Scientific Research Publishing

Advances in Infectious Diseases, 2025, 15(3), 499-515
https://www.scirp.org/journal/aid
ISSN Online: 2164-2656
ISSN Print: 2164-2648

Assessment of Constraints in the HIV Input Supply Chain in N'Djamena, Chad

Adoum Fouda Abderrazzack[1,2*], Serge Mbaitoloum Beoudal[1], Tchonfiene Passiri Patedjoré[3], Emmanuel Issa[2], Oumalher Adam Youssouf[2], Alain Nahaskida[4], Abdoulaye Anou Nassour[4], Fridam Dounia[4], Brahim Boy Otchom[2], Ali Mahamat Moussa[3], Abdelsalam Tidjani[5], Ameyapoh Yaovi[6], Franck Jean Daniel Mennechet[7], Thierry Verdel[8], Patrick Thonneau[8]

[1]Department of Biomedical and Pharmaceutical Sciences, Faculty of Human Sciences and Health, University of N'Djamena, N'Djamena, Chad
[2]Faculty of Science and Technology, Toumai University, N'Djamena, Chad
[3]Department of Medicine, Faculty of Sciences and Human Health, University of N'Djamena, N'Djamena, Chad
[4]Laboratory of the N'Djamena Psycho-Medical Support Center, N'Djamena, Chad
[5]Department of Public Health, Faculty of Sciences and Human Health, University of N'Djamena, N'Djamena, Chad
[6]Laboratory of Microbiology and Quality Control of Foodstuffs, School of Biological and Food Techniques, University of Lom, Lomé, Togo
[7]Pathogenesis and Control of Chronic and Emerging Infections (PCCEI), INSERM, Montpellier, France
[8]Department of Public Health, University Senghor, Alexandrie, Egypt
Email: *razzackadoum@yahoo.fr

How to cite this paper: Abderrazzack, A.F., Beoudal, S.M., Patedjoré, T.P., Issa, E., Youssouf, O.A., Nahaskida, A., Nassour, A.A., Dounia, F., Otchom, B.B., Moussa, A.M., Tidjani, A., Yaovi, A., Mennechet, F.J.D., Verdel, T. and Thonneau, P. (2025) Assessment of Constraints in the HIV Input Supply Chain in N'Djamena, Chad. *Advances in Infectious Diseases*, **15**, 499-515.
https://doi.org/10.4236/aid.2025.153037

Received: June 23, 2025
Accepted: August 11, 2025
Published: August 14, 2025

Abstract

Introduction: Continuous access to HIV inputs, particularly Antiretrovirals (ARVs), diagnostic tests, and cotrimoxazole, is essential for quality care of people living with HIV (PLHIV). However, stock-outs persist in health facilities (FOSA) in N'Djamena, Chad. This study aims to assess the availability of these inputs in care centers in the Chadian capital. **Material and Methods**: A comprehensive prospective descriptive study was conducted from July to August 2021 on the 16 FOSA providing care for PLHIV in N'Djamena. Data was collected from stock cards, registers, order forms, inventories, and semi-structured interviews with stock managers at FOSA, and at central and provincial warehouses. A standardized stock-out monitoring form and checklist were used to document stock-outs and assess storage conditions. **Results:** On the day of the survey, 91.7% of FOSA (11 out of 12 responding) experienced a stock-out of at least one ARV. Stock-outs of adult ARVs affected 75% of facilities, and pediatric ARVs 66.7%. Cotrimoxazole was unavailable in 58.3% of FOSA, and HIV tests in 33.3%. The most frequently out-of-stock adult ARVs included: Efavirenz 600 mg (71.4%), DTG/3TC/TDF (40%), ABC/3TC 600/300 mg (22.2%), AZT/3TC 300/150 mg (37.5%) and AZT/3TC/NVP 300/150/200 mg (18.2%). Pediatric ARVs most frequently unavailable included: Efavirenz 200 mg (62.5%),

ABC/3TC 60/30 mg (55.6%), Nevirapine syrup 50 mg (40%), and LPV/r 100/25 mg (33.3%). **Conclusion:** FOSA in N'Djamena faces frequent HIV input stock-outs, compromising treatment continuity and patient retention. Strengthening logistics systems, planning, and stock monitoring is needed to secure the supply chain.

Keywords

HIV, Inputs, Stock-Out, FOSA, N'Djamena, Chad

1. Introduction

Since the discovery of the Human Immunodeficiency Virus (HIV) in the early 1980s, antiretroviral (ARV) treatments have profoundly transformed its management, turning HIV from a fatal infection into a controllable chronic condition [1]. In 2019, UNAIDS estimated that 38 million people were living with HIV worldwide, of which 25.4 million were on antiretroviral therapy [2]. Despite these advances, 690,000 AIDS-related deaths and 1.7 million new infections were still recorded [2].

Sub-Saharan Africa remains the epicenter of the epidemic, accounting for nearly two-thirds of people living with HIV. Adolescent girls and young women aged 15 to 24 are particularly vulnerable due to social, economic, and behavioral factors [3].

In Chad, HIV infection remains a major public health concern, with a prevalence of 1.2% among adults aged 15 to 49 in 2020, down from 3.3% in 2005 [4]. This prevalence is higher among women (1.5%) and in urban areas (4.3%) [2]. In 2019, nearly 120,000 people were living with HIV, about 69,000 of whom were on treatment [4]. ARVs, HIV test kits, and cotrimoxazole prophylaxis are essential to control the disease, prevent opportunistic infections, and limit transmission [5] [6]. However, their effectiveness depends on uninterrupted availability. In resource-limited settings, stock-outs of HIV inputs are frequent, compromising adherence, retention in care, and patient trust, while promoting the emergence of resistance [7].

In Chad, the supply chain for HIV inputs remains fragile, with limited up-to-date data on actual availability in health facilities. This study aims to assess the availability of HIV inputs in health facilities (FOSA) in N'Djamena, identify the types of products most affected by stock-outs, and highlight persistent logistical challenges.

2. Materials and Methods

2.1. Study Type and Setting

This is a descriptive cross-sectional study conducted from July to August 2021 in health facilities (FOSA) providing HIV care. All HIV treatment centers in N'Dja-

mena were included. At the time of the survey, sixteen (16) centers provided HIV care in the Chadian capital. The study assessed the availability of essential inputs for the care of people living with HIV (PLHIV), including antiretrovirals (ARVs), HIV test kits, and medications for the prevention of opportunistic infections.

In addition, three key institutions involved in the supply chain were included: Central Pharmaceutical Purchasing Agency (CPA), Provincial Pharmaceutical Procurement Pharmacy (PPA) of N'Djamena and the Sectoral Program for the Fight Against AIDS, Hepatitis and STIs (PSLSH/IST).

The study was limited to N'Djamena due to logistical constraints but also because the capital accounts for about 33% of the national active file. Moreover, it represents a diversity of supply schemes and population (socio-economic, cultural, religious), reducing selection bias.

2.2. ARV and HIV Test Supply Chain in N'Djamena

For N'Djamena, the CPA ensures the supply of ARVs and other HIV inputs to several reference health facilities, including National Referral University Hospital Center (CHU-RN), Chad-China Friendship Hospital (HATC), Military Instruction Hospital (HMI), University Hospital for Mother and Child (HME), University Hospital of the Renaissance, and Agency for Prevention and School Health (APMS).

These facilities, along with the PPA, submit their purchase orders directly to the PSLSH/IST. The procurement and stock management unit (GASL) of PSLSH/IST evaluates and validates orders before sending them to the CPA, which prepares the deliveries. Each health facility then collects its products from the CPA using its own logistics.

The PPA of N'Djamena supplies eleven (11) other treatment centers, including district hospitals and some university hospital centers. In this circuit, FOSA orders are centralized by the PPA, validated by the HIV focal points of the districts or hospitals, and then sent to the provincial health directorate for final validation. Each center then collects its supplies from the PPA.

2.3. Survey Tools and Process

The survey was conducted from July to August 2021, depending on the availability of those responsible for ARV stock management in each center and logistical constraints. Several centers could be visited on the same day when possible.

A standardized questionnaire, based on early warning indicators of ARV stock-outs defined by the SIAPS program (Systems for Improved Access to Pharmaceuticals and Services), was used. By definition in the national protocol, a stock-out is the period during which medicines are unavailable on pharmacy shelves for at least 14 consecutive days. Three specific versions were adapted according to the type of structure: Treatment centers: assessment of internal organization, availability of inputs on the survey day and in the previous six months, causes of stock-outs; CPA and PPA: description of operations, interactions with centers and

PSLSH/IST, stock status. PSLSH/IST: role in the supply chain and interactions with other stakeholders.

Evaluated inputs encompassed all ARVs used in the various therapeutic lines, Cotrimoxazole (480 mg tablets and 240 mg syrup), and Determine HIV 1/2 and SD Bioline test kits, in accordance with the National HIV Clinical and Therapeutic Management Guide (March 2019).

Product availability or stock-out was verified by physical inventory, stock cards, registers, and inventory documents. Expired products in stock were also considered. A discrepancy of less than 10% between physical and theoretical stock was deemed acceptable.

2.4. Statistical Analysis

The data were entered into Microsoft Excel 2007 and analyzed using Epi Info software, version 7.2.4.0.

2.5. Ethical Considerations

The study was approved by the surveyed health facilities. Verbal informed consent was obtained from all staff members interviewed at each facility.

3. Results

3.1. Characteristics of the Studied Facilities

The city of N'Djamena currently has 16 HIV/AIDS treatment centers. For the purposes of this study, all these centers were initially selected. However, due to administrative, logistical, and time constraints, only 12 centers were effectively surveyed, representing 75% of the total. These 12 health facilities (FOSA) provide care to 22,736 people living with HIV (PLHIV), accounting for 91.40% of PLHIV residing in the capital. The 4 centers not surveyed represented 8.60% of all PLHIV followed in the capital.

The central supply structures—the Central Pharmaceutical Purchasing Agency (CPA) and the Provincial Pharmaceutical Procurement Pharmacy (PPA) of N'Djamena—were included in the study as key actors in the HIV supply chain (**Figure 1**).

3.2. Distribution According to the Level of the Health Pyramid (Figure 2)

Among these structures, approximately 50% were district hospitals and 42% were national-level establishments.

3.3. HIV Commodities Ordering and Management

3.3.1. Internal Organization

All FOSA have a central pharmacy. In 75% of them, a dedicated unit for the dispensing of ARVs is functional. In the remaining 25%, dispensing is either carried out by the prescribing physician (2 FOSA) or directly by the central pharmacy (1

FOSA).

Supply Channels and Specific Supply for PMTCT of the 12 FOSA studied, 42% are supplied by the CPA (four national hospitals and one specialized center), while 58% are supplied by the PPA (six district hospitals and one university hospital). Regarding prevention of mother-to-child transmission (PMTCT) and pediatric care, 92% of the FOSA are involved. Among them, 36% receive their commodities through UNICEF (three national hospitals and one specialized center), while 64% are supplied by the PPA (six district hospitals and one university hospital).

Ordering Methods for Commodities (Table 1)

3.3.2. Order Validation

In 83.33% of the health facilities (FOSA), no formal validation of orders is performed before submission. Only one FOSA benefits from verification by the central pharmacist, while another is subject to validation by the district medical officer.

3.3.3. Order Frequency

The distribution of FOSA according to the frequency of their orders and their supply source. The majority of FOSA (91.67%) reported placing orders according to a schedule established by their supplying partner, though not based on minimum or maximum stock levels.

Among these, 50% place monthly orders, primarily those facilities supplied by the PPA. Other FOSA follow a quarterly ordering schedule (33.33%), while a few place orders every four or six months—the latter frequency observed in select cases.

Level of Satisfaction of Health Facilities (FOSA) with Their Supply Chain (Figure 3)

The satisfaction of health facilities (FOSA) with their supply chain varies depending on the source of inputs. Approximately 50% of FOSA reports being generally satisfied. This satisfaction rises to 80% among facilities supplied by the CPA, compared to only 28.57% for those supplied by the PPA.

3.4. Management and Storage of HIV Commodities

The management of Antiretroviral (ARV) stock presents several challenges for the surveyed health facilities (FOSA). Only 25% of facilities use a computerized system for HIV stock management, and among these, only one also integrates computerized dispensing.

One FOSA reported a loss of ARVs due to flooding, highlighting the vulnerability of certain sites to environmental risks. Furthermore, 50% of the facilities have inadequate ARV storage, characterized by non-compliance with the FEFO (First Expired, First Out) principle, poor label visibility, and mixing of products. Alarmingly, 33.33% of FOSA stores had expired products in the same area as valid ones, posing a significant health risk. However, all stocks are stored in locked prem-

ises with a designated person in charge, ensuring a degree of security. Regarding storage conditions, half of FOSA have ventilated storage rooms, and 83.33% use pallets to avoid direct contact between products and the floor. Finally, only one facility has a dedicated vehicle for pharmaceutical transport, which may limit supply logistics.

3.4.1. Storage of HIV Commodities

The quality of HIV commodities storage varies depending on the level of the health facility (FOSA). Approximately 50% of the facilities have inadequate ARV storage, with non-compliance with the FEFO (First Expired, First Out) principle and poor product positioning. This situation affects certain categories of hospitals more significantly, emphasizing the importance of better stock organization based on the level of the health facility.

3.4.2. Dispensing Practices

Two-thirds of the facilities (66.7%) dispense a three-month supply of ARVs, while 25% provide a one-month supply, and only 8.3% offer a two-month supply. All FOSA supplied by the Central Pharmaceutical Procurement Agency (CPA) follow a quarterly dispensing schedule. In contrast, the dispensing duration varies more among facilities supplied by the Provincial Procurement Platform (PPA), ranging from one to three months.

3.4.3. Monitoring and Evaluation

Among the twelve health facilities (FOSA) assessed, only one has not received any supervision regarding the management of HIV commodities in the past two years—neither from its partner supplier nor the Ministry of Health. This lack of follow-up raises concerns about the quality of stock management and the sustainability of supply in that facility.

Stock-Outs (Table 2)

A total of 48 stock-outs were documented during the survey. Of these, 35 involved antiretroviral drugs (ARVs)—19 for adult patients and 16 for pediatric patients. The remaining 13 were related to cotrimoxazole (8 cases) and HIV test kits (5 cases).

The most frequent stock-outs affected both adult and pediatric ARVs. For adult ARVs: DTG 50 mg had a 100% stock-out rate (1/1), EFV 600 mg: 71.43% (5/7), DTG/3TC/TDF: 40% (4/10), AZT/3TC 300/150 mg: 37.5% (3/8), ABC/3TC 600/300 mg: 22.22% (2/9), AZT/3TC/NVP: 18.18% (2/11).

3.5. HIV Commodity Stock Management in Health Facilities

Stock management tools and practices were reviewed in key structures: the Peripheral Procurement Pharmacy (PPA) in N'Djamena, the Central Pharmaceutical Procurement Agency (CPA), the National HIV/STI Program (PSLSH/IST), and twelve health facilities (FOSA).

Of the 181 products recorded in the 12 FOSA, only 74 (40.9%) had stock cards. Among these, 34 (45.9%) were accurate (*i.e.*, less than 10% discrepancy between

physical and theoretical stock). Only six FOSA (50%) had stock cards, and only a minority were correctly maintained, revealing poor stock monitoring.

At the N'Djamena PPA, led by a pharmacist, program products are stored in a dedicated area under the responsibility of a stock manager. This manager places orders based on consumption data, maintaining a two-month safety stock and a three-month circulating stock—thus planning for five months of supply. Products are stored on pallets and are well organized.

However, although all stock cards for the 26 products were present, none were updated at the time of the survey. The computerized management system is operational but delayed, affecting the reliability of real-time stock data. The PPA serves 104 health facilities in N'Djamena and surrounding areas but lacks a formal HIV commodity distribution plan and clear knowledge of the actual needs of FOSA. Average order preparation time is less than a week, and FOSA is informed in advance. On the day of the survey, Efavirenz 600 mg and Duovir were out of stock. However, no HIV stock-outs had been reported in the six months prior.

The CPA, also led by a pharmacist, applies strict stock management using both computerized and manual tools. However, the storage space lacks ventilation, which could impact product quality. CPA distributes HIV commodities on demand to both PPA and FOSA and may redistribute excess products not ordered to avoid expiry. No stock-outs were observed at the CPA on the survey day.

PSLSH/IST plays an essential role in quantifying HIV inputs and monitoring distribution. The supply management officer verifies FOSA and PPA orders before forwarding them.

To enhance coordination and communication, a dedicated WhatsApp group for stock managers (including PPA directors, the CPA manager, HIV focal points, and other stakeholders) was created. This platform facilitates order tracking and speeds up communication.

3.6. Stockout Duration

Beyond frequency, the duration of stockouts provides a critical measure of their operational impact on the continuity of care. On the day of the survey, 41.66% of the reported stockouts had lasted more than 30 days, indicating serious and prolonged interruptions in treatment.

The median duration of these stockouts, calculated based on products with available data, was 27 days, with a range from 7 to 61 days, depending on the product involved.

It is important to note, however, that many health facilities still operate manually and do not consistently use stock cards or inventory tracking tools. This lack of proper documentation explains why duration data could not be determined for certain commodities, particularly pediatric antiretrovirals, cotrimoxazole, and HIV test kits (Table 3).

Bivariate Comparison of Supply Source, Ordering Frequency, and Stockout

Occurrence

Figure 4 compares health facilities (FOSA) supplied by the Central Pharmaceutical Agency (CPA) and the Provincial Pharmaceutical Agency (PPA) across six key indicators. Facilities under CPA fully comply with best practices (100% quarterly ordering, three-month dispensing, 80% satisfaction), while those under PPA show fragmented logistics (14.3% quarterly ordering, 42.9% three-month dispensing, 85.7% monthly ordering). Prolonged stockouts occur only in PPA-supported facilities, indicating that frequent, short ordering cycles undermine supply stability. These findings highlight the need to align practices with national standards to ensure continuity of care.

4. Results

4.1. Characteristics of the Studied Facilities

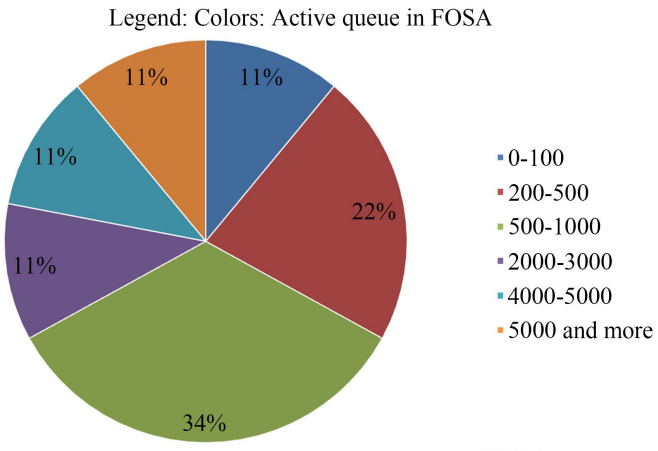


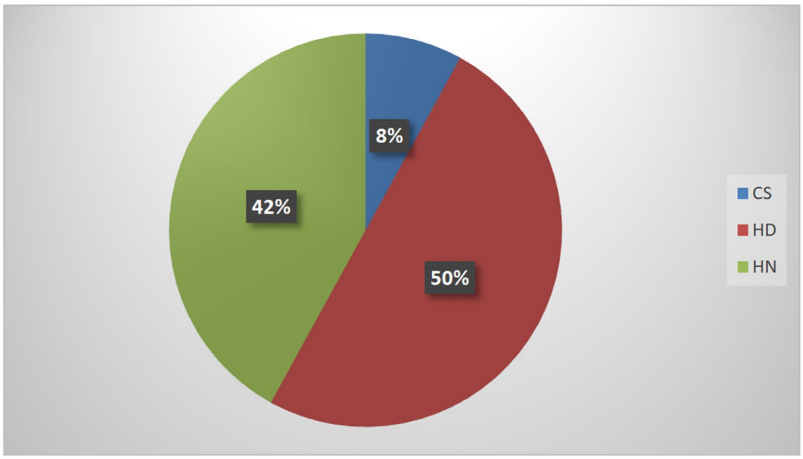
Figure 1. Distribution (%) of health facilities (FOSA) by number of people receiving ARVs.

The city of N'Djamena currently has 16 HIV/AIDS treatment centers. For the purposes of this study, all these centers were initially selected. However, due to administrative, logistical, and time constraints, only 12 centers were effectively surveyed, representing 75% of the total. These 12 health facilities (FOSA) provide care to 22,736 people living with HIV (PLHIV), accounting for 91.40% of PLHIV residing in the capital. The 4 centers not surveyed represented 8.60% of all PLHIV followed in the capital.

The central supply structures—the Central Pharmaceutical Purchasing Agency (CPA) and the Provincial Pharmaceutical Procurement Pharmacy (PPA) of N'Djamena—were included in the study as key actors in the HIV supply chain (Figure 1).

4.2. Distribution According to the Level of the Health Pyramid (Figure 2)

Among these structures, approximately 50% were district hospitals and 42% were national-level establishments.



Legend: CS = Health Center, HD = District Hospital, HN = National Hospital.

Figure 2. Distribution of health facilities (FOSA) by level in the health system.

4.3. HIV Commodities Ordering and Management

4.3.1. Internal Organization

All FOSA have a central pharmacy. In 75% of them, a dedicated unit for the dispensing of ARVs is functional. In the remaining 25%, dispensing is either carried out by the prescribing physician (2 FOSA) or directly by the central pharmacy (1 FOSA).

Supply Channels and Specific Supply for PMTCT of the 12 FOSA studied, 42% are supplied by the CPA (four national hospitals and one specialized center), while 58% are supplied by the PPA (six district hospitals and one university hospital). Regarding prevention of mother-to-child transmission (PMTCT) and pediatric care, 92% of the FOSA are involved. Among them, 36% receive their commodities through UNICEF (three national hospitals and one specialized center), while 64% are supplied by the PPA (six district hospitals and one university hospital) (**Table 1**).

Table 1. Ordering responsibility by facility level.

Responsible	CS	DH	NH	Total
Psychosocial Counselor	0	0	3	3 (25%)
HIV Focal Point	0	6	1	7 (58.33%)
Pharmacy Manager	1	0	1	2 (16.67%)

Legend: CS = Health Center, DH = District Hospital, NH = National Hospital.

In 83.33% of the health facilities (FOSA), no formal validation of orders is performed before submission. Only one FOSA benefits from verification by the central pharmacist, while another is subject to validation by the district medical officer. The distribution of FOSA according to the frequency of their orders and their supply source. The majority of FOSA (91.67%) reported placing orders according to a schedule established by their supplying partner, though not based on

minimum or maximum stock levels.

Among these, 50% place monthly orders, primarily those facilities supplied by the PPA. Other FOSA follow a quarterly ordering schedule (33.33%), while a few place orders every four or six months—the latter frequency observed in select cases.

4.3.2. Level of Satisfaction of Health Facilities (FOSA) with Their Supply Chain

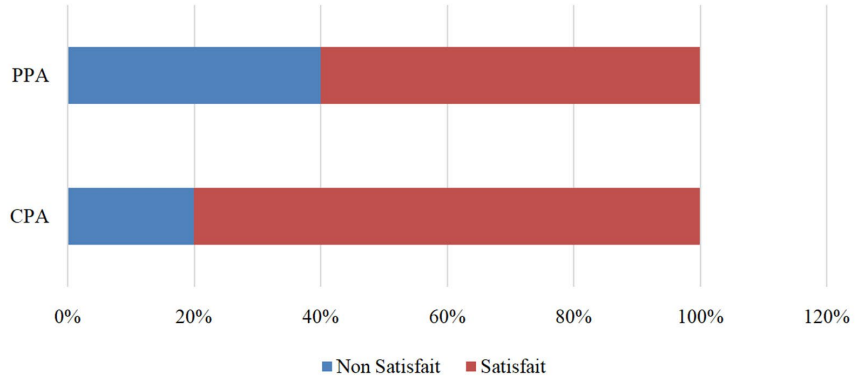


Figure 3. Distribution of health facilities (FOSA) by satisfaction with the supply chain.

The satisfaction of health facilities (FOSA) with their supply chain varies depending on the source of inputs. Approximately 50% of FOSA report being generally satisfied. This satisfaction rises to 80% among facilities supplied by the CPA, compared to only 28.57% for those supplied by the PPA.

4.3.3. Management and Storage of HIV Commodities

The management of antiretroviral (ARV) stock presents several challenges among the surveyed health facilities (FOSA). Only 25% of facilities use a computerized system for HIV stock management, and among these, only one also integrates computerized dispensing.

One FOSA reported a loss of ARVs due to flooding, highlighting the vulnerability of certain sites to environmental risks. Furthermore, 50% of the facilities have inadequate ARV storage, characterized by non-compliance with the FEFO (First Expired, First Out) principle, poor label visibility, and mixing of products. Alarmingly, 33.33% of FOSA stores had expired products in the same area as valid ones, posing a significant health risk. However, all stocks are stored in locked premises with a designated person in charge, ensuring a degree of security. Regarding storage conditions, half of the FOSA have ventilated storage rooms, and 83.33% use pallets to avoid direct contact between products and the floor. Finally, only one facility has a dedicated vehicle for pharmaceutical transport, which may limit supply logistics.

4.3.4. Storage of HIV Commodities

The quality of HIV commodities storage varies depending on the level of the health

facility (FOSA). Approximately 50% of the facilities have inadequate ARV storage, with non-compliance with the FEFO (First Expired, First Out) principle and poor product positioning. This situation affects certain categories of hospitals more significantly, emphasizing the importance of better stock organization based on the level of the health facility.

4.3.5. Dispensing Practices

Two-thirds of the facilities (66.7%) dispense a three-month supply of ARVs, while 25% provide a one-month supply, and only 8.3% offer a two-month supply. All FOSA supplied by the Central Pharmaceutical Procurement Agency (CPA) follow a quarterly dispensing schedule. In contrast, the dispensing duration varies more among facilities supplied by the Provincial Procurement Platform (PPA), ranging from one to three months.

4.3.6. Monitoring and Evaluation

Among the twelve health facilities (FOSA) assessed, only one had not received any supervision regarding the management of HIV commodities in the past two years—neither from its partner supplier nor the Ministry of Health. This lack of follow-up raises concerns about the quality of stock management and the sustainability of supply in that facility.

4.3.7. Stock-Outs

Table 2. Prevalence of stock-outs on the day of the survey.

Commodities	FOSA Using (n)	% in Use	FOSA in Stock-Out (n)	% in Stock-Out
Adult ARVs	12	100%	9	75%
Pediatric ARVs	11	91.67%	8	66.67%
At least one ARV	12	100%	11	91.67%
Cotrimoxazole	12	100%	7	58.33%
HIV Test	12	100%	4	33.33%

A total of 48 stock-outs were documented during the survey. Of these, 35 involved antiretroviral drugs (ARVs)—19 for adult patients and 16 for pediatric patients. The remaining 13 were related to cotrimoxazole (8 cases) and HIV test kits (5 cases).

The most frequent stock-outs affected both adult and pediatric ARVs. For adult ARVs: DTG 50 mg had a 100% stock-out rate (1/1), EFV 600 mg: 71.43% (5/7), DTG/3TC/TDF: 40% (4/10), AZT/3TC 300/150 mg: 37.5% (3/8), ABC/3TC 600/300 mg: 22.22% (2/9), AZT/3TC/NVP: 18.18% (2/11).

4.3.8. HIV Commodity Stock Management in Health Facilities

Stock management tools and practices were reviewed in key structures: the Peripheral Procurement Pharmacy (PPA) in N'Djamena, the Central Pharmaceutical Procurement Agency (CPA), the National HIV/STI Program (PSLSH/IST), and

twelve health facilities (FOSA).

Of the 181 products recorded in the 12 FOSA, only 74 (40.9%) had stock cards. Among these, 34 (45.9%) were accurate (*i.e.*, less than 10% discrepancy between physical and theoretical stock). Only six FOSA (50%) had stock cards, and only a minority were correctly maintained, revealing poor stock monitoring.

At the N'Djamena PPA, led by a pharmacist, program products are stored in a dedicated area under the responsibility of a stock manager. This manager places orders based on consumption data, maintaining a two-month safety stock and a three-month circulating stock—thus planning for five months of supply. Products are stored on pallets and are well organized.

However, although all stock cards for the 26 products were present, none were updated at the time of the survey. The computerized management system is operational but delayed, affecting the reliability of real-time stock data. The PPA serves 104 health facilities in N'Djamena and surrounding areas but lacks a formal HIV commodity distribution plan and clear knowledge of the actual needs of FOSA. Average order preparation time is less than a week, and FOSA is informed in advance. On the day of the survey, Efavirenz 600 mg and Duovir were out of stock. However, no HIV stock-outs had been reported in the six months prior.

The CPA, also led by a pharmacist, applies strict stock management using both computerized and manual tools. However, the storage space lacks ventilation, which could impact product quality. The CPA distributes HIV commodities on demand to both PPA and FOSA and may redistribute excess products not ordered to avoid expiry. No stock-outs were observed at the CPA on the survey day.

PSLSH/IST plays an essential role in quantifying HIV inputs and monitoring distribution. The supply management officer verifies FOSA and PPA orders before forwarding them.

To enhance coordination and communication, a dedicated WhatsApp group for stock managers (including PPA directors, the CPA manager, HIV focal points, and other stakeholders) was created. This platform facilitates order tracking and speeds up communication.

4.3.9. Stockout Duration

Beyond frequency, the duration of stockouts provides a critical measure of their operational impact on the continuity of care. On the day of the survey, 41.66% of the reported stockouts had lasted more than 30 days, indicating serious and prolonged interruptions in treatment.

The median duration of these stockouts, calculated based on products with available data, was 27 days, with a range from 7 to 61 days, depending on the product involved.

It is important to note, however, that many health facilities still operate manually and do not consistently use stock cards or inventory tracking tools. This lack of proper documentation explains why duration data could not be determined for certain commodities, particularly pediatric antiretrovirals, cotrimoxazole, and HIV

test kits (Table 3).

Table 3. Duration and frequency of stockouts for key HIV commodities (Adult, pediatric, and others).

Category	Product	Stockout Rate (%)	Median Duration (days)	Range (days)
Adult ARVs	Efavirenz 600 mg	71.43%	30	15 - 60
	DTG/3TC/TDF	40.00%	28	10 - 45
	AZT/3TC 300/150 mg	37.50%	25	12 - 40
	ABC/3TC 600/300 mg	22.22%	22	7 - 31
	DTG 50 mg	100.00%	61	61 (single case)
Pediatric ARVs	Efavirenz 200 mg	62.50%	ND	ND
	ABC/3TC 60/30 mg	55.56%	ND	ND
	Nevirapine 50 mg (syrup)	40.00%	ND	ND
	LPV/r 100/25 mg	33.33%	ND	ND
Other adult input	Cotrimoxazole 480 mg	25.00%	ND	ND
Other pediatric input	Pediatric Cotrimoxazole	45.45%	ND	ND
HIV test	Determine HIV 1/2	8.33%	ND	ND
HIV test	SD Bioline HIV	33.33%	ND	ND

Legend: ND = Not Determined (duration data could not be documented for these products).

4.3.10. Bivariate Comparison of Supply Source, Ordering Frequency, and Stockout Occurrence

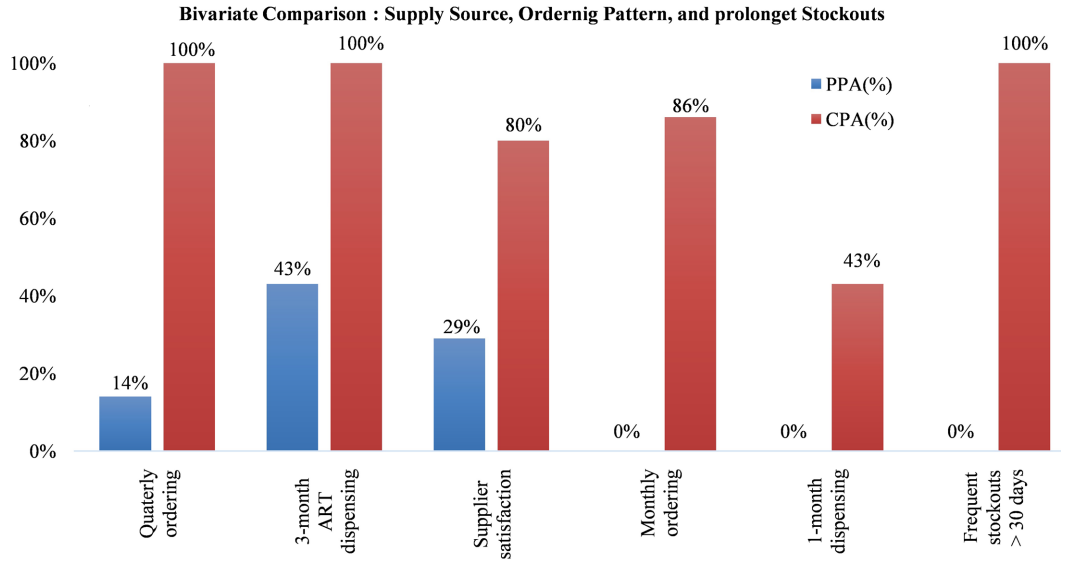


Figure 4. Bivariate comparison of supply source, ordering frequency, and stockout occurrence.

Figure 4 compares health facilities (FOSA) supplied by the Central Pharmaceutical Agency (CPA) and the Provincial Pharmaceutical Agency (PPA) across six key indicators. Facilities under CPA fully comply with best practices (100% quarterly ordering, three-month dispensing, 80% satisfaction), while those under PPA show fragmented logistics (14.3% quarterly ordering, 42.9% three-month dispensing, 85.7% monthly ordering). Prolonged stockouts occur only in PPA-supported facilities, indicating that frequent, short ordering cycles undermine supply stability. These findings highlight the need to align practices with national standards to ensure continuity of care.

5. Discussion

This study was conducted in twelve health facilities (FOSA) out of sixteen, representing 75% (12/16), covering the care of 22,736 people living with HIV (PLHIV), which corresponds to 91.4% of the total PLHIV population in the city. These 12 surveyed centers participated in the study, while the remaining 4 centers (25%) were not surveyed due to administrative, logistical, and time constraints. Although the sizes of the centers vary, their characteristics are generally similar, which limits the potential selection bias.

Supply chain management varies according to the FOSA. In 58.33% of cases, orders for HIV-related commodities (notably adult antiretrovirals and testing kits) are placed by the HIV focal points (PFVIH) at the district level. In 25% of cases, this responsibility is delegated to psychosocial counselors (CPS), personnel not specialized in pharmaceutical logistics. Delegating to non-specialists can lead to errors in needs estimation and inefficient stock management, as corroborated by several previous studies [1] [3].

Although 91.67% of the FOSA (11 facilities) reported making periodic orders, only half did so for a one-month period. In contrast, all FOSA supplied by the CPA maintain stocks that cover three months, which is in line with current recommendations. However, only half of the surveyed FOSA reported satisfaction with the service level provided by their supply partner, with higher satisfaction (80%) among those served by the CPA.

Regarding treatment dispensing, 66.67% of FOSA provide patients with a three-month stock, 25% provide a one-month stock, and only one facility (8.33%) dispenses for two months. This heterogeneity contradicts guidelines recommending quarterly dispensing for stable patients [4]. Only two FOSA-adapted dispensing durations were used during the COVID-19 pandemic, extending from two to three months.

The proportion of FOSA experiencing stock-outs of at least one antiretroviral on the survey day is particularly concerning, reaching 91.67% (n = 11). Specifically, 75% experienced stock-outs of at least one adult ARV, 66.67% of a pediatric ARV, 58.33% of a cotrimoxazole formulation, and 33.33% of an HIV test kit. The most frequently stock-out molecules were: Efavirenz 600 mg (71.43%), DTG/3TC/TDF (40%), ABC/3TC 600/300 mg (22.22%), AZT/3TC 300/150 mg

(37.5%), and AZT/3TC/NVP 300/150/200 mg (18.18%) for adult ARVs; Efavirenz 200 mg (62.5%), ABC/3TC 60/30 mg (55.56%), Nevirapine 50 mg syrup (40%), and LPV/r 100/25 mg (33.33%) for pediatric ARVs; as well as pediatric and adult cotrimoxazole forms, stock-out in 45.45% and 25% of FOSA respectively. For HIV tests, the SD Bioline HIV test was out of stock in one-third of facilities using it. Moreover, 41.66% of the observed stock-outs lasted more than 30 days, indicating a lack of effective corrective mechanisms [5] [6].

Regarding logistics management, only 40.88% (74 out of 181) of examined products had a stock card, and only 50% of FOSA regularly used these tools. Additionally, half of the facilities showed poor stock organization, characterized by inadequate storage and a lack of expiry date management.

Contrary to observations reported by Gils *et al.* in Kinshasa [6], our study did not find a correlation between cohort size and frequency of stock-outs. Indeed, FOSA with the largest cohorts benefits from direct supply via the CPA, suggesting a prioritization logic inverse to that observed in other contexts.

The supply route significantly influences FOSA performance: the average stock-out rate was 25.22% in those supplied by the CPA, compared to 27.39% for those served by the PPA. This difference is explained by the absence of rational planning based on the real needs of the facilities. Deliveries are often conditioned by stock availability in warehouses, generating a chronic under-supply cycle. As one manager stated: "Since the PPA never supplies us with what we order, I stopped sending formal orders to the PPA".

Monthly supply, mainly provided by the PPA, limits logistical maneuvering room and increases the likelihood of stock-outs. This situation is worsened by the fact that 83.33% of orders are placed by personnel whose primary role is not stock management. Without stock cards, dedicated transport means, and rigorous follow-up, stock-outs become inevitable.

Comparison with other contexts is instructive: the overall stock-out rate (91.67%) is higher than the 62% reported in Ethiopia [8] and the 50% observed in Kinshasa [6]. The high frequency of stock-outs for the combined DTG/3TC/TDF treatment (40%) seems related to a too-rapid transition to this drug without sufficient anticipation of needs. Despite its recommendation as a first-line treatment due to its high genetic barrier, dolutegravir was out of stock in nearly half of the FOSA using it. In two facilities, this treatment was not even ordered, either due to lack of awareness of recommendations or due to habitual prescribing practices.

Finally, pediatric ARV stock-outs highlight the complexity of the supply system, requiring close coordination between districts, the Regional Health Delegation, the PPA, and UNICEF. This coordination is often hindered by a lack of human and logistical resources at the local level. In this study, 41.66% of stockouts lasted over 30 days (median 27 days), similar to other settings [9], increasing risks of treatment failure and mortality [10]-[12].

Limited use of stock cards and reliance on paper systems, especially for pediatric ARVs, cotrimoxazole, and rapid tests, worsen the situation [13] [14]. Manual

medicine redistribution during shortages also raises the risk of losses [15].

Strengthening logistics management, adopting digital tools, and improving coordination are crucial to ensuring reliable supply and continuous HIV treatment.

Acknowledgements

We would like to express our sincere gratitude to all the managers of HIV care sites for their kind collaboration in the implementation of this study. We also warmly thank the GASL team of the PSLSH/IST for facilitating the execution of the present research.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

[1] Deeks, S.G., Lewin, S.R. and Havlir, D.V. (2013) The End of AIDS: HIV Infection as a Chronic Disease. *The Lancet*, **382**, 1525-1533. https://doi.org/10.1016/s0140-6736(13)61809-7

[2] ONUSIDA. https://www.unaids.org/fr

[3] Jewell, B.L., *et al.* (2020) HIV Incidence among Adolescent Girls and Young Women in Sub-Saharan Africa: A Systematic Review. *Aids*, **34**, 841-852.

[4] INSEED (2014) Enquête Démographique et de Santé au Tchad. N'Djaména. https://www.dhsprogram.com/pubs/pdf/FR317/FR317.pdf

[5] Cohen, M.S., *et al.* (2011) Prevention of HIV-1 Infection with Early Antiretroviral Therapy. *New England Journal of Medicine*, **365**, 493-505. https://doi.org/10.1056/nejmoa1600693

[6] Ford, N., Mills, E.J. and Egger, M. (2013) Challenges of Scaling up HIV Treatment in Resource-Limited Settings. *Journal of the International AIDS Society*, **16**, 1-8.

[7] Wright, J., *et al.* (2019) Impact of Antiretroviral Stock-Outs on Adherence and Clinical Outcomes in Low-Resource Settings: A Systematic Review. *Aids Care*, **31**, 971-979.

[8] Hasselback, L., *et al.* (2019) Quantifying the Efficiency of HIV Supply Chain Management in Sub-Saharan Africa: A Systematic Review. *BMC Health Services Research*, **19**, Article No. 519. https://doi.org/10.1186/s12913-019-4351-3

[9] Gils, F., Jacobs, J., Peeters, M., *et al.* (2019) Supply Chain Challenges for Antiretroviral Therapy in Kinshasa. *PLOS ONE*, **14**, e0219215.

[10] Herme, M., Grellety, E., Bernard, A., *et al.* (2016) Impact of Antiretroviral Drug Stock-Outs on HIV Treatment Outcomes: A Cohort Study in West Africa. *AIDS*, **30**, 1577-1583.

[11] Fox, M.P. and Rosen, S. (2015) Retention of Adult Patients on Antiretroviral Therapy in Low- and Middle-Income Countries: Systematic Review and Meta-Analysis 2008-2013. *PLOS ONE*, **10**, e0127842.

[12] Médecins Sans Frontières (2018) Situation des ruptures de stock d'ARV en RDC: Report. https://scienceportal.msf.org

[13] Ejigu, Y., Mekonnen, A., Kebede, T., *et al.* (2019) Assessment of Antiretroviral Drug

Stockouts in Ethiopia: Magnitude and Determinants. *BMC Public Health*, **19**, Article No. 652.

[14] Binagwaho, A., Kyamanywa, P., Farmer, P.E., *et al.* (2023) Integration of Electronic Logistics Management Information Systems to Strengthen Supply Chains in Rwanda. *BMC Health Services Research*, **23**, Article No. 345.

[15] Smith, J.A., Mothibi, E., Manyatsi, C., *et al.* (2023) Medicine Redistribution as a Coping Strategy for Antiretroviral Stockouts in South Africa. *BMC Health Services Research*, **23**, Article No. 122.

Abbreviations and Acronyms

HIV—Human Immunodeficiency Virus
ARVs—Antiretrovirals
PLHIV—People Living with HIV
FOSA—Formation Sanitaire
CHU-ME—University Hospital Center for Mothers and Children
HATC—Chad-China Friendship Hospital
PPA—Provincial Supply Pharmacy
CPA—Central Pharmaceutical Purchasing Office
PSLSH/IST—Sectoral Program to Combat AIDS, Viral Hepatitis and STIs
AMPS—Psycho-Medical Social Support
HMI—Military Training Hospital
CHU-RN—Nationally Recognized University Hospital Center
GASL—Supply Management, Stock and Laboratory Department