PMTCT cascade and linkage to ART among HIV-exposed infants (HEI) in the Namacurra Sede - Zambézia Province, Mozambique

Final Report

Date of revised final report: June 2022

Date of release of report: January 2022

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**at the time of program evaluation implementation*

This evaluation and the report of its findings was supported by the Cooperative Agreement Number, U2GGH001943, funded by the Centers for Disease Control and Prevention (CDC). Its contents are solely the responsibility of the authors and do not necessarily represent the official views of the CDC or the Department of Health and Human Services.

Contents

List of Acronyms/Abbreviations

ADS	Associate Director for Science
AIDS	Acquired Immunodeficiency Syndrome
ANC	Antenatal Care
ART	(combination) Antiretroviral Therapy
ARV	Antiretroviral (medications)
CCR	Child-at-Risk Clinic
CDC	Centers for Disease Control and Prevention
CIBS-Z	*Comité Institucional de Bioética para Saúde – Zambézia* (Institutional Research Ethics Committee for Health of Zambézia, in English)
CTZ	Cotrimoxazole
DBS	Dried blood spot
DPS-Z	Provincial Health Directorate of Zambézia
EID	Early infant diagnosis
EPTS	Electronic Patient Tracking System
FGH	Friends in Global Health
F/U	Follow-up
HEI	HIV-exposed infants
HF	Health facility
HIS	Health Information Systems
HIV	Human Immunodeficiency Virus
IQR	Interquartile range
IRB	Institutional Review Board
LTFU	Lost to follow-up
M&E	Monitoring and Evaluation
MCH	Maternal and Child Health
MOH	Mozambican Ministry of Health
NGO	Non-Governmental Organization
NID	Patient Care Identification Number
PCR	Polymerase chain reaction
PEPFAR	President's Emergency Plan for AIDS Relief
PLW	Pregnant and lactating women
PMTCT	Prevention of mother-to-child transmission
PW	Pregnant women
SOW	Scope of work
SSA	Sub-Saharan Africa
STI	Sexually transmitted infections
TB	Tuberculosis
UNAIDS	Joint United Nations Programme on HIV/AIDS
VL	Viral load
VT	Vertical transmission
VUMC	Vanderbilt University Medical Center
WHO	World Health Organization

Executive summary

Introduction

Prevention of mother-to-child transmission (PMTCT) services are an essential component of the global effort to decrease the incidence of new human immunodeficiency virus (HIV) infections and to ensure an HIV- and Acquired Immunodeficiency Syndrome (AIDS)-free generation. Successful implementation and navigation of the PMTCT cascade is especially important in Mozambique, with an estimated HIV prevalence of 11.5% among adults 15 to 49 years of age (UNAIDS 2020) and a vertical (mother-to-child) transmission rate at 18 months of 8.5% among all HIV-exposed infants (HEI) with definitive HIV test results (MOH 2020). Per Mozambique Ministry of Health (MOH) national guidelines, all HEI should be retained in the Child-at-Risk (CCR) Services (including early infant diagnosis [EID]) until at least 18 months of age and/or until final definitive HIV status is identified. These and other services within the PMTCT cascade are available free of charge to patients at public health facilities run by the MOH-led health system, which at the level of Zambézia province is directed by the Provincial Health Directorate of Zambézia (DPS-Z). In an effort to assess PMTCT programmatic outcomes, technical and evaluation team members from Friends in Global Health (FGH), a subsidiary of Vanderbilt University Medical Center (VUMC), in collaboration with the DPS-Z, designed a secondary data analysis to evaluate key components along the PMTCT cascade. The main objective of this evaluation is to evaluate pediatric outcomes, namely uptake of CCR services, uptake of EID HIV testing, and HIV positivity rates, among HEI at a district capital health facility in Zambézia province, Mozambique. We will also attempt to identify factors that influence retention in this cascade of PMTCT services.

Methods

We conducted an internal outcomes evaluation by which a descriptive, retrospective analysis was performed on programmatic data of all pregnant women enrolled in PMTCT services and pediatric outcomes of HIV-exposed infants at the Namacurra Sede health facility, in Zambézia province, Mozambique from October 2016 to October 2018.

Limitations

We acknowledge several limitations identified in this evaluation, including small sample size; inclusion of only one health facility (i.e., not representative); sub-optimal recording along the PMTCT cascade; difficulty linking mother/infant records (which precluded completion of one evaluation objective); and some data incompleteness.

Results

A total of 5,036 pregnant women were included (median age 24; IQR: 21-25); 982 pregnant women registered in HIV services (median age 22; IQR: 19-27) and 815 HEI (423 [52%] female, mean age at enrollment 3 months [standard deviation (sd) 6]). The proportion of women attending their first antenatal care (ANC) visit with a known HIV status was 7%. Among pregnant women who had an HIV test at their first ANC visit, 8% (newly) tested HIV-positive. Thus, among all pregnant women attending their first ANC visit, the HIV prevalence

was 14%. The estimated HIV incidence rate during pregnancy was calculated to be 1% (4 out of 472 pregnant women testing HIV-positive among those retested in ANC).

Uptake to HIV testing among infants registered within the Child-at-risk clinic was 81%; however, availability of HIV test results was only 76%, and when broken down; 50% for DNA PCR HIV testing and 40% for rapid HIV antibody testing. Turn-around-time for DNA PCR test results had a median of 61 days (IQR: 31-83), with 17% of results being available within 30 days, and 49% of DNA PCR results being available within the first 2 months. DNA PCR positivity rates among infants tested between 0-2 months of age was 15%, and it was 8% among those tested between 0-18 months of age.

Conclusions

Despite a non-complete dataset, this pilot project in Namacurra using an electronic database for Mother and Child Health/PMTCT data showed a positivity rate among those receiving HIV testing at first ANC visit of 8%, and an estimated HIV incidence rate of 1% among women presenting for antenatal care and undergoing repeat HIV testing.

Early infant diagnosis (EID) uptake was also not satisfactory, with an overall DNA PCR positivity of 8%, which was even higher among HEI undergoing testing in the immediate post-partum period, namely, 15% among HEI infants tested between 0-2 months of age. Prolonged DNA PCR result turn-around times place HEI at even higher risk for interruptions in care and attrition, to which these HEIs are particularly vulnerable in the immediate post-partum window. Point-of-care (POC) EID devices, introduced after the evaluation was completed, which allow for same day results, should have a significant impact on HIV testing rates thus reducing missed opportunities and reducing HIV-associated morbidity and mortality.

Tracking of mother-infant dyads through, for example, electronic patient tracking systems, might be a viable means of monitoring each step within the PMTCT cascade, beginning with the first ANC visit right up through HEI reaching 18 months of age.

Project Background

Prevention of mother-to-child transmission (PMTCT) services are an essential component of the global effort to decrease the incidence of new human immunodeficiency virus (HIV) infections and to ensure an HIV- and Acquired Immunodeficiency Syndrome (AIDS)- free generation.

The World Health Organization (WHO) promotes a comprehensive approach to PMTCT programs which includes (1):

- preventing new HIV infections among women of childbearing age,
- preventing unintended pregnancies among women living with HIV,
- preventing HIV transmission from a woman living with HIV to her baby,
- providing appropriate treatment, care and support to mothers living with HIV and their children and families.

The cascade of PMTCT services includes lifelong combination antiretroviral therapy (ART) for HIV-positive pregnant and lactating women (PLW), the provision of prophylactic antiretroviral (ARV) medications for HIV-exposed infants (HEI) (i.e., those born to HIV-positive pregnant women [PW]), and serial HIV testing to ensure early infant diagnosis (EID) and the timely initiation of ART among infants who become HIV-positive. The cascade components of EID, pediatric HIV services uptake, and timely ART initiation are each critical for minimizing HIV-associated morbidity and mortality and for achieving optimal health outcomes for HIV-positive infants. Per Mozambique Ministry of Health (MOH) national guidelines, all HEI should be retained in EID services until at least 18 months of age, when HIV infection can be definitively excluded via antibody (ELISA-based) testing, or until final diagnosis before the age of 18 months (negative HIV test two months after weaning/cessation of breastfeeding).

Successful implementation and navigation of the PMTCT 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 incident pediatric HIV infections. Mozambique is a SSA country with an estimated HIV prevalence of 11.5% among adults 15 to 49 years of age (2) and a vertical (mother-to-child) transmission rate at 18 months of 8.5% among all HIV-exposed infants with definitive HIV test results (3). Zambézia Province is a region of Mozambique that has a population of 5.4 million people, is mostly rural, and has been relatively underserved and disproportionately impacted by HIV compared to other provinces within the country.

Friends in Global Health (FGH) is a non-governmental organization (NGO) affiliated with 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), FGH/VUMC supports HIV services, including PMTCT and EID services, at 144 health facilities (HF) of the government-run health system in Zambézia Province. Namacurra Sede is one FGH/VUMC supported HF where individual-level routine Maternal

and Child Health (MCH), PMTCT, EID, and ART linkage data have been electronically captured and databased within the OpenMRS electronic patient tracking system (EPTS).

With this report, we describe the results of a programmatic evaluation of PMTCT services and pediatric outcomes of infants born to HIV-positive PW in Zambézia province, Mozambique from October 2016 to October 2018, as well as possible factors that influence maternal and infant retention in this cascade of PMTCT services.

We plan to share our findings on the following two topics with the Provincial Health Directorate of Zambézia (DPS-Z) and the MOH:

- Uptake and implementation of PMTCT services within Antenatal Care (ANC) and Child-at-Risk Clinic (CCR) sectors;
- Factors that may influence uptake of and/or retention to PMTCT services.

Costs related to the implementation of this evaluation include time spent by evaluation staff to manually collect data in the Namacurra Sede HF, extract data from the electronic patient medical record database, analyze data, and report on the findings.

Purpose and questions

Overall objective

The main goal of this evaluation was to evaluate outcomes among HIV-exposed infants at the Namacurra Sede HF in Zambézia province, Mozambique. We also attempted to identify factors that influence retention in this cascade of services.

General objectives

- Describe HIV prevalence and incidence during pregnancy among women attending ANC;
- Describe the PMTCT cascade for HEI until definite HIV status (i.e., access and retention to HIV prevention care and HIV testing for HEI).

Specific objectives:

1. Calculate HIV positivity rate of women arriving at first ANC (known HIV-positive, first HIV test, not tested for HIV);
2. Calculate HIV incidence among women attending ANC at Namacurra Sede (retesting of HIV among previously HIV-negative);
3. Estimate uptake of HEI to CCR services among women who attended ANC services;

4. Estimate uptake to HIV testing/re-testing among infants at several time points (<2 months of age, <9 months of age, and ever);
5. Estimate turn-around time for EID HIV test results (time from testing to results being available in the clinical file);
6. Calculate proportion of infants receiving HIV test result within 30 days of testing;
7. Estimate infant retention to CCR services, defined as attending 80% of the follow-up (F/U) visits (i.e., missing four or fewer visits) (retention at 6-, 12-, and 18-months);
8. Calculate the HIV positivity rate among HEI (at 2 months, 9 months, and 18 months of age);
9. Compare pediatric outcomes (uptake of EID HIV, uptake of CCR services, HIV positivity rate) among infants born to women diagnosed during ANC versus women diagnosed before current pregnancy (i.e., prior to current entry into ANC services);
10. Evaluate factors (maternal and infant) associated with HEI uptake of and retention in CCR;
11. Explore factors (maternal and infant) associated with uptake of and retention in ART services among mothers and infants diagnosed with HIV during the PMTCT cascade.

Evaluation Outcomes

Key milestones within the PMTCT cascade to be assessed within this evaluation were:

1. Maternal enrollment in ANC;
2. HIV positivity among PW attending ANC;
3. HIV incidence measured through re-testing during pregnancy;
4. Enrollment at CCR;
5. Infant HIV diagnosis:
    - Infant HIV DNA polymerase chain reaction (PCR) by 2 months of age,
    - Infant HIV DNA PCR by 9 months of age,
    - Receipt of HIV DNA PCR results,
    - Receipt of HIV DNA PCR results within 30 days of testing,
    - Turn-around time for HIV DNA PCR results,
    - HIV DNA PCR positivity rate (proxy for vertical transmission [VT] rate among those engaged in care);
6. HEI retention in care within CCR at 6-, 12- and 18-months;
7. Final definitive determination of HIV status (see *Definitions*, below);
8. Vital status at 18 months of age for all HEI (alive, died, lost to follow-up [LTFU], transferred care, etc.);
9. Linkage to ART for the subset of infants who are identified as HIV-positive:
    - Uptake of ART services,

- Uptake of ART services within the 30 days of testing;
- Retention in ART services at 1-, 3-, 6-, and 12-months.

Evaluation Design/ Methods/ Limitations

Evaluation type

We conducted an internal outcomes evaluation, in which programmatic data were analyzed to evaluate the outcomes of interest.

Evaluation design

A retrospective cohort study was performed. We conducted a secondary data analysis on aggregated individual- and HF-level data routinely collected by district and provincial teams for programmatic monitoring and reporting purposes.

Sampling strategy

We have included all routine data available in the EPTS databases of OpenMRS and OpenMRS MCH-PMTCT/EID, as well as the PMTCT register books, and EID database/logbook.

The Namacurra Sede HF was selected for inclusion in this evaluation as (at the time of the evaluation) this was one of the few sites utilizing an OpenMRS MCH/PMTCT database. Collaborators from technical teams indicated a greater likelihood for data availability and higher data quality supported by this novel EPTS.

Methods

We included data from women attending ANC services and all HEI born to HIV-positive women attending CCR services at the Namacurra Sede HF from the start of the use of OpenMRS MCH, from October 2016 to October 2018.

- ***Inclusion criteria***: All women attending ANC services and all HEI attending CCR services at Namacurra Sede HF from October 2016 to October 2018.
- ***Exclusion criteria***: no specific exclusion criteria.

We explored infant and maternal clinical and sociodemographic factors that might influence retention, attrition, and defaulter status. We also intended to identify factors associated with initiating ART among the subset of infants that have confirmed HIV infection.

Indicators and Data Sources used:

See **Appendix 1** for a complete list of indicators of interest and data sources.

To address the intended objectives, data requirements included data extraction and/or manual collection of routinely collected programmatic data from primary sources:

- CCR logbook (Official MOH form *MOD-SIS-B07*) (electronic extraction)
- ANC register book (Official MOH from *MOD-SIS-B01*) (electronic extraction)
- Clinical files in OpenMRS (*HIV care and treatment*) (electronic extraction)
- EID database/logbook (for PCR and HIV data) (manual collection)

Definitions used:

- ***Infant outcome at 18 months***:
    - Definitive determination of negative HIV status; either a negative HIV antibody test after 18 months of age or any negative HIV test (HIV DNA PCR or HIV antibody test) 2 months after weaning (i.e., cessation of breastfeeding);
    - HIV infection; either positive HIV antibody testing after 18 months of age or positive HIV DNA PCR testing at any age (all positive tests should be confirmed with a second DNA PCR test);
    - LTFU, did not receive a definitive HIV diagnosis (HIV-positive or HIV-negative), and not in care at 18 months;
    - Transfer to another clinic (*note*: transfers will not be considered LTFU);
    - Death.
- ***Retention in CCR services***: will be defined as remaining in care for 80% of the follow-up visits at CCR (i.e., missing only four or less visits) until a definitive HIV-diagnosis (HIV-negative or HIV-positive) has been made or the HEI have completed 18 months of follow-up (whichever comes first), or until documented transfer to another clinic. We will also consider retention in CCR services at 3-, 6-, 12-, and 18-months' time points.
- ***Retention to HIV services***: will be defined as remaining in ART services at 1 month, 3 months, 6 months, and 12 months.
- ***HIV incidence***: to calculate the HIV incidence (proportion) among PW attending ANC, the cohort for this indicator should be PW who met the following criteria:
    - Having an HIV test result at first ANC visit that is *negative*;
    - Having at least one definitive result (either *negative* or *positive*) from a follow-up HIV test (i.e., re-test) at a subsequent ANC visit (same pregnancy).

Evaluation Period

The evaluation covered a period of 24 months: from October 2016 to October 2018. Data collection took place in the same period, and these collected data were aggregated and included in this analysis.

Analysis plan

Descriptive analyses were done to describe each step of the PMTCT cascade, from ANC services to final HIV diagnosis of the infant. Results from descriptive analysis were presented in frequency tables.

For HEI registered in CCR, multivariable logistic regression was used to identify factors associated with access to and retention in CCR services. For the subset of HEI identified as HIV-positive, a multivariable logistic regression was run to identify factors associated with access and retention in ART services. For both multivariable models, covariates/predictors were selected based on *a priori* hypotheses and included infant and maternal clinical and sociodemographic factors (e.g., maternal age, education, marital status, occupation, HIV test results at first ANC, etc., infants age and gender.)

All statistical analyses were performed using R version 3.6.3 (4).

Limitations of design

There were several limitations within the realization of this evaluation. The sample size is relatively small, as the cohort of HEI to be included in analysis was limited to the total number of HIV-positive PW (previously known HIV-positive and those tested positive during an ANC visit), such that it was possible to fully track service uptake and retention among the mother/baby dyads along the entire PMTCT cascade. This assessment was carried out in only one HF in the Namacurra Sede location as this was the only supported health facility (at the time of the evaluation) that was piloting the use of OpenMRS-MCH database for MCH electronic data collection. As such, we acknowledge that the results are not necessarily representative or generalizable for the rest of the province, nor for the country.

Care along the PMTCT cascade was not always consistently tracked/recorded for the HIV-positive mothers nor HEI, and there was difficulty in linking patient records for each dyad.

Related to this limited data availability and data linkage challenge, there were two objectives that we were unable to evaluate as intended: it was not possible to build the planned multivariable logistic regressions for Objective #10 (*evaluate maternal and infant factors associated with HEI update of and retention in CCR*) or #11 (*explore maternal and infant factors associated with uptake of and retention in ART services among mothers and infants diagnosed with HIV during the PMTCT cascade*). Interpretation of regression results for Objective 10 is limited by the considerable data missingness, and due to the very small number

of mother/infant dyads whose information could be linked, the analysis for Objective #11 was not performed as results could not have been meaningfully interpreted.

Deviations from Scope of Work (SOW)/protocol

There were no protocol deviations during the implementation of this assessment.

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. All data collected electronically were stored securely on password-protected databases at district- and provincial-level FGH offices. The performance of the program indicators was monitored by HF staff and technical support teams from FGH and DPS-Z. All subsequent indicators were collected and internally reported monthly by the Health Information Systems (HIS) team, following the regular reporting period for program data.

The programmatic data collected manually for use in these analyses were collected by personnel from the FGH Evaluations team, with support from the MCH and M&E teams. Upon receipt of the requested extracted/collected dataset for this evaluation, data were cleaned and reviewed to ensure they were consistent and appropriate with the evaluation inclusion criteria.

Stakeholder engagement

FGH technical teams have ongoing collaborations with key stakeholders working in the health facilities and communities in which we are supporting and engaged. The conceptual note and evaluation plan for this secondary data analysis evaluation were elaborated upon by VUMC/FGH technical and evaluation team members, with support and collaboration from provincial-level MOH authorities (specifically the Provincial MCH Focal Point from the DPS-Z) and approved by sponsoring institution CDC-Mozambique (specifically the Associate Director of Science [ADS]) prior to implementation.

Ethical considerations

The secondary data analysis is covered under the blanket 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)*." This data use and evaluation plan were approved by the VUMC Institutional Review Board (IRB) (#201887), the Institutional Research Ethics Committee for Health of Zambézia (*Comité Institucional de Bioética para Saúde – Zambézia*; CIBS-Z-20) 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 and aggregated data. The electronic databases outlined in the *Methods* section were stored on password protected and encrypted servers at FGH offices. De-identified data were extracted from these secure databases, as well as manually collected from patient registers and sector logbooks and securely stored on password-protected databases. They were sent via secure file transfer to relevant key FGH and VUMC personnel (i.e., the biostatistician) to conduct analyses as necessary.

Findings

1. Descriptive socio-demographics

A total of 5,036 pregnant women (arrived at a first ANC visit) were included in the evaluation (**Table 1**). Data for 982 women who were enrolled in ART services (**Table 2**) and data for 815 HIV-exposed infants born to HIV-positive mothers who were registered in the CCR (**Table 3**) were also included. Among those children registered at CCR, data were available for 56 HEI who were diagnosed as HIV-positive and enrolled in pediatric ART services.

Tables 1 through **3** below present the sociodemographic make-up of the women and infants (respectively) whose data were included in the analysis.

Table 1. Sociodemographic data of pregnant women arrived at first ANC visit (n=5,036).

Variable	Value	Pregnant Women	Valid	Missing
		N (%)	N (%)	N (%)
Age (years)	Median (IQR)	24 (21-25)	5036 (100)	0 (0)
Marital Status			475 (9.4)	4561 (90.6)
	Living with partner	383 (80.6)		
	Married	17 (3.6)		
	Single	65 (13.7)		
	Widowed	10 (2.1)		
Education			593 (11.8)	4443 (88.2)
	None	231 (39.0)		
	Primary school	216 (36.4)		
	Secondary school	137 (23.1)		
	Technical school	9 (1.5)		
Occupation			615 (12.2)	4421 (87.8)
	Domestic worker	413 (67.2)		
	Farmer	137 (22.3)		
	Student	52 (8.5)		
	Teacher	6 (1.0)		
	Other	7 (1.1)		
Gestational Age (weeks)	Median (IQR)	25 (22-28)	5036 (100)	0 (0)
HIV status at 1st ANC visit			4923 (97.8)	113 (2.2)

	Negative	14 (0.3)		
	Positive	323 (6.6)		
	Unknown	4586 (93.2)		
HIV test result at 1st ANC visit			4636 (92.1)	400 (7.9)
	Negative	4220 (91.0)		
	Positive	362 (7.8)		
	Indeterminate	11 (0.2)		
	Not done	43 (0.9)		
Male partner present at 1st ANC visit			3112 (61.8)	1924 (38.2)
	Yes	3103 (99.7)		
	No	9 (0.3)		
Partner HIV test result			2890 (57.4)	2146 (42.6)
	Negative	2801 (96.9)		
	Positive	50 (1.7)		
	Indeterminate	1 (0.0)		
	Not done	38 (1.3)		
Weight (kg)	Median (IQR)	52 (50-57)		
Results of syphilis test			4504 (89.4)	532 (10.6)
	Negative	3269 (72.6)		
	Positive	235 (5.2)		
	Not done	1000 (22.2)		
Cotrimoxazole prophylaxis			90 (1.8)	4946 (98.2)
	Starting regimen	70 (77.8)		
	Continuing regimen	20 (22.2)		

Table 2. Sociodemographic data of women enrolled in ART services (n=982).

Variable	Value	All Women	Valid	Missing
		N (%)	N (%)	N (%)
Age at ART enrollment (years)	Median (IQR)	22 (19-27)	869 (88.5)	113 (11.5)
Marital Status			649 (66.1)	333 (33.9)
	Living with partner	504 (77.7)		
	Married	45 (6.9)		
	Single	89 (13.7)		
	Widowed	11 (1.7)		
Education			788 (80.2)	194 (19.8)
	None	313 (39.7)		
	Primary school	280 (35.5)		
	Secondary school	186 (23.6)		
	Technical school	9 (1.1)		
Occupation			828 (84.3)	154 (15.7)
	Domestic worker	571 (69.0)		
	Farmer	169 (20.4)		
	Student	65 (7.8)		
	Teacher	10 (1.2)		
	Other	13 (1.6)		
HIV status of partner			16 (1.6)	966 (98.4)

	HIV-positive	14 (87.5)		
	No	2 (12.5)		
HIV service entry point			821 (83.6)	161 (16.4)
	PMTCT	698 (85.0)		
	Voluntary Counseling and Testing (VCT)	100 (12.2)		
	Child-at-Risk Clinic (CCR)	8 (1.0)		
	TB clinic (PNCT)	5 (0.6)		
	Other	10 (1.2)		

Table 3. Sociodemographic data of all HEI enrolled in CCR (n=815).

Variable	Value	All HEI	Valid	Missing
		N (%)	N (%)	N (%)
Sex			815 (100)	0 (0)
	Female	423 (51.9)		
	Male	392 (48.1)		
Age at enrollment in CCR (years)	Mean (standard deviation, sd)	0.3 (0.6)	814 (99.9)	1 (0.1%)
Cotrimoxazole prophylaxis			781 (95.8)	34 (4.2)
	Continuing regimen	125 (16.0)		
	Started up to 8 weeks of age	419 (53.6)		
	Started after 8 weeks of age	237 (30.3)		
Infant feeding type			805 (98.8)	10 (1.2)
	Breastfeeding exclusively	800 (99.4)		
	Mixed feeding	4 (0.5)		
	Formula feeding	1 (0.1)		

Data from 951 records were provided to link mothers on ART with their infants being registered in CCR and in ART (**Table 4**). The national identification number (NID) statuses for mother and infant are summarized in **Table 4**. By using the NID information included in these 951 records, 621 out of 982 (63.2%) women enrolled in ART services had ANC visit records, 193 out of 815 (23.7%) infants registered at CCR could be linked to their mother with ART services and ANC visits data, and only 8 out of 56 (14.3%) infants registered at pediatric HIV services could be linked to their mothers with ART services and ANC visits data. (See diagram of available mother and baby records and linkage in **Appendix 2**.)

Table 4. Maternal and infant data used for pair linkage using unique patient identifiers (NID) (n=951).

Variable	Valid	Missing
	N (%)	N (%)
Maternal ART NID	951 (100)	0 (0)
Infant CCR NID	525 (55.2)	426 (44.8)
Infant ART NID	34 (3.6)	917 (96.4)

2. *HIV positivity rate of women arriving at first ANC (Objective 1)*

Of the 5,036 PW for whom ANC data were available, 113 were missing data on HIV test result status as of their first ANC visit. The proportion of PW whose HIV status at first ANC was known HIV-positive is 6.6% (323 out of 4,923) excluding missing, or 6.4% (323 out of 5,036) including missing (**Table 5**).

Table 5. Proportion of PW who already knew HIV status at first ANC (n=5,036).

HIV status upon arrival at first ANC visit	Frequency (*n*)	Percentage (%) *(excluding missing)*	Percentage (%) *(including all PW)*
Known HIV-positive	323	6.6%	6.4%
Known HIV-negative	14	0.3%	0.3%
Unknown	4586	93.2%	91.0%
Missing information	113	-	2.2%

The 323 PW with known HIV-positive status at first ANC visit were not retested at their first visit, and as such were excluded in the following analysis. The proportion of PW who had an HIV test at first ANC visit is 99.1% (excluding missing status) or 97.5% (including missing status). Of those tested, 7.8% (362 out of 4636, excluding missing) or 7.7% (362 out of 4713, including missing) tested HIV-positive (**Table 6**).

Table 6. Test results at first ANC visit (n=4,713)[i].

Test results at first ANC visit	Frequency (*n*)	Percentage (%) *(excluding missing)*	Percentage (%) *(based on all PW)*
HIV-positive	362	7.8	7.7
HIV-negative	4220	91.0	89.5
HIV indeterminate	11	0.2	0.2
Test not done	43	0.9	0.9
Missing information	77	-	1.6

[i] 323 PW with known HIV-positive status were not tested at first ANC visit and were excluded in this analysis.

Overall, combining those with known HIV-positive status and those receiving a positive test result at the visit, a total of 685 (13.5%) women had a documented HIV-positive status at first ANC visit.

3. *HIV incidence among women attending ANC (Objective 2)*

Of those PW whose initial HIV test at their first ANC visit resulted either HIV-negative or indeterminate (4220 + 11 = 4231 in total), we calculated the proportions who had a follow-up HIV test (**Table 7**). A majority (3751 or 88.7%) did not have a re-test at any subsequent ANC visits, while 476 (11.3%) did a single re-test, and 4 PW (0.1%) did two re-tests.

Table 7. Frequency of re-testing during follow-up ANC visits (n=4,231).

Number of re-tests	Frequency (*n*)	Percentage (%)
0	3751	88.7
1	476	11.3
2	4	0.1

HIV incidence was determined among the 472 PW whose HIV test resulted negative at their first ANC visit, and also had a definitive HIV result from a re-test at a subsequent ANC visit (**Table 8**). HIV incidence among women attending ANC services was 0.8% (4 out of 472).

Table 8. HIV incidence among cohort of PW attending ANC (n=472).

Result of re-test	Frequency (*n*)	Percentage (%)
HIV-positive	4	0.8
HIV-negative	468	99.2
Total	472	100

4. *Uptake of HEI to CCR (Objective 3)*

In relation to the 695 PW either with known HIV-positive status or who tested HIV-positive at any ANC visit, there were only 358 HEI registered at CCR (whose data could be linked to these PW). Thus, registration of HEI in CCR was documented for 358 HEI out of 695 HIV-positive PW (51.5%).

5. *Uptake of HIV testing among infants at several time points (Objective 4)*

For these analyses, *all* HEI registered in CCR (815 children) were considered (with some necessary respective exclusions as noted below).

HIV test collections (for PCR testing only)

Considering results of PCR test collection to assess uptake of HIV testing, there were 8 children with a PCR collection date earlier than the child's documented birth date (possibly due to inaccurate record of either the testing or birth date) who were excluded in this specific analysis. The overall proportion of uptake to HIV testing was 80.7% (651/807 children registered at CCR with valid collection dates), with the largest percentage (37%) collected between the infant's first and second month after birth (**Table 9**).

Table 9. The proportion of uptake to HIV testing at various time points (per PCR test collection).

Time period 1st PCR collected*	**Frequency (*n, %*)**
[0m, 1m]	120 (14.9)
[1m, 2m]	297 (36.8)
[2m, 3m]	110 (13.6)
[3m, 6m]	89 (11.0)
[6m, 9m]	24 (3.0)
[9m, 12m]	4 (0.5)
> 12m	7 (0.9)
Never collected	156 (19.3)
Total	807 (100)

* For children with multiple PCR collections, only the first collection was used in this analysis for HIV test coverage.

HIV results available

When considering all available HIV test results (i.e., PCR and rapid test results) data to assess HIV testing uptake, there was one child whose data were excluded from this specific analysis due to inconsistent information on testing dates (e.g., had a test result date earlier than their recorded birth date). The overall proportion of infants receiving any HIV test results was 71.7% (584/814 children registered at CCR with valid test dates), with the largest percentage testing between 3- and 6-months of age (**Table 10**).

It is important to note that when comparing by patient identifier variable (*patient_id*) among PCR collection data and test results data, 168 out of the 651 children (see Table 9 above) who had a PCR sample collected did not have any test result, indicating that 29.9% (168/651) children had PCR sample collected but had no test results recorded.

Table 10. The proportion of HEI uptake to HIV testing at various time points (per PCR and rapid test results).

Time period 1st HIV test result*	Frequency (*n, %*)
[0m, 1m]	3 (0.4)
[1m, 2m]	31 (3.8)
[2m, 3m]	107 (13.1)
[3m, 6m]	211 (25.9)
[6m, 9m]	41 (5.0)
[9m, 12m]	87 (10.7)
> 12m	104 (12.8)
No Result Ever	230 (28.3)
Total	814 (100)

* For children with multiple test results, only one result (first result if more than one was available) was used in this analysis of uptake of HIV test.

Considering only PCR test results as a measure of HIV testing uptake, there was one child with a PCR test result dated earlier than the child's documented birth date who was excluded in this specific analysis. The overall proportion of uptake to HIV PCR test was 50.1% (408/814 children registered at CCR with valid test dates), with the vast majority testing before 6-months of age (**Table 11**).

Table 11. The proportion of uptake to HIV DNA PCR testing at various time points.

Time period PCR test result	Frequency (*n, %*)
[0m, 1m]	2 (0.3)
[1m, 2m]	30 (3.7)
[2m, 3m]	107 (13.1)
[3m, 6m]	210 (25.8)
[6m, 9m]	41 (5.0)
[9m, 12m]	12 (1.5)
> 12m	6 (0.7)
No PCR test done	406 (49.9)
Total	814 (100)

In considering only rapid test results as a measure of HIV testing uptake, there were 72 children who had a rapid test result obtained when they were less than 9 months of age. At the time of this evaluation, MOH guidance included use rapid tests only for HEI over 9 months of age; as such, the data from these 72 children were excluded from this specific analysis. Among those children at least 9 months of age, the overall proportion of uptake to HIV rapid test was 39.5% (322/815 children registered at CCR with valid test dates) (**Table 12**).

Table 12. The proportion of HEI uptake to HIV rapid test at various time points.

Time period rapid test result*	Frequency (*n, %*)
[9m, 12m]	175 (21.5)
> 12m	147 (18)
No rapid result ever	493 (60.5)
Total	815 (100)

* Only rapid test results from children 9 months of age and older were included, per the rationale of following MOH guidance (at the time of this evaluation) for recommended age ranges for administering rapid tests.

6. Estimated turn-around time for EID HIV test results (Objective 5)

By calculating the difference (in days) between DNA PCR result date and DNA PCR collection date for the same child, we estimated the turn-around time for getting HIV DNA PCR test results for 505 children whose DNA PCR collection date and result date were available. If a child had multiple PCR collection and/or result dates recorded, we assumed that the first DNA PCR result came from testing of the sample collected on the first DNA PCR collection date. Estimating the turn-around-time in this way resulted in a median of 61 days, IQR of 31 to 83 days, and a mean of 67 days (sd 52).

7. The proportion of infants receiving HIV test results within 30 days of testing (Objective 6)

The proportion of infants receiving HIV test result within the 30 days of HIV PCR specimen collection is 16.8% (64 out of 382), and 49.5% (189/382) within two months of testing (**Table 13**).

Table 13. Estimated turn-around time for EID HIV test results as categorical variable (n=382).

Turn-around time (months)	Frequency (*n, %*)
[0m, 1m)	64 (16.8)
[1m, 2m)	125 (32.7)
[2m, 3m)	114 (29.8)
[3m, 6m)	69 (18.1)
[6m, 9m)	4 (1.1)

[9m, 12m]	4 (1.1)
> 12m	2 (0.5)
Total	382 (100)

8. Retention to CCR services (Objective 7)

Defining retention in CCR services as attending at least 80% of scheduled follow-up visits (ratio = 0.8), the proportion of HEI retained in CCR was 58.3%, 45.2%, 16.0%, and 0.0% respectively for 3-months, 6-months, 12-months, and 18-months retention (**Table 14**).

Results were also calculated (**Table 14**) for alternate retention definition ratios of those who attended at least 90%, at least 70%, and at least 60% of follow-up CCR visits.

Table 14. HEI retention to CCR services (attending indicated proportion of visits).

Retention in Care	Status	Attending ≥90% of visits	Attending ≥80% of visits	Attending ≥70% of visits	Attending ≥60% of visits	Valid	Missing
		N (%)	N (%)	N (%)	N (%)	N (%)	N (%)
At 3 months						786 (96.4)	29 (3.6)
	Yes	458 (58.3)	**458 (58.3)**	458 (58.3)	661 (84.1)		
	No	328 (41.7)	**328 (41.7)**	328 (41.7)	125 (15.9)		
At 6 months						779 (95.6)	36 (4.4)
	Yes	201 (25.8)	**352 (45.2)**	352 (45.2)	473 (60.7)		
	No	578 (74.2)	**427 (54.8)**	427 (54.8)	306 (39.3)		
At 12 months						705 (86.5)	110 (13.5)
	Yes	60 (8.5)	**113 (16.0)**	162 (23.0)	229 (32.5)		
	No	645 (91.5)	**592 (84.0)**	543 (77.0)	476 (67.5)		
At 18 months						27 (3.3)	788 (96.7)
	Yes	0 (0)	**0 (0)**	1 (3.7)	4 (14.8)		
	No	27 (100.0)	**27 (100.0)**	26 (96.3)	23 (85.2)		

9. HIV positivity rate among HIV-exposed infants (Objective 8)

The positivity proportion was calculated using the available PCR and rapid test results for children in each age range (excluding any rapid test results obtained prior to a child being 9 months of age, per MOH recommendations for use of HIV rapid tests at the time of this evaluation). These calculations are shown in **Table 15**.

Overall, HIV positivity proportion among all 815 HEI was found to increase slightly with each wider age range, from 0.6% (5/815) among HEI 0-2 months of age to 5.3% (43/815) among HEI 0-18 months of age, with the largest single increase seen between 0-2 months of age (0.6%) to 0-6 months of age (2.9%) (**Table 15**).

HIV positivity rate within each age range was largest among HEI 0-2 months of age (5/34 = ~15%), and approximately 7% for each of the other age ranges assessed (0-6, 0-9, 0-12, and 0-18 months of age) (**Table 15**).

Table 15. HIV positivity proportion and rate among HEI at various time points.

HEI age range	HEI HIV test result	Frequency *N* (%)	Total %
0-2 months of age	Positive	5 (14.7)	0.6
N=34	Negative	29 (85.3)	3.6
	Indeterminate	0 (0)	0
0-6 months of age	Positive	24 (6.8)	2.9
N=352	Negative	328 (93.2)	40.2
	Indeterminate	0 (0)	0
0-9 months of age	Positive	29 (7.4)	3.6
N=393	Negative	364 (92.6)	44.7
	Indeterminate	0 (0)	0
0-12 months of age	Positive	33 (6.9)	4
N=480	Negative	441 (91.9)	54.1
	Indeterminate	6 (1.3)	0.7
0-18 months of age	Positive	43 (7.9)	5.3
N=542	Negative	493 (91)	60.5
	Indeterminate	6 (1.1)	0.7

10. Pediatric outcomes among mothers diagnosed during ANC vs. those diagnosed prior to current pregnancy (Objective 9)

Uptake CCR (by mothers' diagnosis as known vs. during ANC)

The proportion of uptake of HEI to CCR was 55.1% and 48.4%, respectively among mothers who entered ANC as known HIV-positive and those who tested HIV-positive within ANC (**Table 16**). There was no statistically significant difference in uptake of HEI to CCR between infants born to known HIV-positive mothers versus mothers who tested HIV-positive during an ANC visit (p=0.091).

Table 16. Uptake of HEI to CCR, by mothers' diagnosis (known vs. during ANC).

Uptake to CCR services	Mother had known HIV-positive status at first ANC visit (*n*, %)	Mother tested HIV-positive in ANC (*n*, %)	Total (*n*, %)
Yes	178 (55.1)	180 (48.4)	358 (51.5)
Missing data	145 (44.9)	192 (51.6)	337 (48.5)
Total	323 (100.0)	372 (100.0)	695 (100.0)

** Chi-square test was used to calculate comparisons, X^2=2.86; p-value 0.09*

Uptake EID (by mothers' diagnosis as known vs. during ANC)

For analysis of the uptake to EID HIV testing, only those children with valid PCR collection data of those with existing linkage between mother's and infant data was used (n=176) (**Table 17**). There was no statistically significant difference found for the uptake of EID HIV between infants born to known HIV-positive mothers versus mothers who tested HIV-positive during an ANC visit.

Table 17. Uptake of EID by HEI, by mothers' diagnosis (known vs. during ANC).

First PCR collected	Mother had known HIV-positive status at first ANC visit (*n*, %)	Mother tested HIV-positive in ANC (*n*, %)	Total (*n*, %)
[0m, 1m)	23 (25.3)	18 (21.2)	41 (23.3)
[1m, 2m)	51 (56.0)	54 (63.5)	105 (59.7)
[2m, 3m)	10 (11.0)	7 (8.2)	17 (9.7)
[3m, 6m)	5 (5.5)	6 (7.1)	11 (6.2)
[6m, 9m)	2 (2.2)	0 (0.0)	2 (1.1)
Total	91 (100.0)	85 (100.0)	176 (100.0)

** Chi-square test was used to calculate comparisons, X^2=3.11; p-value 0.54*

EID positivity rate

Based on available linkage data, only a total of 161 infants who had available PCR results could be linked to mothers with known/tested HIV positive during ANC visit. Overall, the HEI positivity rate at first PCR test was 1/86 among children whose mothers had a known HIV status at first ANC visit, versus 2/75 among children whose mothers tested HIV-positive during ANC visits (**Table 18**). There was no significant difference between mothers with known HIV-positive status at first ANC visit and those tested HIV-positive at ANC for any of the age ranges of HEI.

Table 18. HIV positivity rates among HEI based on available PCR test results.

HEI age range	HEI HIV test result	Mother had known HIV-positive status at first ANC visit (*n*, %)	Mother tested HIV-positive in ANC (*n*, %)
0-2 months of age	Positive	0 (0)	0 (0)
	Negative	10 (100)	5 (100)
	Indeterminate	0 (0)	0 (0)
	Total	10 (100)	5 (100)
0-6 months of age	Positive	0 (0)	0 (0)
	Negative	65 (100)	58 (100)
	Indeterminate	0 (0)	0 (0)
	Total	302 (100)	355 (100)

0-9 months of age	Positive	0 (0.0)	1 (1.5)
	Negative	68 (98.6)	64 (17.7)
	Indeterminate	1 (1.4)	0 (0.0)
	Total	69 (100.0)	65 (100.0)
0-12 months of age	Positive	1 (1.2)	1 (1.4)
	Negative	78 (96.3)	67 (97.1)
	Indeterminate	2 (2.5)	1 (1.4)
	Total	81 (100.0)	69 (100.0)
0-18 months of age	Positive	1 (1.2)	2 (2.7)
	Negative	83 (96.5)	72 (96.0)
	Indeterminate	2 (2.3)	1 (1.3)
	Total	86 (100.0)	75 (100.0)

11. Factors (maternal and infant) associated with access and retention to CCR services (Objective 10)

Data of 193 infant-mother pairs were linked and used in the analysis. Results of integrated maternal, infant and CCR data for likelihood of 3-, 6- and 12-month retention are shown in **Table 19a** (univariate regression) and **Table 19b** (multivariate regression). Due to too small an eligible sample size with the limited data available and linkable, it was not possible to perform logistic regression to evaluate 18-month retention as an outcome.

Table 19a. Univariate analysis results of integrated maternal, infant and CCR retention data.

	3-months retention OR (p-value)		6-months retention OR (p-value)		12-month retention OR (p-value)	
Sex of infant	1.15	0.35	1.19	0.22	1.12	0.58
Age at enrollment	1.13	0.38	0.98	0.89	0.51	0.02
Age mother at enrollment	1.00	1.00	0.99	0.64	0.98	0.43
Educational level	-	0.02	-	0.08	-	0.09
Marital status	0.54	0.25	1.2	0.67	1.2	0.73
Occupation	-	0.64	-	0.88	-	0.67
HIV status at 1ANC	0.74	0.34	0.845	0.57	0.84	0.62

Table 19b. Multivariate analysis results of integrated maternal, infant and CCR retention data.

Infant factors only						
	3-month retention		6-month retention		12-month retention	
Predictors	*Odds Ratio (CI)*	*p*	*Odds Ratio (CI)*	*p*	*Odds Ratio (CI)*	*p*
Sex infant - female	*Ref*		*Ref*		*Ref*	
Sex infant - male	1.15 (0.87 – 1.53)	0.33	1.19 (0.90 – 1.58)	0.22	1.14 (0.76 – 1.71)	0.52
Age infant	1.13 (0.87 – 1.48)	0.37	0.98 (0.75 – 1.29)	0.91	0.51 (0.26 – 0.89)	**0.026**

Maternal factors only						
Age mother	0.95 (0.87 – 1.04)	0.28	0.97 (0.89 – 1.05)	0.43	0.99 (0.90 – 1.08)	0.76
Level of education - no education	*Ref*		*Ref*		*Ref*	
Level of education - primary	2.12 (0.85 – 5.38)	0.11	1.58 (0.67 – 3.78)	0.30	1.25 (0.43 – 3.7)	0.69
Level of education - secondary/ technical	5.0 (1.5 – 20)	**0.014**	2.0 (0.70 – 6.2)	0.20	2.15 (0.65 – 7.3)	0.21
Marital status - Single/ Widowed	*Ref*		*Ref*		*Ref*	
Marital status - Married/ Living with partner	0.8 (0.22 – 2.67)	0.73	1.45 (0.48 – 4.33)	0.50	1.64 (0.47 – 6.9)	0.47
Occupation - farmer	*Ref*		*Ref*		*Ref*	
Occupation - housewife	0.19 (0.03 – 0.89)	0.06	0.96 (0.29 – 3.09)	0.95	1.02 (0.28 – 4.3)	0.98
Occupation - student	0.06 (0.01 – 0.44)	**0.009**	0.74 (0.15 – 3.57)	0.71	1.24 (0.24 – 6.9)	0.80
HIV status at 1ANC - positive	*Ref*		*Ref*		*Ref*	
HIV status at 1ANC - neg/ unknown	0.55 (0.22 – 1.35)	0.20	0.57 (0.25 – 1.28)	0.20	0.55 (0.21 – 1.4)	0.20
Infant and maternal factors						
Sex infant - female	*Ref*		*Ref*		*Ref*	
Sex infant - male	1.2 (0.51 – 2.7)	0.74	1.3 (0.60 – 2.7)	0.53	1.7 (0.71 – 4.1)	0.25
Age infant	0.94 (0.05 – 27.0)	0.97	1.5 (0.13 – 34.8)	0.76	4.2 (0.15 – 118.9)	0.33
Age mother	0.95 (0.87 – 1.0)	0.29	0.97 (0.89 – 1.1)	0.39	0.98 (0.89 – 1.1)	0.67
Level of education - no education	*Ref*		*Ref*		*Ref*	
Level of education - primary education	2.2 (0.86 – 5.5)	0.10	1.6 (0.68 – 3.9)	0.28	1.3 (0.45 – 4.0)	0.63
Level of education - secondary/ technical	5.1 (1.49 – 20.2)	**0.013**	2.1 (0.71 – 6.4)	0.19	2.3 (0.69 – 7.9)	0.18
Marital status - Single/ Widowed	*Ref*		*Ref*		*Ref*	
Marital status - married/ Living with partner	0.81 (0.22 – 2.7)	0.74	1.5 (0.50 – 4.5)	0.47	1.9 (0.50 – 8.6)	0.38
Occupation - farmer	*Ref*		*Ref*		*Ref*	
Occupation - housewife	0.2 (0.03 – 0.92)	0.06	0.98 (0.29 – 3.2)	0.98	1.1 (0.29 – 4.9)	0.89
Occupation - student	0.06 (0.01 – 0.43)	**0.009**	0.73 (0.15 – 3.5)	0.69	1.3 (0.23 – 7.40)	0.79
HIV status at 1ANC - positive	*Ref*		*Ref*		*Ref*	
HIV status at 1ANC - neg/ unknown	0.54 (0.22 – 1.34)	0.19	0.57 (0.24 – 1.3)	0.18	0.56 (0.21 – 1.50)	0.25

12. Factors (maternal and infant) associated with access and retention to ART services (Objective 11)

After linking infant and maternal data, the maternal and infant ART services information was integrated together. The total number of children enrolled in ART services is only 56. Of these, it was only possible to link data from eight children to maternal data. As such, it was determined that the available data for the variables of interest were not sufficient to perform (or warrant performing) the intended regression analysis.

Discussion and Conclusions

We describe the results of a programmatic evaluation examining PMTCT service uptake and pediatric outcomes of infants born to PW living with HIV who received services at one district capital health facility.

HIV status at first ANC visit

For PW entering ANC, results indicated that less than 7% know their HIV status (positive or negative) at the time of entry to care. The vast majority of women initiating ANC do so with an unknown status, meaning they have either never been tested or their last HIV test was more than three months prior. In the absence of a tracking system for information regarding previous testing, universal testing at ANC remains a critical early step in the PMTCT cascade.

With >97% of PW with unknown status being HIV tested at first ANC visit, and less than 1% of PW opting out of testing at first ANC (reasons undocumented), these findings reiterate the efficaciousness of the opt-out strategy for HCT during ANC and are consistent with HCT uptake coverage among PW seen in Mozambique and neighboring countries (3, 5). Though the proportion of PW initiating ANC who do not have a documented HIV test result is relatively low (<2%), and is consistent with other recent findings (3, 6), there is still need to ensure closure of this information gap via universal counseling and testing and/or data quality assurance steps.

The findings indicate a surprisingly higher overall positivity rate among this population of PW (13.5%) compared to rates seen nationally (7%) and in neighboring areas (7). Also concerning, compared to those entering ANC with known HIV-positive status (6%), there is a slightly higher (8%) positivity rate seen among those with unknown status who are HIV tested at their first ANC appointment, underscoring the importance of HIV prevention counseling and testing strategies among women of child-bearing age and their male partners, particularly through community outreach (8).

HIV retesting is one of the main strategies to reduce MTCT, and the first prong of the Global PMTCT strategy (9). HIV incidence among women enrolled in ANC care is found to be low (<1%), however, this may well be in part due to the very low coverage (11%) for HIV retesting during prenatal period for those receiving a negative test result at first ANC visit. While this analysis did not evaluate PW's utilization tendencies of or retention to ANC services, we

hypothesize this finding may be due in part to late initial presentation to ANC care, less than recommended attendance at ANC visits (i.e., <4 visits), and/or ANC care abandonment by some PW (10, 11), and further investigation is needed to ascertain if facility or system-level factors act as barriers to retesting in this area. It is also highly plausible that retesting coverage is low as data were not available regarding HIV retesting and/or clinical outcomes from the maternity ward registry, which is where HIV retesting often takes place for many women receiving care.

Uptake of CCR services

Among this cohort of infants born to mothers identified as or tested HIV-positive during ANC, documented registration of infants to CCR services was particularly suboptimal (51%), even compared to 2019 national data which found CCR services uptake among HEI born to only 79% of HIV-positive PW seen in ANC (3), indicating dissatisfactory performance at national and local (one district in Zambézia province) levels for this critical PMTCT cascade step. Possible explanations for our findings include, most notably, gaps in data completion and/or data quality and challenges in mother-baby data linkage. In this area, many births take place outside of the health facility for various reasons (e.g., cultural/social preferences, access to services, etc.), and in such cases, direct referral of the mother-baby dyad from maternity ward services to CCR services is not feasible. Only if these infants are brought to the health facility, and upon assessment are identified as a child at high-risk, they may be registered in CCR and the dyad engages in the PMTCT cascade at this phase.

Uptake of EID testing

The majority (81%) of HEI who present at CCR and are registered in care get at least one EID test (PCR or rapid test). While this outcome is inferior to the optimal universal HEI testing recommendation, it is only slightly lower than the 2019 national HIV PCR testing rate of 83% among HEI <2 months of age enrolled in CCR, yet markedly less than the 97% testing rate for HEI <9 months of age nationally (3). Results show that a considerably greater proportion of HEI uptake of PCR testing (76%) versus rapid test completion (40%), with a trend in PCR testing in earlier months after birth.

Turnaround time for receipt of PCR results is long among this cohort, averaging roughly two months for results return. It's important to note that point-of-care EID testing capability and programming was first implemented in Zambézia Province in 2019, the impact of which has been seen in readily available EID test results, and the drastic reduction in time for results to be shared with patients/caregivers, which is a key factor in successful linkage to Pediatric ART services for those HEI testing positive.

As this evaluation assessed outcomes among a single cohort of infants, HIV positivity rate (looking at PCR and rapid test results) is notably larger among the HEI ranging from 0 to 2 months of age (~15%) related to the relatively small sample size amidst this age range, and overall, is approximately 8% among HEI at all other age ranges, which potentially reflects a more accurate HIV positivity rate for HEI in this specific population. This finding is consistent with the 2019 national data indicating an EID HIV positivity rate of 8.5% (3), however, more

recent programmatic data indicate significant improvements in HEI positivity trends, with a national rate reduced to 3%, and as low as 2.6% in Zambézia Province by October 2021 (12).

There is no statistically significant difference seen in HEI uptake of CCR services, HEI uptake of EID testing, nor in HEI positivity rate between infants born to women with known HIV-positive status upon entering ANC or women newly diagnosed during ANC.

The Ministry of Health recently approved a new EID algorithm, excluding the HIV Rapid test for children between 9 – 17 months. All positive PCR results should be confirmed with a second PCR test (ART can be started while waiting for confirmation result). Infants with a negative first PCR results should be followed up to 18 months where HIV rapid test is recommended in order to get to a final result.

Retention to CCR services

When retention to services is defined as attending 80% of the scheduled CCR clinic visits, retention is higher in the first months after birth (i.e., the maternal post-partum period), however, it decreases dramatically in the second year of the child's life. This is in line what is seen for other post-partum and child visits in this region (13, 14). Among the population included in this evaluation, only level of maternal education is positively associated with retention to CCR services, while a mother's status as a student and male sex of the infant are associated with reduced likelihood for retention to CCR. Continued evidence-based programming is needed to identify and address potential barriers to retention at this step in the PMTCT cascade, such as strategies that incorporate community-based follow-up, family-tailored counseling and education (15), and differentiated service delivery oriented to mother-baby pairs (14).

Limitations

We acknowledge several limitations impacting the implementation of this evaluation and interpretation of findings. Unfortunately, during the course of data extraction it was discovered that information/data related to HIV testing in the maternity sector was not available in the electronic database (OpenMRS), nor was it possible to obtain this information manually from the maternity register books for inclusion in these analyses.

There were further severe limitations in data availability in the electronic databases; as seen for some dyads, the mother's record does not contain any follow-up information on the infant; for others, the infants' registry did not have information on the infant's mother. This gap in linkage data limited our ability to adequately assess uptake and completion of key steps in the PMTCT cascade (5), as well as clinical outcomes for these high-risk patient groups.

Further complicating follow-up and linkage of service uptake data is the fact that some women deliver at the health facility however they officially reside in a different location, and upon returning to their home area they become disengaged from the facility location where they first entered the cascade PMTCT services. In short, whether these individuals are lost to silent transfers or care abandonment, this reduces the possibility of providing any follow-up or continued service delivery to these women and their infants.

Evidence suggests that a large proportion of MTCT takes place in the post-partum period through breastfeeding, due to incident infections among women who tested HIV-negative in ANC (5, 16). While post-partum PMTCT services are widely available for women with HIV-negative status during ANC, and 2021 saw a trend toward increased post-ANC HIV testing performance nationally (12), without the opportunity to link infant data to post-partum follow-up data (including HIV retesting), there remains great challenge in providing the necessary longitudinal PMTCT care tailored to every mother-baby dyad's needs. In early 2022, the MOH plans to pilot a retesting screening tool to focus testing resources on those HIV-negative PLW at highest risk.

The most significant limitation to this evaluation is the finding that varying proportions of the MCH linkage data/information is lost along the way (i.e., along the PMTCT service cascade). This critically reduced not only the ability to interpret these data for program evaluation findings and for describing and identifying patients' needs, but moreover, this unavailability of reliable linkage information remains a persistent challenge for MCH providers making real time decisions if unable to draw upon or consistently access this information when completing clinical assessments.

As lack of confidence in routine data has been noted as a challenge for evidence-based, data-driven decision-making specifically within the Maternal, Newborn and Child Health and Nutrition program at the national level in Mozambique, it is incumbent on program implementers and policy makers to invest in capacity building and system strengthening to ensure availability of high quality MCH data (17).

The most effective use of the critical PMTCT cascade steps requires the ability to monitor mother-infant pairs and to collect high quality data for dyads eligible for this cascade of services. Evidence supports that gaps in care, especially missing data points, can be reduced through the use innovative monitoring and evaluation tools, such as coordinated cohort monitoring for mother-baby pairs (e.g., mother-baby tracking system), development of a national MCH dashboard, and the use of cloud-based electronic medical records (18, 19).

Dissemination plan

In an effort to share best practices and lessons learned from this evaluation, FGH collaborators have shared and/or plan to share these results with employees and stakeholders from the MOH at the district, provincial (DPS-Z), and central levels. Once approved for dissemination, the findings from this evaluation will be made publicly available through the posting of this report in a VUMC/FGH public website (https://www.vumc.org/friends-in-global-health/evaluations).

These evaluation findings will be used to advocate in particular for improvement in the monitoring system of cohorts of mother-baby pairs (e.g., mother-baby tracking system), for the development of a national MCH dashboard to enhance program monitoring capabilities, and the use of cloud-based electronic medical records for mothers and their infants.

Appendices

Appendix 1: Indicators of interest and data sources

Variable	Data Source
Pregnancy (ANC)	
Patient Care Identification Number (NID) mother ANC	OpenMRS MCH
NID mother ART (if HIV-positive)	OpenMRS MCH
Date of birth PW	OpenMRS MCH
Age at first ANC visit (years)	OpenMRS MCH
Gestational age at first ANC visit (weeks)	OpenMRS MCH
HIV status at first ANC visit	OpenMRS MCH
Date test HIV during ANC (all dates)	OpenMRS MCH
Result test HIV during ANC (at each testing moment)	OpenMRS MCH
Partner present (Yes/No) at each visit (all dates)	OpenMRS MCH
Test(s) HIV partner (dates, results)	OpenMRS MCH
Estimated delivery date (measured at first ANC visit)	OpenMRS MCH
Weight at first ANC visit	OpenMRS MCH
Arm circumference at first ANC visit	OpenMRS MCH
Hemoglobin at first ANC visit	OpenMRS MCH
Blood pressure at first ANC visit	OpenMRS MCH
Sexually transmitted infections (STI) status at first ANC visit	OpenMRS MCH
Syphilis test date and result	OpenMRS MCH
Cotrimoxazole (CTZ) prophylaxis (Yes/No)	OpenMRS MCH
ART regimen (ART at start, ART ongoing)	OpenMRS MCH
Tuberculosis (TB) treatment (Yes/No)	OpenMRS MCH
HIV-exposed infant (HEI)	
NID child CCR	OpenMRS MCH
NID mother ANC	OpenMRS MCH
NID mother ART	OpenMRS MCH
NID child ART	OpenMRS MCH
Gender	OpenMRS MCH
Date of birth	OpenMRS MCH
Place of delivery (HF [name], outside of HF)	OpenMRS MCH
Date of register at CCR	OpenMRS MCH
Birth weight (grams)	OpenMRS MCH
CTZ prophylaxis started (Yes/No)	OpenMRS MCH
Isoniazide prophylaxis started (Yes/No)	OpenMRS MCH
If yes, date Isoniazide prophylaxis started	OpenMRS MCH
Infant feeding type (exclusive breastfeeding, Mixed, Formula)	OpenMRS MCH
Prematurity (Yes/No)	OpenMRS MCH
Date of weaning	OpenMRS MCH
Weight at each visit (grams)	OpenMRS MCH

Height at each visit (centimeters)	OpenMRS MCH
Date(s) HIV test EID (first and all dates)	OpenMRS MCH
Result(s) HIV test EID (first and all results)	OpenMRS MCH
Date(s) rapid HIV test (first and all dates)	OpenMRS MCH
Result(s) rapid HIV test (first and all dates)	OpenMRS MCH
Date final HIV result	OpenMRS MCH
Final HIV result	OpenMRS MCH
Date sending dried blood spot (DBS) sample	EID Laboratory book / database
Date analysis DBS	EID Laboratory book / database
Date return result at HF	EID Laboratory book / database
Date result given to parents	EID Laboratory book / database
ART regimen mother and infant (date initiation and regimen)	OpenMRS MCH
PMTCT regiment infant (date initiation and regiment)	OpenMRS MCH
Dates of follow-up visits	OpenMRS MCH
HIV Care: HIV-positive mother	
NID mother ART	OpenMRS
NID partner ART	OpenMRS
Age mother / Date of birth mother	OpenMRS
Level of education (mother) at enrollment	OpenMRS
Marital status (mother) at enrollment	OpenMRS
Occupation status (mother) at enrollment	OpenMRS
Partner HIV-positive status at enrollment	OpenMRS
Date registry at ART services	OpenMRS
Date ART initiation	OpenMRS
ART regimen mother	OpenMRS
Mother CD4 result and CD4 date (all dates and results)	OpenMRS
Mother VL result and VL date (all dates and results)	OpenMRS
ART pick-up dates (mother) (all dates)	OpenMRS
Next scheduled ART pick-up (mother) (all dates)	OpenMRS
Next scheduled clinic visit (mother) (all dates)	OpenMRS
Status of mother (at time of data extraction)	OpenMRS
HIV Care: HIV-positive child	
NID child	OpenMRS
Infant CD4 result (%, absolute); date CD4 test	OpenMRS
Viral load result and VL date	OpenMRS
Date ART initiation of child	OpenMRS
Date(s) clinic visits and ART pick-ups (all)	OpenMRS
Next scheduled ART pick-up (all dates)	OpenMRS
Next scheduled clinic visit (all dates)	OpenMRS

Appendix 2: Supplemental diagram of data sources and records included in analysis.

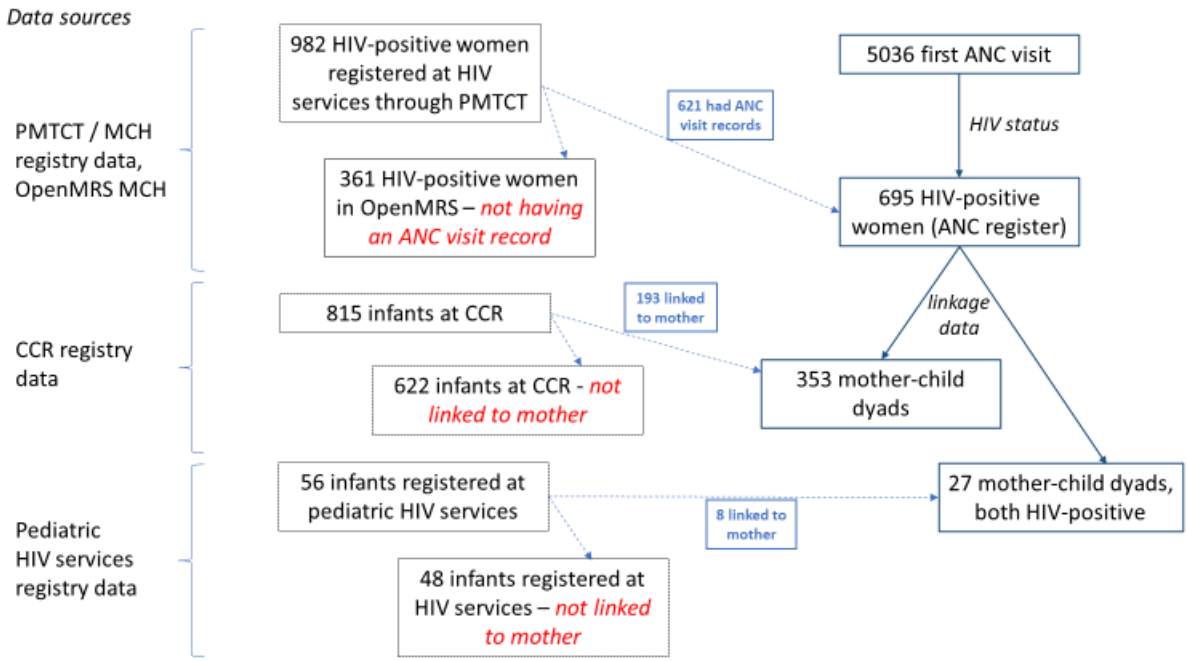


Figure 1. Diagram of number of mother and infant records available for inclusion in analysis.

Appendix 3: Supplemental report components

Approved protocol/ SOW

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.

Informed consent

Informed consent was not required for use of data in this evaluation, as it was a secondary analysis of routinely collected, de-identified, programmatic data. A waiver of consent was approved, as the evaluation involved no more than minimal risk, would not have been possible without the waiver, and the waiver did not adversely affect the rights nor welfare of the patients whose data were included in the evaluation.

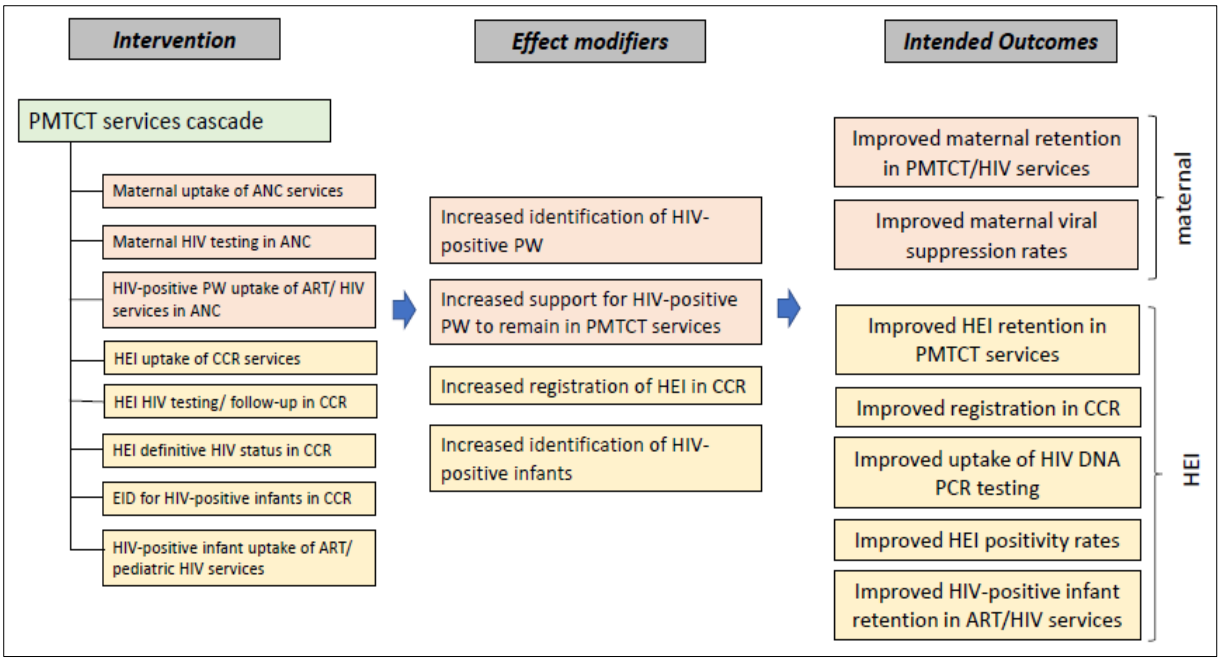
Conflict of interest statement

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).

Logical Framework



Bio-sketches *(provided for first and second co-authors of evaluation)*

BIOGRAPHICAL SKETCH

Provide the following information for the Senior/key personnel and other significant contributors. Follow this format for each person. **DO NOT EXCEED FIVE PAGES.**

NAME: Caroline De Schacht

eRA COMMONS USER NAME (credential, e.g., agency login): cdeschacht

POSITION TITLE: Director of Evaluations

EDUCATION/TRAINING *(Begin with baccalaureate or other initial professional education, such as nursing, include postdoctoral training and residency training if applicable. Add/delete rows as necessary.)*

INSTITUTION AND LOCATION	DEGREE *(if applicable)*	Completion Date MM/YYYY	FIELD OF STUDY
Ghent University, Ghent, Belgium	Licentiate	07/1998	General Medicine
Ghent University, Ghent, Belgium	Specialization	07/2000	Family Medicine
Prince Leopold Institute of Tropical Medicine, Antwerp, Belgium	Diploma	02/2001	Tropical Medicine
London School of Hygiene and Tropical Medicine (Distance learning)	MSc	07/2008	Clinical Trials
Ghent University, Ghent, Belgium	PhD	11/2015	Biomedical Science

A. Personal Statement

For about 20 years, I have been working as an HIV technical advisor and researcher in resource-poor settings, including the last 16 years in Mozambique. As technical advisor, I worked closely with the Ministry of Health and the Provincial Health authorities, and have gained valuable insight into the Mozambican Health System which I will use to help develop study protocols and design. In addition, I managed the start-up of an HIV care and treatment project in Tete and Gaza Provinces, which involved bringing together and coordinating a diverse group of stakeholders. As a researcher, I have been coordinating clinical and operational research activities since 2008. I have been the lead investigator on several studies in Mozambique, of which several related to PMTCT/ HIV prevention. I have been collaborating with the Polana Caniço Research Centre in HIV prevention research among young adults, such as the HIV incidence study, HIV vaccine trial (Tamovac I) and socio-behavioral studies on HIV prevention trials in Maputo city. In my current position, I am the lead of several HIV-related operational research projects in Zambézia province, and manage various secondary data analyses of HIV-program results.

Together with the Provincial Health services, and/ or National Institute of Health Mozambique, I have been serving as a trainer in different capacity building areas (quantitative and qualitative research methods, GCP/research ethics, protocol/abstract/manuscript writing, etc.), and mentor/supervise young researchers and PhD students, since 2005. I am also invited member of the UEM/INS Jury for the Masters in Field Epidemiology (FELTP), and member of the scientific committee of the Mozambican Health Conference where capacity building on dissemination of scientific results is an important component.

I'd like to highlight the following ongoing projects:

<u>Ongoing Research Support</u>

R01MH113478-01 (Audet, PI)
05/14/2017-05/30/2022
The primary objectives of Partners-based HIV Treatment for Sero-concordant Couples attending Antenatal Care are to evaluate the impact and cost-effectiveness of couples-centered services for HIV-infected seroconcordant pregnant women and their partners. Our intervention includes: (1) ANC-based couples HIV testing, ART enrollment, and care for HIV+ expectant couples; (2) Couple-based treatment in the post-partum period; (3) Couple-based education and skills building; and (4) Treatment continuity with the support of expert-patient (peer) supporters from couples who have successfully navigated EMTCT.
Role: In-Country Principal Investigator

U2GGH001943 Centers for Disease Control and Prevention
06/01/2020-12/01/2022
Title: Impact of COVID-19 epidemic on clinical outcomes and service delivery among people living with HIV and health care workers in Mozambique. The goal of this protocol is to determine the incidence, prevalence, and clinical manifestations of SARS-CoV-2 among adults living with HIV and healthcare the health care providers, and to assess the impact that COVID-19 has on them and on the healthcare system.
Role: Co-principal Investigator

GH002367-01-00 Centers for Disease Control and Prevention (PI: Wester) 9/30/2021 - /29/2026
Title - 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)
The purpose of the protocol is to review and summarize all routinely collected data from the HIV care and treatment program in Zambézia province from 2012 onwards. This data will be used for program evaluation, continuous program improvement, and to help inform evidence-based decisions on policies/guidelines, approaches, programs, and interventions that can best address the HIV/AIDS epidemic in Zambézia province. Key programmatic areas include: i) prevention; ii) adult care, support and treatment; iii) HIV/TB; and iv) pediatric care, support, and treatment.
Role: Co-Investigator

B. Positions and Honors

2017 - present Evaluations Director, Friends in Global Health, Mozambique
2014 - 2017 Project Coordinator/Research Advisor, Health Alliance International, Maputo, Mozambique
2008 - 2014 Public Health Evaluation Coordinator, Elizabeth Glaser Pediatric AIDS Foundation, Maputo, Mozambique
2006 - 2008 Clinical Advisor, Care and Treatment, Elizabeth Glaser Pediatric AIDS Foundation, Gaza, Mozambique
2005 - 2006 HIV Advisor/Project Manager, Pharmaccess Foundation, Maputo, Mozambique
2003 - 2004 HIV Clinical Advisor, Prince Leopold Institute of Tropical Medicine, Tete, Mozambique
2003 - 2004 HIV Clinical Advisor, Médecins sans Frontières, Ethiopia and Cambodia
2002 - 2003 HIV Clinician, Prince Leopold Institute of Tropical Medicine, Antwerp, Belgium
2001 - 2002 Project Coordinator, Médecins sans Frontières, Benin

2015; 2018; 2019 Member of Scientific Committee Provincial and National Health Conferences Mozambique
2016- Member of Jury – Masters Course in Field Epidemiology and Laboratory Practices
2010- Member of International Aids Society (IAS)

C. Contributions to Science

HIV epidemiology

Dr. De Schacht contributed to major studies in the epidemiology of HIV in Mozambique. She participated in the first cohort HIV incidence studies among vulnerable populations in Mozambique (youth, pregnant and breastfeeding women). She was PI on the HIV incidence cohort study of pregnant and breastfeeding women. Through the research work, we have been able to estimate the incidence of HIV among pregnant and breastfeeding women in a high HIV prevalence regions of Mozambique, found to be very high.

Viegas EO, Tembe N, Macovela E, Gonçalves E, Augusto O, Ismael N, Sitoe N, ***De Schacht C***, Bhatt N, Meggi B, Araujo C, Sandström E, Biberfeld G, Nilsson C, Andersson S, Jani I, Osman N. Incidence of HIV and the prevalence of HIV, hepatitis B and syphilis among youths in Maputo, Mozambique: a cohort study. PLoS One. 2015 Mar 23;10(3):e0121452

Caroline De Schacht, Heather J. Hoffman, Nédio Mabunda, Carlota Lucas, Catharina L. Alons, Ana Madonela, Adolfo Vubil, Orlando C. Ferreira Jr, Nurbai Calú, Iolanda S. Santos, Ilesh V. Jani, Laura Guay High HIV seroconversion in pregnant women and low reported levels of HIV testing among male partners in Southern Mozambique: results from a mixed methods study. PlosOne 9(12): e115014

De Schacht C, Mabunda N, Ferreira Jr OC, Ismael N, Calú N, Santos I, Hoffman JH, Alons C, Guay L, Jani IV. High HIV incidence in the postpartum period sustains vertical transmission in settings with generalized HIV epidemics: a cohort study in Southern Mozambique. JIAS 2014, 17:18808

Mother-to-Child Transmission of HIV

These publications are result of the contributions to research on mother-to-child transmission of HIV, looking at several aspects that influence retention to PMTCT care, and interventions to decrease vertical transmission rate, such as partner-based treatment.

Jani IV, De Schacht C. Innovations and challenges in early infant diagnosis of HIV. Curr Opin HIV AIDS 2018 Nov 1

Sack DE, Frisby MB, Diemer MA, De Schacht C, et al. Interpersonal reactivity index adaptation among expectant seroconcordant couples with HIV in Zambézia Province, Mozambique. BMC Psychol. 2020 Aug 28;8(1):90

Audet CM, Graves E, Barreto E, De Schacht C, et al. Partners-based HIV treatment for seroconcordant couples attending antenatal and postnatal care in rural Mozambique: A cluster randomized trial protocol. Contemp Clin Trials. 2018 Jun 5;71: 63-69

De Schacht C, Lucas C, Mboa C, Gill M, Macasse E, Stélio AD, Bobrow EA, Guay L. Access to HIV prevention and care for HIV-exposed and HIV-infected infants: a qualitative study in rural and urban Mozambique. BMC Public Health 2014, 14:1240

HIV and TB Care

Arinze F, Gong W, Green AF, ***De Schacht C***, Carlucci JG, Silva W, Claquin G, Tique JA, Stefanutto M, Graves E, Van Rompaey S, Alvim MFS, Tomo S, Moon TD, Wester CW. Immunodeficiency at Antiretroviral Therapy Start: Five-Year Adult Data (2012-2017) Based on Evolving National Policies in Rural Mozambique. AIDS Res Hum Retroviruses. 2020 Jan;36(1):39-47

De Schacht C, Mutaquiha C, Faria F, Castro G, Manaca N, Manhiça I, Cowan J. Barriers to access and adherence to tuberculosis services, as perceived by patients: A qualitative study in Mozambique. PLoS One. 2019 Jul 10;14(7):e0219470

Lynen L, Zolfo M, Huyst V, Louis F, Barnardt P, Van de Velde A, ***De Schacht C***, Colebunders R. Management of Kaposi's sarcoma in resource-limited settings in the era of HAART. AIDS Rev. 2005 Jan-Mar; 7(1):13-21

De Schacht C, Smets RME, Callens S, Colebunders R. Bilateral blindness after starting Highly Active Retroviral Treatment in a patient with HIV infection and cryptococcal meningitis. Acta Clin Belg. 2005 Jan-Feb;60(1):10-2

Colebunders R, ***De Schacht C***, Vanwolleghem T, Callens S. Lopinavir/ritonavir- and indinavir-induced thrombocytopenia in a patient with HIV infection -Letter to the editor. Int J Infect Dis. 2004; 8(5):315-6

Colebunders R, Schueremans L, Robertson-Bell D, Alvarez-Valdes VG, ***De Schacht C***, Mispelters J, Gillisjans F, De Lee G, Ostyn B. Optimal delivery of HAART during hospitalisation. AIDS Read. 2004; 14(4): 198-200. Review

Callens S, ***De Schacht C***, Huyst V, Colebunders R. Pancreatitis in an HIV-infected person on a tenofovir, didanosine and stavudine containing highly active antiretroviral treatment. J Infect 2003; 47(2):188-9

Mother and Child Health Care/ EPI program

Main achievements are the results of research understanding coverage of the vaccination program in Mozambique, contributing to improvement of access to health care for mothers and children.

Small area estimation of under-5 mortality in Bangladesh, Cameroon, Chad, Mozambique, Uganda, and Zambia using spatially misaligned data. Dwyer-Lindgren L, Squires ER, Teeple S, Ikilezi G, Allen Roberts D, Colombara DV, Allen SK, Kamande SM, Graetz N, Flaxman AD, El Bcheraoui C, Asbjornsdottir K, Asiimwe G, Augusto Â, Augusto O, Chilundo B, **De Schacht C**, Gimbel S, Kamya C, Namugaya F, Masiye F, Mauieia C, Miangotar Y, Mimche H, Sabonete A, Sarma H, Sherr K, Simuyemba M, Sinyangwe AC, Uddin J, Wagenaar BH, Lim SS. Popul Health Metr. 2018 Aug 13;16(1):13.

Jani JV, **De Schacht C**, Jani IV, Bjune G. Risk factors for incomplete vaccination and missed opportunity for immunization in rural Mozambique. BMC Public Health. 2008 May 16

Arts M, Geelhoed D, ***De Schacht C***, Prosser W, Alons C, Pedro A. Knowledge, beliefs and practices regarding exclusive breastfeeding of infants younger than 6 months in Mozambique: a qualitative study. J Hum Lact. 2011 Feb;27(1):25-32

Co-Principal Investigator - C. William Wester, M.D., M.P.H.:

BIOGRAPHICAL SKETCH

Provide the following information for the Senior/key personnel and other significant contributors. Follow this format for each person. DO NOT EXCEED FIVE PAGES.

NAME: Wester, C. William

eRA COMMONS USER NAME (agency login): wwester

POSITION TITLE: Associate Professor of Medicine

EDUCATION/TRAINING *(Begin with baccalaureate or other initial professional education, such as nursing, include postdoctoral training and residency training if applicable.)*

INSTITUTION AND LOCATION	DEGREE (if applicable)	Completion Date MM/YYYY	FIELD OF STUDY
Bowdoin College , Brunswick, ME	BA	06/1987	Biology and Economics
Dartmouth Medical School , Hanover , NH	MD	06/1991	Medicine
Harvard School of Public Health, Boston, MA	MPH	11/2010	Quantitative Methods

A. Personal Statement

The goal of my present research includes long-term HIV complications with a focus on implementation science and HIV-associated kidney disease and in resource-limited settings of the world. In addition, I have served as Co-Chair of the IeDEA Site Assessment Working Group (with Denis Nash and Stephany Duda) for the past 3 years and have been actively engaged in the collection and analysis of site level data for the purposes of informing and improving ongoing clinical initiatives/programs in such settings. Recently completed grant-funded studies include the determination of clinical, laboratory, and host genetic risk factors associated with the development of lactic acidosis, pancreatitis, nevirapine-related cutaneous hypersensitivity reactions, and other metabolic/potentially inflammatory mediated complications including HIV-associated renal, hepatic, and cardiovascular disease. This work has bridged outcomes-epidemiology and clinical-translational research domains and has allowed me to successfully attain NIH-funded grants on which I serve as Principal or Co-Principal Investigator.

With my extensive implementation science research experience in resource-limited settings, focused on long-the scale-up of comprehensive HIV services, the prevention of mother-to-child transmission, complications of HIV, as well as work focused on identifying risk factors for untoward outcomes, coupled with my extensive regional experience, namely working (and residing full-time) in Botswana for 8 years (2000-2008) where I worked for the T.H. Chan Harvard School of Public Health and was actively involved in clinical trials, as well as my active involvement (including frequent travel to Mozambique) as Project Director of our large (currently supporting > 110 ART sites) ongoing U.S. government Centers for Disease Control and Prevention (CDC) / President's Emergency Plan for AIDS Relief (PEPFAR)-funded "*Avante: Towards Epidemic Control"* (Cooperative agreement 1NUGGH001943) technical assistance initiative (with renewed funding through 2021), I am uniquely qualified to serve as primary research mentor for team members (both in Mozambique as well as Vanderbilt-based) for many of the program evaluations (plus relevant research protocols) that the "*Avante: Towards Epidemic Control*" team is conducting. Specifically, in this leadership role, I will continue to mentor technical staff and assist them to: a) develop stakeholder-informed context-specific interventions, b) learn approaches to community engagement and intervention design, c) further develop their research skills in HIV implementation science, and d) help them garner the requisite skills to independently lead HIV research studies in Mozambique and other similar settings.

B. Positions and Honors

Positions and Employment

1994 - 1998 Clinical Instructor, Rush Medical College , Chicago, IL

1998 - 2000 Infectious Diseases Attending Physician, Cook County (Stroger Memorial) Hospital, Chicago, IL

1998 - 2000 Assistant Professor of Medicine , Rush Medical College, Chicago, IL

1999 - 2000 Principal Investigator, Terry Beirn Community Programs for Clinical Research on AIDS (CPCRA) , The Core Center, Cook County Hospital, Chicago, IL

1999 - 2000 Co-Investigator, Adult Clinical Trials Group (ACTG) Research Trials, The CORE Center, Cook County Hospital, Chicago, IL

2000 - Research Associate, Harvard School of Public Health, Boston, MA

2000 - 2008 Co-Study Coordinator/Site Leader/Site PI; Adult Antiretroviral Treatment and Drug Resistance ("*Tshepo*") Study, Botswana-Harvard School of Public

	Health AIDS Initiative Partnership for HIV Research and Education (BHP), Gaborone
2001 - 2002	Director; Infectious Disease Care Clinic (outpatient HIV/AIDS clinic) , Princess Marina Hospital; Ministry of Health, Botswana, Gaborone
2007 - 2008	Site Leader/Site Principal Investigator, ACTG and the Gaborone PTT/CRS , Botswana-Harvard School of Public Health AIDS Initiative Partnership Clinical Trials Unit (CTU), Gaborone
2008 - 2014	Assistant Professor of Medicine, Vanderbilt University School of Medicine, Vanderbilt Institute for Global Health (VIGH), Nashville, TN
2014 -	Associate Professor of Medicine, Vanderbilt University School of Medicine, Vanderbilt Institute for Global Health (VIGH), Nashville, TN
2014 -	Co-Director of Global Health Pathway (Internal Medicine Residency, Vanderbilt University School of Medicine)

Other Experience and Professional Memberships

1994 -	Member, Alpha Omega Alpha (AOA) Honor Medical Society
2011 -	Member, International AIDS Society (IAS)
2014 -	Member, International Society of Nephrology (ISN)

Honors

1991	Outstanding Medical Resident Teaching Award, (Six Consecutive and Maximum Eligible Terms), Rush-Presbyterian St. Luke's Medical Center
1992	Outstanding Internal Medicine Resident Annual Award, Rush-Presbyterian St. Luke's Medical Center
1994	Full Scholarship Recipient, SHEA-CDC Training Course
1994	Aesculapios Award (Outstanding Medical Resident), Rush Medical College
2010	William Schaffner Teaching Award Recipient in Infectious Diseases, Vanderbilt University School of Medicine, Division of Infectious Diseases
2010	Teacher Recognition Award , Vanderbilt University School of Medicine
2016	Selected for Vanderbilt University Department of Medicine Mid-Career Leadership Program (year-long leadership skills development program; commenced January 2017)

C. Contribution to Science

Scale-up of Comprehensive HIV/AIDS Services in Resource-limited settings / Implementation Science:

Wester CW, Bussmann H, Koethe J, Moffat C, Vermund S, Essex M, Marlink RG. Adult combination antiretroviral therapy in sub-Saharan Africa: lessons from Botswana and future challenges. *HIV Ther*. 2009 Sep 1;3(5):501-526. PMCID: PMC2774911.

Aliyu MH, Blevins M, Audet C, Shepherd BE, Hassan A, Onwujekwe O, Gebi UI, Kalish M, Lindegren ML, Vermund SH, Wester CW. Optimizing PMTCT service delivery in rural North-Central Nigeria: protocol and design for a cluster randomized study. *Contemp Clin Trials*. 2013 Sep;36(1):187-97. PMCID: PMC3786261.

Aliyu MH, Blevins M, Parrish DD, Megazzini KM, Gebi UI, Muhammad MY, Ahmed ML, Hassan A, Shepherd BE, Vermund SH, Wester CW. Risk factors for delayed initiation of combination antiretroviral therapy in rural north central Nigeria. *J Acquir Immune Defic Syndr*. 2014 Feb 1;65(2):e41-9. PMCID: PMC3818360.

Moon TD, Jequicene T, Blevins M, José E, Lankford JR, Wester CW, Fuchs MC, Vermund SH. Mobile clinics for antiretroviral therapy in rural Mozambique. *Bull World Health Organ*. 2014 Sep 1;92(9):680-4. PMCID: PMC4208568.

Complications of HIV/AIDS (including antiretroviral medication-related toxicity and end-organ complications):

Wester CW, Koethe JR, Shepherd BE, Stinnette SE, Rebeiro PF, Kipp AM, Hong H, Bussmann H, Gaolathe T, McGowan CC, Sterling TR, Marlink RG. Non-AIDS-defining events among HIV-1-infected

adults receiving combination antiretroviral therapy in resource-replete versus resource-limited urban setting. *AIDS.* 2011 Jul 31;25(12):1471-9. PMCID: PMC3188442.
Wester CW, Eden SK, Shepherd BE, Bussmann H, Novitsky V, Samuels DC, Hendrickson SL, Winkler CA, O'Brien SJ, Essex M, D'Aquila RT, DeGruttola V, Marlink RG. Risk factors for symptomatic hyperlactatemia and lactic acidosis among combination antiretroviral therapy-treated adults in Botswana: results from a clinical trial. *AIDS Res Hum Retroviruses.* 2012 Aug; 28(8):759-65. PMCID: PMC3399551.
Abraham AG, Althoff KN, Jing Y, Estrella MM, Kitahata MM, Wester CW, Bosch RJ, Crane H, Eron J, Gill MJ, Horberg MA, Justice AC, Klein M, Mayor AM, Moore RD, Palella FJ, Parikh CR, Silverberg MJ, Golub ET, Jacobson LP, Napravnik S, Lucas GM. End-stage renal disease among HIV-infected adults in North America. *Clin Infect Dis*. 2015 Mar 15;60(6):941-9. PMCID: PMC4357817.
Erlandson KM, Kitch D, Wester CW, Kalayjian RC, Overton ET, Castillo-Mancilla J, Koletar SL, Benson CA, Campbell TB, Robertson K, Lok JJ. The Impact of Statin and Angiotensin-Converting Enzyme Inhibitor/Angiotensin Receptor Blocker Therapy on Cognitive Function in Adults with Human Immunodeficiency Virus Infection. *Clin Infect Dis*. 2017 Nov 29;65(12):2042-2049. doi: 10.1093/cid/cix645.
Prevention of Mother-to-Child Transmission (PMTCT):
Aliyu MH, Blevins M, Audet C, Shepherd BE, Hassan A, Onwujekwe O, Gebi UI, Kalish M, Lindegren ML, Vermund SH, Wester CW. Optimizing PMTCT service delivery in rural North-Central Nigeria: protocol and design for a cluster randomized study. *Contemp Clin Trials*. 2013 Sep;36(1):187-97. PMCID: PMC3786261.
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A full list of my publications (67+) may be found at:
http://www.ncbi.nlm.nih.gov/sites/myncbi/1HSsewwv6gd5A/bibliography/43390763/public/?sort=date&direction=ascending.
D. Research Support
Active Research Support
1NU2GGH001943-02 (PI: Wester) 9/30/2016 - 9/29/2021 6.48 calendar

CDC (PEPFAR)

Avante: Towards Epidemic Control
The purpose of the Avante program is to control the HIV epidemic by supporting the sustainable implementation of Ministry of Health (MOH) HIV and TB services in Zambézia province. Avante will provide technical assistance (TA) to the Government of the Republic of Mozambique (GRM) at the national, provincial, district and health facility level for activities that have a significant impact to control

the epidemic, leveraging community structures that can catalyze program implementation. Key programmatic areas include: i) prevention; ii) adult care, support and treatment; iii) HIV/TB; and iv) pediatric care, support, and treatment.

1U01DK1122770 (MPI/Contact PI: Wester) 9/15/2017 – 8/31/2022 2.4 calendar
NIH/NIDDK
Optimal Management of HIV Infected Adults at Risk for Kidney Disease in Nigeria
In this clinical trial, we plan to determine the optimal means to prevent or slow the progression of kidney disease among genetically at-risk northern Nigerian HIV-infected adults. Based on data from studies of diabetic kidney disease that used medications that block the renin angiotensin aldosterone system (RAAS), we plan to evaluate whether or not RAAS inhibition (using a widely available medication that blocks RAAS) in HIV-infected adults produces similarly promising results.

Integrated Malaria Program (IMaP) in Mozambique
Chemonics International, Inc. (PI: Wester) 12/05/2017 - 07/30/2022
0.72 calendar
U.S. Agency of International Development

Brief description of roles of other evaluation collaborators:

Collaborator	Description of role in evaluation
EG	concept note development, results interpretation, report preparation
PGD	concept note development, technical oversight of program, data collection, result interpretation, and leading of action plan development (based on findings)
PP	data collection
ZY	data analysis, results interpretation, report preparation
SM	technical support for program data extraction
WS	concept note development, technical oversight of program, results interpretation
MB	concept note development, technical oversight of program, result interpretation, and leading of action plan development (based on findings)
MFSA	concept note development, technical oversight of program and data collection
CC	concept note development, results interpretation

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