Description and Impact of Continuous Quality Improvement of PMTCT Services in Sub-Saharan Africa

Christopher Wong

A thesis

Submitted in partial fulfillment of the

Requirements for the degree of

Master of Public Health

University of Washington 2018

Committee:

Kenny Sherr

Sarah Gimbel

Program Authorized to Offer Degree:
Department of Global Health

©Copyright 2018

Christopher Wong

University of Washington

Abstract

Description and Impact of Continuous Quality Improvement of PMTCT Services in Sub-Saharan Africa

Christopher Wong

Chair of the Supervisory Committee:

Kenny Sherr

Department of Global Health

The prevention of mother to child transmission of HIV (PMTCT) is a major global health problem and continuous quality improvement (CQI) has demonstrated a way to address this problem. A lot of work on CQI has demonstrated the efficacy of sequential, small interventions as a single intervention. This paper analyzes CQI for PMTCT at the level of each individual intervention by describing the interventions and their impact. In a secondary analysis of a database of longitudinal PMTCT cascade indicators from 17 facilities across Côte d'Ivoire, Mozambique, and Kenya, we find that there are many interventions that do not directly target these cascade indicators but nonetheless have a broad impact. There are a large number of interventions that focus on service reorganization and strengthening norms. When assessing the impact of individual interventions, we find that targeting an outcome on the PTMCT cascade does not necessarily correspond to an impact in that outcome and sometimes intervention is associated with worse outcomes. This study has important limitations due to bias from time varying covariates and endogeneity, and the suggested associations should be interpreted with caution.

I. Introduction

HIV transmission from pregnant mothers to their infants continues at high rates. In 2017, there were an estimated 1.1 million pregnant women with HIV. It was estimated that 19% of these women were not on antiretroviral (ARV) drugs (*Global Health Observatory Data*). In this same year, an estimated 180,000 infants contracted HIV (UNAIDS Communications and Global Advocacy). A 2012 systematic review in sub-Saharan Africa estimated that rates of HIV screening in antenatal care were 94% and 58% and rates of ARV coverage was 70% and 62% for clinics that had opt-out and opt-in testing respectively (Wettstein et al.).

Ministries of Health and NGOs have turned to continuous quality improvement (CQI) as one solution. Quality improvement as a field is broadly defined as "systematic and continuous action that leads to measurable improvement in health care services" with a characteristic focus on iterative cycles of interventions according to the plan-do-study-act model (*Quality Improvement*). CQI is promising because it is adaptable to varying contexts and creates a learning system to address complicated problems.

Numerous studies demonstrate improvement in PMTCT services associated with quality improvement efforts. Cascade indicators are facility-level measurements that assess the process of a woman and her infant completing the full spectrum of recommended HIV-related care. South Africa provides a dramatic example where formulation of quality improvement plans received national buy-in and dissemination. This was associated with dramatic improvements in cascade indicators nationally (Barker et al.; Kedar S Mate et al.; Youngleson et al.; Bhardwaj et al.). However, overwhelming desire to participate in CQI broke randomization in one study, weakening the available evidence for a causal relationship (Kedar S. Mate et al.). In Malawi, clinics that underwent quality improvement in coordination with a university-affiliated program tended to outperform national cascade indicators (Herce et al.). In Tanzania, Haiti, and Malawi, clinics demonstrated improved indicators after quality improvement efforts, but these studies lack comparison groups (Gamell et al.; Joseph et al.; Hoog et al.).

Experimental and quasi-experimental studies are emerging. Tanzania's nation-wide scale up of quality improvement for PMTCT and their defense force facilities demonstrated effectiveness in a quasi-experimental design (Mwidunda and Eliakimu; Y. M. Kim et al.; Bazant et al.). A randomized controlled trial in Northern Nigeria did not find statistical significance in any primary outcomes, but the study did find a significant difference in early infant testing (Oyeledun et al.). We have previously reported findings from a RCT that demonstrated large and favorable effect sizes in the change of PMTCT cascade indicators that showed significant improvements from baseline when stratified by country (Alison S Rustagi et al.). Protocols for additional experimental designs and metanalyses have been published (Yotebieng et al.; Cowan et al.; Landes et al.).

There is strong evidence for the effectiveness of quality improvement in PMTCT in Sub-Saharan Africa, but it is not clear what factors predict successful quality improvement interventions. Past research has focused on patient characteristics and demographics associated with loss to follow up in PMTCT (Flax et al.; M. H. Kim et al.; Creek et al.; Wettstein et al.; Tweya et al.). There is some literature that assesses more systemic factors. Past qualitative work investigated policy and clinic level factors, mainly drawing upon expert opinion and the expnerience of the health workforce (Aarons et al.; Nuwagaba-Biribonwoha et al.). Research from North-Central Nigeria suggests that lost to follow up is

associated with institutional factors like the year someone happened to give birth or the clinic where mothers received care (Aliyu et al.).

In sum, the literature surrounding CQI in PMTCT in low and middle-income countries has demonstrated individual reports and case studies of effective continuous quality improvement now with an emerging experimental body of evidence. However, the literature has not described CQI at the granular level of the individual interventions that in sum make up CQI, nor have there been attempts to investigate how different types of interventions differentially impact outcomes. The present study aims to describe these individual interventions and quantify the associated impacts across different categories of interventions.

II. Methods

A. Study design and setting

This is a secondary data analysis of data from two previous SAIA studies (Alison Silvis Rustagi et al.; Gimbel, Voss, et al.). Data was collected from health facilities in Kenya's Central and Eastern provinces, Mozambique's Sofala province, and Côte d'Ivoire's Vallée du Bandama Department. At the start of data collection in 2012, the national HIV prevalence among adults (15-49 years old) in these countries were 3.2% in Côte d'Ivoire, 6.1% in Kenya, and 11.1% in Mozambique (UNAIDS). Option B+ had been implemented by 2012 in Côte d'Ivoire and Kenya as national policy (Gimbel and Rustagi). In Mozambique, the Ministry of Health implements a combination of Option B+ and Option A (Gimbel and Rustagi).

Facilities were selected following several steps. First, the study team began with all public and non-profit health facilities with pMTCT services in the study regions. Clinics were excluded if they were more than 20 kilometers from a main transport corridor, refused to participate, or were participating in a similar systems enhancement technique. Out of an original 90 clinics, 55 met eligibility criteria. 36 of these facilities underwent stratified randomization based on country and high versus low ANC volume[1](Gimbel and Rustagi). 18 of these facilities received the quality improvement intervention, but one facility in Kenya refused to participate in the intervention. The present secondary data analysis consists of the 17 facilities that underwent the intervention.

B. Description of intervention

Each of these clinics received the SAIA intervention. This is a CQI initiative that consists of five iterative steps (Gimbel, Rustagi, et al.) These steps are identifying and prioritizing areas for improvement, process mapping, implement facility workflow adaptation to eliminate bottlenecks, assess workflow modification effect on PMTCT cascade, and repeating analysis and improvement cycles. Each intervention facility was introduced to these steps over a 4-day training period by a study nurse. Each cycle through these steps lasted 4 to 6 weeks on average and all the cycles together lasted 9 months from February 2014 to November 2014.

[1] High and low ANC volume was defined as having ANC volume above or below the 50th percentile for the clinics listed in their respective country.

C. Data collection

Data on facility-level characteristics were obtained using a survey administered from 2012-2013 using a combination of facility visits, interviews with staff and managers, district-level data on human resources, registers, and the routine health information system (Gimbel, Voss, et al.). To insure quality data, these surveys were piloted in Portuguese, French, and English, and all data were double entered for accuracy. This data collected for a separate study, and so did not include all 17 study facilities. This missing data for key variables were collected individually after the initial survey. Data on facility-level PMTCT cascade outcomes from 2013-2015 came from health facility registries extracted by two trained study team members (Gimbel and Rustagi). Data on individual micro-interventions were based on semi-structured group interviews with health facility staff.

D. Analysis

Analysis consisted of qualitatively categorizing interventions, describing facility characteristics stratified by country, describing the distribution of intervention categories across facilities, and regressing facility-level outcomes over cumulative sums of interventions and potential confounders.

Three facility-level PMTCT outcomes were calculated to correspond with different key points in the PMTCT cascade. Outcome 1 was the odds that a woman was tested for HIV at her first antenatal care visit (ANC1). Outcome 2 was the odds that a HIV positive woman was prescribed ARV at ANC1. Outcome 3 was the odd that an HIV exposed infant (HEI) would be tested for HIV using dried blood spot DNA PCR (DBS). The denominator for outcome 3 includes a projected number of newborns eligible for DBS screening in a given month. This projection was made by recording gestational age in 10 HIV positive and 10 HIV negative women from October 2013 to December 2013. The percent of women at each gestational age served as weights for the number of ANC visits over the 9 months leading up to the month of interest. This weighted sum gave the project number of newborns eligible for screening by DBS.

$$Outcome\ 1 = \frac{Number\ screened}{1 - \ Total\ number\ of\ ANC1}$$

$$Outcome\ 2 = \frac{Number\ of\ monthly\ ARV\ perscriptions}{1 - \ Number\ of\ HIV + women}$$

$$Outcome\ 3 = \frac{Number\ of\ HEI\ screened\ within\ 6\ wks\ of\ birth}{1 - Projected\ number\ of\ newborns\ eligible\ for\ screening}$$

1. Qualitative analysis

Qualitative analysis consisted of coding the descriptions of interventions in two different ways: (1) the outcome that they most targeted and (2) the type of intervention that was executed. In August 2015, programmatic staff at the University of Washington, Health Alliance International, and counterparts in Kenya, Mozambique, and Côte d'Ivoire gathered in Seattle to form an end of study team. The study team met in small groups to iteratively code the interventions. Next, a larger group met to resolve discrepancies. The study team assessed each intervention and recorded the sum of interventions in each category for each round of interventions. The coding was not mutually exclusive.

In June 2018, these sums over each round were used as the basis for coding each individual intervention. For the present study, coding was made mutually exclusive for interpretability of

covariates. Although interventions could theoretically target more than one outcome, they tended to effect one most predominantly or impact some broad outcome best categorized as "other." Coding was completed as closely as possible to the original end of study team's insights, and the coder consulted with a member of the end of study team on any divergence from the end of the team's work. We report summary statistics on the distribution of types of interventions and what outcomes they targeted stratified by facility characteristics and baseline outcomes.

2. Descriptive statistics

We report descriptive statistics for the 17 clinics included in the study. We report quartile of facility catchment area, year of the start of PMTCT services, status as either a public or private facility, quartile of monthly first antenatal care visits (ANC1), number of nurses, and the ratio of average monthly ANC1 and number of nurses. We stratify these results by country. We also quantify the distribution of the types of interventions across facility characteristics.

3. Statistical modeling

We used a generalized linear mixed model to account for clustering by facility. We separately regress three outcomes over the time in months since study start, year that facilities started offering PMTCT services, country, the cumulative sum of interventions targeting outcome 1, the cumulative sum of interventions targeting outcome 2, the cumulative sum of interventions targeting outcome 3, and the cumulative sum of interventions that target a miscellaneous outcome. Changing focus to interventions categorized by type rather than target, we also individually regressed the three outcomes over months since study start, year that facilities started offering PMTCT services, country, and the cumulative sums of interventions categorized under service reorganization, patient knowledge, communication, data, and strengthening norms. For these models, we used maximum likelihood estimation. We utilized a diagonal correlation structure, which assumes that within-subject errors do not have serial correlation. We assign a random effect for each facility as mentioned earlier. We do not include random slopes for the cumulative sums of interventions because these interventions only take place over 9 months within 27 measured months. We report odds ratios with 95% confidence intervals.

III. Results

A. Description of study sample

Descriptive analysis of the facilities demonstrates roughly similar facilities (Table 1). There are 5 facilities from Kenya because one facility randomized to intervention in the original study refused to participate. Health facilities in Côte d'Ivoire tended to be smaller in catchment size and volume of first antenatal care visits. Average baseline outcomes differed across countries. Kenya tended to have lower rates of screening women and prescribing ARVs, but higher rates of screening for HIV exposed infants.

B. Key Results

1. Results of Qualitative Analysis

The end of study team qualitatively decided upon categorizing interventions based on which outcome was targeted and the type of activity that was involved. When categorized by target, categories include interventions that targeted outcome 1, outcome 2, outcome 3, or "other". When categorized by type, the end of study team categorized interventions as service reorganization, patient knowledge, communication, data, or strengthening norms. Service reorganization refers to reordering

existing processes in the health facility to improve outcomes without adding new or substantive activities. Strengthening norms refers to a renewed commitment to execute a norm the health facility has been falling short of.

1. Results of Statistical Analysis

Table 2 reports the counts and proportions of interventions within each of these categories stratified by country. Results are notable for a large total number of interventions in Kenya (n = 82) compared to Côte d'Ivoire (n = 35) and Mozambique (n = 42). Among the 82 interventions in Kenya, service reorganization (n = 39) and strengthening norms (n = 30) when categorized by type and interventions that targeted "other" outcomes (n = 30) predominated when categorized by target. Overall, the interventions that targeted the "other" outcome made up the largest category when coded by target, and interventions categorized as service reorganization or strengthening norms made up 64.8% of all interventions when coded by type.

Table 3 reports odds ratios with 95% confidence intervals derived from the unadjusted model. In both models categorizing by target and type, we observe odds ratios for outcomes 1 and 2 significantly below 1 when comparing observations differing by 1 month. Because the cumulative sum of interventions is held constant, this time covariate represents time since the last intervention was initiated, not time longitudinal across the entire study period.

Facilities that planned one additional intervention targeting screening at ANC1 had significantly higher odds of screening at ANC1 (OR 1.37; CI 1.32-1.43). However, there was no significant improvement in odds of ARV prescription of HEI screening when comparing facilities differing by an additional intervention targeting the respective outcomes. Notably, interventions categorized as targeting the "other" outcome were associated with significantly improved odds of screening at ANC1 (OR 1.62; CI 1.54-1.7), ARV prescription (OR 1.28; CI 1.17-1.4), and HEI screening (OR 1.45; CI 1.29-1.64).

Focusing on the models that regressed over categorization by type, we observe that facilities differing by one intervention dedicated to service reorganization had significantly higher odds of screening at ANC1 (OR 1.59; CI 1.52-1.66), ARV prescription (OR 1.22; 1.09-1.35), and HEI screening (OR 1.21; 1.05-1.37). Similarly, facilities differing by one additional intervention focusing on data were associated with improved odds of screening at ANC1 (OR 1.29; CI 1.2-1.38), prescription of ARV (OR 1.34; CI 1.2-1.51), and screening of HEI (OR 1.46; 1.29-1.66).

We also observe worsening outcomes with increasing interventions. For example, facilities differing by one intervention targeting HEI screening saw worsening of odds of screening women at ANC1 (OR .91; CI .87-.95). Facilities differing by an additional intervention that improved patient knowledge had lower odds of ARV prescription (OR .75, CI .68-.86), and those differing by an additional intervention categorized as strengthening norms had lower odds of HIV screening at ANC1 (OR .92; 0.88-0.96).

IV. Discussion

Two observations are gleaned from the descriptive analysis of the interventions. First, many interventions do not seem to directly target outcomes. The category for interventions that targeted an outcome other than those explicitly part of the PMTCT cascade made up 35.8% of interventions across all countries. Second, health facilities in different countries took different approaches to micro-

interventions. Kenya favored service reorganization and strengthening norms by a large margin. Mozambique and Côte d'Ivoire a more even distribution of interventions across categories, but Mozambique had a lower number of interventions on communication while Côte d'Ivoire completed more interventions in data and strengthening norms. The past studies discussed earlier treat continuous quality improvement as a single intervention. Specific details about the individual interventions are not reported. Our descriptive analysis provides more granular insights into what defines continuous quality improvement as an effective intervention for PMTCT.

Our statistical models provide insights into the impact of continuous quality improvement. Of importance, interventions that were categorized as targeting something other than the predefined outcomes were associated with improved odds of key outcomes. This provides preliminary evidence in favor of flexibility as one of the core strengths of continuous quality improvement. Health facility staff may have expertise on their unique situations and continuous quality improvement empowers these intuitions by providing sufficient latitude for high impact decisions that could not be predicted on solely a general understanding of PMTCT. Considering that interventions that target the "other" category are prevalent, this provides preliminary suggestions that policy makers and programmatic personnel should at the very least avoid discouraging interventions if health facility personnel feel strongly about their benefit.

We did not find consistent evidence that interventions categorized as targeting a particular outcome impacts that outcome. Although interventions targeting screening at ANC1 were associated with improved odds of screening, we did not find similar patterns for interventions targeting ARV prescription of HEI screening.

Lastly, it is possible that interventions can worsen outcomes as we saw with interventions targeting HEI screening and those categorized as working on improving data and strengthening norms. This should be taken into context of the primary analysis of this data (Gimbel, Rustagi, et al.). Overall, we know that these interventions demonstrated improvements in outcomes and did not cause harm as a series of interventions. Future qualitative work on characterizing interventions associated with poorer outcomes may act as an opportunity to improve the overall impact of CQI. Another possible explanation is that this iterative cycle of trial and error is one factor that drives success of CQI.

V. Limitations

There are important limitations and sources of bias that should be addressed in further analysis of this data. These are primarily driven by the longitudinal structure of the data. First, there is the potential for confounding by indication. Facilities that do worse in certain outcomes may have targeted those outcomes, weakening any associations that would demonstrate the benefit of interventions targeting that outcome. Second, our covariates for the cumulative sum of interventions may be biased because they are being used simultaneously in a multivariate model. Our predictors of interest are cumulative sums of interventions, which are inherently dependent upon past interventions. These past interventions in turn may be associated with all cumulative sums of interventions, not just the single cumulative sum being tested. Thus, controlling for all other covariates while trying to interpret a single cumulative sum may ignore some of the true effect.

Future sensitivity studies may address this with inverse probability weighting. Probabilities may be modeled by using GEE to regress the probability of observing an exposure of interest over past

outcomes and other covariates. These weights would then be used in the main model regressing outcomes over a single cumulative sum. Applied to an example from this study, one might consider regressing the log odds of pregnant women screened at her first ANC visit over the cumulative sum of interventions targeting screening at ANC visits, weighted by the inverse probability as estimated by a model regressing the probability of observing different cumulative sums over all the covariates in our naïve model and previous outcomes. Extensive work must be done to fit such a model that accurately predicts the probability of exposure to these cumulative sums, but this would theoretically provide results free from the previously discussed bias (Robins et al.).

Tables

Table 1: Health facility characteristics

	Côte d'Ivoire	Kenya	Mozambique	Overall
n	6	5	6	17
Catchment (%)				
(1.8e+04,3.45e+04]	0 (0.0)	1 (20.0)	3 (50.0)	4 (23.5)
(3.45e+04,4.83e+04]	1 (16.7)	1 (20.0)	2 (33.3)	4 (23.5)
(4.83e+04,1.91e+05]	1 (16.7)	2 (40.0)	1 (16.7)	4 (23.5)
[54,1.8e+04]	4 (66.7)	1 (20.0)	0 (0.0)	5 (29.4)
Year of PMTCT Initiation (%)				
(2006,2007]	1 (16.7)	0 (0.0)	1 (16.7)	2 (11.8)
(2007,2010]	4 (66.7)	1 (20.0)	1 (16.7)	6 (35.3)
(2010,2013]	0 (0.0)	1 (20.0)	1 (16.7)	2 (11.8)
[2001,2006]	1 (16.7)	3 (60.0)	3 (50.0)	7 (41.2)
Public or Private (%)				
Public	4 (66.7)	5 (100.0)	4 (66.7)	13 (76.5)
Private	2 (33.3)	0 (0.0)	2 (33.3)	4 (23.5)
Average monthly number of ANC1 visits (%)				
(121,166]	0 (0.0)	3 (60.0)	1 (16.7)	4 (23.5)
(166,389]	0 (0.0)	2 (40.0)	2 (33.3)	4 (23.5)
(86.7,121]	3 (50.0)	0 (0.0)	1 (16.7)	4 (23.5)
[23.5,86.7]	3 (50.0)	0 (0.0)	2 (33.3)	5 (29.4)
Number of nurses (%)				
(17,152]	0 (0.0)	2 (40.0)	1 (16.7)	3 (17.6)
(4,6]	1 (16.7)	2 (40.0)	1 (16.7)	4 (23.5)
(6,17]	2 (33.3)	1 (20.0)	2 (33.3)	5 (29.4)
[3,4]	3 (50.0)	0 (0.0)	2 (33.3)	5 (29.4)
Monthly ANC1 visits divided by Nurses (%)				
(15.4,22.2]	2 (33.3)	1 (20.0)	1 (16.7)	4 (23.5)
(22.2,35.6]	1 (16.7)	1 (20.0)	2 (33.3)	4 (23.5)
(8.59,15.4]	2 (33.3)	1 (20.0)	1 (16.7)	4 (23.5)
[2.56,8.59]	1 (16.7)	2 (40.0)	2 (33.3)	5 (29.4)
Average proportion of ANC1 patients screened across baseline (mean (sd))	0.94 (0.04)	0.85 (0.07)	0.95 (0.07)	0.92 (0.07)
Average proportion of HIV+ patients prescribed ARV across base line(mean (sd))	0.83 (0.17)	0.55 (0.13)	0.76 (0.21)	0.72 (0.21)
Average proportion of HEI tested by PCR (mean (sd))	0.36 (0.13)	0.41 (0.14)	0.23 (0.17)	0.33 (0.16)

Number of facilities with refrigeration (%)	3 (50.0)	4 (80.0)	4 (66.7)	11 (64.7)
Number of facilities with air conditioning (%)	4 (66.7)	3 (60.0)	3 (50.0)	10 (58.8)

Table 2: Description of Interventions

	Côte d'Ivoire	Kenya	Mozambique	Overall
n	35	82	42	159
Category by target				
HIV Screening at ANC1	8 (22.9)	13 (15.9)	2 (4.8)	23 (14.5)
ARV Prescription	13 (37.1)	13 (15.9)	10 (23.8)	36 (22.6)
Screening for HEI	6 (17.1)	18 (22.0)	19 (45.2)	43 (27.0)
Other	8 (22.9)	38 (46.3)	11 (26.2)	57 (35.8)
Category by type				
Service Reorganization	7 (20.0)	39 (47.6)	10 (23.8)	56 (35.2)
Patient Knowledge	5 (14.3)	3 (3.7)	9 (21.4)	17 (10.7)
Communication	4 (11.4)	3 (3.7)	4 (9.5)	11 (6.9)
Data	10 (28.6)	7 (8.5)	11 (26.2)	28 (17.6)
Strengthening Norms	9 (25.7)	30 (36.6)	8 (19.0)	47 (29.6)

Table 3: Unadjusted models

	Outcome 1	Outcome 2	Outcome 3
Targets			
Date of PMTCT (centered)	1 (0.87-1.14)	1.04 (0.94-1.14)	0.92 (0.83-1.02)
Kenya	0.14 (0.05-0.38)	0.19 (0.09-0.42)	0.74 (0.32-1.71)
Mozambique	0.39 (0.16-0.96)	0.31 (0.15-0.63)	0.97 (0.46-1.07)
Months after intervention start	0.96 (0.96-0.97)	0.96 (0.95-0.97)	0.99 (0.95-1.02)
Interventions targeting outcome 1	1.37 (1.32-1.43)	1.25 (1.11-1.42)	1.03 (0.87-1.23)

Interventions targeting outcome 2	1.02 (0.97-1.09)	1.05 (0.93-1.19)	1.29 (1.12-1.48)
Interventions targeting outcome 3	0.91 (0.87-0.95)	1.12 (1.03-1.21)	1.08 (0.97-1.2)
Interventions targeting other	1.62 (1.54-1.7)	1.28 (1.17-1.4)	1.45 (1.29-1.64)
Categories			
Date of PMTCT (centered)	0.99 (0.88-1.12)	1.04 (0.95-1.14)	0.93 (0.85-1.01)
Kenya	0.16 (0.06-0.39)	0.19 (0.09-0.41)	1.05 (0.51-2.14)
Mozambique	0.35 (0.16-0.8)	0.31 (0.16-0.61)	1.03 (0.55-1.92)
Months after intervention start	0.95 (0.94-0.96)	0.96 (0.95-0.97)	0.98 (0.94-1.01)
Service Reorganization Interventions	1.59 (1.52-1.66)	1.22 (1.09-1.35)	1.21 (1.05-1.37)
Patient Knowledge Interventions	1.22 (1.12-1.32)	0.76 (0.68-0.86)	1.26 (1.09-1.47)
Communication Interventions	0.98 (0.86-1.13)	1.58 (1.27-1.97)	1.09 (0.86-1.36)
Data Interventions	1.29 (1.2-1.38)	1.34 (1.2-1.51)	1.46 (1.29-1.66)
Norm Strengthening Interventions	0.92 (0.88-0.96)	1.16 (1.02-1.32)	1.05 (0.91-1.21)

Aarons, Gregory A., et al. *Concept Mapping of PMTCT Implementation Challenges and Solutions Across 6 Sub-Saharan African Countries in the NIH-PEPFAR PMTCT Implementation Science Alliance*. Vol. 72, no. 0812, 2016, pp. 202–06.

Aliyu, M., et al. *Correlates of Suboptimal Entry into Early Infant Diagnosis in Rural North Central Nigeria*. Vol. 67, no. 1, 2015, pp. 1–16, doi:10.1097/QAI.0000000000000215.Correlates.

Barker, Pierre, et al. "The Role of Quality Improvement in Achieving Effective Large-Scale Prevention of Mother-To-Child Transmission of HIV in South Africa." *Aids*, vol. 29, no. April, 2015, pp. S137–43, doi:10.1097/QAD.0000000000000718.

Bazant, Eva, et al. "Effects of a Performance and Quality Improvement Intervention on the Work Environment in HIV-Related Care: A Quasi-Experimental Evaluation in Zambia." *Human Resources for Health*, vol. 12, no. 1, 2014, pp. 1–11, doi:10.1186/1478-4491-12-73.

Bhardwaj, S., et al. "Elimination of Mother-to-Child Transmission of HIV in South Africa: Rapid Scale-up Using Quality Improvement." *South African Medical Journal*, vol. 104, no. 3, 2014, pp. 239–43, doi:10.7196/SAMJ.7605.

Cowan, James F., et al. "Early ART Initiation among HIV-Positive Pregnant Women in Central Mozambique: A Stepped Wedge Randomized Controlled Trial of an Optimized Option B+ Approach." *Implementation Science*, vol. 10, no. 1, ???, 2015, pp. 1–10, doi:10.1186/s13012-015-0249-6.

Creek, Tracy, et al. "Factors Associated with Low Early Uptake of a National Program to Prevent Mother to Child Transmission of HIV (PMTCT): Results of a Survey of Mothers and Providers, Botswana,

2003." *AIDS and Behavior*, vol. 13, no. 2, 2009, pp. 356–64, doi:10.1007/s10461-007-9322-8.

Flax, Valerie L., et al. *Factors Influencing Postnatal Option B + Participation and Breastfeeding Duration among HIV-Positive Women in Lilongwe District , Malawi : A Qualitative Study*. 2017, pp. 1–13.

Gamell, Anna, et al. *O PERATIONAL R ESEARCH : C LINICAL S CIENCE An Integrated and Comprehensive Service Delivery Model to Improve Pediatric and Maternal HIV Care in Rural Africa*. Vol. 73, no. 5, 2016, pp. 67–75.

Gimbel, Sarah, Alison S. Rustagi, et al. "Evaluation of a Systems Analysis and Improvement Approach to Optimize Prevention of Mother-To-Child Transmission of HIV Using the Consolidated Framework for Implementation Research." *JAIDS Journal of Acquired Immune Deficiency Syndromes*, vol. 72, 2016, pp. S108–16, doi:10.1097/QAI.0000000000001055.

Gimbel, Sarah, Joachim Voss, et al. "What Does High and Low Have to Do with It? Performance Classification to Identify Health System Factors Associated with Effective Prevention of Mother-to-Child Transmission of HIV Delivery in Mozambique." *Journal of the International AIDS Society*, vol. 17, 2014, pp. 1–10, doi:10.7448/IAS.17.1.18828.

Gimbel, Sarah, and Alison Rustagi. *Systems Analysis and Improvement to Optimize PMTCT: A Cluster Randomized Trial Standard Operating Procedures (SOP) Manual*. Vol. 7, 2013, p. 41 p.

Global Health Observatory Data. 2018, http://apps.who.int/gho/data/view.main.23500REG?lang=en.

Herce, Michael E., et al. *Supporting Option B + Scale up and Strengthening the Prevention of Mother-to-Child Transmission Cascade in Central Malawi : Results from a Serial Cross-Sectional Study*. BMC Infectious Diseases, 2015, pp. 1–13, doi:10.1186/s12879-015-1065-y.

Hoog, Anna H. Van't, et al. "Preventing Mother-to-Child Transmission of Operational Issues." *Jaids*, vol. 40, no. 3, 2005, pp. 344–49.

Joseph, Jean Paul, et al. "Going beyond the Vertical: Leveraging a National HIV Quality Improvement Programme to Address Other Health Priorities in Haiti." *Aids*, vol. 29, no. April, 2015, pp. S165–73, doi:10.1097/QAD.0000000000000715.

Kim, Maria H., et al. "The Tingathe Programme: A Pilot Intervention Using Community Health Workers to Create a Continuum of Care in the Prevention of Mother to Child Transmission of HIV (PMTCT) Cascade of Services in Malawi." *Journal of the International AIDS Society*, vol. 15, no. Suppl 2, 2012, pp. 1–11, doi:10.7448/IAS.15.4.17389.

Kim, Young Mi, et al. "Evaluation of a Quality Improvement Intervention to Prevent Mother-to-Child Transmission of HIV (PMTCT) at Zambia Defence Force Facilities." *BMC Health Services Research*, vol. 13, no. 1, BMC Health Services Research, 2013, p. 1, doi:10.1186/1472-6963-13-345.

Landes, Megan, et al. "The Effectiveness of Interventions to Improve Uptake and Retention of HIV-Infected Pregnant and Breastfeeding Women and Their Infants in Prevention of Mother-to-Child Transmission Care Programs in Low- and Middle-Income Countries : Protocol for a Systemat." *Systematic Reviews*, Systematic Reviews, 2015, pp. 1–6, doi:10.1186/s13643-015-0136-x.

Mate, Kedar S., et al. "A Case Report of Evaluating a Large-Scale Health Systems Improvement Project in an Uncontrolled Setting: A Quality Improvement Initiative in KwaZulu-Natal, South Africa." *BMJ Quality and Safety*, vol. 22, no. 11, 2013, pp. 891–98, doi:10.1136/bmjqs-2012-001244.

Mate, Kedar S., et al. “A Quality Improvement Model for the Rapid Scale-up of a Program to Prevent Mother-to-Child HIV Transmission in South Africa.” *International Journal for Quality in Health Care : Journal of the International Society for Quality in Health Care / ISQua*, vol. 25, no. 4, 2013, pp. 373–80, doi:10.1093/intqhc/mzt039.

Mwidunda, Patrick E., and Eliudi Eliakimu. “Creating a National Culture of Quality: The Tanzania Experience.” *Aids*, vol. 29, no. April, 2015, pp. S175–77, doi:10.1097/QAD.0000000000000714.

Nuwagaba-Biribonwoha, H., et al. “Challenges Faced by Health Workers in Implementing the Prevention of Mother-to-Child HIV Transmission (PMTCT) Programme in Uganda.” *Journal of Public Health*, vol. 29, no. 3, 2007, pp. 269–74, doi:10.1093/pubmed/fdm025.

Oyeledun, Bolanle, et al. “The Effect of a Continuous Quality Improvement Intervention on Retention-In-Care at 6 Months Postpartum in a PMTCT Program in Northern Nigeria.” *JAIDS Journal of Acquired Immune Deficiency Syndromes*, vol. 75, 2017, pp. S156–64, doi:10.1097/QAI.0000000000001363.

Quality Improvement. 2011.

Robins, J. M., et al. “Marginal Structural Models and Causal Inference in Epidemiology.” *Epidemiology*, vol. 11, no. 5, 2000, pp. 550–60, doi:10.1097/00001648-200009000-00011.

Rustagi, Alison S., et al. “Health Facility Factors and Quality of Services to Prevent Mother-to-Child HIV Transmission in Côte d’Ivoire, Kenya, and Mozambique.” *International Journal of STD & AIDS*, vol. 28, no. 8, 2017, pp. 788–99, doi:10.1177/0956462416668766.

Rustagi, Alison Silvis, et al. “Implementation and Operational Research: Impact of a Systems Engineering Intervention on PMTCT Service Delivery in Côte d’Ivoire, Kenya, Mozambique: A Cluster Randomized Trial.” *Journal of Acquired Immune Deficiency Syndromes*, vol. 72, no. 3, 2016, pp. e68–76, doi:10.1097/QAI.0000000000001023.

Tweya, Hannock, et al. “Understanding Factors, Outcomes and Reasons for Loss to Follow-up among Women in Option B+ PMTCT Programme in Lilongwe, Malawi.” *Tropical Medicine and International Health*, vol. 19, no. 11, 2014, pp. 1360–66, doi:10.1111/tmi.12369.

UNAIDS. “GLOBAL REPORT: UNAIDS Report on the Global AIDS Epidemic 2013.” *Unaids*, 2013, doi:JC2502/1/E.

UNAIDS Communications and Global Advocacy. *2017 Global Hiv Statistics*. no. July, 2018, pp. 1–5.

Wettstein, Celine, et al. “Missed Opportunities to Prevent Mother-to-Child-Transmission in Sub-Saharan Africa : Systematic Review and Meta-Analysis.” *Aids*, vol. 26, no. 18, 2013, pp. 2361–73, doi:10.1097/QAD.0b013e328359ab0c.Missed.

Yotebieng, Marcel, et al. *Continuous Quality Improvement Interventions to Improve Long-Term Outcomes of Antiretroviral Therapy in Women Who Initiated Therapy during Pregnancy or Breastfeeding in the Democratic Republic of Congo : Design of an Open-Label , Parallel , Group Randomiz*. BMC Health Services Research, 2017, pp. 1–7, doi:10.1186/s12913-017-2253-9.

Youngleson, Michele S., et al. “Improving a Mother to Child HIV Transmission Programme through Health System Redesign: Quality Improvement, Protocol Adjustment and Resource Addition.” *PLoS ONE*, vol. 5, no. 11, 2010, doi:10.1371/journal.pone.0013891.