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REVIEW

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Optimization of the vertical transmission prevention program in Guinea: impact of the improvement plan on performance indicators at large-cohort sites

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Abstract

Introduction Vertical transmission of HIV remains a major challenge in Guinea, especially, in low-resource rural areas. This paper presents the results of a pilot project designed to enhance the prevention of vertical transmission through a comprehensive improvement plan implemented across 66 large-cohort sites.

Methods Data from 66 large-cohort of mother to child transmission prevention (PMTCT) sites from 2019 to 2022 were analysed to compare PMTCT metrics before (2019–2020) and after (2021–2022) the improvement initiative. Key indicators were reviewed, and trends were statistically analysed using Mann–Whitney tests, with a p value less than 0.05 indicating statistical significance.

Results The implementation of this strategy significantly increased the antiretroviral therapy rate among HIV-positive pregnant women from 66 to 94%, and full antiretroviral prophylaxis coverage was achieved in infants. However, early infant diagnosis via polymerase chain reaction testing falls short of the national target, highlighting deficiencies in laboratory and specimen transport capacities. The study also revealed regional disparities in the use of PMTCT services.

Conclusion The improvement plan effectively enhanced antiretroviral therapy and prophylaxis use, demonstrating the benefits of structured interventions and capacity development. Despite improvements, challenges such as insufficient polymerase chain reaction (PCR) testing and uneven access to services remain. Future initiatives should aim to equip PMTCT sites with essential resources and promote community-driven health-seeking behaviours in underserved areas.

Keywords HIV, PMTCT, Vertical transmission, B+option, Guinea

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Introduction

The prevention of mother-to-child transmission (PMTCT) of human immunodeficiency virus (HIV) has been established as an effective approach for combating HIV [1–6]. This approach facilitates early screening of HIV-positive pregnant women and the initiation of antiretroviral therapy (ART), thereby reducing or preventing the transmission of HIV to infants [2, 4, 7]. The World Health Organization (WHO) adopted new guidelines on the use of antiretrovirals (ARVs) for PMTCT, aimed at treating pregnant women and preventing infant infection, known as the option B+strategy [8, 9]. This strategy entails providing ART to HIV-infected pregnant women, irrespective of the CD4 cell (T cell) count [10–12]. The WHO also recommends early detection of exposed infants using virological polymerase chain reaction (DNA-PCR) testing beginning at 6 weeks after birth to better tailor Infant exposed to HIV follow-up [13–15]. Some countries in Asia and sub-Saharan Africa have adopted this approach to enhance the performance of PMTCT programs [11, 16, 17]. Several studies conducted in these countries have demonstrated that this approach is effective in reducing the vertical transmission of HIV [18–21].

In 2014, Guinea adopted the WHO guidelines for PMTCT, recommending immediate initiation of ART for all HIV-positive pregnant women (Option B+strategy). However, the 2018 annual report from UNAIDS indicated that the PMTCT indicators in Guinea remained low (UNAIDS Data 2018). This report revealed that 62% of pregnant women were tested during antenatal care (ANC) visits, but only 38% were initiated on ART. During the same period, 11% of Infant exposed to HIV received early HIV testing, 14% of whom tested positive for HIV. These figures fall short of UNAIDS targets, which aim for at least 95% of HIV-positive pregnant women and infant exposed to HIV newborns to be tested and started on ART (*UNAIDS Data 2018)*Infant. To improve the PMTCT indicators, the National AIDS and Hepatitis Control Program has undertaken actions to eliminate vertical transmission. With financial support from its partners, this program conducted a needs assessment in 66 large-cohort PMTCT sites (250 patients or more). The results revealed deficiencies in staff training, outdated facilities, a lack of equipment and laboratory supplies, irregular provision of ARVs, and low motivation among healthcare personnel. Based on these findings, an improvement plan was developed and implemented. During the pilot phase (2020 to 2022), 66 large-cohort sites in three regions of Guinea were selected. Since the implementation of this approach, no operational research has been conducted to provide a rational basis for decision-making, aiming to improve efficiency and minimize costs in the scale-up phase. Furthermore, evaluations and research are essential for adapting and strengthening PMTCT program interventions. The present study aimed to analyze key PMTCT indicators before and after the implementation of the improvement plan at the 66 sites. This study could support the adaptation of intervention strategies to enhance the care of HIV-infected pregnant women and infants exposed to HIV.

Methods

Study design

We conducted a retrospective study based on routine data from 66 large-cohort PMTCT sites. We secondary analysis of these data, which were extracted from the District Health Information Software 2 (DHIS2) database for the period from 2019 to 2022. We compared PMTCT data from the periods before (2019–2020) and during (2021–2022) the implementation of the improvement plan. The measured variables included the initiation of ARV treatment and the delivery of HIV-positive pregnant women. For infants, we measured the initiation of ARV prophylaxis and early HIV testing within the first week. We utilized Donabedian's theoretical framework to explain how the established structure and the deployment process of the strategy influenced the PMTCT indicators at these sites [22]. DHIS2 data extraction and literature review were conducted from June 3 to 21, 2023.

Donabedian's framework

Donabedian's theoretical framework for evaluating the quality of care underpins the measurement of improvement [22]. This model comprises three components: structure, process, and outcomes. According to Donabedian, structural measures impact process measures, which in turn affect outcome measures. Together, these measures form the foundation of an effective set of metrics. The reality, however, is that cause–effect relationships are more complex, particularly in health care services, where patient variability (on an individual level) is substantial (Fig. 1).

Study population and sites

The study targeted 66 large-cohort PMTCT sites, which are sites where more than 250 HIV-positive pregnant women are being followed. These sites were selected following a needs assessment conducted at 160 sites by the National AIDS and Hepatitis Control Program. They are in urban areas within the regions of Conakry (26 sites), Kindia (16 sites), Boké (12 sites), and Kankan (12 sites) (Fig. 1).

All HIV-positive pregnant women who initiated ART, as well as infants born to HIV-positive mothers at the 66 large-cohort sites between January 1, 2019, and December 31, 2022, were included in this study. Before the implementation of the improvement plan, there were

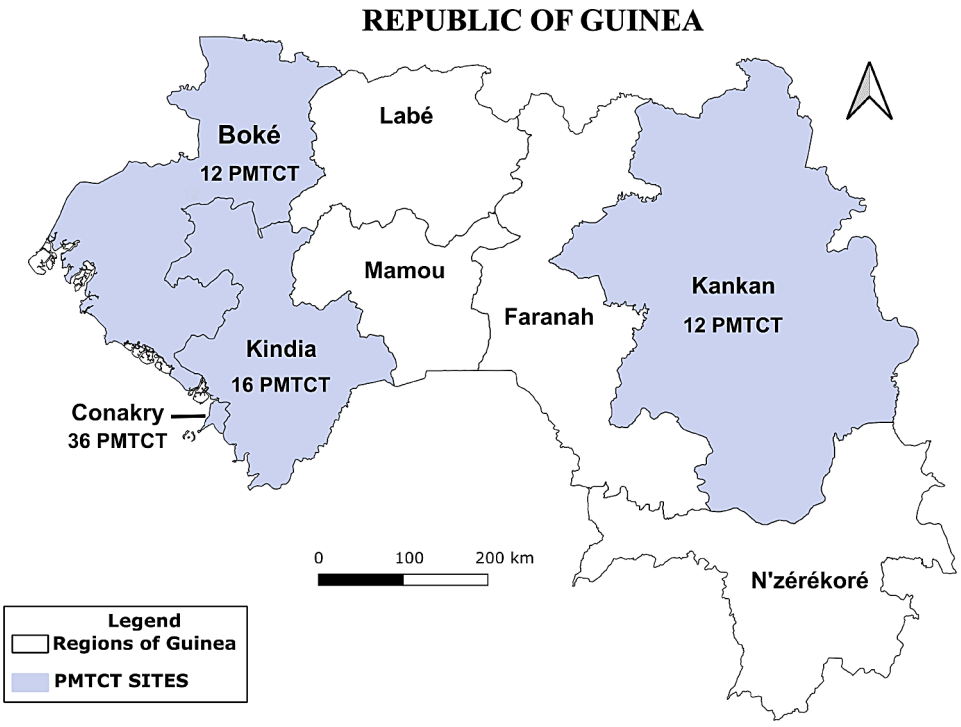

Fig. 1 Large-cohort PMTCT sites in Guinea. Map of Guinea downloaded from www.google.com and modified

8,359 HIV-positive pregnant women and 5,227 HIV-exposed infants. During the implementation of this plan, there were 7,974 HIV-positive pregnant women and 8,737 HIV-exposed infants.

Brief description of the improvement plan

The prevention of mother-to-child transmission (PMTCT) of HIV is a significant challenge in Guinea. To address this issue, the Global Fund (GF) supported a capacity-building project for large-cohort PMTCT sites from 2019 to 2022. The project was conducted in three phases, starting with a needs assessment in 2019 across 160 large-cohort sites in eight regions. The assessment revealed issues such as outdated infrastructure, insufficient staff training, inadequate equipment, and frequent shortages of laboratory supplies and ARVs. Based on these findings, a workshop in 2019 developed a capacity-building plan for 66 sites in three regions (Conakry, Kindia, Boké, and Kankan) for a pilot phase from 2020 to 2022. Service provision to HIV-positive pregnant women and infant exposed to HIV began in 2021. The program aimed, on the one hand, to improve the working environment, including the renovation of the sites, provision of equipment, enhancement of service quality, training of staff, and supply of medicines and laboratory inputs. On the other hand, it sought to provide tailored services for HIV-positive pregnant women. Additional technical support measures were implemented, including the mentorship of providers by experienced health care personnel, supervision by the National AIDS and Hepatitis Control Program, and the organization responsible for implementing activities at the PMTCT sites. Consequently, the implementation of planned actions should contribute to better care for mother–child pairs and significantly improve PMTCT indicators.

Data collection and analysis

Data were extracted from DHIS2 using a standardized questionnaire and compiled in Microsoft Excel. The data were analyzed using R software version 4.4.0. The main PMTCT indicators analyzed included (i) the number of infants exposed to HIV born to HIV-positive mothers, who received ARV prophylaxis from birth up to six weeks, divided by the number of infants born at the PMTCT sites, (ii) the number of infant exposed to HIV born to HIV-positive mothers who underwent at least one DNA-PCR test before the sixth week of age, divided by the number of Infant exposed to HIV who received ARV prophylaxis; (iii) the number of HIV-positive pregnant women who started ART, divided by the number of HIV-positive pregnant women and (iv) the number of HIV-positive pregnant women on ART who delivered at the PMTCT sites,. divided by the number of HIV-positive pregnant women who initiated ART A trend analysis was performed to compare these indicators before and during the improvement plan implementation periods. The Mann–Whitney test was used, which was deemed appropriate due to the nonparametric nature and structure of

our data, with a significance threshold set at $p<0.05$.This test allowed comparisons of the pre- and postintervention periods for each indicator, using the rate of change calculated as:

$$\%\ variation = \frac{(After\ intervention - Before\ intervention)}{Before\ intervention} \times 100$$

Additionally, the Donabedian framework helped explain possible causes of variations in the PMTCT indicator between the two periods and ways to improve the efficiency and quality of services at these sites.

Ethical considerations

Ethical approval for the study was obtained from the National Ethics Committee for Health Research of Guinea (060/NECHR/23). The study consisted of collecting anonymous and confidential secondary data from the DHIS2 database. No consent was needed, as patient information was not included in the analysis or results.

Results

Before and during the implementation of the PMTCT site improvement plan

Before the implementation of the improvement plan at the 66 large-cohort sites (2019–2020), the cohort included 8,359 HIV-infected pregnant women. Among these women, 5,467 (66%) had started ART. Of these women, 3,323 (61%) gave birth at the sites. During the same period, 5,227 infants exposed to HIV received ARV prophylaxis. Of the infants exposed to HIV, 2,202 (42%) underwent DNA-PCR screening before reaching two months of age (Table 1).

Out of a total of 7,974 HIV-positive pregnant women who benefited from the services offered during the implementation of the improvement plan (2021–2022) at the 66 large-cohort PMTCT sites, 7,495 (94%) had started ART. Of these women, 4,840 (65%) gave birth at the sites. In addition, 8,737 (100%) infants exposed to HIV followed up at the PMTCT sites were started on ARV prophylaxis. Among the Infants exposed to HIV, 3,462 (40%) were screened by DNA-PCR, of whom 149 (4%) were HIV-positive (Fig. 2).

The Donabedian framework demonstrated that during the implementation of the improvement plan, each structural element directly contributed to the effectiveness of the processes, which in turn produced measurable and significant outcomes in terms of the treatment and prevention of HIV among HIV-positive pregnant women and infant exposed to HIV (Fig. 3).

Table 1 Comparison of PMTCT indicators for pregnant women and newborns who received services at 66 sites in Guinea from 2019 to 2022

	Test PW	HIV-positive PW, *n* (%)	HIV-positive PW who received ART *n* (%)	HIV-positive PW who received ART and delivered at a PMTCT site, *n* (%)	Infant exposed to HIV born at a PMTCT site, *n* (%)	Infant exposed to HIV who received ARV prophylaxis, *n* (%)	Infant exposed to HIV who underwent DNA-PCR testing, *n* (%)	Infant exposed to HIV who underwent DNA-PCR testing and had a positive result, *n* (%)
Before intervention (2019–2020)	465 461	8 256 (2%)	5 467 (66%)	3 323 (61%)	3432 (62%)	[b]5 227 (152%)	2 205 (42%)	184 (8%)
After Intervention (2021–2022)	651 558	7 974 (1%)	7 495 (94%)	4 840 (65%)	3988 (53%)	8 737 (219%)	3 462 (40%)	149 (4%)
[a]% Variation	40	-3	37	45	16	67	57	-19
* P value	$p=0.669$	$p<0001$	$p<0001$	$p<0001$	$p<0001$	$p<0001$	$p=0.68$	$p=0.09$

* P value Mann–Whitney Test

a: $\%\ \text{variation} = \frac{(After\ intervention - Before\ intervention)}{Before\ intervention} \times 100$

b: the percentage of more than 100% explained by the fact that these sites treated INFANT EXPOSED TO HIV s from other health facilities in the region

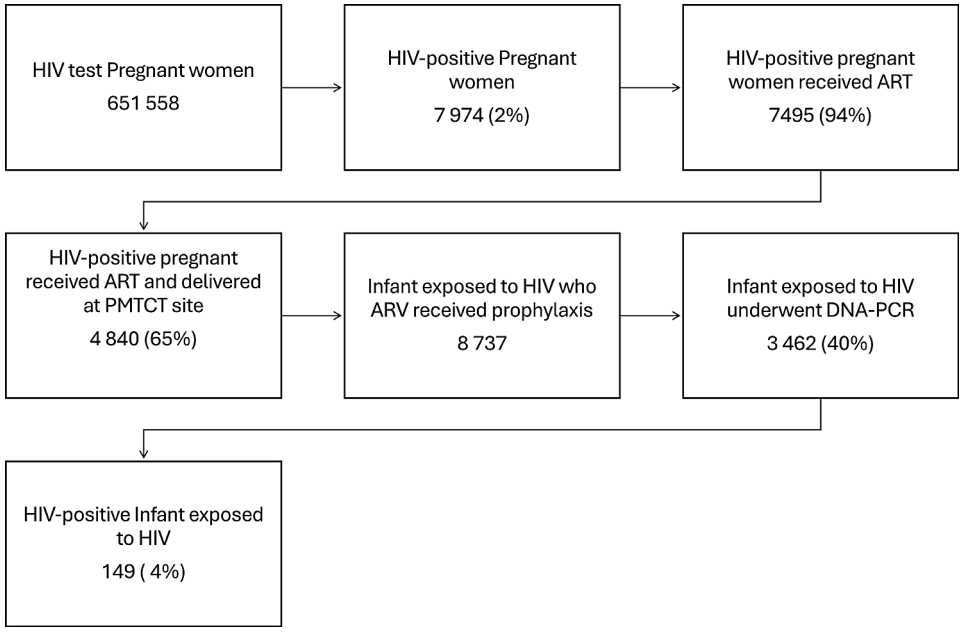

Fig. 2 PMTCT cascade during the implementation of the improvement plan

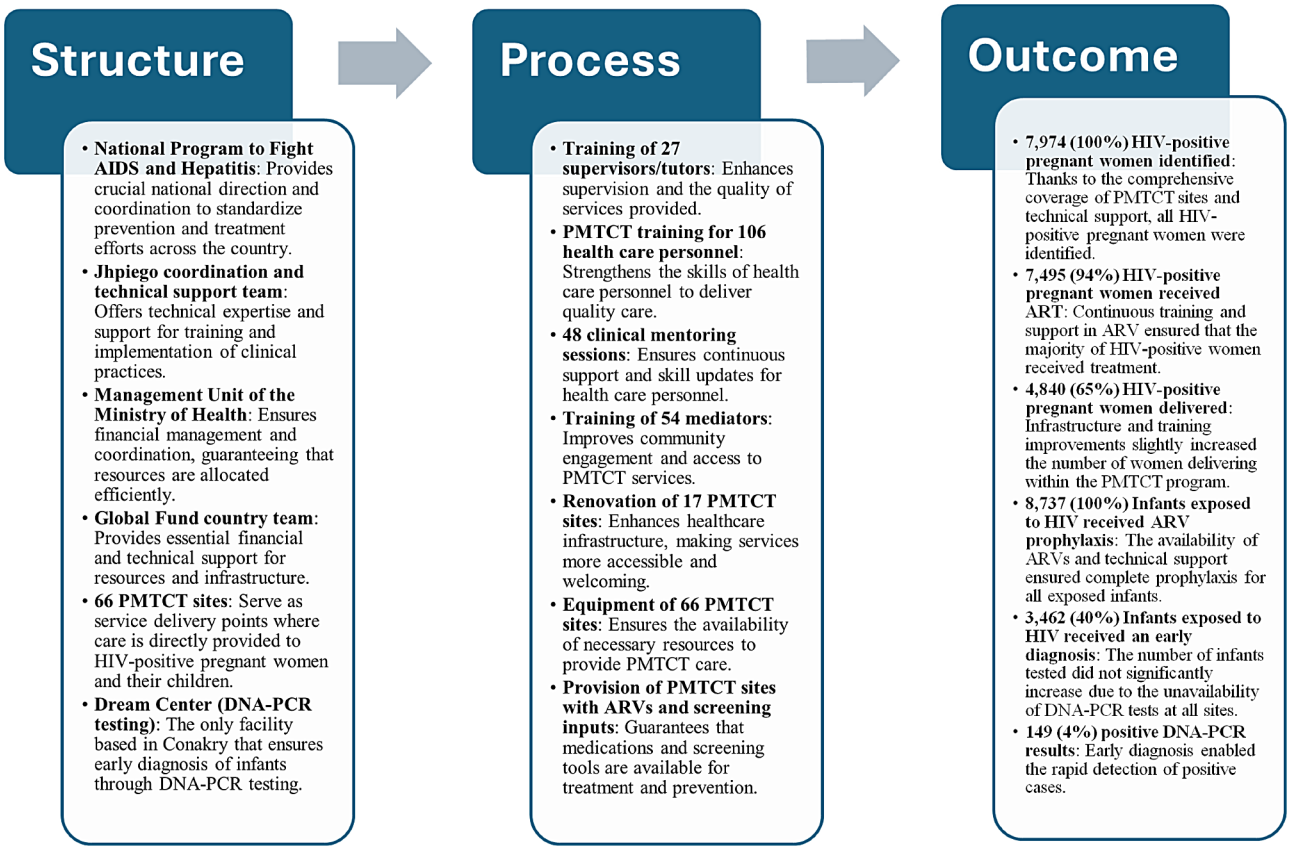

Fig. 3 Results of the implementation of the PMTCT site improvement plan in a large cohort (2021–2022), inspired by the Donabedian theoretical framework

Comparison of the PMTCT indicators at the sites before and after the implementation of the improvement plan

The comparison of PMTCT performance indicators at these sites before (2019–2020) and during (2021–2022) the implementation of the improvement plan revealed that the rate of initiation of ART for pregnant women increased from 66 to 94% (Table 1), showing a significant positive change of 37% ($p<0.001$). This comparison also highlighted a significant positive change of 67% ($p<0.001$) in infants exposed to HIV receiving ARV prophylaxis during the implementation of the plan compared to before (2019–2020) (Table 1). The proportion of HIV-positive pregnant women who delivered at the PMTCT sites also significantly increased by 45% ($p<0.001$). The proportion of infants exposed to HIV as determined tested DNA-PCR remained consistent across both periods, at 42% before and 40% during the implementation of the improvement plan, representing a nonsignificant increase of 57% ($p=0.68$).

However, during the implementation of the improvement plan, we also observed disparities between regions. Notably, the rate of institutional childbirth remained low overall, reaching a particularly low level the in Kankan region (18%). Furthermore, the rate of early diagnosis for infants exposed to HIV has remained low nationally, a situation that is even more concerning in the Kindia region, where the rate is only 14.6% (Fig. 4).

Discussion

The present study, using routine data from the National AIDS and Hepatitis Control Program, demonstrated that the implementation of an improvement plan across 66 large-cohort PMTCT sites in Guinea led to significant increases in ART initiation among HIV-infected pregnant women and ART prophylaxis among infants born to these women. However, despite enhancements in health facility capacity, early infant diagnosis using DNA-PCR remains significantly below the national target, as does the utilization of institutional delivery services in the country's interior regions.

A significant increase in the proportion of HIV-infected pregnant women receiving antiretroviral therapy and infants exposed to HIV receiving antiretroviral prophylaxis was observed during the implementation of the improvement plan. This could be explained by the availability of ARVs and the establishment of an effective distribution plan for these medications, supported by partners, ensuring delivery to the last mile. This significantly reduced medication stockouts at the sites during this period. Our findings are consistent with similar research conducted within the African context [4, 9, 23–25]. These studies highlight that the training of healthcare personnel, the improvement of health facility infrastructure, the strengthening of staff supervision and the availability of medications have contributed to the enhancement of mother-to-child transmission prevention indicators in PMTCT programs.Despite these

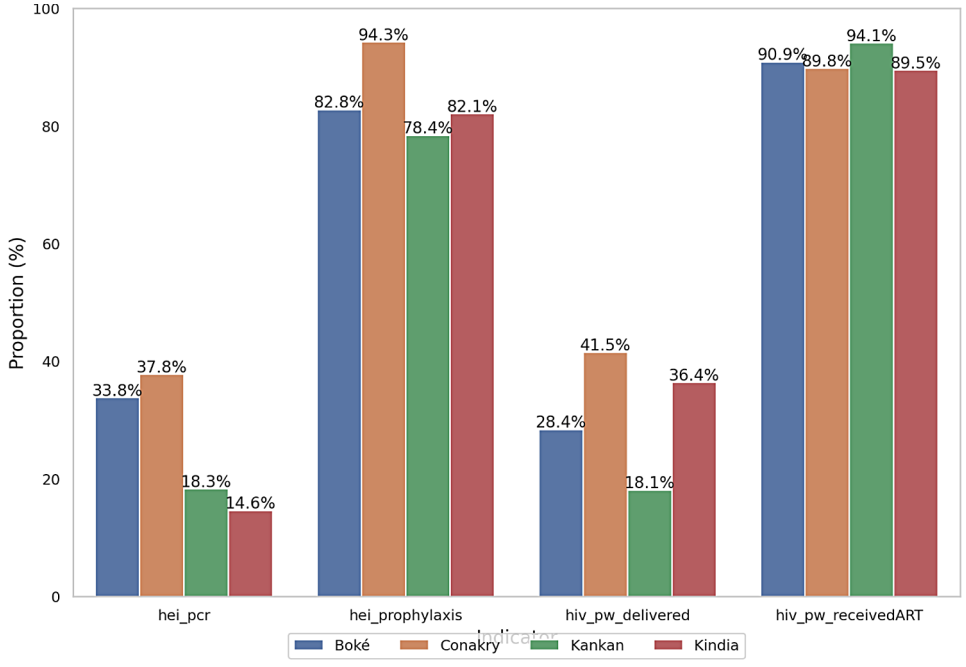

Fig. 4 Proportions of HIV-positive pregnant women and infants exposed to HIV who benefited from PMTCT services by region, 2019–2022. hei_pcr: infants exposed to HIV tested using DNA-PCR. hei_prophylaxis: infants exposed to HIV received prophylaxis ARV. hiv_pw_delivered: HIV- positive pregnant women delivered. hiv_pw_received ART: HIV- positive pregnant received ART

gains, only 40% of infants were diagnosed early via DNA-PCR at six weeks after birth during the implementation of the improvement plan, which is significantly below the national target of 95% (*National Strategic Framework for the Fight against AIDS 2018–2022, Guinea*). This shortfall can be attributed to the lack of qualified laboratories for DNA-PCR at all sites. Our findings are consistent with several studies conducted in sub-Saharan Africa on early infant diagnosis [14, 15, 26–29]. In our study, blood samples from infants exposed to HIV were collected at these sites and sent to the Dream Center in Conakry, the sole laboratory specializing in DNA-PCR testing at the time. Additional challenges included difficulties in transporting samples, delays in communicating DNA-PCR test results, and the distribution of bonuses to health workers at PMTCT sites. Given that early infant diagnosis is a crucial measure for assessing the effectiveness of PMTCT programs, it serves as a key indicator for measuring the reduction of new HIV infections. our findings underscore the urgency of bringing qualified laboratories closer to PMTCT sites. For instance, by installing these biomedical analysis units in each region, we could reduce the transportation time for collected blood samples as well as the time needed to communicate results. It is evident that establishing these laboratories requires the training of healthcare personnel and maintenance teams, as well as the continuous availability of essential supplies. Within the African context, several studies reflect this challenge, suggesting that the establishment of an effective PMTCT program requires investments in deploying and maintaining early infant diagnosis equipment at care facilities, ensuring the availability of essential supplies, and providing training for health care staff [29–35]. In contrast, a study conducted in 15 health districts in Cambodia that benefited from capacity-building at HIV care sites demonstrated a significant improvement. The rate of early diagnosis of children by DNA-PCR testing increased from 41 to 74%. This improvement was attributed to the availability of DNA-PCR tests at the sites and the follow-up activities for postpartum women [20]. This example highlights the potential impact of capacity-building and resource availability on improving early infant diagnosis rates.

The incidence of institutional childbirth among seropositive pregnant women and early infant diagnosis at the national level are generally low, with concerns regarding the regions of Kindia, Kankan, and Boké. These findings highlight the need for urgent actions to improve access to PMTCT services at these sites. These findings highlight that, in addition to the need for innovative initiatives for early infant diagnosis, sites must have specific plans to increase the utilization of childbirth services at PMTCT sites, especially those in predominantly rural areas. A study conducted in Nigeria examining the correlation between healthcare facilities for HIV-positive pregnant women and t infants exposed to HIV in the place of residence revealed similar findings [36]. It has been reported that 86% of urban women, but only 47% of rural women, have access to professional prenatal care, and only 22% of rural women, compared to 62% of urban women, deliver in health facilities. These findings underscore the critical role of healthcare personnel training and community-based interventions in improving the utilization of childbirth healthcare services, especially in rural areas.

Limitations of the study

Our study has several limitations. First, this study has inherent limitations due to its before-and-after design, such as the absence of a rigorous control group and the inability to demonstrate that the observed changes are solely attributable to the implementation of the improvement plan. Additionally, the study faced constraints related to the small sample size and the quality of routine data. Second, the study relied on secondary data from the DHIS2 database, despite the implementation of a data quality control measures, we encountered inaccuracies in the registration, including duplicate entries and missing data. We imputed missing data using the median, an appropriate technique for the application of the Mann–Whitney test, to maintain the robustness of the analysis. However, this method may lead to a loss of variability, distortion of distributions, and potential estimation bias. To estimate the "number of pregnant women started on ART," we only considered data on pregnant women who were newly screened and started on ART during our study period due to inaccuracies in the data concerning previously identified HIV-positive pregnant women already included in the cohort at the beginning of the study. Finally, we could not describe the characteristics of pregnant women living with HIV and infants exposed to HIV, such as age and residence, as this information was unavailable.

Infant exposed to HIV infant exposed to HIV

Despite these challenges, our study offers valuable insights that could enhance the implementation of PMTCT programs in Guinea. It represents the first piece of operational research conducted on a pilot project launched through the government's partnership with the Global Fund aimed at improving the performance of the PMTCT Program in Guinea. Our analysis highlights the strengths and areas for improvement of this initiative. The findings can serve as a benchmark for the government and its partners, particularly in contexts with limited resources, to refine PMTCT programs and deploy interventions that meet criteria for system health resilience and sustainability.

Conclusion

This study highlights significant progress in the prevention of mothers-to-Child transmission (PMTCT) of HIV in Guinea through an improvement plan across 66 large-cohort sites. Key gains include increased ART initiation among HIV-positive pregnant women and ARV prophylaxis for HIV-exposed infants. However, challenges persist, particularly in early infant diagnosis and institutional childbirth in rural regions. Targeted strategies, enhanced laboratory capacities, and community-based interventions are needed. Strong partnerships with technical and financial partners, such as the Global Fund, have been crucial. The success of the pilot project offers a valuable framework for optimizing PMTCT programs in resource-limited contexts.

Abbreviations

ART	Antiretroviral Therapy
ARV	Antiretroviral
DHIS2	District Health Information Software 2
HIV	Infants exposed to HIV
Nb	Newborn
NGO	Non-Governmental Organization
Option B+	A treatment approach for pregnant women living with HIV that involves providing antiretroviral therapy (ART) for life, regardless of Infant exposed to HIV CD4 count during pregnancy
DNA-PCR	Polymerase Chain Reaction
PMTCT	Prevention of Mother-To-Child Transmission
PW	Pregnant Women
UNAIDS	United Nations Program on HIV/AIDS
WHO	World Health Organization

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Author contributions

SC, AD and AS drafted the study protocol, collected the data and drafted the manuscript. Data analyses were performed by CGH and SC. TMM, DK, KJJOK, and SS performed critical reading. All authors approved the submitted version of the manuscript.

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Data availability

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Code availability

The codes used for data analysis in R software are available from the corresponding author upon reasonable request.

Declarations

Ethical approval

Ethical approval for the study was obtained from the National Ethics Committee for Health Research of Guinea (060/NECHR/23).

Consent to participate

The study consisted of collecting anonymous and confidential secondary data from the DHIS2 database. No consent was needed, as patient information was not included in the analysis or results.

Consent for publication

All the authors agreed to publish the results of this study.

Competing interests

The authors declare no competing interests.

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