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EARLY INTERVENTION, LIFELONG PROTECTION: REVIEW OF HIV PREVENTION IN CHILDREN UNDER FIVE

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ABSTRACT

Human immunodeficiency virus (HIV) remains a significant threat to child health globally, with children under five years particularly vulnerable to infection primarily via mother-to-child transmission (MTCT). Early intervention strategies targeting both maternal health and infant care have been pivotal in reducing new pediatric HIV cases. Lifelong protection for these children hinges on timely diagnosis, sustained antiretroviral therapy (ART), and integrated health services that address biological, social, and systemic challenges. This review explores current practices, challenges, and innovations in pediatric HIV prevention, focusing on early intervention and long-term management to improve survival and quality of life for children at risk. Effective prevention of HIV in children under five involves a comprehensive approach that includes maternal ART during pregnancy and breastfeeding, infant antiretroviral prophylaxis, and early infant diagnosis (EID). The integration of these interventions within maternal and child health services has led to substantial declines in pediatric HIV incidence globally. However, barriers such as late maternal diagnosis, poor ART adherence, limited access to early infant testing, and socio-cultural challenges continue to impede progress. Emerging technologies and community-driven approaches provide promising avenues for enhancing pediatric HIV prevention. Innovations in long-acting ART formulations, point-of-care diagnostics, and digital health platforms facilitate adherence, early detection, and continuity of care. Addressing systemic challenges through integrated, patient-centered care models and strengthening community support are essential to achieving the global goal of an HIV-free generation under five years of age.

Keywords: *Pediatric HIV prevention, Early infant diagnosis, Mother-to-child transmission, Antiretroviral therapy, Lifelong HIV care*

Introduction

Human immunodeficiency virus (HIV) infection in children under five years remains a significant global health concern, despite remarkable progress in the fight against the epidemic. Pediatric HIV is predominantly acquired through mother-to-child transmission (MTCT), which can occur during pregnancy, labor, delivery, or breastfeeding [1-2]. Without intervention, the risk of MTCT ranges from 15% to 45%, but this risk can be reduced to below 5% with effective prevention strategies. Early intervention and lifelong protection for these children are essential not only to prevent new infections but also to ensure optimal growth, development, and survival for those already infected [3-4]. The global scale-up of antiretroviral therapy (ART) has transformed the landscape of pediatric HIV prevention. Programs such as the World Health Organization's (WHO) Option B+, which recommends lifelong ART for all pregnant and breastfeeding women living with HIV, have been critical in achieving viral suppression and drastically reducing transmission rates. Nonetheless, disparities in access to ART, especially in low- and middle-income countries, and challenges related to retention in care, adherence, and timely diagnosis of infants continue to limit the full potential of these interventions [5-6].

Early infant diagnosis (EID) plays a pivotal role in the prevention and management of pediatric HIV. Prompt identification of HIV-exposed infants enables immediate initiation of ART, which is crucial for reducing infant mortality and morbidity.

However, the traditional EID approach, reliant on centralized laboratories, often results in delayed diagnosis and loss to follow-up. Innovations such as point-of-care (POC) testing have improved turnaround times and accessibility, especially in resource-limited settings, but universal implementation remains a work in progress [7-8]. Infant antiretroviral prophylaxis complements maternal ART by providing an additional protective barrier against HIV transmission during labor and breastfeeding. The choice of prophylactic regimen, timing, and duration depend on the maternal viral load and infant feeding practices. This tailored approach requires a well-functioning health system and effective counseling to ensure adherence and mitigate risks associated with drug toxicity or resistance [9-10].

Beyond biomedical interventions, social determinants of health, including stigma, poverty, gender inequality, and lack of education, significantly affect the uptake and success of pediatric HIV prevention programs. Community engagement, male partner involvement, and culturally sensitive health education are necessary to overcome these barriers and support sustained adherence to prevention and treatment protocols. Strengthening community health systems and mobilizing peer support networks have demonstrated positive impacts on maternal and infant health outcomes [11-12]. Innovations in technology and service delivery are reshaping pediatric HIV prevention. Long-acting antiretroviral formulations, mobile health applications, and integrated mother-child health services enhance

adherence, improve early diagnosis, and promote retention in care. These advances offer opportunities to overcome logistical challenges and improve equity in access to care, especially in underserved populations [13-14].

Aim

This review aims to comprehensively examine current strategies, innovations, and challenges in preventing HIV infection among children under five years of age, with a particular focus on the roles of maternal health interventions, infant prophylaxis, early diagnosis, and integrated community and health system support.

Methods

This narrative review was conducted to synthesize current evidence on HIV prevention in children under five, focusing on vertical transmission, early infant diagnosis, antiretroviral prophylaxis, breastfeeding, and community interventions. Comprehensive searches were performed across PubMed, Scopus, Web of Science, and Google Scholar for publications up to the most recent available literature. Keywords included combinations of HIV, pediatric HIV, PMTCT, early infant diagnosis, ART, breastfeeding, and child health interventions. Eligible sources included original research, observational studies, systematic and narrative reviews, clinical guidelines, and reports from international organizations. Case reports were included when higher-level evidence was limited. Selection was based on relevance to pediatric HIV prevention strategies and outcomes. Data extraction focused on study setting, population, intervention type, outcomes,

and implementation challenges. A qualitative synthesis approach was adopted due to heterogeneity in study designs.

Maternal Interventions for Prevention of Vertical Transmission

Prevention of mother-to-child transmission (PMTCT) of HIV begins with optimizing maternal health, which is fundamental to protecting infants from acquiring the virus. The cornerstone of maternal intervention is the initiation and maintenance of antiretroviral therapy (ART) during pregnancy and breastfeeding. Effective maternal ART suppresses the viral load to undetectable levels, significantly reducing the risk of vertical transmission to less than 2% when adherence is sustained. The widespread adoption of the World Health Organization's Option B+, which recommends lifelong ART for all HIV-positive pregnant and breastfeeding women regardless of CD4 count or clinical stage, has been pivotal in expanding access and simplifying treatment protocols worldwide [15-16]. Early and repeated HIV testing during antenatal care is essential to identify HIV-positive women promptly and link them to care. This includes routine testing at the first antenatal visit and re-testing later in pregnancy or during breastfeeding, particularly in high-prevalence settings where seroconversion can occur. Early diagnosis enables timely initiation of ART, which is most effective when started before conception or as early as possible during pregnancy. Alongside ART, comprehensive antenatal services must include counseling on adherence, nutrition, management of co-infections (such as tuberculosis and

sexually transmitted infections), and preparation for safe delivery practices [17]. Despite advances in ART access, challenges remain in ensuring consistent maternal adherence and retention in care throughout pregnancy and the breastfeeding period. Factors such as stigma, socioeconomic constraints, and health system barriers can impede sustained treatment, increasing the risk of transmission. Interventions such as peer support groups, community health worker engagement, and integration of PMTCT services within routine maternal and child health care can improve adherence and retention. Additionally, male partner involvement in antenatal care has been associated with better maternal ART adherence and reduced MTCT rates, highlighting the importance of family-centered approaches [18-19].

Safe delivery practices are another critical aspect of maternal intervention. Elective cesarean section before labor onset and rupture of membranes can reduce MTCT risk in cases where maternal viral load is not fully suppressed. However, in resource-limited settings, access to surgical delivery may be limited, making viral suppression through ART even more crucial. Postnatal care must emphasize continued ART adherence during breastfeeding, as the virus can be transmitted through breast milk. WHO guidelines recommend exclusive breastfeeding with maternal ART for the first six months, followed by continued breastfeeding with appropriate complementary feeding up to 12 months or longer, balancing the benefits of breastfeeding against the risk of HIV transmission (Table 1) [20-21].

Table 1: Maternal Interventions for Prevention of Vertical HIV Transmission

Intervention	Timing/Target Population	Mechanism of Action	Clinical Outcome
Antiretroviral Therapy (ART)	HIV-positive pregnant women (all trimesters)	Suppresses maternal viral load, reducing transplacental and perinatal exposure	Decreased in utero and intrapartum transmission rates
Maternal Viral Load Monitoring	Throughout pregnancy	Identifies women requiring intensified ART or regimen adjustment	Optimizes viral suppression, lowers transmission risk
Treatment of Opportunistic Infections	During pregnancy	Reduces maternal immune activation and viral replication	Indirectly reduces vertical transmission risk
Nutritional Support	Pregnancy and lactation	Supports immune function and ART efficacy	Improves maternal health, indirectly reducing transmission
Pre-Exposure Prophylaxis for High-Risk Mothers	HIV-negative but at high risk	Reduces maternal acquisition during pregnancy	Prevents seroconversion and vertical transmission
Safe Delivery Practices	Labor and delivery	Minimizes exposure to maternal blood and secretions	Reduces intrapartum transmission
Counseling on ART Adherence	Throughout pregnancy and postpartum	Ensures consistent drug intake	Sustained viral suppression, reduced vertical transmission
Education on	Postpartum	Promotes exclusive	Reduces postnatal

Breastfeeding and ART		breastfeeding with maternal ART adherence	transmission while supporting child nutrition
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Infant Prophylaxis and Early Diagnosis

Infant antiretroviral prophylaxis plays a vital role in preventing HIV transmission during and after birth, providing an additional protective layer alongside maternal antiretroviral therapy (ART). Administering prophylactic antiretrovirals to newborns soon after delivery reduces the risk of viral acquisition during labor, delivery, and breastfeeding. The World Health Organization recommends daily nevirapine

or zidovudine for HIV-exposed infants, with the duration and regimen tailored based on the mother's viral load status and breastfeeding practices. For infants whose mothers have achieved viral suppression, a shorter prophylaxis course may be sufficient, while infants exposed to unsuppressed maternal viral loads or mixed feeding require extended prophylaxis to minimize transmission risk (Table 2) [23].

Table 2: Infant Prophylaxis and Early Diagnosis

Intervention	Timing	Mechanism of Action	Clinical Outcome
Antiretroviral Prophylaxis (Nevirapine, Zidovudine, or combination)	Immediately after birth for 4–6 weeks	Prevents viral replication during high-risk early exposure	Reduced risk of HIV acquisition in exposed infants
Extended Prophylaxis for High-Risk Infants	Birth to 12 weeks	Maintains antiviral protection when maternal viral suppression is suboptimal	Further reduction in vertical transmission rates
Early Infant Diagnosis (Virological Testing)	4–6 weeks of age	Detects HIV infection using PCR-based methods	Enables prompt ART initiation and improved survival outcomes
Repeat Testing	6 months and at cessation of breastfeeding	Monitors for late postnatal transmission	Ensures early detection and treatment of new infections
Cotrimoxazole Prophylaxis	From 6 weeks until HIV status confirmed negative	Prevents opportunistic infections that can complicate HIV	Reduced morbidity and mortality among exposed infants
Infant ART Initiation	Immediately after positive virological diagnosis	Suppresses viral replication and prevents disease progression	Improved survival and long-term health outcomes

Early infant diagnosis (EID) is critical for identifying HIV infection in exposed infants promptly, allowing for timely initiation of antiretroviral therapy that significantly improves survival and reduces disease progression. Conventional EID relies on polymerase chain reaction (PCR) testing of dried blood spots, usually performed in centralized laboratories. However, delays

in specimen transport, result processing, and communication to caregivers often lead to late diagnosis and loss to follow-up, compromising outcomes. To address these challenges, point-of-care (POC) diagnostic technologies have been developed, enabling rapid, onsite testing with same-day results. This innovation facilitates immediate linkage to care and treatment

initiation, particularly in resource-limited settings where laboratory infrastructure is scarce [24-25]. Integrating EID services into routine immunization and postnatal care visits has improved coverage and retention of HIV-exposed infants in testing programs. Despite advances, barriers such as stigma, geographic accessibility, and healthcare workforce limitations persist, affecting early diagnosis rates. Strengthening health systems to ensure supply chain reliability for testing kits, training of healthcare workers, and community-based support for caregivers is crucial to maximize the benefits of EID. In addition, educating caregivers about the importance of follow-up testing at 6 weeks and beyond during breastfeeding is vital to detect postnatal infections early [26].

Innovations in Pediatric HIV Prevention

The landscape of pediatric HIV prevention is rapidly evolving with the introduction of innovative strategies that address the limitations of traditional approaches. One of the most promising advancements is the development of long-acting antiretroviral formulations, including injectable agents that offer extended drug release over weeks or months. These formulations have the potential to improve adherence by reducing the frequency of dosing for both mothers and infants, thereby lowering the risk of missed doses that can lead to viral replication and transmission. Clinical trials investigating long-acting cabotegravir and rilpivirine, among others, are ongoing, with preliminary results showing favorable safety and efficacy profiles in adults, and adaptation for pediatric use is anticipated [27-28].

Point-of-care (POC) technologies continue to revolutionize early infant diagnosis (EID) by enabling rapid, accurate HIV testing at or near the site of care. These tools eliminate the delays inherent in centralized laboratory testing, allowing healthcare providers to make immediate clinical decisions and initiate timely treatment. Emerging diagnostic platforms are becoming more user-friendly, cost-effective, and capable of multiplex testing for HIV alongside other common infections, further enhancing the comprehensiveness of pediatric care in resource-limited settings. Integration of these technologies into maternal and child health services strengthens the continuum of care and reduces loss to follow-up [29-30].

Digital health solutions are also playing an increasingly important role in pediatric HIV prevention. Mobile health (mHealth) applications and SMS-based reminders support adherence to antiretroviral therapy by providing personalized alerts, educational content, and virtual support networks for caregivers. These tools have demonstrated improvements in medication adherence and retention in care, particularly in regions with high mobile phone penetration. Additionally, data systems that track mother-infant pairs through pregnancy, delivery, and postnatal periods facilitate timely interventions and program monitoring [31-32]. Integration of HIV prevention services with broader maternal, neonatal, and child health programs enhances access and efficiency. Combining HIV testing, ART provision, immunization, nutrition, and family planning into one-stop clinics reduces missed opportunities and

streamlines care delivery. Such integrated models foster stronger health system linkages and improve patient satisfaction and outcomes. Moreover, community health worker programs and peer-led support groups provide culturally sensitive education, reduce stigma, and encourage uptake of prevention services [33].

Community and Health System Strengthening

Effective prevention of pediatric HIV hinges not only on biomedical interventions but also on the robustness of community engagement and health system infrastructure. Strengthening health systems to deliver comprehensive, accessible, and quality HIV prevention services is fundamental to achieving sustained reductions in mother-to-child transmission (MTCT). This includes enhancing the capacity of healthcare facilities, ensuring consistent availability of antiretroviral drugs and diagnostic supplies, training healthcare workers, and establishing efficient referral and tracking systems to support mother-infant pairs throughout the prevention cascade [34-35]. Task shifting and decentralization of HIV services to primary healthcare and community settings have proven to increase access, especially in resource-limited environments where specialist care is scarce. By empowering nurses, midwives, and community health workers to provide HIV testing, counseling, and treatment services, health systems can better reach pregnant women and infants early in the care continuum. Furthermore, integrating HIV services with maternal, neonatal, and child health programs fosters holistic care,

reducing stigma and encouraging routine use of health services by families [36].

Community engagement is equally crucial in addressing social and cultural barriers that hinder the uptake of HIV prevention services. Stigma, misinformation, gender inequality, and poverty often discourage women from seeking antenatal care or adhering to treatment. Community-based interventions, such as peer support groups, male partner involvement programs, and culturally tailored health education campaigns, have demonstrated success in improving ART adherence, retention in care, and infant testing rates. These programs empower families with knowledge, reduce fear and discrimination, and create supportive environments conducive to lifelong HIV prevention [37]. Additionally, the involvement of community leaders, traditional birth attendants, and local organizations can enhance trust and acceptance of HIV prevention efforts. Their participation facilitates the dissemination of accurate information and mobilizes resources to support vulnerable populations. Social protection programs addressing food insecurity, transportation costs, and other socioeconomic determinants further remove barriers to accessing care [38]. Digital tools and data management systems also strengthen health system responsiveness by enabling real-time monitoring of program performance and patient outcomes. These systems help identify gaps, reduce loss to follow-up, and optimize resource allocation. Ensuring data privacy and confidentiality is essential to maintain

community trust and encourage continued engagement [39].

Conclusion

Preventing HIV infection in children under five requires a multifaceted approach that integrates early maternal interventions, effective infant prophylaxis, timely diagnosis, and sustained community and health system support. Advances in antiretroviral therapy and innovative diagnostic technologies have significantly reduced mother-to-child transmission rates, yet challenges in adherence, retention, and equitable access remain. Addressing these gaps through holistic strategies that combine biomedical, behavioral, and structural interventions is essential for achieving the global goal of an HIV-free generation. Maternal health optimization through early HIV diagnosis and lifelong ART initiation remains the cornerstone of pediatric HIV prevention. Complementing this, infant prophylaxis and early infant diagnosis ensure prompt protection and treatment initiation, improving survival and long-term outcomes. Innovations such as long-acting antiretrovirals, point-of-care testing, and digital health tools offer promising avenues to overcome persistent barriers and enhance program effectiveness.

Conflicts of Interest

The author declares no conflict of interest

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Abbreviations

ART – Antiretroviral Therapy

EID – Early Infant Diagnosis

HIV – Human Immunodeficiency Virus

LMICs – Low- and Middle-Income Countries

MTCT – Mother-to-Child Transmission

PMTCT – Prevention of Mother-to-Child Transmission

PrEP – Pre-Exposure Prophylaxis

WHO – World Health Organization

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