Journal of Molecular Biomarkers & Diagnosis

Faye et al., J Mol Biomark Diagn 2019, 10:3

Research Article Open Access

Molecular Evaluation of HIV-1 Mother to Child Transmission in Senegal

Babacar Faye[1,2,3*], Seynabou Mangane[1], Rémi Charlebois[4], Aissatou Ngom-Fall[5], Salimata Gueye Diouf[1], Mouhamadou Moustapha Diagne[1], Mbacké Sembène[6] and Alioune Dièye[3]

[1]*Laboratory of Molecular Biology, Military Hospital of Ouakam (HMO), Dakar-Senegal*

[2]*AIDS Program of the Senegalese Armed Forces, Senegal*

[3]*Department of Pharmacy, Faculty of Medicine, Service of Immunology, Pharmacy and Odonto- Stomatology of Cheikh Anta Diop University of Dakar, Senegal*

[4]*Global Scientific Solutions for Health (GSSHealth), Baltimore, MD, USA*

[5]*Pediatric Service, Military Hospital of Ouakam (HMO), Dakar-Senegal*

[6]*Department of Animal Biology, Faculties of Science and Technology, Genetics Team of Population Management, Cheikh Anta Diop University of Dakar, Senegal*

[*]**Corresponding author:** Dr. Babacar Faye, Laboratory of Molecular Biology, Military Hospital of Ouakam (HMO), Dakar-Senegal, Tel: +221776341070/+221 338601989; E-mail: bab_faye@yahoo.fr

Received Date: June 11, 2019; **Accepted Date:** July 08, 2019; **Published Date:** July 16, 2019

Abstract

Context: Early detection and treatment of children infected by HIV positive mothers remain a health priority to limit the spread of the HIV/AIDS epidemic and related morbidity and mortality. In 2017 in Senegal, only 23% of children born to mothers infected with HIV-1 benefited from early infant diagnosis. This is reflected by similar numbers in the sub-Saharan region. The dissemination of early infant diagnosis is needed to assess the effectiveness of HIV-1 mother-to-child transmission (MTCT) prevention programs in resource-limited settings.

Objective: The objective of our study is to evaluate the rate of HIV-1 mother-to-child transmission in Senegal among children under 15 months of age born to HIV-1-positive mothers and identify risk factors.

Material and method: This study carried out between September 2016 and May 2018, including 393 children born to HIV+ mothers from different health facilities throughout the country. The sample used is dried blood spot (DBS). Early infant diagnosis (EID) was done by PCR on Cobas®AmpliPrep/Cobas®TaqMan®HIV-1 Qualitative V. 2.0. The data was analyzed with R Studio.

Results: Of the 393 children born to HIV-positive mothers, 28 are PCR-positive showing an HIV-1 MTCT rate of 7.1%. There was no significant association between the rate of MTCT and the following sociodemographic characteristics: sex, children prophylaxis, and geographic area of infancy ($p>0.05$). The MTCT of HIV-1 was significantly associated with maternal prophylaxis, ethnicity, and type of breastfeeding ($p <0.05$).

Conclusion: Transmission rate is higher than those described in the previous national surveys of 2010, 2014 and 2016 that were respectively 4.2%; 3.1% and 3.3%.

Keywords: Mother to child transmission; Senegal; HIV-1; Early infant diagnosis; PCR

Introduction

According to the 2018 UNAIDS report, 36.9 million people were living with HIV worldwide in 2017, including 34.8 million adults (17.8 million women) with 2.1 million under 15 years of age [1]. Sub-Saharan Africa is the region of the world most affected by this epidemic with 70% of the global burden (25.7 million people living with HIV) where 58% are women [2]. Of the 10 million HIV- infected young people aged 15-24 in the world, 6 million live in sub-Saharan Africa and three-quarters of them are female [1].

Although the prevalence is rather low in Senegal (0.7%) in the general population, there is an important feminization of the epidemic marked by a ratio F/M of 1.6 [3].

Feminization of HIV/AIDS prevalence combined with an important proportion of women in childbearing age increases the risk of mother-to-child transmission. In the absence appropriate care, mother-to-child transmission can happen during pregnancy by passing the virus through the placenta, during childbirth, or when breastfeeding [4,5]. The rate of transmission varies from 15 to 45% in the absence of care for the mother living with HIV.

In Senegal, the mother-to-child transmission rate (MTCT) went from 7.2% in 2008 to 3.6% in 2017 [3]. The risk of MTCT increases by at least 10 to 15%, depending on the immuno-virological status of the mother and the duration of breastfeeding [6,7]. Transmission increases by two-fold in cases of HIV-related clinical symptoms, CD4 <200/ mm^3, or plasma viral load (VL) >10,000 copies/ml [8].

Placental factors, (bacterial or parasitic chorioamnionitis, immune changes) and obstetric factors (premature rupture of membranes, premature delivery, genital infection, sexually transmitted infections, vaginal delivery) increase the risk of this transmission [9,10]. MTCT can be prevented almost completely by administering antiretrovirals to both mother and child as early as possible during pregnancy and during breastfeeding [11]. A number of antiretroviral drugs,

zidovudine and lamivudine or nevirapine, or combination antiretroviral therapy (ART) has reduced mother-to-child transmission of HIV [12]. In 2016, 55% of HIV-positive women were under antiretroviral therapy in Senegal [13].

Mothers whose HIV status is known (and when the child is not contaminated or is unaware of its HIV status) should feed their child exclusively to the breast for the first six months of life, after introducing supplement fit, and continue to breastfeed for the first 12 months of life [14].

In children born to HIV-positive mothers, the diagnosis of HIV infection is difficult given the presence of maternal antibodies (IgG) up to the age of 18 months preventing any serologic diagnosis due to the higher likelihood of false positive results [15]. After contamination, the virus RNA is detectable from the 10-12th day and the p24 antigen around the 12-14th day [16] allowing molecular diagnosis with these targets for children 18 months of age.

Therefore, the diagnosis of HIV infection in children can only be established by molecular tests such as those detecting the presence of viral RNA, proviral DNA or the direct serological test detecting p24 [17].

HIV DNA PCR can be performed on whole blood samples dried on a filter paper such as Dried Blood Spot (DBS) without significant loss of sensitivity or specificity [18]. This technique detects infected lymphocytes no-matter the state of the virus (in replication, latent, or defective).

In Senegal, screening of children born to HIV-positive mothers is a directive of the National Program for the prevention of MTCT of HIV. It is done on DBS collected from children born to HIV+ mothers aged 1 to 18 months. This can be achieved using a method such as COBAS® AmpliPrep/COBAS®TaqMan® HIV-1 Qualitative Test v2.0 (Roche®Diagnostics GmbH, SandhoferStrabe Mannheim, Germany). With this technique the nucleic acid amplification targets two regions of the HIV-1 genome, gag and LTRs these regions are known to be affected by mutation likely to happen with misuse of ARVs, hence providing reliable results even in case of mutations of one of the two regions. In 2017, only 23% of children born to HIV-positive mothers received this test in Senegal [19]. Periodic evaluation of the transmission rate is essential for evaluating mother-to-child transmission prevention programs.

Thus, the main objective of this study is to evaluate the rate of mother-to-child transmission of HIV in Senegal. The specific objective of this study is to identify risk factors for vertical transmission of HIV.

Material and Method

This study was conducted at the molecular biology laboratory of the AIDS program of the Senegalese armed forces located at Ouakam Military Hospital (HMO). Samples used in this study have been received by the lab between September 2016 and May 2018.

Study population

This retrospective study looked at a sample of 393 children under 15 months of age born to HIV-1 positive mothers. These children were tested to assess their HIV status and initiate ARV treatment as needed in agreement with the National Program for Prevention of MTCT of HIV. Consent was not required for these patients as testing were done as part of standard EID.

Samples

Samples consisted of whole blood collected in BD K2E (EDTA) tubes 7.2 mg (ref 368861, Becton Dickinson, NJ, USA) or directly on DBS (ref 8.460.0013.A Rev.0, Ahlstrom Germany GmbH Niederschalg 109471 Bärenstein, Germany), from 55 hospitals and health facilities in all regions of Senegal. Samples were taken from the heel of newborns on the lateral or medial side of the foot. After sanitizing the site, an incision is made using a lancet. The first drop of blood is removed with cotton and pressure is applied to form a large drop of blood, which is deposited on the circle of the blotting paper. If the blood was collected in EDTA tubes, 250 µL of blood was put on the blotting paper using a pipette. The cards were allowed to dry at room temperature, sheltered from the sun on a rack for at least 3 hours or overnight. Samples were stored in plastic bags with a desiccant prior to shipping.

Molecular diagnostic method

COBAS® AmpliPrep/COBAS®TaqMan® HIV-1 Qualitative Test v2.0 is a qualitative nucleic acid amplification test that detects HIV-1 RNA and proviral HIV-1 DNA in plasma, whole blood, and DBS.

Pre-extraction treatment

A 12 mm spot is cut out with a puncher for each DBS sample and placed in an S tube, then 1,200 µl of SPEX (Specimen Pre-Extraction Reagent) (Roche Diagnostics GmbH, Mannheim, Germany) is added in each tube. A negative and positive controls are run simultaneously. Samples and controls are incubated in a thermomixer (Thermo-Shaker, TS-100C, Biosan, Germany) at 56°C for 10 minutes before being processed in the extraction automaton.

DNA extraction, DNA amplification, Real-time detection

Extraction is done with COBAS®AmpliPrep and amplification and detection by COBAS®TaqMan® 96 with Roche COBAS®AmpliPrep/COBAS®TaqMan® HIV-1 Qualitative Test Reagent, v2.0 (Roche Diagnostics GmbH, Mannheim, Germany). Samples and controls are tested for HIV-1 nucleic acid in the Roche CAP/CTM according to the manufacturer's protocol. The extracted samples are immediately transferred to the CAP/CTM analyzer, which is a closed system automaton combining extraction, real-time PCR and detection, reducing contamination. The analyzer automatically validates the manipulation and determines the presence or absence of HIV-1 nucleic acids according to a threshold cycle value (Ct value), which is the PCR cycle from which the detected signal indicates the presence of the amplicons.

Statistical analysis

In order to evaluate correlation of MTCT with biological, clinical and demographic all data were entered on Excel 2010 and then analyzed with the R Studio software version 099.902 of 2016 for windows as well as on XLSTAT 2018 version 1. Pearson's chi-squared test was used to analyze data, the statistical significance threshold was set at $p < 0.05$.

Results

A total of 393 children under 15 months of age born to HIV-1 positive mothers were tested for HIV. The median age was 3 months with a range of 1 to 15 months.

Overall rate of MTCT

Out of a total of 393 children, 28 were found to be HIV-1 positive, representing an overall rate of 7.1%. The MTCT rate was 8.1% and 6.1% for male and female children respectively (Table 1; p=0.45) indicating no relation between sex of the infant and MTCT.

Parameter	Total	Positives	Rate in %	IC 95%	P-values
Population	393	28	7.1	4.5-9.6	
Sex					
Male	196	16	8.1	5.4-10.8	
Female	197	12	6.1	3.7-8.5	0.45
Feeding method					
PBF	276	10	3.62	1.8-5.5	
BF	53	8	15.09	11.6-18.6	
MF	9	2	22.22	18.1-26.3	
FF	20	2	10	7-13	
Unspecified	35	6	17.14	13.4-20.9	0.049
Child prophylaxis					
Antiretrovirals	277	10	3.61	1.8-5.5	
No treatment	62	11	17.74	14-21.5	
Unspecified	54	7	13	9.8-16.3	0.62
Mother treatment					
Antiretrovirals	340	17	5	2.9-7.1	
No treatment	19	5	26.3	21.9-30.6	
Unspecified	34	6	17.64	13.9-21.4	0.008
PBF: Protected Breastfed; BF: Breastfed; MF: Mix-fed; FF: Formula Fed					

Table 1: HIV-1 MTCT rate by sex, breastfeeding pattern, prophylaxis of the child and treatment of the mother.

MTCT rate according to the feeding method

Children who were under protected breastfeeding, that is, breastfeeding on ARVs had the lowest rate of MTCT at 3.62%, those who were under breastfeeding without ARV treatment had an MTCT of 15.09%. Breastfeeding combined with formula feeding had the highest rate of MTCT at 22.22%, and formula feeding rates were of 10%, (Table 1; p=0.049). Feeding method showed statistical significance in the rates of MTCT.

MTCT rate according to ARV treatment of child and mother

The MTCT was 3.61% and 17.74% for children who benefited and did not benefited prophylaxis respectively (Table 1; p=0. 62).

Similarly, children whose mothers were on ARV treatment had the lowest transmission rate, 5% compared to those whose mothers had no treatment, 26.3% (Table 1; p=0.008), showing a strong statistical significance.

HIV-1 MTCT rate according to ethnicity

The analysis of MTCT according to the ethnic groups made it possible to note a prevalence of rates of 8.48% MTCT among Peulhs, 8% in Mandingues, 5.88% in Sereres and 1.69% in Wolofs. The other ethnic groups combined MTCT equal to 9.8% (Table 2; p=0.00016).

Parameter	Total	Positives	Rate in %	IC 95%	P-values
Ethnic group					
Peulhs	165	14	8.48	5.7-11.2	
Serer	68	4	5.88	3.5-8.2	
Wolofs	59	1	1.69	0.4-3	
Mandingues	50	4	8	5.3-10.7	
Autres	51	5	9.8	6.9-12.7	0.00016
Regions					
Dakar	137	7	5.1	2.9-7.3	
Sine-Saloum	32	4	12.5	9.2-15.8	
Kaffrine	43	2	4.6	2.5-6.7	
Haute casamance	40	3	7.5	4.9-10.1	
Matam	37	5	13.5	10-16.9	
Saint-Louis	45	3	6.6	4.1-9.1	
Tambacounda	40	4	10	7-13	0.67
Year					
2016	108	8	7.4	5-10.2	
2017	211	19	9	6.2-11.8	
2018	74	1	1.3	0.2-2.4	0.0001
Sine-Saloum: Fatick -Kaolack; Haute Casamance: Kolda- Sédhiou					

Table 2: HIV-1 mother-to-child transmission rate by ethnicity, region and year.

MTCT rate according to the administrative region

The Matam region had the highest rate of MTCT with 13.5% followed by that of Sine-Saloum (Fatick and Kaolack) at 12.5% and Tambacounda, 10%. For the other regions our results showed HIV-1 MTCTs of 7.5%, 6.6%, 5.1% and 4.6% respectively for the regions of Kolda and Sedhiou, Saint- Louis, Dakar and Kaffrine (Table 2; p=0.67). Showing no statistical significance.

MTCT rates per year

We assessed the rate of HIV-1 transmission over three years. Our results showed rates of 7.4%, 9% and 1.3% for the years 2016, 2017 and 2018 respectively (Table 2). Showing a peak in 2017 and a statistically significant reduction in 2018 (p=0.0001).

Discussion

Our objective was to evaluate the rate of MTCT of HIV-1 in Senegal using DBS samples of children born to HIV-positive mothers from across the country with an analysis of risk factors. Our study used a data set of 393 DBS from children born to HIV-1 positive mothers between 2016 and 2018. Of the 393 children tested 28 were positive showing a rate of MTCT of 7.1%. Our result is similar to the 7% MTCT rate described in Bangui, Central African Republic [20], but lower than the 12.7% rate previously described in Lubumbashi, DRC [21]. The MTCT rate of HIV-1 was 8.1% in male children and 7.1% in female children (P=0.45), showing no link between the transmission rate and the sex of the children. While a study in Ethiopia, found a higher rate of MTCT for girls (17.6%) compared to boys (13.8%) in a similar cohort to ours, their results were not statistically significant [22].

We also assessed the rates of MTCT according to the ethnic group of the child. The rate of MTCT, except for the other ethnic groups that had an MTCT rate of 9.8%, is higher among Pulhars 8.48%, followed by Mandingues at 8% (p=0.0016). Our results show that there is a significant difference in MTCT by ethnicity in Senegal. The regional difference in HIV prevalence and inter-ethnic mobility and some socio-cultural factors (reluctances to seek medical care) may explain this variability in rates of MTCT. These two ethnic groups are considered nomadic and are migrating within areas most affected by HIV, this represents a favoring factor for MTCT [23].

Evaluation of the MTCT rate by type of breastfeeding showed lower transmission in children under exclusive breastfeeding with a mother under ARV (EB-ARV) at 3.62% compared to those under exclusive breastfeeding with mothers not under ARV (EB) at 15.09% and under mixed breastfeeding (MB) at 22.22%. This can be explained by the fact that HIV transmission may occur during breastfeeding; hence an EB-ARV decreases the risk of unprotected breastfeeding such as EB. The high rate in children on MB can be explained by the hypothesis of the fragility of the intestinal wall of the infant during the first six months of life. Foods that are given in parallel with breast milk (providing maximum protection of the child's mucous membranes by its antibodies) can damage this wall and thus further promote the transmission of the virus [24]. Another study conducted in South Africa measured a significantly lower rate of MTCT in exclusively breastfed children 14.6%, compared to children under mixed feeding 24.1% [6]. Worldwide progress noted between 1999 and 2018 in the prevention of mother-to-child transmission (PMTCT) may explain this difference. In our study, the rate of MTCT for children under formula feeding was 10%. Note that although decreasing the risk of MTCT, formula feeding alone cannot guarantee the risk of zero infection because transmission can be done upstream during delivery and/or during pregnancy. Some studies have shown that, very often, mothers who are strictly breastfeeding nonetheless give their children breastfeeds for various cultural or social reasons, perceptions that value breastfeeding are very much rooted in African cultures [25]. Our results indicate a link between feeding method and MTCT of HIV-1 (p=0.049).

Depending on the ARV treatment received or not by the child (prophylaxis), our results showed MTCT rates of 3.61% and 17.74% (p=0.62) for children undergoing treatment and those not receiving treatment respectively. Rates of 5% and 26.3% (p=0.008) were found in children whose mothers were on treatment and those whose mothers were not on treatment. These results clearly show the benefit of treatment in the reduction of MTCT but are based mainly on the perinatal administration of antiretrovirals both in the mother and in the newborn [14,26,27]. Most common treatment was AZT+3TC+EFV or TDF+3TC+EFV or AZT+3TC+NVP (data not shown).

In Metropolitan France, the MTCT rate of HIV-1 decreased from 15-20% to 0.54% over the period 2005-2011 [28,29]. These results, mainly due to testing programs and ARV administration, confirm the importance of ARV treatment in reducing the rate of MTCT.

The geographical location in Senegal did not show an influence on the MTCT of HIV-1. Our results showed a higher rate in the North of Senegal, which is a more affected region, but this difference was not significant (p=0.67). Men from northern Senegal migrate to the country's major urban centers [30] or go abroad looking for work, particularly in France, Ivory Coast and the Central African countries [31]. Migrant workers traveling to other African countries face greater risk of HIV infection than less mobile Senegalese [32]. According to another study, conducted in eleven villages around Matam, 27% of male migrant workers, who were foreigners, were HIV / AIDS-infected, compared to one percent of non-migrant men [23]. This study also found that 20 of the 22 HIV-positive women in one of the groups surveyed had contracted AIDS from their spouses, migrant workers. Once infected women are at risk to pass it on to their children this could explain the high rate of MTCT observed in the Matam area (13.5%). Infected people unaware of their status can contaminate their regular partners when they return, which increases the rate of transmission in the locality. This situation could explain the higher MTCT rate (10%) seen in Tambacounda region which has gold mines attracting workers from other regions. Higher rate of MTCT have also been observed in the region of Fatick/Kaolack (12.5%) which are at the center of the country and are crossroads cities. The Kaffrine area, despite being in the center, is a new region and has a small population, which may explain its lower MTCT rate (4.6%). The regions of Kolda/Sédhiou (7.5%) and Saint Louis (6.6%) are border regions which has an impact on the rate of MTCT due to the interactions between their populations and those of neighboring countries. The capital region of Dakar, although it receives a lot of foreigners and also has a very high population density, has a lot of hospitals and access to healthcare and treatment is much easier, which may explain why despite its size of children born to HIV-positive mothers (137) only 7 were positive, i.e. a rate of MTCT of 5.1%.

Pregnancy monitoring is an opportunity to prevent anemia, neonatal tetanus, malaria, HIV transmission and hepatitis from mother to child and to prepare the mother for breastfeeding. In the remote areas, the technical platform of the health structures does not allow full care of pregnant women, to make early detection of HIV or even make them follow a normal treatment [33]. For cultural, economic or accessibility reasons, some women give birth at home. In the case of an HIV- positive mother, the risk of transmitting HIV to her child increases as she does not or rarely benefit from prenatal consultation, serologic screening and all PMTCT interventions, administration of tri-therapy at the beginning of work, the antiseptic cleaning of the genital [20].

The evolution of the rate of MTCT increased from 7.4% to 9.0% between 2016 and 2017 and a fell to 1.3% in 2018. The Senegalese national HIV report of 2016 indicated an MTCT rate of 2.6% for 620 children screened, for the year 2017 a MTCT of 2.6% was shown with a sample of 1,174 children screened [34]. These rates of MTCT do not include our cohort and analysis was not done in regard to feeding method and ethic group. Combination of both database and

longitudinal analysis would be necessary to monitor risk factors in Senegal to improve public health intervention.

Conclusion

Our results showed a relatively high mother-to-child transmission rate of HIV-1 in Senegal. This transmission is influenced by the child's breastfeeding method, ARV treatment of the HIV+mother and socio-cultural factors of the ethnic groups. The sex, the prophylaxis of the child, the administrative region of the child's belonging did not show a relation to MTCT according to our study. The implementation of prevention policies has led to a favorable evolution of mother-to-child transmission between 2016 and 2018.

Acknowledgement

We would like to extend our acknowledgement to the US Department of Defense HIV/AIDS Prevention Program (DHAPP) and Africare for their precious collaboration to the AIDS Program of the Senegalese Armed Forces.

References

1. Unaids J (2017) Fact sheet—latest global and regional statistics on the status of the AIDS epidemic. Geneva: UNAIDS.
2. https://www.who.int/news-room/fact-sheets/detail/hiv-aids
3. https://www.cnls-senegal.org/wp-content/uploads/2001/01/Rapport-CNLS-2017.pdf
4. Rouzioux C, Costagliola D, Burgard M, Blanche S, Mayaux MJ, et al. (1993) Timing of mother-to-child HIV-1 transmission depends on maternal status. The HIV Infection in Newborns French Collaborative Study Group. AIDS (London, England) 7: S49-S52.
5. Kourtis AP, Bulterys M (2010) Mother-to-child transmission of HIV: pathogenesis, mechanisms and pathways. Clin Perinatol 37: 721-737.
6. Coutsoudis A, Pillay K, Spooner E, Kuhn L, Coovadia HM, et al. (1999) Influence of infant-feeding patterns on early mother-to-child transmission of HIV-1 in Durban, South Africa: a prospective cohort study. Lancet 354: 471-476.
7. Charurat M, Datong P, Matawal B, Ajene A, Blattner W, et al. (2009) Timing and determinants of mother - to - child transmission of HIV in Nigeria. Int J Gynaecol Obstet 106: 8-13.
8. Mandelbrot L, Berrébi A, Matheron S, Blanche S, Tubiana R, et al. (2014) Infection par le VIH et grossesse: nouvelles recommandations 2013 du groupe d'experts français. J Gynecol Obstet Biol Reprod 43: 534-548.
9. Gumbo FZ, Duri K, Kandawasvika GQ, Kurewa NE, Mapingure MP, et al. (2010) Risk factors of HIV vertical transmission in a cohort of women under a PMTCT program at three peri-urban clinics in a resource-poor setting. J Perinatol 30: 717.
10. International Perinatal HIV Group (1999) The mode of delivery and the risk of vertical transmission of human immunodeficiency virus type 1—a meta-analysis of 15 prospective cohort studies. N Engl J Med 340: 977-987.
11. https://www.who.int/hiv/PMTCT_update.pdf
12. Newell ML, Dunn DT, Peckham CS, Semprini AE, Pardi G (1996) Vertical transmission of HIV-1: maternal immune status and obstetric factors. The European Collaborative Study. AIDS (London, England) 10: 1675-1681.
13. https://www.cnls-senegal.org/wp-content/uploads/2018/07/PSN-2018-2022.pdf
14. Becquet R, Ekouevi DK, Arrive E, Stringer JS, Meda N, et al. (2009) Universal antiretroviral therapy for pregnant and breast-feeding HIV-1-infected women: towards the elimination of mother-to-child transmission of HIV-1 in resource-limited settings. Clinical infectious diseases 49: 1936-1945.
15. Read JS (2007) Diagnosis of HIV-1 infection in children younger than 18 months in the United States. Pediatrics 120: e1547-e1562.
16. https://devsante.org/articles/diagnostic-serologique-des-infections-a-vih
17. Coutlee F (1994) Molecular diagnosis of HIV-1 infection: potential roles and applications. L'union medicale du Canada 123: 348-358.
18. Govender K, Parboosing R, Siyaca N, Moodley P (2016) Dried blood spot specimen quality and validation of a new pre-analytical processing method for qualitative HIV-1 PCR, KwaZulu-Natal, South Africa. Afr J Lab Med 5: 1-6.
19. https://www.unaids.org/en/regionscountries/countries/senegal
20. Diemer SC, Ngbale RN, Longo JD, Dienhot OB, Gaunefet CE (2017) Les facteurs de risque de transmission du VIH de la mère à l'enfant à Bangui. Médecine et Santé Tropicales 27: 195-199.
21. Ngwej DT, Mukuku O, Mudekereza R, Karaj E, Odimba EB, et al. (2015) Study of risk factors for HIV transmission from mother to child in the strategy «option A» in Lubumbashi, Democratic Republic of Congo. Pan Afr Med J 22: 18.
22. Wudineh F, Damtew B (2016) Mother-to-child transmission of HIV infection and its determinants among exposed infants on care and follow-up in Dire Dawa City, Eastern Ethiopia. AIDS Res Ther 2016: 1-6.
23. Kane F, Alary M, Ndoye I, Coll AM, M'boup S, et al. (1993) Temporary expatriation is related to HIV-1 infection in rural Senegal. AIDS (London, England) 7: 1261-1265.
24. Stringer EM, Sinkala M, Stringer JS, Mzyece E, Makuka I, et al. (2003) Prevention of mother-to-child transmission of HIV in Africa: successes and challenges in scaling-up a nevirapine-based program in Lusaka, Zambia. AIDS (London, England) 17: 1377.
25. Coulibaly M, Noba V, Rey JL, Msellati P, Ekpini R, et al. (2006) Assessment of a programme of prevention of mother-to-child transmission of HIV in Abidjan, Ivory Coast (1999-20002). Med Trop 66: 53-58.
26. Boer K, Nellen JF, Kreyenbroek ME, Godfried MH (2009) Treatment of HIV-infected pregnant women: prevention of virus transmission and adverse effects in mother and child. Ned Tijdschr Geneeskd 153: B410.
27. Reshi P, Lone IM (2010) Human immunodeficiency virus and pregnancy. Arch Gynecol Obstet 281: 781-792.
28. Dabis F, Msellati P, Meda N, Welffens-Ekra C, You B, et al. (1999) 6-month efficacy, tolerance, and acceptability of a short regimen of oral zidovudine to reduce vertical transmission of HIV in breastfed children in Côte d'Ivoire and Burkina Faso: a double-blind placebo-controlled multicentre trial. Lancet 353: 786-792.
29. Chenadec L (1996) Obstetric factors and mother-to-child transmission of human immunodeficiency virus type 1: The French perinatal cohorts. Am J Obstet Gynecol 175: 661-667.
30. Wade CS, Wade A (2018) La migration, facteur urbanisant et de développement socio territorial dans la vallée du fleuve Sénégal. Études caribéennes 2018: 39-40.
31. Guilmoto CZ (1991) Demography and development in the middle valley of the Senegal River. Demography and Development in the Middle Senegal River Valley ", in N'Guessan Koffi et al., Eds., Master of Population Growth and Development in Africa 1991: 403-417.
32. Lalou R, Piché V (2004) Les migrants face au sida: entre gestion des risques et contrôle social. Population 59: 233-268.
33. Faye A, Faye M, Bâ IO, Ndiaye P, Tal-Dia A (2010) Facteurs déterminant le lieu d'accouchement chez des femmes ayant bénéficié au moins d'une consultation prénatale dans une structure sanitaire (Sénégal). Revue d'Epidemiologie et de Sante Publique 58: 323-329.
34. https://www.unaids.org/sites/default/files/country/documents/SEN_narrative_report_2015.pdf