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Achieving HIV Epidemic Control and Improving Maternal Healthcare Services with Community-Based HIV Service Delivery in Zambia: Mixed-Methods Assessment of the SMACHT Project

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Abstract

Novel community-based approaches are needed to achieve and sustain HIV epidemic control in Zambia. Under the Stop Mother and Child HIV Transmission (SMACHT) project, the Community HIV Epidemic Control (CHEC) differentiated service delivery model used community health workers to support HIV testing, ART linkage, viral suppression, and prevention of mother-to-child

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Consent to Participate All qualitative participants provided informed consent; the IRBs waived informed consent for quantitative data as it was de-identified aggregate data.

Consent for Publication All qualitative participants provided informed consent; the IRBs waived informed consent for quantitative data as it was de-identified aggregate data.

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transmission (MTCT). A multi-methods assessment included programmatic data analysis from April 2015 to September 2020, and qualitative interviews from February to March 2020. CHEC provided HIV testing services to 1,379,387 clients; 46,138 were newly identified as HIV-positive (3.3% yield), with 41,366 (90%) linked to ART. By 2020, 91% (60,694/66,841) of clients on ART were virally suppressed. Qualitatively, healthcare workers and clients benefitted from CHEC, with provision of confidential services, health facility decongestion, and increased HIV care uptake and retention. Community-based models can increase uptake of HIV testing and linkage to care, and help achieve epidemic control and elimination of MTCT.

Keywords

PBFW; PMTCT; Test & start; HIV; Differentiated service delivery; Sub-Saharan Africa

Introduction

Sub-Saharan African countries such as Zambia face significant challenges as they seek to control their national epidemics of human immunodeficiency virus (HIV). As of 2016, Zambia had an HIV prevalence of 12.0% among persons 15–59 years [1]. Zambia adopted the *Test and Start* approach in 2016 to help achieve the United Nations Programme on HIV/AIDS (UNAIDS) HIV epidemic control goals of 90% of people living with HIV diagnosed, 90% of those on antiretroviral therapy (ART), and 90% of those virally suppressed by 2020 [2, 3]. However, health systems in Zambia did not have capacity to absorb the influx of patients needing testing, treatment, counseling, and ART.

Furthermore, pregnant women living with HIV are often underserved by existing health care infrastructure. Currently, 18.8 million women live with HIV globally, representing half of the 37.9 million people living with HIV, 80% of whom live in sub-Saharan Africa [4]. Each year, more than 1.2 million of these women become pregnant, with the risk of transmitting HIV to their children [5]. Access to ART for pregnant women living with HIV has greatly improved over the past eight years, with the percentage receiving ART increasing from 43 to 85% in the 23 UNAIDS focus countries [6]. However, in 2018 the annual rate of vertical HIV transmission by the end of breastfeeding in Eastern and Southern Africa was 9%, with nearly 100,000 infants born with HIV—the highest of any region in the world [4]. With early initiation of ART and complete viral load suppression, the rate should be near zero [7].

Despite progress in increasing access to ART for Zambian pregnant women living with HIV, significant gaps remain. Zambian women are disproportionately affected by HIV, with prevalence of 14.6% compared to 9.3% among Zambian men [8]. As of 2014, only 88% out of the recommended 100% of pregnant and breastfeeding women (PBFW) in Zambia received HIV counseling during antenatal (ANC) visits [9]. Zambian guidelines recommend that the first ANC appointment occur by 12 weeks [10], yet an estimated 81% of Zambian women present late to their first ANC appointment [11], at a median of 20 gestational weeks [9] when intrauterine transmission may have already occurred. Overall, the estimated rate of vertical transmission remains high at 11% in 2019 [6], and retention remains low among

mother-infant pairs in Zambia [12]. These gaps highlight the need for innovative approaches to increase ART uptake and retention among PBFW.

To reach the goals of 90–90–90 HIV epidemic control and reduction of mother-to-child transmission (MTCT) to less than 5% by end of breastfeeding, effective differentiated service delivery (DSD) interventions were needed. DSD interventions move away from a one-size-fits-all health model and adapts care to be client-centered, including mov-ing stable patients to less clinic-based and more community-based care, and thus reduce the burden on the health system and on the client [13-15]. DSD encompasses different strategies including offering HIV services in the community or facility, and task-shifting from physicians or nurses to other types of health providers including community health workers (CHWs) [16-18]. Evidence suggests that DSD models are comparable to standard of care for clinical outcomes and improve patient satisfaction [16, 19].

Studies of CHW-based DSD models across sub-Saharan Africa demonstrate that such approaches improve uptake of maternal healthcare services [20, 21]. The World Health Organization (WHO) recommends shifting routine tasks to lay workers as a key strategy to increase ANC uptake, facility-based delivery, and HIV care for women and their HIV-exposed infants [22, 23]. Studies have shown that CHWs effectively locate high-risk clients, conduct index testing, improve linkage to care, and facilitate testing of HIV-exposed infants [24-27]. CHWs also tend to be highly accepted for in-home delivery of HIV services [27]. CHW-based DSD models may help decongest healthcare facilities and reduce inpatient healthcare expenditure by enhancing outpatient care [28].

To help Zambia improve outcomes for PBFW and HIV-exposed infants and to implement *Test and Start* for all people living with HIV, the University of Maryland, Baltimore (UMB) implemented the Stop Mother And Child HIV Transmission (SMACHT) project in partnership with the Zambia Ministry of Health (MOH), with funding from the U.S. President's Plan for Emergency AIDS Relief (PEPFAR) via the U.S. Centers for Disease Control and Prevention (CDC). Building on more than a decade of HIV program implementation and medical education in Zambia [29], we developed and implemented the Community HIV Epidemic Control (CHEC) model, a comprehensive CHW-based DSD, to improve HIV outcomes in the Southern Province of Zambia [30]. The CHEC model builds on UMB's community approach in providing high-quality care [31] and improving retention in adult ART programs [32]. Initial pilot results demonstrated that implementing the CHEC model improved HIV testing and ART uptake for PBFW by over 300% [33], while another CHEC model pilot demonstrated stable patients who received home delivery of ART achieved viral load suppression of 97% [34].

In this paper, we describe the implementation of the CHEC model under the SMACHT project in Southern Province, Zambia. We aim to assess HIV prevention, HIV testing, and ART linkage outcomes among pregnant women and the general population. Finally, we also assess the experiences and perceptions of program beneficiaries and implementers of the SMACHT project.

Methods

Study Design

We conducted a descriptive multi-methods assessment of HIV service delivery under the SMACHT project using retrospective analysis of routinely collected programmatic aggregated data from 1 April 2015 to 30 September 2020 in quarterly intervals. A qualitative case study was conducted in February and March 2020 in sites purposively sampled to capture a range of facility and community characteristics, stratified by district. Methods included in-depth interviews (IDIs) and focus group discussions (FGDs).

Study Setting

SMACHT was implemented across selected districts in Zambia's Southern Province, which varied yearly in accordance with CDC priority designations, ranging from five to 11 districts. The population of Southern Province was estimated at 1,853,464 people in 2015 [35]. Southern has one of the higher provincial burdens of HIV in Zambia, with prevalence of 12.4% among adults 15–49 years in 2018 compared to 12.0% nationally [1], and low overall population viral load suppression at 63.7%, though higher than the national estimate of 59.8% as of 2016 [8].

For the first two years of implementation (2015–2017), SMACHT supported care of PBFW living with HIV and their infants at 75 facilities. In the third and fourth years (2018–2019), SMACHT was scaled up to 295 facilities and expanded its scope to provide comprehensive care across the HIV continuum, including testing, linkage, ART, and adherence to promote viral load suppression. In SMACHT's final year (2020), service delivery was implemented by the Southern Provincial Health Office with technical assistance from UMB.

Study Population

Quantitative analysis included children and adults regardless of age and sex who received HIV prevention and treatment services at health facilities supported by SMACHT. The latter included PBFW attending ANC or presenting in labor and infants born to HIV-positive women who received HIV testing services and treatment.

For the qualitative component, we sampled nine healthcare facilities and corresponding catchment areas of three districts: Choma, Kalomo, and Livingstone. The sample was restricted to sites with longer program continuity (i.e. supported by SMACHT) and was purposively sampled to capture a range in facility size and location (urban or rural) and performance indicators, based on facility-level monitoring data including proportion of pregnant women living with HIV on ART. We conducted IDIs with government and community officials, program implementers, PBFW engaged in PMTCT or HIV-exposed infant care, as well as FGDs with CHWs and community members (Table 4).

SMACHT Project Description and the CHEC Model

In the CHEC DSD model, trained CHWs provide health education and HIV service delivery in their communities; HIV service delivery includes HIV testing, home treatment delivery, and retention support (Fig. 1). Under SMACHT, UMB implemented two adaptations of

the CHEC model: one for care of pregnant women living with HIV and their infants, and another to facilitate HIV testing and linkage to care and treatment for the general population following introduction of *Test and Start*. CHWs were selected by facility staff, with priority given to those with experience in maternal and child health and living in the catchment area. CHWs were supervised by experienced community liaison officers working with MOH staff in the corresponding health facilities (Table 1); community liaison officers are social workers who link communities to health facilities.

CHWs were trained to provide psychosocial and adherence counselling, rapid HIV testing, HIV/AIDS information, and basic nursing procedures (e.g., vital signs), as well as identification of warning signs in pregnancy (e.g., edema or bleeding). A total of 800 CHWs were trained, mentored, and deployed into the community, collaborating with key gatekeepers such as village headmen, civic leaders, and neighborhood health committees. Each CHW was allocated a catchment area, ranging from a population of 100–500 people within a community.

The trained CHWs were mentored monthly to ensure services were delivered per the CHEC model SOP and MOH guidelines. Additionally, they received refresher trainings in psychosocial counselling and proficiency assessments in HIV testing biannually to ensure that quality HIV services were being provided to their communities.

The CHWs ensured that all supported PBFW received HIV prevention and routine HIV testing per Zambian PMTCT guidelines. CHWs conducted mother-infant follow-up visits with pregnant women living with HIV and counseled them on adherence to ART, prophylaxis, and immunizations for the baby. Mother-infant pairs are engaged at all stages of the continuum of care through a unified intervention, from finding PBFW in the community and recruiting them into ANC care to ensuring pregnant women living with HIV are retained on ART. In addition, CHWs followed HIV-exposed infants to ensure serial HIV testing, as well as initiation of ART and co-trimoxazole prophylaxis for HIV-positive infants.

To support *Test and Start* guidelines [2], SMACHT used the CHEC model to find people living with HIV in the community and link them to care. CHWs conducted community HIV testing services, escorted clients to initiate ART, and delivered ART to stable-on-care clients, defined as those on ART for > 12 months with a suppressed viral load and willing to receive ART at home.

Outcomes

The PMTCT outcomes of interest included: (1) number of pregnant women who attended both ANC and labor and delivery; (2) number and proportion of pregnant women HIV tested at first ANC visit or already identified as HIV-positive; (3) number and proportion of pregnant women identified as HIV-positive (prior or new diagnosis); (4) number and proportion of new pregnant women living with HIV initiated on ART; (5) number of infants born to pregnant women living with HIV who received a first virologic HIV test by 12 months of age, and (6) proportion of infants born to pregnant women living with HIV who received a first virologic HIV test by 12 months, using the number of pregnant women living with HIV as a proxy denominator for total HIV-exposed infants.

HIV care cascade outcomes for the general population included: (1) number of persons tested for HIV; (2) number of persons who tested HIV-positive; (3) proportion of individuals newly tested positive (positivity yield); (4) number and proportion of newly diagnosed people living with HIV enrolled on ART; (5) number of persons with a documented VL; (6) the cumulative number and proportion of persons with viral load suppression, defined as viral load < 1000 copies/mL. Wide-scale viral load testing only became available in 2019, and in 2020 all clients who had been on ART for 6 months or longer were eligible to receive a viral load test. We used definitions and guidance from the PEPFAR Monitoring, Evaluation, and Reporting Indicator Reference Sheet (MER) version 2.3; however, if indicators changed over time, data definitions were harmonized at the time of final analyses [36].

The qualitative study aimed to: (1) assess experiences and perceptions concerning the implementation of the program, with a focus on activities concerning PMTCT and HIV-exposed infants, from program implementers, beneficiaries, and other stakeholders, and (2) identify the perceived facilitators and barriers to using the CHEC model for PMTCT and HIV-exposed infant care.

Data Sources and Collection

All quantitative data were aggregated quarterly and abstracted from routine Zambian MOH HIV testing services, index testing, linkage, ANC, PMTCT, and ART, and HIV-exposed infant registers. At community level, each CHW collected patient-level information on individual community HIV testing services and index elicitation forms. At the facility level, community liaison officers merged these data and entered them into facility registers. For PMTCT programs, individuals were uniquely identified using a client number established at initial client visits. For the general population, multiple efforts were made to uniquely identify individuals to avoid double counting; these efforts included using names, date of birth, testing history, and HIV testing services number.

The qualitative data were collected by a team of six trained and supervised Zambian qualitative fieldworkers with prior qualitative research experience who were fluent in both predominantly-used local languages in Southern Province. Supervisors and a qualitative research consultant with extensive fieldwork expertise conducted a weeklong training before the start of data collection. During this training, the interview guides were iteratively refined, translated by language experts, and further refined by the research team for local vernacular. The training included pre-testing interviews and focus group discussion guides with CHWs and beneficiaries from a facility not participating in the assessment. In addition, nightly debriefs among the team during data collection resulted in additional updates to the guides to improve flow. Interviews and focus groups were recorded using digital voice recorders and notes were taken to describe nonverbal details. The beneficiary interview guide focused on experience with their own, and their infant's (when relevant) HIV treatment, and perceptions of the care they received to support PMTCT. Implementers' guides explored perceptions of the SMACHT project, experience with offering PMTCT services, and perceptions of the effectiveness of the CHEC model for PMTCT. Beneficiaries were asked questions such as, "I'd like you to talk a bit now about your experience with

considering treatment for HIV. Can you talk about everything that influenced your decisions around any treatment? Can you talk about who helped you to access these medicines? “

Analysis

Quantitative Study Methods—The quantitative analysis was descriptive by year. Because a pregnant woman counted in one reporting year may deliver her child in the following reporting year, not all events in the numerator are from clients in the denominator; this difference in time creates the greatest discrepancy for the proportion of infants tested in the first year of life to the number of HIV-positive women identified. The magnitude of the discrepancy decreases when data over a longer period is summarized. Summary statistics such as proportions, means, and interquartile ranges were used to describe indicators of interest.

Qualitative Study Methods—Interviews were transcribed and simultaneously translated verbatim into English by field interviewers. Three supervisors spot-checked interview transcripts by comparing audio to transcript for completeness and accuracy of translation. All transcripts were anonymized. Transcripts were then imported into *NVivo (version 12)* for coding and analysis. Thematic analysis approaches were used to code the data [37]. Data were classified and organized first by a deductive code list, drawn from the interview guides, and then new codes were added to capture emergent concepts. The code list captured participants’ experiences and perceptions of the provision of current services, adherence and retention to patient care, and quality of patient contact with the healthcare workers. The final code list was used to identify broader themes in the data. A hierarchical code tree was developed that demonstrated the relationship between individual codes and the broader themes that these represented. The final code tree captured a series of emergent themes in the data. Two patient narratives experiences were further detailed as vignettes.

Ethical Approval

Ethical approval for this study was provided under the SMACHT quantitative and qualitative protocols, approved by the ERES Converge Zambian Institutional Review Board (IRB) (Reference numbers 2018-Feb-006, 2018-Feb-005), the Zambian National Health Research Authority (NHRA 3/4/2018, NHRA 3/4/2018), and the UMB IRB (HP-00080438, HP-00080636). This project was reviewed in accordance with CDC human research protection procedures and was determined to be non-research by the CDC. All qualitative participants provided informant consent; the IRBs waived informed consent for quantitative data as it was de-identified aggregate data.

Results

Quantitative PMTCT Results

Across sites supported by SMACHT, pregnant women attending ANC increased from 46,253 in the first year (2015–2016) to 67,802 in the fourth year (2018–2019) of PMTCT technical support. Pregnant women who either received an HIV test at their first ANC visit or already knew their status improved from 84% in year one to 100% by year four, with 95% overall across the project lifespan. In total, SMACHT identified 22,181 new or prior known

pregnant women living with HIV. Of these, 21,093 were linked to ART, for an overall ART linkage of 95%. Linkage was highest in the first year at 99%. Overall, 22,265 HIV-exposed infants received at least one HIV test in the first 12 months, leading to an estimated 105% of HIV-exposed infants tested (Table 2). Note that this is a proxy measurement as births lag pregnancies and thus can result in overestimation.

Quantitative General Population Results

From 2015 to 2020, SMACHT provided HIV testing services to 1,379,387 clients, of whom 46,138 (3.3%) were identified as HIV-seropositive (Table 3). Positivity yield ranged from 1.3 to 2.4% in the project's first three years, when CHWs were conducting home-based HIV testing. Following implementation of targeted testing strategies in year four, yield increased to 3.6% and then 4.5% by year five.

Of 46,138 clients identified as HIV-seropositive, 41,366 were linked to ART, with 90% linkage overall. While the linkage was highest in the first year at 98%, that rate included a small number of clients (1,623). By year five, this number grew to 21,805, and linkage remained high at 90%.

Wide-scale VL testing was implemented in 2017 and scaled up by 2019. By year five, 66,841 clients on ART received a VL test, and 60,694 were suppressed for 91% viral load suppression.

Qualitative Results

Qualitative data served to help understand how the SMACHT program was perceived by beneficiaries and implementers, and help shed light on the components of the program that facilitated its success. We conducted 62 IDIs and 14 FGDs across three districts (Table 4). Key themes included: the feasibility of integration of the CHEC model into existing systems; the work of CHWs in improving knowledge of the care cascade for HIV-exposed infants; trust in CHWs; and providers' perception of improved viral load suppression. Challenges included transitioning job responsibilities, concerns around sustainability of the project, and rapidly evolving national guidelines for identifying HIV-positive cases.

The CHEC Model was Feasibly Integrated into Existing Services—Stakeholders and implementers indicated they felt SMACHT—and the underlying DSD model central to this program—had been smoothly integrated into existing programs and therefore had potential to enhance care. As one In-charge at a health facility mentioned:

> …the [CHEC program] was in line with other [facility] services because even before Maryland … as a center we already had [an HIV] program, but for example, the challenge we had was how do we make a follow-up. … For us, it was a challenge, so, meaning that the coming of Maryland, with that agenda of training the community personnel who will be provided with testing kits or logistics to perform a test just at the doorstep, it was something which helped our program or services.
>
> - *Facility In-charge IDI*

According to health facility staff and CHWs, significant changes were recognized following CHEC implementation, including heightened patient monitoring and readily available medication for people living with HIV on treatment programs. CHWs suggested it was easier to identify HIV-exposed infants by tracking HIV-positive mothers and following up to ensure clinic-based testing occurred.

Facility-based healthcare workers described how they benefited from the CHW's services, which made facility-based work easier: CHWs followed up with patients in the community, consequently decongested clinics, and ensured ongoing engagement in care. As one In-charge described:

> They have supported our work in making follow-ups, the defaulters, the roles to follow. They make follow-ups. Even for HIV-exposed babies, they make follow-ups.
>
> - *Facility In-charge IDI*

Improved Education of PBFW Living with HIV and Their Infants—Both healthcare workers and CHWs perceived increases in ANC uptake and facility-based delivery and retention in care for HIV-exposed infants. Clients described a high level of knowledge and understanding of necessary treatments and testing for HIV-exposed infants, reflecting the efforts of CHWs to work with clients to improve their understanding of the HIV care cascade. For example, one HIV-positive mother in Kalomo described with detail the care plan indicated for her exposed baby:

> When she was one month two weeks, she was tested, then again when she was six months, and then when she was nine months, she was tested. And when she reaches one year six months, I should bring her.

Other beneficiaries expressed similar levels of understanding of this complex testing and treatment regime, reflecting effective communication with providers including CHWs.

Trust in Skilled Community Health Workers—Central to the perceived success of the CHEC model for PMTCT and related services was the belief CHWs could be trusted to provide confidential and quality care. Both CHWs and clients reflected on the increased trust attributed to CHWs following UMB's confidentiality training.

> These people are trustworthy. …When I was given medicine here I was told to help them choose a trusted person from my community to become a CHW because there was no one representing my area. So, they would give him medicine to bring for me at home, and if I had any issues relating to health, I would confer with him. Even when we would come to the facility, we would find him here and he would also help us here, that's why I trust him.
>
> - *Community member, FGD*

CHWs felt that the trust and confidence clients had in them improved their working relationships and helped them reach community members more effectively. CHWs described how their knowledge and skills impressed their fellow community members.

> Nowadays we are more appreciated because we were trained by UMB and have the knowledge and skill. So, when a person asks you a question, you know where to start from and end. So now community members even ask, “Are you nurses now?” Like, when you are visiting those stable on care, you have to go and check his BP, weight and the like. So, when they see that, they say “these people are now knowledgeable,” and they appreciate [us] more as compared to way back. …. The work that UMB gave us is what has made us respected in these communities. That is a benefit also.
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> - *Community Health Worker FGD, Choma District*

Viral Load Suppression—Finally, providers perceived SMACHT had had success in increasing viral load suppression within the community catchment areas. Implementers and community members perceived that the CHEC model promoted viral load suppression among clients. CHWs were trained and able to pick up and deliver the drugs for clients classified as stable-on-care. CHWs felt delivering drugs improved clients’ adherence and helped clients reach viral load suppression.

> I had another pregnancy. They came and encouraged me that “You should be mindful of drinking medicine, you shouldn’t be skipping, skipping.” The key is you, the parent; when you are drinking medicine, the child you will give birth to will be just okay. Yes. That’s how when I got pregnant; it just came out negative. They came and tested him for the first time, [and] “No, he is just fine.” For the second test, “No.” For the third, “No, he is just fine.” That’s the child I had on my medicine.
>
> - *Client, mother living with HIV, Choma District*

Selected patient vignettes are highlighted in Boxes 1 and 2. Names have been changed to protect client confidentiality.

Discussion

The SMACHT project implemented the CHEC model, an innovative, community-based DSD approach to HIV service delivery in Zambia from 2015 to 2020. The CHEC model helped clients in Southern Province achieve two of the WHO 95% process indicators for the elimination of new infant infections [38], with over 95% PBFW receiving HIV testing and over 95% of pregnant women living with HIV on ART. Furthermore, SMACHT helped Southern Province achieve the latter two 90’s of UNAIDS epidemic control. SMACHT was the first CDC-funded project to pilot and implement *Test and Start* services. SMACHT tested 1.4 million people for HIV, identified nearly 50,000 people living with HIV, and linked more than 90% of them to treatment; by the end of the project, SMACHT supported over 60,000 people on ART, among whom viral load suppression was over 91%.

The SMACHT project was likely a major contributor to helping Southern Province progress towards HIV epidemic control. We do not have baseline surveys or comparators; however, Zambia conducted population-based HIV surveys with the objectives of measuring national HIV incidence, sub-national VLS, and progress towards the 90–90–90 goals in 2016 [8]

and 2021 [39]. These ZAMPHIA surveys provide an objective measure of progress towards HIV indictors in the intervening five years. Country-wide, the proportion of adult PLHIV aware of their status rose from 71% in 2016 to 89% in 2021, while the proportion of those PLHIV on treatment rose from 87 to 98%, and the proportion of PLHIV on ART who were virally suppressed rose from 89 to 96% [8, 39]. In Southern Province, where SMACHT implemented the CHEC model from 2015 to 2020, the proportion of persons on ART who were virally suppressed rose from 64 to 99% among adults aged 15–59 years in 2016 and among adults aged 15 and above in 2021 [8, 39]. Province level diagnosis and linkage data from ZAMPHIA 2021 are not yet available for comparisons on the first two 90s. The gains in Southern Province cannot be exclusively attributed to SMACHT, as there were other implementing partners and other factors in play. However, SMACHT was responsible for implementing HIV diagnosis and treatment services in the most densely populated urban areas of the province over the five years; reaching the largest proportion of the Southern Province population during this time. This data suggests that SMACHT played an important role in helping Southern Province move towards HIV epidemic control.

CHWs identified pregnant women in the community early in pregnancy and provided a comprehensive care pathway integrated with clinical activities. CHWs focused on providing health education to PBFW, ensured linkage to ANC for continuity of care and HIV testing, and provided longitudinal follow-up to ensure adherence. Quantitative PMTCT results showed that ANC outcomes increased over the course of the community PMTCT program. This finding is in line with other studies reporting improved attendance in ANC via lay health workers and mentor mothers [26]. Studies assessing CHWs' effectiveness found benefits on PMTCT-related outcomes; for example, Ahmed et al. found CHW support increased HIV-exposed infants monthly enrollment more than seven-fold [40]. Other studies identified knowledge gaps amongst PBFW regarding MTCT, which can impact retention in PMTCT follow-up services and negatively impact their HIV treatment as well as treatment of their infants. For example, one study showed that a majority of participants did not know mothers can transmit HIV to their infants during pregnancy, labor, and after birth [26, 41].

Mother-infant pair retention in care is another key indicator. Ugandan Mentor Mothers found higher retention after birth and breastfeeding in the intervention group than in the control arm; additionally, a higher percentage of HIV-positive mothers at the intervention site remained active on ART 12 months after ART initiation compared to control sites [42].

During the SMACHT project, we achieved 92% early infant diagnosis coverage (EID) by 12 months, leaving an 8% gap. Improvement in EID would require additional strategies, such as ensuring sufficient test kits to optimize EID coverage, cohort monitoring, and proactive follow-up of mother-baby pairs. Testing was often limited by supply stock-outs from weak commodity and supply chain systems. Other strategies reported for improvement included discharge referral of HIV-exposed infants with direct accompaniment, which was independently associated with a tripling of the odds of follow-up for EID within three months [43]. Scheduling appointments to coincide with routine infant vaccination eliminated the need for additional testing visits and resulted in HIV testing of more than two-thirds of the HIV-exposed infants [44]. Ideally, HIV-exposed infants should be tested by two months of age, and future research should examine more granular EID results.

In addition to enhancing uptake of PMTCT, the SMACHT project was effective at providing HIV service delivery in the community during the implementation of *Test and Start*. Using the CHEC DSD model, SMACHT achieved over 90% ART linkage and over 91% viral load suppression among supported clients in Southern Province. Population-based testing increased diagnosis and linkage to care but yields were low, necessitating targeted HIV testing strategies. In subsequent UMB projects, CHWs implemented targeted testing strategies such as index testing (testing of contacts of index cases) and subpopulation-specific strategies. These strategies resulted in up to 45% positivity yields and ART linkage of more than 93% among newly identified positives [25]. A systematic review comparing HIV testing service approaches found mobile and campaign testing had the highest uptake at 97% while HIV testing service uptake via in-home testing was lower at 82% [45]. Another study reported a preference for and moderate linkage rates of 77% with in-home testing services for children [46]. In our project, adherence was additionally supported by providing in-home delivery of ART to stable clients which helped achieve high viral load suppression.

Our qualitative study findings suggest the CHEC model for PMTCT was perceived as effective at increasing community understanding of HIV, with some providers indicating they felt it influenced reductions in MTCT. Health facility workers and beneficiaries reported benefiting from the CHEC model via decongestion of services, increased ART uptake, and retention in HIV care. Community members described increased trust in CHWs to provide confidential HIV-related services and demonstrated high levels of knowledge about the care cascade for the prevention of HIV for HIV-exposed infants. Client trust in healthcare providers is extremely important: beneficiaries and CHWs alike reflected on the benefit of CHWs receiving additional training in this regard. CHW training included an emphasis on protecting the confidentiality of clients, a concern that often plagues CHW programs [47, 48]. Honoring patient confidentiality is critical, particularly with respect to HIV given the ongoing burden of stigma associated with it in this context [49]. Without gains in the trust of CHWs, the program would not been able to succeed. In addition, as described by the CHWs and reflected in the knowledge of their clients, training also improved CHWs' medical expertise, which they reported with pride. This in turn may also contribute to the trust instilled in CHWs and the services they can provide. That said, there were some ongoing challenges noted among participants. Moreover, educated clients who have come to understand the importance of testing and treating their exposed babies at specific times to prevent MTCT are likely far more motivated to return to the clinic as needed. While many spoke with admiration for the CHWs, a few participants did indicate ongoing concerns with confidentiality. One participant recommended more CHW training; raising the potential importance for refresher trainings on key topics—a consideration for programs going forward. Health facility workers perceived better retention in care across HIV treatment cascades under SMACHT and also conveyed that their relationships with CHWs were positive. Challenges included transitioning responsibilities, project sustainability, and shifting guidelines for identifying HIV-positive cases.

Our study included similar findings to other studies that implemented community-based programming and care cascade models. A qualitative study assessing CHWs for PMTCT in Zambia found CHWs improved breastfeeding practices among pregnant women living with HIV, but cultural practices limited the impact [50]. SMACHT did not face such cultural

challenges, which we ascribe to enhanced training of CHWs. A qualitative study of the Mothers2Mothers intervention in Zimbabwe found mentor mothers helped in addressing individual-level barriers to seeking healthcare [51]; we observed a similar effect in our study. A South African study found partnering with local community groups greatly assisted overwhelmed health facilities and reinforced establishing and maintaining links between PMTCT mothers, their local facilities, and care cascade [52]. Zimbabwean and Kenyan studies evaluating mentor mother support found improved retention and adherence among clients [51, 53].

Finally, comprehensive community programs such as CHEC can be expensive. An economic evaluation of four different DSD models in Zambia found they were more expensive than usual care [54]. This costing analysis, however, only examined one aspect of the CHEC model—support for stable patients in care—it did not account for the comprehensive CHEC intervention and all related health and social benefits across the cascade of care [55].

There are several notable limitations to this study. First, we relied on routine program data collected quarterly and analyzed in aggregate. Therefore, some analyses were not possible, including individual-level analysis of testing and clinical outcomes. Aggregate data limited our ability to examine socio-demographic factors associated with uptake of the CHEC interventions. We could not estimate achievement towards the first 90 of epidemic control, and our estimates of the second and third 90’s are based on programmatic data, not survey data.

In addition, there is a risk of bias, as CHEC deployment was not random and only took place at sites defined by CDC; thus, there may be systematic differences in the distribution of client characteristics at sites. Over the same period, other partners were implementing HIV-related projects in Southern Province, which could lead to confounding. However, SMACHT likely reached the largest proportion of the population in the province during this time. There was a risk of missing data due to incomplete reporting, though the amount and type of missing data were likely to be non-differential across sites. SMACHT-supported districts and facilities varied year by year based on CDC directives.

The qualitative study was not free of limitations. The qualitative data collection occurred during a period of civil unrest [56] which necessitated the data collection team being accompanied by police officers; this may have affected uptake and responses. Second, results of the quantitative analysis were not available at the time to inform the qualitative study, which would have yielded more insights into the program.

Conclusions

We found that a CHW-based DSD model resulted in high HIV testing uptake and linkage to ART among pregnant women in the Southern Province of Zambia. The SMACHT project was also very successful at reaching people living with HIV and linking them to care and treatment, achieving the latter two 90’s of HIV epidemic control by the end of five years. The household-based testing approach resulted in high testing coverage but low positivity yields. As a result, these findings necessitated a change to more targeted HIV testing

strategies such as index testing, which resulted in more people testing and higher positivity yields. Such CHW-based DSD models of care can play a key role in helping countries in sub-Saharan Africa achieve eMTCT and sustainable and long-lasting HIV epidemic control.

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Data Availability

Quantitative data is property of the Ministry of Health.

Code Availability

Available upon request.

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Box 1:

Florence & Alina, PMTCT Patient Vignettes

Florence began volunteering at the health facility in 2012 and has been a CHW for four years. She calls pregnant and breastfeeding women in her catchment area like Alina one to two days before every ANC appointment. She also organizes meetings in the community to promote early ANC and testing for HIV and STIs, as well as health screening and other services.

Florence recalls counseling a pregnant woman who initially declined ART because it meant she would be on treatment for life. “I followed her every week. She was not happy to see me. [I asked her] ‘Would it be good if your child goes [to] school and is taking tablets, but the other children aren’t taking tablets?’ Following these dialogues, the woman chose to start ART.

“Right now, we have not had a single child born positive from an HIV-positive mother. Not one mother has died at home [in childbirth]. They all come to the clinic.” she proudly said.

Alina is one of Florence’s clients and recounts her experience: “I came to the clinic on my own because I wanted to know my status. I found out I was reactive, but I wasn’t aware I was pregnant… my first child was ok [HIV negative], so I have to adhere. My community health worker has been very helpful. In the first days, it wasn’t easy to make every appointment. She called and reminded me to collect my drugs. She was always counseling me and giving me advice: ‘You’re not the first one. Others have taken the drugs and been fine.’”

Box 2:

Juliet and Lloyd, Home ART Patient Vignette

Juliet, a CHW at an urban government clinic in Livingstone, is visiting her client Lloyd at his house for a stable-on-care visit. Lloyd and his wife are both HIV-positive and receive medications from Juliet at their home. “There used to be long queues at the clinic when I went to pick up the medications,” Lloyd said. “I appreciate [the CHEC program]. It’s really good. I want the program to continue. It gives me a chance to concentrate on other things. Juliet comes to encourage me. Now, I’m strong. I wasn’t like this before.”

Lloyd, and many other clients like him, is one of Juliet’s greatest accomplishments; as Juliet says, “A long time ago, we were seeing so many bedridden clients. Today clients are no longer bedridden. Most are now mobile.”

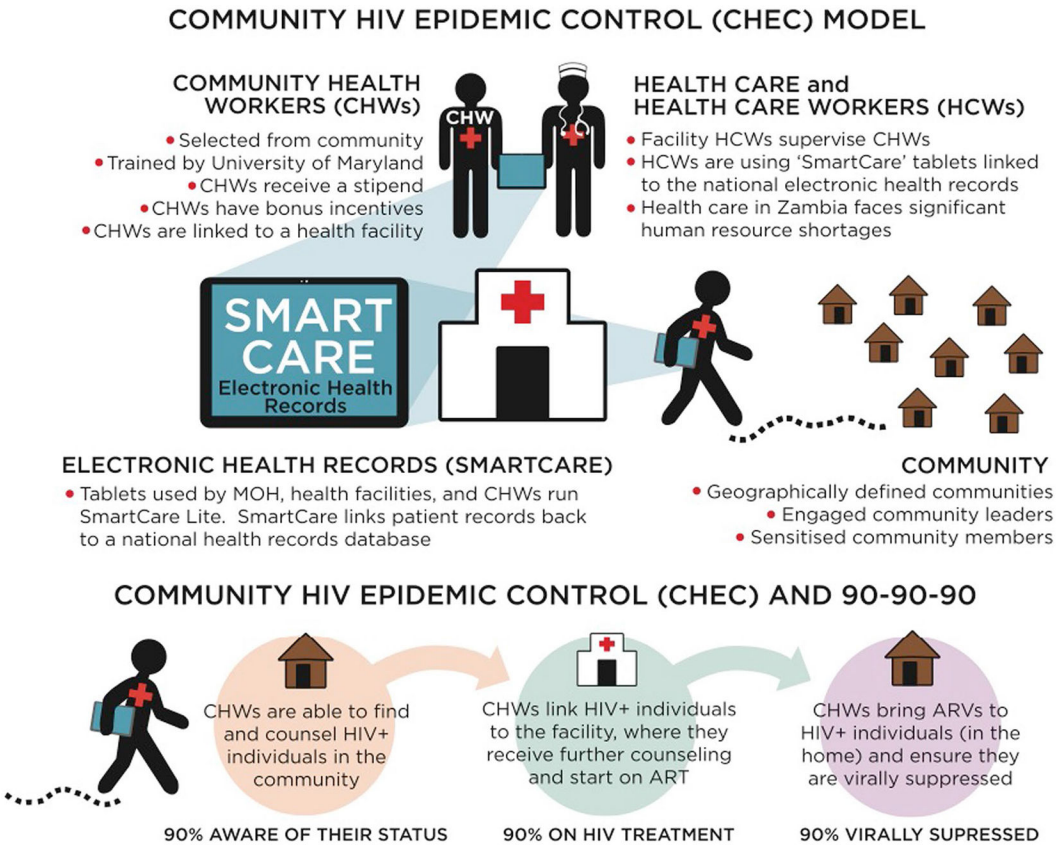

Fig. 1.
The community HIV epidemic control model

Table 1

SMACHT staffing across supported districts (2015–2019)

Southern provincial hub	Hub team	Supported districts	District community liaison officers	SMACHT-supported facilities	CHWs in district
Livingstone	1 Hub Lead 6 clinical, 1 lab, 1 logistics 1 CQI, 5 admin, 8 M&E 5 community mobilizers	Livingstone	5	23	168
		Kalomo	4	41	141
		Zimba	3	8	68
		Kazungula	4	43	136
Mazabuka	1 Hub Lead 3 clinical, 1 lab, 1 logistics 6 admin, 7 M&E, 5 community mobilizers	Mazabuka	5	38	242
		Monze	8	40	182
		Chikankata	2	16	99
Choma	1 Hub Lead 7 clinical, 2 lab, 4 admin 5 M&E, 7 community mobilizers	Choma	7	32	310
		Sinazongwe	2	18	138
		Namwala	2	20	188
		Pemba	4	16	115
Total		11	46	295	1787

N.B. *SMACHT* Stop Mother and Child HIV Transmission, *CHW* community health worker, *CQI* continuous quality improvement, *M&E* monitoring and evaluation

Table 2

PMTCT care cascade outcomes under the SMACHT project, 2015–2020

Year	1 2015–2016	2 2016–2017	3 2017–2018	4 2018–2019	5 2019–2020	Total
No. of pregnant women who attended ANC	46,253	25,237	42,373	67,802	41,984	223,649
No. of pregnant women tested for HIV or previously known to be HIV-positive	38,810	23,041	41,622	67,801	41,374	212,648
Proportion of pregnant women tested for HIV or previously known to be HIV-positive to total pregnant women	84%	91%	98%	100%	99%	95%
No. of pregnant women identified as HIV-positive (prior or new diagnosis)	6928	2388	3148	5918	3799	22,181
Proportion of pregnant women identified as HIV-positive to total pregnant women	18%	10%	8%	9%	9%	10%
No. of HIV-positive pregnant women who received ART during pregnancy	6881	2035	2896	5583	3698	21,093
Proportion of HIV-positive pregnant women who received ART during pregnancy to number of pregnant women identified as HIV-positive	99%	85%	92%	94%	97%	95%
No of infants born to HIV-positive women who had a first virologic HIV test sample collected by 12 months of age	4582	2546	3887	5847	5403	22,265
Proportion of infants born to HIV-positive women who had a first virologic HIV test sample by 12 months of age to no. of pregnant women identified as HIV-positive	66%	107%	123%	99%	142%	105%

N.B. ANC antenatal care; *ART* antiretroviral therapy; *PMTCT* prevention of mother to child transmission

Table 3

HIV care cascade outcomes under the SMACHT project, 2015–2020

Year	1 2015–2016	2 2016–2017	3 2017–2018	4 2018–2019	5 2019–2020	Total
No. persons tested for HIV	66,153	224,298	288,257	311,072	489,607	1,379,387
No. persons who tested positive for HIV	1652	3208	4321	12,642	24,315	46,138
Positivity yield %	2.5%	1.3%	1.4%	3.6%	4.5%	3.3%
No. of newly diagnosed HIV-positive people enrolled on ART	1623	2832	3978	11,128	21,805	41,366
Proportion of newly diagnosed enrolled on ART to no. of clients who tested positive for HIV %	98%	88%	92%	88%	90%	90%
No. persons with a documented VL (cumulative)	n/a	n/a	1,463	25,537	66,841	66,841
No. clients with a suppressed VL (cumulative)	n/a	n/a	1,392	21,667	60,694	60,694
VL suppression rate % (cumulative)	n/a	n/a	95%	85%	91%	91%

N.B. ART antiretroviral therapy; *VL* viral load

Table 4

SMACHT qualitative evaluation methods by study population in each district

Methods by study population	District			Total
	Choma	Kalomo	Livingstone	
Stakeholders				
District officers—IDIs	1	1	1	3
Community leaders—IDIs	3	3	2	8
Community members—FGDs	3	3	3	9
Implementers				
Community Health Workers—FGDs	2	1	2	5
Community Health Workers—IDIs	3	4	3	10
Facility-based healthcare worker—IDIs	3	3	3	9
Community Liaison Officer—IDIs	2	1	1	4
Clients				
HIV+ Pregnant women—IDIs	3	3	3	9
HIV+ mothers (of HIV+ and HIV− children)—IDIs	6	6	6	18
Sub-totals				
Total IDIs by district	21	22	19	62
Total FGDs by district (6–8 participants per FGD)	5	4	5	14

N.B. IDIs in-depth interviews; *FGDs* focus group discussions