., Das, C., Das, U., Kumar, A., Priyam, N., Ranjan, V., Sahu, D., Rai, S. K., Godbole, S. V., Arumugam, E., Pvm, L., Dutta, S., Devi, H. S., Pandey, A., Reddy, D. C. S., Mehendale, S., & Rajan, S. (2023). Augmenting progress on the elimination of vertical transmissions of HIV in India: Insights from spectrum-based HIV burden estimations. *PLOS Global Public Health*, *3*(8), e0002270. https://doi.org/10.1371/journal.pgph.0002270

Kumar, C., Kumar, V., Karir, S., Haider, S., & Kashyap, V. (2020). Awareness about HIV/AIDS Among pregnant women attending PPTCT centre RIMS, ranchi, jharkhand. *Journal of Comprehensive Health*.

Lamina, M. (2012). A survey of awareness and knowledge of mother-to-child transmission of HIV in pregnant women attending olabisi onabanjo university teaching hospital, sagamu, Nigeria. *Open Journal of Obstetrics and Gynecology*, *02*, 98–105. doi:10.4236/ojog.2012.22019

Larson, B. A., Tsikhutsu, I., Bii, M., Halim, N., Agaba, P., Sugut, W., Muli, J., & Sawe, F. (2023). The effects of revised peer-counselor support on the PMTCT cascade of care: Results from a cluster-randomized trial in Kenya (the EMMA study). *BMC Infectious Diseases*, *23*(1), 257. https://doi.org/10.1186/s12879-023-08246-4

Mofenson, L. M. (2010). Antiretroviral drugs to prevent breastfeeding HIV transmission. *Antiviral Therapy*, *15*(4), 537–553. https://doi.org/10.3851/IMP1574

Napyo, A., Tylleskär, T., Mukunya, D., Tumuhamye, J., Musaba, M. W., Ojok Arach, A. A., Waako, P., Tumwine, J. K., & Ndeezi, G. (2020). Barriers and enablers of adherence to infant nevirapine prophylaxis against HIV 1 transmission among 6-week-old HIV exposed infants: A prospective cohort study in northern Uganda. *PLoS One*, *15*(10), e0240529. https://doi.org/10.1371/journal.pone.0240529

National AIDS Control Organisation & ICMR-National Institute of Medical Statistics, New Delhi, Ministry of Health & Family Welfare, Government of India. (2022). India HIV estimates 2021: Technical Report. Available at: https://naco.gov.in/sites/default/files/India%20HIV%20Estimates.pdf.

National AIDS Control Organization. (2013). Updated guidelines for prevention of parent to child transmission (PPTCT) of HIV using multi drug anti-retroviral regimen in India. Available at: http://naco.gov.in/sites/default/files/National_Guidelines_for_PPTCT_0.pdf.

National AIDS Control Organization. (2022). SANKALAK: Status of National AIDS Response. Available from: https://naco.gov.in/sites/default/files/Sankalak_Report_1.pdf.

National AIDS Control Organization. (2024). Elimination of vertical transmission of HIV & Syphilis [Internet] [cited 2024 Feb 7]. Available at: https://naco.gov.in/elimination-vertical-transmission-hiv-syphilis.

National AIDS Control Organization & ICMR-National Institute of Medical Statistics, New Delhi, Ministry of Health and Family Welfare, Government of India. (2018). HIV estimations 2017: Technical report. Available at: https://naco.gov.in/sites/default/files/HIV%20Estimations%202017%20Report_1.pdf.

National AIDS Control Organization & ICMR-National Institute of Medical Statistics, New Delhi: NACO, Ministry of Health and Family Welfare, Government of India. (2022). India HIV estimates 2021: Fact sheet. Available at: https://naco.gov.in/sites/default/files/India%20HIV%20Estimates%202021%20_Fact%20Sheets__Final_Shared_24_08_2022.pdf.

National AIDS Control Organization (NACO), Department of AIDS Control Operational Guidelines for Care & Support Centres, New Delhi, India. (2013). Available from: https://naco.gov.in/sites/default/files/CSC%20Guidelines.pdf.

Ndubuka, J., Ndubuka, N., Li, Y., Marshall, C. M., & Ehiri, J. (2013). Knowledge, attitudes and practices regarding infant feeding among HIV-infected pregnant women in Gaborone, Botswana: A cross-sectional survey. *BMJ Open*, *3*(11), e003749. https://doi.org/10.1136/bmjopen-2013-003749

Okanda, J. O., Borkowf, C. B., Girde, S., Thomas, T. K., & Lecher, S. L. (2014). Exclusive breastfeeding among women taking HAART for PMTCT of HIV-1 in the kisumu breastfeeding study. *BMC Pediatrics*, *14*, 280. https://doi.org/10.1186/1471-2431-14-280

Panditrao, M., Darak, S., Jori, V., Kulkarni, S., & Kulkarni, V. (2015). Barriers associated with the utilization of continued care among HIV-infected women who had previously enrolled in a private sector PMTCT program in maharashtra, India. *AIDS Care*, *27*(5), 642–648. https://doi.org/10.1080/09540121.2014.990868

Philemon, R. N., Mmbaga, B. T., Bartlett, J., Renju, J., Mtuy, T. B., Mboya, I. B., & Msuya, S. E. (2022). Adherence to optimal breastfeeding practices Among HIV-positive mothers in Kilimanjaro, Tanzania. *Patient Preference and Adherence*, *16*, 841–852. https://doi.org/10.2147/PPA.S343213

Rastogi, S., Charles, B., & Sam, A. E. (2012). Knowledge of antiretrovirals in preventing parent-to-child transmission of HIV: A cross-sectional study among women living with HIV in tamil nadu, India. *WHO South-East Asia Journal of Public Health*, *1*(3), 268–278. https://doi.org/10.4103/2224-3151.207023

Sagili, H., Kumar, S., Lakshminarayanan, S., Papa, D., & Abi, C. (2015). Knowledge of HIV/AIDS and attitude toward voluntary counselling and testing Among antenatal clinic attendees at a tertiary care hospital in India. *Journal of Obstetrics and Gynaecology of India*, *65*(2), 104–110. https://doi.org/10.1007/s13224-014-0606-4

Suryavanshi, N., Kadam, A., Gupte, N., Hegde, A., Kanade, S., Sivalenka, S., Kumar, V. S., Gupta, A., Bollinger, R. C., Shankar, A., McKenzie-White, J., & Mave, V. (2020). A mobile health-facilitated behavioural intervention for community health workers improves exclusive breastfeeding and early infant HIV diagnosis in India: A cluster randomized trial. *Journal of the International AIDS Society*, *23*(7), e25555. https://doi.org/10.1002/jia2.25555

Teshale, A. B., Tessema, Z. T., Alem, A. Z., Yeshaw, Y., Liyew, A. M., Alamneh, T. S., Tesema, G. A., & Worku, M. G. (2021). Knowledge about mother to child transmission of HIV/AIDS, its prevention and associated factors among reproductive-age women in sub-saharan Africa: Evidence from 33 countries recent demographic and health surveys. *PLoS One*, *16*(6), e0253164. https://doi.org/10.1371/journal.pone.0253164

UNAIDS. (2020). Start free, stay free, aids free, final report on 2020, targets. 2020. Retrieved on November 2, 2022, from https://www.unaids.org/sites/default/files/media_asset/2021_start-free-stay-free-aids-free-final-report-on-2020-targets_en.pdf.

UNAIDS. (2021). UNAIDS data 2021. License: CC BY-NC-SA 3.0 IGO Available at: https://www.unaids.org/sites/default/files/media_asset/JC3032_AIDS_Data_book_2021_En.pdf.

UNAIDS. (2023). *The path that ends AIDS: UNAIDS global AIDS update 2023*. Joint United Nations Programme on HIV/AIDS. License: CC BY-NC-SA 3.0 IGO. Available at: https://thepath.unaids.org/wp-content/themes/unaids2023/assets/files/2023_report.pdf.

UNICEF. (2019). Elimination of mother-to-child transmission - UNICEF DATA [Internet]. Available at: https://data.unicef.org/topic/hivaids/emtct/.

WHO. (2010). Antiretroviral drugs for treating pregnant women and preventing HIV infection in infants: recommendations for a public health approach. – 2010 version. 2010. Available at: https://iris.who.int/bitstream/handle/10665/75236/9789241599818_eng.pdf.

WHO. (2013). Consolidated guidelines on the use of antiretroviral drugs for treating and preventing HIV infection:

recommendations for a public health approach June 2013. Available at: https://iris.who.int/bitstream/handle/10665/85321/9789241505727_eng.pdf.

WHO. (2017). Global guidance on criteria and processes for validation: elimination of mother-to-child transmission of HIV and syphilis, 2nd edition. License: CC BY-NC-SA 3.0 IGO Available at: https://iris.who.int/bitstream/handle/10665/259517/9789241513272-eng.pdf.

WHO. (2023). HIV estimates, July 2023 Global HIV, Hepatitis and STI Programmes. Available at: https://cdn.who.int/media/docs/default-source/hq-hiv-hepatitis-and-stis-library/hiv-estimates-ppt-2023-final.pdf.