

SYSTEMATIC REVIEW

Open Access



Pregnancy and neonatal outcomes of HIV infection in pregnant women in Iran: a systematic review and meta-analysis

Hosein Azizi^{1,2}, Elham Davtalab Esmaeili^{3*}, Mahsa Tabean², Khalil Maleki Chollou¹, Shamsi Abbasalizadeh¹ and Zhaleh Behrouzi²

Abstract

Background HIV infection is a major public health concern among pregnant women globally. Beyond the risk of mother-to-child transmission, it can lead to serious complications and negative pregnancy and neonatal outcomes. In Iran, there is currently no comprehensive meta-analysis evidence measuring the adverse pregnancy and neonatal complications of HIV infection among pregnant women. The review objective is to provide pregnancy outcomes, the prevention of mother-to-child transmission (PMTCT), and antiviral therapy (ART) of pregnant women infected with HIV in Iran.

Methods The review systematically searched PubMed, Scopus, ISI, Embase, and also the Iranian national databases up to 25th September 2024. Any records that reported pregnancy and neonatal outcomes among pregnant women in Iran were included in the inclusion criteria. The study outcomes included any pregnancy and neonatal implications related to HIV infection in pregnant women, as well as PMTCT, ART therapy, delivery type, and HIV morbidity in spouse. Meta-analysis was carried out to estimate pooled prevalence with 95% confidence intervals (CIs) for all the study outcomes.

Results The study pooled data from 497 pregnant women infected with HIV across seven eligible studies. The majority of participants had no university education, lived in urban areas, and were infected by their spouses. The most frequent adverse pregnancy outcome was abortion. The pooled proportions and 95% CIs for each outcome were: HIV-positive spouses 78% (95% CI: 73–83%), wanted pregnancy 63% (95% CI: 46–80%), ART and/or PMTCT uptake 94% (95% CI: 89–98%), cesarean delivery 88% (95% CI: 77–98%), live birth rate 98% (95% CI: 96–100%), newborns who were HIV positive 1.0% (95% CI: 0.0–1.0%), and newborn prophylaxis 100% (95% CI: 99–100%).

Conclusion Although most pregnant women with HIV are enrolled in PMTCT programs and adverse pregnancy and neonatal outcomes are rare, longitudinal, population-based studies are still needed to better understand the situation of pregnant women with HIV in Iran.

Keywords HIV, Pregnancy, Sexually transmitted infections, Infant, Epidemiology, Iran

*Correspondence:

Elham Davtalab Esmaeili
elhamdavidlab67@yahoo.com

¹Sarab Faculty of Medical Sciences, Sarab, Iran

²Women's Reproductive Health Research Center, Tabriz University of Medical Sciences, Tabriz, Iran

³Research Center of Psychiatry and Behavioral Sciences, Tabriz University of Medical Sciences, Tabriz, Iran



Background

The human immunodeficiency virus (HIV) infection is a major public health concern among pregnant women around the world [1]. By the end of 2021, the World Health Organization's statistics show that there were about 38.4 million people worldwide who had been infected with HIV, of which about 19.7 million people, i.e. more than half of the infected, were women over 15 years old [2, 3]. Due to unequal cultural, social and economic conditions, young women (10–24 years) are twice as likely as their male counterparts to be infected with HIV [4]. Also, according to statistics, about one million and three hundred thousand women and girls infected with HIV become pregnant every year [2, 5].

During pregnancy, delivery, and breastfeeding, HIV may also be transmitted from mother to child (MTCT) among pregnant women [6]. MTCT is the cause of >90% of pediatric HIV infections, as more than 1600 children are infected with HIV each day [7]. The rate of MTCT fluctuates between 15 and 45% without any intervention. According to estimates, the transmission rate during pregnancy, the post-partum period, and breastfeeding is 35, 65, and 7–22%, respectively [8]. The risk of MTCT persists in Iran due to inadequate healthcare standards, inadequate perinatal care, delayed diagnosis, lack of anti-retroviral therapy, and inadequate interventions to prevent it [9, 10]. The prevention of MTCT may be hindered by the behavioral features of mothers, in addition to the quality of clinical care [11].

In recent years, women in Iran have experienced an increase in the prevalence of HIV infection [12]. This rise has heightened the risk of MTCT, underscoring the need to strengthen preventive measures in this area [13]. According to statistical modeling, there are over 80,000 HIV infections in Iran [14, 15].

Iranian health system's basic prevention programs such as Prevention of mother-to-child transmission (PMTCT) program, and Antiretroviral therapy (ART) were initiated in Iran in 2013 [13].

However, among pregnant women with HIV, adverse pregnancy and neonatal outcomes in Iran remain poorly understood. A recent study analyzed 1,750 HIV-positive and 664 HIV-negative women, covering a total of 1,356 pregnancies, and found that 43.2% resulted in live birth while 34.6% ended in abortion [16]. Evidence also indicates that the abortion rate has decreased among newborns of mothers enrolled in the PMTCT program, to approximately 2.5% [13, 17].

There is no meta-analysis of summary effect sizes for estimating adverse pregnancy outcomes related to HIV infection among pregnant women in Iran. Therefore, this study aimed to gather and synthesize evidence on pregnancy outcomes, PMTCT, and treatment and ART of HIV infection in pregnant women in Iran.

Methods

Search strategy

This review was conducted in accordance with the PRISMA guidelines for systematic reviews and meta-analyses [18]. The study systematically searched any published records in English and Persian languages from PubMed, ISI, Scopus, Embase, Google scholar, and Persian databases including Iran doc, MedLib, IranMedex, SID, and Google free search up to 25th September 2024. The OpenGrey website, congress, and Google search were explored for grey literature. The review searched any records reporting pregnancy and neonatal outcomes, ART, and PMTCT among pregnant women in Iran.

Both free text and medical subject headings (MeSH terms) were used in the search. In the first step, the search terms were "HIV" OR "pregnant women" in the title and/or abstract. Relevant MeSH terms and text words related to HIV were used in the final search among pregnant women in conjunction with "pregnancy" OR "fertility" OR "mother" AND "HIV" OR "AIDS" OR "Acquired Immunodeficiency Syndrome" AND "pregnancy outcome" OR "adverse pregnancy" OR "prevention" OR "antiviral" OR "mortality" OR "neonate" OR "newborn" OR "infant" OR "child". The reference lists of the recovered records were also screened with the purpose to identify other potential data sources.

Eligibility criteria

The inclusion criteria were any paper that reported any pregnancy and/or neonatal outcomes, PMTCT, or any treatment and ART in pregnant women with positive HIV in Iran. Exclusion criteria included studies conducted among non-pregnant women and /or men, studies evaluated only pregnant women knowledge and attitude, reviews, letters, conference abstracts, editorials, commentaries, and qualitative studies. The study also excluded records with incomplete data regarding pregnant women infected with HIV.

Data extraction

Two reviewers conducted the eligibility assessment of the papers independently, blindly, and standardized it (HA, ZB). In cases where two reviewers disagreed, the third reviewer made the final decision (EDE).

The review extracted following data including the year of publication, name of the first author, study design, province/city, number of pregnant women (sample size), socio-demographic characteristics of patients, type of pregnancy, HIV positive rate among spouses/partners, ART therapy, pregnancy outcomes, delivery, PMTCT, live birth rate, newborn prophylaxis, HIV positive status among infants, and infant growth status.

Quality assessment

Crombie's tool was used to assess the quality and strength of the included papers [19, 20]. The Crombie tool consists of seven items that assess the quality of cross-sectional studies. These items included (1) sample size, (2) representativeness, (3) appropriateness of methods, (4) measurement and data collection (reliability and validity of data and measurements), (5) clarity and reporting of non-respondents, (6) appropriateness of statistical methods, and adequacy, and (7) reporting of results. Quality scoring ranged from 0 to 7 for each article.

Risk of bias assessment

The risk of bias was evaluated using parameters from the Newcastle-Ottawa Scale [20, 21]. The risk of bias assessment was accounted for by the following parameters: using correct sampling method, acceptable sample size, correct and unbiased data collection methods, sufficient response rate, eligibility, correct and appropriate statistical analysis. Each eligible article received 11 criteria to rate various risk of bias elements out of a total of 12 scores in the final scoring system. The risk of bias in studies was divided into three levels: low risk (9–12 points), moderate risk (5–8 points), and high risk (< unk >5 points) (Table 1) [26].

Outcomes

The study outcomes were the pooled proportions of HIV positive in spouse, wanted pregnancy, cesarean delivery, ART therapy, abortion, live birth rate, newborn prophylaxis, PMTCT, and other neonatal outcomes.

Statistical analysis

The absolute and crude quantitative data, along with qualitative information, were entered into an Excel sheet. Subsequently, the data was transferred to STATA version

14.0 (Stata Corp, College Station, TX, USA). First, raw data and/or absolute numbers were transformed to logit for pooled estimation of the proportions for the study outcomes. The summary prevalence and 95% Confidence Interval (CI) were estimated for pooled proportions of newborn prophylaxis, HIV positive rates in newborn infants, live birth rates, cesarean deliveries, antiviral therapy, wanted pregnancies, and HIV positive rates among spouses/partners using the “metaprop” command by random effects model [27]. Since prevalence and outcome proportions vary by geographic areas and context, a random-effects meta-analysis was conducted. Furthermore, the review included seven records in the meta-analysis, and there were four or five studies for most outcomes, so there was no need to draw a funnel plot to assess publication bias.

Results

Baseline characteristics

Searching for potentially relevant studies resulted in the retrieval of 27,853 records. Due to duplicate and abstract screening, 27,831 studies were excluded, leaving 22 studies that can be assessed full-text for final inclusion. In the end, 7 articles were included in the systematic review and meta-analysis that assessed the maternal and neonatal outcomes of HIV infection among pregnant women (Fig. 1).

Table 1 shows the baseline characteristics of the studies that were included. A total of 497 pregnant women infected with HIV have participated in included studies. All seven eligible studies were descriptive and/or descriptive-analytical designs. Studies were published between 2016 and 2023. No studies designed with a control group, such as cohort or case-control studies, were found that could compare pregnancy and neonatal outcomes using epidemiological measures of association

Table 1 Baseline characteristics of the included studies

Author	Year	Design	Province/City	Samples	Age (mean/range)	Education (non-college)	Residency (urban)	Risk of bias (overall)*
Afsar Kazeroni. P [13]	2021	Descriptive-analytical	Pilot, national	76	Mean: 31 years	96%	79%	Low risk
Lorestani. R [22]	2023	Descriptive-analytical	Kermanshah	95	Mean: 35.9 years	81%	NR	Low risk
Bokharaei Salim.F [23]	2018	Descriptive-analytical	Tehran	54	Mean: 30.1 years 26–34: 66.7%	100%	NR	Low risk
Shikhansari. S [24]	2022	Descriptive-analytical	Rasht & Tehran,	81	35–44: 55.4%	NR	70.50%	Moderate risk
Ghasemi.M [25]	2021	Descriptive-analytical	Ahvaz	112	33.06 years	95%	NR	Moderate risk
Salmanzadeh. Sh [9]	2016	Descriptive	Khuzestan	39	26.7 years	NR	NR	Moderate risk
Mohraz.M [17]	2018	Descriptive	Tehran	40	26–30 years: 42.5%	90%	97.50%	Low risk

NR: not reported

*Bias due to confounding, selection bias, information bias, Bias due to inadequacy of samples and sampling methods, Bias in measurement of outcomes, missing data, and bias in selection of the reported results

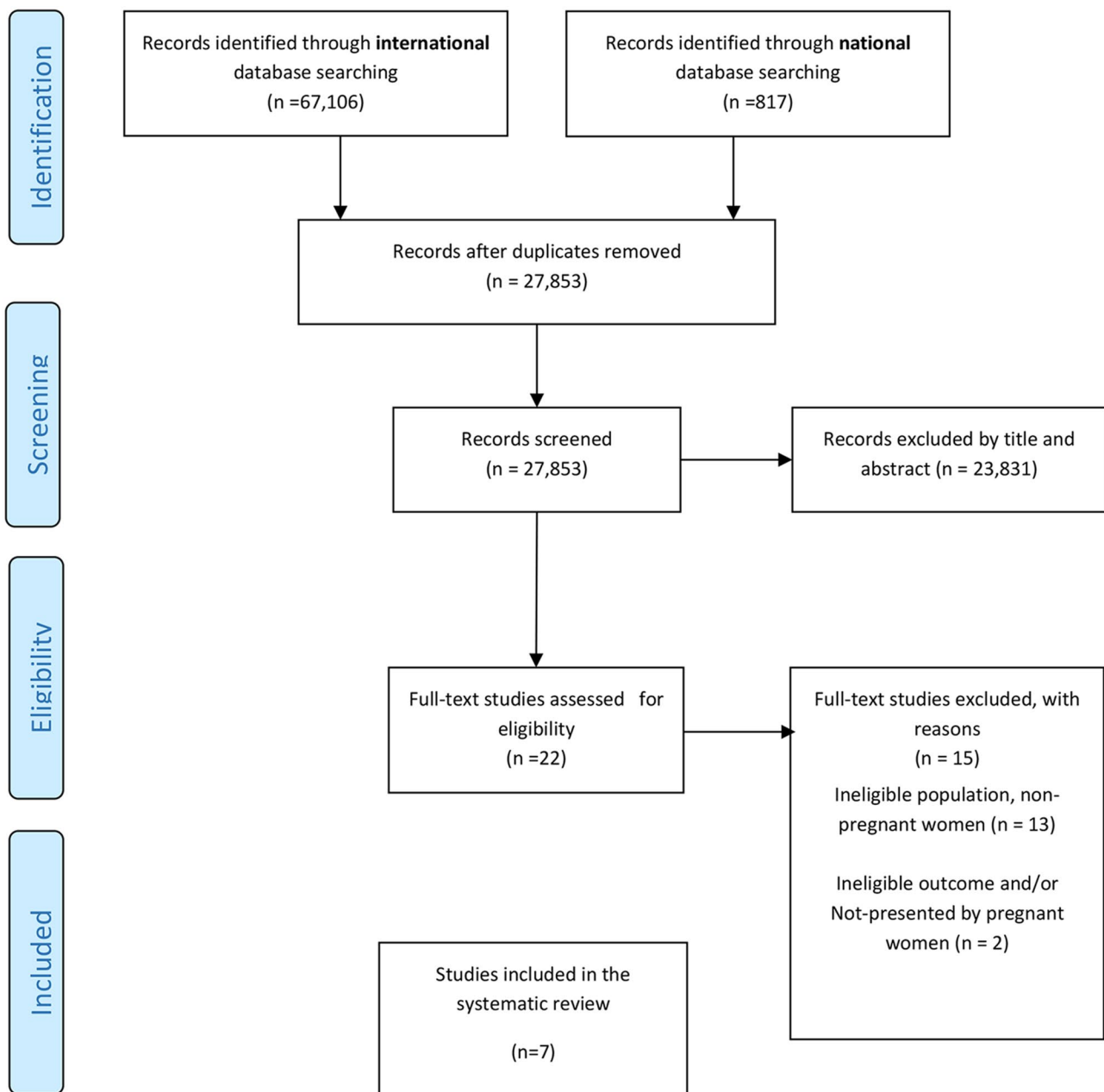


Fig. 1 PRISMA flow diagram

between HIV-infected and non-HIV-infected pregnant women. In general, very few analytical studies have been published regarding HIV in pregnant women in Iran. Most of the studies had small sample sizes, with the largest being 112 and the smallest 39. Out of the 7 studies, 3 were conducted in Tehran. In most studies, the average age of pregnant women was 30 years or older. The majority of pregnant women with HIV had non-university education and lived in urban areas.

Concerning the transmission of HIV in pregnant women, most studies reported that the virus is transmitted through a spouse and/or partner. The lowest

percentage of ART prescriptions was 82%. The CD4 levels were > 350 in the majority of patients in the included studies. The live birth rate in most studies was nearly 100%.

Nonetheless, the most common adverse neonatal complication was abortion. Out of seven studies, two did not report abortion data; in two studies there were no abortions among pregnant women with HIV; two studies reported abortion rates of 2.5% and 2.6%; and one study provided an odds ratio (OR) = 1.06 (95% CI 0.50–2.22) for the risk of abortion. Birth weight and infant growth were reported positively in most studies, and the majority

Table 2 Pregnancy and neonatal outcomes for pregnant women infected with HIV in Iran

First author	Transmission	ART treatment	CD4 (after)	Outcome of pregnancy	Newborn prophylaxis	HIV positive infant	Infant growth status
Afsar Kazeroni. P [13]	NR	86.80%	> 350; 82.5%	Live birth; 88.2%; abortion: 2.6%; Pregnant: 9.2%	95.50%	1.50%	79%; Normal range
Lorestani. R [22]	79% from spouse	82.20%	496.95 ± 289.53	Live birth: 100%	100%	0.00%	Birth weight: 2868 g
Bokharaei Salim.F [23]	57.4% sexual intercourse	NR	574 ± 233; ≥351: 81.5%	Live birth: 100%	100%	20%	NR
Shikhansari. S [24]	NR	NR	NR	NR	NR	2%	NR
Ghasemi.M [25]	NR	NR	NR	Live birth: 94%; preterm risk: 10(1.52–23.78); Abortion risk: 1.06(0.50–2.22)	NR	NR	Birth weight: 88% were above 2500 g
Salmanzadeh. Sh [9]	NR	NR	> 500: 40.5%	NR	NR	25.7%	92% Powdered milk; 77.1% were 2500–3500 g
Mohraz.M [17]	67.5% sexual	100%	439.2 ± 23.6; 55% ranged 200–499	Live birth: 97.5%; abortion: 2.5%; no fetal defects	100%	0.00%	All normal Apgar

of infants had normal birth weights. More details are reported in Table 2. Infant feeding was with powdered milk in over 90% of cases, although many studies had limited information on this issue and other pregnancy outcomes. Out of 7 eligible studies, the HIV positive rate was 0.0% in 2 studies, while in the others it was less than 25%. More details on the maternal and neonatal outcomes of HIV infection in pregnant women are presented in Table 2.

Meta-analysis

Figure 2 shows meta-analysis proportions of spouse HIV-positive and wanted pregnancy in pregnant women infected with HIV using a random effects model. The summary proportions of HIV-positive and wanted pregnancy were 78%; (95% CI 73–83%) and 63%, (95% CI 46–80%), respectively. Likewise, ART therapy and cesarean delivery proportions were 94%; (95% CI 89–98%) and 88%, (95% CI 77–98%), respectively (Fig. 3).

Meta-analysis indicated that the live birth rate among pregnant women with HIV based on PMTCT program is close to 100%. So that a meta-analysis utilizing the random effects model indicated a pooled live birth rate of 98% (95% CI: 96–100%); and the proportion of HIV-positive newborns was 1.0% (95% CI: 0.0–1.0%) (Fig. 4). Figure 5 demonstrates the meta-analysis proportion of newborn prophylaxis and/or PMTCT among HIV-infected newborn infants. The analysis revealed that the pooled prevalence of newborn prophylaxis is nearly 100%; (95% CI: 99% – 100%).

Discussion

This review is the first meta-analysis to demonstrate the pregnancy and neonatal complications of HIV infection in pregnant women, as well as the status of HIV treatment and prophylaxis in pregnant mothers and newborns, along with demographic and clinical features in Iran. Findings indicate that there are few studies directly estimating HIV incidence in pregnant women with HIV and its consequences for mothers and infants in Iran. Holistic and population-based studies focused on pregnant women are necessary to present and evaluate the overall prevalence of HIV infection and its consequences. This meta-analysis, by combining the results of existing studies through a statistical approach and qualitative assessment of bias risk, was able to provide a comprehensive evaluation of the status of HIV in pregnant women in Iran, as well as fertility and newborn outcomes.

The findings of this review indicate a need for more comprehensive primary studies utilizing cohort and longitudinal designs, alongside comparisons with control groups. Additionally, it is essential to consider broader pregnancy and neonatal outcomes, including the status of ART and prophylaxis in mothers and their newborns, as well as clinical features, morbidity, and mortality rates among pregnant women and infants. Other adverse neonatal complications such as preterm birth, low birth weight, stillbirth, and both spontaneous and induced abortions should also be examined.

Globally, the estimated rates of HIV transmission during pregnancy, postpartum, and breastfeeding are 35%, 65%, and 7–22%, respectively [28]. These rates remain high in developing countries due to inadequate health-care standards, insufficient perinatal care, late diagnoses, lack of antiretroviral treatment, and ineffective

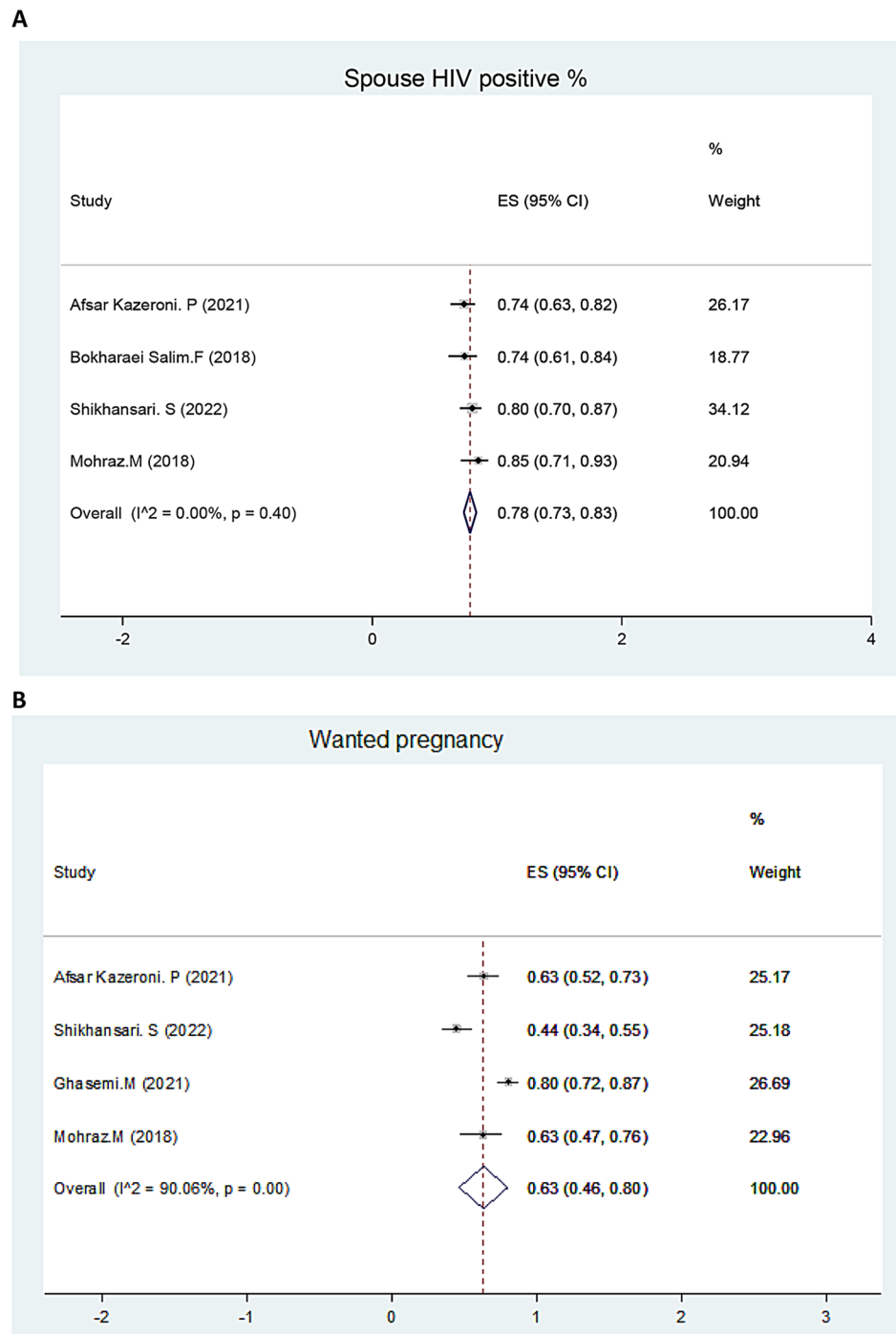


Fig. 2 Meta-analysis of HIV positive in spouse (A) and wanted pregnancy (B) in pregnant women infected with HIV

interventions to prevent mother-to-child transmission. Besides the quality of clinical care, the behavioral characteristics of mothers may also pose barriers to PMTCT [29]. Unlike other population groups in Iran, there have been very few studies conducted on pregnant women with HIV. Therefore, very little information is available about the rate of HIV transmission during pregnancy and breastfeeding in Iran. However, evidence shows that

in recent years the pattern of transmission has changed from injecting substance/drug use to sexual contacts, and HIV infection in pregnant women is increasing. Lorestani et al. study indicated that the most of pregnant women with HIV infected through their infected spouses [22].

The findings revealed that the pooled proportion of HIV-positive newborns in Iran is 1.0%, while the pooled

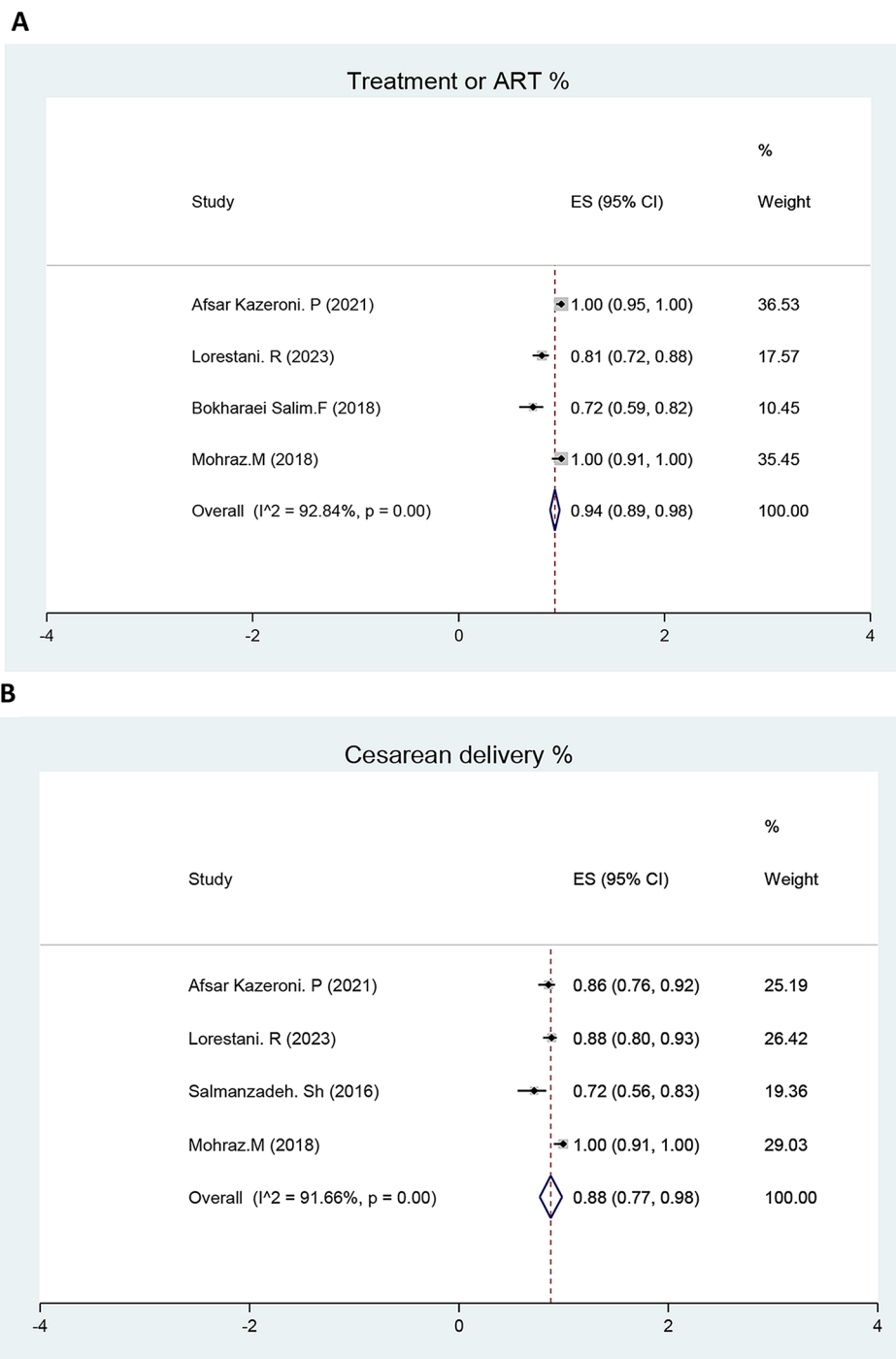


Fig. 3 Meta-analysis of antiviral therapy (A) and cesarean delivery proportion (B) in pregnant women infected with HIV

live birth rate stands at 98%. The average HIV incidence rate for pregnant and breastfeeding women in sub-Saharan Africa was found to be 3.6 per 100 person-years, as indicated by a systematic review and meta-analysis [30]. Additionally, we found that the pooled prevalence of newborn prophylaxis is nearly 100%. These findings highlight the favorable effectiveness of the PMTCT program for HIV in Iran. Nonetheless, it remains unclear how the

original studies have managed to account for all pregnant women, both those receiving care and those who are not.

The World Health Organization recommends that all mothers with HIV receive ART during pregnancy. In this review, the pooled proportion of ART in pregnant women was 94% [31]. ART for pregnant women with HIV is essential for preserving maternal health and preventing perinatal and sexual HIV transmission. Approximately

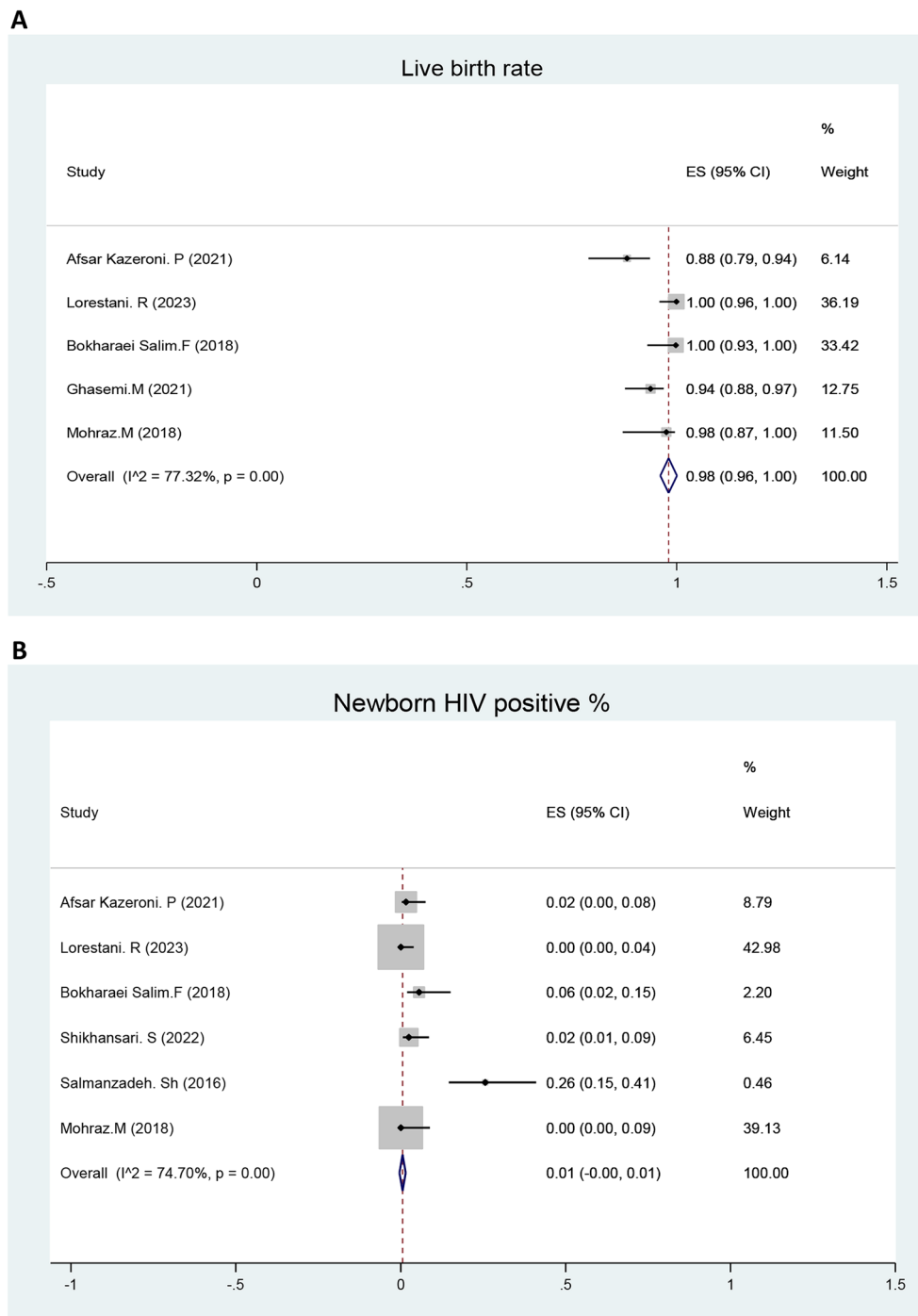


Fig. 4 Meta-analysis of live birth rate (A) and HIV positive in newborns (B) of pregnant women infected with HIV

15% to 40% of pregnant or breastfeeding HIV-positive individuals will have HIV-infected children without ART. However, using ART early in pregnancy with sustained viral suppression reduces the risk of perinatal and postpartum transmission to less than 2%. Antiretroviral therapy is being received by about 81% of pregnant people with HIV worldwide currently [32–34]. In a study involving 104 pregnant women in Romania, the prevalence of

HIV-infected infants was 14.7%, whereas no HIV infections occurred among women receiving ART [35]. Therefore, administering ART during pregnancy is crucial for preventing MTCT of HIV and ensuring the health of HIV-positive mothers.

A study conducted in Namibia in 2020 revealed that the proportion of MTCT was 33.6% among pregnant mothers who did not receive ART [36]. Approximately 15% to

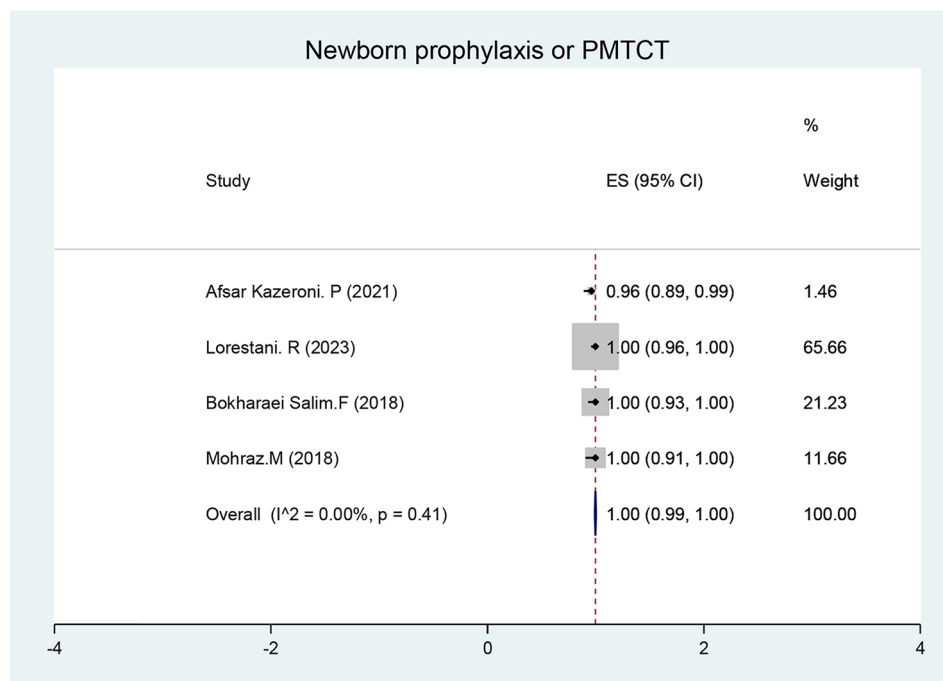


Fig. 5 Meta-analysis of newborn prophylaxis and/or PMTCT among HIV infected newborn infants PMTCTP: prevention of mother-to-child prevention

40% of pregnant or breastfeeding individuals with HIV will have a child who is also HIV positive if they don't receive ART. With sustained viral suppression, ART can reduce the risk of perinatal and postpartum transmission to less than 2% [32, 36].

The pooled prevalence of cesarean delivery was 88% in this review. The type of delivery is one of the most crucial considerations in PMTCT. Cesarean section prior to labor and before the rupture of membranes has been introduced as an intervention for PMTCT [37]. Some findings have recommended cesarean section for HIV-infected women who are not taking ART during pregnancy or are taking only zidovudine for PMTCT of HIV [37]. However, another study suggested that HIV-infected women on ART therapy with a low viral load can safely choose vaginal delivery in the absence of obstetrical risk factors [38].

In this meta-analysis, the summary measure of HIV positivity among spouses/partners of HIV-infected pregnant women was 78%. Furthermore, our findings indicated that the primary method of virus transmission in the majority of infected pregnant women was through an infected spouse and/or partner. Therefore, screening of infected spouses and administering ART therapy to them is essential to prevent HIV transmission [39]. In the study by Lorestani et al., 79% of HIV transmissions were reported to be from their spouse [22].

Limitations

The outcome of HIV infection in pregnant women in Iran is indicated in this first systematic review and meta-analysis. However, the current study had limitations. The primary concern was the insufficient number of studies and the absence of cohort studies or studies with a control group (healthy pregnant women) to estimate effect sizes such as odds ratios and risk ratios.

It seems there are few published articles on pregnant women with HIV in Iran, so patients outside the national health system may have been referred to centers or private physicians and thus not identified by the health system.

Conclusion

Although most pregnant women with HIV are enrolled in the PMTCT program and adverse pregnancy and neonatal outcomes are uncommon, longitudinal and population-based studies are still needed for a clearer understanding of the situation of pregnant women with HIV in Iran.

It is recommended to improve registration and identification of mothers with HIV infection by reducing social stigma, increasing access, and strengthening intersectoral cooperation — especially by obtaining patient data from other centers and private physicians — as well as facilitating and conducting research among this vulnerable group. This can serve as a starting point for enhancing the care system and expanding published data.

Abbreviations

ART	Antiviral therapy
CI	Confidence interval
HIV	Human immunodeficiency virus
PMTCT	Prevention of mother-to-child transmission
MTCT	Mother-to-child transmission
HF	Health facilities
HW	Health workers
RDT	Rapid diagnostic tests
WHO	World Health Organization

Acknowledgements

The authors would like to thank statistical supports of "Clinical Research Development Unit of Al-Zahra Hospital" at Tabriz University of Medical Sciences.

Author contributions

HA was responsible for designing this review study. All authors contributed to conceiving the study, conducting searches, extracting relevant records, and synthesizing the data that informed the manuscript, or they played a significant role in acquiring, analyzing, and interpreting the data, or both. The manuscript was drafted by all authors, who also provided substantial suggestions for revision. The final submitted version was approved by all authors.

Funding

The study was funded by Tabriz University of Medical Sciences (Grant number: 73543).

Data availability

The datasets generated and/or analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

This study was approved by ethics committee of Tabriz university of Medical Sciences to number: IR.TBZMED.REC.1403.112. No primary data were collected for this study.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

Received: 6 October 2024 / Accepted: 21 November 2025

Published online: 25 November 2025

References

- Esmaili ED, Azizi H, Dastgiri S, Kalankesh LR. Does telehealth affect the adherence to ART among patients with HIV? a systematic review and meta-analysis. *BMC Infect Dis*. 2023;23:169.
- Jahagirdar D, Walters MK, Novotney A, Brewer ED, Frank TD, Carter A, Biehl MH, Abbastabar H, Abhilash E, Abu-Gharbieh E. Global, regional, and national sex-specific burden and control of the HIV epidemic, 1990–2019, for 204 countries and territories: the global burden of diseases study 2019. *Lancet HIV*. 2021;8:e633–51.
- Mehrabi F, Karamouzian M, Farhoudi B, Moradi Falah Langeroodi S, Mehmandoust S, Abbaszadeh S, Motaghi S, Mirzazadeh A, Sadeghirad B, Sharifi H. Comparison of safety and effectiveness of antiretroviral therapy regimens among pregnant women living with HIV at preconception or during pregnancy: a systematic review and network meta-analysis of randomized trials. *BMC Infect Dis*. 2024;24:417.
- Abdi F, Alimoradi Z, Alidost F. Pregnancy outcomes and effects of antiretroviral drugs in HIV-positive pregnant women: a systematic review. *Future Virol*. 2019;14:197–210.
- Mathews C, Cheyip M, Beauclair R, Puren A, Lombard C, Jonas K, Ayalew K, Govindasamy D, Kuo C, Dietrich JJ. HIV care coverage among HIV-positive adolescent girls and young women in South africa: results from the herstory study. *South Afr Med J*. 2021;111:460–8.
- Dong Y, Guo W, Gui X, Liu Y, Yan Y, Feng L, Liang K. Preventing mother to child transmission of HIV: lessons learned from China. *BMC Infect Dis*. 2020;20:1–10.
- Alemu FM, Yalew AW, Fantahun M, Ashu EE. Antiretroviral therapy and pregnancy outcomes in developing countries: a systematic review. *Int J MCH AIDS*. 2015;3:31.
- Cardenas MC, Farnan S, Hamel BL, Mejia Plazas MC, Sintim-Aboagye E, Littlefield DR, Behl S, Punia S, Enninga EAL, Johnson E. Prevention of the vertical transmission of HIV; A recap of the journey so far. *Viruses*. 2023;15:849.
- Salmanzadeh S, Nashibi R, Mahmoudi E, Fazeli MA, Maniavi F. Investigating the impacts of medicinal prevention with antiretroviral drugs in pregnant mothers with HIV on HIV transmission to infants in Khuzestan Province. *Int J Pharm Res ALLIED Sci*. 2016;5:407–11.
- Miranda AE, Santos PC, Coelho RA, Pascom ARP, de Lannoy LH, Ferreira ACG, Gaspar PC, Maciel EL, Barreira D, Pereira GFM. Perspectives and challenges for mother-to-child transmission of HIV, hepatitis B, and syphilis in Brazil. *Front Public Health*. 2023;11:1182386.
- Kissin DM, Mandel MG, Akatova N, Belyakov NA, Rakhmanova AG, Voronin EE, Volkova GV, Yakovlev AA, Jamieson DJ, Vitek C. Five-year trends in epidemiology and prevention of mother-to-child HIV transmission, St. Petersburg, russia: results from perinatal HIV surveillance. *BMC Infect Dis*. 2011;11:1–11.
- Sajadi L, Mirzazadeh A, Navadeh S, Osooli M, Khajehkazemi R, Gouya MM, Fahimfar N, Zamani O, Haghdoost AA. HIV prevalence and related risk behaviours among female sex workers in iran: results of the National biobehavioural survey, 2010. *Sex Transm Infect*. 2013;89:iii37–40.
- Kazeroni PA, Gouya MM, Tira M, Sargolzaie M, Eybpoosh S, Majdfar Z, Zareie B, Rasouli MA, Ghaderi E. Prevention of mother-to-child HIV transmission program in Iran. *BMC Public Health*. 2021;21:1–8.
- Mohammadi Y, Mirzaei M, Shirmohammadi-Khorram N, Farhadian M. Identifying risk factors for late HIV diagnosis and survival analysis of people living with HIV/AIDS in Iran (1987–2016). *BMC Infect Dis*. 2021;21:390.
- Sharifi H, Mirzazadeh A, Shokoohi M, Karamouzian M, Khajehkazemi R, Navadeh S, Fahimfar N, Danesh A, Osooli M, McFarland W. Estimation of HIV incidence and its trend in three key populations in Iran. *PLoS ONE*. 2018;13:e0207681.
- Haddad LB, Wall KM, Mehta CC, Golub ET, Rahangdale L, Kempf MC, Karim R, Wright R, Minkoff H, Cohen M, et al. Trends of and factors associated with live-birth and abortion rates among HIV-positive and HIV-negative women. *Am J Obstet Gynecol*. 2017;216:71.e1–71.e16.
- Mohraz M, Salary P, Afshar ZR, Bayanolhagh S, Hajabdolbaghi M, Aminabad FJ, Mirzapour P, Jozani ZB, Moalemi S. Drugs side effects in pregnant women infected with HIV referred to Imam Khomeini Hospital, voluntary counseling and testing center Tehran, Iran 2009–2013. *J Therapy Manage HIV Infect*. 2018;6:23–7.
- Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, Shamseer L, Tetzlaff JM, Akl EA, Brennan SE. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ*. 2021, 372.
- Zeng X, Zhang Y, Kwong JS, Zhang C, Li S, Sun F, Niu Y, Du L. The methodological quality assessment tools for preclinical and clinical studies, systematic review and meta-analysis, and clinical practice guideline: a systematic review. *J evidence-based Med*. 2015;8:2–10.
- Azizi H, Majdzadeh R, Ahmadi A, Esmaili ED, Naghili B, Mansournia MA. Health workers readiness and practice in malaria case detection and appropriate treatment: a meta-analysis and meta-regression. *Malar J*. 2021;20:420.
- Wells GA, Shea B, O'Connell D, Peterson J, Welch V, Losos M, Tugwell P. The Newcastle–Ottawa Scale (NOS) for assessing the quality of nonrandomised studies in meta-analyses. Oxford: University of Oxford; 2000.
- Lorestani RC, Rostamian M, Akya A, Rezaeian S, Afsharian M, Habibi R, Bozorgomid A, Kazemisafa N, Jafari S, Yeilaghi S. Prevention of mother-to-child transmission of HIV in Kermanshah, West of Iran from 2014 to 2021. *BMC Pediatr*. 2023;23:29.
- Bokharaei-Salim F, Kalantari S, Gholampour Z, Najafi A, Keyvani H, Esghaei M, Monavari SH, Khanaliha K, Bastani M-N, Fakhim A. Investigation of the effects of a prevention of mother-to-child HIV transmission program among Iranian neonates. *Arch Virol*. 2018;163:1179–85.
- Shikhansari S, Khalesi ZB, Rad EH. Factors associated with the reproductive health of women living with HIV in Iran. *Eur J Obstet Gynecol Reproductive Biology*: X. 2022;13:100136.
- Ghasemi M, Javadnoori M, Cheraghian B, Abbaspoor Z. HIV* women's reproductive and sexual health in iran: studying samples referring to behavioral diseases counseling centers. *J Adv Pharm Educ Res*. 2021;11:150–6.

26. WHO. Guidelines for the treatment of malaria. World Health Organization; 2015.
27. Esmaili ED, Azizi H, Sarbazi E, Khodamoradi F. The global case fatality rate due to COVID-19 in hospitalized elderly patients by sex, year, gross domestic product, and continent: A systematic review, meta-analysis, and meta-regression. *New Microbes New Infections*. 2023;51:101079.
28. Barral MF, Oliveira GRd, Lobato RC, Mendoza-Sassi RA, Martínez AM, Gonçalves CV. Risk factors of HIV-1 vertical transmission (VT) and the influence of antiretroviral therapy (ART) in pregnancy outcome. *Revista Do Instituto De Medicina Tropical De São Paulo*. 2014;56:133–8.
29. Bassey EA, Abasiubong F, Ekanem U, Abasiatai AM. Attitude of antenatal attendees to people living with HIV/AIDS in Uyo, south-south Nigeria. *Afr Health Sci*. 2007;7.
30. Graybill LA, Kasaro M, Freeborn K, Walker JS, Poole C, Powers KA, Mollan KR, Rosenberg NE, Vermund SH, Mutale W. Incident HIV among pregnant and breast-feeding women in sub-Saharan africa: a systematic review and meta-analysis. *Aids*. 2020;34:761–76.
31. World Health Organization. Adapting WHO normative HIV guidelines for national programmes: essential principles and processes Geneva: World Health Organization; 2011.
32. Eke AC, Lockman S, Mofenson LM. Antiretroviral treatment of HIV/AIDS during pregnancy. *JAMA*. 2023;329:1308–9.
33. Zash R, Jacobson DL, Diseko M, Mayondi G, Mmalane M, Essex M, Petlo C, Lockman S, Makhema J, Shapiro RL. Comparative safety of antiretroviral treatment regimens in pregnancy. *JAMA Pediatr*. 2017;171:e172222.
34. Omonaiye O, Kusljic S, Nicholson P, Manias E. Medication adherence in pregnant women with human immunodeficiency virus receiving antiretroviral therapy in sub-Saharan africa: a systematic review. *BMC Public Health*. 2018;18:805.
35. Lăzureanu V, Moisil T, Musta V, Costa R. Retrospective study on HIV infected pregnant women and their babies in the western part of romania. *BMC Infect Dis*. 2013;13:O11.
36. Agabu A, Baughman AL, Fischer-Walker C, de Klerk M, Mutenda N, Rusberg F, Diergaardt D, Pentikainen N, Sawadogo S, Agolory S. National-level effectiveness of ART to prevent early mother to child transmission of HIV in Namibia. *PLoS ONE*. 2020;15:e0233341.
37. Read JS, Newell ML, CHART Group. Efficacy and safety of cesarean delivery for prevention of mother-to-child transmission of HIV-1. *Cochrane Database Syst Rev*. 2011.
38. Briand N, Jasseron C, Sibiude J, Azria E, Pollet J, Hammou Y, Warszawski J, Mandelbrot L. Cesarean section for HIV-infected women in the combination antiretroviral therapies era, 2000–2010. *Am J Obstet Gynecol*. 2013;209:335.e331–335. e312.
39. Ngangue P, Fleurantin M, Adekpedjou R, Philibert L, Gagnon M-P. Involvement of male partners of pregnant women in the prevention of mother-to-child transmission (PMTCT) of HIV in haiti: a mixed-methods study. *Am J Men's Health*. 2021;15:15579883211006003.

Publisher's note

Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.