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Preventing HIV in Infancy and Early Childhood: The Role of Maternal Health and Infant Care

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Abstract

Pediatric HIV infection predominantly results from mother-to-child transmission (MTCT) during pregnancy, delivery, or breastfeeding, making prevention efforts crucial in infancy and early childhood. Maternal health plays a central role in reducing transmission risk, as consistent use of antiretroviral therapy (ART) suppresses maternal viral load, which is the primary driver of vertical HIV transmission. Early diagnosis of HIV in pregnant women and initiation of lifelong ART significantly reduce pediatric infections and improve maternal outcomes. Infant care strategies complement maternal interventions through the administration of antiretroviral prophylaxis shortly after birth and during breastfeeding to protect HIV-exposed infants. Early infant diagnosis (EID) enables timely detection of infection and prompt initiation of treatment, critical for reducing infant morbidity and mortality. Innovations such as point-of-care diagnostic technologies and extended prophylactic regimens are enhancing access to care, particularly in resource-limited settings, by reducing delays and improving adherence. Integrated approaches that combine maternal health services, infant care, and community support are essential to sustaining prevention efforts. Addressing social determinants of health, stigma, and healthcare access barriers, alongside emerging long-acting drug formulations and digital health interventions, can further improve outcomes. Collectively, these strategies advance the goal of eliminating pediatric HIV and ensuring healthy development for children born to HIV-positive mothers.

Keywords: Pediatric HIV prevention, Maternal health, Early infant diagnosis, Antiretroviral therapy, Community support

Introduction

Human immunodeficiency virus (HIV) infection in infants and young children remains a major global health concern, especially in sub-Saharan Africa and other resource-limited settings. Despite significant advances in prevention and treatment, pediatric HIV continues to cause substantial morbidity and mortality. The majority of HIV infections in children under five years of age result from mother-to-child transmission (MTCT) during pregnancy, labor, delivery, or breastfeeding. Without any intervention, the risk of MTCT ranges from 15% to 45%, underscoring the critical need for effective prevention strategies focused on both maternal and infant health [1-2].Preventing pediatric HIV infection is complex and multifaceted, requiring interventions targeted at different stages of the perinatal period. Maternal viral load is the single most important predictor of transmission risk, making the health and treatment of HIV-positive mothers central to pediatric HIV prevention. The implementation of antiretroviral therapy (ART) during pregnancy and breastfeeding has been shown to dramatically reduce the risk of vertical transmission by suppressing maternal viral replication. The World Health Organization's (WHO) recommendation of lifelong ART for all pregnant and breastfeeding women living with HIV, known as Option B+, has expanded ART access and significantly decreased MTCT rates worldwide [3-5].

However, numerous challenges remain that compromise the full potential of maternal ART in preventing pediatric HIV. Late HIV diagnosis during pregnancy, suboptimal adherence to therapy, drug resistance, and poor retention in care are common obstacles. Furthermore, social determinants such as stigma, gender inequality, and poverty often hinder women's ability to engage consistently in care. These factors highlight the need for comprehensive maternal health services that integrate clinical care with psychosocial support and community engagement [6-7].Infant care is an equally important component of pediatric HIV prevention. Infants born to HIV-positive mothers require antiretroviral prophylaxis during the early post natal period to reduce the risk of infection acquired during delivery and breastfeeding. Early infant diagnosis (EID) using molecular techniques is crucial for detecting HIV infection in exposed infants. Timely diagnosis allows for the prompt initiation of ART, which markedly improves survival and long-term health outcomes. Unfortunately, many infants in high-burden regions face delays in diagnosis due to limited laboratory capacity, logistical challenges, and loss to follow-up [8-9].

Recent technological innovations in point-of-care (POC) diagnostic tools have the potential to revolutionize early infant diagnosis by providing rapid, on-site results, enabling immediate clinical decision-making. Similarly, new prophylactic drug formulations, including long-acting antiretrovirals, are being developed to simplify dosing and improve adherence. These advances, combined with the integration of maternal and child health services, hold promise for closing gaps in prevention and care [10-11].In addition to biomedical interventions, the role of community support and engagement cannot be overstated. Addressing barriers such as stigma and gender dynamics through male partner involvement, peer support groups, and community health workers enhances adherence and retention. Moreover, leveraging digital health platforms can improve communication and follow-up, particularly in underserved populations. A holistic approach that combines maternal health optimization, infant prophylaxis and diagnosis, and community-based strategies is essential to achieve the global target of an HIV-free generation under five years old [12-14].

Maternal Health and Prevention of Vertical Transmission

Preventing mother-to-child transmission (MTCT) of HIV begins with ensuring optimal maternal health, as the viral load in the mother is the principal determinant of transmission risk. Effective suppression of HIV replication through consistent and early initiation of antiretroviral therapy (ART) is the cornerstone of vertical transmission prevention. Maternal ART reduces

viral load to undetectable levels, significantly lowering the likelihood of the virus crossing the placental barrier during pregnancy, exposure during labor, or through breast milk [15-16].The World Health Organization's Option B+ strategy, which recommends lifelong ART for all pregnant and breastfeeding women living with HIV regardless of their CD4 count or clinical stage, has been a transformative approach in reducing pediatric HIV infections globally. This approach simplifies treatment guidelines and promotes sustained maternal viral suppression, reducing the risk of transmission throughout pregnancy and breastfeeding. Additionally, antenatal care (ANC) platforms serve as critical points for early HIV testing, linkage to care, and counseling, ensuring that women receive ART as early as possible during pregnancy [17-19].

Despite these advances, challenges remain in achieving universal viral suppression among pregnant women. Late presentation to care, loss to follow-up, suboptimal ART adherence, and socioeconomic barriers including stigma and poverty impede the effectiveness of prevention programs. Moreover, co-infections such as tuberculosis or sexually transmitted infections and nutritional deficiencies may compromise maternal immune function, increasing transmission risk. Comprehensive maternal care thus requires a multifaceted approach encompassing clinical management, psychosocial support, adherence counseling, and addressing social determinants of health [20-21].Maternal adherence to ART during breastfeeding is particularly critical, as breastfeeding accounts for a substantial proportion of postnatal HIV transmissions. Continuous maternal ART during the breastfeeding period drastically reduces viral shedding in breast milk, lowering transmission risk. Counseling on infant feeding options aligned with WHO recommendations supports mothers in making informed decisions balancing the benefits of breastfeeding with transmission risk [22-23].Routine maternal viral load monitoring throughout pregnancy and breastfeeding is essential for timely detection of virologic failure, allowing for prompt intervention through regimen adjustment or enhanced adherence support. Integration of viral load testing into antenatal and postnatal services is increasingly prioritized to optimize maternal outcomes and prevent pediatric HIV [24].

Infant Care: Antiretroviral Prophylaxis and Early Diagnosis

Complementing maternal interventions, infant care plays a critical role in preventing HIV infection during infancy and early childhood. Antiretroviral prophylaxis for newborns exposed to HIV is a standard practice designed to provide additional protection against infection acquired during labor, delivery, or breastfeeding. The administration of prophylactic drugs such as nevirapine or zidovudine shortly after birth, typically continued for several weeks, has been shown to reduce the risk of vertical transmission significantly, especially in cases where maternal viral suppression may be incomplete [25-26].The timing, duration, and choice of prophylactic regimen depend on maternal viral load status and breastfeeding practices. Infants born to mothers who are virally suppressed may receive shorter prophylaxis courses, while those with higher risk due to unsuppressed maternal viral load or mixed feeding practices may require extended prophylaxis throughout the breastfeeding period. These tailored approaches help optimize protection while balancing drug exposure and potential toxicity [27].

Early infant diagnosis (EID) is another crucial pillar in pediatric HIV prevention. Detecting HIV infection in exposed infants as early as possible allows for the prompt initiation of antiretroviral therapy, which substantially improves clinical outcomes, reduces mortality, and prevents disease progression. Conventional diagnostic methods such as polymerase chain reaction (PCR) testing of dried blood spots are highly accurate but often suffer from delays due to centralized laboratory processing and logistical challenges in resource-limited settings [28-29].To address these barriers, point-of-care (POC) diagnostic technologies have been developed, enabling rapid on-site HIV testing of infants with results available within hours. This innovation facilitates immediate

clinical decision-making and initiation of ART when necessary, reducing loss to follow-up and improving retention in care. Integrating EID with routine immunization visits and postnatal care services further enhances coverage and timely diagnosis [30].

Innovations and Integrated Approaches

Recent advances in biomedical technology and healthcare delivery are reshaping the landscape of pediatric HIV prevention, providing new tools to overcome existing barriers and improve outcomes. Innovations in antiretroviral drug formulations, diagnostic technologies, and service integration are helping to streamline prevention efforts and increase accessibility for both mothers and infants, particularly in resource-limited settings [31-32].Long-acting antiretroviral formulations represent a promising development that could transform HIV prevention in infants and breastfeeding mothers. Injectable or implantable drugs that maintain effective drug levels for weeks or months could reduce the need for daily oral medication, thereby improving adherence and minimizing the risk of missed doses. Such formulations are currently under investigation for adult use and hold potential for adaptation in maternal and pediatric populations, offering a simpler and more effective prophylactic regimen [33].On the diagnostic front, point-of-care (POC) testing for early infant diagnosis is revolutionizing pediatric HIV care by providing rapid, on-site results. These technologies bypass the delays associated with centralized laboratory testing, allowing healthcare providers to immediately identify HIV-positive infants and initiate treatment without delay. Coupled with mobile health applications and digital platforms, POC testing enhances patient tracking and follow-up, reducing loss to care and improving retention rates [34-35].

Integrated service delivery models are also critical in optimizing prevention of mother-to-child transmission (PMTCT) programs. Combining maternal HIV services with antenatal care, immunization clinics, and routine child health visits minimizes missed opportunities for testing, treatment, and counseling. This “one-stop-shop” approach fosters continuity of care, reduces stigma by normalizing HIV services within general healthcare, and improves maternal and infant health outcomes. Training healthcare workers to provide comprehensive maternal and pediatric HIV care enhances service quality and patient satisfaction [36-37].Community engagement and support are essential components of integrated approaches. Involving male partners, community leaders, and peer support groups helps address social and cultural barriers, promotes adherence to ART, and encourages early infant diagnosis. Health education campaigns and stigma reduction initiatives further empower families to access and remain in care [38].

Conclusion

Preventing HIV infection in infancy and early childhood requires a comprehensive approach that prioritizes both maternal health and infant care. Effective maternal antiretroviral therapy to suppress viral load remains the cornerstone of reducing mother-to-child transmission, while infant antiretroviral prophylaxis and early diagnosis are critical to protecting exposed newborns and ensuring timely treatment. Together, these interventions have dramatically decreased pediatric HIV incidence worldwide, yet persistent challenges hinder universal success. Innovations in drug delivery, rapid point-of-care diagnostics, and integrated healthcare models hold great promise for closing existing gaps, especially in resource-limited settings where the burden of pediatric HIV is highest. Community engagement and support are equally essential for overcoming social and structural barriers, improving adherence, and fostering sustained retention in care. Multisectoral collaboration between healthcare systems, policymakers, researchers, and communities is necessary to implement these advances effectively and equitably.

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