System-level factors associated with performance of prevention of mother-to-child transmission (PMTCT) services in Côte d'Ivoire

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A thesis

submitted in partial fulfillment of the

requirements for the degree of

Master of Public Health

University of Washington

2017

Committee

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Program Authorized to Offer Degree:

Global Health

University of Washington

Abstract

System-level factors associated with performance of prevention of mother-to-child transmission (PMTCT) services in Côte d'Ivoire

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Background: Although the coverage of antiretrovirals (ARVs) for prevention of mother to child transmission (PMTCT) has increased globally after efforts, the uptake of PMTCT services remains low. We aim to identify system-level barriers to uptake HIV test and maternal prophylaxis during pregnancy in the existing national program in Côte d'Ivoire.

Method: Data of 46 sites during November 2011 to October 2015 were analyzed. Multiple Poisson regression models were used to 1) investigate systems-level factors associated with HIV testing and the delivery of maternal ARVs under Option B (Nov. 2012- Oct. 2015); 2) and highlight the differences in these associations between the Option A (Nov.2011-Oct.2012) and the Option B (Nov. 2012- Oct. 2015) periods. A significance level of 0.05 was used to determine factors associated with each outcome.

Result: In those 46 sites, 39 (85%) sites are public and 7 (15%) sites are privately-operated. During the Option B period, after adjusting for confounders, regional hospitals had higher rates of HIV testing compared to other health facilities (RR: 1.24; p=0.001) and lower rates of maternal ARV delivery (RR: 0.73; p=0.02). Conversely, privately-operated health facilities reported lower rates of HIV testing than public facilities (RR: 0.92; p<0.001), but higher rates of ARV delivery (RR: 1.23; p=0.008). Modifiable systems-level factors associated with rate

of HIV testing included: the lack of on-site laboratory facilities (RR: 0.90; p=0.002); stock-outs of ARVs (RR: 0.88; p=0.046) and testing supplies (RR: 0.87; p=0.003). Stock-outs of general supplies were associated with low rates of delivery of maternal ARVs (RR: 0.79; p=0.046) as were stock-outs of ARVs, but with an inverse relation (RR: 1.41; p=0.005). While available charts, providing on-site CD4 tests, delay of ARV delivery were not significantly associated with either HIV test rate or delivery rate of appropriate maternal prophylaxis during the Option B period. Rural health facilities were associated with lower HIV testing rate (RR: 0.83; p=0.04), and big health facilities (>200 first antenatal care per month) were associated with higher delivery ratio of appropriate maternal prophylaxis (RR:1.39, p=0.01) as were available charts (RR:1.04, p=0.01) during the Option A period, but those associations were not significant during Option B period.

Discussion: HIV testing rates were higher in public health facilities and health facilities with a laboratory, while the privately-operated health facilities performed better in the delivery of appropriate maternal prophylaxis. Thus, when access to HIV tests is improving in low prevalence areas, especially in public facilities, specific attention should be paid to risks of loss to follow up from HIV testing to delivery of ARVs. Regional hospitals which served the largest population size had higher HIV testing rate but lower prophylaxis ratio. This implies bigger challenges to follow up pregnant women after HIV tests in facilities which serves a large population. Stock-outs of HIV test kits, general supply of ARVs limited the performance of HIV tests and maternal prophylaxis delivery. And supply of ARVs became more challenging when Option B guidelines were applied, which is likely to be an increasingly important issue as Option B+ guidelines are implemented. This study also

highlights the need for further research regarding the association between system-level factors and adherence to ARVs, which might be one of the biggest challenges to improve PMTCT in Côte d'Ivoire under Option B+.

ABBREVIATIONS:

ANC Antenatal care

ART Antiretroviral therapy

ARV Antiretroviral

DHS Demographic and Health Survey

HCWs health care workers

HIS health information systems

HIV human immunodeficiency virus

MSHP *Ministère de la Santé et de l'Hygiène Publique* (Côte d'Ivoire Ministry of Health)

MTCT Mother-to-child transmission

PMTCT prevention of mother-to-child transmission of HIV

USAID United States Agency for International Development

WHO World Health Organization

INTRODUCTION

Mother-to-child transmission (MTCT) of human immunodeficiency virus (HIV) accounts for nearly all new infections in young children around the world[1]. Although the incidence rate of HIV has declined in most parts of the world over the last 15 years, the World Health Organization (WHO) estimates that in 2015, more than 1.4 million pregnant women globally lived with HIV.[2] Without treatment, an HIV-positive pregnant woman has a 30-35% risk of transmitting the infection to her child[3]. USAID estimates that 150,000 children in the world became infected with HIV through MTCT in 2015.[4]

The risk of MTCT of HIV can be nearly eliminated with early detection followed by appropriate treatment.[5] Antiretroviral therapy (ART) provided to the pregnant woman before, during, and after delivery and to the newborn is the main intervention to prevent such transmission from mother to child. However, successful prevention of mother-to-child transmission (PMTCT) of HIV programs rely on a specific package of services that include HIV testing kits, availability of trained clinical counselors, and a reliable supply of antiretroviral (ARV) medications.[6] In 2010 WHO announced two new ARV treatment strategies for PMTCT: Option B and Option B+. WHO encouraged Ministries of Health to consider the cultural and logistical context of implementation when selecting which guideline to adopt.

In Côte d'Ivoire, a nationwide PMTCT program was introduced in 2007 by the Côte d'Ivoire Ministry of Health—*Ministère de la Santé et de l'Hygiène Publique* (MSHP)—following the WHO Option A guidelines. Under Côte d'Ivoire's Option A program, all HIV-positive pregnant women with a CD4 count ≤ 350 started lifelong ART soon after diagnosis and women with CD4 count > 350 started with twice daily zidovudine (AZT) from 28 weeks of gestation, a single dose of nevirapine (sdNVP) and first dose of AZT + 3TC (lamivudine) at the onset of labor, and AZT + 3TC throughout 7 days postpartum. In 2012, in response to WHOs 2010 guidelines, the MSHP launched the National PMTCT Scale-up Plan, which transitioned the PMTCT treatment standards from WHO's Option A regimen to the Option B regimen.[7,8] Under Option B, the treatment regimen for pregnant women with a CD4 count ≤ 350 remained the same, while women with CD4 count > 350 were recommended to start triple ARV treatment as early as 14 weeks of gestation and through childbirth if not breastfeeding or until 1 week after cessation of all breastfeeding. In October 2015, Côte d'Ivoire revised its national PMTCT policy once more to adopt WHO's Option B+ guidelines recommending that all pregnant and breastfeeding HIV positive women initiate lifelong triple ART, regardless of CD4 count and clinical stage[9].

Prior to the adoption of the Option B+ guidelines, the MSHP supported a nationwide facility-level operations research study to identify key challenges faced by the existing national PMTCT program and to assess program effectiveness.[10] The study was carried out jointly by Health Alliance International, the MSHP, and the University of Washington with support from Population Council under the USAID-funded HIVCore Task Order.[9] The study found that although the rates of HIV testing and delivery of ARVs increased with the shift from Option A to Option B, the rate for retention in care remained steady. The study also found that half of all patient loss-to-follow up occurred within the first 90 days after enrollment. While most loss to follow up seemed to happen after initiation of ARVs, failing to access the earlier stage of the PMTCT cascade of care (HIV testing and delivery of ARVs) had impacts on retention at childbirth, when the risk of transmission is highest.[9]

In terms of the impact of system-level characteristics on PMTCT programs, variables such as health facility location, size, density and the availability of certain services such as laboratory, supplies, and long waiting-times by the patients have been shown to be associated with service delivery performance.[11,12,13,14,15,16] However, most of these studies were conducted in Southern and East Africa. Several studies have also found the shortage of material and human resources to be a key barrier to implementation of integrated care in Sub-Saharan Africa.[16,17,18,19] Such studies underscored that the supply chains for components such as HIV test kits and ARV medications were crucial for a fully functioning PMTCT program.[17] A separate analysis conducted using the same dataset showed that the association between workforce patterns and PMTCT service delivery was small, highlighting the need to further understand how other system-level factors beyond workforce density impact PMTCT program success in Côte d'Ivoire.[20]

This thesis intends to use the Côte d'Ivoire country-wide operation research study data to (1) understand, under Option B, system level factors associated with PMTCT services in Côte d'Ivoire, and (2) highlight differences in associated factors between the Option A (Nov.2011-Oct.2012) and the Option B (Nov.2012-Oct.2015) periods.

METHODS

1. Study sample

Data for selection of the study sample were drawn from the MSHP 2013 national PMTCT database which covered 1,279 health facilities providing PMTCT services. Health facilities eligible to be selected for this study reported ≥10 new HIV cases in 2013, and totaled 368 (29%) facilities[9]

50 sites were selected using a two-stage sampling strategy. First, the number of sites per region was determined by the regional HIV prevalence among women of child-bearing age (15–49) and population distribution across 11 geographic regions according to the 2011–12 Côte d'Ivoire Demographic and Health Survey (DHS) data.[10] In the second stage, using probability proportional to size sampling, 50 sites were independently selected across the 11 regions based on the number of reported women attending ANC at each site.[10] Data for this study were collected from these 50 sites.

Over the course of the study, three out of the 50 sites were identified as ineligible for inclusion in the analysis due to extended periods during which HIV care services were not offered. Two of these three sites were located in a rural area and one site in an urban area. Another site requested to be removed from the study following initial data collection. That site was subsequently removed from data analysis[9] leaving a total of 46 sites included in the analysis.

2. Data collection, cleaning, and imputation

The data collection teams were trained to abstract quantitative data from health information systems (HIS) monthly reports and facility-based registries. For each of the 46 selected sites, the data collectors completed standardized study tools by hand and later transferred the data to an electronic form. This data collection took place in June and July 2015 and again in March and April 2016[9]. Fourteen indicators were collected for the period of November 2011 to October 2015 from HIS reports and registries. When monthly reports or observations were missing at a site, reports at district health offices and on-site registries were consulted. If no additional

information was found and PMTCT activities occurred during the timeframe in question, the observation for that activity was marked "missing" and imputed using the AMELIA II programming package in R, a bootstrap-based expectation maximization algorithm. Table 1 lists those variables with missing data and their proportions.

Table 1: List of the health information system (HIS) indicators with missing data in the percentage

HIS indicators	% Missing Data in Option A period (Nov 2011 to Oct 2012)	% Missing Data in Option B period (Nov 2012 to Oct 2015)
# of 1st ANC visit	22%	4%
# of pregnant women tested for HIV	24%	5%
# of pregnant women with known HIV-positive status presenting in ANC	89%	24%
# of pregnant women with known HIV-positive status presenting at maternity	88%	39%
# of pregnant women tested HIV-positive in ANC	23%	5%
# of pregnant women tested HIV-positive at maternity	21%	23%
#of HIV-positive pregnant women who initiated ART	29%	9%
# of HIV-positive pregnant women who received ARV prophylaxis intended for the mother	29%	8%

3. Statistical Analysis

In order to distinguish Option A data from Option B data (because of the different standards of treatment for HIV-positive pregnant women with CD4 count >350 recommended in Option A and Option B), we selected the official date of the adoption of Option B as national policy in Côte d'Ivoire as our cut off. All data following that date (November 2012) we considered to fall under option B (see limitation below). This resulted in the Option A period to be between Nov.2011-Oct.2012 and the Option B period to be between Nov.2012-Oct.2015.

3.1 Definition of outcome indicators

HIV testing rate

In this study, HIV testing rate was defined as the number of HIV tests per 1st ANC visits, which was calculated as the number of pregnant women who were tested for HIV over the total number of pregnant women who had a first ANC visit. As a result, testing rates could be >100% if pregnant women were tested multiple times during the same pregnancy. We chose the total number of HIV tests during antenatal care as numerator instead of the number of HIV tests performed at ANC1 because of the high percentage of missing data in the later variable (92% missing during the Option A period and 27% missing during the Option B period).

Delivery ratio of appropriate maternal prophylaxis

This variable was defined as the proportion of women who received ARV prophylaxis and ART out of the total number of HIV-positive women. The number of HIV-positive pregnant women who initiated ART plus the number of HIV-positive pregnant women who received ARV prophylaxis intended for the mother were used as numerator; and the total number of HIV positive pregnant women was used as denominator. This included pregnant women tested HIV positive in ANC, pregnant women with known HIV positive status presenting at ANC, pregnant women tested HIV positive at maternity, and pregnant women with known HIV positive status presenting at maternity. For health facilities that did not have a maternity, we used the number of pregnant women tested HIV-positive in ANC, and the number of pregnant women with known HIV-positive status presenting in ANC as denominator instead and the same numerator as other health facilities.

3.2 Definition of key study variables

Urban/ rural setting of the health facility

The nature of geographic setting of each health facility, whether urban or rural was indicated by health care workers [HCWs] at each site[9] based on the Côte d'Ivoire government administrative classification.

Health Facility type

There are six health facility types in this study: regional hospital (CHR), general health center (HG), urban health center (CSU), Maternal Child Health Post (PMI), rural health center (CSR), and health post (DISPENSAIRE). The abbreviations are French acronyms. Regional hospitals and general health centers had the largest catchment area and the highest levels of human resources, while rural health centers and health post had the smallest catchment area and were located in rural settings.

Health Facility size

We used the number of ANC1 visits per month as a proxy for facility size. We treated this variable as a categorical variable with three intervals: small size site (≤100 1st ANC visits per month); medium size site (101-200 1st ANC visits per month), and large size site (>200 1st ANC visits per month).

Stock-outs

The existence of stock-outs of HIV test kits, ARV medication, general medical supplies (e.g., lancets and capillary tubes), patient charts, registries, and general supplies (see below) in the two three-month periods were reported by local health care workers. The length of time of stock-outs for certain items was collected separately for the Option A period and the Option B period. The stock-outs of general supplies included examination materials (such as vacutainer); laboratorial materials (such as stromatoliseur); hygiene material (such as ethanol). We included these variables as binary 'yes/no' variables to indicate any stocks during the reference period.

3.3 Descriptive analysis

Facility-level characteristics were summarized overall and stratified by public versus privately-operated classification using medians and interquartile ranges for continuous factors and percentages for categorical factors

3.4 Inferential analysis

The primary analyses investigated whether facility-level factors were associated with the outcome measures of the rate of HIV testing and provision of appropriate maternal prophylaxis. Poisson regression models were used to assess associations between facility characteristics and the outcomes. Unadjusted and adjusted models were fit for each characteristic of interest. A risk ratio or rate ratio (RR) and associated 95% confidence interval (95% CI) were reported and a p-value of 0.05 was used as a threshold for statistical significance. Analyses were conducted using Stata/IC 14.1.[21]

Potential confounders were identified through a mixed *a priori* and data-driven approach: firstly, *a priori* risk factors for the HIV testing and prophylaxis ratio were identified based on the scientific background and a directed acyclic graph (DAG) was used to clarify causal hypotheses and identify the minimal adjustment set. Second, the association between the variables in this set and the exposure variables was evaluated based on bivariate frequency tables. Facility type (public versus privately-operated) and facility size (total number of 1st ANC visits per month) were identified as potential confounders. Both factors were associated with baseline variables in the sample, were thought to have causal relationships with HIV testing rate and delivery of appropriate prophylaxis in ANC rate, and were not thought to be caused by any baseline variables. For adjustment purpose, we decided to include facility size as a continuous variable after checking the linear relationship between facility size and the two outcome indicators.

RESULTS

Characteristics of the selected health facilities (table 2)

Of the 46 sites that were included in this analysis, 39 (84.78%) sites were public and 7 (15.22%) were privately-operated. Facility-level characteristics, stratified by public or privately-operated, are provided in Table 2. In general, privately-operated sites were smaller than public sites with regard to the number of ANC1 visits per month (public vs privately-operated: Option A: 110.00 vs 102.55; Option B: 111.81, 81.60). Privately-operated sites were also less likely to have stock-outs of HIV test kits or ARVs (public vs privately-operated: Option A: 36% vs 0%; Option B: 15% vs 0%). But, privately-operated sites had longer average time of delay between HIV testing and ARV delivery than public sites (average delay time in public vs privately-operated sites throughout two periods: 29.13 vs 36.42).

Stock-outs of supplies occurred in relatively few facilities. However, when stock-outs occurred, they typically lasted for more than two weeks. The distribution of the stock-outs varied between the Option A period and the Option B period. The most common stock-outs occurred with general supplies (28.6% of sites in Option A and 88.2% of sites in Option B), followed by ARVs stock-outs (20% of sites in Option A and 8.7% of sites in Option B) and HIV test kits (14.6% of sites in Option A and 6.5% of sites in Option B).

Table 2: Summary of site characteristics

	Overall sites (N=46) *Median (IQR) or N(%)*	Public (N=39) *Median (IQR) or N(%)*	Privately-operated (N=7) *Median (IQR) or N(%)*
Available charts	67% (44-98)	67% (44-100)*	70% (40-92)
# of days between HIV test and ARV delivery (mean)	30.69 (19.72-40.33)	29.13 (19.41-40.33)*	36.42 (20.91, 52.96)
# of ANC 1 visits/month			
Nov.2011-Oct.2012	109.76 (78.67, 223.03)	110.00 (78.67, 224.82)	102.55 (72.67, 164.67)
Nov.2012-Oct.2015	111.14 (75.02-213.81)	111.81 (75.02-214.08)	81.60 (66.94-156.25)
Geographic setting			
Urban	41 (89.13%)	35(89.74%)	6 (85.71%)
Rural	5 (10.87%)	4 (10.26%)	1 (14.29%)
Health facility type			
Urban health center	21 (45.65%)	17 (43.59%)	4 (57.14%)
Regional hospital	4 (8.7%)	4 (10.26%)	0 (0%)
General health center	13 (28.26%)	13 (33.33%)	0 (0%)
Maternal child health post	6 (13.04%)	4 (10.26%)	2 (28.57%)
Rural health center	1 (2.17%)	1 (2.56%)	0 (0%)
Health post	1 (2.17%)	0 (0%)	1 (14.29%)
Existence of a laboratory on site	33 (71.74%)	24 (61.54%)	6 (85.71%)
On-site CD4 testing	26 (56.52%)	2(40%)	2 (28.57%)
Stock-outs of HIV test kits			
Nov.2011-Oct.2012**			
No Stock-outs	35 (85.37%)	30 (83.33%)	5 (100%)
Stock-outs<14 days	5 (12.20%)	5 (13.89%)	0 (0%)
Stock-outs≥14 days	1 (2.44%)	1 (2.78%)	0 (0%)
Nov.2012-Oct.2015			
No Stock-outs	43 (93.48%)	36 (92.31%)	7 (100%)
Stock-outs<14 days	2 (4.35%)	2 (5.136%)	0 (0%)
Stock-outs≥14 days	1 (2.17%)	1 (2.56%)	0 (0%)
Stock-outs of ARVs			
Nov.2011-Oct.2012*			
No Stock-outs	32 (80.00%)	27 (77.14%)	5 (100%)
Stock-outs<14 days	1 (2.50%)	1 (2.86%)	0 (0%)
Stock-outs≥14 days	7 (17.50%)	7 (20.00%)	0 (0%)
Nov.2012-Oct.2015			
No Stock-outs	42 (91.30%)	35 (89.74%)	7 (100%)
Stock-outs<14 days	1(2.17%)	1 (2.56%)	0 (0%)
Stock-outs≥14 days	3 (6.52%)	3 (7.69%)	0 (0%)

Stock-outs of general medical supplies			
Nov.2011-Oct.2012**			
No Stock-outs	35 (85.37%)	30 (83.33%)	5 (100%)
Stock-outs<14 days	2 (4.88%)	2 (5.56%)	0 (0%)
Stock-outs≥14 days	4 (9.76%)	4 (11.11%)	0 (0%)
Nov.2012-Oct.2015			
No Stock-outs	37 (80.43%)	32 (82.05%)	5 (71.43%)
Stock-outs<14 days	2 (4.35%)	2 (5.13%)	0 (0%)
Stock-outs≥14 days	7 (15.22%)	5 (12.82%)	2 (28.57%)
Stock-outs of patient charts			
Nov.2011-Oct.2012***			
No Stock-outs	31 (88.57%)	26 (86.67%)	5 (100%)
Stock-outs<14 days	1 (2.86%)	1 (3.33%)	0 (0%)
Stock-outs≥14 days	3 (8.57%)	3 (10.00%)	0 (0%)
Nov.2012-Oct.2015##			
No Stock-outs	33 (78.57%)	28 (80.00%)	5 (71.43%)
Stock-outs<14 days	2 (4.76%)	2 (5.71%)	0 (0%)
Stock-outs≥14 days	7 (16.67%)	5 (14.29%)	2 (28.57%)
Stock-outs of registry			
Nov.2011-Oct.2012****			
No Stock-outs	11 (100%)	10 (100%)	1 (100%)
Stock-outs<14 days	0 (0%)	0 (0%)	0 (0%)
Stock-outs≥14 days	0 (0%)	0 (0%)	0 (0%)
Nov.2012-Oct.2015##			
No Stock-outs	13 (92.86%)	11 (91.67%)	2 (100%)
Stock-outs<14 days	0 (0%)	0 (0%)	0 (0%)
Stock-outs≥14 days	1 (7.14%)	1 (8.33%)	0 (0%)
Stock-outs of general supplies			
Nov.2011-Oct.2012*****			
No Stock-outs	10 (71.43%)	9 (69.23%)	1 (100%)
Stock-outs<14 days	0 (0%)	0 (0%)	0 (0%)
Stock-outs≥14 days	4 (28.57%)	4 (30.77%)	0 (0%)
Nov.2012-Oct.2015###			
No Stock-outs	2 (11.76%)	2 (13.33%)	0 (0%)
Stock-outs<14 days	3 (17.65%)	3 (20.00%)	0 (0%)
Stock-outs≥14 days	12 (70.59%)	10 (66.67%)	2 (100%)

*Overall N=40, Public N=35, Privately-operated N=5; ** Overall N=41, Public N=36, Privately-operated N=5; ***Overall N=35, Public N=30, Privately-operated N=5; ****Overall N=11, Public N=10, Privately-operated N=1; *****Overall N=14, Public N=13, Privately-operated N=1;

Overall N=42, Public N=35, Privately-operated N=7; ## Overall N=14, Public N=12, Privately-operated N=2; ### Overall N=17, Public N=15, Privately-operated N=2.

Rates of HIV testing and provision of maternal prophylaxis in public vs privately-operated sites (Table 3)

During the Option A period (Nov. 2011 to Oct. 2012), the median rate of HIV testing per 1st ANC visit for all sites combined was 1.05 (IQR: 1.00 to 1.17) with a non-significant 7% lower mean rate of testing among privately-operated health facilities as compared to public health facilities (RR=0.93; p=0.07). For the same period, the median ratio of appropriate maternal prophylaxis provision for all the sites combined was 0.61 (IQR: 0.50 to 0.80), with a 25% higher likelihood of maternal prophylaxis at privately-operated facilities (RR=1.25; p=0.02).

During the Option B period (Nov. 2012 to Oct. 2015), the median rate of testing for all sites combined was 1.10 per 1st ANC visit (IQR: 1.07 to 1.22) with a significant 9% lower mean testing rate at privately-operated facilities as compared to public facilities (RR=0.91; p<0.001). The median ratio of appropriate maternal prophylaxis was 0.71 (IQR: 0.58 to 0.86) with a 16% greater likelihood of provision of prophylaxis at privately-operated facilities (RR=1.16; p=0.046).

Table 3: Summary of HIV testing rate and appropriate maternal prophylaxis rate

	Total # of sites N=46 *Median (IQR)*	Public N=39 *Median (IQR)*	Privately-operated N=7 *Median (IQR)*
Option A period (Nov. 2011-Oct.2012)			
HIV testing rate (# tests per 1st ANC)*	1.05 (1.00, 1.17)	1.07 (1.00-1.19)	1.03 (0.94-1.07)
Delivery of appropriate maternal prophylaxis rate** (# delivery of appropriate prophylaxis per HIV+ women)	0.61 (0.50-0.80)	0.60 (0.44-0.78)	0.80 (0.61-0.87)
Option B period (Nov.2012-Oct.2015)			
HIV testing rate (# tests per 1st ANC)*	1.10 (1.07-1.22)	1.11 (1.08-1.27)	1.06 (1.03-1.10)
Delivery of appropriate maternal prophylaxis rate (# delivery of appropriate prophylaxis per HIV+ women)	0.71 (0.58-0.86)	0.70 (0.53-0.86)	0.85 (0.70-0.96)

* rate can be more than 1 due to repeated testing during pregnancy

**Overall N=45, Public N=38, Privately-operated N=7

Health system factors with impact on access to HIV testing and maternal prophylaxis during Option B period (Nov. 2012- Oct. 2015) (table 4 and 5)

To better assess health system factors that may influence HIV testing and maternal prophylaxis services, we focus our assessment on the Option B period with the assumption that this period is most comparable to the current conditions of the PMTCT program in Côte d'Ivoire.

Geography, health facility size, available charts, on-site CD4 testing, delay between HIV test and ARV delivery, and stock-outs of general medical supplies (including lancet and Capillary tubes) and patient charts were found to not be significantly associated with either rate of testing or delivery of maternal prophylaxis ratio under Option B. However, we did find several facility-level factors that were significantly associated with HIV testing and/or provision of prophylaxis.

Health facility type

After adjusting for facility size, compared to urban health centers, we found that regional hospitals reported a 22% higher rate of HIV testing (p=0.01, 95% CI: 1.05, 1.42), while rural health centers and maternal child health posts had significant lower testing rates, by 4% lower (p=0.08; 95% CI: 0.93, 1.00) and 6% lower (p=0.03, 95%CI: 0.88, 0.99), respectively. There was no significant difference between urban health centers and general hospitals or health posts.

For the delivery of maternal prophylaxis, compared to urban health centers, regional hospitals and rural health centers had a 27% (p=0.02, 95%CI: 0.56, 0.94) and 47% (p<0.001, 95% CI: 0.48, 0.60) lower maternal prophylaxis ratio, respectively. Health posts reported a 24% higher ratio (p=0.001, 95% CI: 1.10, 1.40) after adjusting for facility size. The ratio in general health centers and maternal child health posts were not significantly different from that in urban health centers.

Public or privately-operated health facilities

After adjusting for facility size, the HIV testing rate was 8% lower in privately-operated facilities than that in public facilities (p<0.001, 95% CI: 0.87, 0.96), and the prophylaxis ratio was 23% higher in privately-operated facilities than that in public facilities (p=0.008, 95%CI: 1.06, 1.43).

Existence of a laboratory on site

After adjustment, the HIV testing rate was 11% higher in facilities with a laboratory than in facilities without a laboratory (p=0.002, 95% CI: 1.04, 1.18). But presence of a laboratory was not significantly associated with the prophylaxis ratio.

Stock-outs of ARVs

After adjustment, the HIV testing rate was 12% lower in facilities with stock-outs of ARVs compared to facilities without stock-outs of ARVs (p=0.046, 95% CI: 0.78, 1.00); however, the prophylaxis ratio was 41% higher in facilities with stock-outs of ARVs.

Stock-outs of HIV test kits

After adjustment, the HIV testing rate was 17% lower in facilities with stock-outs of HIV test kits (p=0.003, 95% CI: 0.79, 0.95); but HIV test kits stock-outs were not significantly associated with the prophylaxis ratio.

Stock-outs of general supplies

After adjustment, stock-outs of general supplies were not significantly associated with HIV testing rate, while the prophylaxis ratio was 21% lower in health facilities with stock-outs of general supplies (p=0.046, 95% CI: 0.63, 1.00) as compared to health facilities such without stock-outs.

Table 4: Estimated incident rate ratios of interest for HIV testing at first ANC visit, generated by Poisson regression models during Nov. 2012-Oct. 2015

Characteristic of health facilities	Tests	1st ANC	Rate (tests per 1st ANC)#	Crude			Adjusted		
				RR	95%CI	p-value	RR	95%CI	p-value
Geographic setting									
Urban	177	153	1.16	1	Reference		1*	Reference	
Rural	74	67	1.09	0.95	0.91, 0.99	0.01	0.95	0.89, 1.01	**0.09**
Facility type									
Urban health center	131	114	1.12	1	Reference		1*	Reference	
Regional hospital	119	87	1.37	1.22	1.06, 1.42	0.007	1.22	1.05. 1.42	**0.01**
General health center	247	212	1.18	1.05	0.98, 1.13	0.18	1.04	0.96, 1.12	0.32
Maternal child health post	172	160	1.05	0.94	0.89, 1.00	0.03	0.94	0.88, 0.99	**0.03**
Rural health center	85	79	1.08	0.96	0.92, 1.00	0.04	0.96	0.93, 1.00	**0.08**
Health post	75	67	1.12	1.00	0.96, 1.04	0.86	1.00	0.96, 1.05	0.92
Public/Privately-operated									
Public	174	149	1.16	1	Reference		1*	Reference	
Privately-operated	120	113	1.06	0.91	0.87, 0.96	<0.001	0.92	0.87, 0.96	**<0.001**
Facility size									
≤100 1st ANC visits/month	81	71	1.13	1	Reference		1**	Reference	
101~200 1st ANC visits/month	165	142	1.17	1.04	0.96, 1.13	0.30	1.04	0.96, 1.12	0.32
>200 1st ANC visits/month	315	273	1.16	1.03	0.94, 1.13	0.53	1.02	0.93, 1.12	0.66
Existence of a laboratory on site									
Yes	184	157	1.18	1	Reference		1***	Reference	
No	119	109	1.08	0.92	0.87, 0.97	0.003	0.90	0.85, 0.96	**0.002**
On-site CD4 testing									
Yes	200	173	1.17	1	Reference		1***	Reference	

No	121	106	1.12	0.95	088, 1.01	0.13	0.96	0.89, 1.04	0.30
Stock-outs of HIV test kits									
No	173	149	1.16	1	Reference		1***	Reference	
Yes	67	66	1.02	0.88	0.82, 0.96	0.003	0.87	0.79, 0.95	**0.003**
Stock-outs of ARVs									
No	172	148	1.16	1	Reference		1***	Reference	
Yes	96	88	1.04	0.90	0.80, 1.01	0.07	0.88	0.78, 1.00	**0.046**
Stock-outs of general medical supplies									
No	166	143	1.15	1	Reference		1***	Reference	
Yes	165	148	1.16	1.01	0.89, 1.15	0.82	1.02	0.90, 1.16	0.73
Stock-outs of patient charts									
No	188	162	1.16	1	Reference		1***	Reference	
Yes	119	103	1.14	0.98	0.92, 1.05	0.55	0.98	0.91, 1.05	0.60
Stock-outs of general supplies									
No	457	334	1.37	1	Reference		1***	Reference	
Yes	123	108	1.13	0.82	0.78, 0.87	<0.001	0.89	0.77, 1.02	**0.09**

*: adjust for facility size

**: adjust for public/ privately-operated

***: adjust for public/ privately-operated and facility size

#: rate can be more than 1 due to repeated testing during pregnancy

Table 5: Estimated incident rate ratios of interest for delivery of appropriate maternal prophylaxis, generated by Poisson regression during Nov. 2012-Oct. 2015

Characteristic of health facilities	Numerator[&]	Denominator[^]	Ratio[#]	Crude			Adjusted		
				RR	95%CI	p-value	RR	95%CI	p-value
Geographic setting									
Urban	6.52	8.27	0.74	1	Reference		1[*]	Reference	
Rural	2.20	3.27	0.67	0.91	0.70, 1.18	0.47	1.01	0.76, 1.34	0.94
Facility type									
Urban health center	4.11	5.56	0.75	1	Reference		1[*]	Reference	
Regional hospital	4.33	8.36	0.52	0.70	0.54, 0.90	0.006	0.73	0.56, 0.94	**0.02**
General health center	10.33	12.03	0.71	0.95	0.75, 1.21	0.68	0.82	0.67, 1.00	**0.05**
Maternal child health post	5.98	7.01	0.90	1.20	1.04, 1.39	0.01	1.12	0.90, 1.41	0.31
Rural health center	1.01	2.67	0.38	0.51	0.46, 0.55	<0.001	0.53	0.48, 0.60	**<0.001**
Health post	3.50	4.06	0.86	1.16	1.05, 1.27	0.003	1.24	1.10, 1.40	**0.001**
Public/Privately-operated									
Public	6.29	8.09	0.71	1	Reference		1[*]	Reference	
Privately-operated	4.74	5.66	0.83	1.16	1.00, 1.35	0.046	1.23	1.06, 1.43	**0.008**
Facility size									
≤100 1st ANC visits/month	2.58	4.15	0.68	1	Reference		1[**]	Reference	
101~200 1st ANC visits/month	5.30	7.45	0.72	1.05	0.87, 1.27	0.58	1.06	0.89, 1.27	0.51
>200 1st ANC visits/month	12.94	14.27	0.83	1.22	0.98, 1.52	0.08	1.25	1.00, 1.56	0.05
Available charts (per 10 %)				1.02	0.99, 1.04	0.25	1.01[***]	0.99, 1.03	0.36
Existence of a laboratory on site									
Yes	7.20	8.96	0.73	1	Reference		1[***]	Reference	
No	3.15	4.59	0.72	0.98	0.81, 1.19	0.84	1.08	0.88, 1.32	0.47

On-site CD4 testing									
Yes	7.64	9.54	0.73	1	Reference		1***	Reference	
No	3.98	5.36	0.74	1.01	0.85, 1.20	0.87	1.09	0.91, 1.31	0.36
# of days between HIV test and ARV delivery (mean)	6.05	7.72	0.73	1.00	1.00, 1.00	0.28	1.00[a]	1.00, 1.00	**0.05**
Stock-outs of HIV test kits									
No	6.31	7.98	0.73	1	Reference		1***	Reference	
Yes	2.29	4.08	0.72	0.99	0.59, 1.64	0.96	1.16	0.69, 1.97	0.58
Stock-outs of ARVs									
No	6.24	8.01	0.72	1	Reference		1***	Reference	
Yes	4.06	4.74	0.87	1.22	0.96, 1.53	0.10	1.41	1.11, 1.79	**0.005**
Stock-outs of general medical supplies									
No	5.20	7.36	0.70	1	Reference		1***	Reference	
Yes	9.52	9.21	0.85	1.21	0.94, 1.54	0.14	1.17	0.98, 1.39	**0.08**
Stock-outs of patient charts									
No	7.14	8.98	0.74	1	Reference		1***	Reference	
Yes	3.73	5.13	0.72	0.98	0.84, 1.14	0.80	1.06	0.92, 1.23	0.43
Stock-outs of general supplies									
No	14.38	17.18	0.83	1	Reference		1***	Reference	
Yes	4.17	5.76	0.75	0.90	0.81, 1.01	0.09	0.79	0.63, 1.00	**0.046**

&: number of initiated treatment (ART) per month + number of received ARV prophylaxis per month

^: number of tested HIV-positive in antenatal care per month + number of known HIV-positive cases in antenatal care per month + number of tested HIV-positive at maternity per month + number of known HIV-positive cases at maternity per month

#: delivery of prophylaxis per HIV-positive women

*: adjust for facility size

**: adjust for public/privately-operated

***: adjust for public/privately-operated and facility size

Similarities and differences from Option A period to Option B period (table 6 & 7)

We compared the results from adjusted Poisson models during the Option A period and the Option B period and highlighted similarities and differences in the characteristics found to have an association in one or both periods with a p-value <0.10 for the outcomes of interest. See Table 6-7.

Geographic setting

The HIV testing rate at rural facilities was significantly lower than the rate at urban facilities during the Option A period, while the difference was not significant during the Option B period. The difference in prophylaxis ratios were not significantly different between urban and rural facilities in either period.

Health facility type

Compared to urban health centers, regional hospitals had statistically higher rates of HIV testing during the option B period, but during the Option A period, there was no similar statistical difference; however, regional hospitals had consistently lower prophylaxis ratios during both periods. Rural health center had lower prophylaxis ratios during Option B period but not in Period A; however, rural health center had consistently lower HIV testing rate during both periods. General hospitals had better performance in HIV testing during the Option A period, but the difference was not significant during the Option B period, For the prophylaxis ratio, they were lower in Option B period but not in the Option A period. Maternal child health posts had lower HIV testing rates in the Option B period but not in the Option A period; and they had higher delivery ratio of maternal prophylaxis during Period A, but the difference was not significant. Health posts had similar HIV testing rates with urban health centers during both the Option A and the Option B periods; but the maternal prophylaxis ratio was higher in health posts during the Option B period.

Public/privately-operated facilities

During both the Option A and Option B periods, privately-operated health facilities had lower HIV testing rate but higher delivery ratio of maternal prophylaxis than those in public health facilities.

Existence of a laboratory on site

The HIV testing rates were higher among facilities with a laboratory on site during both Option A and Option B periods. But there was no significant difference with prophylaxis ratio in either period.

Facility size

Larger health facilities (>200 1st ANC visits/month) had higher prophylaxis ratio than smaller health facilities (≤100 1st ANC visits/month) during the Option A period, but the difference was not significant during the Option B period.

Available charts

Facilities with a higher percentage of expected patient charts available on site during data collection had higher prophylaxis ratio during Option A period, but not during Option B period.

Stock-outs of HIV test kits

Health facilities with stock-outs of HIV test kits had lower HIV testing rate than facilities without stock-outs during Option B period, but not during Option A period.
On the contrary, health facilities with stock-outs of HIV test kits had higher prophylaxis ratio during Option B period, but not during Option A period.

Stock-outs of ARVs

Facilities with stock-outs of ARVs had lower HIV testing rate but higher prophylaxis ratio during Option B period, but no significant difference during Option A period.

Stock-outs of general medical supplies

There was no significant association with HIV testing rates and stock-outs of general medical supplies during both periods. Facilities with stock-outs of general medical supplies had higher prophylaxis ratio during Option B period, but no significant difference during Option A period.

Stock-outs of general supplies

Facilities with stock-outs of general supplies had higher HIV testing rate and lower prophylaxis ratio during Option B period, but no significant differences during Option A period.

Table 6. HIV testing rate in November 2011-November 2012 and November 2012-October 2015

Characteristic of health facilities	November 2011-October 2012			November 2012-October 2015		
	Adjusted			Adjusted		
	RR	95%CI	p-value	RR	95%CI	p-value
Geographic of health facility						
Urban	1*	Reference		1*	Reference	
Rural	0.83	0.69, 0.99	**0.04**	0.95	0.89, 1.01	0.09
Health facility type						
Urban health center	1*	Reference		1*	Reference	
Regional hospital	1.02	0.90, 1.15	0.81	1.22	1.05. 1.42	**0.01**
Rural health center	0.87	0.79, 0.91	**<0.001**	0.96	0.93, 1.00	0.08
General health center	1.10	1.02, 1.19	**0.02**	1.04	0.96, 1.12	0.32
Maternal child health post	1.00	0.79, 1.27	0.98	0.94	0.88, 0.99	**0.03**
Health post	0.95	0.88, 1.03	0.21	1.00	0.96, 1.05	0.92
Public/Privately-operated						
Public	1*	Reference		1*	Reference	
Privately-operated	0.93	0.85, 1.01	**0.08**	0.92	0.87, 0.96	**<0.001**
Existence of a laboratory on site						
Yes	1***	Reference		1***	Reference	
No	0.88	0.79, 0.99	**0.03**	0.90	0.85, 0.96	**0.002**
Stock-outs of HIV test kits						
No	1***	Reference		1***	Reference	
Yes	1.02	0.89, 1.17	0.78	0.87	0.79, 0.95	**0.003**
Stock-outs of ARVs						
No	1***	Reference		1***	Reference	
Yes	0.94	0.87, 1.02	0.15	0.88	0.78, 1.00	**0.046**
Stock-outs of general supplies						
No	1***	Reference		1***	Reference	
Yes	0.93	0.70, 1.22	0.59	0.89	0.77, 1.02	0.09

*: adjust for public/privately-operated and facility size; **: adjust for facility size; ***: adjust for public/privately-operated

Table 7. Delivery of appropriate maternal prophylaxis in November 2011-November 2012 and December 2012-October 2015

Characteristic of health facilities	November 2011-October 2012			November 2012-October 2015		
	Adjusted			Adjusted		
	RR	95%CI	p-value	RR	95%CI	p-value
Health facility type						
Urban health center	1*	Reference		1*	Reference	
Regional hospital	0.79	0.61, 1.02	**0.07**	0.73	0.56, 0.94	**0.02**
Rural health center	1.13	0.95, 1.35	0.17	0.53	0.48, 0.60	**<0.001**
General health center	1.16	0.90, 1.50	0.26	0.82	0.67, 1.00	**0.05**
Maternal child health post	1.42	1.04, 1.93	**0.03**	1.12	0.90, 1.41	0.31
Health post	1.03	0.86, 1.24	0.75	1.24	1.10, 1.40	**0.001**
Public/Privately-operated						
Public	1*	Reference		1*	Reference	
Privately-operated	1.28	1.08, 1.53	**0.005**	1.23	1.06, 1.43	**0.008**
Facility size						
≤100 1st ANC visits/month	1**	Reference		1**	Reference	
101~200 1st ANC visits/month	1.01	0.80, 1.29	0.91	1.06	0.89, 1.27	0.51
>200 1st ANC visits/month	1.39	1.09, 1.77	**0.01**	1.25	1.00, 1.56	0.05
Available charts (per 10 %)	1.04***	1.01, 1.08	**0.01**	1.01***	0.99, 1.03	0.36
# of days between HIV test and ARV delivery (mean)	1.00***	1.00, 1.00	1.00	1.00[a]	1.00, 1.00	**0.05**
Stock-outs of HIV test kits						
No	1***	Reference		1***	Reference	
Yes	0.77	0.57, 1.03	**0.08**	1.16	0.69, 1.97	0.58
Stock-outs of ARVs						
No	1***	Reference		1***	Reference	
Yes	1.00	0.82, 1.21	0.96	1.41	1.11, 1.79	**0.005**

Stock-outs of general medical supplies						
No	1***	Reference		1***	Reference	
Yes	0.97	0.69, 1.37	0.88	1.17	0.98, 1.39	**0.08**
Stock-outs of general supplies						
No	1***	Reference		1***	Reference	
Yes	0.78	0.38, 1.58	0.48	0.79	0.63, 1.00	**0.046**

*: adjust for public/privately-operated and facility size

**: adjust for facility size

***: adjust for public/privatel-operated

DISCUSSION

This study revealed significant associations between HIV testing in ANC and the following system-level factors under PMTCT Option B: health facility type, public or privately-operated of the facility, the existence of a laboratory on site, and stock-outs of both ARVs and HIV test kits. In addition, the study also identified significant associations between the delivery of appropriate maternal prophylaxis under Option B and the following system-level factors: health facility type, public or privately-operated of the facility, and stock-outs of both ARVs and general supplies. Specifically, the HIV testing rate was highest in regional hospitals and lowest in maternal and child posts. The delivery ratio of appropriate maternal prophylaxis was highest in health posts and lowest in rural health centers. It should be noted that there was only one rural health center and one health post in those 46 eligible sites. After excluding these two sites, the delivery ratio of appropriate maternal prophylaxis was lowest in regional hospitals and no significant difference was noted among urban health centers, general health center and maternal child health posts. Privately-operated facilities had lower HIV testing rates but higher delivery ratio of appropriate maternal prophylaxis as compared to public facilities. Having a laboratory on site was associated with higher HIV testing rate. Stock-outs of ARVs were associated with lower HIV testing rates but higher prophylaxis ratios. Stock-outs of HIV test kits were only associated with lower HIV testing rates. On the other hand, stock-outs of general supply were associated with lower prophylaxis ratios and not with testing rates.

In comparing the Option A and B periods, some factors were significantly associated with the two outcomes under Option A period but not under Option B. Notably, the HIV testing rate during the Option A period was significantly lower in facilities in rural areas than in facilities located in urban areas. The prophylaxis ratio during the Option A period was higher in facilities with large volume activities (>200 1st ANC visits/month) as compared to facilities with smaller volume of activities. The prophylaxis ratio was also higher in facilities with higher percentage of available charts.

Uptake of PMTCT

Although documented increases in the uptake of ARVs by pregnant women since WHO PMTCT guidelines were announced shows that PMTCT service delivery efforts have been effective[2], WHO estimates that, globally, an estimated 54% of pregnant women were not tested for HIV in 2013[22] and only 76% of all HIV-positive pregnant women accessed medicines for PMTCT in 2016.[23] Previous studies showed that the HIV testing rate among pregnant women attending antenatal care in sub-Saharan African countries was 45-70%, and only 50-85% of identified HIV-positive women were provided with ARV prophylaxis in ANC by 2015.[18,24,25,26]

The parent study in Côte d'Ivoire estimated that the HIV testing rate was 83% during the final 12 months of Option A period (November 2011- October 2012), and 92% during 12-months prior to the first Option B+ training (November 2014 - October 2015).[9] In this analysis, the data from the Option B period includes all time between the official roll-out of Option B as a national policy (November 2012) through the formal adoption of Option B+ in October 2015. Also in contrast to the parent study, for the purposes of this study, the HIV testing rate refers to HIV tests conducted during all ANC visits per ANC1 visit, due to large amounts of missing data in the number of HIV tests conducted during ANC1. The HIV testing rate in this study is often reported at >100% due to repeated testing during pregnancy. However, an HIV testing rate

of >100% does not necessarily mean that all pregnant women got tested. Thus, the HIV testing rate in this study is more important in terms of understanding the association with system-level factors, and should not be interpreted as an individual-level testing rate. The delivery ratio of 71% [58-68] for appropriate maternal prophylaxis during Option B period (November 2012 to October 2015) is similar to the UNAIDS estimate of 73% [56-87] of pregnant women with HIV in Côte d'Ivoire received ARVs in 2015,[27] but slightly lower than the 79% found by the parent study which only considered the last 12 months of Option B implementation.[9]

System-level factors of interest

Facility Location, Size, and Type

While health facilities located in urban areas were associated with better performance in HIV testing rate among pregnant women during the Option A period compared to facilities located in rural areas, the difference was not significant during the Option B period. An explanation for this could be that gaps between urban and rural facilities in this study have narrowed throughout time. Although, the small number of health facilities in rural areas in the study may have limited the representativeness of the result. More symmetrical samples of facilities located in urban and rural areas should be included in future studies in order to better understand the association between location of facilities and uptake of PMTCT services.

Facility size was measured by the number of ANC visits per month in each site in this study because the catchment area data was not representative of size due to overlap, but no significant association was found. However, facility type may be a proxy for catchment population. In this study, comparing to urban health centers, regional hospitals and general health centers had the larger catchment population, and had higher HIV testing rates but lower prophylaxis ratio. Health posts had the smallest catchment population and had higher prophylaxis ratio during Option B period.

Some studies showed that larger facility size was associated with poor performance. A study found that health facilities with small or medium numbers of ANC attendance had performed better in treatment delivery in PMTCT services, compared to facilities with larger numbers of ANC attendance (>100 per month).[26] Another study in Mozambique in 2012 showed that larger catchment population sizes was associated with high clinic performance.[16] Although no significant association was found between the number of ANC visits per month and outcomes in our study, health facilities with larger catchment population had higher HIV testing rate but lower prophylaxis delivery. This might imply that when a health facility serves a larger population, it might have bigger challenges to follow up pregnant women after HIV tests. It is hard to understand the relationship between facility size and the two outcomes without information about availabilities of human resource (HCW-to-patient ratio).

Related to facility size and catchment area, availabilities of human resource has been shown elsewhere to be associated with uptake of PMTCT services. Several qualitative studies have reported health provider perceptions that high patient loads lead to long waiting-times,[11,28] poor quality of counselling about PMTCT,[29] staff stress, and staff failings and misunderstandings,[17] which led to poor clinic performance. The relationship of patient loads and the uptake of PMTCT services were also shown in some quantitative studies.[16,19] The study in Mozambique found that higher numbers of health care workers were associated with high clinic performance.[16] Another study in Ethiopia found that the uptake of PMTCT services increased

by 7.2 times with every additional nurse per 1500 patients.[19] Although we did not include human resource factors in this analysis, an earlier investigation using the same project data showed that the associations between workforce patterns and PMTCT service delivery were small. It estimated that an additional healthcare worker trained per year only increased testing for only 7.7 patients per year. Given these findings, in this context, additional staff hiring does not appear to be a cost-effective way to improve PMTCT delivery in isolation.[20]

In this study, privately-operated health facilities were associated with low HIV testing rates but higher provision of prophylaxis. In a longitudinal assessment study of PMTCT programs conducted during 2000 and 2011 in sub-Saharan African countries, non-governmental organizations (NGOs) and international agencies (IAs) had higher treatment delivery rates compared to government organizations.[26] The similar findings might suggest that even though public health facilities have higher HIV testing rates for pregnant women in our study, more pregnant women were lost to follow up between HIV test and delivery of maternal prophylaxis in public health facilities. Some potential reasons might help understand the difference. First, a relatively higher percentage of available charts and less frequency of stock-outs in privately-operated health facilities in this study might contribute to better follow-up from HIV tests to the delivery of treatment. Secondly, public health facilities had generally bigger facility size than privately-operated facilities in this study, which might lead to high demand of services in public facilities. Also, privately-operated facilities with smaller size might have fewer decision makers and layers of regulations, which can lead to more nimble operation to develop and mobilize resources, and implement and modify programs.[26] Thirdly, pregnant women who attend privately-operated facilities are likely to be wealthier and more educated, and maybe more likely to follow up with care due to access to these material and immaterial resources.[30]

Availability of Complementary Services

In this study, health facilities with a laboratory on site had higher HIV testing rate, but no significant association with prophylaxis ratios. Also, neither providing on-site CD4 services nor delay of delivery of ARVs after HIV testing were significantly associated with either of the outcomes. In other studies, inadequate laboratory capacity in sub-Saharan African countries limited pregnant women getting PMTCT services.[16,31,32] A study in Ethiopia revealed that adding one laboratory technician for every 3100 people improved the odds of getting PMTCT services for a mother by 9.27 fold.[19] Delay of delivery of ARVs after HIV testing, which might be caused by waiting for CD4 counts results, was thought to reduce the likelihood of women accessing PMTCT services.[33] Failing to find a significant association between existence of laboratory and CD4, and delay of prophylaxis delivery with prophylaxis ratios in this study might imply that there were other factors impacting the maternal prophylaxis delivery under Option A and Option B. In this context, confusing and complex treatment regime under different guideline for health workers might be a possible barrier for delivering maternal prophylaxis even with CD4 counts result, which is mentioned by health community workers in the parent study during Option A.[9] Although treatment regime was simpler under Option B, it might still impact the maternal prophylaxis delivery.

Availability of PMTCT-related Supplies and Tools

Although no significant association was found between available charts and prophylaxis ratio during Option B period, we are not denying the importance of effective data collection and management, especially since charts are typically opened after HIV testing and concurrently with initial delivery of ARVs. Failure to document patients and medical activities poses challenges to data use, monitoring, and evaluation of PMTCT services.[34] In this project, an Active Patient Tracking (APT) intervention was piloted from August 2015 in 30 of the 46 sites. A toolkit aimed at patient identification, chart identification, patient flow mapping, and health information system mapping were provided to each site. It ended up increasing the total number of available patients charts significantly, resulting in overall higher number of patients with documented retention in care.[9] In Uganda, a new approach that employed a weekly reporting system for PMTCT program data using short message service technology was adopted in 2012. It allowed a real-time monitoring system and enabled leaders in Uganda to response to programmatic problems more quickly and improved the PMTCT service.[34] While paper records are still used commonly in many resource-limited settings, innovative interventions or approaches should be considered with the goal of improving the data quality in PMTCT programs. Also, future research is needed for understanding how chart availability impacts long-term retention.

Moreover, in this study, Stock-outs of HIV test kits and ARVs were both associated with lower HIV testing rate, but stock-outs of ARVs were associated with higher prophylaxis ratios during Option B period. Stock-outs of HIV test kits or ARVs were reported in 30.4% health facilities during the Option A period and 13.4% during the Option B period, respectively. In other studies, stock-outs of material (including stock-outs of HIV test kits, and drugs) was noted in many resource-limited settings.[16,17,18] The inverse association between stock-outs of material and uptake of PMTCT services were mentioned in several qualitative studies.[11,29] Although, in one quantitative study, stock-outs of material were not significantly associated with clinic performance.[16] In this study, the interpretation of the higher prophylaxis ratio in facilities that reported stock-outs of ARVs is that health facilities with higher prophylaxis delivery ratios experience more frequent stock-outs of ARVs (prophylaxis ratio: 87% among facilities with stock-outs of ARVs vs 72% among facilities without stock-outs of ARVs) because they were depleting their ARV supplies but did not have a robust supply chain in place to maintain adequate stocks (Table 5). This might imply the weakness of supply chain system in both public and privately-operated facilities and different size facilities. Stock-outs of ARVs were not significantly associated with HIV testing rate or prophylaxis ratio during Option A period, which may indicate that supply chain of ARVs is more important in situations where more pregnant women are eligible to initiation of ARVs.

Limitations

There are several limitations in our study including selection bias, misclassification, and information bias. Selection bias occurred based on the eligibility requirement that sites had reported 10 or more new HIV cases in 2013. Therefore, this study is more likely to represent larger (and more urban) health facilities in Côte d'Ivoire.

Another limitation is potential misclassification. Misclassification relates to the Option A and the Option B time periods. We used the official date of transition of the national policy as

the cut-off between the Option A period and the Option B period. However, in reality, roll-outs of new national strategies occur more gradually. Therefore, misclassification may occur when some records in the Option B period were actually generated when the sites were still following the Option A guidelines. This could have distorted the between-period comparisons of the associations between system-level factors and the two outcomes.

Additional limitations in our study relate to information bias caused by data quality. Firstly, recall bias might have played into the retrospective reporting of frequency and length of stock-outs, as stock-outs information was obtained through informal interviews with health facility staff. Secondly, as mentioned in the methods section, the availability of records for key variables varied among facilities. The considerable amount of missing data limited our ability to precisely measure the outcome variables. For example, HIV testing rate was defined as all HIV tests during all ANC visits per ANC1 because of the poor quality of records about HIV tests conducted during ANC1. Although we chose to use variables with less percentage of missing data, the imputation process might affect the significance of associations in analysis as well. It is hard to measure the effect of this, given that all the variables we used to define outcome variable had at least 20% and 5% missing data during the Option A period and the Option B period, respectively. However, our study focused on the association between outcome variables and system-level factors instead of only focusing on how HIV testing rate and prophylaxis ratio change. How this could affect the result is not clear and would depend on if the occurrence of missing data is associated with any system-level factors. Moreover, comparing the Option A period and the Option B period, the data quality differed between the two periods. For example, more missing data existed during the Option A period compared to the Option B period, especially for some indicators of interest (Table 1). This might limit this study to detect the difference of the associations between system-level factors and key measure during two periods.

Temporality is another limitation of this study. Causation cannot be confirmed when it is unclear whether the exposure caused the outcome or the outcome caused the exposure. For example, information about stock-outs of ARVs was collected during the middle of the Option B period. Therefore, it is not clear whether stock-outs of ARVs caused higher prophylaxis ratio or high prophylaxis ratio caused the occurrence of stock-outs of ARVs. Thus, we do not know whether improving the supply chain will increase prophylaxis, or whether facilities with high prophylaxis need better supply chains. Regardless, the supply chain of ARVs is more important under option B and Option B+. Further studies are needed to understand whether we should improve the overall supply chains of ARVs or focus on providing better supply chains to health facilities with higher prophylaxis first.

Although we identified likely confounders, it is possible that there were other relevant unmeasured confounds. Our study tried to understand how a particular system-level factor affected the first two steps of the PMTCT cascade, which might tell us how to further increase the total number of pregnant women who complete PMTCT services. Future research is needed to better understand how a particular system-level factors would contribute to improved PMCTC retention after initiating ARVs, which is of great concern under Option B and Option B+ guidelines since more pregnant women are considered eligible for initiating ARVs.

Conclusion

This study provides an assessment of the specific relationships between system-level factors and HIV testing coverage and delivery of appropriate maternal prophylaxis. In summary, HIV testing rates were higher in public health facilities and health facilities with a laboratory on site, while the privately-operated health facilities performed better in the delivery of appropriate maternal prophylaxis. Thus, when access to HIV tests is improving in low prevalence areas, especially in public facilities, specific attention should be paid to risks of loss to follow up from HIV testing to delivery of ARVs. Facilities with larger catchment population had higher HIV testing rate but lower prophylaxis ratio, which implies that facilities which serve a bigger population might have bigger challenges to follow up pregnant women after HIV tests. Stock-outs of HIV test kits, general supply of ARVs limited the performance of HIV tests and maternal prophylaxis delivery. And supply of ARVs became more challenging when Option B guideline were applied, which is likely to be an increasingly important issue as Option B+ guidelines are implemented. This study also highlights the need for further research about the association between system-level and adherence to ARVs, which might be one of the biggest challenges to improving PMTCT in Côte d'Ivoire under Option B+.

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