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# Evaluation of Immunological and Virological Parameters of HIV-1-Infected Pregnant Women on ARVs in Chad

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## Abstract

**Introduction:** AIDS is the fourth leading cause of death worldwide, so the majority of infected people are young adults, and young women are a particularly vulnerable group. In HIV-1-infected pregnant women, biological monitoring is essential for the management of HIV-1 infection and for the prevention of mother-to-child transmission. The aim of this study is to assess the biological parameters of HIV-1 pregnant women on ARVs in Chad. **Methodology:** We carried out a prospective descriptive cross-sectional study from June 2021 to January 2023 on 183 women undergoing antiretroviral treatment. Molecular techniques were used with a GENERIC HIV device for maternal viral load and a BD device for TCD4 lymphocytes. **Results:** 183 pregnant women on ARV e therapy were registered and monitored as normal. In this sample, the 20 - 30 age group of mothers was the most represented, with a frequency of 53.0%. In the city of Ndjamena, the TCD4 lymphocyte rate of 0 - 200 Cell/mm$^3$ was 20% at inclusion and 99.3% of the TCD4 lymphocyte rate > 500 Cell/mm$^3$ at M12. In Abéché at M0, 18.8% of mothers had a TCD4 lymphocyte count of 0 - 200/mm$^3$, and at the twelfth month of treatment, 94.3% of patients had a TCD4 lymphocyte count > 500/mm$^3$. A significant increase in CD4 count and a drop in viral load were observed. **Conclusion:** This study demonstrated the importance of antiretroviral treatment in assessing the biological parameters of pregnant women on ARVs, and in the early diagnosis of children born to HIV-1-positive mothers on antiretrovirals. Elimination of mother-to-child transmission of HIV is a possibility in Chad.

**Keywords**

HIV, Positive Mothers, ARVs, Chad

## 1. Introduction

The human immunodeficiency virus (HIV), responsible for acquired immunodeficiency syndrome (AIDS), is a global epidemic affecting almost all countries, both industrialized and developing [1]. HIV/AIDS infection is a major public health problem, constituting the fourth leading cause of death worldwide [2]. According to a United Nations report for 2023, some 39 million people are infected with HIV, including 37.5 million adults and 1.5 million children aged 0 - 14. Women and girls account for 53% of cases [3]. Sub-Saharan Africa is particularly hard hit, accounting for around two-thirds of global cases. In low-income countries, HIV prevalence remains high despite control efforts, with many new cases reported every year.

In Chad, the population is estimated at 16 million [4], of whom 120,000 are living with HIV. In 2014-2015, the national HIV prevalence rate was 1.6%, mainly affecting the 15 - 49 age group [5]. A 2020 survey revealed a regression in the prevalence rate, estimated at 1.2%.

Monitoring biological parameters in pregnant women on ARVs is crucial. These parameters are essential indicators of HIV replication and immune status, notably through CD4 counts [6]. Routine testing is essential for all HIV+ patients [7]. Despite the fact that ARVs and laboratory tests are free of charge in Chad, it remains to be determined whether proper biological monitoring of HIV-1-positive pregnant women can reduce mother-to-child transmission (MTCT). The aim of this study is to assess the biological parameters of pregnant women on antiretroviral therapy and to examine the diagnosis of newborns in Chad.

This research will provide a detailed assessment of biological parameters in pregnant women on ARVs and analyze the impact of these treatments on transmission of the virus from mother to child. Numerous studies have been carried out in developed and some African countries to assess the efficacy of antiretroviral multitherapies [8] [9]. However, there is a crying need for data specific to the Chadian context.

The general objective is to determine the virological parameters of HIV-1-infected pregnant women on ARVs in Chad.

## 2. Material and Method

### 2.1. Study Setting and Study Period

The study took place at the Centre Hospitalier Universitaire d'Abéché, Centre Hospitalier Universitaire de la Mère et de l'Enfant, Centre Polyvalent Alnadjma.

Our study lasted 18 months, from June 2021 to December 2022.

We conducted a prospective, descriptive, cross-sectional and analytical study of

pregnant women on ARVs.

### 2.2. Study Population

For this study, 183 HIV-1-positive pregnant women on ARVs were followed from pregnancy to delivery. All these women followed the PMTCT protocol and antenatal consultation (ANC).

### 2.3. Inclusion Criteria

HIV-1-positive mothers who had given their consent were included in this study.

### 2.4. Non-Inclusion Criteria

HIV-2 positive women and non-consenting women were not included in this study.

### 2.5. Ethical Considerations

We had obtained clearance from the French National Committee on Ethics in Human Health Research, giving approval to carry out the study. In addition, the research sites had given their own authorization for the study.

Finally, each participant gave informed consent to be included in the study. Confidentiality was ensured by coding the data collection forms.

### 2.6. Biological Material

The biological material used in this study was blood collected in an EDTA tube for quantitative PCR/RT.

### 2.7. Diagnostic Techniques for HIV Infection

Assessment of viral load in pregnant women on ARVs was carried out using the HIV-1 expert gene device and the biocentric system according to protocol.

The TCD4 lymphocyte count was then assessed using the BD presta device, according to the same protocol.

### 2.8. Statistical Analysis

Data were recorded on an Excel 2013 workbook and processed using SPSS Version 25.0 software.

## 3. Results and Discussion

### 3.1. Socio-Demographic Characteristics of HIV-1-Positive Pregnant Women on Antiretroviral Therapy

#### *Age distribution*

Analysis of the age distribution of HIV-1-positive mothers on ARVs reveals distinct trends between the cities of N'Djamena and Abéché.

In N'Djamena, the most represented age group is 15 - 25 years, with 61% (83/136) of women, and an average age of 24.2 ± 5.39 years (Table 1). In Abéché,

on the other hand, the average age of mothers is slightly higher, at 25.89 with a standard deviation of 5.93, with women aged 26 - 35 being the most represented (49.1%) (**Table 1**). These results are comparable to those obtained in other studies carried out in sub-Saharan Africa. For example, DAKE's study found that the age group [36 - 45] was in the majority, with 32.80% [10]. This confirms that HIV affects the most active population of which our age group is a part.

This predominance of young women can be explained by the fact that this age group corresponds to a period of maximum sexual activity, thus increasing the risk of transmission of sexually transmitted infections, including HIV.

***Educational level***

Our study revealed that the majority of HIV-1 positive mothers are in school, with 86.3% in N'Djamena and 82.5% in Abéché (**Table 1**). This high proportion of women attending school could be linked to greater awareness and knowledge of HIV/AIDS and the risks of mother-to-child transmission. Indeed, better-informed women are more likely to undergo screening and treatment during pregnancy. Education plays a crucial role in acceptance and adherence to PMTCT programs. A higher level of education is associated with a better understanding of the risks and benefits of treatment, leading to better compliance and more favorable outcomes, and facilitating communication and understanding of the care offered.

***Marital status and occupation of pregnant women***

In our two study sites, the majority of HIV-1 positive women were married: 69.1% in N'Djamena and 70.2% in Abéché. In addition, a significant proportion of these women were housewives: 60.3% in N'Djamena and 73.7% in Abéché (**Table 1**). These results are comparable with those of Diop in 2021, who reported that 90.3% of the pregnant women in her study were married and 52.8% were housewives [11]. In the African context, and more particularly in Chad, it is common for women of childbearing age to be married and to devote themselves to household tasks. Married women often benefit from the support of their spouse, which can facilitate access to healthcare services and improve compliance with treatment. Our results also show a variation from other studies. For example, these results are comparable to those of BAGAYOKO [12] and SAMAKE [13] who found a percentage of 59% and 67.8% respectively among married people. Samaké (2023) found that 93.3% of the women surveyed were married and 64.4% were housewives [13]. This difference may be attributed to socio-cultural variations between different regions of Africa.

In summary, our results show that HIV-1 positive women on ARV in the cities of N'Djamena and Abéché are predominantly young, educated, married and housewives. These socio-demographic characteristics influence their access to care and adherence to ARV treatment, which is crucial to the success of PMTCT programmes.

### 3.2. Assessment of TCD4+ Lymphocyte Levels in Pregnant Women on ARVs

This section concerns the distribution of TCD4+ lymphocyte levels in pregnant

women on ARV in Ndjamena (Table 2) and Abéché (Table 3).

Table 1. Breakdown of HIV-1 positive pregnant women by socio-demographic characteristics.

| Ndjamena | | | ABECHE | |
|---|---|---|---|---|
| **Age** | Frequency | Percentage (%) | Frequency | Percentage (%) |
| 15 - 25 years | 83 | 61.0 | 27 | 43.8 |
| 26 - 35 years | 47 | 34.6 | 28 | 49.1 |
| 36 - 45 years | 6 | 4.4 | 4 | 7.01 |
| Total | 136 | 100.0 | 57 | 100.0 |
| **Level of education** | | | | |
| Out of school | 20 | 14.7 | 10 | 17.5 |
| Primary | 49 | 33.1 | 28 | 49.1 |
| Secondary | 45 | 36.0 | 10 | 17.5 |
| Higher | 22 | 16.2 | 9 | 15.7 |
| Total | 136 | 100.0 | 57 | 100.0 |
| **Marital status** | | | | |
| Single | 25 | 18.4 | 6 | 10.5 |
| Divorced | 12 | 8.8 | 9 | 15.8 |
| Married | 94 | 69.1 | 40 | 70.2 |
| Widowed | 5 | 3.7 | 2 | 3.5 |
| Total | 136 | 100.0 | 57 | 100.0 |
| **Function** | | | | |
| Retailer | 24 | 15.4 | 7 | 14.0 |
| Student | 7 | 5.1 | 0 | 0 |
| Student | 2 | 1.5 | 0 | 0 |
| Civil servant | 21 | 17.6 | 8 | 12.3 |
| Housewife | 82 | 60.3 | 42 | 73.7 |
| Total | 136 | 100.0 | 57 | 100.0 |

### *City of N'Djamena*

At inclusion (M0), the mean CD4 cell count in pregnant women on ARV treatment in N'Djamena was 292.4 ± 19.97 cells/mm$^3$ with 20% CD4 counts of 0 - 200 cells/mm$^3$. This count increased significantly, reaching 699.7 ± 31.72 cells/mm$^3$ at M6, and 956.12 ± 98.928 cells/mm$^3$ at M12 (Table 2). This progressive and significant increase ($p < 0.0001$) demonstrates significant immune restoration under ARV treatment. At M12, the vast majority of women (99.3%) had a TCD4 lymphocyte count greater than 500/mm$^3$, indicating a good immune response and a reduced risk of disease progression.

### *City of Abéché*

In Abéché, the trend was similar. At M0, 18.8% of women had a CD4 count of less than 200 cells/mm$^3$. However, by the sixth month of treatment, 84.9% of patients had a CD4 count above 500 cells/mm$^3$, reaching 84.9% at M9 and 960.26 ± 130.030 cells/mm$^3$ at M12, *i.e.* 94.3% CD4 count above 500 cells/mm$^3$. Comparison of CD4 counts at baseline and at M12 also showed a significant difference ($P < 0.0001$), indicating an improvement in the immune status of women on ARV (Table 3).

Both our results are superior to those of Saka *et al.* (2018) in Togo, who observed less marked increases in TCD4 lymphocyte levels in pregnant women on ARVs (Sangaré, 2007) [14]. This difference could be attributed to variations in treatment protocols, patient adherence to treatment, and the quality of care available. The significant increase in TCD4 lymphocytes observed in our study indicates an effective immune response to ARV treatment, reducing the risk of opportunistic infections and improving the quality of life of HIV-positive pregnant women. These results underline the importance of regular monitoring of TCD4 levels to adjust treatment if necessary and ensure optimal outcomes for both mother and child.

Our results show a significant increase in TCD4 lymphocyte levels in pregnant women on ARV in the cities of N'Djamena and Abéché, confirming the efficacy of the treatment.

Table 2. Profile of changes in TCD4+ lymphocyte levels in pregnant women on ARVs in Ndjamena.

| CD4 | Frequency (N) | Percentages (%) |
|---|---|---|
| | **CD4M0** | |
| 0 - 200 | 26 | **20** |
| 201 - 500 | 60 | 46.2 |
| >500 | 44 | 33.8 |
| Total | 132 | 100 |
| | **CD4M3** | |
| 0 - 200 | 3 | 2.3 |
| 201 - 500 | 68 | 51.5 |
| >500 | 61 | 46.2 |
| Total | 132 | 100 |
| | **CD4M6** | |
| 0 - 200 | 0 | 0 |
| 201 - 500 | 27 | **20.5** |
| >500 | 103 | 79.5 |
| Total | 132 | 100 |

**Continued**

| | | |
|---|---|---|
| **CD4M9** | | |
| 0 - 200 | 0 | 0 |
| 201 - 500 | 4 | **3** |
| >500 | 128 | 97 |
| Total | 132 | 100 |
| **CD4M12** | | |
| 0 - 200 | 0 | 0 |
| 201 - 500 | 1 | 0.70 |
| >500 | 131 | 99.3 |
| Total | 132 | 100 |

Table 3. Profile of changes in TCD4+ lymphocyte levels in M0 - M12 patients in the town of Abéché.

| CD4 | Frequency (N) | Percentage (%) |
|---|---|---|
| **CD4 M0** | | |
| 0 - 200 | 10 | 18.8 |
| 201 - 500 | 32 | 60.5 |
| >500 | 11 | 20.7 |
| Total | 53 | 100.0 |
| **CD4 M3** | | |
| 0 - 200 | **7** | 13.2 |
| 201 - 500 | 15 | 28.3 |
| >500 | 31 | 58.5 |
| Total | 53 | 100.0 |
| **CD4 M6** | | |
| 0 - 200 | 0 | 0 |
| 201 - 500 | 17 | 32.07 |
| >500 | 36 | 67.93 |
| Total | 53 | 100.0 |
| **CD4 M9** | | |
| 0 - 200 | 0 | 0 |
| 201 - 500 | **7** | 13.20 |
| >500 | **45** | 84.9 |
| Total | 57 | 100.0 |
| **CD4 M12** | | |
| 0 - 200 | 0 | 0 |
| 201 - 500 | 3 | 5.7 |
| >500 | 50 | 94.3 |
| Total | 53 | 100.0 |

### 3.3. Trends in Plasma Viral Load Levels

Plasma viral load is a key indicator of the efficacy of antiretroviral treatment and the risk of mother-to-child transmission of HIV. Effective antiretroviral treatment should reduce the viral load to undetectable levels, thereby minimising the risk of transmission of the virus.

*City of N'Djamena*

At the start of treatment (M0), 68.5% of patients had a viral load greater than 1000 copies/ml. Over the course of the study, this proportion decreased significantly. At M3, 16.9% of patients had an undetectable viral load, rising to 33.86% at M6, 91.2% at M9, and 90.8% at M12. Our result is better than that obtained by DAKE, which obtained 82.05% of patients with a CD4 count >500 cells/mm 35 [10].

However, patients gained an average of 303.43 cells/mm$^3$, which is in line with our results. The mean viral load fell from 17332.82 ± 72899.105 copies/ml at M0 to 68.73 ± 167.245 copies/ml at M12.

*City of Abéché*

In Abéché, 94.3% of patients initially had a viral load greater than 1000 copies/ml, with a mean of 4064.75 ± 9394.078 copies/ml. At M9, the mean was 875.51 ± 192.932 copies/ml, with 75.5% of patients having an undetectable viral load. At M12, the mean was 2423.79 ± 9980.594 copies/ml, with 92.8% of patients having an undetectable viral load.

Our results show improved viral suppression compared with Diallo *et al.* (2016) in Guinea, where 36.6% of mothers followed up had an undetectable viral load [15].

DAKE found an undetectable viral load in 92.31% of patients started on TLD after six months of treatment [10]. This increased efficacy can be attributed to improved adherence to treatment, rigorous care management and increased support for PMTCT programmes in Chad. The results of our study show that antiretroviral therapy is effective in improving the immune profile of HIV-positive pregnant women and reducing the plasma viral load to undetectable levels. These improvements reduce the risk of mother-to-child transmission of HIV (**Table 4**, **Table 5**).

**Table 4.** Trends in plasma viral load in pregnant women on ARVs in N'Djamena.

| CV | Frequency (N) | Percentage (%) |
|---|---|---|
| | **CVM0** | |
| <40 | **0** | 0 |
| 41 - 1000 | 41 | 31.5 |
| >1000 | 89 | 68.5 |
| Total | 130 | 100.0 |
| | **CVM3** | |
| <40 | 22 | 16.9 |
| 41 - 1000 | **48** | 36.9 |

Continued

| | | |
|---|---|---|
| >1000 | 60 | 46.2 |
| Total | 130 | 100.0 |
| **CVM6** | | |
| <40 | 44 | 33.86 |
| 41 - 1000 | 56 | 43.07 |
| >1000 | 30 | 23.07 |
| Total | 130 | 100.0 |
| **CVM9** | | |
| <40 | 118 | 90.8 |
| 41 - 1000 | 7 | 5.4 |
| >1000 | 5 | 3.8 |
| Total | 130 | 100.0 |
| **CVM12** | | |
| <40 | 127 | 97.8 |
| 41 - 1000 | **2** | 1.5 |
| >1000 | 1 | 0.7 |
| Total | 130 | 100.0 |

### 3.4. Evolution of the Plasma Viral Load Rate during Our Study Period

Table 5. Distribution of viral load in Abéché.

| CV | Frequency (N) | Percentage (%) |
|---|---|---|
| **CV0** | | |
| <40 | 0 | 0 |
| 41 - 1000 | **3** | 5.7 |
| >1000 | 50 | 94.3 |
| Total | 53 | 100.0 |
| **CV3** | | |
| <40 | 12 | 22.7 |
| 41 - 1000 | **3** | 5.7 |
| >1000 | 38 | 71.6 |
| Total | 53 | 100.0 |
| **CV6** | | |
| <40 | 25 | 46.9 |
| 41 - 1000 | 3 | 5.8 |
| >1000 | 25 | 47.3 |
| Total | 53 | 100.0 |

**Continued**

| | | |
|---|---|---|
| **CV9** | | |
| <40 | 40 | 75.5 |
| 41 - 1000 | 2 | 3.8 |
| >1000 | 11 | 20.7 |
| Total | 53 | 100.0 |
| **CV12** | | |
| <40 | 46 | 86.8 |
| 41 - 1000 | 1 | 1.9 |
| >1000 | **6** | 11.3 |
| Total | 53 | 100.0 |

### *City of Abéché*

In Abéché, 94.3% of patients initially had a viral load greater than 1000 copies/ml, with a mean of 4064.75 ± 9394.078 copies/ml. At M9, the mean was 875.51 ± 192.932 copies/ml, with 75.5% of patients having an undetectable viral load. At M12, the mean was 2423.79 ± 9980.594 copies/ml, with 92.8% of patients having an undetectable viral load.

Our results show improved viral suppression compared with Diallo *et al.* (2016) in Guinea, where 36.6% of mothers followed up had an undetectable viral load [15]. This increased efficacy can be attributed to better adherence to treatment, rigorous care management and strengthened support for PMTCT programmes in Chad.

The significant reduction in plasma viral load observed in our study testifies to the efficacy of antiretroviral therapy in reducing mother-to-child transmission of HIV. This sustained reduction in viral load is essential to prevent transmission of the virus to the newborn and to improve the health prospects of HIV-positive mothers. The efforts of the Chadian government, notably through awareness campaigns, the increase in PMTCT sites and the provision of free ARVs, have played a crucial role in improving the results of our study.

The results of our study show that antiretroviral therapy is effective in improving the immune profile of HIV-positive pregnant women and in reducing the plasma viral load to undetectable levels. These improvements reduce the risk of mother-to-child transmission of HIV. PMTCT strategies must continue to be strengthened and adapted to maintain these positive results and achieve the ultimate goal of zero vertical transmission of HIV.

## 4. Conclusions

We have carried out a prospective, descriptive and analytical study in the two cities of Chad: Abéché and Ndjamena:

Biological monitoring of pregnant women infected with HIV-1 has made considerable progress in Chad recently with the widespread availability of free an-

tiretroviral drugs.

In the city of Ndjamena, at inclusion (M0): 68.5% had a viral load greater than 1000 copies/, M12: 97.8% had an undetectable viral load.

In Abéché, at the start of treatment 94.3% of patients had a viremia greater than 100 copies/ml. At M12, 86.9% had an undetectable viral load.

Properly administered first-line antiretroviral treatment can control HIV replication by achieving an undetectable plasma CV in less than 6 months.

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## Conflicts of Interest

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

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