

The outcome of prevention of mother-to-child transmission of HIV infection at King Abdulaziz University Hospital, Western Region of Saudi Arabia

A Descriptive Study

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ABSTRACT

الأهداف: لوصف فعالية التوجيهات الإرشادية الخاصة بفيروس نقص المناعة البشرية في الوقاية من انتقال العدوى من الأم إلى الطفل (PMTCT).

المنهجية: أجريت مراجعة بأثر رجعي خلال الفترة من يناير 2009م إلى ديسمبر 2018م في مستشفى جامعة الملك عبد العزيز (KAUH)، جدة ، المملكة العربية السعودية. كانت مقاييس النتائج الرئيسية خصائص المرضى المعرضين لفيروس نقص المناعة البشرية ومعدل الانتقال.

النتائج: اشتملت الدراسة على 18 من الأمهات المصابات بفيروس نقص المناعة البشرية و 26 رضيعهم. كان متوسط عمر الأمهات عند الولادة 31.69 سنة ، وكان 50% منهن دون سن 30 عام. تلقت جميع الأمهات العلاج المضاد للفيروسات القهقرية مدى الحياة، باستثناء واحدة لم يتم تشخيصها حتى الأسبوع السابع والعشرين من الحمل. من بين الأمهات ، امتثلت 83% لأنظمة العلاج، ولدى 11% مقاومة للعلاج بمضادات الفيروسات القهقرية. كان تفاعل البلمرة المتسلسل لفيروس نقص المناعة البشرية (PCR) غير قابل للكشف في 19 حالة حمل. كانت سبع أمهات مصابات بعدوى انتهازية وبدأ العلاج على الفور. بعد مراجعة اختبارات HIV PCR للرضع ، كانت معدلات انتقال فيروس نقص المناعة البشرية 0% لكل من الولادة المهبلية والتلقائية والولادة القيصرية.

الخلاصة: تواجه العديد من التحديات الجهود المبذولة لتقليل انتقال فيروس نقص المناعة البشرية عمودياً، وهناك حاجة إلى تركيز خاص على التحولات بين مراحل الرعاية. نعتقد أن الفحص المبكر والاستشارة والمتابعة المنتظمة قد ساهمت في التخلص من MTCT.

Objectives: To describe the effectiveness of HIV guidelines in prevention of mother-to-child transmission (PMTCT).

Methods: A retrospective review from January 2009 to December 2018 at the King Abdulaziz University Hospital (KAUH), Jeddah, Kingdom of Saudi Arabia. The main outcome measures were characteristics of HIV-exposed patients and transmission rate.

Results: A total of 18 HIV-positive mothers and their 26 infants were included. The mean age of mothers at delivery was 31.69 years, and 50% were under 30

years old. All mothers received lifelong ART, except one who was not diagnosed until the 27th week of gestation. Among the mothers, 83% complied with treatment regimens, and 11% had ART resistance. Human immunodeficiency virus polymerase chain reaction (PCR) was undetectable in 19 pregnancies. Seven mothers had opportunistic infections and treatment was immediately initiated. After reviewing the infants' HIV PCR tests, the transmission rates of HIV were 0% for both spontaneous vaginal delivery and cesarean section.

Conclusion: Many challenges face the efforts to decrease vertical HIV transmission, and a particular focus on the transitions between stages of care is needed. We believe that early screening, counseling, and regular follow-up have contributed to MTCT elimination.

Keywords: human immunodeficiency virus; transmission, prevention

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There has been a noticeable increase in the extent of the human immunodeficiency virus (HIV), impacting individuals, population health, and economic growth.¹ In Saudi Arabia, 10,217 HIV cases were recorded between 2000 and 2009; this number has been increasing each year.² The high incidence of HIV brings to attention the need to establish multiple strategies that minimize the prevalence rate. The Saudi Ministry of Health (MOH) has reported that total elimination of HIV would be achieved by 2030, through the “90-90-90: Strategy for the Eradication of HIV.”³ This is applied by early HIV screening so that medical treatment can be provided before symptoms develop, which will reduce patient mortality and prevent HIV spread.⁴ Previously, screening was voluntary and only for pregnant women at high risk for HIV infection.^{4,5} Nowadays, screening is mandatory during antenatal visits, to prevent mother-to-child transmission (MTCT) of HIV. Mother-to-child transmission can occur in utero, intrapartum, and through breastfeeding, the cumulative rate of MTCT of HIV without medical care was 35-40%.^{1,6} Furthermore, transmission could be minimized to less than 1% through adherence to antiretroviral therapy (ART) during gestation.⁷ Furthermore, the optimal mode of delivery may reduce the rate to less than 2%.⁸ Polymerase chain reaction (PCR) tests are reliable in detecting HIV during gestation and in the neonatal period.⁹

This study aimed to review the approaches followed at the King Abdulaziz University Hospital (KAUH), Jeddah, Saudi Arabia, with HIV-positive mothers and infants outcomes from 2009 to 2018.

Methods. This is a retrospective descriptive study targeting all HIV-positive mothers and their delivered infants from January 2009 to December 2018 at KAUH. The ethical committee of KAUH has approved this study. We excluded 3 infants: 2 twins considering the high risk of infection in the firstborn twin, and one infant whose file could not be accessed. Our sample size included 18 HIV-positive mothers aged 24 to 50 years old and their 26 infants. The mothers were already known cases of HIV except for one who was diagnosed, in the 27th week of pregnancy during antenatal visits, based on enzyme-linked immunosorbent assay (ELISA) and Western blot tests. Descriptive data were created for all variables, based on KAUH's strategies followed by the AIDS Clinical Trials Group Protocol 076 to reduce the risk of MTCT of HIV,¹⁰ consisting of the mother's current treatment, compliance, and resistance to ART, and immunologic and virologic statuses.

Other variables were near-term CD4 T-lymphocyte counts (categorized as <200 cells, 200-399, and ≥400 cells/mm³), intrapartum prophylaxis, and mode of delivery. Antenatal visits and coinfections diagnosed in pregnancy were recorded as well as gestational age measured by ultrasound (US). Newborn data included HIV PCR tests and HIV antibody measurements calculated at birth and 2 to 4, 6, 12, and 18 months. It also comprised infant gender, birth weight, Apgar score, postpartum prophylaxis, and breast feeding status. All data were obtained from the medical records, and infants who lost to follow-up in the pediatric clinic were reported. Simple descriptive statistics including percentages, means, and standard deviations were calculated using Microsoft Excel.

Results. We reviewed the medical records of 18 mothers and their 26 infants delivered at KAUH between 2009 and 2018. The mean age of mothers at delivery was 31.69 years, and 50% were under 30 years old. All of them were prescribed lifelong ART before pregnancy, except for one mother who started ART at 27 weeks of pregnancy. During 15 of the pregnancies (65.2%), the mothers were receiving nucleoside reverse-transcriptase inhibitor (NRTI) therapy plus a protease inhibitor (PI); in 4 pregnancies (17.4%), the mothers were receiving NRTI/non-nucleoside reverse-transcriptase inhibitor (NNRTI) therapy; in 2 pregnancies (8.7%), they were on NRTI/PI/integrase inhibitor (IH); in 1 pregnancy (4.3%), the mother was on NRTI/IH; and in 1 (4.3%), the mother was on NRTI/NNRTI/PI.

Table 1 details the types of ART used by the HIV-positive mothers for each pregnancy concerning their CD4 cell counts. Fifteen mothers were compliant with their treatment regimens while 3 were not compliant, because of either depression or expiration of ID (iqama), and one mother had an unknown reason in her 3 pregnancies. Antiretroviral therapy resistance was noticed in 2 cases; one was a non-compliant mother with depression for one year, who developed resistance to the NRTI emtricitabine and was then assigned to a PIs/NRTI combination (boosted lopinavir, Truvada, and raltegravir). The other patient acquired resistance to the combination NRTI/ NNRTI/ PI and was treated with boosted lopinavir, lamivudine, and efavirenz, which was later switched to the NRTI/PIs (Truvada, boosted darunavir and raltegravir). Twenty of the 26 pregnancies (76.9%) ended with vaginal delivery. Eighteen of the patients who delivered vaginally had undetectable viral loads; however, 2 had CSs planned but delivered by emergency SVD instead. Their viral loads reached 49,421 and 4,245 copies/mL. Six pregnancies were

delivered by CS: 4 were associated with a viral load of more than 1000 copies/mL, and the remaining 2 had undetectable viral loads (one was accompanied with AIDS and a history of pulmonary tuberculosis, while the other had the obstetric indication severe preeclampsia).

Table 2 summarizes the deliveries of the HIV-positive mothers in relation to total deliveries each year, compliance with ART in the antenatal period, and the effect of viral load on the mode of delivery. All mothers received zidovudine (AZT) prophylaxis during labor

Table 1 - Types of ART used in the treatment of HIV-positive mothers in relation to their CD4 cell counts.

ART	PI/NRTI	NNRTI/NRTI	PI/NRTI, NNRTI	NRTI and IH	PI, NRTI, IH	Missing	Total
Pregnancies	15 (15.4)	4 (15.4)	1 (3.8)	1 (3.8)	2 (7.7)	3 (11.5)	26 (100)
CD4 >400	9	4	1	1	-	-	17 (65.4)
CD4 200-400	3	-	-	-	-	-	3 (11.5)
CD4 <200	1	-	-	-	2	-	3 (11.5)

Values are expressed as number and percentage (%). ART: antiretroviral therapy, IH: integrase inhibitors, NNRTI: non-nucleoside reverse transcriptase inhibitor, NRTI: nucleoside reverse transcriptase inhibitor, PI: protease inhibitors

Table 2 - Number of deliveries of the HIV-positive mothers related to total deliveries each year, their compliance to ART antenatally, and the effect of the viral load on mode of delivery (N=26).

Year	Total number of mothers who gave birth	HIV-mothers who gave birth	Compliance with ART	Viral load (copies/mL)	Mode of delivery
2018	5698	1 mother	Compliant	952,038	Emergency CS
2017	4321	2 mothers	Compliant	Undetectable	Emergency SVD
2016	3997	4 mothers	Compliant	Undetectable	Emergency SVD
			Noncompliant	52,997	Elective CS
			Noncompliant	9,292	Elective CS
			Compliant	Undetectable	Emergency SVD
2015	3553	5 mothers	Compliant	Undetectable	Emergency SVD
			Noncompliant	3,822	Elective CS
			Compliant	Undetectable	Elective CS
			Compliant	Undetectable	Elective SVD
			Compliant	Undetectable	Emergency SVD
2014	3283	2 mothers	Compliant	Undetectable	Emergency SVD
			Compliant	Undetectable	Elective CS
2013	4373	6 mothers	Compliant (newly diagnosed at 27 weeks)	49,421	Emergency SVD
			Compliant	41	Elective SVD
			Compliant	28	Emergency SVD
			Compliant	Undetectable	Emergency SVD
			Compliant	Undetectable	Emergency SVD
			Noncompliant	Undetectable	Elective SVD
2012	4599	3 mothers	Compliant	Undetectable	Emergency SVD
			Compliant	Undetectable	Emergency SVD
			Compliant	Undetectable	Emergency SVD
2011	4766	1 mother	Noncompliant	4,245	Emergency SVD
2010	4238	1 mother	Compliant	213	Emergency SVD
2009	4243	1 mother	Compliant	Undetectable	Emergency SVD

ART: antiretroviral therapy, CS: cesarean section, SVD: spontaneous vaginal delivery

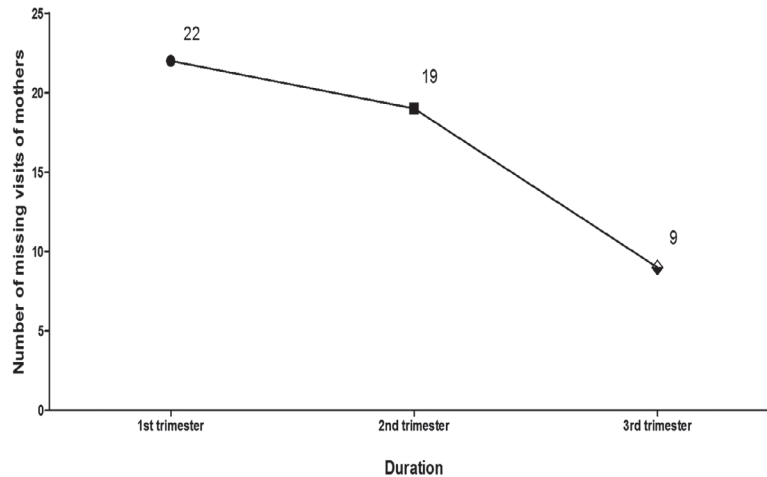


Figure 1 - Missed antenatal visits of HIV-positive mothers for each pregnancy (N=26).

as part of hospital protocol. Opportunistic infections were found in 7 mothers (during 11 pregnancies), with one of the following infections for each: disseminated cytomegalovirus, *Pneumocystis carinii* pneumonia, intra-abdominal tuberculosis, *Human papillomavirus* type 6, *Candida esophagitis*, cryptococcosis of the central nervous system, and pulmonary tuberculosis. All mothers started treatment at the time of diagnosis. There were 18 recorded antenatal visits for 26 pregnancies. The highest number of visits were registered in the third trimester; as they became closer to their due dates.

Figure 1 shows the number of missed antenatal visits. Each of the 26 newborn babies was carefully checked after birth by 1- and 5- minute Apgar scores: 1-minute scores were recorded for 25 of the newborns, and the score was missing for one newborn. The lowest scores were found in 2 newborns, who scored 2 and 6 out of 10 (8% of the cases), indicating that the infants required ventilation assistance and immediate resuscitation. However, in 96.2% of the cases, the 5-minute Apgar score was reassuring. The infant mortality rate was 0.04 (3.8%), which was a case with severe intrauterine growth restriction (IUGR).

Table 3 shows an overview of newborn characteristics. Human immunodeficiency virus PCR results of samples that were collected after birth were undetectable for all newborns. None of the newborns proved to have HIV infection since there were no 2 consecutive positive HIV PCR assays confirmed. Furthermore, the HIV-antibody test was positive in 4 cases. Laboratory test results are summarized in **Table 4**.

Table 3 - Characteristics of HIV-positive mothers' newborns (N=26).

Characteristics	n	(%)
Gender (n=26)		
Boys	17	(65.4)
Girls	9	(34.6)
Birth Weight (n=26)		
Underweight (<2.5 kg)	9	(34.6)
Normal weight (2.5-4.5 kg)	17	(65.4)
Apgar score at 1 min (out of 10), (n=25)		
Resourcing score (7, 8 and 9)	23	(92.0)
Fair score (6,5 and 4)	1	(3.8)
Low Apgar score (below 3)	1	(3.8)
Apgar score at 5 min (out of 10), (n=25)		
Resourcing score (7, 8 and 9)		(96.1)
Fair score (6,5 and 4)	-	-
Low Apgar score (below 3)	1	(3.8)
Prophylaxis (n=25)	25	(96.2)
Infant mortality (n=26)	1 (due to IUGR)	(3.8)

Data are expressed as number (%) or mean +/- standard deviation (minimum-maximum). IUGR: intrauterine growth restriction.

Figure 2 shows the number of HIV-exposed infants who were lost to follow-up for unclear reasons.

Discussion. The most significant policies legislated to restrict HIV transmission in Saudi Arabia include lifelong ART for HIV-positive women and AZT prophylaxis during labor. For the newborn, exclusive formula feeding plus AZT prophylaxis starting

from birth to 6 weeks of life will decrease the risk of transmission to less than 2%.^{11,12} In some settings, these strategies may not be sufficient to prevent MTCT of HIV and HIV antigens could be detected. This study was designed to describe the PMTCT of HIV between 2009 and 2018 at KAUH and to discuss how HIV screening tests could change the epidemiology of HIV in Saudi Arabia. Maternal HIV viral load is considered the most critical factor in determining

full viral suppression after the initiation of ART by the time of delivery.¹³ A study has reported that HIV transmission rates were 20% for untreated women and 1.2% for women receiving ART.¹⁴ In this study, ZDV was used during the intrapartum period, following the AIDS Clinical Trials Group 076 Protocol,¹⁰ to reduce transmission risk. According to this study, the majority of the mothers had undetectable viral loads by the time of delivery (64.4%), and eventually, the transmission rate was zero. These low rates were comparable to other studies.^{15,16} Moreover, we observed no transmission among 9 cases with detectable viral loads, due to either failure of diagnosing HIV at the right time or inability to control HIV replication because of nonadherence to regimens.^{17,18}

The data in the study described the loss to follow-up (LTFU) in infants after delivery, based on clinic schedules. The median ages at first and last infant follow-up visits were 3 weeks and 18 months, respectively. The reason for their LTFU could be that when the infant's first HIV PCR result is negative, the mother dismisses further follow-up.¹⁹ The major challenge facing today's PMTCT care program is keeping the patients under medical care, typically up to 24 months of age. A meta-analysis of HIV-exposed infants showed that their LTFU within 3 months of birth was 33.9%.²⁰ These analyses determine the magnitude of LTFU, which is critical to the global PMTCT response. Exploring the reasons for LTFU may be used to inform further policy development and resource allocation for PMTCT programs to achieve the elimination of pediatric HIV infection in the Kingdom of Saudi Arabia.

Our findings also emphasize the ongoing need for preconception care of HIV-positive women, because they present later in pregnancy than what is recommended

Table 4 - Laboratory test results for HIV-exposed children, (N=25)*

Laboratory test	n	(%)
<i>At birth (n=26)</i>		
PCR undetectable	25	(96.2)
ELASIA positive	4	(15.4)
Western blot positive	3	(11.5)
<i>At 6 weeks</i>		
PCR undetectable	19	(73.1)
ELASIA positive	3	(11.5)
Western blot positive	1	(3.8)
<i>At 6 months</i>		
PCR undetectable	8	(30.8)
ELASIA positive	1	(3.8)
<i>At 12 months</i>		
PCR undetectable	3	(11.5)
ELASIA positive	1	(3.8)
<i>At 18 months</i>		
PCR undetectable	3	(11.5)
ELASIA positive	1	(3.8)

*Excluding one infant who died immediately after birth.
Abbreviations: PCR, polymerase chain reaction; ELASIA, enzyme-linked immunosorbent assay.

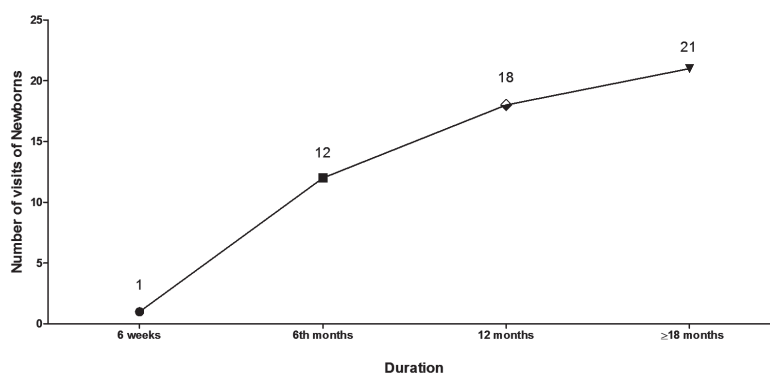


Figure 2 - Number of HIV-exposed infants lost to follow-up (LTFU) (n=25*). *Excluding one infant who died immediately after birth.

by current guidelines.²¹ This study strongly emphasized the implementation of research to evaluate ways to improve the integration of services,²² particularly transitions from antenatal to delivery and pediatric care. A variety of research-based studies suggest strategies to improve follow-up care for HIV-exposed infants, such as an integration of services,²² male husband,²³ active patient tracking,²⁴ nutritional supplements,²⁵ use of mobile technology for reminders,²² and accompaniment between clinics.²⁶

Although the interpretation of infant outcomes in the study was limited due to LTFU even with available DNA PCR results, outcomes were excellent, especially among infants whose mothers were compliant within the PMTCT care program. A previous study noted that 35% of HIV-positive infants not receiving ART were expected to die during the first year of life and 52% by 2 years of age.²⁷ These findings support that follow-up and early initiation of ART will suppress the viral load, slow disease progression, and reduce mortality rates.²⁷ Additionally, the study did not adequately identify women at risk. However, since the overall rate of transmission was statistically equivalent to zero, it suggests that large-scale prevention applications have the potential to achieve superior results.

The principles of MOH recommendations for HIV screening of pregnant women have remained unchanged for a long time in Saudi Arabia. Human immunodeficiency virus screening was voluntary and offered only for high-risk women during antenatal visits,²⁸ and the MOH has enforced the HIV screening test for all pregnant women as a routine part of prenatal care in 2019. There remains a particular challenge facing the screening program. For instance, screening services are unacceptable among Saudi individuals, partially due to lack of awareness about HIV and not expecting that it exists in Arab, Muslim cultures. Instead, most men and women do not realize that they are potentially at risk. Often, these limitations have served to not adhere with the guidelines,²⁹ even with the established laws by the Bureau of Experts at the Council of Ministers; a Saudi citizen who is infected with HIV is entitled to free medical care and has the protection of his or her privacy.³⁰ Even though, we acknowledge that effective programs are complicated by social barriers, stigmatization, and discrimination associated with the disease, all of which may prevent individuals from seeking voluntary HIV testing and counseling.³¹

Finally, the screening test should be modified to ensure that it is accessible across the country, such as

to the 17.9% of the population living in rural areas.³² More awareness campaigns, educational seminars, and innovative healthcare policies for attracting Saudi pregnant women to undergo HIV screening tests are fundamentally needed.

Intrapartum care for HIV-positive mothers includes 2 mg/kg/hour of AZT followed by 1 mg/kg/hour administered intravenously as soon as signs of labor begin and until the infant is delivered. Within the first 8 to 12 hours after birth, the newborn infant should receive AZT syrup 2 mg/kg/dose every 6 hours for 6 weeks. If the mother's viral load is above 1000 copies/mL, CS is preferred to prevent MTCT, and AZT must be administered 3 hours before the procedure and until the newborn is delivered. Otherwise, vaginal delivery is recommended.²⁸ There is no need to isolate the mother or her baby; however, breast feeding is contraindicated. Postpartum care for HIV-exposed newborns includes referring to an infectious disease pediatrician to determine the baby's status. The diagnosis of HIV in exposed infants depends on serial blood tests: HIV antibody test (ELISA), and HIV viral load measurements (PCR test).³³

Study limitations. While the present study provides insights into the prevention of MTCT of HIV, it has been affected by some limitations. First is the small number of enrolled subjects which may affect the generalization of our findings among all Saudi regions. The second limitation is being conducted from a single center which may carry some sort of selection bias and affects the credibility of our results. Nonetheless, we believe that this report is a preliminary groundwork for future research in Saudi Arabia aiming to curb HIV transmission to newborns.

In conclusion, ensuring HIV screening for all pregnant women is crucial to detect the disease and prevent transmission to newborns. Various studies have assessed the efficacy of screening tests, counseling, ART, elective CS, breastfeeding avoidance, and early ART for newborns; and all have contributed to MTCT elimination. Therefore, it is important to establish HIV/acquired immunodeficiency syndrome (AIDS) awareness and educational efforts together with mandating HIV screening programs and linking to care which can lead to MTCT elimination in the community.

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References

1. Mondal MNI, Shitan M. Factors affecting the HIV/AIDS epidemic: an ecological analysis of global data. *Afr Health Sci* 2013; 13: 301-310.
2. Madani TA, Al-Mazrou YY, Al-Jeffri MH, Al Huzaim NS. Epidemiology of the human immunodeficiency virus in Saudi Arabia; 18-year surveillance results and prevention from an Islamic perspective. *BMC Infect Dis* 2004; 4: 25.
3. Sennaroglu L, Bajin MD. Management of stapes footplate fistula in inner ear malformations. *International Journal of Pediatric Otorhinolaryngology* 2021; 140: 110525.
4. Patel D, Johnson CH, Krueger A, Maciak B, Belcher L, Harris N, DiNunno EA. Trends in HIV testing among US adults, aged 18-64 years, 2011-2017. *AIDS Behav* 2020; 24: 532-539.
5. Almilaibary AA. A mixed methods study of the factors associated with HIV testing uptake among young people in Saudi Arabia. *Academic Journals* 2018; 10: 96-102.
6. Vrazo AC, Sullivan D, Phelps BR. Eliminating mother-to-child transmission of HIV by 2030: 5 strategies to ensure continued progress. *Glob Health Sci Pract* 2018; 6: 249-256.
7. Barral MFM, de Oliveira GR, Lobato RC, Mendoza-Sassi RA, Martínez AMB, Gonçalves CV. Risk factors of HIV-1 vertical transmission (VT) and the influence of antiretroviral therapy (ART) in pregnancy outcome. *Rev Inst Med Trop Sao Paulo* 2014; 56: 133-138.
8. Arora N, Sadovsky Y, Dermody TS, Coyne CB. Microbial vertical transmission during human pregnancy. *Cell Host Microbe* 2017; 21: 561-567.
9. Chen X, Laurent S, Onur OA, Kleineberg NN, Fink GR, Schweitzer F, et al. A systematic review of neurological symptoms and complications of COVID-19. *J Neurol* 2021; 268: 392-402.
10. Connor EM, Sperling RS, Gelber R, Kiselev P, Scott G, O'Sullivan MJ, et al. Reduction of maternal-infant transmission of human immunodeficiency virus type 1 with zidovudine treatment. Pediatric AIDS Clinical Trials Group Protocol 076 Study Group. *N Engl J Med* 1994; 331: 1173-1180.
11. Townsend CL, Cortina-Borja M, Peckham CS, de Ruiter A, Lyall H, Tookey PA. Low rates of mother-to-child transmission of HIV following effective pregnancy interventions in the United Kingdom and Ireland, 2000-2006. *AIDS* 2008; 22: 973-981.
12. Myer L, Phillips TK, McIntyre JA, Hsiao NY, Petro G, Zerbe A, Ramjith J, Bekker LG, Abrams EJ. HIV viraemia and mother-to-child transmission risk after antiretroviral therapy initiation in pregnancy in Cape Town, South Africa. *HIV Med* 2017; 18: 80-88.
13. Read PJ, Mandalia S, Khan P, Harrisson U, Naftalin C, Gilleece Y, et al. When should HAART be initiated in pregnancy to achieve an undetectable HIV viral load by delivery? *AIDS* 2012; 26: 1095-1103.
14. Cooper ER, Charurat M, Mofenson L, Hanson IC, Pitt J, Diaz C, et al. Combination antiretroviral strategies for the treatment of pregnant HIV-1-infected women and prevention of perinatal HIV-1 transmission. *J Acquir Immune Defic Syndr* 2002; 29: 484-494.
15. Achievements in public health. Reduction in perinatal transmission of HIV infection--United States, 1985-2005. *MMWR Morb Mortal Wkly Rep* 2006; 55: 592-597.
16. Boer K, Nellen JF, Patel D, Timmermans S, Tempelman C, Wibaut M, et al. The AmRo study: pregnancy outcome in HIV-1-infected women under effective highly active antiretroviral therapy and a policy of vaginal delivery. *BJOG* 2007; 114: 148-155.
17. Scott GB, Brogly SB, Muenz D, Stek AM, Read JS, International Maternal Pediatric Adolescent AIDS Clinical Trials Group, P1025 Study Team. Missed opportunities for prevention of mother-to-child transmission of human immunodeficiency virus. *Obstet Gynecol* 2017; 129: 621-628.
18. Siemieniuk RA, Jadavji T, Gill MJ. Limitations of opt-out HIV screening and mother-child HIV transmission. *Am J Public Health* 2010; 100: 388-389; author reply 389.
19. Shargie MB, Eek F, Abaychew A. Prophylactic treatment uptake and compliance with recommended follow up among HIV exposed infants: a retrospective study in Addis Ababa, Ethiopia. *BMC Res Notes* 2011; 4: 563.
20. Sibanda EL, Weller IV, Hakim JG, Cowan FM. The magnitude of loss to follow-up of HIV-exposed infants along the prevention of mother-to-child HIV transmission continuum of care: a systematic review and meta-analysis. *AIDS* 2013; 27: 2787-2797.
21. American College of Obstetricians and Gynecologists. Labor and delivery management of women with human immunodeficiency virus infection. [Updte 2018; Access 2020 Sept 4]. Available from: <https://www.acog.org/clinical/clinical-guidance/committee-opinion/articles/2018/09/labor-and-delivery-management-of-women-with-human-immunodeficiency-virus-infection>
22. Tudor Car L, van-Velthoven MH, Brusamento S, Elmoniry H, Car J, Majeed A, et al. Integrating prevention of mother-to-child HIV transmission (PMTCT) programmes with other health services for preventing HIV infection and improving HIV outcomes in developing countries. *PLoS One* 2012; 7: e35268.
23. Farquhar C, Kiarie JN, Richardson BA, Kabura MN, John FN, Nduati RW, et al. Antenatal couple counseling increases uptake of interventions to prevent HIV-1 transmission. Journal of acquired immune deficiency syndromes (1999). *J Acquir Immune Defic Syndr* 2004; 37: 1620-1626.
24. Thomson KA, Cheti EO, Reid T. Implementation and outcomes of an active defaulter tracing system for HIV, prevention of mother to child transmission of HIV (PMTCT), and TB patients in Kibera, Nairobi, Kenya. *Trans R Soc Trop Med Hyg* 2011; 105: 320-326.
25. Kundu CK, Samanta M, Sarkar M, Bhattacharyya S, Chatterjee S. Food supplementation as an incentive to improve pre-antiretroviral therapy clinic adherence in HIV-positive children--experience from eastern India. *J Trop Pediatr* 2012; 58: 31-37.
26. Jani IV, Meggi B, Loquiha O, Tobaiwa O, Mudenyanga C, Zitha A, Mutsaka D, Mabunda N, Vubil A, Bollinger T, Vojnov L. Effect of point-of-care early infant diagnosis on antiretroviral therapy initiation and retention of patients. *AIDS* 2018; 32: 1453-1463.
27. Kiyaga C, Narayan V, McConnell I, Elyanu P, Kisaakye LN, Kekitiinwa A, et al. Retention outcomes and drivers of loss among HIV-exposed and infected infants in Uganda: a retrospective cohort study. *BMC Infect Dis* 2018; 18: 416.
28. Edathodu J, Halim MM, Dahham MB, Alrajhi AA. Mother-to-child transmission of HIV: experience at a referral hospital in Saudi Arabia. *Ann Saudi Med* 2010; 30: 15-17.

29. Fageeh WM. Should We Screen for HIV in Saudi Arabia? . JKAU: *Med Sci* 2010; 17: 45-54.
30. Bureau of Experts at the Council of Ministers. Attached to the system for the prevention of acquired immune deficiency syndrome (AIDS) and the rights and duties of sufferers. [Update 2018, Access 2020 Sept 4]. Available from: <https://laws.boe.gov.sa/BoeLaws/Laws/Viewer/bd60c847-2450-4d5a-a215-a9ed0119f68b?lawId=9d240ae2-a709-48ee-ac82-a9ed0119f62d>.
31. Mazroa MAAI, Kabbash IA, Felemban SM, Stephens GM, Al-Hakeem RF, Zumla AI, et al. HIV case notification rates in the Kingdom of Saudi Arabia over the past decade (2000-2009). *PLoS One* 2012; 7: e45919.
32. UN Habitat. Saudi Arabia - Urban Issues [Update 2021; Accessed 2020 Sept 4]. Available from: <https://unhabitat.org/saudi-arabia-urban-issues>.
33. Association of Public Health Laboratories. Limitations for the use of HIV-1 western blot in plasma/serum. [cited 2015]. Available from: https://www.aphl.org/aboutAPHL/publications/Documents/ID_HIV-1-1-WesternBlotBrief_62015.pdf
34. Styer LM, Sullivan TJ, Parker MM. Evaluation of an alternative supplemental testing strategy for HIV diagnosis by retrospective analysis of clinical HIV testing data. *J Clin Virol* 2011; 52 Suppl 1: S35-S40.
35. Masciotra S, McDougal JS, Feldman J, Sprinkle P, Wesolowski L, Owen SM. Evaluation of an alternative HIV diagnostic algorithm using specimens from seroconversion panels and persons with established HIV infections. *J Clin Virol* 2011; 52 Suppl 1: S17-S22.