The Effect of a Mentor Mothers Program on Maternal and Infant PMTCT Outcomes in Zambézia Province, Mozambique

Final Report

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Executive Summary

Background: Mentor Mothers (MM) provide peer support to pregnant and lactating women with HIV (PLWH) navigating the cascade of prevention of mother-to-child transmission (PMTCT) services. MM were implemented in Zambézia Province, Mozambique starting in August 2017. The objectives of this evaluation were to determine whether MM had an effect on retention of PLWH in PMTCT services, HIV viral suppression among PLWH, and HIV DNA PCR positivity rates among HIV-exposed infants (HEI).

Methods: A retrospective interrupted time series analysis was done using routinely collected aggregate data from 85 health facilities in nine districts of Zambézia. Data were captured from August 2016 through April 2019. All PLWH who enrolled in PMTCT services and initiated antiretroviral therapy (ART) and their HEI were included. Outcomes included the proportion per month per district of: PLWH retained in care 1-, 3-, 6-, and 12-months after ART initiation; PLWH with viral suppression (HIV RNA <1,000 copies/ml); and HIV DNA PCR positivity rates among HEI (as a proxy for vertical transmission) tested for HIV by 2- and 9-months of age. Temporal trends in outcomes were adjusted by districts, and the effect of MM on outcomes were assessed using logistic regression.

Results: Median 12-month retention rates among PLWH, median viral suppression rates among PLWH, and median DNA PCR positivity rates among HEI were determined for each of the nine districts. In the year before MM implementation, median district-level 12-month retention ranged from 35% in Mulevala to 61% in Maganja da Costa. In the year during MM implementation, 12-month retention ranged from 56% in Gilé to 72% in Inhassunge. Province-wide, the odds of 12-month retention increased 1.5% per month in the pre-MM period, compared to an increase of 7.6% per month with-MM ($p<0.001$). Similar statistically significant improvements in retention were observed at 1-, 3- and 6-months after ART initiation. In the year pre-MM implementation, median district-level viral suppression ranged from 49% in Ile to 85% in Mocubela and Pebane. In the year with-MM, viral suppression ranged from 59% in Gilé to 80% in Mocubela. Province-wide, the odds of being virally suppressed decreased by 0.9% per month in the pre-MM period, compared to an increase of 3.9% per month with-MM ($p<0.001$). In the pre-MM period, median district-level HEI DNA PCR positivity rates ranged from 0% in Mulevala to 14% in Ile and Maganja da Costa. In the year with-MM, DNA PCR positivity ranged from 4% in Alto Molócuè and Ile to 10% in Namacurra. The odds of DNA PCR positivity decreased 8.9% per month in the pre-MM period, compared to a decrease of 0.4% per month with-MM ($p<0.001$). Similar statistically significant trends in DNA PCR positivity before and after MM implementation were observed among HEI aged 0-2 months of age. The odds of DNA PCR uptake (the proportion of HEI who received DNA PCR testing) by 2-months and 9-months of age were significantly higher in the with-MM period compared to the pre-MM period ($p<0.001$).

Limitations: We were unable to adjust for individual-level characteristics or intensity of and fidelity to the MM strategy. Causal inference was further limited by concurrent programmatic changes.

Conclusions: Implementation of a MM program was associated with improved retention in PMTCT services and higher viral suppression rates among PLWH. While there was ongoing but diminishing improvement in DNA PCR positivity rates among HEI following MM

implementation, this might be explained by having reached a plateau or increased uptake of HIV testing among high-risk HEI who were previously not getting tested.

Project Background

Prevention of mother-to-child transmission of HIV (PMTCT) services are an essential component of the global effort to decrease the incidence of new HIV infections and to ensure an HIV/AIDS free generation. The cascade of PMTCT services includes lifelong combination antiretroviral therapy (ART) for pregnant and lactating women living with HIV (PLWH), the provision of prophylactic antiretroviral medications for HIV-exposed infants (HEI; those born to PLWH), and serial HIV testing to ensure early infant diagnosis (EID) and timely initiation of ART for those infants with confirmed HIV infection. Sustained maternal ART promotes viral suppression, optimizes maternal health outcomes, and minimizes the risk of vertical (mother-to-child) transmission. EID and timely ART initiation are important for minimizing HIV-related morbidity and mortality and for achieving optimal infant outcomes. PLWH and HEI should be retained in care throughout the cascade of PMTCT/EID services.

Successful implementation and navigation of the PMTCT/EID cascade is especially important in sub-Saharan Africa (SSA), where the vast majority of people living with HIV reside and where there is an unacceptably high rate of new pediatric HIV infections. Mozambique is a SSA country with an HIV prevalence of 13%.[1] Zambézia Province is a region of Mozambique that has a population of approximately 5.5 million people, it is mostly rural, and it has been relatively underserved. As such, Zambézia Province has been disproportionately impacted by HIV compared to other regions in Mozambique, with an HIV prevalence of 15.1% and an estimated vertical transmission rate of 6-18%.[1-3]

Friends in Global Health (FGH) is a non-governmental organization and subsidiary of Vanderbilt University Medical Center (VUMC). With funding from the United States Centers for Disease Control and Prevention (CDC) and the President's Emergency Plan for AIDS Relief (PEPFAR), VUMC/FGH has provided technical assistance and support for HIV services, including PMTCT and EID services, in Zambézia Province since 2006, and currently supports 144 health facilities in Zambézia.

Mentor Mothers Program Description

VUMC/FGH started implementation of a Mentor Mothers (MM) program in August 2017. The MM program is an intensive peer support service, through which experienced HIV-affected women, "Mentor Mothers," provide personalized assistance to PLWH as they navigate the cascade of PMTCT services. The goals of the MM program include: i) improving mother and infant retention in PMTCT/EID services; ii) improving rates of infant HIV DNA PCR testing; iii) decreasing vertical transmission rates; and iv) improving adherence to ART and viral suppression among PLWH.

VUMC/FGH's MM program was modeled after programming originally developed by mothers2mothers® (M2M), a South Africa non-governmental organization that pioneered peer mentorship for PLWH; however, the VUMC/FGH MM program was adapted to meet the local context and staffing resources. Key programmatic differences include the following:

- VUMC/FGH MM are volunteers who work four days per week and receive a subsidy of 2500 meticais, while M2M MM are staff who work five days a week and receive a salary of 7000 meticais.
- VUMC/FGH MM are primarily community based, while M2M services are primarily facility based.
- M2M hires MM only if they meet selective criteria, while VUMC/FGH is less strict with recruitment of MM because it is otherwise very difficult to find MM to serve PLWH receiving care at rural health facilities (HF).

Under the MM program supported by VUMC/FGH, MM conduct at least monthly support visits (preventative and problem-focused) to PLWH, beginning at enrollment in antenatal care (ANC) and continuing through the cascade of PMTCT and EID services. All home visits and telephone calls for PLWH and infants/children are carried out by MM. All MM conduct these and other activities through linkage with a dedicated HF, at a ratio of one MM to approximately 20 PLWH enrolled in HIV/ART services. The design of the MM program is as follows: The Community Health Officer conducts an initial mapping of MM for the neighborhoods covered by the HF. The MM lists by neighborhood is provided in the ANC clinic, Child at Risk Clinic (CRC), and pediatric HIV/ART services sectors, so that health counselors in these sectors make the initial allocation of patients to the MM. As new pregnant women start ART, or when women already on ART become pregnant, the ANC health counselor assigns a MM to support them based on the best selection for the patient's family and MM availability. Each MM supports approximately 20 mother-baby dyads at a given time. Health counselors ensure that all MM have an updated list of patients they monitor. The same MM follows and provides support to the mother-baby dyad during the pregnancy and postpartum/breastfeeding periods, until the child has been discharged from the CRC after definitive HIV testing is performed (typically after at least 18 months of age). If the child tests positive and is confirmed to have HIV infection, the MM continues to support the mother and child in their receipt of HIV/ART services.

The MM program has been gradually implemented across VUMC/FGH-supported HF in Zambézia Province since August 2017. The implementation of the MM program started in the rural districts of Zambézia Province, and in October 2017 implementation began in the Provincial Capital of Quelimane. At each site, complete implementation was preceded by a three-month period of recruitment and training. Additionally, in November 2018, 23 MM "supervisors" (MM-S) were trained to support/enhance the MM programs previously implemented at 18 selected HF (**Appendix 1**).

Evaluation costs were limited to the personnel time required for extraction and analysis of routine secondary data, results review and discussion, and report preparation (anticipated expenditures equal to <1% of the total Avante Zambézia budget) (**Appendix 2**).

The aim of this evaluation was to assess the impact of a MM program and MM supervisors on i) retention of PLWH in PMTCT services, ii) viral suppression among PLWH, and iii) DNA PCR positivity rates (proxy for vertical transmission) among HEI in Zambézia Province, Mozambique.

Evaluation Purpose and Questions

This concept was developed in collaboration with the Ministry of Health (MOH), and this evaluation was a collaborative partnership between the MOH, the CDC, the provincial health directorate (DPS-Zambézia), and VUMC/FGH investigators. The primary objective of this evaluation was to determine the effect of a MM program and MM supervisors* (*see note below*) on retention in the cascade of PMTCT/EID services and on HEI outcomes in Zambézia Province, Mozambique. Specifically, we were interested to know whether MM lead to improved:

- Uptake/coverage of ANC*
- Institutional/HF delivery rate*
- Maternal retention (retention among PLWH who started ART in ANC)
    - Retention 1-month after ART initiation
    - Retention 3-months after ART initiation
    - Retention 6-months after ART initiation
    - Retention 12-months after ART initiation
- Maternal viral suppression rates (proportion with viral load (HIV RNA) <1,000 copies/ml among all available maternal viral load results); viral suppression among PLWH during the period of observation
- Proportion of HEI registered in CRC among those eligible (among mothers who accessed ANC or delivered at a HF)*
- Uptake of HIV DNA PCR testing among HEI
    - By 2 months of age/postpartum
    - By 9 months of age/postpartum
- Infant HIV DNA PCR positivity rates (proxy for vertical transmission rate)
    - By 2 months of age/postpartum
    - By 9 months of age/postpartum
    - By 12 months of age/postpartum
- Proportion of HEI with a definitive HIV status (positive or negative) documented by 18 months of age*
- Linkage to ART for infants that are identified as HIV positive*

The secondary objective of this evaluation was to understand the fidelity to implementation of MM services and whether variations in fidelity modify the effect of the MM program on retention in the cascade of PMTCT/EID services and on HEI outcomes in Zambézia Province, Mozambique. Under ideal circumstances, MM are expected to perform monthly preventative/support home visits and as needed tracing home visits when pregnant or lactating women miss an appointment or are classified as lost to follow-up. However, it is understood that there is not perfect fidelity to these MM services, and it is possible that fidelity varies between HF. We aimed to understand to what extent support and tracing visits were performed, and whether fidelity to these services modifies the outcomes outlined for the primary objective, above.*

Note: All variables and outcomes of interest that were included in the approved concept note are listed, above; however, those we were unable to fully evaluate are noted with an asterisk (*), and further explanation is provided below in the *Limitations* section.

Evaluation Design, Methods, and Limitations

Evaluation Type

To meet the above objectives, our team conducted an internal outcomes evaluation, in which routine programmatic data were analyzed to evaluate the outcomes of interest.

Evaluation Design

This was a retrospective evaluation of routinely collected patient data. All PLWH who enrolled in PMTCT services and initiated ART and their HEI were eligible for inclusion if: (i) enrolled in care at one of 85 VUMC/FGH supported HF in nine districts (**Appendix 1**); and (ii) enrolled in care from August 2016 (1-year pre-MM program implementation in August 2017) to April 2019 (end of evaluation period; however, the MM program continues at all sites). We excluded districts/HF that: i) did not support maternal-child health services; ii) had previously been or currently were supported by M2M (*see more below*); iii) were not supported by VUMC/FGH during the pre-MM period (e.g., Quelimane District; *see more below*); or (iv) were noted to have systematic (non-random) missingness in their data (*see more below*).

We excluded districts/HF supported by M2M – an alternate and independent mentoring program for PLWH – to ensure comparability across intervention sites (i.e., internal validity). Additionally, we lacked pre-implementation data for M2M supported sites, since VUMC/FGH only took over support in these districts (e.g., Nicoadala) in October 2018.

During the pre-MM period, Quelimane District was supported by another clinical implementing partner (International Center for AIDS Care and Treatment Programs [ICAP]). Thus, pre-MM data were only available starting from October 2017 when VUMC/FGH began supporting HF in this district, and this coincided the rollout of MM activities in Quelimane.

Additionally, some HF were systematically missing data before or after a certain time point (i.e., data were not missing at random). These HF were excluded from analyses in which the outcome variable of interest was systematically missing (**Appendix 1**). More specifically:

- One HF (CS Ilha Idugo in Mocubela) was excluded (the other 84 HF were included) from analysis of retention and viral suppression among PLWH because it started the MM program much later (September 2018) compared to other health facilities and only had the first seven months of data for these outcomes after MM implementation (i.e., insufficient follow-up time).
- For all of the outcomes derived from District Health Information Software (DHIS) data, except for institutional delivery, 71 HF were included, and 14 HF were excluded due to systematic missingness.

- For the institutional delivery variable, 70 HF were included and 15 HF were excluded due to systematic missingness.

Evaluation Settings

Each HF included (**Appendix 1**) offers comprehensive HIV services, including clinical care, laboratory testing, and pharmacy services. Each district-level health system consists of one large central HF/referral center and smaller peripheral HF.

Definitions/Outcomes

In this evaluation, we were most interested in the effect of MM program on three outcomes:

- *Retention* among PLWH was defined relative to time from ART initiation in ANC; we determined the proportion of PLWH per month who were still in care at 1-, 3-, 6, and 12-months after ART initiation. At each month, the number of PLWH who initiated ART 1- , 3- , 6- , and 12-months prior (i.e., the denominator), and the number of PLWH who were still in care (i.e., the numerator) were recorded in the electronic Open Medical Record System (OpenMRS)^{TM} for each HF. The retention proportion for each district were calculated using the aggregated district-level numbers. Specifically, retention at the various timepoints was defined as follows:
  - 1-month retention: patients who started ART in the previous month, and who are marked as pregnant or lactating also in the previous month, excluding patients who transferred from that HF.
  - 3-month retention: patients who started ART in the 90-120 day period before the end date, and who are marked as pregnant or lactating in the 90-120 day period before the end date, excluding patients who transferred from that HF.
  - 6-month retention: patients who started ART in the period 6-9 months before the end date, and who are marked as pregnant or lactating in the period 6-9 months before the end date, excluding patients who transferred from that HF.
  - 12-month retention: pregnant or lactating women who started ART and are active in care 12 months after ART initiation.
- *Viral suppression* among PLWH was defined as a viral load (HIV RNA PCR) <1000 copies/ml. For this analysis, we determined the proportion of PLWH per month per district with viral suppression among all available viral load results for PLWH during the period of observation. At each month, the number of PLWH who were tested for viral load (i.e., the denominator), and the number of PLWH who were virally suppressed (i.e., the numerator) were recorded in OpenMRS for each HF. The viral suppression proportion for each district were calculated using the aggregated district-level numbers.
- *DNA PCR positivity* (proxy for vertical transmission) among HEI was determined for the periods 0-2 months postpartum and 0-9 months postpartum. This was defined as the proportion of positive DNA PCR results among all DNA PCR tests performed

during the specified time period. At each month, the number of DNA PCR tests for HEI within 0-2 months and 0-9 months (i.e., the denominator), and the corresponding number of positive DNA PCR results (i.e., the numerator) were recorded in DHIS for each HF. The DNA PCR positivity rate for each district were calculated using the aggregated district-level numbers.

Other than major outcomes, above, we also aimed to explore any potential effect of the MM program on other pertinent outcomes, including:

- *Uptake of ANC* was determined by the absolute number of pregnant women living with HIV who attended their first ANC visit. Ideally, this should be defined as the proportion of pregnant women living with HIV attending their first ANC clinic among all eligible to attend their first ANC during the specified time period, but this true denominator could not be determined, so we were limited to working with absolute numbers. This number was recorded in DHIS monthly for each HF, and the aggregated district-level numbers were used for analyses.
- *Institutional delivery* was determined by the number of pregnant women living with HIV who registered at maternity wards. Ideally, this should be defined as the proportion of pregnant women living with HIV registered at maternity wards among all pregnant women living with HIV due for delivery during the specified time period, but this true denominator could not be determined, so we were limited to working with absolute numbers. This number was recorded in DHIS monthly for each HF, and the aggregated district-level numbers were used for analyses.
- *Uptake of HIV DNA PCR testing* among HEI was determined for the periods 0-2 months postpartum and 0-9 months postpartum. Ideally, this should be defined as the proportion of DNA PCR tests among all eligible HEI during the specified time period. At each month, the number of DNA PCR test for HEI within 0-2 months and 0-9 months (i.e., the numerators) were recorded in DHIS, but the exact number of eligible HEI was not available, so the number of HIV-positive pregnant women registered at the first ANC 6 months earlier (i.e., the denominator) was used as a proxy.
- *Registration of HEI in CRC* was determined by the number of HEI registered at CRC. Ideally, this should be defined as the proportion of HEI registered at CRC among all HEI eligible to register at CRC during the specified time period, but this true denominator could not be determined, so we were limited to working with absolute numbers. This number was recorded in DHIS monthly for each HF, and the aggregated district level numbers were used for analyses.

Data Sources

Aggregate OpenMRS and DHIS data from 85 HF in nine districts were included. Data were captured from August 2016 (one year prior to MM implementation) through April 2019. For each of the outcomes, we used aggregate PMTCT/EID data from each HF included in the evaluation. Routinely collected, de-identified data were extracted from both databases for this retrospective cohort analysis (**Table 1**).

A copy of the limited, de-identified data extracted and exported from the secure OpenMRS or DHIS database was encrypted and electronically transferred via secure file transfer to relevant key personnel (e.g., the biostatistician(s) and investigator at VUMC) using encryption protected folders via internally used internet (Google) drive share. Each recipient received an email containing a unique download URL, along with a second follow-up email with the password (for greater security) for downloading the file. De-identified data sent to biostatisticians was stored on a secure and encrypted computer.

All raw data were in the ".xls /.xlsx" format. Each excel file was loaded into R using read.xls function in gdata package and cleaned, the variables used for defining aforementioned outcomes were extracted, and the monthly HF-level data were aggregated to district-level data accounting for respective start time of MM service. All processed data from different excel files were integrated by district and months of implementing MM service for statistical analyses.

Table 1. Variables and data sources

Variable	**Data source**
# of women registered in ANC (monthly)	DHIS
# of ANC visits *	DHIS
# of women with institutional delivery	DHIS
# of HIV-exposed infants registered in CRC (monthly)	DHIS
# DNA PCR tests performed (monthly) By 2 months By 9 months	DHIS
# DNA PCR tests positive (monthly) By 2 months By 9 months By 12 months *	DHIS
# of HIV-exposed infants with definitive HIV status documented (monthly) *	Manual data collection
# of HIV-positive infants linked to ART (monthly) *	Manual data collection
# women who started ART in ANC retained in care (monthly) 1 month after ART start 3 months after ART start 6 months after ART start 12 months after ART start	OpenMRS
# women with viral load testing among pregnant and lactating women (monthly)	OpenMRS
# pregnant and lactating women with viral suppression (VL <1000) (monthly)	OpenMRS
# of preventative visits (total per facility; not per women) *	DHIS
# women enrolled in MM program (monthly) *	Manual data collection
# women participated in MM group (monthly) *	Manual data collection
# PL women receiving a preventive visit (monthly) *	OpenMRS
# PL women receiving a tracing visit (monthly) *	OpenMRS
Health facility size (# of patients on ART) *	OpenMRS
Average time of follow up by mentor mothers *	Manual data collection
Health facility type (district center vs. non-center) *	
District *	

* *Outcomes for which we were unable to perform analysis due to lack of data. Please see additional details in Limitations, below.*

Statistical Analyses

To account for the phased implementation of MM services at the various HF (i.e., to account for the different start dates (**Appendix 1**), outcomes were assessed at the HF-level, accounting for respective implementation dates, and looking at 12 months before and 12 months after MM implementation. Then the pre/post outcomes were aggregated at the district-level for comparison. More specifically, monthly HF-level data were aggregated to district-level by: i) setting the MM start timepoint for each HF; ii) defining a new variable for each HF representing the MM implementation months (*mm_month* = the calendar year/month - MM start year/month); and iii) aggregating HF data within each district based on *mm_month* (instead of calendar year/month). Any HFs with identified as having systematically missing data were omitted during aggregation.

For each outcome, a descriptive analysis was first performed. Since all outcomes varied temporally (i.e., from -12 to 12 *mm_month* and 25 months in total) and spatially (i.e., across 9 districts), the descriptive statistics (including minimum, Q1, median, Q3, maximum, mean, and standard deviation) along time were obtained within each district for pre- and post-MM periods separately, as well as for the entire study period. Each descriptive statistic was then compared across all nine districts. In particular, we were most interested in comparing median values across districts.

As mentioned above in Definitions/Outcomes, a proxy denominator was used to define some outcomes due to lack of exact denominator, which led to 17 out of 225 (~7.6%) proportions in the *Uptake of HIV DNA PCR Testing* analysis being greater than 1. To address this issue of invalid proportion, three approaches were employed for a sensitivity analysis: i) cap all proportions greater than 1 at a value of 1; ii) randomly replace each of them with a number between 0.9 and 1; and, iii) simply exclude all invalid proportions from analysis. The results showed that all three approaches yielded similar results with only slight differences in odds ratios. Thus, only the results from the first approach (i.e., capping at 1) is presented in this report.

For each specific objective described above, we assessed the effect of MM program via interrupted time series analysis using monthly district-level aggregate data. More specifically, an indicator variable named *mm* was defined by assigning "no" for pre_MM period and "yes" otherwise, and a multivariable regression model focusing on *mm*, *mm_month*, and *district* was built to explore effect of MM program adjusted by district. The interaction term between *mm* and *mm_month* was also included in the model first, and it was retained in the model only if it was statistically significant. Otherwise, a new model without this interaction term was built to assess the effect of MM program. For outcomes in the format of absolute number, a linear regression model was built, while logistic regression was used to model rate/proportion outcomes given that these outcomes are within the interval of 0 to 1.

All statistical analyses were conducted using R statistical software 3.6.3.[4]

Limitations

We acknowledge several limitations for this analysis and evaluation. First and foremost, our study design does not allow us to establish a causal relationship between implementation of a MM program and the outcomes of interest. Rather, this interrupted time series analysis has the potential to identify whether there was a statistically significant difference in outcomes before and

after MM were implemented. We acknowledge that there are many documented and undocumented programmatic changes over time, and there is also expected improvement with program maturation, and our study design is not able to control for these potential confounders. That said, we attempted to isolate the effect of MM over time by using a sophisticated interrupted time series approach that accounted for the specific implementation dates of MM services at individual HF. For each HF, we established baseline trends for each of the outcomes, and then establish trends for each of the outcomes post-implementation.

We had also planned to apply this same approach to the subset of HF that have more recently implemented MM supervisors, but this analysis was not performed because: (i) half of the sites with MM supervisors were in Quelimane District (**Appendix 1**), and Quelimane was excluded from this analysis due to lack of pre-MM data; (ii) the other nine HF at which MM supervisors were implemented were predominantly district referral centers already supported by a disproportionate number of MM compared to smaller peripheral HF, so any conclusions would be greatly confounded and difficult to interpret; and (iii) MM supervisors were trained and introduced as part of program support between November 2018 to January 2019, which corresponds to months 11 to 15 into the MM implementation period. Thus, for the purpose of this evaluation, where we defined the with-MM (i.e., MM implementation period) period cutoff at 12-months, the role of MM supervisors was not sufficiently represented in the implementation period to be included in the analysis.

Another notable limitation for this study involves the decision to exclude Quelimane data. It was unfortunate to have to exclude a large number of supported sites (16 HF in total) and particularly those representing much of the urban population served by the program. However, we determined that without pre-implementation data it would be difficult to interpret analysis results if included.

We were also unable to link individual-level maternal and infant data. Instead, we utilized aggregate outcomes and exposures (district- and/or HF-level). This prevented us from being able to adjust for maternal and infant characteristics. Furthermore, we were unable to determine whether MM tracing/searching ("buscas" in Portuguese) resulted in re-engagement in care (i.e., found in tracing activities and came back to HF for services) and thereby influenced retention and other related outcomes.

Additionally, there were two outcomes that we were unable to evaluate: i) proportion of HEI with a definitive HIV status (positive or negative) documented by 18 months of age, and ii) linkage to ART for infants that are identified as HIV-positive. These data were only available by way of manual data collection from hardcopy records, and we did not have the resources to pursue this manual data collection for this evaluation. Furthermore, there were also concerns about the completeness/accuracy of these data in hardcopy records, so even if we had the resources, missingness or reliability might preclude interpretation. Therefore, these analyses were not performed.

Similarly, manual data collection would have been required to determine the number of women enrolled in MM services at each HF, the number of women who attended monthly MM groups at each HF, and the frequency and duration of MM services for each recipient of those services. As such, we were unable to assess these exposures/mediators. That said, intensity of and

fidelity to MM services and whether these modulate PMTCT/EID outcomes is an area of interest that we hope to explore with future research.

Lastly, we were unable to fully assess MM impact on: PLWH enrollment in ANC, institutional deliveries, and HEI enrolled in the CRC clinics. For each of these, prospective enrollment and follow-up of all persons "at-risk" for the outcome of interest would be necessary. Rather, this was a retrospective study, so the true denominator for each of these outcomes were unknown. For example, we are able to state the number of PLWH enrolled in ANC and whether these absolute numbers changed over time, but we do not know the absolute numbers of PLWH who *should have been* enrolled in ANC (i.e., all pregnant women living with HIV in the community), and therefore cannot make a determination about whether the proportion of at-risk women enrolled in care changed over time or with respect to MM implementation.

Ethical Considerations and Assurances

This data use and evaluation plan were approved by the VUMC Institutional Review Board (201887), the Institutional Research Ethics Committee for Health of Zambézia Province (*Comité Institucional de Bioética para Saúde – Zambézia*; 16-CIBS-Z-18), and was reviewed in accordance with the CDC human research protection procedures and was determined to be research, but CDC investigators did not interact with human subjects or have access to identifiable data or specimens for research purposes.

All data included in this analysis were de-identified programmatic data. The electronic databases outlined in the *Methods* section were stored on password protected and encrypted servers at FGH. De-identified data were extracted from these secure databases and sent via secure file transfer to relevant key personnel (i.e., the biostatisticians at VUMC).

Deviations from Scope of Work (SOW)/Protocol

There were no significant deviations from the proposed concept note. However, as detailed in the *Limitations* section above, there were some variables that we were unable to evaluate in these analyses due to the data not being available and/or excessive missingness.

Data Quality Assurance

Programmatic data used in this evaluation were subject to routine data verification processes conducted by trained members of FGH's Monitoring and Evaluation (M&E) team and were stored securely on password-protected databases at district and provincial level offices. The performance of the program indicators was monitored by HF staff. All subsequent indicators were collected and internally reported monthly by the Health Information Systems (HIS) team, following the regular reporting period for program data.

Findings

Uptake of Antenatal Care

As shown in **Table 2**, the median number of PLWH enrolled in ANC per month ranged from 15 in Mulevala to 171 in Namacurra in the year before MM implementation. In the year during MM implementation median monthly ANC enrollment ranged from 15 in Mulevala to 188 in Namacurra. While there was significant variability in the absolute number of PLWH enrolled in ANC across districts ($p<0.001$), there was not a statistically significant difference in ANC enrollment numbers before and after MM implementation ($p=0.38$). Furthermore, the absolute number of PLWH who were eligible for ANC enrollment is unknown, so we were unable to determine if the proportion of eligible PLWH enrolled in ANC changed over time or with respect to implementation of MM services.

Table 2. Monthly enrollment of PLWH in antenatal care per district one year before (pre-MM) and one year after (with-MM) implementation of MM services.

District	Period	Min	Q1	Median	Q3	Max	Mean	SD
ALTO MOLÒCUÉ	Pre_MM	50	55	57	66	70	59	7
	With_MM	54	62	63	71	74	64	6
	Entire period of evaluation	50	56	62	67	74	62	7
GILÉ	Pre_MM	43	60	66	67	81	63	10
	With_MM	55	65	67	78	92	71	11
	Entire period of evaluation	43	61	66	74	92	67	11
ILE	Pre_MM	25	34	38	45	54	39	8
	With_MM	31	37	39	45	52	41	6
	Entire period of evaluation	25	34	39	45	54	40	7
INHASSUNGE	Pre_MM	49	56	62	73	84	64	11
	With_MM	65	68	77	84	103	79	12
	Entire period of evaluation	49	63	71	80	103	72	14
MAGANJA DA COSTA	Pre_MM	76	93	102	111	140	105	17
	With_MM	81	96	100	113	121	103	11
	Entire period of evaluation	76	94	102	113	140	104	14
MOCUBELA	Pre_MM	33	66	70	83	111	73	19
	With_MM	70	72	82	87	114	83	12
	Entire period of evaluation	33	70	80	87	114	78	17
MULEVALA	Pre_MM	8	14	15	16	22	15	4
	With_MM	8	14	15	18	26	16	5
	Entire period of evaluation	8	14	15	18	26	15	4
NAMACURRA	Pre_MM	129	150	171	180	201	166	22

District	Period	Min	Q1	Median	Q3	Max	Mean	SD
	With_MM	148	172	188	204	214	185	23
	Entire period of evaluation	129	159	174	195	214	176	24
PEBANE	Pre_MM	121	137	145	158	193	148	20
	With_MM	139	154	167	176	190	165	15
	Entire period of evaluation	121	143	155	171	193	157	19

Institutional Delivery

As shown in **Table 3**, the median number of PLWH who gave birth at a HF per month ranged from 2 in Mulevala to 116 in Namacurra in the year before MM implementation. In the year during MM implementation median monthly institutional deliveries ranged from 7 in Mulevala to 127 in Namacurra. There was significant variability in the absolute number of institutional deliveries across districts ($p<0.001$). There was also a significant increase in the absolute number of institutional deliveries over time (13.2 per year; $p<0.001$), but in the period with MM there were 9 fewer institutional deliveries than would be expected based on data from the pre-MM period ($p=0.001$). That said, the absolute number of PLWH who *should have* given birth at a HF is unknown, so we were unable to determine if the proportion of institutional deliveries as a function of all possible deliveries changed over time or with respect to implementation of MM services.

Table 3. Monthly number of PLWH who gave birth at a health facility per district one year before (pre-MM) and one year after (with-MM) implementation of MM services.

District	Period	Min	Q1	Median	Q3	Max	Mean	SD
ALTO MOLÒCUÉ	Pre_MM	22	28	31	38	44	33	7
	With_MM	15	30	33	37	47	33	7
	Entire period of evaluation	15	29	31	37	47	33	7
GILÉ	Pre_MM	24	36	38	43	50	38	8
	With_MM	27	36	40	45	66	43	12
	Entire period of evaluation	24	36	39	44	66	41	10
ILE	Pre_MM	12	14	16	19	26	17	4
	With_MM	8	13	16	18	24	16	4
	Entire period of evaluation	8	13	16	19	26	16	4
INHASSUNGE	Pre_MM	34	40	52	58	66	50	11
	With_MM	37	52	56	75	80	60	15
	Entire period of evaluation	34	45	53	66	80	55	14
MAGANJA DA COSTA	Pre_MM	36	46	58	59	64	53	10
	With_MM	38	50	53	57	75	54	9

District	Period	Min	Q1	Median	Q3	Max	Mean	SD
	Entire period of evaluation	36	49	56	59	75	54	9
MOCUBELA	Pre_MM	22	30	32	36	50	34	8
	With_MM	28	30	35	42	46	36	7
	Entire period of evaluation	22	30	33	40	50	35	7
MULEVALA	Pre_MM	2	2	2	4	8	4	2
	With_MM	1	6	7	7	10	6	3
	Entire period of evaluation	1	2	5	7	10	5	3
NAMACURRA	Pre_MM	88	92	116	122	130	110	16
	With_MM	101	115	127	140	168	128	19
	Entire period of evaluation	88	109	118	130	168	119	19
PEBANE	Pre_MM	69	92	97	106	118	98	14
	With_MM	87	101	105	116	131	107	13
	Entire period of evaluation	69	96	104	115	131	103	14

Retention 1-Month After ART Initiation

In the year before MM implementation, median district-level 1-month retention ranged from 34% in Mulevala to 59% in Alto Molócuè. In the year during MM implementation, 1-month retention ranged from 53% in Maganja da Costa to 71% in Alto Molócuè and Gilé (**Table 4**). Province-wide, the odds of 1-month retention increased 1.3% per month in the pre-MM period, compared to an increase of 5% per month with-MM (p=0.001; **Figure 1**).

Table 4. Proportion of PLWH who were retained in care 1-month after ART initiation per month per district one year before (pre-MM) and one year after (with-MM) implementation of MM services.

District	Period	Min	Q1	Median	Q3	Max	Mean	SD
ALTO MOLÒCUÉ	Pre_MM	0.482	0.557	0.586	0.644	0.741	0.595	0.071
	With_MM	0.444	0.542	0.706	0.870	0.905	0.711	0.165
	Entire period of evaluation	0.444	0.542	0.640	0.733	0.905	0.655	0.139
GILÉ	Pre_MM	0.393	0.470	0.568	0.626	0.636	0.543	0.094
	With_MM	0.387	0.647	0.706	0.762	0.900	0.680	0.144
	Entire period of evaluation	0.387	0.500	0.629	0.706	0.900	0.614	0.139
ILE	Pre_MM	0.417	0.518	0.555	0.628	0.684	0.559	0.080
	With_MM	0.454	0.483	0.556	0.611	0.741	0.564	0.085
	Entire period of evaluation	0.417	0.515	0.556	0.615	0.741	0.562	0.081
INHASSUNGE	Pre_MM	0.429	0.464	0.555	0.616	0.676	0.550	0.090
	With_MM	0.528	0.583	0.618	0.684	0.857	0.654	0.102
	Entire period of evaluation	0.429	0.548	0.593	0.658	0.857	0.604	0.108

District	Period	Min	Q1	Median	Q3	Max	Mean	SD
MAGANJA DA COSTA	Pre_MM	0.453	0.482	0.531	0.550	0.617	0.525	0.054
	With_MM	0.298	0.500	0.526	0.627	0.696	0.546	0.112
	Entire period of evaluation	0.298	0.493	0.526	0.604	0.696	0.536	0.088
MOCUBELA	Pre_MM	0.415	0.476	0.544	0.597	0.704	0.536	0.086
	With_MM	0.500	0.553	0.659	0.688	0.875	0.641	0.105
	Entire period of evaluation	0.415	0.500	0.594	0.675	0.875	0.591	0.109
MULEVALA	Pre_MM	0.091	0.282	0.339	0.500	0.571	0.370	0.150
	With_MM	0.438	0.600	0.640	0.750	0.875	0.664	0.134
	Entire period of evaluation	0.091	0.385	0.538	0.640	0.875	0.523	0.204
NAMACURRA	Pre_MM	0.420	0.467	0.500	0.514	0.681	0.503	0.070
	With_MM	0.538	0.569	0.611	0.628	0.667	0.602	0.043
	Entire period of evaluation	0.420	0.500	0.552	0.614	0.681	0.554	0.076
PEBANE	Pre_MM	0.451	0.492	0.540	0.563	0.628	0.531	0.056
	With_MM	0.500	0.564	0.582	0.623	0.773	0.596	0.068
	Entire period of evaluation	0.451	0.520	0.564	0.598	0.773	0.564	0.070

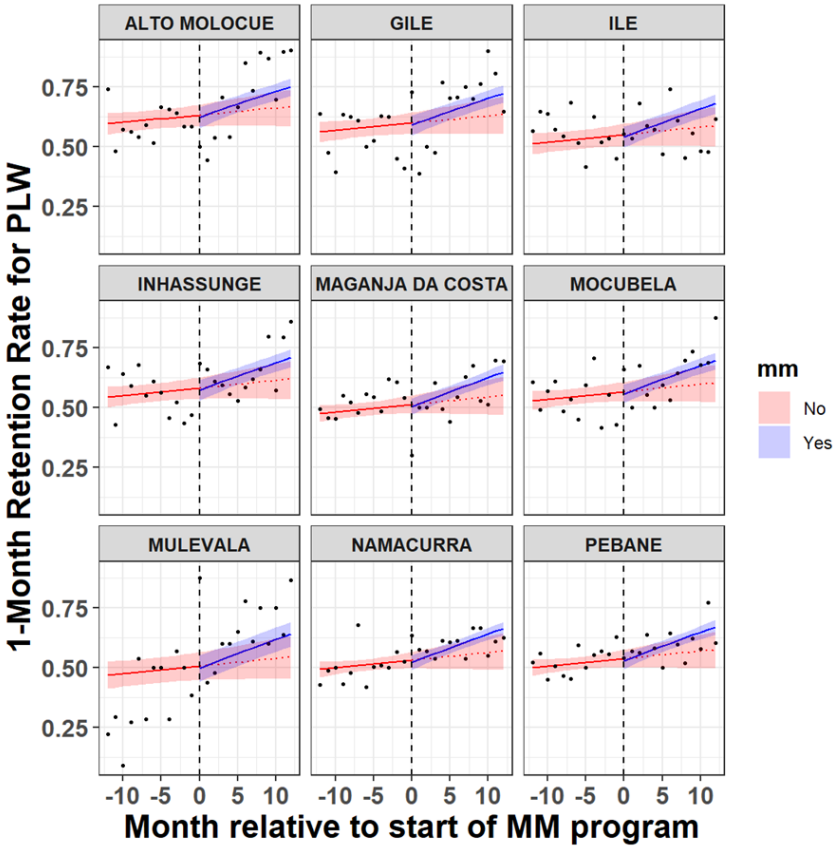


Figure 1. One-month retention rate for PLWH. The vertical dashed line represents the start of MM implementation, with the 12 months prior to MM implementation to the left and 12 months with MM to the

right. The red line represents what happened in the pre-MM period and projects what would have happened if MM had not been implemented. The blue line represents what was observed after MM implementation.

Retention 3-Months After ART Initiation

In the year before MM implementation, median district-level 3-month retention ranged from 15% in Mulevala to 47% in Inhassunge. In the year during MM implementation, 3-month retention ranged from 37% in Ile to 49% in Mocubela (**Table 5**). Province-wide, the odds of 3-month retention increased 1.6% per month in the pre-MM period, compared to an increase of 6% per month with-MM ($p<0.001$; **Figure 2**).

Table 5. Proportion of PLWH who were retained in care 3-months after ART initiation per month per district one year before (pre-MM) and one year after (with-MM) implementation of MM services.

District	Period	Min	Q1	Median	Q3	Max	Mean	SD
ALTO MOLÒCUÉ	Pre_MM	0.162	0.308	0.333	0.349	0.390	0.316	0.064
	With_MM	0.167	0.333	0.435	0.615	0.900	0.474	0.199
	Entire period of evaluation	0.162	0.310	0.345	0.435	0.900	0.398	0.168
GILÉ	Pre_MM	0.214	0.270	0.341	0.396	0.442	0.333	0.083
	With_MM	0.250	0.300	0.419	0.581	0.710	0.451	0.170
	Entire period of evaluation	0.214	0.286	0.368	0.442	0.710	0.394	0.146
ILE	Pre_MM	0.167	0.251	0.368	0.395	0.486	0.339	0.104
	With_MM	0.182	0.304	0.368	0.404	0.600	0.381	0.121
	Entire period of evaluation	0.167	0.290	0.368	0.404	0.600	0.361	0.113
INHASSUNGE	Pre_MM	0.269	0.396	0.466	0.536	0.556	0.445	0.100
	With_MM	0.233	0.406	0.480	0.568	0.775	0.479	0.148
	Entire period of evaluation	0.233	0.406	0.467	0.546	0.775	0.462	0.125
MAGANJA DA COSTA	Pre_MM	0.269	0.309	0.333	0.352	0.540	0.343	0.069
	With_MM	0.254	0.357	0.422	0.444	0.475	0.399	0.072
	Entire period of evaluation	0.254	0.309	0.357	0.429	0.540	0.372	0.075
MOCUBELA	Pre_MM	0.293	0.390	0.432	0.499	0.529	0.433	0.076
	With_MM	0.256	0.378	0.490	0.562	0.733	0.477	0.143
	Entire period of evaluation	0.256	0.378	0.444	0.529	0.733	0.456	0.115
MULEVALA	Pre_MM	0.000	0.100	0.154	0.308	0.429	0.185	0.139
	With_MM	0.217	0.364	0.476	0.636	0.667	0.489	0.152
	Entire period of evaluation	0.000	0.154	0.357	0.476	0.667	0.343	0.211
NAMACURRA	Pre_MM	0.208	0.328	0.348	0.364	0.465	0.348	0.063
	With_MM	0.369	0.391	0.429	0.472	0.663	0.444	0.079
	Entire period of evaluation	0.208	0.353	0.381	0.444	0.663	0.398	0.086
PEBANE	Pre_MM	0.278	0.341	0.391	0.430	0.486	0.383	0.065

District	Period	Min	Q1	Median	Q3	Max	Mean	SD
	With_MM	0.369	0.418	0.468	0.485	0.630	0.461	0.070
	Entire period of evaluation	0.278	0.370	0.427	0.474	0.630	0.424	0.077

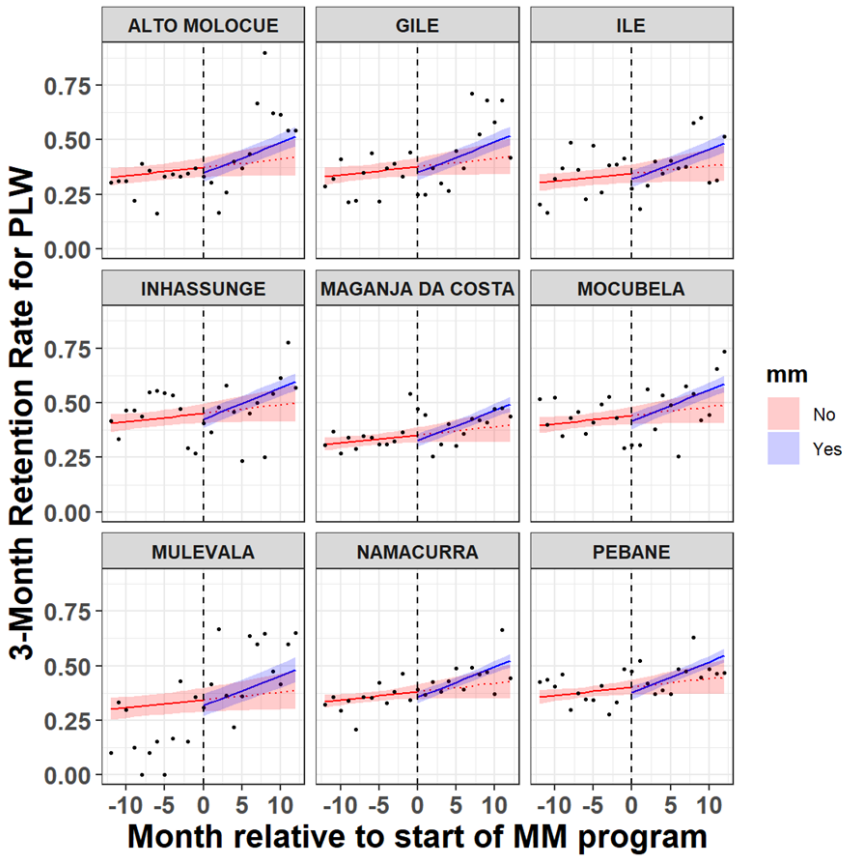


Figure 2. Three-month retention rate for PLWH. The vertical dashed line represents the start of MM implementation, with the 12 months prior to MM implementation to the left and 12 months with MM to the right. The red line represents what happened in the pre-MM period and projects what would have happened if MM had not been implemented. The blue line represents what was observed after MM implementation.

Retention 6-Months After ART Initiation

In the year before MM implementation, median district-level 6-month retention ranged from 33% in Mulevala to 67% in Inhassunge. In the year during MM implementation, 6-month retention ranged from 56% in Ile to 70% in Inhassunge and Mulevela (**Table 6**). Province-wide, the odds of 6-month retention increased 1.1% per month in the pre-MM period, compared to an increase of 4.3% per month with-MM (p<0.001; **Figure 3**).

Table 6. Proportion of PLWH who were retained in care 6-months after ART initiation per month per district one year before (pre-MM) and one year after (with-MM) implementation of MM services.

District	Period	Min	Q1	Median	Q3	Max	Mean	SD
ALTO MOLÒCUÉ	Pre_MM	0.370	0.438	0.467	0.487	0.564	0.467	0.049

District	Period	Min	Q1	Median	Q3	Max	Mean	SD
	With_MM	0.580	0.595	0.658	0.720	0.765	0.663	0.064
	Entire period of evaluation	0.370	0.473	0.580	0.658	0.765	0.569	0.114
GILÉ	Pre_MM	0.374	0.497	0.546	0.608	0.625	0.538	0.079
	With_MM	0.412	0.495	0.606	0.644	0.719	0.582	0.100
	Entire period of evaluation	0.374	0.495	0.547	0.615	0.719	0.561	0.092
ILE	Pre_MM	0.349	0.377	0.406	0.506	0.514	0.430	0.066
	With_MM	0.443	0.521	0.561	0.615	0.657	0.564	0.065
	Entire period of evaluation	0.349	0.408	0.508	0.561	0.657	0.500	0.094
INHASSUNGE	Pre_MM	0.622	0.653	0.674	0.692	0.794	0.680	0.044
	With_MM	0.612	0.674	0.696	0.730	0.853	0.710	0.074
	Entire period of evaluation	0.612	0.654	0.686	0.719	0.853	0.696	0.062
MAGANJA DA COSTA	Pre_MM	0.449	0.504	0.528	0.567	0.608	0.530	0.048
	With_MM	0.536	0.568	0.632	0.682	0.735	0.628	0.064
	Entire period of evaluation	0.449	0.529	0.568	0.632	0.735	0.581	0.075
MOCUBELA	Pre_MM	0.475	0.617	0.645	0.663	0.868	0.649	0.089
	With_MM	0.599	0.628	0.664	0.700	0.768	0.667	0.053
	Entire period of evaluation	0.475	0.617	0.652	0.685	0.868	0.658	0.071
MULEVALA	Pre_MM	0.178	0.272	0.330	0.390	0.480	0.328	0.090
	With_MM	0.588	0.629	0.704	0.742	0.853	0.699	0.083
	Entire period of evaluation	0.178	0.333	0.588	0.704	0.853	0.521	0.207
NAMACURRA	Pre_MM	0.486	0.528	0.552	0.569	0.639	0.552	0.043
	With_MM	0.560	0.582	0.639	0.694	0.710	0.635	0.055
	Entire period of evaluation	0.486	0.557	0.582	0.639	0.710	0.596	0.065
PEBANE	Pre_MM	0.550	0.593	0.616	0.627	0.653	0.609	0.033
	With_MM	0.615	0.658	0.678	0.691	0.713	0.673	0.026
	Entire period of evaluation	0.550	0.615	0.651	0.678	0.713	0.642	0.043

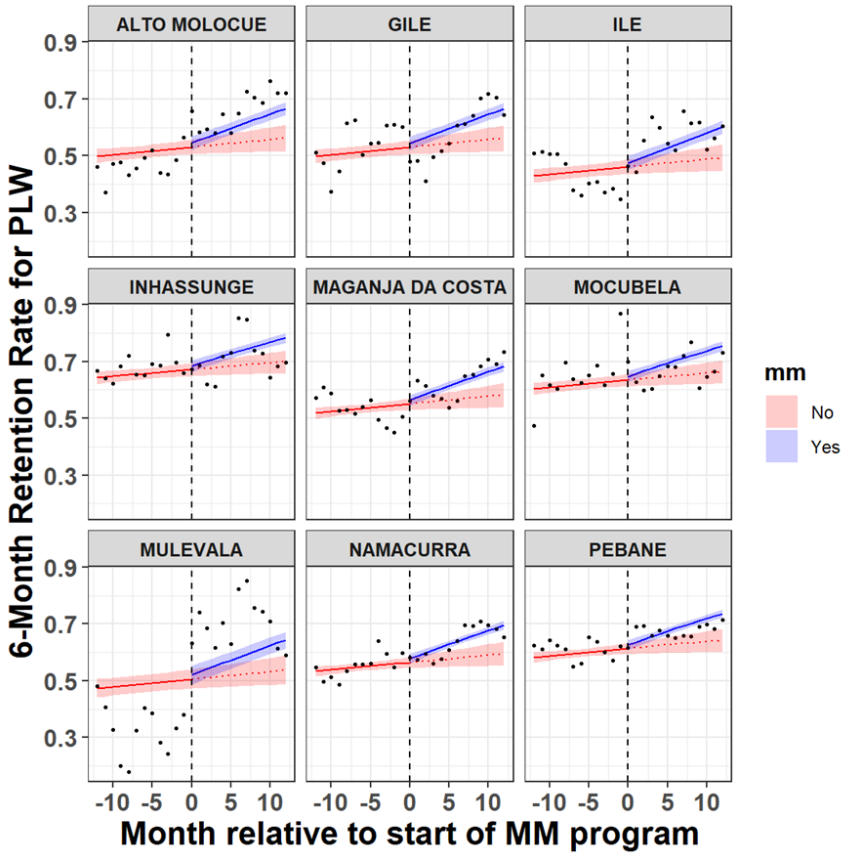


Figure 3. Six-month retention rate for PLWH. The vertical dashed line represents the start of MM implementation, with the 12 months prior to MM implementation to the left and 12 months with MM to the right. The red line represents what happened in the pre-MM period and projects what would have happened if MM had not been implemented. The blue line represents what was observed after MM implementation.

Retention 12-Months After ART Initiation

In the year before MM implementation, median district-level 12-month retention ranged from 35% in Mulevala to 61% in Maganja Da Costa. In the year during MM implementation, 12-month retention ranged from 56% in Gilé to 72% in Inhassunge (**Table 7**). Province-wide, the odds of 12-month retention increased 1.5% per month in the pre-MM period, compared to an increase of 7.6% per month with-MM (p<0.001; **Figure 4**).

Table 7. Proportion of PLWH who were retained in care 12-months after ART initiation per month per district one year before (pre-MM) and one year after (with-MM) implementation of MM services.

District	Period	Min	Q1	Median	Q3	Max	Mean	SD
ALTO MOLÒCUÉ	Pre_MM	0.306	0.422	0.475	0.549	0.731	0.490	0.108
	With_MM	0.436	0.591	0.688	0.706	0.833	0.662	0.104
	Entire period of evaluation	0.306	0.474	0.579	0.700	0.833	0.579	0.136
GILÉ	Pre_MM	0.486	0.519	0.562	0.596	0.742	0.572	0.073
	With_MM	0.444	0.537	0.561	0.629	0.676	0.577	0.069

District	Period	Min	Q1	Median	Q3	Max	Mean	SD
	Entire period of evaluation	0.444	0.520	0.561	0.629	0.742	0.575	0.070
ILE	Pre_MM	0.353	0.455	0.510	0.561	0.667	0.501	0.088
	With_MM	0.314	0.500	0.613	0.741	0.929	0.618	0.175
	Entire period of evaluation	0.314	0.471	0.560	0.650	0.929	0.562	0.150
INHASSUNGE	Pre_MM	0.433	0.523	0.594	0.649	0.769	0.585	0.097
	With_MM	0.682	0.720	0.724	0.778	0.895	0.752	0.067
	Entire period of evaluation	0.433	0.600	0.697	0.725	0.895	0.672	0.117
MAGANJA DA COSTA	Pre_MM	0.466	0.524	0.606	0.627	0.780	0.596	0.089
	With_MM	0.454	0.561	0.583	0.648	0.700	0.590	0.070
	Entire period of evaluation	0.454	0.536	0.600	0.638	0.780	0.593	0.078
MOCUBELA	Pre_MM	0.413	0.568	0.600	0.695	0.730	0.605	0.094
	With_MM	0.514	0.595	0.619	0.722	0.767	0.636	0.080
	Entire period of evaluation	0.413	0.585	0.614	0.696	0.767	0.621	0.086
MULEVALA	Pre_MM	0.000	0.210	0.345	0.511	0.667	0.340	0.230
	With_MM	0.273	0.467	0.600	0.667	0.889	0.572	0.172
	Entire period of evaluation	0.000	0.333	0.500	0.625	0.889	0.461	0.230
NAMACURRA	Pre_MM	0.352	0.460	0.484	0.551	0.726	0.502	0.097
	With_MM	0.446	0.590	0.678	0.855	0.925	0.695	0.166
	Entire period of evaluation	0.352	0.474	0.568	0.726	0.925	0.602	0.167
PEBANE	Pre_MM	0.464	0.487	0.539	0.636	0.684	0.557	0.082
	With_MM	0.532	0.562	0.660	0.696	0.724	0.634	0.071
	Entire period of evaluation	0.464	0.532	0.597	0.676	0.724	0.597	0.084

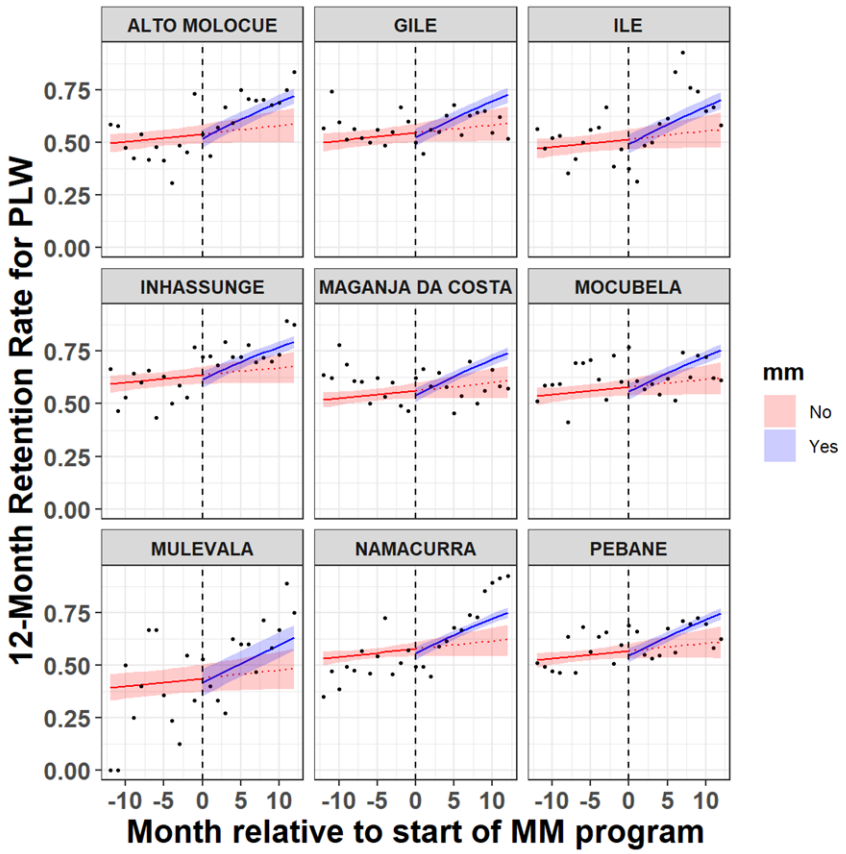


Figure 4. Twelve-month retention rate for PLWH. The vertical dashed line represents the start of MM implementation, with the 12 months prior to MM implementation to the left and 12 months with MM to the right. The red line represents what happened in the pre-MM period and projects what would have happened if MM had not been implemented. The blue line represents what was observed after MM implementation.

Viral Suppression

In the year pre-MM implementation, median district-level viral suppression ranged from 49% in Ile to 85% in Mocubela and Pebane. In the year with-MM, viral suppression ranged from 59% in Gilé to 80% in Mocubela (**Table 8)**. Province-wide, the odds of being virally suppressed decreased by 0.9% per month in the pre-MM period, compared to an increase of 3.9% per month with-MM (p<0.001; **Figure 5**).

Table 8. Proportion of PLWH who were virally suppressed per month per district one year before (pre-MM) and one year after (with-MM) implementation of MM services.

District	Period	Min	Q1	Median	Q3	Max	Mean	SD
ALTO MOLÒCUÉ	Pre_MM	0.476	0.504	0.518	0.541	0.571	0.519	0.027
	With_MM	0.584	0.636	0.676	0.693	0.694	0.659	0.042
	Entire period of evaluation	0.476	0.519	0.584	0.676	0.694	0.592	0.079
GILE	Pre_MM	0.453	0.511	0.537	0.570	0.603	0.536	0.048
	With_MM	0.561	0.574	0.589	0.595	0.604	0.585	0.014

District	Period	Min	Q1	Median	Q3	Max	Mean	SD
	Entire period of evaluation	0.453	0.542	0.574	0.591	0.604	0.561	0.042
ILE	Pre_MM	0.350	0.417	0.490	0.527	0.570	0.475	0.073
	With_MM	0.564	0.583	0.621	0.635	0.647	0.611	0.029
	Entire period of evaluation	0.350	0.506	0.568	0.621	0.647	0.546	0.088
INHASSUNGE	Pre_MM	0.598	0.613	0.628	0.635	0.667	0.628	0.021
	With_MM	0.651	0.686	0.717	0.727	0.733	0.704	0.030
	Entire period of evaluation	0.598	0.628	0.655	0.717	0.733	0.668	0.046
MAGANJA DA COSTA	Pre_MM	0.453	0.526	0.605	0.641	0.708	0.586	0.084
	With_MM	0.525	0.593	0.649	0.704	0.714	0.642	0.066
	Entire period of evaluation	0.453	0.554	0.635	0.686	0.714	0.615	0.079
MOCUBELA	Pre_MM	0.777	0.789	0.846	0.857	0.909	0.832	0.042
	With_MM	0.770	0.800	0.804	0.835	0.844	0.811	0.024
	Entire period of evaluation	0.770	0.790	0.806	0.846	0.909	0.821	0.035
MULEVALA	Pre_MM	0.600	0.714	0.714	1.000	1.000	0.805	0.149
	With_MM	0.667	0.706	0.717	0.739	0.757	0.718	0.028
	Entire period of evaluation	0.600	0.707	0.714	0.751	1.000	0.760	0.112
NAMACURRA	Pre_MM	0.510	0.535	0.543	0.566	0.572	0.546	0.019
	With_MM	0.583	0.612	0.649	0.699	0.711	0.649	0.049
	Entire period of evaluation	0.510	0.546	0.583	0.649	0.711	0.600	0.064
PEBANE	Pre_MM	0.718	0.769	0.849	0.855	0.857	0.815	0.052
	With_MM	0.710	0.738	0.746	0.774	0.789	0.753	0.024
	Entire period of evaluation	0.710	0.744	0.774	0.848	0.857	0.783	0.050

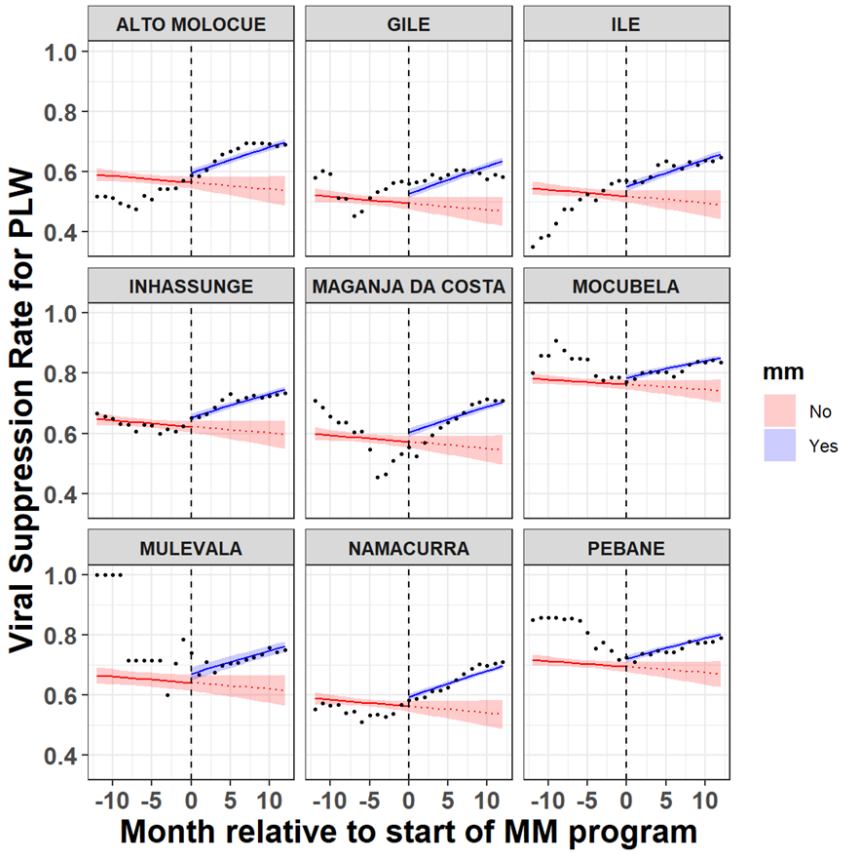


Figure 5. Viral suppression rate for PLWH. The vertical dashed line represents the start of MM implementation, with the 12 months prior to MM implementation to the left and 12 months with MM to the right. The red line represents what happened in the pre-MM period and projects what would have happened if MM had not been implemented. The blue line represents what was observed after MM implementation.

Child at Risk Clinic (CRC) Registration

As shown in **Table 9**, the median number of HEI enrolled in CRC per month ranged from 8 in Mulevala to 116 in Namacurra in the year before MM implementation. In the year during MM implementation median monthly CRC enrollment ranged from 19 in Mulevala to 165 in Namacurra. There was significant variability in the absolute number of HEI enrolled in CRC across districts ($p<0.001$). There was also a significant increase in the absolute number of HEI enrolled in CRC over time (20.2 per year; $p<0.001$); however, there was not a statistically significant change in CRC enrollment during the period with MM compared to the pre-MM period ($p=0.67$). That said, the absolute number of HEI who *should have* been enrolled in CRC is unknown, so we were unable to determine if the proportion of HEI enrolled in CRC as a function of all possible CRC enrollments changed over time or with respect to implementation of MM services.

Table 9. Proportion of HEI who were enrolled in Child at Risk Clinic per month per district one year before (pre-MM) and one year after (with-MM) implementation of MM services.

District	Period	Min	Q1	Median	Q3	Max	Mean	SD
ALTO MOLÒCUÉ	Pre_MM	24	32	40	48	61	40	11
	With_MM	41	51	57	63	75	57	9
	Entire period of evaluation	24	40	50	61	75	49	13
GILÉ	Pre_MM	20	35	44	59	75	46	16
	With_MM	40	53	62	75	149	69	27
	Entire period of evaluation	20	43	55	62	149	58	25
ILE	Pre_MM	21	26	29	32	55	32	10
	With_MM	27	33	43	60	64	45	14
	Entire period of evaluation	21	28	33	48	64	39	14
INHASSUNGE	Pre_MM	30	43	60	67	70	55	14
	With_MM	41	70	75	89	102	74	18
	Entire period of evaluation	30	52	67	75	102	65	18
MAGANJA DA COSTA	Pre_MM	56	74	81	88	117	82	17
	With_MM	67	90	104	107	138	100	18
	Entire period of evaluation	56	76	90	107	138	91	20
MOCUBELA	Pre_MM	53	62	67	91	121	77	22
	With_MM	84	102	104	111	124	106	10
	Entire period of evaluation	53	68	98	109	124	92	22
MULEVALA	Pre_MM	3	6	8	8	13	7	3
	With_MM	7	14	19	21	24	18	5
	Entire period of evaluation	3	7	11	19	24	13	7
NAMACURRA	Pre_MM	99	112	116	145	163	126	22
	With_MM	128	150	165	174	196	163	21
	Entire period of evaluation	99	118	150	165	196	145	28
PEBANE	Pre_MM	87	103	113	120	141	113	15
	With_MM	112	131	158	169	180	152	23
	Entire period of evaluation	87	112	127	158	180	133	28

Uptake of DNA PCR Testing by 2-Months of Age

In the year pre-MM implementation, median district-level uptake of DNA PCR testing among HEI by 2-months of age ranged from 26% in Mulevala to 67% in Mocubela. In the year with-MM, 2-month DNA PCR uptake ranged from 67% in Alto Molócuè, Gilé, and Namacurra to 99% in Mocubela (**Table 10)**. Province-wide, the odds of DNA PCR uptake by 2-months of age

increased by 4.4% per month in pre-MM period, compared to an increase of 12.3% per month with-MM (p<0.001; **Figure 6**).

Table 10. Proportion of HEI who received HIV DNA PCR testing by 2-months of age per month per district one year before (pre-MM) and one year after (with-MM) implementation of MM services.

District	Period	Min	Q1	Median	Q3	Max	Mean	SD
ALTO MOLÒCUÉ	Pre_MM	0.286	0.470	0.589	0.630	0.794	0.557	0.135
	With_MM	0.451	0.608	0.672	0.762	0.871	0.667	0.134
	Entire period of evaluation	0.286	0.531	0.613	0.679	0.871	0.614	0.143
GILÉ	Pre_MM	0.321	0.392	0.471	0.570	0.662	0.474	0.110
	With_MM	0.324	0.571	0.672	0.739	1.000	0.662	0.197
	Entire period of evaluation	0.321	0.413	0.571	0.672	1.000	0.572	0.185
ILE	Pre_MM	0.333	0.395	0.494	0.637	0.714	0.517	0.133
	With_MM	0.467	0.518	0.676	0.868	0.960	0.686	0.173
	Entire period of evaluation	0.333	0.481	0.579	0.714	0.960	0.605	0.175
INHASSUNGE	Pre_MM	0.324	0.427	0.567	0.681	0.820	0.563	0.164
	With_MM	0.476	0.792	0.845	0.987	1.000	0.840	0.169
	Entire period of evaluation	0.324	0.560	0.736	0.845	1.000	0.707	0.216
MAGANJA DA COSTA	Pre_MM	0.394	0.458	0.507	0.566	0.833	0.528	0.120
	With_MM	0.393	0.592	0.727	0.951	1.000	0.734	0.193
	Entire period of evaluation	0.393	0.500	0.589	0.728	1.000	0.635	0.190
MOCUBELA	Pre_MM	0.202	0.479	0.669	0.859	0.972	0.651	0.254
	With_MM	0.568	0.857	0.989	1.000	1.000	0.904	0.133
	Entire period of evaluation	0.202	0.583	0.857	0.989	1.000	0.782	0.235
MULEVALA	Pre_MM	0.133	0.202	0.261	0.368	1.000	0.327	0.234
	With_MM	0.357	0.583	0.750	1.000	1.000	0.763	0.244
	Entire period of evaluation	0.133	0.273	0.500	1.000	1.000	0.553	0.323
NAMACURRA	Pre_MM	0.450	0.465	0.519	0.543	0.675	0.521	0.066
	With_MM	0.408	0.626	0.669	0.818	0.912	0.701	0.153
	Entire period of evaluation	0.408	0.515	0.555	0.675	0.912	0.615	0.149
PEBANE	Pre_MM	0.318	0.382	0.419	0.537	0.781	0.475	0.136
	With_MM	0.429	0.590	0.734	0.812	0.972	0.695	0.155
	Entire period of evaluation	0.318	0.429	0.550	0.742	0.972	0.589	0.182

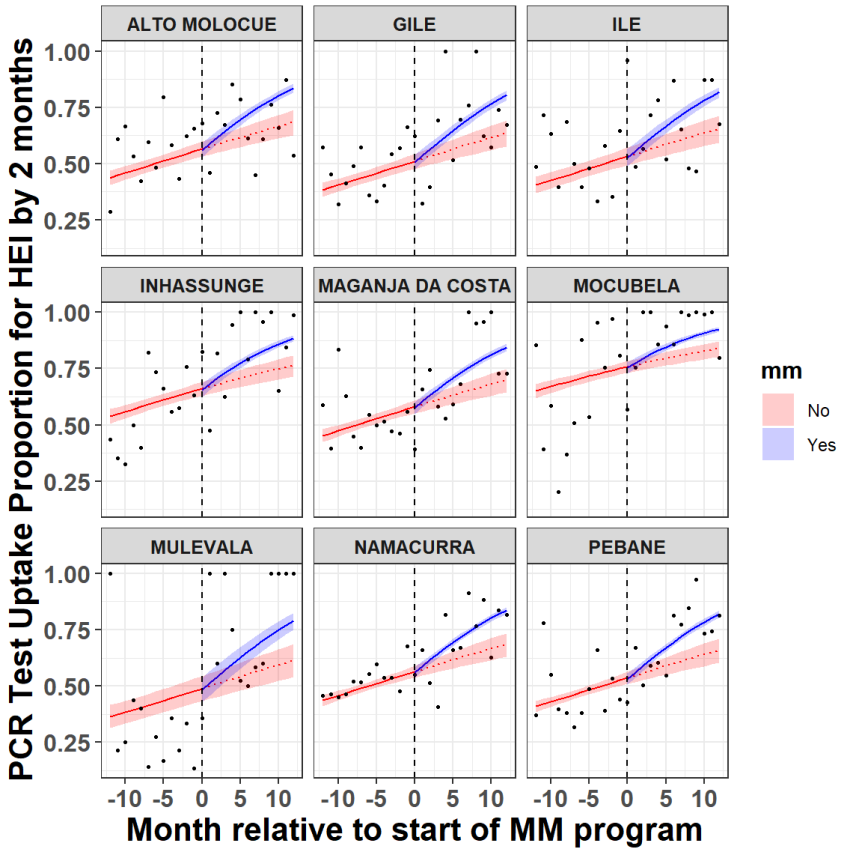


Figure 6. DNA PCR uptake among HEI by 2-months of age. The vertical dashed line represents the start of MM implementation, with the 12 months prior to MM implementation to the left and 12 months with MM to the right. The red line represents what happened pre-MM and projects what would have happened if MM had not been implemented. The blue line represents what was observed after MM implementation.

Uptake of DNA PCR Testing by 9-Months of Age

In the year pre-MM implementation, median district-level uptake of DNA PCR testing among HEI by 9-months of age ranged from 48% in Mulevala to 100% in Mocubela. In the year with-MM, 9-month DNA PCR uptake ranged from 87% in Gilé to 100% in Inhassunge, Mocubela, and Mulevala (**Table 11)**. Province-wide, the odds of DNA PCR uptake by 9-months of age increased by 1.4% per month in pre-MM period, compared to an increase of 8.1% per month with-MM ($p<0.001$; **Figure 7**).

Table 11. Proportion of HEI who received HIV DNA PCR testing by 9-months of age per month per district one year before (pre-MM) and one year after (with-MM) implementation of MM services.

District	Period	Min	Q1	Median	Q3	Max	Mean	SD
ALTO MOLÒCUÉ	Pre_MM	0.508	0.713	0.793	0.910	0.941	0.793	0.129
	With_MM	0.620	0.790	0.967	1.000	1.000	0.889	0.135
	Entire period of evaluation	0.508	0.732	0.851	0.967	1.000	0.843	0.138
GILÉ	Pre_MM	0.464	0.740	0.877	0.911	0.983	0.808	0.159

District	Period	Min	Q1	Median	Q3	Max	Mean	SD
	With_MM	0.437	0.770	0.869	1.000	1.000	0.840	0.171
	WEntire period of evaluationhole	0.437	0.743	0.869	0.918	1.000	0.825	0.162
ILE	Pre_MM	0.479	0.595	0.795	0.936	1.000	0.769	0.199
	With_MM	0.556	0.818	0.941	1.000	1.000	0.866	0.164
	Entire period of evaluation	0.479	0.632	0.865	1.000	1.000	0.819	0.185
INHASSUNGE	Pre_MM	0.588	0.748	0.855	0.938	1.000	0.837	0.135
	With_MM	0.635	0.939	1.000	1.000	1.000	0.922	0.127
	Entire period of evaluation	0.588	0.761	0.939	1.000	1.000	0.881	0.135
MAGANJA DA COSTA	Pre_MM	0.705	0.802	0.923	1.000	1.000	0.889	0.112
	With_MM	0.700	0.829	0.884	1.000	1.000	0.897	0.111
	Entire period of evaluation	0.700	0.826	0.894	1.000	1.000	0.893	0.109
MOCUBELA	Pre_MM	0.797	1.000	1.000	1.000	1.000	0.969	0.072
	With_MM	0.851	1.000	1.000	1.000	1.000	0.982	0.045
	Entire period of evaluation	0.797	1.000	1.000	1.000	1.000	0.976	0.059
MULEVALA	Pre_MM	0.200	0.306	0.483	0.560	1.000	0.464	0.224
	With_MM	0.583	0.786	1.000	1.000	1.000	0.888	0.147
	Entire period of evaluation	0.200	0.500	0.700	1.000	1.000	0.684	0.284
NAMACURRA	Pre_MM	0.712	0.791	0.867	0.888	1.000	0.853	0.078
	With_MM	0.647	0.787	0.898	0.954	1.000	0.867	0.112
	Entire period of evaluation	0.647	0.787	0.883	0.914	1.000	0.861	0.096
PEBANE	Pre_MM	0.667	0.695	0.778	1.000	1.000	0.817	0.141
	With_MM	0.643	0.827	0.932	1.000	1.000	0.902	0.113
	Entire period of evaluation	0.643	0.772	0.837	1.000	1.000	0.861	0.132

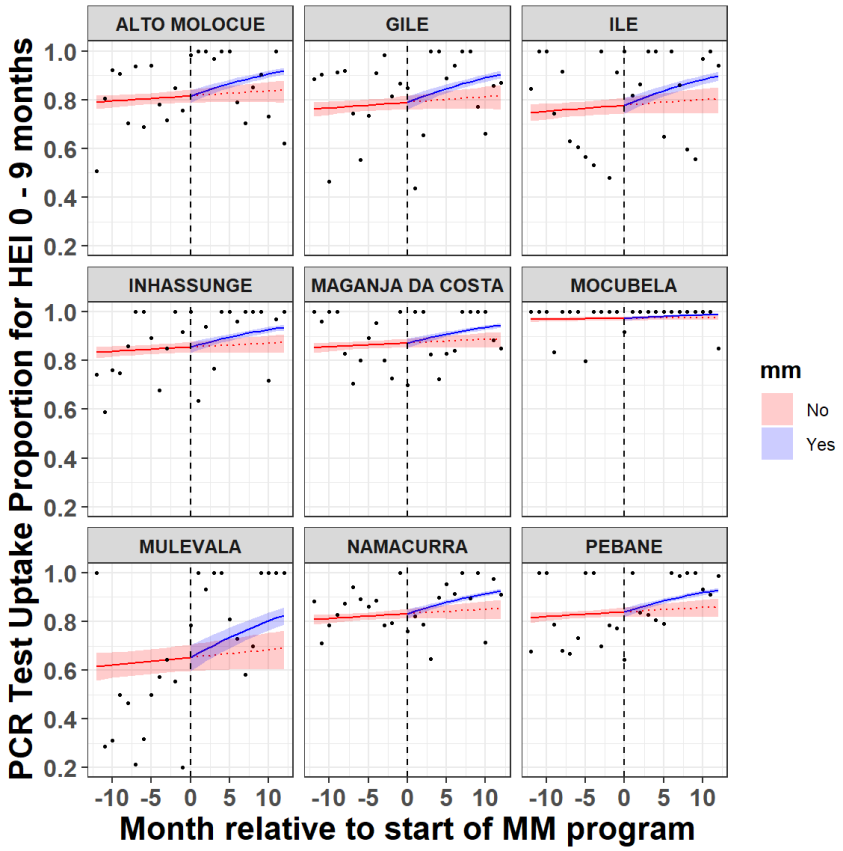


Figure 7. DNA PCR uptake among HEI by 9-months of age. The vertical dashed line represents the start of MM implementation, with the 12 months prior to MM implementation to the left and 12 months with MM to the right. The red line represents what happened in pre-MM and projects what would have happened if MM had not been implemented. The blue line represents what was observed after MM implementation.

DNA PCR positivity 0-2 months of age

In the year pre-MM implementation, median district-level DNA PCR positivity rates among HEI tested by 2-months of age ranged from 0% in Mulevala to 8% in Gilé and Maganja da Costa. In the year with-MM, 2-month DNA PCR positivity ranged from 0% in Mulevala to 8% in Namacurra (**Table 12**). The odds of DNA PCR positivity decreased 9.4% per month in the pre-MM period, compared to an increase of 1% per month with-MM (p<0.001; **Figure 8**).

Table 12. DNA PCR positivity among HEI who received DNA PCR testing by 2-months of age per month per district one year before (pre-MM) and one year after (with-MM) implementation of MM services.

District	Period	Min	Q1	Median	Q3	Max	Mean	SD
ALTO MOLÒCUÉ	Pre_MM	0.000	0.023	0.066	0.098	0.111	0.060	0.043
	With_MM	0.000	0.000	0.022	0.079	0.104	0.038	0.038
	Entire period of evaluation	0.000	0.018	0.032	0.088	0.111	0.048	0.041
GILÉ	Pre_MM	0.000	0.039	0.078	0.101	0.375	0.098	0.104
	With_MM	0.000	0.000	0.065	0.139	0.182	0.075	0.068

District	Period	Min	Q1	Median	Q3	Max	Mean	SD
	Entire period of evaluation	0.000	0.031	0.065	0.105	0.375	0.086	0.087
ILE	Pre_MM	0.000	0.034	0.068	0.108	0.333	0.097	0.109
	With_MM	0.000	0.000	0.044	0.107	0.250	0.068	0.072
	Entire period of evaluation	0.000	0.000	0.049	0.107	0.333	0.082	0.091
INHASSUNGE	Pre_MM	0.000	0.015	0.062	0.108	0.167	0.068	0.059
	With_MM	0.000	0.030	0.044	0.064	0.114	0.051	0.031
	Entire period of evaluation	0.000	0.026	0.050	0.085	0.167	0.059	0.047
MAGANJA DA COSTA	Pre_MM	0.017	0.042	0.081	0.136	0.279	0.106	0.091
	With_MM	0.000	0.029	0.045	0.068	0.114	0.051	0.032
	Entire period of evaluation	0.000	0.029	0.060	0.091	0.279	0.077	0.071
MOCUBELA	Pre_MM	0.027	0.034	0.049	0.074	0.148	0.063	0.041
	With_MM	0.000	0.022	0.032	0.047	0.083	0.034	0.022
	Entire period of evaluation	0.000	0.027	0.042	0.056	0.148	0.048	0.035
MULEVALA	Pre_MM	0.000	0.000	0.000	0.000	0.143	0.012	0.041
	With_MM	0.000	0.000	0.000	0.091	0.231	0.060	0.085
	Entire period of evaluation	0.000	0.000	0.000	0.053	0.231	0.037	0.070
NAMACURRA	Pre_MM	0.020	0.029	0.040	0.058	0.121	0.050	0.030
	With_MM	0.026	0.044	0.076	0.090	0.162	0.074	0.036
	Entire period of evaluation	0.020	0.036	0.052	0.080	0.162	0.063	0.035
PEBANE	Pre_MM	0.000	0.046	0.071	0.090	0.138	0.067	0.037
	With_MM	0.000	0.018	0.044	0.069	0.097	0.044	0.033
	Entire period of evaluation	0.000	0.027	0.049	0.076	0.138	0.055	0.036

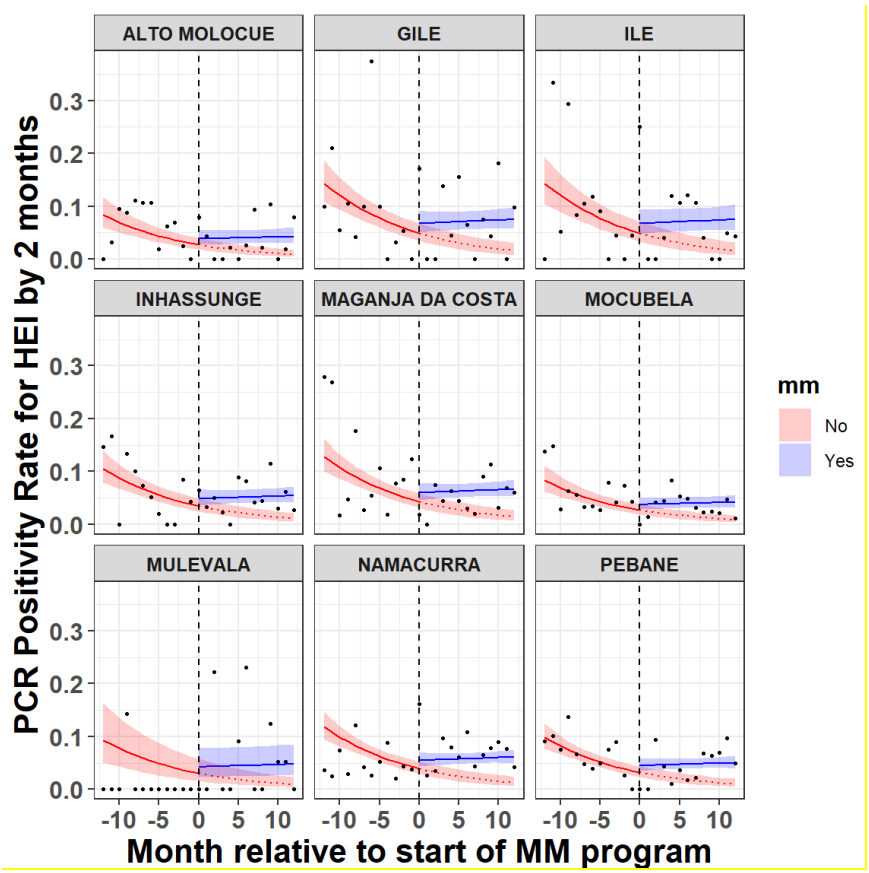


Figure 8. DNA PCR positivity among HEI tested from 0-2 months of age. The vertical dashed line represents the start of MM implementation, with the 12 months prior to MM implementation to the left and 12 months with MM to the right. The red line represents what happened pre-MM and projects what would have happened if MM had not been implemented. The blue line represents what was observed after MM implementation.

DNA PCR positivity 0-9 months of age

In the year pre-MM implementation, median district-level DNA PCR positivity rates among HEI tested by 9-months of age ranged from 0% in Mulevala to 14% in Ile and Maganja da Costa. In the year with-MM, 9-month DNA PCR positivity ranged from 4% in Alto Molócuè and Ile to 10% in Namacurra (**Table 13**). The odds of DNA PCR positivity decreased 8.9% per month in the pre-MM period, compared to a decrease of 0.4% per month with-MM (p<0.001; **Figure 9**).

Table 13. DNA PCR positivity among HEI who received DNA PCR testing by 9-months of age per month per district one year before (pre-MM) and one year after (with-MM) implementation of MM services.

District	Period	Min	Q1	Median	Q3	Max	Mean	SD
ALTO MOLÒCUÉ	Pre_MM	0.019	0.052	0.066	0.143	0.200	0.097	0.060
	With_MM	0.000	0.016	0.041	0.100	0.159	0.054	0.050
	Entire period of evaluation	0.000	0.020	0.062	0.109	0.200	0.074	0.058

District	Period	Min	Q1	Median	Q3	Max	Mean	SD
GILÉ	Pre_MM	0.000	0.037	0.104	0.128	0.270	0.102	0.079
	With_MM	0.000	0.055	0.081	0.129	0.157	0.083	0.055
	Entire period of evaluation	0.000	0.038	0.097	0.129	0.270	0.092	0.067
ILE	Pre_MM	0.000	0.049	0.141	0.195	0.292	0.138	0.096
	With_MM	0.000	0.031	0.037	0.125	0.231	0.076	0.072
	Entire period of evaluation	0.000	0.031	0.094	0.162	0.292	0.106	0.088
INHASSUNGE	Pre_MM	0.000	0.039	0.098	0.157	0.308	0.116	0.099
	With_MM	0.000	0.050	0.078	0.103	0.135	0.072	0.039
	Entire period of evaluation	0.000	0.046	0.085	0.116	0.308	0.093	0.076
MAGANJA DA COSTA	Pre_MM	0.059	0.088	0.140	0.194	0.286	0.153	0.084
	With_MM	0.009	0.060	0.076	0.095	0.157	0.076	0.041
	Entire period of evaluation	0.009	0.063	0.095	0.157	0.286	0.113	0.075
MOCUBELA	Pre_MM	0.012	0.069	0.084	0.127	0.297	0.101	0.071
	With_MM	0.000	0.019	0.048	0.064	0.091	0.044	0.030
	Entire period of evaluation	0.000	0.029	0.064	0.084	0.297	0.071	0.060
MULEVALA	Pre_MM	0.000	0.000	0.000	0.000	0.125	0.010	0.036
	With_MM	0.000	0.000	0.048	0.118	0.214	0.062	0.075
	Entire period of evaluation	0.000	0.000	0.000	0.053	0.214	0.037	0.064
NAMACURRA	Pre_MM	0.028	0.071	0.100	0.126	0.270	0.113	0.068
	With_MM	0.060	0.063	0.098	0.098	0.168	0.092	0.030
	Entire period of evaluation	0.028	0.063	0.098	0.116	0.270	0.102	0.052
PEBANE	Pre_MM	0.000	0.082	0.134	0.142	0.280	0.120	0.069
	With_MM	0.000	0.053	0.063	0.083	0.203	0.069	0.052
	Entire period of evaluation	0.000	0.058	0.083	0.139	0.280	0.094	0.065

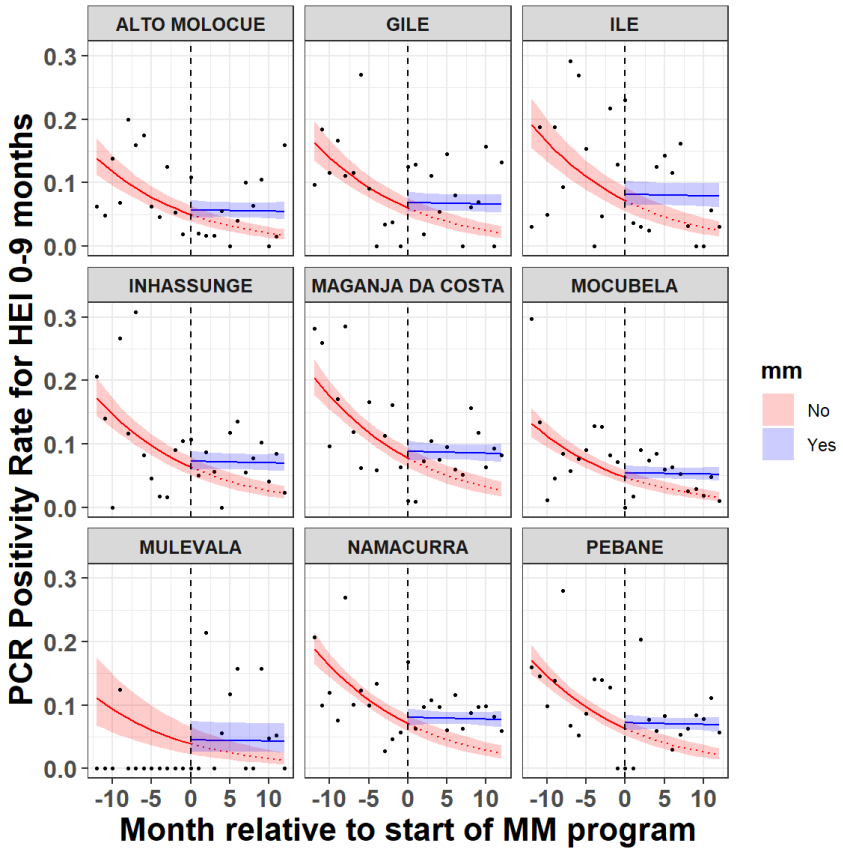


Figure 9. DNA PCR positivity among HEI tested from 0-9-months of age. The vertical dashed line represents the start of MM implementation, with the 12 months prior to MM implementation to the left and 12 months with MM to the right. The red line represents what happened the pre-MM and projects what would have happened if MM had not been implemented. The blue line represents what was observed after MM implementation.

Conclusions and Recommendations

This retrospective evaluation was done in Zambézia Province, Mozambique, to assess the effect of a MM program on retention to care, viral suppression, and vertical transmission in the period of 2016-2019. The main finding was that implementation of a MM program was associated with improved retention in PMTCT services and higher viral suppression rates among PLWH. The proportion of PLWH retained in care was significantly higher in the period with MM implementation compared to the period prior to MM implementation, and this trend was consistently observed at all time points (1-month, 3-months, 6-months, and 12-months) after ART initiation. While our study design is unable to definitively determine causality, this sustained association between MM implementation and retention in care likely contributed to the observed improvements in viral suppression rates during the period with MM implementation. In other words, sustained engagement in care is the cornerstone for promoting optimal ART adherence and

achieving and maintaining viral suppression, and MM have the potential to positively influence these outcomes.

A review showed the importance of lay health worker support in the management of PLWH and HEI; however, evidence for lay worker impact on adherence to ART and virologic outcomes was lacking.[5] The results of our study clearly support a positive effect of MM on retention and viral suppression among PLWH. As such, MM may have an important role to play in nudging ever closer to attaining "the third 95" of the UNAIDS 95-95-95 goals (i.e., that 95% of those on ART are virally suppressed).[6] However, even though we saw significant improvements in retention and viral suppression after implementation of MM, in the year with-MM median district-level 12-month retention ranged from 56% to 72% and viral suppression ranged from 59% to 80%, well short of the "third 95" target. This is also consistent with global statistics; in 2019, only about two-thirds of PLWH in SSA were retained in care and achieved HIV viral suppression.[7] Therefore, additional investments and implementation research are needed to understand and realize the full potential of MM and other strategies for optimizing PMTCT outcomes.[8] Already, there is evidence that peer support through MM approaches is acceptable,[9] an important factor for success of these strategies, but other implementation outcomes including fidelity to the strategy still need to be explored.

In the pre-MM period, the proportion of PLWH retained in care was already trending in a positive direction, but the rate of rise significantly increased with MM implementation. It is possible that the pre-MM improvements in retention were attributable to program maturation and/or other initiatives aimed at improving retention in care, and that MM implementation led to additional or synergistic gains. On the other hand, viral suppression rates were decreasing prior to MM implementation, but significantly increased in the period with MM. Decreasing viral suppression rates in the pre-MM period might have been the result the concurrent gains in retention of a sub-group of PLWH who previously were not in care and therefore not receiving viral load monitoring. While in the with-MM period, perhaps, PLWH were not only better retained in care but also had better adherence to ART and virologic control because of MM support. Randomized clinical trials have also shown a beneficial impact of peer/mentoring support on maternal PMTCT outcomes.[10-12] However, both the Mother Mentor (MoMent) study in Nigeria and the Mother and Infant Retention for Health (MIR4Health) study in Kenya only assessed these outcomes through 6 months postpartum,[10,11] and MIR4Health tested a combination intervention that made it difficult to isolate the relative contribution of MM to improved outcomes.[11] While our study design is more limited than these controlled studies in its ability to assess causality, our real-world assessments of viral suppression and retention up to 12-months after ART initiation in the year after MM implementation are strengths.

Despite considerable improvements in viral suppression among PLWH in the period with MM implementation, this did not translate into comparable declines in DNA PCR positivity rates (a proxy for vertical transmission) among HEI. In the period prior to MM implementation, there were steady declines in DNA PCR positivity, with rates approaching 5% or less in most districts; however, in the with-MM period there was diminishing improvement in DNA PCR positivity rates

among HEI 0-9 months of age, and DNA PCR positivity actually slightly increased among HEI 0-2 months of age. These observations might be explained by having reached a plateau (i.e., diminishing returns) or increased uptake of HIV testing in the with-MM period (i.e., increased testing among HEI at higher risk for vertical transmission, but who were less likely to be tested in the pre-MM period). In fact, there was a significant increase in the absolute number of HEI enrolled in CRC over time, and the odds of DNA PCR uptake by 2-months and 9-months of age were significantly higher in the with-MM period compared to the pre-MM period. The MoMent study also demonstrated that MM services were associated with improved rates of HEI presentation for DNA PCR testing by 2 months of age.[13] While the ultimate goal is to eliminate vertical transmission, it should still be viewed as a success if MM are helping high-risk mothers and their babies stay in care, access diagnostic testing, and get linked to care and treatment when indicated. Furthermore, it may be the case that the retention benefits of MM are more immediate, viral suppression is further down the causal pathway, and improvements in vertical transmission are even further downstream; in other words, we may need more than one year of observation after implementation of MM to realize and measure the full impact of MM on maternal *and* infant outcomes.

Notably, while there were clear trends in the aggregate data, there was considerable variability in outcomes between health facilities and districts. Some of this might be attributable to relatively small numbers at some sites where outliers skew the data. Alternatively, some of this variability could be due to heterogeneity in how MM services were delivered across sites. Indeed, other studies also support MM as an effective strategy for promoting optimal PMTCT outcomes, but the extent to which MM impact maternal retention in care, viral suppression, HEI uptake of diagnostic testing, and vertical transmission has varied between diverse SSA contexts and depends on the content and implementation of MM strategies.[10-15] In the Mother-Infant Visit Adherence and Treatment Engagement (MOTIVATE) cluster-randomized trial in Kenya, there was a non-significant trend toward MM having a positive impact on retention of PLWH in the intention-to-treat analysis, while in the per-protocol analysis there were significantly increased odds of 12-month retention when PLWH received at least 80% of the MM intervention, suggesting MM services are most impactful when implemented with high-fidelity (*unpublished data; manuscript under review*). MOTIVATE data also show that depression, stigma, and intimate partner violence further modulate PMTCT outcomes within the context of MM strategies, indicating a need to develop tailored MM strategies that can respond to the specific needs of HIV-affected mother-infant dyads.[16] While protocols for training and supervision of MM was consistent across sites included in this evaluation, MM at each site were unique individuals, as were the mother-infant dyads they served, and we were unable to adjust for individual-level characteristics or fidelity to MM protocols. Ideally, we would have accounted for the extent to which MM supportive and tracing visits were performed, as well as the content and intensity of the support provided. Implementation research is needed to understand and address the complex needs of HIV-affected mother-infant dyads, the type of MM interactions than can best serve those needs, and organizational factors that will allow for high-fidelity implementation of MM strategies.

In summary, MM are HIV-affected peer advocates embedded within PMTCT programs, and they provide personal and practical support to HIV-affected mother-infant dyads, with the potential to positively influence optimal PMTCT outcomes. In this evaluation, we found that implementation of a MM program was associated with improved retention in PMTCT services and higher viral suppression rates among PLWH. While there was ongoing but diminishing improvement in DNA PCR positivity rates among HEI following MM implementation, this might be explained by having reached a plateau or increased uptake of HIV testing among high-risk HEI who were previously not getting tested. While it is difficult to infer causality from this interrupted time series study design, and there could have been concurrent but unmeasured program improvements confounding these results, our findings indicate significant improvements in PMTCT outcomes associated with the implementation of MM services. Therefore, we recommend maintaining and strengthening MM services in this context, while concurrently attempting to measure exposures/mediators and outcomes that were beyond the scope and resources of this evaluation. Future expansion or adaptation of the MM strategy should be guided by further implementation research, which is needed to understand and realize the full potential of MM and other strategies for optimizing PMTCT outcomes.

Dissemination plan

This concept was developed in collaboration with the Ministry of Health (MOH), and this evaluation was a collaborative partnership between the MOH, the CDC, the provincial health directorate (DPS-Zambézia), and VUMC/FGH investigators. VUMC/FGH, who has led the analysis for this evaluation, will share English and Portuguese versions of the recently completed final results, including lessons learned and potential future directions, with provincial- and national-level MOH authorities. For the purposes of wider dissemination an abstract was accepted for presentation as an e-poster to the International AIDS Society conference in July 2021. A manuscript will also be developed for peer-reviewed publication in a high-impact public health journal.

Appendices

Appendix 1: Evaluation Settings

Mentor Mother (MM) program implementation in relation to district/health facility and time.

District Health Facility	**Implementation period for MM *program***	**Number of MM per health facility**	**Implementation period for MM *supervisor*** (number of MM supervisors per health facility)
Alto Molòcué			
CS B. Gruveta [b]	Dec 2017 – Feb 2018	4	N/A
CS Caiaia	Dec 2017 – Feb 2018	2	N/A
CS Chapala	Dec 2017 – Feb 2018	4	N/A
CS Cololo	Dec 2017 – Feb 2018	1	N/A
CS Ecole	Dec 2017 – Feb 2018	1	N/A

CS Malua	Dec 2017 – Feb 2018	2	N/A
CS Moiua	Dec 2017 – Feb 2018	2	N/A
CS Mutala	Dec 2017 – Feb 2018	3	N/A
CS Nacuacua	Dec 2017 – Feb 2018	2	N/A
CS Nauela	Dec 2017 – Feb 2018	4	N/A
CS Nimala	Dec 2017 – Feb 2018	2	N/A
CS Nivava	Dec 2017 – Feb 2018	2	N/A
CS Novanana	Dec 2017 – Feb 2018	2	N/A
HR Alto Molòcué	Nov 2017 – Jan 2018	29	Nov 2018 – Jan 2019 (1)
Gilé			
CS Alto Ligonha	Nov 2017 – Jan 2018	3	N/A
CS Intxotxa [a]	Mar – May 2018	2	N/A
CS Kayane	Nov 2017 – Jan 2018	6	N/A
CS Mamala	Nov 2017 – Jan 2018	5	N/A
CS Moneia	Nov 2017 – Jan 2018	6	N/A
CS Muiane	Nov 2017 – Jan 2018	8	N/A
CS Namuaca	Nov 2017 – Jan 2018	2	N/A
CS Pury	Nov 2017 – Jan 2018	3	N/A
CS Uape	Nov 2017 – Jan 2018	3	N/A
HD Gilé	Dec 2017 – Feb 2018	13	N/A
Ile			
CS Curruane [a]	Dec 2017 – Feb 2018	1	N/A
CS Ile	Dec 2017 – Feb 2018	15	Nov 2018 – Jan 2019 (1)
CS Massira [a]	Dec 2017 – Feb 2018	1	N/A
CS Mucuaba [a]	Dec 2017 – Feb 2018	3	N/A
CS Mugulama	Dec 2017 – Feb 2018	8	N/A
CS Mulequela	Dec 2017 – Feb 2018	4	N/A
CS Namanda [a]	Dec 2017 – Feb 2018	6	N/A
CS Niboia	Dec 2017 – Feb 2018	2	N/A
CS Phalane [a]	Dec 2017 – Feb 2018	2	N/A
CS Socone	Dec 2017 – Feb 2018	3	N/A
CS Ualasse [a]	Dec 2017 – Feb 2018	1	N/A
Inhassunge			
CS Bingagira	Dec 2017 – Feb 2018	7	N/A
CS Cherimane	Dec 2017 – Feb 2018	6	N/A
CS Gonhane	Dec 2017 – Feb 2018	11	N/A
CS Ilova	Dec 2017 – Feb 2018	3	N/A
CS Inhassunge	Dec 2017 – Feb 2018	16	Nov 2018 – Jan 2019 (1)
CS Olinda	Dec 2017 – Feb 2018	3	N/A
CS Palane-Mucula	Dec 2017 – Feb 2018	9	N/A
Maganja da Costa			
CS Alto Mutola	Aug – Oct 2017	6	N/A
CS Cabuir	Aug – Oct 2017	6	N/A
CS Cariua	Aug – Oct 2017	4	N/A
CS Mabala	Aug – Oct 2017	8	N/A
CS Maganja da Costa	Aug – Oct 2017	36	Nov 2018 – Jan 2019 (2)
CS Mapira	Aug – Oct 2017	2	N/A
CS Moneia [a]	Aug – Oct 2017	3	N/A
CS Muzo	Aug – Oct 2017	2	N/A
CS Nante	Aug – Oct 2017	12	N/A
Mocubela			
CS Gurai	Aug – Oct 2017	8	N/A
CS Ilha Idugo [a]	Sep – Nov 2018	6	N/A
CS Maneia	Aug – Oct 2017	4	N/A
CS Mocubela	Aug – Oct 2017	11	N/A
CS Naico	Aug – Oct 2017	8	N/A
CS Tapata	Aug – Oct 2017	17	Nov 2018 – Jan 2019 (1)
Mulevala			
CS Chiraco	Feb – Apr 2018	4	N/A
CS Jajo [a]	Feb – Apr 2018	3	N/A
CS Marropino [a]	Apr – Jun 2018	2	N/A
CS Morrua [a]	Apr – Jun 2018	1	N/A
CS Mulevala	Feb – Apr 2018	5	N/A
CS Tebo [a]	Apr – Jun 2018	3	N/A
Namacurra			
CS Furquia	Oct – Dec 2017	19	N/A

CS Macuse	Oct – Dec 2017	13	Nov 2018 – Jan 2019 (1)
CS Malei	Jan – Mar 2018	7	N/A
CS Mbaua	Oct – Dec 2017	13	N/A
CS Mixixine	Oct – Dec 2017	14	N/A
CS Muceliua	Oct – Dec 2017	7	N/A
CS Muebele	Oct – Dec 2017	12	N/A
CS Mugubia	Oct – Dec 2017	5	N/A
CS Mutange [a]	Feb – Apr 2018	3	N/A
CS Namacurra	Oct – Dec 2017	24	Nov 2018 – Jan 2019 (2)
Pebane			
CS 7 Abril	Aug – Oct 2017	14	Nov 2018 – Jan 2019 (1)
CS Alto Maganha	Aug – Oct 2017	8	N/A
CS Impaca	Aug – Oct 2017	4	N/A
CS Magiga	Aug – Oct 2017	13	N/A
CS Malema	Aug – Oct 2017	5	N/A
CS Mihecue	Aug – Oct 2017	2	N/A
CS Mulela	Aug – Oct 2017	3	N/A
CS Muligode	Aug – Oct 2017	4	N/A
CS Naburi	Aug – Oct 2017	7	N/A
CS Pebane	Aug – Oct 2017	16	Nov 2018 – Jan 2019 (1)
CS Pele-Pele	Aug – Oct 2017	6	N/A
CS Tomea	Aug – Oct 2017	2	N/A

** This table does not include districts/health facilities that: did not support maternal-child health services, those previously or currently supported by the "Mothers 2 Mothers" (M2M), those who implemented MM services after December 2018, or those in Quelimane District (see exclusion criteria).*

[a] Fourteen health facilities were excluded due to systematic missingness when analyzing outcomes from DHIS (i.e., all outcomes except for maternal retention and viral suppression).

[b] One additional health facility was excluded due to systematic missingness when analyzing the outcome of institutional delivery.

Appendix 2: Other Supporting Materials

Approved evaluation SOW/protocol

This secondary data analysis is covered under the "blanket" program evaluation protocol "*Quality Improvement for HIV Care and Treatment in Zambézia province of the Republic of Mozambique under the President´s Emergency Plan for AIDS Relief (PEPFAR)*", which has approvals from Mozambique ethics committee, CIBS-Z, and the VUMC IRB. The concept note describing this evaluation was reviewed and approved by CDC-Mozambique ADS. The approved blanket protocol and concept note for this specific evaluation are submitted electronically along with this final report for reference.

Data collection instruments/tools

Not applicable.

Informed consent

There was no consent form necessary for use of data for this evaluation, as only routinely collected, de-identified, programmatic data were included in the analysis for this evaluation.

Waiver of consent did not adversely affect the rights nor welfare of the patients whose data were included in the evaluation.

Biosketches

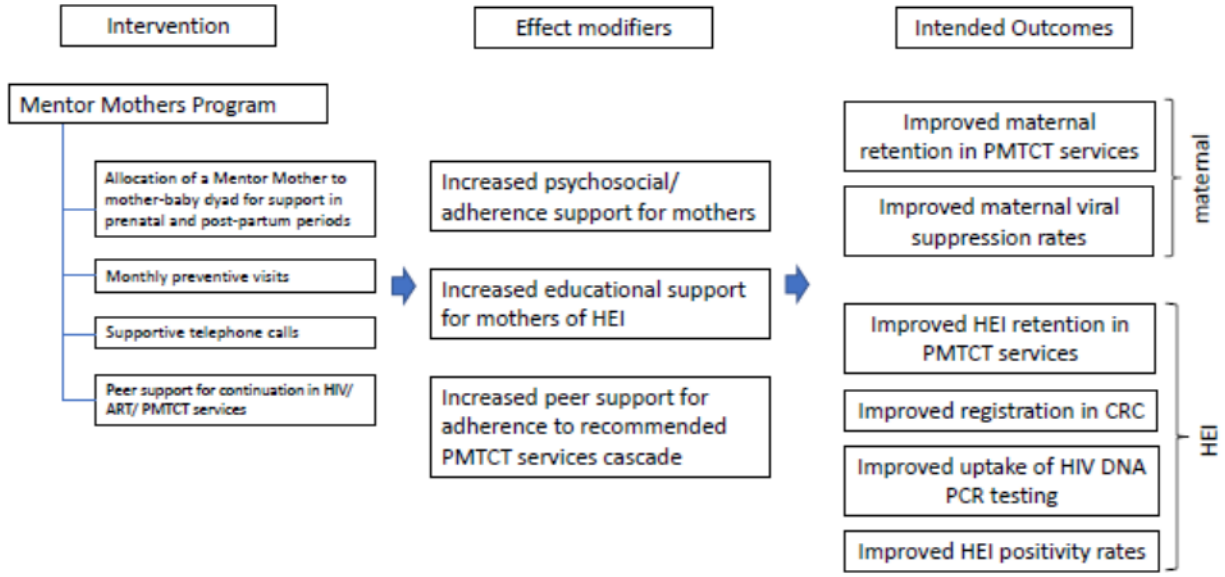
Provided for first (James Carlucci) and senior (C. William Wester) co-authors of this evaluation. These are submitted electronically along with this final report for reference.*Conflict of interest statement*

The collaborators in this evaluation have no conflicts of interest to declare.

Evaluation costs

Evaluation costs were limited to the personnel time required for extraction and analysis of routine secondary data, results review and discussion, and report preparation (anticipated expenditures equal to <1% of the total Avante Zambézia budget).

Results or Logical Framework



Logic framework for intended pathway for improved maternal and HEI PMTCT outcomes.

References

1. Instituto Nacional de Saúde, Instituto Nacional de Estatística, ICF Internacional. Inquérito de Indicadores de Imunização, Malária e HIV/SIDA em Moçambique

(IMASIDA) 2015: Relatório de Indicadores Básicos de HIV. *Maputo, Moçambique.* March 2017.
2. República de Moçambique Conselho Nacional de Combate ao SIDA. Resposta Global à SIDA Relatório do Progresso, 2016. *Maputo, Moçambique.* April 2016.
3. República de Moçambique Ministério da Saúde Serviço Nacional de Saúde. Relatório Anual 2018: Relatório Anual das Actividades Relacionadas ao HIV/SIDA. *Maputo, Moçambique.* March 2019.
4. The R Project for Statistical Computing. www.r-project.org. Accessed.
5. Schmitz K, Basera TJ, Egbujie B, et al. Impact of lay health worker programmes on the health outcomes of mother-child pairs of HIV exposed children in Africa: A scoping review. *PloS one.* 2019;14(1):e0211439.
6. Joint United Nations Programme on HIV/AIDS (UNAIDS). 90-90-90 - An ambitious treatment target to help end the AIDS epidemic. http://www.unaids.org/en/resources/documents/2017/90-90-90. Published 2017. Accessed 21 Feb 2019.
7. Joint United Nations Programme on HIV/AIDS (UNAIDS). UNAIDS Data 2020. https://www.unaids.org/sites/default/files/media_asset/2020_aids-data-book_en.pdf. Published 2020. Accessed 6 March 2021.
8. Abuogi LL, Humphrey JM, Mpody C, et al. Achieving UNAIDS 90-90-90 targets for pregnant and postpartum women in sub-Saharan Africa: progress, gaps and research needs. *J Virus Erad.* 2018;4(Suppl 2):33-39.
9. Wanga I, Helova A, Abuogi LL, et al. Acceptability of community-based mentor mothers to support HIV-positive pregnant women on antiretroviral treatment in western Kenya: a qualitative study. *BMC Pregnancy Childbirth.* 2019;19(1):288.
10. Sam-Agudu NA, Ramadhani HO, Isah C, et al. The Impact of Structured Mentor Mother Programs on 6-Month Postpartum Retention and Viral Suppression among HIV-Positive Women in Rural Nigeria: A Prospective Paired Cohort Study. *J Acquir Immune Defic Syndr.* 2017;75 Suppl 2:S173-S181.
11. Fayorsey RN, Wang C, Chege D, et al. Effectiveness of a Lay Counselor-Led Combination Intervention for Retention of Mothers and Infants in HIV Care: A Randomized Trial in Kenya. *J Acquir Immune Defic Syndr.* 2019;80(1):56-63.
12. Phiri S, Tweya H, van Lettow M, et al. Impact of Facility- and Community-Based Peer Support Models on Maternal Uptake and Retention in Malawi's Option B+ HIV Prevention of Mother-to-Child Transmission Program: A 3-Arm Cluster Randomized Controlled Trial (PURE Malawi). *J Acquir Immune Defic Syndr.* 2017;75 Suppl 2:S140-S148.
13. Sam-Agudu NA, Ramadhani HO, Isah C, et al. The Impact of Structured Mentor Mother Programs on Presentation for Early Infant Diagnosis Testing in Rural North-Central Nigeria: A Prospective Paired Cohort Study. *J Acquir Immune Defic Syndr.* 2017;75 Suppl 2:S182-S189.

14. Onono M, Odwar T, Wahome S, et al. Behavioral Interventions can Mitigate Adverse Pregnancy Outcomes Among Women Conceiving on ART and Those Initiated on ART During Pregnancy: Findings From the MOTIVATE Trial in Southwestern Kenya. *J Acquir Immune Defic Syndr.* 2021;86(1):46-55.
15. Cataldo F, Sam-Agudu NA, Phiri S, Shumba B, Cornelius LJ, Foster G. The Roles of Expert Mothers Engaged in Prevention of Mother-to-Child Transmission (PMTCT) Programs: A Commentary on the INSPIRE Studies in Malawi, Nigeria, and Zimbabwe. *J Acquir Immune Defic Syndr.* 2017;75 Suppl 2:S224-S232.
16. Onono M, Odwar T, Abuogi L, et al. Effects of Depression, Stigma and Intimate Partner Violence on Postpartum Women's Adherence and Engagement in HIV Care in Kenya. *AIDS Behav.* 2020;24(6):1807-1815.