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Eliminating Mother-To-Child HIV Transmission Will Require Major Improvements In Maternal And Child Health Services

DOI: 10.1377/hlthaff.2012.0267
HEALTH AFFAIRS 31,
NO. 7 (2012): 1489–1497

ABSTRACT Although some low- and middle-income countries have made progress toward eliminating mother-to-child transmission of HIV, others lack health systems that can deliver accessible and reliable care. We modeled how access to maternal and child health services and the effective delivery of interventions would affect efforts to eliminate HIV transmission during pregnancy and after childbirth in low- and middle-income countries. In countries with high HIV rates, our model predicts transmission rates of 19.7 percent at current levels of access and efficiency of maternal and child health and HIV treatment. Even if current treatment programs were carried out at or near perfect levels, we predict that significant residual mother-to-child transmission (7.9 percent) would remain. The model suggests that under current conditions, poor access to routine health services contributes three times more to overall mother-to-child HIV transmission than do current suboptimal levels of efficiency of anti-HIV-transmission interventions. We conclude that current efforts to optimize programs to prevent mother-to-child HIV transmission will not, on their own, eliminate HIV in newborns. Access to maternal and child health services will need to be dramatically improved, as will prevention measures, such as identifying and treating HIV before pregnancy.

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Much progress has been made to address the HIV/AIDS epidemic that has claimed so many lives around the world. Nonetheless, an additional 2.7 million people were infected with HIV in 2010, and 14 percent of those were infants and children.[1] The President's Emergency Plan for AIDS Relief (PEPFAR) was established in 2003 as a direct response to the AIDS epidemic in developing countries. Through PEPFAR funding, treatment programs to prevent mother-to-child transmission of HIV have helped reduce the number of new HIV infections in infants transmitted from their mothers during pregnancy, childbirth, and breast-feeding.[2]

Global health agencies and programs, including PEPFAR, have been laying the groundwork to eliminate mother-to-child HIV transmission. They aim to reduce the number of new HIV infections in children by 90 percent and to reduce the number of AIDS-related maternal deaths by 50 percent.[3] The United Nations Millennium Development Goals include a set of ambitious targets to reduce maternal and child mortality in low- and middle-income countries by 2015.[4] These two global initiatives hold out hope that outcomes for mothers and their infants in developing countries will improve greatly over the next few years.

The clinical interventions needed to reduce new HIV infections in children and reduce maternal and child mortality are well documented, and most are inexpensive and cost-effective.[3,4]

For both areas, maternal and child health and HIV, some countries have met Millennium Development Goal targets, which suggests that these ambitious global goals can be realized.[5,6]

Global targets to reduce HIV infections in children and reduce maternal and child mortality are interlinked. However, high HIV burden in many countries is a major contributor to premature maternal and child death.[7,8] Efforts to eliminate mother-to-child HIV transmission cannot succeed where maternal and child health care services are inaccessible or services fail to deliver effective care for complex conditions such as HIV.

Countries with the highest burdens of HIV infection often have health systems that are the least capable of delivering reliable and accessible care.[9] Furthermore, in many low- and middle-income countries, the critical clinical intervention for patients with AIDS—antiretroviral therapy—is often delivered in a completely separate location from the usual maternal and child health care setting. This creates unnecessary system barriers and the potential for breakdowns in the delivery of effective care.

In this article we model how access to maternal and child health services and the effective delivery of key interventions to prevent mother-to-child transmission of HIV would affect efforts to eliminate HIV transmission during pregnancy and childbirth in low- and middle-income countries. We then discuss the implications of our findings for global efforts to improve HIV-free child survival.

Background

Mortality rates for infants and children in many low- and middle-income countries have improved over the past two decades.[10] However, progress on mortality rates for mothers and newborns has been slow,[11] and interventions to improve maternal and newborn outcomes on a large scale are lacking.[12]

The HIV epidemic in Africa has directly affected mortality rates for both mothers and children. In some countries—notably, South Africa—child mortality rates have worsened in the past decade.[11,13] Much of the deterioration can be attributed to the effects of the HIV epidemic.

Antiretroviral drugs can effectively eliminate the risk of mother-to-child HIV transmission during pregnancy and breast-feeding and can improve maternal survival.[14,15] Clinical studies have demonstrated dramatic reduction in mother-to-child HIV transmission rates among infants that receive antiretroviral therapy either before or after birth—offering hope that about 350,000 babies can be spared from HIV infection each year.[2] Antiretrovirals administered to mothers or infants can provide effective protection from HIV transmission to infants during breast-feeding.[16] This outcome allows health planners to return to actively promoting breast-feeding in all populations, providing further hope for survival of infants.

Effective implementation of lifesaving antiretroviral interventions is essential to preventing mother-to-child HIV transmission.[3] However, evidence is thin on how to effectively introduce and expand interventions to achieve this outcome. Recent data from Africa suggest improvement in reported rates of HIV testing and treatment of eligible HIV-positive women.[1] Yet despite a decade of great progress, in 2010 only 42 percent of pregnant women in sub-Saharan Africa had an HIV test, and only 60 percent of those who were eligible received some form of antiretroviral therapy.[1]

ACCESS TO MATERNAL, NEONATAL, AND INFANT CARE Prevention of mother-to-child HIV transmission in any region depends on both the ability of the local population to gain access to appropriate health services and the reliability of services actually delivered. Recent data show that lack of access to facility-based prenatal, obstetric, and postnatal care remains a major barrier to the widespread receipt of most maternal and child health services.

In 2010 a survey of sixty-eight low- and middle-income countries reported that 82 percent of pregnant women obtained prenatal care at least once.[17] Such prenatal visits offer the primary opportunity to test mothers for HIV and, if the result is positive, to deliver at least one of the main antiretroviral interventions: zidovudine therapy. Subsequent prenatal care visits provide the opportunity to administer or refer the mother for three-drug highly active antiretroviral therapy, if needed.

However, only half of pregnant women received the recommended four or more prenatal care visits, according to the survey. In the survey countries, babies were born with a skilled attendant present only 54 percent of the time.[17] Thus, almost half of the women giving birth missed the opportunity to receive two important antiretrovirals—nevirapine and zidovudine—both for themselves and for their newborns.

Further opportunities to prevent HIV transmission after childbirth occur when women and their newborns obtain postnatal care. Access to postnatal care is higher than access to prenatal care: Vaccination and vitamin A treatment rates—proxies or indicators for receipt of postnatal care—show that infants receive these services in early postnatal care visits 83 percent and 86 percent of the time, respectively.[11]

Postnatal visits are an opportunity to introduce HIV-positive mothers to medications and methods that will reduce transmission of HIV through breast-feeding, while still enabling mothers to breast-feed their infants. However, after the first immunization, postnatal care visits tend to decrease substantially,[17] thereby limiting this possible intervention opportunity.

EFFECTIVENESS OF PREVENTION PROGRAMS For the 60 percent of eligible mothers in low- and middle-income countries who reported having received antiretroviral therapy, the quality, nature, and completeness of protection from transmission is likely to be highly variable and, in many cases, ineffective.

In a review of four African national programs (those in Cameroon, Côte d'Ivoire, South Africa, and Zambia), Elizabeth Stringer and colleagues documented the steps of the mother-to-child care pathway and found that the two principal steps that were tracked—successful testing of mothers for HIV and ingestion of the antiretroviral nevirapine by HIV-positive mothers—were successful 87 percent and 76 percent of the time, respectively.[18] These averages included both the reliability of the medical process and the mother's level of compliance with the process.

At these performance levels, researchers were able to confirm definitively that mothers had ingested antiretrovirals in only 51 percent of the cases they reviewed.

Study Data And Methods

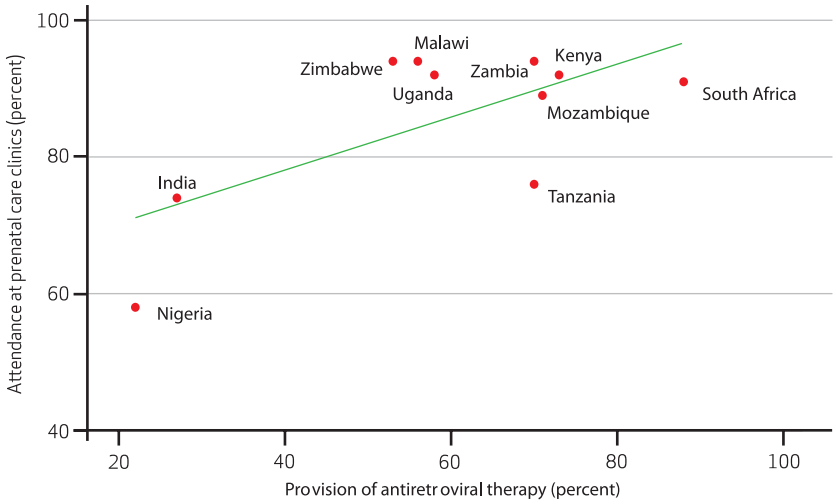
We desired to test the relationship between access to maternal health care and reported provision of antiretroviral drugs to HIV-infected pregnant women in the ten countries with the highest HIV burden in the world (South Africa, Nigeria, Mozambique, Uganda, Tanzania, Kenya, Zambia, Malawi, Zimbabwe, and India). To do so, we compared national data on receipt of prenatal care, as reported by the Countdown to 2015 Campaign—a global effort by academics and international agencies to report country progress toward the Millenium Development Goals.[17] We also used the most recent data on provision of antiretrovirals to mothers in the same countries.[1]

We created a scatterplot and used simple regression analysis to compare and quantify the rates of prenatal care provision with the reported rates of maternal antiretroviral provision in the period shortly before and after birth (Exhibit 1).

MODEL FRAMEWORK There are several routes for transmission of HIV from mothers to their infants, and multiple points for clinical intervention to prevent transmission. There are also multiple opportunities for mothers and infants to drop out of treatment.

EXHIBIT 1

Relationship Between Attendance At Prenatal Care Clinics And Provision Of Antiretroviral Therapy To Pregnant Women In Ten Countries



SOURCES World Health Organization, United Nations Children's Fund (UNICEF) (Note 17 in text); and World Health Organization, United Nations Joint Programme on HIV/AIDS (UNAIDS), UNICEF (Note 1 in text).

A model to determine the probability of mother-to-child transmission of HIV infection for a population of HIV-infected mothers depends on two key system performance attributes: the ability of mother-infant pairs to obtain maternal and child health care, and the efficiency of specific clinical interventions in preventing HIV transmission from mother to child. For example, out of 100 HIV-positive women, if only 82 attended prenatal clinics, and of those only 85 percent were tested for HIV, then only 70 percent (85 percent of 82 eligible women) would be tested for HIV. (See the online Appendix for more details.)[19]

DATA To model the current and potential states of health care systems that provide preventive and therapeutic care for pregnant women and their infants, we used aggregate data from two key sources.

For access to maternal and postnatal health care, we averaged the clinic attendance data reported for the ten countries that account for the majority of the HIV burden in the world.[17] Average receipt of one or more prenatal care visits was 85 percent, the attendance of a skilled health professional at birth was 53 percent, and receipt of one key element of postnatal care (completion of three courses of diphtheria, tetanus, and polio immunization) was 73 percent.

For program effectiveness, we used the survey by Stringer and colleagues[18] of the key processes of care for prevention of mother-to-child HIV

transmission programs in four African countries. This is the largest study available of the efficiency of systems to prevent mother-to-child transmission of HIV.

MODEL VARIABLES Mothers and infants must navigate a complex sequence of clinic visits from conception through the end of breast-feeding. Amid this complexity, multiple chances exist for them to miss out on HIV prevention if they fail to adhere to this demanding schedule. Even if they do attend clinic visits consistently, the clinic system may fail to deliver reliable preventive care.

To determine which variables had the greatest impact on HIV transmission, we modeled the relative effects of both access and efficiency on rates of mother-to-child HIV transmission for the population of HIV-infected mothers.

MODEL SCENARIOS We modeled five scenarios: first, a perfect scenario in which all mothers and infants are present for health services and receive perfect care to prevent maternal-to-child transmission 100 percent of the time; a second scenario in which mothers and infants obtain health services 95 percent of the time and receive care to prevent transmission 95 percent of the time; a third, "current state," scenario, in which access to health services is variable, ranging from 50 percent to 85 percent, and correct care to prevent transmission is given about 85 percent of the time; a fourth scenario testing the effect of variable access to services, in which mothers and infants have access 50–85 percent of the time and correct anti-transmission care is given 100 percent of the time; and a fifth scenario, in which women and infants have access to health services 100 percent of the time and reflecting current levels of anti-transmission care, or 85 percent (Exhibit 2).

We validated the model using actual country-level data on mothers' access to maternal and child health services from South Africa[20]—a country for which complete data are available on access to services, HIV program performance, and HIV transmission outcomes. Using survey data from a population of mothers attending postnatal care clinics, our model predicted an overall perinatal mother-to-child HIV transmission rate of 8.9 percent. The actual measured perinatal transmission rate in the study population was 7.1 percent.[20] (See the Appendix for more details.)[19]

The clinical transmission rates used in the model were derived from two previously reported models that identified the best studies of drug interventions for HIV-infected women during pregnancy, and for mothers and HIV-exposed infants after birth.[21,22] We updated our earlier model[22] to reflect the World Health Organization's 2010 guidelines on preventing transmission in the postnatal period during infant feeding.[23] For the purposes of the model the perinatal period (for both mother and child) encompasses pregnancy up to six weeks after delivery—the time of the recommended first HIV test for infants. (See the Appendix for more details.)

LIMITATIONS The model assumes that the clinical trial data were derived from test systems with perfect access, efficiency, and compliance. We know that this is never the case, so although well-conducted clinical trials will have very high levels of compliance, we expect that the model will overestimate transmission rates to a small degree because access to services, efficiency, and compliance will be lower in real life.

The precision of our model's predictions should also be interpreted with caution, because significant variation exists in the confidence in-

EXHIBIT 2

Modeling The Effect Of Access To And Efficiency Of Health Services On HIV Transmission Rates During Perinatal And Infancy Periods

	Mother-to-child transmission (%)			Contribution to overall mother-to-child transmission (%)		
Scenario	Overall HIV transmission, perinatal and infant (%)	Perinatal transmission only (%)	Infant transmission only (%)	Access to maternal and child care	Efficiency of PMTCT program	"Unavoidable" MTCT
Ideal state	4.0	2.0	2.0	0	0	100
Aspirational state	7.9	5.1	2.8	37	23	40
Current state	19.7	14.0	5.7	67	19	14
Test of effect of access	18.1	13.5	4.6	88	0	12
Test of effect of efficiency	10.1	6.3	3.9	0	54	46

SOURCES Transmission rates for different drug regimens during perinatal and infant periods were derived from those reported in UNAIDS Reference Group (Note 21 in text) and Barker et al. (Note 22 in text). **NOTES** The five scenarios are described in greater detail in the text. The perinatal period (for mother and infant) encompasses pregnancy up to six weeks after delivery. Infancy is defined as six weeks to twelve months of life. PMTCT is preventing mother-to-child transmission. MTCT is mother-to-child transmission.

tervals of the reported clinical trial transmission rates used for the model (see the Appendix).[19]

Also, we have much to learn about the challenges of real-world implementation of HIV treatment programs in the postnatal period, where the focus is on providing effective drug treatment to prevent HIV infection in infants receiving HIV-infected breast milk.

Our model might not accurately predict the true performance of the postnatal prevention of mother-to-child HIV transmission for two reasons. The model assumes that 100 percent of mothers will exclusively breast-feed (overestimating transmission rates) and that it will be possible to achieve 85 percent reliability in treating HIV-exposed breast-feeding infants (underestimating transmission rates).

In fact, levels of receipt of child health care beyond the first immunization visit tend to decrease substantially,[17] which suggests major challenges for interventions to prevent mother-to-child HIV transmission for HIV-infected mothers who breast-feed their infants beyond the first few months of life.

Also, reported levels of infants being exclusively breast-fed at six months of age are very low in the ten countries studied (the average is 38 percent, and the range is from 8 percent in South Africa to 61 percent in Zambia).

Our model is also limited by the lack of availability of sound public health data on mother-to-child HIV transmission from health systems constrained by limited resources. Most countries in sub-Saharan Africa have yet to establish reliable national systems to measure perinatal and postnatal HIV transmission.

Where measurement systems do exist, the data are incomplete or inaccurate. Data on access to maternal and child health services and programs tend to be better established, but major weaknesses persist, particularly around multiple prenatal postnatal visits.

Study Results

Examination of the relationship between access to maternal and child health services and provision of antiretrovirals shows a significant correlation ($p = 0.02$; $r^2 = 0.5$) for the ten high-burden countries we studied (Exhibit 1). Results suggest that countries with high levels of prenatal care access (such as South Africa) had high levels of antiretroviral provision, and countries with low use of prenatal care (such as Nigeria and India) had low levels of antiretroviral provision. This relationship has been reported previously.[18]

Both South Africa and Botswana have recently reported very low HIV transmission rates in the context of very high (greater than 95 percent) rates of access to prenatal and maternity services.[24,25]

Our modeling scenarios, which varied access to maternal and child health services and varied program efficiency, yielded results on the contribution of these factors to overall mother-to-child transmission. In the first two scenarios, the "ideal state" (scenario 1) and the "aspirational state" in which access and care are at least at or near desirable levels (scenario 2), antiretroviral and maternal and child health performance levels gave predicted combined perinatal and infant HIV transmission rates of 4 percent and 7.9 percent, respectively (Exhibit 2). The results imply a high proportion of largely "unavoidable" HIV transmission.

Scenario 3 modeled the "current state" for rates of access to maternal and child health services and reported median levels of prevention of program performance for African countries. The model predicted an overall mother-to-child HIV transmission rate of 19.7 percent (14.0 percent perinatal transmission rate and 5.7 percent postnatal transmission rate).

Scenario 4 tested the effect of access on mother-to-child HIV transmission. Health system access was based on current median levels for countries in sub-Saharan Africa but assumed that 100 percent of mothers who were HIV-positive were seen and actually got antiretroviral therapy. We estimated an overall mother-to-child HIV transmission rate of 18.1 percent (13.5 percent perinatal transmission and 4.6 percent postnatal transmission).

In contrast, scenario 5 tested the effect of efficiency. We held maternal and child health system access constant at 100 percent and varied system performance according to current estimated levels in four African countries.[17] Results predicted a 10.1 percent rate of overall mother-to-child HIV transmission (6.3 percent perinatal transmission and 3.9 percent postnatal transmission).

Discussion

Our model estimates the independent and combined effects of two key components of maternal and child health in countries with a high burden of HIV infection in sub-Saharan Africa: the accessibility and efficiency of maternal and child health services, and programs to prevent transmission of HIV from mother to child.

The model suggests that under current conditions, poor access to routine health services contributes three times more (67 percent of the total) to overall mother-to-child HIV transmission than do current suboptimal levels of efficiency (19 percent of the total). Current efforts to optimize programs to prevent mother-to-child HIV

transmission will not, on their own, eliminate HIV in newborns. Results suggest that attention will need to be directed toward improving access to maternal and child health services and other strategies.

Based on the results of our model, countries that have high levels of access to maternal and child health services, such as Malawi, Zimbabwe, and Uganda, could achieve rapid progress toward preventing mother-to-child transmission of HIV. They could accomplish this by making optimal use of their effective maternal and child health services to deliver antiretrovirals reliably for better results in reducing transmission.

SUCCESS STORIES Two countries with a high burden of HIV in sub-Saharan Africa have reduced perinatally acquired HIV by improving the performance of the programs to prevent mother-to-child HIV transmission. Both South Africa and Botswana have reported low rates of perinatal transmission in recent years.[24–26]

▶**SOUTH AFRICA:** The experience in South Africa is particularly illustrative. Two impact studies conducted three years apart showed a major improvement in reducing mother-to-child HIV transmission rates in KwaZulu-Natal province, from 21.2 percent to 7.1 percent[20,27] without major changes in access to prenatal and postnatal care. This achievement suggests that the primary reason for the decrease in transmission rates was improved performance at each step of the HIV prevention processes during pregnancy and childbirth. The South African example indicates that progress can be made toward reducing HIV transmission to newborns in a large country with a high burden of HIV.

▶**BOTSWANA:** Botswana demonstrates what is achievable with a combination of very high levels of access to maternal and child health services[17] and high levels of reliability in its perinatal program to prevent HIV transmission. Together these resulted in very low levels of perinatal and infant HIV infection.[1,25,26]

This achievement was accomplished through a combination of factors: early implementation of effective HIV programs by the government of Botswana, supported by PEPFAR partners; a small population that was relatively localized around the capital city; and a historically strong maternal and child health program promoted by the Ministry of Health.

▶**TANZANIA:** We may gain insights from other countries such as Tanzania, in which high levels of antiretroviral provision during pregnancy[1] have been achieved despite modest access to maternal and child health services.[17] In this example, a relatively high rate of antiretroviral provision (70 percent) was achieved with a 74 percent rate of receipt of a first prenatal care clinic.

This achievement suggests that women in Tanzania who do get access to maternal health services are reliably tested and given medications to prevent HIV transmission to their infants. It also suggests that provision of antiretrovirals would quickly increase with a focus on better access to prenatal care.

VALIDATING THE FINDINGS In our validation exercise with actual data from South Africa, the modeled rate (8.9 percent) differed from the measured rate (7.1 percent). This could be explained by small numbers from two potential groups of HIV-infected infants who would not have been captured in the measured rate: those who were not brought to a clinic for care, and those who died before their first clinic visit.

Policy Implications

ELIMINATING MOTHER-TO-CHILD TRANSMISSION OF HIV Our model allows a quantitative demonstration of the close interrelationship between performance in the maternal and child health system and eliminating mother-to-child HIV transmission. Neither eliminating mother-to-child HIV transmission nor achieving Millennium Development Goals to reduce infant and maternal mortality (goals 4 and 5) will be possible without improving both access to maternal and child health services and performance of the programs to prevent mother-to-child HIV transmission for mothers and infants who do access the system.

Although our model does not explicitly predict maternal survival, evidence indicates that improving HIV-infected mothers' access to antiretroviral therapy will improve their own survival. This in turn should improve their children's chances of surviving.[14,15]

Much attention has been focused on what it will take to effectively eliminate mother-to-child transmission of HIV. Global rates of new infections in children have decreased by about a third in low- and middle-income countries.[2] However, our model suggests that although investment in improving access to maternal and child health systems will yield higher rates of provision of antiretrovirals, additional strategies are needed to eliminate mother-to-child HIV transmission and reduce new infections in children by 90 percent.[2] Achieving target levels of perinatal HIV transmission alone will require access and system performance levels of 98 percent or better.

The core intention of our model was to test the relationship between maternal and child health services and successful delivery of antiretrovirals—the key interventions in the current

prevention of mother-to-child HIV transmission program. Delivering three-drug antiretroviral regimes to pregnant women with AIDS is a complex undertaking. However, there are compelling reasons to integrate all of the HIV treatment programs for mothers into primary care health services.

Separation of adult and pediatric antiretroviral treatment programs for AIDS patients from the specific antiretroviral delivery program for pregnant women was most likely an appropriate (and successful) initial emergency response from PEPFAR and other donors. However, it is hard to justify the continued separation of HIV treatment and maternal and child health care, unless a country's underlying health system is so dysfunctional that the case for an ongoing emergency response remains.

The biggest danger in keeping the systems separate is that mothers eligible for three-drug antiretroviral treatment will get lost during the hand-offs between parallel care systems, resulting in avoidable HIV transmission to infants and maternal mortality.

Early results from evaluation of South Africa's recent switch to nurse-initiated care and treatment programs suggests that nurses can begin and deliver antiretroviral treatment.[28] We believe that further simplification of existing antiretroviral regimens will make integrated HIV and maternal and child health care services at the primary care level more feasible.

In addition, as simpler, more efficacious therapeutic interventions, rapid diagnostic techniques, and changing regulatory approaches are validated and put into action, greater declines in mother-to-child HIV transmission rates can be expected at all levels of maternal and child health care access.

To truly achieve the goal of eliminating mother-to-child HIV transmission, policy makers will have to look beyond the traditional interventions to a more comprehensive approach: prevention of HIV infection among women of childbearing age; prevention of unintended pregnancies among women living with HIV; provision of rapid and appropriate treatment for all women with HIV; care and support to women living with HIV and their families; and addressing unmet family planning needs.[3] Our model helps quantify the "unavoidable" transmission that may be amenable to these other interventions.

IMPLICATIONS FOR THE GLOBAL HEALTH INITIATIVE These modeling predictions have important implications for PEPFAR and the US government's broader Global Health Initiative, which provides the framework for US health assistance in developing countries.

The initiative has prioritized maternal and child health in line with Millennium Development Goals 4 and 5, in addition to its focus on prevention, care, and treatment of HIV. The ambitious goal to eliminate mother-to-child HIV transmission simply cannot be realized, in most cases, without major investment in improving access to maternal and child health services.

In addition, this model confirms the view that despite our best efforts, many children will continue to be born with HIV in the near term. PEPFAR must continue to make funding available for the treatment of these pediatric HIV cases until full implementation of the prevention strategy described above can realize the goal of eliminating pediatric HIV infection.

Conclusion

The model described above, and the information available on access to maternal and child health care services and mother-to-child HIV transmission performance, should allow countries to make strategic decisions on how to sequence investments of limited resources. For some of the countries with a high burden of HIV infection in infants, that means a major investment in improving access to maternal and child health services.

For countries with adequate maternal and child health access, that will mean focusing investment on improving the delivery of key antiretroviral interventions to prevent transmission. For countries with good access to health services and with good system performance in prevention of mother-to-child HIV transmission, the goal of eliminating pediatric HIV will require proposed interventions outside of the routine perinatal care pathway[3]—that is, identifying and treating HIV before pregnancy, treating all eligible HIV-positive mothers, preventing unintended pregnancy in HIV-positive women, and finding effective ways to improve the efficiency of treatment for HIV-infected mothers who are breast-feeding their infants. ■

The authors thank Jane Roessner and Ashley Fryer for their review and assistance with preparing the manuscript.

NOTES

1 World Health Organization, Joint United Nations Programme on HIV/AIDS, United Nations Children's Fund. Global HIV/AIDS response: epidemic update and health sector progress towards universal access. Progress report 2011. Geneva: WHO; 2011.

2 Mahy M, Stover J, Kiragu K, Hayashi C, Akwara P, Luo C, et al. What will it take to achieve virtual elimination of mother-to-child transmission of HIV? An assessment of current progress and future needs. Sex Transm Infect. 2010;86(Suppl 2): ii48–55.

3 Joint United Nations Programme on HIV/AIDS. Countdown to zero: global plan towards the elimination of new HIV infections among children by 2015 and keeping their mothers alive. Geneva: UNAIDS; 2011.

4 End Poverty 2015 Millennium Campaign. Overview: about the Millennium Development Goals [Internet]. New York (NY): United Nations; [cited 2012 Feb 21]. Available from: http://www.endpoverty2015.org/goals

5 Thior I, Lockman S, Smeaton L, Shapiro R, Wester C, Heymann S, et al. Breastfeeding plus infant zidovudine prophylaxis for 6 months vs formula feeding plus infant zidovudine for 1 month to reduce mother-to-child HIV transmission in Botswana: a randomized trial: the Mashi Study. JAMA. 2006; 296(7):794–805.

6 Kilewo C, Karlsson K, Massawe A, Lyamuya E, Swai A, Mhalu F. Prevention of mother-to-child transmission of HIV-1 through breast-feeding by treating infants prophylactically with lamivudine in Dar es Salaam, Tanzania: the Mitra Study. J Acquir Immune Defic Syndr. 2008;48(3):315–23.

7 Newell M-L, Coovadia H, Cortina-Borja M, Rollins N, Gaillard P, Dabis F. Mortality of infected and uninfected infants born to HIV-infected mothers in Africa: a pooled analysis. Lancet. 2004;364:1236–43.

8 Ng'weshemi J, Urassa M, Isingo R, Mwaluko G, Ngalula J, Boerma T, et al. HIV impact on mother and child mortality in rural Tanzania. J Acquir Immune Defic Syndr. 2003; 33:393–404.

9 Friberg IK, Kinney MV, Lawn JE, Kerber KJ, Odubanjo MO, Bergh A-M, et al. Sub-Saharan Africa's mothers, newborns, and children: how many lives could be saved with targeted health interventions? PLoS Med. 2010;7(6):e1000295.

10 Rajaratnam J, Marcus J, Flaxman A, Wang H, Levin-Rector A. Neonatal, postneonatal, childhood, and under-5 mortality for 187 countries, 1970–2010: a systematic analysis of progress towards Millennium Development Goal 4. Lancet. 2010; 375(9730):1988–2008.

11 Bhutta Z, Chopra M, Axelson H, Berman P, Boerma T, Bryce J. Countdown to 2015 decade report (2000–10): taking stock of maternal, newborn, and child survival. Lancet. 2010;375(9730):2032–44.

12 Bryce J, Gilroy K, Jones G, Hazel E, Black RE, Victora CG. The Accelerated Child Survival and Development programme in west Africa: a retrospective evaluation. Lancet. 2010; 375(9714):572–82.

13 Chopra M, Daviaud E, Pattinson R, Fonn S, Lawn J. Saving the lives of South Africa's mothers, babies, and children: can the health system deliver? Lancet. 2009;374:835–46.

14 Ndirangu J, Newell M-L, Thorne C, Bland R. Treating HIV-infected mothers reduces under 5 years of age mortality rates to levels seen in children of HIV-uninfected mothers in rural South Africa. Antivir Ther. 2012;17:81–90.

15 Paintsil E, Andiman W. Update on successes and challenges regarding mother-to-child transmission of HIV. Curr Opin Pediatr. 2009;21(1): 94–101.

16 World Health Organization. Rapid advice: use of antiretroviral drugs for treating pregnant women and preventing HIV infection in infants. Geneva: WHO; 2009.

17 World Health Organization, United Nations Children's Fund. Countdown to 2015 decade report (2000–2010) with country profiles: taking stock of maternal, newborn and child survival. Geneva: WHO; 2010.

18 Stringer E, Ekouevi D, Coetzee D, Tih P, Creek T, Stinson K. Coverage of nevirapine-based services to prevent mother-to-child HIV transmission in 4 African countries. JAMA. 2010;304(3):293–302.

19 To access the Appendix, click on the Appendix link in the box to the right of the article online.

20 Horwood C, Vermaak K, Butler L, Haskings L, Phakathi S, Rollins N. Elimination of paediatric HIV in KwaZulu-Natal, South Africa: large-scale assessment of interventions for the prevention of mother-to-child transmission. Bull World Health Organ. 2012;90:168–75.

21 UNAIDS Reference Group on Estimates, Modelling, and Projections. Working paper on mother-to-child HIV transmission rates for use in Spectrum [Internet]. Geneva: United Nations; 2011 6 Jun [cited 2012 Feb 21]. Available from: http://www.epidem.org/Publications/MTCTratesworkingpaper.pdf

22 Barker PM, Mphatswe W, Rollins N. Antiretroviral drugs in the cupboard are not enough: the impact of health systems' performance on mother-to-child transmission of HIV. J Acquir Immune Defic Syndr. 2011;56(2): e45–8.

23 World Health Organization. Guidelines on HIV and infant feeding 2010: principles and recommendations for infant feeding in the context of HIV and a summary of evidence. Geneva: WHO; 2010.

24 Goga A, Dinh T, Jackson D. Results of an evaluation of effectiveness of the national PMTCT programme at six weeks postpartum, SA. Paper presented at: Fifth South African AIDS Conference; Durban, South Africa; 2011.

25 Joint United Nations Programme on HIV/AIDS. Botswana [Internet]. Geneva: UNAIDS; 2010 [cited 2012 Mar 6]. Available from: http://www.unaids.org/en/Regionscountries/Countries/Botswana/

26 Stover J, Fidzani B, Molomo BC, Moeti T, Musuka G. Estimated HIV trends and program effects in Botswana. PLoS ONE. 2008;3(11): e3729.

27 Rollins N, Little K, Mzolo S, Horwood C, Newell ML. Surveillance of mother-to-child transmission prevention programmes at immunization clinics: the case for universal screening. AIDS. 2007;21(10): 1341–7.

28 Cameron D, Gerber A, Mbatha M, Mutyabule J, Swart H. Nurse-initiation and maintenance of patients on antiretroviral therapy: are nurses in primary care clinics initiating ART after attending NIMART training? S Afr Med Journal. 2012; 102(2):98–100.

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In this month's *Health Affairs*, Pierre Barker and Kedar Mate of the Institute for Healthcare Improvement report on their study modeling the relationship between access to maternal and child health services and mother-to-child HIV transmission. The model suggests that poor access to routine health services contributes three times more to overall mother-to-child transmission rates than do current suboptimal levels of efficiency of interventions to curb the transmission of HIV. The authors conclude that access to maternal and child health services will need to be dramatically improved, if declines in maternal-to-child HIV transmission rates are to continue.

Barker is a senior vice president at the Institute for Healthcare Improvement (IHI). He is responsible for IHI's expanding portfolio of large-scale health system improvement initiatives in low- and middle-income countries. Previously, he served as a senior adviser to IHI's programs in Africa and India and as a director of IHI's South Africa projects.

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