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Adoption and effectiveness of community-based ART initiation among key populations in Cameroon: a Type 1 hybrid effectiveness–implementation study using overlap weighting

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Abstract

Background. Key populations carry a disproportionate HIV burden but face structural barriers to treatment, especially where same-sex practices and sex work are criminalised. Cameroon adopted community-based ART initiation (CBARTI) in 2023, yet its uptake and effectiveness among key populations were unknow. Within a Type 1 hybrid effectiveness–implementation design, we assessed the adoption and effectiveness of CBARTI relative to standard facility-based ("handshake") initiation.

Methods. We conducted a quasi-experimental, post-test-only study with a non-randomised comparison group in Yaoundé and Douala. We enrolled 288 key-population members living with HIV who had been on ART for ≥12 months (134 community-initiated, 154 facility-initiated). Outcomes followed Proctor's taxonomy: adoption (implementation), same-day ART initiation (service), and viral suppression (≤40 copies/mL) and health-related quality of life (HRQoL; WHOQOL-HIV BREF) (client). Reasons for the choice of initiation site were analysed qualitatively by lexical analysis and thematic grouping. Measured confounding was addressed with propensity-score overlap weighting. Weighted risk ratios (RRw) for same day ART inititation was estimated by modified Poisson regression; for viral suppression, it was estimated by Firth penalised-likelihood Poisson regression with a Morel correction; ratios of mean HRQoL domain scores were estimated by robust Gamma regression.

Results. Among 158 newly diagnosed individuals free to choose their site, 134 (84.8%; 95% CI 78.2–90.0) chose community initiation. The leading reasons for choosing community initiation were *community and peer support, proximity and ease of access, promptness of initiation, and privacy/confidentiality*, whereas facility choice rested mainly on *proximity* and *trust in providers***.** After overlap weighting, same-day initiation was 29% more likely with CBARTI (RR 1.29 (95% CI 1.11–1.50)). Conditional viral suppression was high in both arms but 12% lower in the intervention arm (RR 0.88 (95% CI 0.79–0.98)). HRQoL was comparable across five of six domains; only social relationships was 18% lower with CBARTI (ratio of mean scores 0.82 (95% CI 0.77–0.87).

Conclusions. CBARTI was widely adopted and accelerated ART initiation without compromising most quality-of-life domains. Lower conditional viral suppression and social-relationship scores most likely reflect expanded reach rather than inferior care. Scale-up should embed adherence support, viral-load monitoring and psychosocial and stigma-reduction services within a strengthened community–facility continuum.

Background

Key populations (KP), including men who have sex with men (MSM), transgender individuals, Female Sex Workers (FSWs), and people who inject drugs (PWID), bear a disproportionate burden of HIV infection globally [1]. In 2022, MSM had a 23-fold higher risk of acquiring HIV compared to the general population, while PWID and sex workers had 14-fold and 9-fold higher risks, respectively [1]. Despite global efforts, new HIV infections among MSM increased by 11% between 2010 and 2022, particularly outside sub-Saharan Africa. Access to comprehensive HIV prevention services remains insufficient, with only 40% of MSM reporting access to at least two prevention interventions in the previous three months [2]. Structural determinants, including criminalization, stigma, discrimination, and violence, continue to exacerbate vulnerability and limit

access to HIV services. Evidence from sub-Saharan Africa shows that HIV prevalence among MSM is significantly higher in countries where same-sex relationships are criminalized, with even greater disparities observed in contexts with active legal prosecution [3]. Bisexual practices are also common among MSM, increasing the potential for onward transmission to the general population [4].

Sex workers remain highly vulnerable to HIV infection, with persistent structural barriers limiting access to prevention and treatment services. Although new infections among sex workers declined substantially in sub-Saharan Africa between 2010 and 2022, coverage of prevention and antiretroviral therapy (ART) remains suboptimal, particularly among younger individuals [2]. Criminalization, stigma, and exposure to violence further hinder healthcare utilization and exacerbate health inequities [5, 6]. Similarly, PWID face substantial barriers to HIV services due to punitive drug policies, stigma, and limited access to harm reduction interventions, resulting in low coverage of both prevention and treatment services globally [2].

Community-based and peer-led approaches have emerged as effective strategies to improve access to HIV services among key populations. These approaches leverage community trust and contextual knowledge to enhance linkage to care, retention, and treatment adherence, particularly in marginalized settings [7–9].

In Cameroon, HIV remains a major public health concern despite a decline in prevalence in the general population from 5.4% in 2004 to 2.7% in 2018 [10]. The epidemic is increasingly concentrated among key populations, with prevalence estimates exceeding 20% among MSM and sex workers between 2016 and 2022 [11, 12]. Although ART coverage reached 93.3% in the general population in 2023, it remains lower than 90% among key populations, highlighting persistent inequities in access to care [13]. These disparities are particularly concerning given the interactions between key populations and the broader population, including a high prevalence (60%) of bisexual behavior among MSM [14, 15]. Structural barriers, including the criminalization of same-sex practices and sex work, further limit access to timely diagnosis and treatment [15].

To address these challenges, community-based ART initiation (CBARTI) has been promoted as an innovative strategy to improve access to treatment and accelerate linkage to care. Evidence from sub-Saharan Africa suggests that community-based ART models can improve treatment uptake, retention, and viral suppression compared to facility-based approaches, particularly among underserved populations [16–18]. In line with global recommendations, Cameroon adopted CBARTI in November 2023, with implementation beginning in early 2024 through selected community-based organizations.

However, early programmatic evaluation did not demonstrate clear superiority of CBARTI over conventional facility-based referral models in terms of linkage to care. Moreover, critical outcomes such as adoption, quality of life, and viral suppression among key populations were not assessed. While previous studies have demonstrated improvements in clinical outcomes with community-based models [19], evidence remains limited regarding their adoption and their impact on broader patient-centered outcomes, particularly quality of life. Existing literature consistently reports reduced quality of life among people living with HIV within key populations [20–25] due to structural, social, and psychosocial constraints, yet comparative evidence assessing the influence of service delivery models on this outcome is lacking.

Following Proctor's framework [26], this study distinguishes between implementation, service, and client outcomes. "Adoption" is conceptualized as an implementation outcome reflecting the uptake [27, 28] of the CBARTI intervention by KP. "Same-day ART initiation" is conceptualized as a service outcome reflecting timeliness and health system performance, while "Viral Load Suppression" and "Health-Related Quality of Life (HRQoL)" are considered client outcomes capturing biological and patient-reported health effects. Using the Type 1 effectiveness – implementation hybrid framework [29], this study aims to evaluate the adoption and effectiveness of community-based ART initiation among key populations in Cameroon.

Methods

Study design and setting

We conducted a quasi-experimental post-test-only study with a non-randomized comparison group based on natural geographic allocation in Yaoundé and Douala, Cameroon.

Two groups were defined: (i) an intervention group consisting of participants initiated on antiretroviral therapy (ART) through the CBARTI strategy, and (ii) a comparison group comprising participants initiated on ART in health facilities through the standard facility-based model.

Outcomes were assessed after implementation of the intervention without baseline measurements in either group. This post-test-only design is appropriate in programmatic settings where randomization is not feasible due to operational, logistical, or ethical constraints [30–35]

Intervention description

CBARTI was delivered by trained providers within community-based organizations (CBOs) using two approaches: (i) initiation at the CBO following HIV testing conducted on-site, and (ii) initiation at the CBO following HIV testing conducted at other community locations. All CBOs operated under the supervision of linked health facilities, which provided clinical oversight and technical support.

Implementation of the intervention required several preconditions, including: formal linkage with a supervising health facility; availability of appropriate and confidential spaces for service delivery; access to basic equipment for initial client assessment; availability of standardized data collection tools; uninterrupted supply of antiretroviral therapy (ART) and tuberculosis preventive treatment; adequate organizational capacity; robust client follow-up mechanisms; integration of community-initiated patients into facility-based cohorts; effective collaboration between CBOs and health facilities; incorporation of commodity needs into the supply chain; coordinated implementation across health system levels; and integration of monitoring and evaluation within the national health information system. Any KP individual testing HIV-positive with an infection or pregnancy was ineligible for CBARTI and referrals were made to health facilities of choice.

Reference arm

In the reference arm, key populations were tested for HIV within CBOs or other community settings. Individuals with reactive results were actively referred to a health facility of their choice for ART initiation

through the standard facility-based “handshake” model.

Study period

The study was conducted between February 2024 and November 2025. Data collection took place from October to November 2025.

Study population and sampling

The study population comprised key populations living with HIV, including MSM, transgender (TG) individuals, FSWs, clients of FSWs, and PWID.

Eligible participants were those eligible for CBARTI, initiated on ART between February and November 2024, aged 21 years or older, on treatment for at least 12 months, and who provided informed consent. Individuals were excluded if they were not eligible for CBARTI, were initiated on ART after November 2024, had changed their site of follow-up after initiation, were younger than 21 years, or declined participation.

A combination of exhaustive and voluntary sampling strategies was used. All community-based organizations (CBOs) involved in community ART initiation in Yaoundé and Douala, including those assessed but not initially selected for implementation, were considered as study sites. Within these sites, participants were recruited using voluntary sampling, a method commonly applied in studies involving sensitive or stigmatized populations [36, 37].

The sample size was calculated using the World Health Organization formula for hypothesis testing of an odds ratio, assuming a 5% significance level, 80% power, and a two-sided alternative hypothesis [38, 39]. Based on national data indicating that approximately 20% of key populations were not linked to ART in health facilities [13] and considering a relative risk of 2 as clinically meaningful, the minimum required sample size was estimated at 150 participants per group (300 total). Ultimately, 288 participants were included, representing 96% of the initially required sample size. Therefore, the study was close to the planned sample size, although slightly below the initial target. Because the main analysis relied on propensity score overlap weighting, the effective amount of statistical information was also assessed post hoc using the effective sample size. This diagnostic was not used to determine eligibility or recruitment targets but to evaluate information retention after weighting.

Data collection and measurements

Community health worker pairs received a two-day training on digital data collection, research integrity, and ethics. Data were collected through face-to-face interviews using a structured questionnaire (Supplementary material 1) administered to participants in both study arms, complemented by a standardized data extraction form capturing routine clinical information from community-based organizations (CBOs) and medical records.

The questionnaire comprised three components: (i) socio-demographic characteristics and contextual assessment, (ii) clinical and (iii)health-related quality of life (HRQoL). The first component captured socio-demographic characteristics (age, key population identity, education, and residence) and living conditions (household composition and access to basic amenities). The Synthetic Economic Well-being Indicator (SEWI) was constructed from four binary indicators of household access to durable goods and essential services (running water, electricity, refrigerator, television), following the asset-index approach [40, 41]. Given the dichotomous nature of the variables, Multiple Correspondence Analysis (MCA) was used as the main method [42, 43], with the Benzécri/Greenacre correction applied to the explained inertia. Each household's score on the first factorial axis was retained as the synthetic indicator and rescaled to 0–100 using a Min–Max normalisation. Robustness was assessed through polychoric PCA on the tetrachoric correlation matrix and standard Filmer–Pritchett PCA [44], all three scores yielding convergent results. Internal consistency was verified via the KR-20 coefficient [45], and households were subsequently classified into tertiles and quintiles. Full methodological details are provided in the Supplementary Material (Supplementary material 2).

The second component captured HIV care pathways (testing site, ART initiation site, reasons for choice, and timing of key events), disclosure of HIV status and self-reported symptoms, as well as treatment-related information. Psychological distress was assessed using five self-reported items (such as insomnia, nightmares, dizziness, nervousness, and concentration difficulties) rated on a four-point Likert scale (from “never (1)” to “regularly (4)”). These five-item psychological distress score was developed specifically for this study.

Virological follow-up was assessed using viral load data (availability, date, and most recent value), with measurements (copies/mL). Viral load data and Same-day ART initiation were extracted from participants’ medical records.

The third component captured HRQoL and it was measured using the validated French version of the WHOQOL-HIV BREF instrument, a 31-item self-reported questionnaire covering six domains (physical, psychological, level of independence, social relationships, environment, and spirituality), along with two general items assessing overall quality of life and health status. Each item is rated on a five-point Likert scale, with higher scores indicating better perceived quality of life. The instrument has demonstrated good psychometric properties in French-speaking populations [46, 47].

Outcomes, exposure, and covariates

The primary outcome was adoption of CBARTI, health-related quality of life (HRQoL), measured using the WHOQOL-HIV BREF instrument.

Secondary outcomes included same -day ART initiation and viral suppression. Same-day ART initiation was defined as zero days between HIV diagnosis and ART initiation. Viral load suppression was defined as a viral load ≤ 40 copies/mL.

The main independent variable (exposure) was the site of ART initiation and follow-up, defined as community-based or facility-based (through handshake model).

Potential confounders included age, key population identity (MSM/transgender individuals, female sex workers, people who inject drugs, and clients of female sex workers), level of education, parental survival status, disclosure of HIV status, disclosure of key population status, Body Mass Index (BMI), the Synthetic Economic Well-being Indicator and psychological distress score.

Statistical analysis

All variables were defined a priori. Categorical variables were summarised as frequencies and proportions, and continuous variables as medians with interquartile ranges (IQR), except for health-related quality of life (HRQoL) scores, which were reported as means and standard deviations in accordance with the WHOQOL-HIV BREF manual [48].

The 'psychological distress' score was computed as the mean of the item responses, with higher scores indicating greater psychological distress. The internal structure of the five-item scale was assessed by robust exploratory factor analysis based on the matrix of polychoric correlations (appropriate for the asymmetric ordinal items). The number of dimensions was determined using the optimal implementation of parallel analysis [49, 50], and the factor was extracted with the MORGANA procedure [51], with bias-corrected and accelerated bootstrap 95% confidence intervals (1,000 resamples) and the LOSEFER correction for the goodness-of-fit statistics. Parallel analysis and the closeness-to-unidimensionality indices supported a single, essentially unidimensional factor with good model fit and salient loadings on all items. Internal consistency was evaluated using McDonald's ordinal omega and Cronbach's alpha [52, 53]. Details regarding item development, content validity, factorial structure, reliability, and scoring are provided in Supplementary Material (Supplementary material 3).

A qualitative approach combining lexical analysis and thematic grouping was used to analyse open-ended questions [54] relating to the motivations for choosing the site of initiation. First, the raw responses were standardised. Then, semantically similar entries were grouped into coherent themes, taking into account the specific context of community-based ART for key populations (Supplementary material 4). The most salient motivations expressed by participants are presented as Sankey diagram, in which the width of each term is proportional to its frequency of occurrence.

HRQoL was assessed using the 29-item WHOQOL-HIV BREF. Negatively worded items (n = 7) were reverse-coded, and domain scores were computed by multiplying the mean of items within each domain by four, yielding six domain scores ranging from 4 to 20, with higher scores indicating better HRQoL [48].

Given the non-randomised design, causal effects of the INIC strategy were estimated using a propensity score approach to control for measured confounding. The propensity score, defined as the probability of receiving CBARTI versus facility-based initiation, was estimated using a multivariable logistic regression model including potential confounders, with continuous covariates (age, BMI, psychological distress score), and categorical variables modelled using dummy indicator terms with prespecified reference categories (female sex workers for key population type, secondary education for educational level, and both parents alive for parental vitality, low for SEWI tertil). Disclosure of HIV status and key population status were included as binary variables (reference: no). These confounders were selected based on their presumed

associations with both exposure and outcomes, consistent with causal inference principles rather than statistical significance [55].

Overlap weighting was applied to estimate treatment effects in the population with the greatest covariate overlap [56–60, 55, 61–66]. Weights were defined as $1 - PS$ for individuals in the CBARTI group and PS for those in the facility-based initiation group, thereby emphasising observations within the region of common support and reducing the influence of extreme propensity scores [60, 62].

To evaluate the quality of the Overlap Weighting (OW) method, two complementary indicators were examined: the balance of covariates and the effective sample size (ESS). Covariate balance was assessed using standardised mean differences (SMD), with values below 0.10 indicating adequate balance, and evaluated graphically using Love plots [55, 58]. All covariates achieved acceptable balance after weighting. (Fig. 6). Moreover, the effective sample size was calculated using the formula proposed by Kish [67]: $\mathrm{ESS} = (\sum \mathrm{w})^2 / \sum (\mathrm{w}^2)$. The ESS was 170.31 of 288 observations, corresponding to 59.1% of the original sample size. This value should not be interpreted as the number of participants analysed; rather, all 288 participants contributed to the weighted analysis, but their statistical contribution varied according to their overlap weights [62, 67, 68]. The ESS indicates that the weighted analysis retained an amount of information equivalent to approximately 170 equally weighted observations. The weighted pseudo-population size of approximately 41 participants per arm reflects the sum of the overlap weights and should not be interpreted as the actual number of participants analysed per group.

Outcome analyses were conducted in the weighted sample without data-driven variable selection. Associations between study arm and binary outcome “Same day ART iniation” were estimated using modified Poisson regression models with robust (sandwich) variance, yielding weighted risk ratios (RRw) with 95% confidence intervals [69–72]. However, for the binary outcome “viral suppression”, the data were completely separated, as all participants in the control arm were virally suppressed (no detectable viral load), creating a zero cell; the maximum-likelihood estimates therefore did not converge to finite values. For this outcome, the weighted risk ratio was estimated using a robust poisson regression with Firth penalized-likelihood combined with a small-sample bias-corrected sandwich variance estimator, implemented in the *firthb* R package [73]. This approach provides finite, bias-reduced point estimates and valid confidence intervals under (quasi-)complete separation and in small samples. HRQoL domain scores (six WHOQOL domains, 4–20 scale) were analysed using generalised linear models with a Gamma distribution and a log link, fitted with overlap weights and a small-sample bias-corrected sandwich (robust) variance estimator, yielding weighted ratios of mean domain scores with 95% confidence intervals [74, 75]. Justification of choice of the regression model was detailed in supplementary material (Supplementary material 5). The robustness of the findings to the distributional assumption was confirmed in sensitivity analyses using robust ordinary least squares and Beta regression, which gave consistent results (Supplementary Material 5).

For quantitative analysis, all tests were two-sided, with statistical significance set at $p < 0.05$. Analyses were performed using SPSS version 27, R version 4, Excel 365, Factor version 12.06.09 and Python 3.13. Qualitative analysis was performed using Atlas ti 9 software.

Ethical considerations

Data were anonymized and securely coded to ensure confidentiality. The study complied with the Declaration of Helsinki [76] and International ethical guidelines for health-related research involving humans [77].

Results

Figure 1 presents the participant flow. Of 318 key population members approached, 288 were included in the study after 30 exclusions; 154 were assigned to the reference arm and 134 to the CBARTI intervention arm. All 288 participants contributed to the overlap-weighted causal analysis, none was excluded by the weighting, each weighted by their overlap weight to form a balanced pseudo-population (sum of overlap weights ≈ 41 per arm, ≈ 83 in total). The corresponding effective sample size (Kish) was ≈ 170 (59% of the original sample).

Adoption of the CBARTI strategy

Among the 158 participants newly diagnosed with HIV through community-based testing by the CBOs implementing the CBARTI strategy, all (100%) had knowledge of the strategy and all (100%) freely chose their site of ART initiation. Of these, 134 (84.8%; 95% CI 78.2–90.0) initiated ART in the community and 24 (15.2%) at a health facility (Fig. 2).

Motivations for the choice of ART initiation site

The analysis of the open-ended responses yielded eight motivation themes, displayed as frequency of occurrence in the Sankey diagram (Fig. 3). For the choice of community-based initiation (CBARTI), the most frequently expressed motivation was "*community and peer support"* (37 occurrences), followed by "*proximity and ease of access"* (30), "*promptness of initiation*" (27) and "*privacy/confidentiality and discretion"* (24); "*comfort and wellbeing"* (8), "*absence of stigma and discrimination*" (6) and "*extended or flexible hours*" (6) were also expressed. For the choice of facility-based initiation, motivations centred on "*proximity and ease of access*" (16), "*trust in providers*" (5) and "*privacy/confidentiality*" (3) (Fig. 3).

Two themes were articulated in relation to both options, "*proximity and ease of access*", and "*privacy"*, whereas "*community and peer support*", "*promptness of initiation*", "*comfort and wellbeing*", "*absence of stigma*", and "*flexible hours*" were expressed exclusively in connection with community-based initiation, and trust in providers exclusively in connection with the facility (Fig. 3). Beyond their distribution, the nature of these motivations points to two distinct logics of choice: community-based initiation was valued chiefly for relational and experiential reasons, peer support, a stigma-free and comfortable environment, speed and flexibility — while the facility was chosen on more conventional grounds of practical access and confidence in health providers. Notably, privacy was articulated far more often in relation to the community option (24 occurrences) than to the facility (3) and was therefore not perceived as a distinctive advantage of facility-based care among these participants (Fig. 3).

Characteristics of the study population before overlap weighting

The study population comprised 288 members of key populations (154 in the control arm and 134 in the intervention arm). The median age was 31 years (IQR 26–39). MSM and transgender people (44.1%) and

female sex workers (41.0%) accounted for most of the sample, with smaller proportions of clients of female sex workers (11.5%) and people who inject drugs (3.5%). Most participants had a secondary level of education (58.7%), just over half had both parents alive (53.8%), and economic well-being was most often high (47.2%) or low (32.6%). The median psychological distress score was 1.80 (IQR 1.20–2.20) and the median body mass index 25.1 kg/m². About two-thirds had disclosed their HIV-positive status (65.3%) and their key-population status (62.2%) to at least one close contact (Table 1).

The two arms were comparable on several characteristics (age, proportion of female sex workers, disclosure of key-population status) but differed on others before weighting (|SMD| or |Cohen's d| > 0.10). The most pronounced difference concerned the psychological distress score, which was markedly higher in the intervention arm (Cohen's d = − 0.97); imbalances were also observed for parental survival status (mother alive only; both parents alive), tertiary education, economic well-being, and key-population composition (MSM and transgender people, PWID, and clients of FSWs). These baseline imbalances motivated the use of overlap weighting to render the arms comparable (Table 1).

Table 1

Baseline characteristics of the study population by arm (before overlap weighting)

Characteristic	Control (n = 154)	Intervention (n = 134)	Overall (n = 288)	SMD
Sociodemographic characteristics				
Participant age, median [IQR]	31 [26–39]	31 [25–39]	31 [26–39]	-0.083
Level of education				
Primary or less	44 (28.6%)	41 (30.6%)	85 (29.5%)	+ 0.044
Secondary	87 (56.5%)	82 (61.2%)	169 (58.7%)	+ 0.096
Tertiary	23 (14.9%)	11 (8.2%)	34 (11.8%)	**−0.211**
Parental survival status				
Both parents alive	73 (47.4%)	82 (61.2%)	155 (53.8%)	**+ 0.280**
Both parents deceased	27 (17.5%)	23 (17.2%)	50 (17.4%)	−0.010
Father alive only	13 (8.4%)	13 (9.7%)	26 (9.0%)	+ 0.044
Mother alive only	41 (26.6%)	16 (11.9%)	57 (19.8%)	**−0.379**
Economic well-being				
Low	56 (36.4%)	38 (28.4%)	94 (32.6%)	**−0.172**
Medium	25 (16.2%)	33 (24.6%)	58 (20.1%)	**+ 0.209**
High	73 (47.4%)	63 (47.0%)	136 (47.2%)	−0.008
Key population				
MSM and transgender people	61 (39.6%)	66 (49.3%)	127 (44.1%)	**+ 0.195**
Female sex workers (FSWs)	65 (42.2%)	53 (39.6%)	118 (41.0%)	−0.054
People who inject drugs (PWID)	7 (4.5%)	3 (2.2%)	10 (3.5%)	**−0.128**
Clients of FSWs	21 (13.6%)	12 (9.0%)	33 (11.5%)	**−0.148**
Clinical and behavioural characteristics				
Psychological distress score, median [IQR]	1.4 [1.0–2.0]	2.0 [1.8–2.4]	1.8 [1.2–2.2]	**-0.970**
Body mass index (BMI), median [IQR]	25.4 [23.7–27.1]	24.8 [22.7–27.2]	25.1 [23.3–27.1]	**0.147**
Disclosure of HIV-positive status to ≥ 1 close contact	97 (63.0%)	91 (67.9%)	188 (65.3%)	**+ 0.104**

Footnote: Data are presented as n (%) for categorical variables and as median [IQR] for continuous variables. Only the 'yes' category of each dichotomous indicator (dummy) variable is reported. IQR, interquartile range [P25–P75].

Characteristic	Control (n = 154)	Intervention (n = 134)	Overall (n = 288)	SMD
Sociodemographic characteristics				
Disclosure of key-population status to ≥ 1 close contact	95 (61.7%)	84 (62.7%)	179 (62.2%)	+ 0.021

Footnote: Data are presented as n (%) for categorical variables and as median [IQR] for continuous variables. Only the 'yes' category of each dichotomous indicator (dummy) variable is reported. IQR, interquartile range [P25–P75].

SMD = standardised mean difference, computed as (p_intervention − p_control) / √[(p_int(1−p_int) + p_ctrl(1−p_ctrl))/2] for binary variables. A positive value denotes a higher proportion in the intervention arm. An |SMD| > 0.10 (highlighted in bold) indicates potential between-arm imbalance before weighting. SMD was computed for continuous variables with "Cohen's d".

MSM, men who have sex with men; TG, transgender; FSWs, female sex workers; PWID, people who inject drugs.

Description of the outcomes in the unweighted sample

Same-day ART initiation was observed in 237 of the 288 participants overall (82.3%, 95% CI 77.4–86.5). It was reported in 118 of the 134 participants in the intervention arm (88.1%, 95% CI 81.3–93.0) and in 119 of the 154 participants in the control arm (77.3%, 95% CI 69.8–83.6) (Fig. 4).

Of the 288 participants on ART at least 12 months, a viral load test was performed in 260 (90.3%), a result was available for 198 (68.8%), and 189 (65.6%) were unconditional virally suppressed (undetectable). The losses between steps correspond to 28 participants (9.7%) without a viral load test and 62 (21.5%) with a pending result (Fig. 5A).

Among the 198 participants with an available viral load result, 189 were virally suppressed (95.5%, 95% CI 91.5–97.9). Viral suppression was 100% in the control arm (118/118, 95% CI 96.9–100.0) and 88.8% in the intervention arm (71/80, 95% CI 79.7–94.7) (Fig. 5B).

Across the whole sample, mean WHOQOL-HIV BREF domain scores ranged from 10.28 (environment) to 14.41 (physical health) on the 4–20 scale. The highest-scoring domains were physical health (14.41) and spirituality/personal beliefs (14.15), and the lowest were environment (10.28) and social relationships (12.29) (Table 2). By study arm (descriptive, unweighted), mean scores were higher in the control arm than in the intervention arm for all six domains (Table 2). The largest absolute difference was observed for social relationships (control 13.60 vs intervention 10.79), followed by level of independence (14.53 vs 13.07) and environment (10.85 vs 9.62); the smallest differences were for physical health (14.86 vs 13.90) and the psychological domain (13.77 vs 12.80). Internal consistency varied across domains and arms (Table 2). Overall, Cronbach's α ranged from 0.52 (spirituality/personal beliefs) to 0.71 (environment). Across arms, α ranged from 0.32 (spirituality, control arm) to 0.76 (environment, control arm). Values reached or exceeded the conventional 0.70 threshold only for the environment domain (overall 0.71; control 0.76) and the level-of-

independence domain in the control arm (0.75); the remaining domain-by-arm estimates were below 0.70, with the lowest values for spirituality (control 0.32) and social relationships (control 0.41) (Table 2).

Covariate balance after overlap weighting

Covariate balance before and after overlap weighting is shown in Fig. 6. Before weighting, several baseline covariates differed between the two groups, the largest imbalance being for the psychological distress score (|SMD| ≈ 0.97), followed by parental survival status (mother alive only) and several education and economic-well-being categories. After overlap weighting, all absolute standardised mean differences were reduced to approximately zero (well below the 0.10 threshold), indicating that the two weighted groups were balanced on every measured covariate (Fig. 6). The corresponding weighted characteristics of each arm are reported in Supplementary File (Supplementary material 6).

Table 2

Health-related quality of life (WHOQOL-HIV BREF) domain scores and internal consistency, overall and by study arm.

Characteristic	Overall (N = 288)	Control (N = 154)	Intervention (N = 134)
Physical health (4 items)			
Mean (SD) [min–max]	14.41 (2.48) [7.0–20.0]	14.86 (2.60) [7.0–20.0]	13.90 (2.23) [7.0–18.0]
Cronbach's α [95% CI]	0.59 [0.51–0.66]	0.58 [0.46–0.68]	0.67 [0.56–0.75]
Psychological (5 items)			
Mean (SD) [min–max]	13.32 (2.39) [6.4–19.2]	13.77 (2.53) [8.0–19.2]	12.80 (2.12) [6.4–17.6]
Cronbach's α [95% CI]	0.58 [0.49–0.65]	0.55 [0.43–0.65]	0.62 [0.51–0.71]
Level of independence (autonomy) (4 items)			
Mean (SD) [min–max]	13.85 (2.99) [5.0–20.0]	14.53 (3.35) [5.0–20.0]	13.07 (2.27) [7.0–20.0]
Cronbach's α [95% CI]	0.67 [0.60–0.73]	0.75 [0.67–0.81]	0.45 [0.29–0.59]
Social relationships (4 items)			
Mean (SD) [min–max]	12.29 (2.80) [5.0–19.0]	13.60 (2.56) [6.0–19.0]	10.79 (2.26) [5.0–15.0]
Cronbach's α [95% CI]	0.63 [0.55–0.69]	0.41 [0.24–0.55]	0.65 [0.54–0.74]
Environment (8 items)			
Mean (SD) [min–max]	10.28 (2.20) [4.0–18.0]	10.85 (2.54) [4.0–18.0]	9.62 (1.49) [5.5–14.0]
Cronbach's α [95% CI]	0.71 [0.66–0.76]	0.76 [0.70–0.82]	0.53 [0.39–0.64]
Spirituality / personal beliefs (4 items)			
Mean (SD) [min–max]	14.15 (2.81) [7.0–20.0]	14.69 (2.41) [7.0–20.0]	13.52 (3.11) [7.0–18.0]
Cronbach's α [95% CI]	0.52 [0.42–0.61]	0.32 [0.12–0.48]	0.68 [0.58–0.76]

Foot note. Domain scores are on the 4–20 scale (higher scores indicate better quality of life). Data are mean (standard deviation) [minimum–maximum] for domain scores, and Cronbach's α [95% confidence interval] for internal consistency. The α 95% CI is taken from the average measures intra-class correlation coefficient, which is numerically equal to Cronbach's α. WHOQOL-HIV BREF, World Health Organization Quality of Life HIV instrument, brief version.

Causal effects of the CBARTI strategy after overlap weighting

In the overlap-weighted population, the causal effect of the CBARTI strategy was estimated for same-day ART initiation, viral suppression, and each of the six WHOQOL-HIV BREF domains. Effect estimates were expressed as risk ratios for binary outcomes and ratios of mean scores for quality-of-life domains, together with their 95% confidence intervals. The null value was 1.00; estimates above 1.00 indicated higher outcome levels in the CBARTI arm, whereas estimates below 1.00 indicated higher outcome levels in the facility-based initiation arm (Table 3).

In the overlap-weighted population, same-day ART initiation was more frequent in the intervention arm than in the reference arm (91.2% versus 70.9%; RR 1.29 (95%CI: 1.11–1.50); p = 0.001) (Table 3).

Among participants with an available viral-load result (n = 198), all reference-arm participants were virally suppressed (100.0%) compared with 87.9% in the intervention arm; the corresponding risk ratio was below one (RR 0.88, 95% CI 0.79–0.98), indicating lower suppression in the intervention arm. Because the reference arm showed complete separation, this estimate was obtained by Firth penalised-likelihood regression with a Morel-corrected robust variance and was corroborated by Fisher's exact test (p < 0.001) (Table 3).

For health-related quality of life, the six WHOQOL-HIV BREF domains showed no difference between arm, except for social relationships, which was 18% lower in the intervention arm (ratio of mean scores = 0.82 (95% CI 0.77–0.87); p < 0.001) (Table 3). The five remaining domains — physical health (ratio of mean scores = 1.00 (95CI: 0.95–1.05)], psychological (ratio of mean scores = 0.97 (95%CI: 0.92–1.02)), level of independence (ratio of mean scores = 0.99 (95%CI: 0.92–1.06)), environment (ratio of mean scores = 0.96 (95%CI: 0.90–1.03)) and spirituality/personal beliefs (ratio of mean scores = 0.96 95%CI: 0.90–1.02)) — all had confidence intervals including one (Table 3).

Table 3

Overlap-weighted effects of the CBARTI strategy on programme outcomes and health-related quality of life (intervention versus reference arm).

Outcome / domain	Reference (weighted %)	Intervention (weighted %)	Effect estimate (95% CI)	p
Programme outcomes — risk ratio (RR)				
Same-day ART initiation, %	70.9	91.2	RR 1.29 (1.11–1.50)	0.001
Viral suppression, % †‡	100.0	87.9	RR 0.88 (0.79–0.98)	0.023
Health-related quality of life (WHOQOL-HIV BREF) ratio of mean domain scores				
Physical health	13.91	13.84	1.00 (0.95–1.05)	0.86
Psychological	13.23	12.78	0.97 (0.92–1.02)	0.18
Level of independence	13.31	13.12	0.99 (0.92–1.06)	0.69
Social relationships	12.92	10.55	0.82 (0.77–0.87)	< 0.001
Environment	10.03	9.63	0.96 (0.90–1.03)	0.25
Spirituality / personal beliefs	13.96	13.38	0.96 (0.90–1.02)	0.17

Foot note All estimates are overlap-weighted (average treatment effect in the overlap population), with the overlap weights treated as analysis weights and a robust (sandwich) variance. An estimate above 1 indicates a higher value — risk or mean score — in the intervention arm.

Programme outcomes: risk ratios from modified Poisson regression with robust (sandwich) variance. For viral suppression, Firth penalised-likelihood Poisson regression with robust variance and the Morel small-sample correction was used because the reference arm showed complete separation (all participants suppressed).

WHOQOL-HIV BREF: ratios of weighted mean domain scores from Gamma regression (log link) with robust (HC3) variance; domain scores range from 4 to 20, higher scores indicating better quality of life.

† Among participants with an available viral-load result (n = 198: 118 reference, 80 intervention).

‡ The lower viral suppression in the intervention arm was corroborated by Fisher's exact test ($p < 0.001$).

ART, antiretroviral therapy; CI, confidence interval; RR, risk ratio.

Discussion

In this Type 1 hybrid effectiveness–implementation study among key populations in Cameroon, community-based ART initiation (CBARTI) was compared with the standard facility-based “handshake” referral model, using overlap weighting to emulate a target population in clinical equipoise. Outcomes were organised along

Proctor's taxonomy of implementation, service and client outcomes [26]: adoption (uptake of CBARTI by newly diagnosed key populations) as the implementation outcome, same-day ART initiation as the service outcome, and viral suppression and health-related quality of life (HRQoL) as client outcomes.

CBARTI was widely adopted among newly diagnosed individuals free to choose their initiation site, 134 of 158 (84.8%, 95% CI 78.2–90.0) opted for community initiation. It markedly increased the likelihood of same-day ART initiation, the primary service-level outcome, by 29% compared with facility-based initiation (weighted risk ratio [RRw] = 1.29; 95% CI: 1.11–1.50). Among participants with an available viral-load result, viral suppression was high in both groups (≥ 88%); however, the probability of suppression was 12% lower in the intervention arm (RRw = 0.88; 95% CI: 0.79–0.98). HRQoL was comparable between the two arms across five of the six WHOQOL-HIV BREF domains. The only difference was observed in the social relationships domain, for which the ratio of mean score was 18% lower in the intervention arm (ratio of mean scores = 0.82; 95% CI: 0.77–0.87).

The high adoption of CBARTI is itself a central implementation finding. Within Proctor's framework, adoption denotes the uptake of an intervention by its intended recipients or delivery settings [26–28], and the fact that more than four in five newly diagnosed key-population members chose community initiation when genuinely free to do so indicates a strong fit between the model and the populations it targets. Participants' own accounts pointed to proximity and ease of access, privacy, peer and community support, promptness of initiation, a stigma-free and comfortable environment, and flexible hours as the dominant reasons for choosing the community option, whereas facility choice rested chiefly on conventional confidence in health providers. This pattern is consistent with sub-Saharan African evidence that key populations prefer community- and peer-led services perceived as less stigmatising and more accessible [17, 19], and with reports of high acceptability and retention in key-population-led treatment services elsewhere [78]. High adoption is a prerequisite for any downstream service- or client-level effect: a model that is not taken up can neither accelerate initiation nor improve patient outcomes.

The acceleration of same-day initiation, the service-level outcome, is consistent with the rationale for community-based and differentiated service delivery, which removes the facility-referral step at which many newly diagnosed key-population members are lost. By delivering testing and treatment in trusted community settings, often through peer or lay providers, CBARTI shortens the path between diagnosis and treatment, in keeping with the World Health Organization recommendation for rapid and same-day ART and with the documented benefits of rapid initiation, including faster viral suppression and reduced pre-treatment attrition [16–18, 79]. In the DO ART randomised trial in South Africa and Uganda, community-based initiation, monitoring and resupply improved engagement and viral suppression through mechanisms that included reduced travel and waiting times, longer and more flexible provider interactions, and the consolidation of several services into a single contact [16, 80]. A quasi-experimental evaluation in Botswana similarly found that simplifying initiation and bringing it closer to clients raised same-day uptake and shortened the time to documented viral suppression [81], while a meta-analysis of community-based initiation models reported higher uptake with at least comparable retention and suppression relative to facility care [17]. Our findings extend this evidence to a criminalised key-population context, in which stigma, fear of disclosure and mistrust of public facilities make the facility-referral step particularly fragile [82].

The lower conditional viral suppression in the intervention arm is counterintuitive and should be interpreted cautiously, in light of both its conditional nature and its statistical fragility. Suppression was estimated only among the 198 participants with an available result (69% of those eligible), and the reference arm showed complete separation (100% suppressed); the estimate therefore rested on a small number of unsuppressed events and required penalised-likelihood methods. More importantly, the comparison is susceptible to differential selection. Under facility referral, only individuals who successfully linked, initiated and were retained long enough to undergo viral-load testing contribute to the denominator, yielding a highly selected group in which near-universal suppression is expected. By initiating treatment in the community on the same day, CBARTI reaches and treats a broader, less-selected population, including people who, under facility referral, would have disengaged before initiation, which mechanically dilutes the proportion suppressed among those reaching a viral-load result. This selection mechanism has been described for same-day initiation studies, in which apparently lower engagement or suppression in comparison arms is driven chiefly by higher pre-treatment disengagement rather than by inferior outcomes among those who start treatment [83, 84]. Randomised evaluations that begin follow-up at testing have found no excess attrition or lower suppression attributable to same-day initiation itself [85], and syntheses of community-based initiation in sub-Saharan Africa have generally reported suppression at least comparable to facility care [17, 86]. The observed difference therefore more plausibly reflects the expanded treatment coverage of harder-to-reach individuals than a genuine detrimental effect of CBARTI on virological outcomes; it nonetheless signals the need for strengthened adherence support, active retention monitoring and complete viral-load coverage within community models.

Reassuringly, CBARTI was not associated with poorer quality of life across the physical health, psychological, level-of-independence, environmental and spiritual domains, indicating that community delivery does not compromise patient-reported wellbeing relative to facility-based care. The lower score in the social relationships domain in the intervention arm nonetheless merits attention. This domain captures personal relationships, perceived social support and intimacy, dimensions strongly shaped by HIV- and key-population-related stigma, disclosure and social-network composition [20–25]. Several mechanisms may account for it in this criminalised setting: a heightened fear of disclosing HIV or key-population status, linked to the visibility of attending community structures identified as serving key populations; a reorganisation or rupture of family and partner support networks following the diagnosis; and a tension between the discretion participants seek and the community affiliation that the model entails. Community-based initiation may also reach more socially isolated or marginalised individuals, and improved access to treatment alone may be insufficient to repair the relational dimensions of wellbeing, which require dedicated psychosocial and peer-support components together with stigma-reduction interventions. This pattern contrasts with literature emphasising the protective role of peer networks and social support for quality of life among key populations [21, 23], suggesting that, where intersectional stigma is intense [87], community initiation may broaden access while leaving, or even exposing, relational vulnerabilities unaddressed. This finding is hypothesis-generating and warrants qualitative exploration and longitudinal follow-up.

Taken together, these results support CBARTI as an effective implementation strategy: it is readily adopted by criminalised key populations and accelerates ART initiation, while indicating that scale-up should be coupled with robust viral-load monitoring, retention and adherence support, and explicit attention to social support and stigma. The hybrid effectiveness–implementation design [26, 29] proved valuable in distinguishing a

clear implementation and service-level benefit (high adoption and timeliness of initiation) from client-level outcomes (viral suppression and quality of life) that depend on the broader continuum of care. A further consideration is the maturity of the model: much of the African evidence concerns well-established community models with formalised referral pathways, functional information systems and uninterrupted ART supply [17], whereas CBARTI in Cameroon is an early-phase, still-heterogeneous model whose capacity and clinical oversight vary across community-based organisations. This contrast helps explain why service-level gains were achieved while some client-level dimensions lagged and underscores that the benefits of community models depend closely on the degree of implementation fidelity, supervision and integration into the health system.

This study has several strengths. It used a rigorous causal-inference framework: overlap weighting targeted the average treatment effect in the population of clinical equipoise, achieved exact covariate balance, and retained the full sample, with every participant contributing to the weighted analysis. Inference relied on robust (sandwich) variance estimators, with penalised-likelihood methods to accommodate complete separation, and the conclusions were stable across sensitivity analyses using alternative model specifications. The study also addressed hard-to-reach, criminalised populations and combined implementation, service and patient-reported outcomes within a single hybrid design anchored in an explicit implementation-science framework [26, 29].

Several limitations should be considered. The design was non-randomised; although overlap weighting balanced the measured confounders, residual confounding by unmeasured factors cannot be excluded. Recruitment was confined to community organisations in Yaoundé and Douala and used voluntary sampling, which may limit generalisability. Viral suppression was assessed cross-sectionally and conditionally on an available result, with 31% of eligible participants having no result or a pending one; this, together with complete separation and few unsuppressed events, limits the precision of that estimate and may introduce selection bias. Quality of life and several covariates were self-reported and thus subject to social-desirability and courtesy bias. Because CBARTI was still in an early implementation phase, with capacity and structuring that varied across organisations, the observed effects, particularly on the social dimensions of quality of life, may partly reflect the immaturity of the model rather than community delivery per se. Finally, the absence of longitudinal retention and durable-suppression data precludes conclusions about long-term effectiveness, and the social relationships finding requires confirmation.

Conclusion

Among key populations in Cameroon, community-based ART initiation was widely adopted and substantially increased same-day treatment initiation without compromising most domains of quality of life. The lower conditional viral suppression and social relationships scores in the intervention arm most likely reflect the broader, less-selected population reached through community delivery rather than inferior care, and they underscore the need to embed adherence support, viral-load monitoring and psychosocial services within community models. Interpreted through Proctor’s framework, CBARTI demonstrates strong performance at the implementation and service levels while client-level outcomes remain contingent on the surrounding continuum of care. These findings support the scale-up of CBARTI as a patient-centred strategy to advance

equitable HIV care among criminalised key populations, provided that its psychosocial components and CBO–facility continuum are strengthened and its financing stabilised.

Abbreviations

ART
antiretroviral therapy
BMI
body mass index
CBARTI
community–based ART initiation
CBO
community–based organisation
CI
confidence interval
ESS
effective sample size
FSW
female sex worker
GLM
generalised linear model
HIV
human immunodeficiency virus
HRQoL
health–related quality of life
IQR
interquartile range
KP
key population(s)
KR
20–Kuder–Richardson Formula 20
MCA
multiple correspondence analysis
MSM
men who have sex with men
OLS
ordinary least squares
OW
overlap weighting
PCA
principal component analysis
PS

propensity score
PWID
people who inject drugs
RR
risk ratio
RRw
weighted risk ratio
SD
standard deviation
SEWI
Synthetic Economic Well–being Indicator
SMD
standardised mean difference
TG
transgender
WHO
World Health Organization
WHOQOL
HIV BREF–World Health Organization Quality of Life HIV instrument, brief version.

Declarations

Ethics approval and consent to participate

The study was approved by the Cameroonian National Ethics Committee for Human Health Research (No. 2025/09/168/CE/CNERSH/SP) and the Institutional Ethics Committee of the Catholic University of Central Africa – School of Health Sciences (No. 2025/02055/CEIRSH/ESS/MSP). Administrative authorization was granted by the Cameroonian Ministry of Public Health (No. 631-4425). Written informed consent was obtained from all study participants.

Consent for publication

Not applicable, as no personally identifiable information or individual data is published.

Availability of data and materials

The datasets generated and/or analysed during the current study are not publicly available because, despite the removal of direct identifiers, the combination of sensitive clinical and sociodemographic variables may pose a risk of participant re-identification. In addition, secondary analyses examining factors associated with CBARTI adoption are ongoing. The data may be made available by the corresponding author upon reasonable request, subject to appropriate data-use agreement.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

JPYAN and ELAO conceptualised the study and contributed to its design. JPYAN led data management, data cleaning, coding, statistical analysis and interpretation of the findings, provided technical input into the qualitative analysis, and co-wrote the original draft of the manuscript. ELAO coordinated field activities and data collection, contributed to data analysis and interpretation, and co-wrote the original draft.

JN and RKD contributed to data entry, data cleaning, coding and statistical analysis.

JLNL, JA and ACZKB provided methodological and scientific guidance, supervised the study, contributed to the interpretation of the findings, and critically revised the manuscript.

All authors reviewed and approved the final version of the manuscript and agreed to be accountable for all aspects of the work.

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Figures

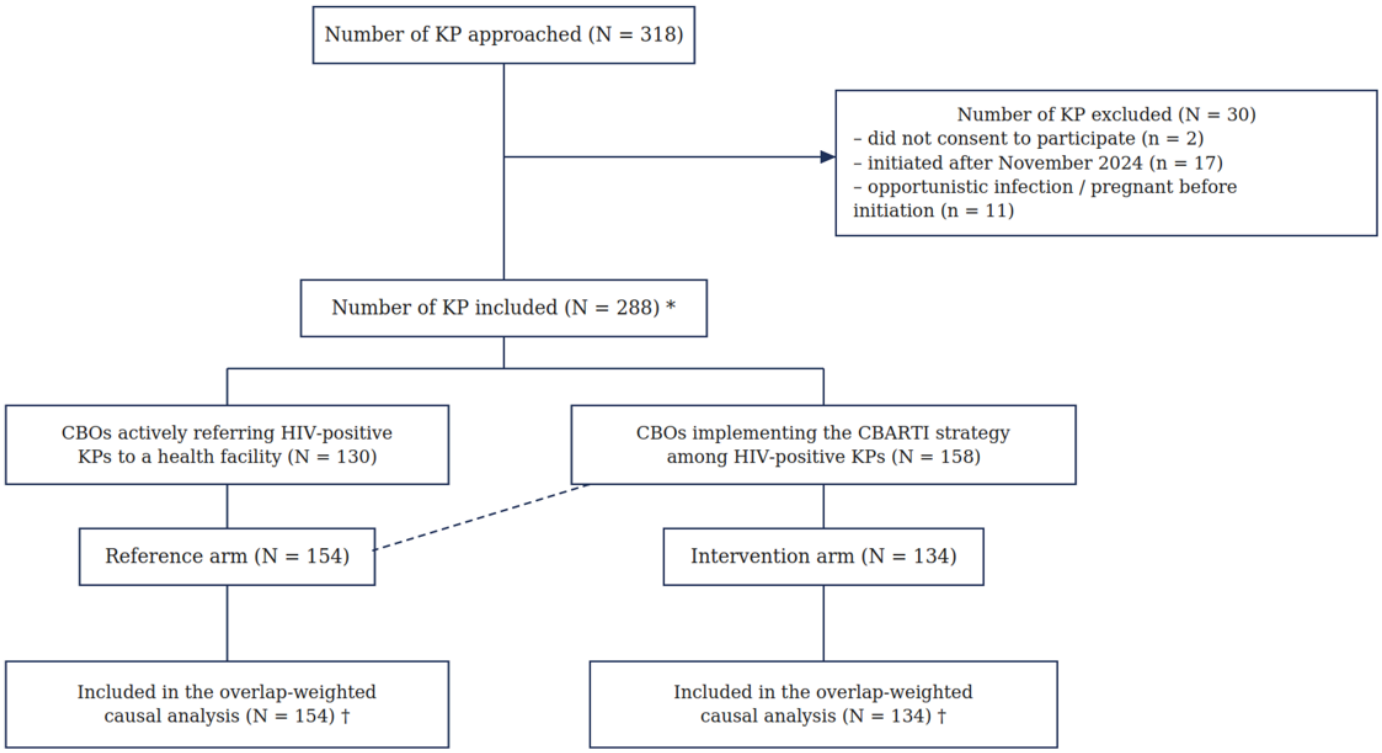


Figure 1

Participant flow and weighted analytic sample after overlap weighting.

* Inclusion period and arm-definition note. † No participant was excluded by the weighting: all 288 participants (154 reference, 134 intervention) contributed to the overlap-weighted causal analysis, each weighted by their overlap weight. The weighted pseudo-population (sum of overlap weights) was ≈ 41 per arm (≈ 83 in total); the effective sample size (Kish) was ≈ 170 overall (≈ 90 reference and ≈ 81 intervention), i.e. 59% of the original sample.

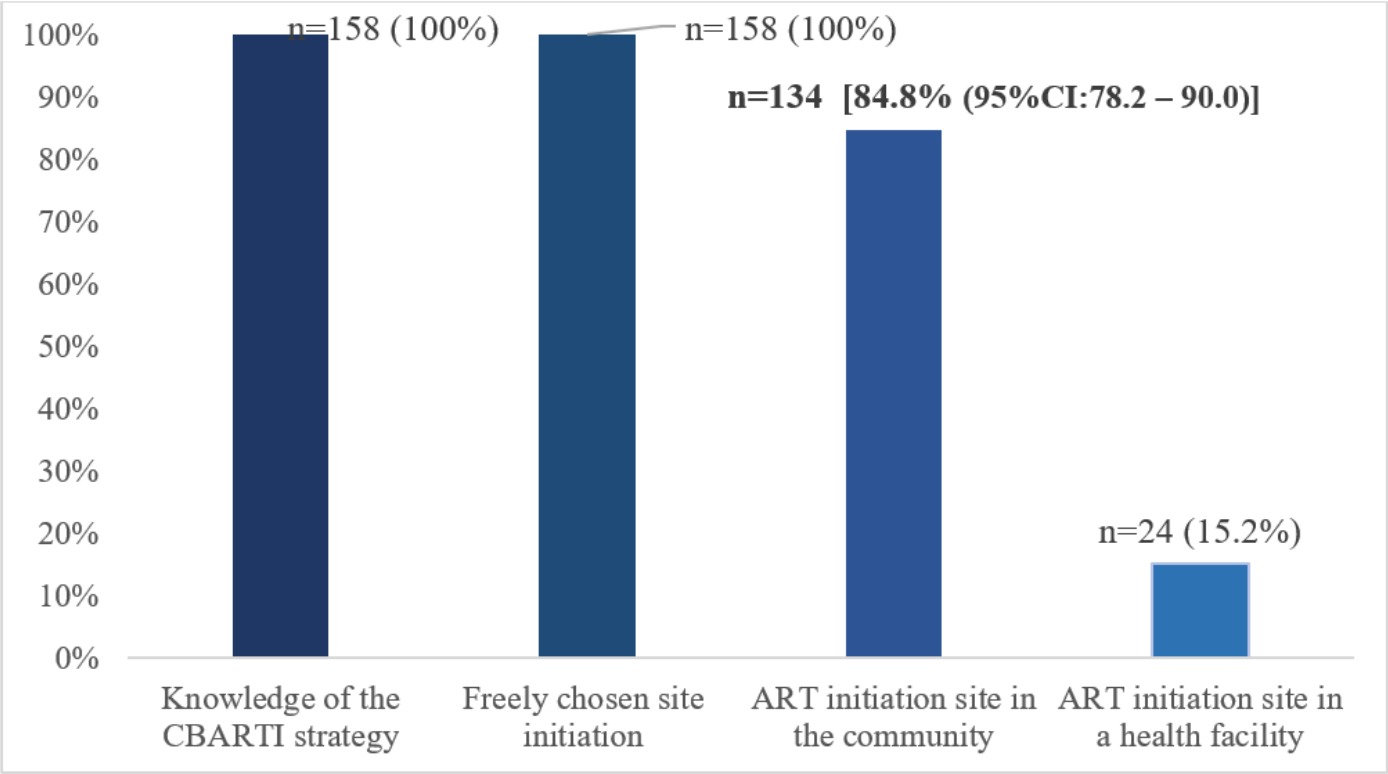


Figure 2

Awareness and adoption of the Community Based ART Initiation strategy

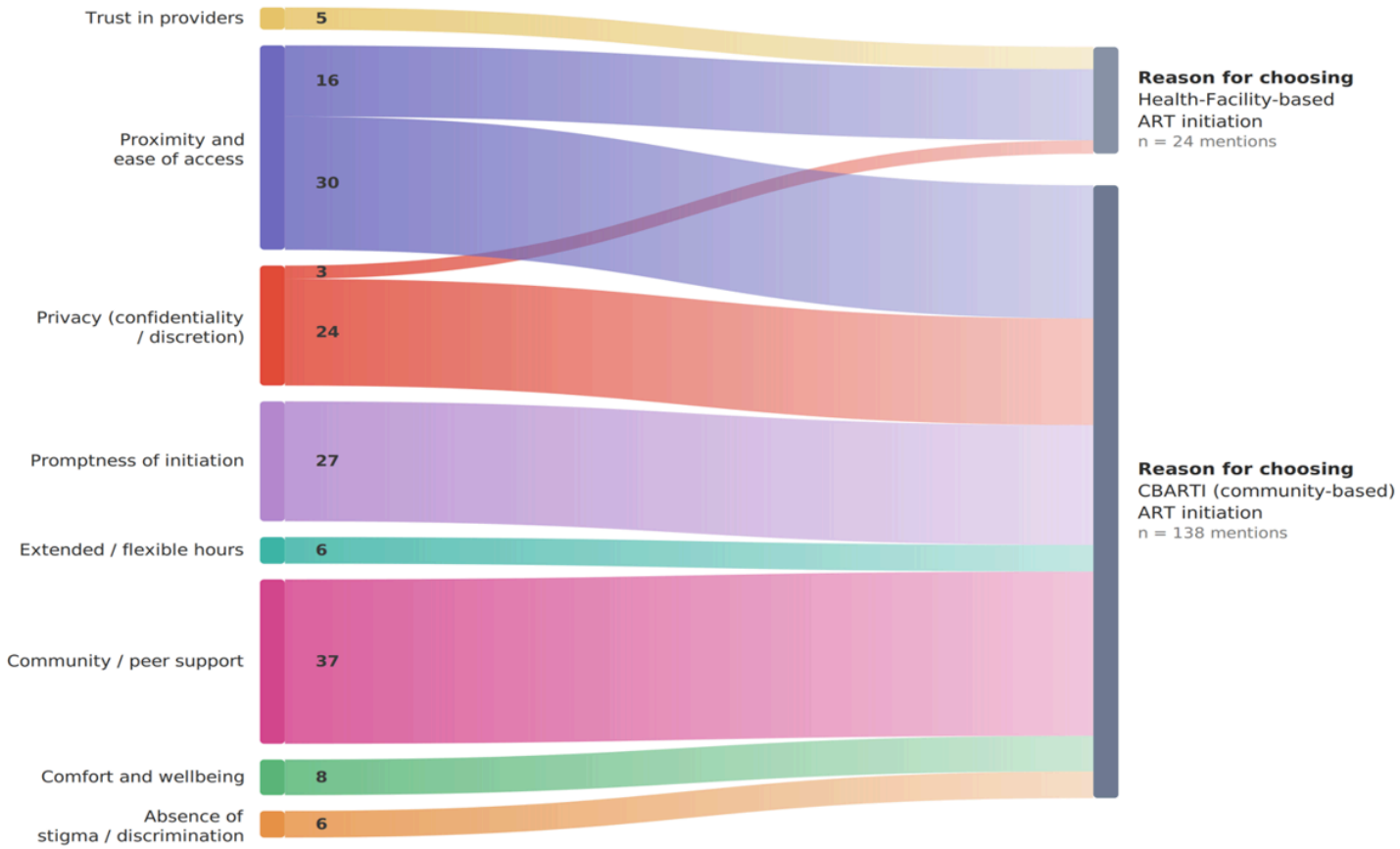


Figure 3

Reasons for choosing community- versus facility-based ART initiation: a Sankey diagram of motivations expressed in open-ended responses.

Legend: Open-ended responses to the two questions on the reasons for the freely chosen site of ART initiation (community-based initiation [CBARTI] versus health-facility-based initiation) were analysed among the 158 participants newly diagnosed with HIV by the community-based organisations implementing the CBARTI. Of these, 134 chose community-based initiation (132 provided a reason) and 24 chose a health facility. The width of each flow is proportional to the frequency of occurrence of the theme, shown by the figures on the diagram. As a response could express more than one motivation, the totals exceed the number of respondents. ART, antiretroviral therapy; CBARTI, community-based ART initiation.

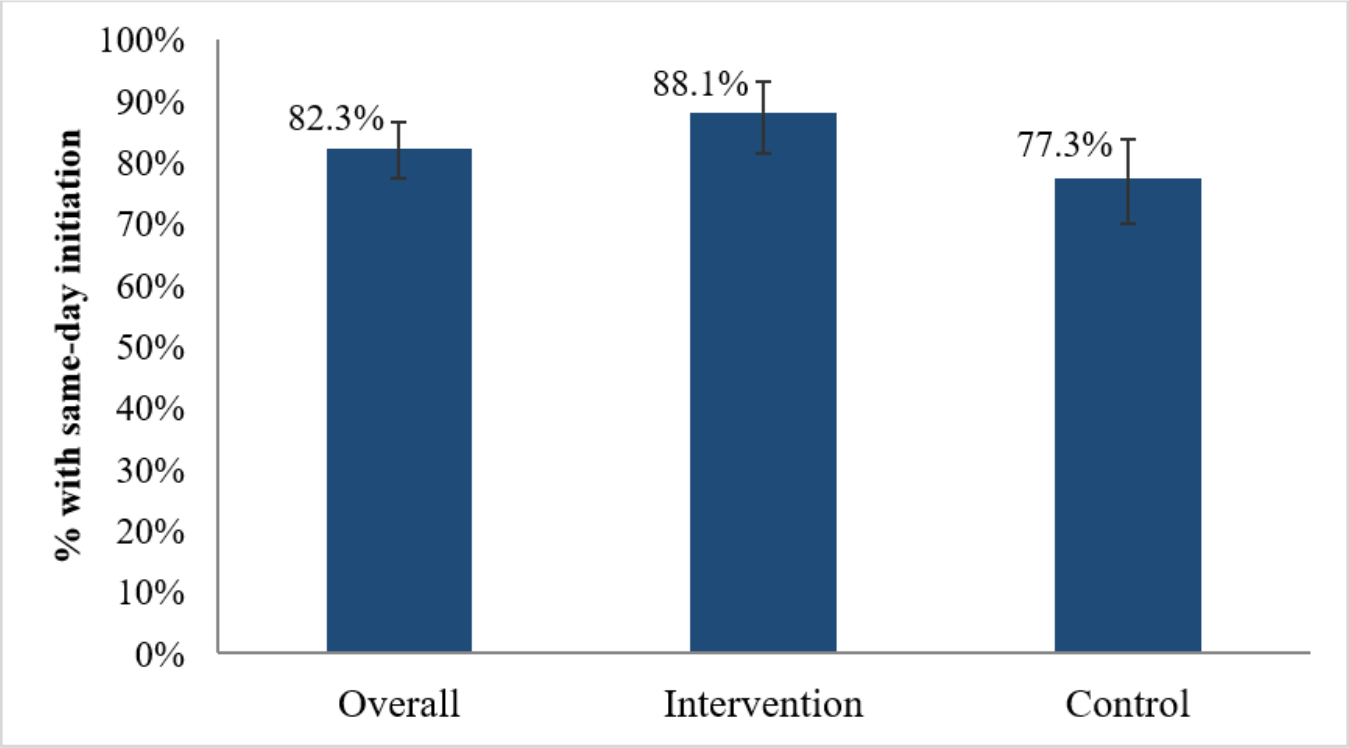


Figure 4

Same-day ART initiation, overall and by study arm.

Legend: Proportion of participants with same-day ART initiation, overall (N = 288) and by study arm (control, n = 154; intervention, n = 134). Error bars represent 95% confidence intervals (Clopper-Pearson exact method). Proportions are descriptive and unweighted; no between-arm comparison is implied — the adjusted comparison is reported in the overlap-weighted analysis.

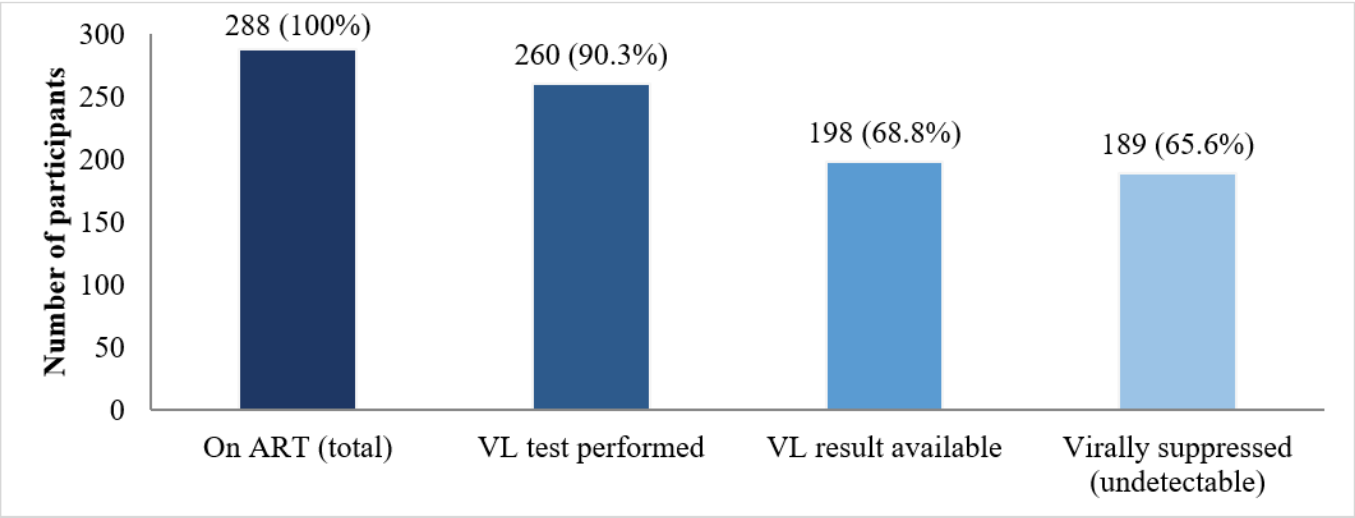


Figure 5A.

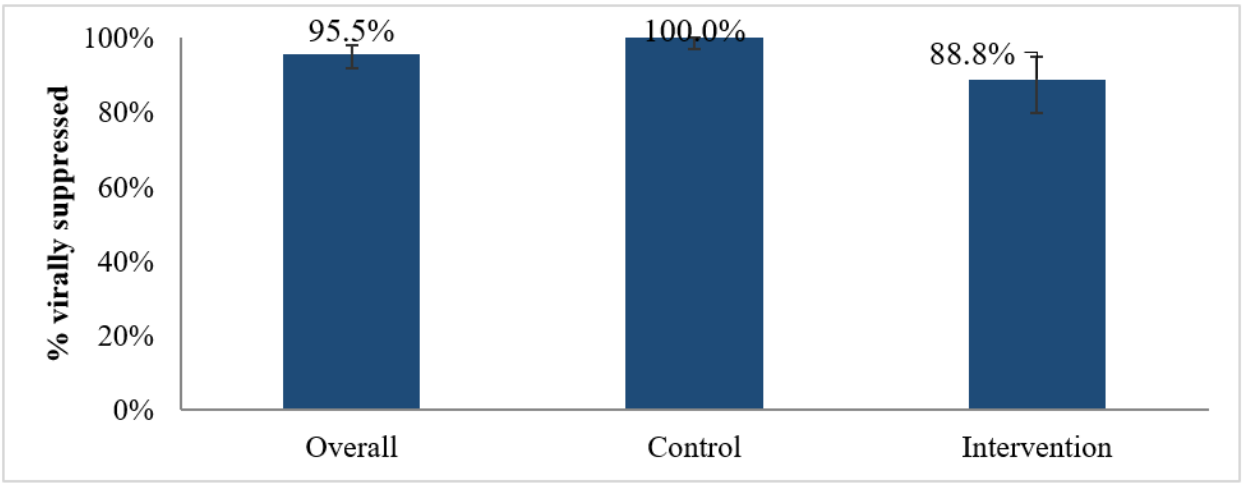


Figure 5B

Figure 5

A. **Unconditional viral load cascade among participants on ART (N = 288).**

Legend: Bars show the number of participants (with percentage of the total) at each step: viral load test performed, result available, and virally suppressed (undetectable viral load). Twenty-eight participants (9.7%) had no viral load test and 62 (21.5%) had a pending result.

B. **Conditional viral suppression (undetectable viral load) among participants with an available viral load result (n = 198), overall and by study arm (control, n = 118; intervention, n = 80).**

Legend: Error bars represent 95% confidence intervals (Clopper-Pearson exact method). Proportions are descriptive and unweighted; no between-arm comparison is implied — the adjusted comparison is reported in the overlap-weighted analysis.

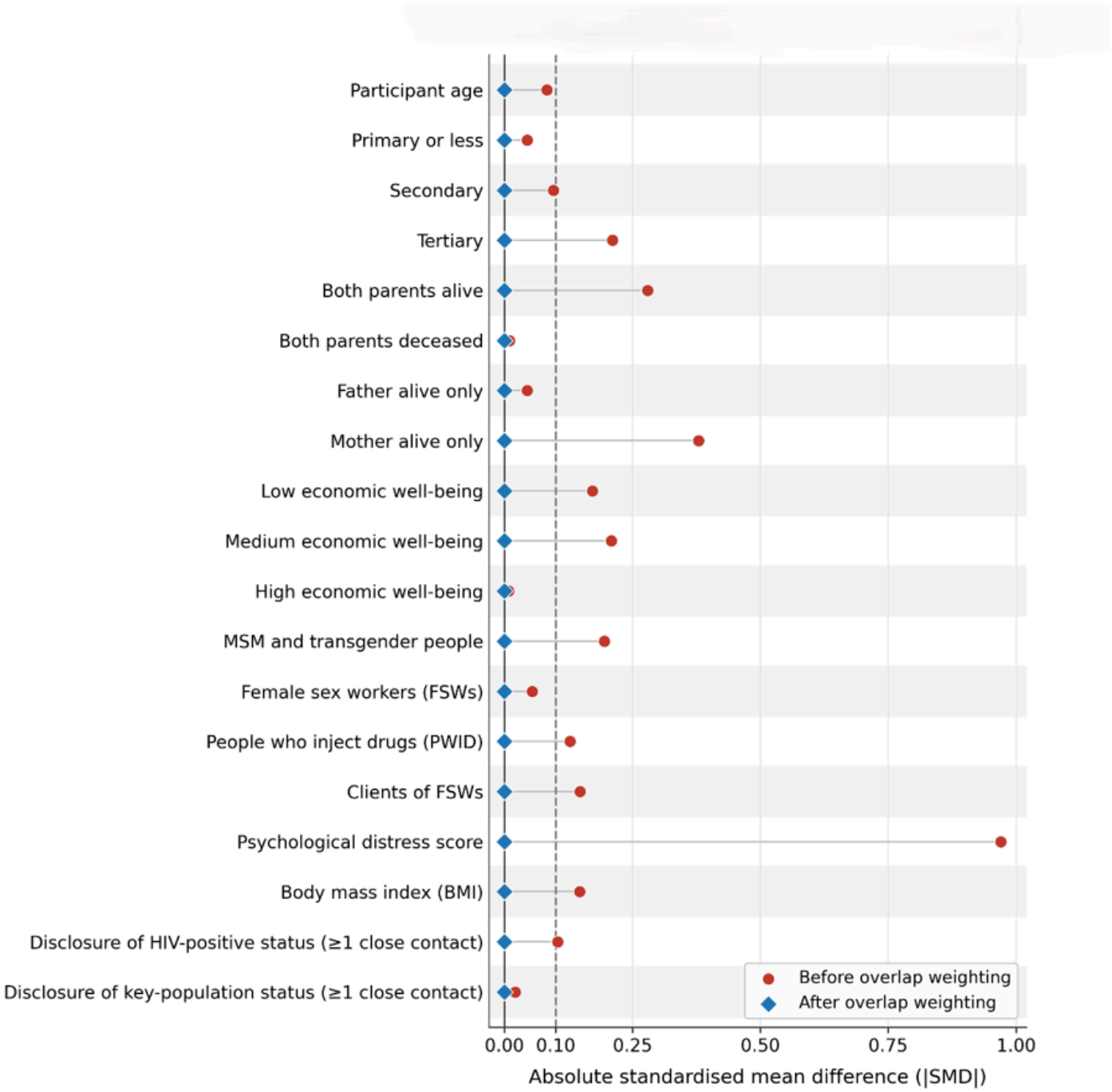


Figure 6

Covariate balance before and after overlap weighting.

Legend: Absolute standardised mean differences (|SMD|) for each baseline covariate, before overlap weighting (red circles) and after overlap weighting (blue diamonds). The solid vertical line marks an |SMD| of 0 and the dashed line the conventional 0.10 balance threshold. After overlap weighting, all standardised mean differences were reduced to approximately zero, indicating that the weighted study arms were balanced on every measured covariate. SMD, standardised mean difference; MSM, men who have sex with men; FSWs, female sex workers; PWID, people who inject drugs; BMI, body mass index.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- SupplementaryMaterial1Questionnaire.docx
- SupplementaryMaterial2SEWISyntheticEconomicWellbeingIndicator.xlsx
- SupplementaryMaterial3Dimensionalityfactorstructureandreliabilityofthepsychologicaldistressscale.docx
- Supplementarymaterial4SemanticharmonisationandcodingReasonsforchoiceofsiteinitiation.docx
- Supplementarymaterial5HRQoLmodeljustificationandSensitivityanalysis.docx
- Supplementarymaterial6Characteristicsofthestudypopulationbyarmafteroverlapweighting.docx