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Navigating the HIV continuum of care from treatment to retention strategies in Carnot, Central African Republic: a sequential explanatory mixed-methods study

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ABSTRACT

Background HIV remains a major public health challenge globally, including in the Central African Republic (CAR). Despite progress in awareness, prevention and access to antiretroviral therapy (ART), notably with dolutegravir (DTG), significant challenges persist. This study aimed to describe clinical status, virological failure (VF), ART resistance and reasons for disengagement among people living with HIV at Médecins Sans Frontières-supported sites in CAR.

Methods A sequential explanatory mixed-methods study was conducted in Carnot district, comprising: (1) a retrospective cohort analysis (2011–2022); (2) a cross-sectional study estimating VF and resistance profiles in patients on ART ≥6 months; and (3) a qualitative component exploring factors influencing engagement and disengagement in HIV care from patients, healthcare workers and key informants. The cross-sectional component included clinical exams, CD4 counts, viral load (VL) and resistance testing for patients with VL ≥500 copies/mL. VF was defined as VL ≥1000 copies/mL. Qualitative data were collected through semistructured interviews and analysed using content analysis.

Results Since 2011, over 5400 adults living with HIV have been managed in Carnot. By 2022, 46.5% remained in care, 35.5% were lost to follow-up and 11.3% had died; median follow-up was 32.7 months dropping to 16.6 months among those who died. After Test & Treat, over 80% initiated ART at diagnosis, but differentiated service delivery did not improve long-term retention. By 2022, 96% received DTG-based regimens; 88% achieved VL <1000 copies/mL, but only 32% were fully suppressed. Qualitative data identified insecurity, distance, food insecurity, stigma and health system barriers as key drivers of attrition and poor adherence.

Conclusion Sustained ART delivery and high DTG uptake were achievable in this fragile context, yet retention and full viral suppression remain limited. Attrition and suboptimal adherence driven by insecurity and health system barriers underscore the need for context-adapted, patient-centred and community-responsive HIV care models.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Delivering long-term HIV care in conflict-affected and fragile settings is challenging due to insecurity, weak health systems and limited data.

WHAT THIS STUDY ADDS

⇒ This study shows that sustained antiretroviral therapy delivery is possible over a decade in a conflict-affected area encouraging viral suppression rates with dolutegravir (DTG).

⇒ It highlights persistent gaps in retention, paediatric care and differentiated service implementation and provides rare data on DTG resistance in Central African Republic.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ Findings emphasise the need for patient-centred, community-responsive HIV care models tailored to fragile contexts.

⇒ Strengthening viral load monitoring, decentralisation and psychosocial support could improve retention and outcomes, informing future policy and programme design in similar settings.

INTRODUCTION

The Central African Republic (CAR), one of the world's most fragile and impoverished nations[1] and affected by decades-long internal conflict and insecurity, faces chronic disruptions in access to essential health services, including HIV care. Despite significant progress, CAR remains one of the

countries most affected by HIV epidemics in the Central African region,[2 3] with indicators still far from reaching the 95-95-95 global targets.[2]

Collaborative efforts by the CAR government, non-governmental organisations such as Médecins Sans Frontières (MSF) and international agencies have expanded antiretroviral (ARV) access[4] through the gradual introduction of differentiated service delivery (DSD) models since 2016. In the MSF-supported Carnot programme, these models were introduced progressively between 2016 and 2018. These include differentiated antiretroviral therapy (ART) delivery models such as community ART groups (CAG), multi-month dispensing, limited decentralisation of drug refills to peripheral sites, designed to improve retention, and, by extension, the life expectancy and quality of life of people living with HIV (PLHIV).[5 6] While multi-month dispensing is now widely implemented, enrolment in CAGs and decentralisation remain limited in scale and geographical coverage (programmatic data). Between 2019 and 2022, HIV-related deaths declined by 18.2%,[2] and prevalence was estimated at 3.4% in the general population.[2] However, in 2022, only 59% of PLHIV knew their status,[2] mainly due to the suspension of voluntary screening since 2018, following cuts in supplies and funding.[2] Among those diagnosed, 83% were receiving ART, and 88% of them had achieved viral suppression (VS).[2] These gaps in the HIV cascade of care reflect broader structural barriers in a context of weak health system coverage, including limited geographical access, shortages of trained staff and frequent disruption to supply chains and commodities which have been documented as major impediments to continuous HIV service delivery and uptake in low-resource settings.[7 8]

Engagement in HIV care remains difficult in sub-Saharan Africa,[9] especially in conflict-affected settings like CAR, where insecurity, displacement and poverty often lead to disengagement.[10 11] The rollout of dolutegravir (DTG), a potent integrase (INT) inhibitor, has improved tolerability and reduced resistance risk,[12] yet drug resistance (DR) remains a threat in settings lacking routine viral load (VL) and resistance testing.[13] In response, in 2019, the WHO updated its recommendations for the use of DTG with two nucleoside reverse transcriptase inhibitors (NRTIs) for all age groups,[14] which were adopted by CAR in 2020.[2] DSD models were also introduced to adapt HIV care to the diverse needs of PLHIV and improve outcomes,[15–18] though evidence suggests that in sub-Saharan Africa they may not outperform conventional care in retention or suppression.[19] However, most available evidence comes from relatively stable settings, and the effectiveness and added value of DSD in fragile and conflict-affected contexts such as CAR remain poorly documented. Moreover, few studies have examined the implementation of combined DSD approaches that integrate multi-month dispensing, CAGs and decentralised refill models.

We conducted a study designed to examine virological failure (VF), resistance patterns and factors affecting retention in care and adherence. Given the high attrition rates observed in the Carnot cohort, the research explores the continuum of care, including long-term retention, adherence, access to differentiated models of care and availability of monitoring services such as VL and CD4 testing. It also investigated factors influencing patient engagement, drawing on the perspectives of PLHIV, healthcare providers and stakeholders involved in planning, coordinating and delivering HIV services.

METHODS

Study design and setting

This emergent sequential explanatory mixed-methods research study included (1) a retrospective cohort analysis, (2) a cross-sectional study and (3) a qualitative inquiry. The retrospective component assessed survival, adherence and retention in care; the cross-sectional component estimated VF and DR; and the qualitative component explored perspectives on engagement in care from patients, healthcare workers and stakeholders.

In Carnot, CAR, HIV prevalence is estimated at ~4% in the Gadzi-Carnot Health district,[2] which serves over 203 000 inhabitants.[20] The District Hospital, supported by MSF, is the sole facility in the district providing HIV screening and ART initiation. Since 2019, patients have been receiving care at the 'Carnot follow-up clinic', which provides free, integrated outpatient services for chronic conditions including HIV, diabetes and hypertension. HIV care follows national guidelines and incorporates DSD models. By 2022, the active cohort (≥15 years old) on ART included 2205 patients.

Three DSD models were introduced between 2016 and 2018: (1) *multi-monthly dispensing ART*: stable patients receive 6-month ART prescriptions, with the second 3-month supply collected directly from the pharmacy; (2) CAGs: on a rotating basis, one member collects ARVs every 3 months on behalf of the other members living in the same area; and (3) *decentralised collection sites*: patients (often in CAGs) collect ART at remote sites in Mboula, Belou and Ndinguiri (online supplemental figure S1) which are several hours' drive from Carnot.

Study participants

The quantitative phase included a retrospective cohort analysis and a cross-sectional study. The retrospective component covered patients aged ≥15 years enrolled in the MSF-supported HIV programme in Carnot from 2011 to 2022. The cross-sectional study targeted patients (≥5 years) on first-line or second-line ART for ≥6 months at Carnot District Hospital, with a target sample size of 342 individuals, calculated to estimate VF prevalence with a 95% confidence level and a 5% margin of error, assuming 30% prevalence (based on programmatic and literature information) and accounting for non-response and operational constraints. Participants were randomly

selected from the scheduled appointment lists (for medication refill or follow-up visit) to minimise selection bias.

The qualitative phase involved semistructured interviews with four groups: (1) purposively selected active patients (aged ≥18 years); (2) traced patients who had interrupted care within the past 6 months (convenience sampling); (3) all HIV care providers in Carnot and Ndinguiri; and (4) key informants with strategic or clinical HIV expertise (purposive and snowball sampling).

Study participants for both the quantitative and qualitative phases were enrolled between April and June 2023.

Study procedures

Quantitative component

For the retrospective component, a preparatory phase was undertaken to ensure data accuracy and reliability. Demographic, clinical, biochemical and programmatic data were collected from the existing Follow-Up and Care of HIV Infection and AIDS (FUCHIA) database.

In the cross-sectional component, sociodemographic data, clinical assessment and venous blood samples were collected: CD4 counts (30 µL) were measured using the PIMA point-of-care device (Alere, Germany) at Carnot District Hospital. HIV-1 plasma RNA VL quantification was performed weekly at the Institut Pasteur in Bangui using GeneXpert (Cepheid, USA). Samples with VL ≥500 copies/mL were sent to the WHO HIVResNet reference lab–Kenya Medical Research Institute in Kenya for genotypic resistance testing. For the DR analysis, HIV-1 reverse transcriptase, protease and INT regions were sequenced using the Applied Biosystem HIV-1 Genotyping Kit with RNA via the QiaAmp Viral RNA Mini Kit (Qiagen, Chatsworth, California). Sequences were processed with ReCALL v2.2, quality checked using WHO tools and analysed with the Stanford HIVdb v9.4 for resistance mutations. Subtyping was performed using the REGA HIV-1 Subtyping Tool v3.0. All participants gave written informed consent/assent.

Qualitative component

Eligible active patients were identified in collaboration with staff from the Carnot follow-up clinic and the Ndinguiri health post, among those scheduled for routine visits. Selection ensured gender and age diversity, recognising their influence on engagement with HIV care.[21] Patients with interrupted care were identified from clinic registers and traced by members of a local PLHIV network (Réseau Centrafricain des Personnes Vivant avec le VIH/SIDA (RECAPEV)) in Carnot and by the health centre team in Ndinguiri.

Health workers involved in HIV care at study sites were invited to participate and interviewed outside work hours, with compensation. Key informants were selected from relevant institutions in Bangui and Carnot, with additional participants identified through recommendations.

All participants gave written informed consent to be interviewed and audio recorded. Two trained local researchers conducted individual interviews using semistructured guides tailored to each group (active patients, patients with interrupted care and healthcare workers), focusing on contextual, social and personal factors affecting engagement in HIV care. Interviews were conducted in Sango, the local language. Interviews with the key informants were conducted in French by two of the coauthors (PL and DMM) using an unstructured thematic guide, which was adapted to the key informant's role, position or function (online supplemental table S1). The criteria established by the literature were used to estimate the number of interviews needed to reach saturation (the point at which no new information emerges from the data), which ranged from 9 to 17 interviews.[22 23]

Study analysis

Statistical analysis and definitions

Descriptive statistics were used to summarise patients' demographic and baseline characteristics. Continuous variables (eg, age, VL, time on ART) were reported as median with IQR while categorical variables (eg, sex, type of follow-up) were presented as frequencies and proportions.

Survival analysis followed patients from ART initiation until death with right censoring at the earliest of: (1) last recorded clinic visit for patients lost to follow-up (LTFU), (2) transfer out or (3) the administratively defined time points (6, 12, 24 or 36 months post-ART initiation).

Kaplan-Meier methods were used to estimate survival and retention probabilities for patients followed up in the cohort. Mortality data were extracted from FUCHIA.

LTFU was defined as missing the last appointment by ≥30 days. As a proxy for *adherence*, we used appointment delay patterns, following a method described in a previous study[24 25]: patients with delay (≥1 day delay from scheduled appointment date) in <5% of appointments were considered 95% or more adherent; those with 5–9% delay were considered 90–94% adherent; and those with delay ≥10% were considered less than 90% adherent. *Retention* was defined as the probability that a PLHIV remained engaged in medical care over a specified period, assessed through attendance at scheduled visits.

For the cross-sectional component, proportions were reported with 95% CI. VF, defined as VL ≥1000 copies/mL, was estimated from a representative sample of active patients. HIV DR was classified into five levels using the Stanford HIVdb v9.4 algorithm: susceptible, potentially low level, low level, intermediate or high level. Resistance was defined as low, intermediate or high to at least one drug class (NRTIs, non-NRTIs (NNRTIs), protease inhibitors or INT inhibitors) based on penalty scores: 15–29 (low), 30–59 (intermediate) and ≥60 (high),[26] with a score ≥15 indicating any DR.

All analyses were performed using Stata V.17 (College Station, Texas, USA).

Qualitative analysis

All interviews were transcribed verbatim and translated from Sango into French by trained transcribers. Analyses were conducted by a coauthor (PL), a social epidemiologist with expertise in mixed-methods research. Transcripts were uploaded in ATLAS.ti (Windows software V.9.1.6.0) and reviewed iteratively to ensure familiarity with the data. Content analysis was applied, identifying meaning units, coding them and grouping codes into categories and themes.[27 28] A predetermined codebook was used and expanded inductively to retain the manifest meaning and authentically reflect participants' viewpoints and experiences. Validation strategies were implemented, and illustrative quotes were selected to support findings.

The Indicators of HIV Care and AntiRetroviral Engagement (InCARE) framework[29] guided the conceptualisation of engagement in HIV care, defining it as a dynamic state comprising three interlinked dimensions: (1) *retention*, ongoing interactions with health services; (2) *adherence to ART*, consistent ART uptake; and (3) *active self-management*, patient empowerment and ownership of care (online supplemental figure S2). This framework integrates clinical, contextual, health system and individual factors that shape engagement.[10]

RESULTS

Retrospective component

Since 2011, a total of 5479 patients have been enrolled in the HIV programme in Carnot, of whom 3731 (68.1%) were women and 359 (6.6%) were aged under 15 years. A total of 4745 (86.6%) initiated ART, and over 80% of them across all age groups started ART under the Test & Treat strategy, implemented from 2018.

By December 2022, among the 4745 individuals who had been initiated on ART, 11.3% (n=537) had died, 6.4% (n=306) were transferred, 35.5% (n=1684) were LTFU and 46.5% (n=2205) remained in care (table 1). Median duration of ART follow-up (for people aged ≥15 years, 4437) was 32.7 months overall, ranging from 16.6 months among adults who were deceased by December 2022 to 59.4 months for those still on ART.

At 12 months, survival probability (mortality only) was 94% (95% CI: 94% to 95%) among all adults who initiated ART (online supplemental table S2). When broken down by year of initiation, survival rates at 12 months were 98% (95% CI: 96% to 99%) for those who started treatment in 2019, 99% (95% CI: 97% to 99%) for those who started in 2020 and 98% (95% CI: 95% to 99%) for those who started in 2021.

Figure 1 shows changes in the probability of retention at 12 and up to 48 months, respectively. The probability of retention in care decreased with time (0.7 in 2011–2015, 0.5 in 2016–2019 and 0.4 in 2020–2022). The analysis of adherence, based on a proxy indicator, shows that on average nearly half (48.2%) of patients had adherence levels below 80% and less than 10% had a high adherence level (≥95%) (online supplemental figure S3).

Cross-sectional component

A total of 342 participants were included in the final cross-sectional analysis, with 19 individuals (5.6%) younger than 18 years (table 2). The majority (n=321, 93.9%) was from Carnot. The median duration of treatment was 7.2 years (or 87 months) (IQR 3.75–9.8 years), and most participants (n=326, 95.3%) were on a DTG-based regimen. At study inclusion, 13 individuals (3.8%) were receiving second-line therapy; five were transitioned

Table 1 Follow-up status of ART patients (≥15 years) by December 2022

All patients initiated on ART		Patients still on ART	
	n=4437		n=2079
Status, n (%)		**Follow-up time, n (%)**	
Death	485 (10.9)	<6 months	191 (9.2)
Transferred	283 (6.4)	6–12 months	123 (5.9)
Lost to follow-up	1579 (35.6)	12–24 months	189 (9.1)
Treatment follow-up	2079 (46.9)	24–36 months	191 (9.2)
Follow-up without treatment at last visit	7 (0.2)	36–48 months	182 (8.8)
Uncertain	4 (0.1)	>48 months	1203 (57.9)
Duration of follow-up-by-follow-up status (months), median (IQR)		**Current treatment, n (%)**	
All	32.7 (8.7–74.5)	Second line	73 (3.5)
Death	16.6 (3.6–47.8)	DTG based	1996 (96.0)
Lost to follow-up	17.2 (3.0–41.8)		
Still on ART	59.4 (24.9–96.6)		

ART, antiretroviral therapy; DTG, dolutegravir.

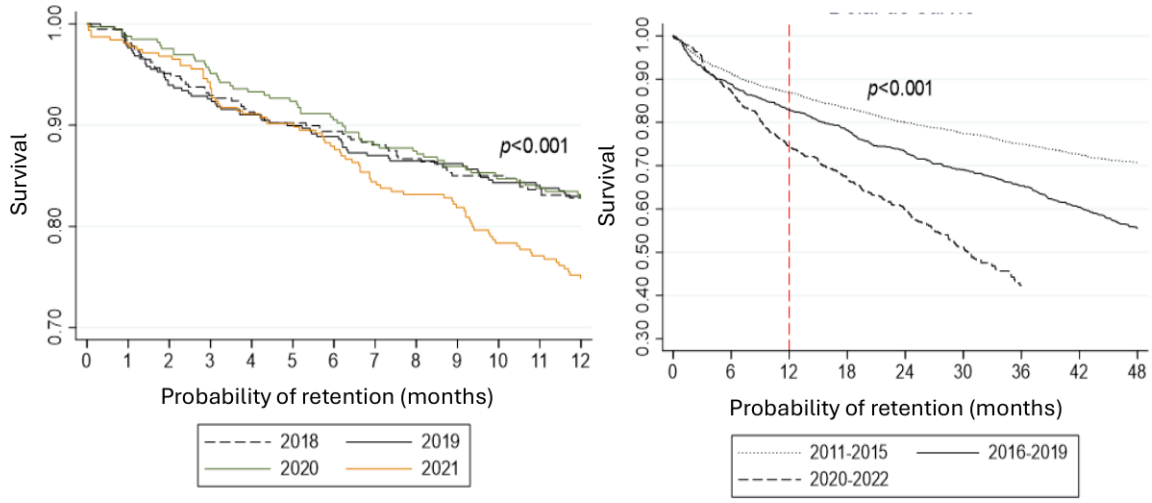

Figure 1 Probability of retention at 12 months (left) and 48 months (right) by year of antiretroviral therapy (ART) initiation.

Table 2 Baseline characteristics of patients included in the cross-sectional analysis

	Number (n=342)	% or median	95% CI or (IQR)
Sex, female	232	67.8	
Age, years			
Median (IQR)		39	(32–47)
5–14	17	5.0	2.9 to 7.8
15–24	14	4.1	2.5 to 6.7
25–34	66	19.3	15.4 to 23.6
≥35	245	71.6	66.5 to 76.4
CD4 count, cells/µL			
Median (IQR)		609	(446–842)
<200	4	1.1	0.3 to 3.0
200–350	32	9.4	0.6 to 12.9
≥350	306	89.5	85.7 to 92.5
WHO clinical stage			
Stage 1	288	84.2	79.9 to 87.9
Stage 2	46	13.4	10.0 to 17.5
Stages 3–4	8	2.4	1.0 to 4.5
Time on ART, months			
Median (IQR)		87	(45–119)
6–24	37	10.8	7.7 to 14.6
≥25	305	89.2	85.4 to 92.3
Treatment at inclusion			
DTG based (1st line)	326	95.3	92.5 to 97.3
LPV/r based (2nd line)	11	3.2	1.6 to 5.7
ATV/r based (2nd line)	2	0.6	*0.07 to 2.1*
Other	3	*0.8*	*0.18* to 2.5

ART, antiretroviral therapy; ATV, atazanavir; DTG, dolutegravir; LPV, lopinavir; r, ritonavir.

to a DTG-based regimen on the day of study inclusion resulting in 331 participants (96.7%) on DTG by the end of the study. The median time on DTG was 19 months (1.5 years (IQR 16–27.5 months)). Most participants (334; 97.7%) were clinically stable (WHO stages 1–2). All but one of the 342 participants were able to provide a sample for the VL test on the day of inclusion. Nearly one-third (32.0%, n=109) of the 341 analysed samples had an undetectable VL, while 40 (11.7%) met the WHO criteria for VF (table 3). For those with a detectable VL, the median VL was 308 copies/mL (IQR 88–96 000). One patient with 494 copies/mL underwent ARV resistance testing although the eligibility for DR testing was set at 500 copies/mL. Among the 40 participants with VF, median age was 32 years (IQR 14.5–38.5), and more than one-quarter (n=11, 27.5%) of the patients were children and teenagers aged between 5 and 15 years. Three-quarters

Table 3 Plasma viral load (HIV RNA) results at study inclusion (cross-sectional component)

	Number (Total n=341)	%	95% CI
No virological failure (VL <1000 copies/mL)	301	88.3	84.4 to 91.5
Target not detected*	109	32.0	27.0 to 37.2
Low VL (40–999 copies/mL)	192	56.3	49.4 to 60.2
Virological failure (VL ≥1000 copies/mL)	40	11.7	8.5 to 15.6
1000–9999 copies/mL	6	0.17	0.6 to 3.8
10 000–99 999 copies/mL	11	3.2	1.6 to 5.7
≥100 000 copies/mL	23	6.7	4.3 to 9.9

*Target not detected, the viral load is below the assay's limit of detection.
VL, viral load.

(n=30, 75%) of participants had a CD4 count ≥350 cells/µL and only one (2.5%) was clinically unstable (WHO stage 3). Most patients who had VF (n=35, 87.5%) were on DTG treatment, while 12.5% (n=5) were on abacavir (ABC)/azidothymidine/lamivudine (3TC)/Protease Inhibitor (PI).

The median time on ART among participants with VF was 6.5 years (78 months (IQR 38–110 months)), while for those on DTG-based treatment the median time on DTG was 1.6 years (19 months (IQR 15–32 months)). Of the 326 patients exposed to DTG, 157 (48.2%) had a VL result available prior to treatment change: of these, 35 (22.3%) had VF before switching to DTG. Among patients who had VF and were on DTG, 21 out of 35 (60.0%) already had a VL of ≥1000 copies/mL before switching to DTG.

A total of 42 plasma samples were tested for DR, and only one amplification failed. The predominant HIV-1 subtype was A1 (n=13, 31.7%). Among patients with available genotypic resistance data, the prevalence of any HIV DR was 58.5% (95% CI 42.1% to 73.7%). The distribution of resistance is shown in online supplemental figure S4. DR to NRTI was frequently observed in nearly one-third (29.3%, 95% CI 16% to 45%) of the tested samples, and it was mainly driven by high-level resistance to 3TC/emtricitabine (FTC). Resistance to tenofovir (TDF) was low (9.8%) and classified as low or intermediate level. Dual resistance to TDF+3TC was observed in 9.8% of cases (95% CI 2.7% to 23.1%), while resistance to ABC+3TC was notably higher at 31.7% (95% CI 18% to 48%), suggesting a greater vulnerability of the ABC+3TC combination to resistance mutations.

When stratified by current ART regimen (online supplemental table S3), NRTI resistance was observed across all regimen groups. Among participants on DTG+TDF-based regimens (n=24), resistance to TDF, ABC and 3TC was observed in 12.5% each, and DTG resistance in 4.2%. In the DTG+ABC group (n=11), resistance to ABC and 3TC was observed in 45%, with no DTG resistance detected. Participants receiving ABC/3TC/lopinavir (LPV)/r (n=4) showed high levels of resistance to 3TC and ABC (75% each), whereas resistance to LPV/r and DTG was rare or absent.

Only two patients out of 41 (4.9%) had mutations conferring resistance to PIs, and one patient had accessory mutations (G118R, E138K and T66A) in the genes involved in INT resistance but, interestingly, a high level of resistance that conferred resistance to all the classes of INTs.

Qualitative component

Participant description

A total of 91 interviews were conducted with 43 active patients, 18 patients who had interrupted their care and 14 healthcare staff (nurses, healthcare assistants, midwives, therapeutic educators, administrative staff and community health workers) from the MSF-supported Carnot follow-up clinic and the Ndinguiri health post (online supplemental table S4). 16 key informants were also interviewed, including representatives of the National Reference Centre for STIs and ART of the Ministry of Health, the National AIDS Control Committee, Joint United Nations Programme on HIV/AIDS, the French Red Cross, the RECAPEV, the Plateforme de la Société Civile Centrafricaine contre le SIDA, the Réseau Centrafricain sur l'Ethique et le Droit, the Carnot District Hospital, the Health District and MSF.

HIV care challenges from the operational perspective

Key informants highlighted the persistent gaps in HIV care despite the implementation of the ambitious 2023–2027 national strategic plan[30] aiming to achieve the three 95% care cascade targets. They emphasised its fragmented state, exacerbated by weak data systems, the shortage of trained healthcare workers, the difficulties in managing the late presentation of HIV cases and advanced AIDS, insecurity hampering both care provision and access, as well as poor retention due to patients interrupting care or being LTFU. While community-based strategies for HIV prevention, screening and care, such as DSD models, were encouraged, implementation challenges remained, despite the availability of protocols, guidelines, guides and technical documents. Shared insights highlighted the disconnect between policy intentions and on-the-ground realities, as well as the need to strengthen DSD model implementation and supervision to sustain patient retention. In Carnot, key informants stated that although the implementation of DSD models of care within MSF's long-standing HIV programme had improved care availability, retention issues persisted, with grave consequences for patient outcomes. Barriers to HIV care engagement were examined through the lens of the three domains of the InCARE framework: retention in care, adherence to ART and self-management. Our analyses revealed that multiple contextual, health system and individual factors interconnected with and influenced these domains (table 4).

Barriers to HIV care engagement: contextual factors

Identified contextual barriers included (a) distance, transport costs and insecurity; (b) food insecurity; (c) socioeconomic status and competing priorities; and (d) social stigma.

In Carnot and Ndinguiri, distance, transport costs and insecurity were found to be major barriers to retention. The Carnot follow-up clinic serves a wide area, including sites over 100 km away, and those living in outlying areas often encountered difficulties due to the scarcity of means of transport and high costs (reaching 40 000–60 000 CFA francs (~€61–91) for round trips). Several participants, including pregnant women and the elderly, reported that they had to walk for days to consult at the clinic. Insecurity due to armed groups and robbers on the roads could deter patients from travelling, with several interrupted care participants revealing that they

Table 4 Qualitative data analysis framework

Contextual factors	Health system factors	Individual factors
► Distance, transport cost and insecurity (retention)	► Organisation of HIV services (retention)	► Knowledge about HIV and HIV care (self-management)
► Food insecurity (adherence)	► Patient therapeutic education (retention, adherence, self-management)	► HIV management competencies and self-efficacy (self-management)
► Socioeconomic status, competing priorities (retention, adherence)	► ART delivery models (retention, adherence)	► Trust in the healthcare system (self-management)
► Social stigma (retention)	► Patient tracing strategies (retention)	► Stigma management (self-management)
		► Social and family dynamics (self-management)
		► Physical and mental health (self-management)

ART, antiretroviral therapy.

had been attacked and/or kidnapped on the way to the clinic, as one explained:

> I respect my ARV treatment …but… the rebels attacked us, they took [all] my money, they kept us until 3pm…. I called, I sent someone to take my ARV treatment, [but] they said it was time for the CD4 count appointment, I had to come myself… I couldn't find [a way of getting there more] quickly. (Interrupted care patient (5 months), Ndinguiri)

Food insecurity was another prominent barrier to ART adherence, as hunger exacerbated treatment side effects (headaches, dizziness, vomiting), making medication intake physically difficult. Healthcare providers noted that food-insecure patients could develop risky coping strategies by skipping doses or taking medications at irregular times, as one asserted:

> Patients tell us that they haven't eaten for two or three days, they don't have any support to find food, and [this] prevents them from taking their treatment regularly… they are really hungry, which means they don't [comply with] taking ARV medication … (Health staff, Carnot)

Interventions implemented to address malnutrition among patients living with HIV, such as food kit distribution by the World Food Program, were considered inadequate because the eligibility criteria, based solely on anthropometric measurements, failed to account for socioeconomic vulnerabilities.

Such vulnerabilities, and ensuing competing survival needs, directly undermined care engagement. Many participants lived in precarious conditions, relying on small-scale farming and/or occasional mining as their sole means of subsistence. This required substantial mobility for long periods, during which their ART supply could be depleted. Returning in time for a clinic visit meant losing critical income-generating time and incurring high transport costs, so seeking treatment was often postponed to prioritise securing food and/or income. As one participant explained:

> We fight to get money … so that we can take our ARV treatment, but as we have no money we go anywhere, [we go] to work until late at night, people have travel difficulties [and sometimes] the appointment date for the ARV treatment has passed… (Interrupted care patient, Ndinguiri)

Lastly, social stigma was pervasive, with HIV being widely perceived as both 'a diabolical disease' and a moral failing. This stigma manifested through public shaming, mockery, humiliations, insults, discrimination, restrictions, exclusion and isolation, and particularly affected marriage prospects and social connections. Several patients admitted avoiding the Carnot follow-up clinic altogether due to exposure risks, and in some cases opting to consult at distant health facilities despite the greater access barriers.

Barriers to HIV care engagement: health system factors

Health system barriers were shown to stem from dysfunctions in (a) organisation of HIV services, (b) patient therapeutic education, (c) ART delivery models and (d) patient tracing strategies.

While patients expressed their appreciation for the high quality of care, the professional attitude of providers and the availability of free comprehensive services at the clinic, including DSD models, laboratory tests and management of opportunistic diseases, critical aspects of the clinic's services undermined retention, notably the long waiting times, which could last up to 6 or 8 hours. Health workers reported unsustainable workloads due to many patients presenting without appointments and single clinicians often managing up to 30 patients daily. This negatively impacted patient therapeutic education, a major pillar of patient support. Consultations had to be rushed, focusing on general advice and on adherence to ART and follow-up appointments, rather than more complex issues such as the role of CD4 and the significance of VL, the topics for which patients require the most explanations. Patient overload also had negative repercussions on the dispensing of ART and other

consumables and disrupted the conduct and delivery of results of laboratory tests, and delayed administrative tasks and data flow.

Satisfaction with DSD models varied. On the one hand, 3–6 months' refills for stable patients were highly appreciated, as they reduced health providers' workload and limited patients' wait time. However, engagement was compromised when 1-month supplies were enforced during stock shortages or for patients who were re-engaging after having interrupted care as it disproportionately burdened remote patients or those having transport difficulties, perpetuating the cycle of delays and interruptions, as one participant described:

> It's just the problem of transport and distance… if they [only] give me [medication for] one or two months, I'm not at peace. My [village] is far from here, and then I'm also almost full term [pregnant] … I often come on foot. I don't know what will happen to me if they only give me 1 month's supply, and if during that month I give birth there, what will I do to still have the strength to walk the long way to come here to get the medicine? (Interrupted care patient, Ndinguiri)

CAGs of stable patients based on geographical proximity were perceived as very promising by both healthcare staff and key informants, but had limited uptake, involving only about 10% of the cohort. Furthermore, failures often occurred due to disagreements between members, lack of trust and support among members, fraud, ART theft, non-compliance with rotation rules and contribution to the cost of transport. Most concerning was breach of confidentiality when delivering ART to members and a frequent stated reason for refusal to join a CAG. In response to these challenges, healthcare providers stressed the need to implement standardised and structured CAG supervision systems so as to maintain essential clinical oversight, as they cautioned that over-reliance on CAGs without proper monitoring could compromise care quality.

Decentralised collection site coverage was considered inadequate. For key informants and healthcare staff, the implementation model was too limited and did not comprehensively address access problems, with only four sites offering ART. For participating patients, the service offer lacked critical components of a comprehensive HIV care package, such as patient therapeutic education, couple testing and counselling, treatment for opportunistic diseases and laboratory tests, for which they had to return to the Carnot clinic. They emphasised the need to holistically address patients' health needs, including nutritional assistance and free primary care for the treatment of common illnesses such as malaria.

Lastly, patient tracing strategies, implemented by the project to support retention in care and address the overflow of participants during consulting hours, and involving RECAPEV volunteers and community mediators, were minimally effective, as they were restricted to a 5 km radius around Carnot due to lack of means of transport, while most patients missing appointments originated from remote locations.

Barriers to HIV care engagement: individual factors

Individual barriers were linked to (a) patients' knowledge about HIV and HIV care, (b) HIV management competencies and self-efficacy, (c) trust in the healthcare system, (d) stigma management, (e) social and family dynamics, as well as (f) physical and mental health.

While most participating patients, both active and interrupted care, demonstrated basic knowledge of ART's benefits and the need to adhere to daily dosing schedules, the data revealed significant gaps and misconceptions concerning HIV management. Several patients, including some on long-term treatment, believed HIV could be 'cured' and that treatment could eventually be discontinued if asymptomatic. Few displayed understanding of monitoring tools, such as VL, CD4 and resistance testing, and of their clinical significance.

Conversely, self-management competencies and self-efficacy positively influenced care engagement. Unlike interrupted care patients, most active participants used strategies to mitigate structural barriers. These included securing temporary work to fund their transport, scheduling livelihood activities around appointments and at times even relocating their household for proximity. In addition, daily rituals were developed to ensure ART was taken as prescribed. Self-efficacy was strongest among patients with longer treatment experience, who prioritised their HIV care, even amid difficult life circumstances and competing demands.

Trust and positive experiences with competent and supportive clinical interactions at the clinic were decisive in helping patients overcome avoidance and despair, as confirmed by a healthcare worker:

> I put [my knowledge] into practice to help HIV patients who don't want to take ARV treatment, we support them so that they don't lose heart in life…they think that HIV is the end of their life… they're just waiting to die. (Healthcare staff, Carnot)

Such support also helped allay internalised stigma, expressed as feelings of shame and guilt, and manifested by refusing healthcare and support, avoiding health facilities for fear of being seen, resisting joining a DSD model, hoarding medication and even discontinuing treatment. Several active participants explained that thanks to clinical counselling and peer support, they had gradually managed to regain their self-esteem, prioritise their health and achieve stable engagement. As one participant noted:

> My initial experience was that when I came to the hospital … if I saw certain people from my neighbourhood, I couldn't go in, but little by little with the advice given [I was] strengthened not to feel ashamed, and [I am] committed to taking my treatment. MSF has helped us a lot. (Active patient, Carnot)

Social and family dynamics also played a crucial role in patient engagement. Interrupted care patients more frequently reported social isolation or substantial caregiving and family duties, including supporting multiple dependents or managing emergencies that disrupted consistent engagement. On the other hand, active participating patients often reported receiving financial, material and/or emotional support from their intimates or social circle.

Lastly, physical and mental health problems conflicted with care engagement. Some interrupted care participants cited physical illness as a reason for interrupting care, explaining that they did not have the strength or energy to travel to the care facility, especially from a remote location. Psychological concerns, including depressive thoughts, suicidal ideation and alcohol addiction, arising from economic challenges, insecurity, family responsibilities, stigmatisation and social isolation could also compromise retention and adherence. As one participant admitted:

> The difficulty is not taking my ARV medication, what is difficult for me is when I see that my children are not doing well at school, they are not getting enough to eat … Sometimes [for one or more] weeks I don't take my ARV medication, and I think a lot…. If I find a job to do, I'll be at ease, I'll take my ARV medication…but when I look at my children's lives and the problem of this disease, I say Lord, it's no longer worth it. (Interrupted care patient, Carnot)

DISCUSSION

This study shows that a decade-long HIV care programme can be sustained in a conflict-affected setting such as Carnot. Since 2011, over 4700 adults have initiated ART through the MSF programme, reflecting both the magnitude of the HIV burden and the programme's ability to deliver treatment despite persistent logistical, security and health system challenges. The cohort is dominated by adults and women, highlighting the need for interventions targeting men,[19 31–33] while the under-representation of children under 15 years underscores gaps in paediatric HIV care.[34]

The implementation of the Test & Treat strategy in 2018 enabled early ART initiation, with over 80% of patients starting treatment thanks to this approach. Yet attrition remained substantial and major challenges persist: among 4745 patients on ART, 11.3% had died, 35.5% were LTFU and only 46.5% remained in active care by 2022.

Mortality is likely underestimated due to difficulties in tracking patients LTFU and the lack of official death registries. This highlights the urgent need to strengthen patient tracing and improve data quality, which is essential for evaluating HIV programme impact and transitioning to patient-centred ART models.

To prevent disengagement, strategies such as longer refill intervals, flexible and participatory CAGs, financial support and decentralised services need to be strengthened and adapted, as their current limited coverage, restrictive eligibility criteria and weak implementation reduced their potential impact in Carnot. Although the loss to follow-up rate is slightly lower than the broader CAR health regional average (43.2%)[19]—likely reflecting the additional support provided by MSF in Carnot—persistent attrition underscores the need for stronger retention efforts.

The median follow-up time (32.7 months) exceeds that of more stable regions,[35] but patients who died had a median of just 16.6 months, raising concerns about late diagnosis and comorbidity management.[36] Patients LTFU had a median of 17.2 months, possibly reflecting silent transfers or unreported deaths—pointing to the need for tailored follow-up strategies. These issues are directly linked to testing strategies in CAR, where voluntary counselling and testing is not supported, and where patients are typically diagnosed with HIV only when presenting at a health facility and the clinician suspects HIV infection.

Qualitative findings further demonstrate how engagement is undermined by contextual, health-level and individual-level barriers.[37 38] Short-term retention was encouraging (94% survival at 12 months), but longer term trends showed gradual decline, echoing other CAR cohorts.[39] The introduction of DSD models in 2016 was not associated with improved retention, as shown in another study,[40] likely due to weak implementation, limited decentralisation, lack of monitoring of CAGs and the exclusion of high-risk patients from multi-month dispensing,[40] highlighting systemic challenges, exacerbated by the COVID-19 pandemic and data quality issues. Taken together, these findings provide a clear empirical basis for strengthening patient-centred and context-adapted HIV care models in fragile settings.

Retention is further affected by travel distance, insecurity, economic pressures and stigma. Health system shortcomings—including long wait times, limited therapeutic education and inadequate tracing—exacerbated these challenges.[41]

Adherence, assessed through appointment delays, was below 80%, consistent with sub-Saharan African levels,[42] and was often compromised by food insecurity, poverty and competing livelihood demands.

Qualitative findings show that while the three differentiated ART delivery models in Carnot are relevant, they fall short of meeting patients' needs. Implementation, supervision and eligibility criteria are inadequate: decentralised collection sites are few and lack essential HIV services, CAGs lack monitoring mechanisms and patients who interrupt care are excluded from multi-month dispensing—despite being those who would benefit most.

Access to models like multi-month dispensing and CAGs helped reduce stressors. However, effective self-management depends on individual factors such as HIV knowledge, self-efficacy, trust in the health system and ability to cope with stigma and life challenges. While family burden, comorbidities and mental health issues often undermine them, the data nonetheless suggest that

individual-level capacities for sustained engagement in such circumstances can be developed and maintained despite challenges with adequate psychosocial support at facility level and through supportive networks.

This study is highly relevant in the context of evolving HIV treatment guidelines, as it provides recent, real-world data from CAR on the introduction of DTG. It fills a long-standing gap, given the limited research on HIV and DR in CAR. The findings offer a baseline for monitoring DTG resistance over time, with insights specific to Carnot. To date, only one study has reported virological outcomes of DTG in Central Africa (Cameroon),[41] while most research has focused on Southern and Eastern Africa, where HIV prevalence is higher and care systems are more advanced.

The transition to DTG-based therapy is particularly relevant. By 2022, 96% of patients were on DTG-containing regimens, showing strong adoption of global recommendations. VS rates were encouraging, with 88% achieving VL <1000 copies/mL, though only 32% were fully suppressed. Suppression rates fell short of the WHO 95% target and were lower than in other African cohorts,[43–47] yet remain promising given the challenges of lifelong therapy in such a setting. Encouraging VS rates suggest that DTG-based regimens may be improving treatment outcomes. However, caution is needed: the rollout is recent, and it is too early to assess the long-term clinical or public health impact. Notably, 56.3% of patients had low detectable VLs (40–1000 copies), a group potentially at risk of treatment failure. The clinical significance of low-level viraemia on DTG remains unclear—some studies suggest minimal impact, while others link it to future failure, resistance and ongoing immune activation.[48]

Importantly, most patients with VF already had VL >1000 copies/mL before switching to DTG, although guidelines recommended switching to DTG only after confirming VS. The high prevalence of NNRTI resistance reflects historical exposure to NNRTI-based regimens and is less relevant for current outcomes with DTG-based therapy. By contrast, low circulating levels of resistance to TDF (9.8%) and moderate levels of NRTI resistance (29.3%), predominantly involving 3TC, suggest that adherence, rather than resistance, is the main driver of poor outcomes, as already highlighted by the retrospective analysis. Consistently low rates of resistance to NRTIs and rare DTG resistance further support this interpretation, although the identification of high-level DTG resistance in one patient underscores the need for strengthened VL monitoring and DR surveillance.[47 49] The greater impact observed for ABC-based backbones likely reflects their widespread historical use in this setting, although detailed usage data were not available. Strengthening support for patients and developing and sustaining more patient-centred strategies (barely a third of study participants are part of a CAG) would therefore appear to be a crucial measure for improving therapeutic outcomes. Resistance to DTG was rare. Younger patients remain particularly vulnerable: more than a quarter of those with suspected VF were under 18, highlighting the need for tailored paediatric and adolescent interventions.

This study has several limitations. The retrospective cohort was affected by incomplete and poor-quality data, thus limiting analyses of key outcomes such as VL. The cross-sectional survey included only patients in active care, with 40% of the randomly selected sample unavailable, raising concerns about selection bias and overly favourable results. Moreover, patients LTFU were not captured; while those with interrupted care described disengagement as involuntary and shaped by socioeconomic and structural barriers, it is likely that those LTFU experienced even greater obstacles.

Despite these limitations, the findings provide significant insights into HIV care in CAR. They highlight systemic, social and individual factors undermining retention and adherence, while showing that DTG-based regimens are being widely adopted and can achieve encouraging suppression levels. Moving forward, strengthening patient-centred strategies—including longer refill intervals, flexible and participatory CAGs, decentralised services and enhanced tracing—will be critical to sustain engagement in care and improve outcomes in this fragile context.

CONCLUSION

This study offers a rare picture of long-term HIV care in a fragile humanitarian setting, showing that ART can be sustained for over a decade despite conflict and weak health systems. Access and VS are achievable in such contexts, particularly with external support, but high attrition, poor adherence and gaps in differentiated care threaten sustainability. Uptake of DTG-based regimens is encouraging, though low-level viraemia and treatment failure require close monitoring. Strengthening VL surveillance, adherence support and patient-centred delivery adapted to real-life constraints is essential. The findings highlight the need for community-responsive care models—strengthening community-based support and peer accompaniment and addressing food insecurity, stigma and mobility—to maintain engagement. In Carnot, continuity of care depends not only on coverage but also on trust, flexibility and collaboration between the Ministry of Health and MSF to advance differentiated models suited to fragile systems.

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