Original Article

Cost-Effectiveness of Universal Repeat Human Immunodeficiency Virus Screening in Pregnancy: A Cross-Sectional Study from Western India

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Abstract

Objective: The objective of the study was to evaluate the cost-effectiveness of universal repeat human immunodeficiency virus (HIV) screening late in pregnancy as opposed to the existing system of single HIV test early in pregnancy. **Background:** Strategy of universal repeat HIV screening in pregnancy to achieve Elimination of mother to child transmission in a low prevalence setting such as India should be examined from the cost-effectiveness point of view. **Methodology:** In a cross-sectional study, 2500 pregnant women with 32 weeks gestation or more and screened HIV nonreactive at least 3 months before the study were offered repeat HIV screening. A decision analysis model was used to determine cost-effectiveness of a repeat HIV screening late in pregnancy in both government (societal) and healthcare payer perspectives, followed by one-way sensitivity analysis at different rates of incident HIV in pregnancy. **Results:** The incidence of HIV infection during pregnancy was 1.18/1000 women years (95% confidence interval: 0.29–4.7). The existing system of single HIV test is 1.9 times costlier per quality adjusted life years gained than the proposed system of repeat HIV screening. **Conclusion:** When the incidence of HIV in pregnancy is 1.18/1000 woman-years, even in settings with antenatal HIV positivity rates as low as 0.01%, repeat HIV screening in pregnancy is cost effective.

Keywords: Cost effectiveness, elimination of mother to child transmission of HIV, antenatal HIV screening

Introduction

Elimination of mother-to-child transmission of HIV (EMTCT) is one of the cornerstones in the control and reversal of human immunodeficiency virus (HIV) epidemic. The prevention of mother-to-child transmission (MTCT) is vital in keeping burden of disease including cost of lifelong care of HIV-infected newborn (testing and antiretroviral therapy [ART]) and the risk of subsequent transmission, under check. Cost of treatment of opportunistic infections, acquired immunodeficiency syndrome (AIDS) defining illnesses, and loss of Quality Adjusted Life Years (QALY)[1] are other consequences of HIV infection in newborns. The risk of MTCT is about 30%–45% in the absence of ART in the mother, which reduces to <2% in a breastfeeding mother on ART and <1% in a nonbreast feeding mother on ART.[2] In order to initiate ART in a pregnant woman with HIV infection, first, she needs to be identified through screening. In India, the national guidelines recommend screening all pregnant women once in the antenatal period for early detection of HIV and linkage to ART.[3] In Gujarat and Surat, HIV positivity among pregnant women was 0.04% and 0.05%, respectively, in 2018–2019,[4] and the HIV prevalence in general population is estimated to be 0.20%.[5] The WHO recommends repeat HIV screening in pregnant women only in high prevalence settings.[6] Accordingly, most pregnant women in India receive only one HIV screening test, and a second test is based on the discretion of the clinician. On the other hand, there are studies which show that repeat HIV screening can avert HIV transmission and eventual burden on health-care system.[7] Thus, to propose universal repeat HIV screening in

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pregnancy in a low prevalence country, the cost-effectiveness of such a proposed strategy had to be determined.

Objective

The objective of the study was to evaluate the cost-effectiveness of universal repeat HIV screening late in pregnancy as opposed to the existing system of single HIV test early in pregnancy.

Methodology

The study was conducted in a prevention of parent-to-child transmission (PPTCT of HIV) clinic attached to an Antenatal Clinic in a Government tertiary care hospital of South Gujarat state of India between August 2018 and July 2019. Pregnant woman aged between 15 and 45 years with 32 weeks of gestation or more who had been screened HIV nonreactive in the current pregnancy at least 3 months before the study were included. During the study period, out of 8070 pregnant women in third trimester of pregnancy attending the antenatal clinic, 5568 (69%) did not meet the inclusion criteria. Two participants refused to provide consent for the study due to a lack of time to participate. Hence, the final sample size achieved for repeat screening was 2500. The data collected from all the 2500 participants included sociodemographic profile, date of previous HIV screening, and cost incurred for HIV screening. The cost incurred for HIV screening included the cost of travel, loss of wages, and cost of first HIV screening (if carried out in a private hospital). Pre- and posttest counseling was provided. The venous blood sample was screened using qualitative, immunochromatography assay for detection of antibodies specific to HIV 1 and 2.[8] These rapid diagnostic screening test kits were provided by Gujarat State AIDS Control Society (standard kit approved by NACO) for this study purpose. Those participants who were screened positive on repeat testing were referred back to PPTCT counselor to offer posttest counseling and linkage to ART center after confirmation of diagnosis. The study was approved by the Institutional Human Research Ethics Committee, and written consent was taken before undertaking the study.

Data analysis

Microsoft Excel 2007 (Microsoft Corp., Washington, USA).[9,10] The cost inputs were derived from the present study as well as contracts awarded by NACO.[11-16] QALYs gained were assigned based on existing literature.[7] The decision analysis model was built comparing: (a) the existing system of single HIV and (b) the proposed system of a repeat HIV screening after 32 weeks of pregnancy [Figure 1]. The model used the probabilities and costs derived for the 2500 pregnant women who were enrolled in the study to compare the two scenarios and analysis model was run in 1000 Monte Carlo simulations. Cost-effectiveness was estimated both in terms of societal (government) perspective (cost of consumables, logistics, and manpower for providing services) and health-care payer (pregnant woman/client) perspective (costs incurred by pregnant women in availing services). The various input parameters of the decision analysis model are given in Table 1. Probability of HIV-positive woman (after first test) starting on ART was taken as 0.6.[17] Risk of transmission of HIV infection from mother on ART to her child was considered as 2% and without ART; it was taken as 45%.[18] The probability of positive result in repeat test after an initial negative test was taken as 0.118% (from the present study). Probability of woman starting on ART after the second screening test was considered as 1 based on the current study. Life expectancy of HIV uninfected child was taken as 65 years (rounded off from national average of 67.9 years for the ease of calculation)[19] with QALY per year as 1, for HIV-infected child on ART, the life expectancy was 30 years with QALY per year as 0.83, and for a HIV infected child not on ART, life expectancy was considered 2 years with QALY per year as 0.73.[7,20] One-way sensitivity analysis was performed to learn the cost-effectiveness in two scenarios: (a) At different rates of HIV incidence in pregnancy and (b) at different rates of HIV positivity among pregnant women.

Results

The study included 2500 participants, with a mean age of 23.4 years (standard deviation ± 3.5). Most of them were multigravida (56%). Among 2500 participants, contributing to 1699.67 women years of exposure to pregnant state, two new HIV infections were detected. The incidence of HIV infection during pregnancy was 1.18/1,000 women years (95% confidence interval [CI]: 0.29–4.7). Decision analysis model which was used for cost-effectiveness analysis is given in Figure 1. In the conditions of this study setting, i.e., at antenatal HIV positivity of 0.05% and incident HIV rate of 0.118% in pregnancy, the existing system is 1.44 and 2.03 times costlier per QALY gained than the proposed system in governmental (societal) and health-care payer's perspectives, respectively. In overall perspective, existing system is 1.9 times costlier per QALY gained than the proposed system of repeat HIV screening [Table 2].

One-way sensitivity analysis of cost and effectiveness of proposed (universal repeat HIV screening) and existing (single HIV test in pregnancy) strategies at different rates of incident HIV in pregnancy, at antenatal HIV positivity of 0.05% [Table 2] was carried out. When the antenatal HIV positivity rate is 0.05%, in the government perspective, proposed system was cost saving per QALY gained as long as the incident HIV rate was more than 0.05% or 0.5/1000 woman-years. It was cost saving in a health payer perspective and overall perspective at all rates of incident HIV.

Similarly, one way sensitivity analysis of cost and effectiveness of proposed (universal repeat HIV screening) and existing (single HIV test in pregnancy) strategies was carried out at different rates of antenatal HIV positivity, when the rate of incident HIV in pregnancy was 1.18/1000 woman-years [Table 3]. Even when antenatal HIV positivity was as low as 0.01%, the proposed system was cost saving compared to the existing system.

Discussion

In its 2020 report, the UNAIDS has remarked how significant

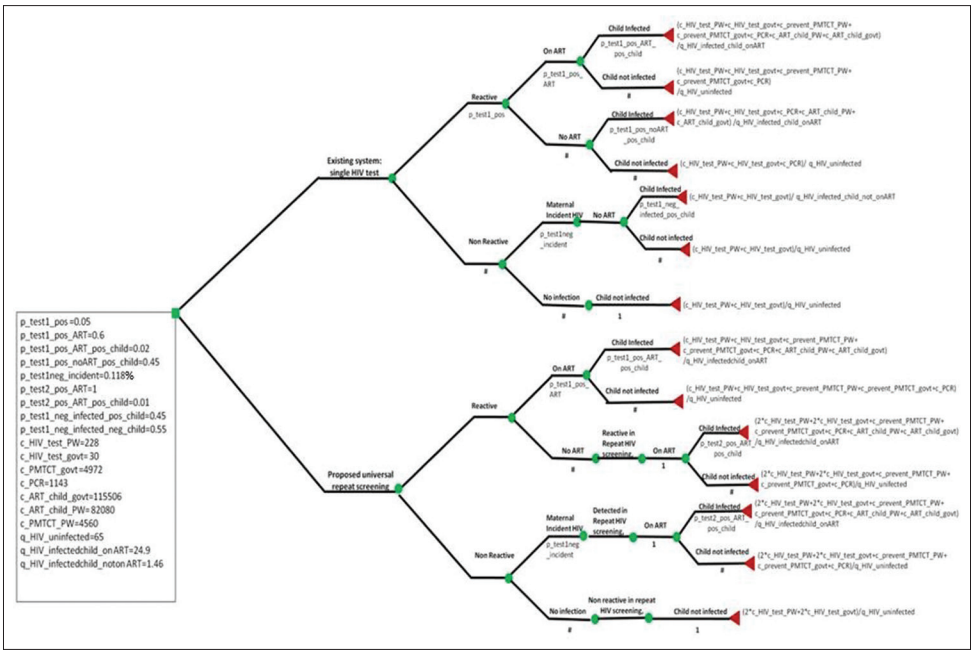

Figure 1: Decision analysis model comparing the existing system of single HIV test with proposed system of universal HIV screening

Table 1: Input parameters in the decision analysis model

Cost inputs (reference)	Description	Mean cost (Rupees)
Cost borne by the pregnant woman (healthcare payer perspective)		
c_HIV_test_PW*	Cost of travel and loss of wages at each visit	226
Cost borne by the Government (Societal perspective)		
c_HIV_ test_government[12,14]	HIV test kits, vacutainers, other consumables, staff wages	30
c_ PMTCT_government[11,13]	Cost of ART for the infected mother during postpartum and breastfeeding and ARV prophylaxis for child	4897
c_PCR [23]	Cost of DNA PCR test	1132
c_ART_ child_government[13,16]	Cost of ART for infected child (pediatric and adult formulation) for 30 years	114748
Life expectancy		QALY
Uninfected child[19]	65 years	1
HIV infected child on ART[7,20]	30 years	0.83
HIV infected child, not on ART[7,20]	2 years	0.73
Probabilities		
P_test 1_pos	Probability of first test being positive, based on HIV positivity among pregnant women in Gujarat	0.05
*P*_test 1_pos_ART	Probability of ART initiation when first test is positive[17]	0.6
*P*_test 1_pos_ART_pos_child	Probability of HIV transmission to newborn while on ART after the first positive test[18]	0.01-0.02
*P*_test 1_pos_noART_pos_child	Probability of HIV transmission to newborn while not on ART after the first positive test[18]	0.45
*P*_test 1neg_incident*	Probability of HIV incidence in pregnant women	0.00118
*P*_test 2_pos_ART*	Probability of initiating ART in a pregnant woman detected with HIV infection in repeat test	1
*P*_test 2_pos_ART_pos_child	Probability of HIV transmission to newborn while on ART after second positive test[18]	0.01
*P*_test 1_neg_infected_pos_child	Probability of a pregnant woman with incident HIV infection in pregnancy transmitting the infection to newborn in the absence of ART[18]	0.45

INR: Indian Rupee (Rs.), HIV: Human Immunodeficiency Virus, PMTCT: Prevention of Mother to Child Transmission, ART: Anti Retroviral Therapy, QALY: Quality Adjiusted Life Years, ARV: Anti retroviral, PCR: Polymerase chain reaction, *From present study

Table 2: One way sensitivity analysis of mean cost (in INR) and effectiveness of proposed (universal repeat HIV screening) and existing (single HIV test in pregnancy) strategies at different rates of incident HIV in pregnancy, when antenatal HIV positivity=0.05%

Incidence of HIV in pregnancy (%)	Strategy	Government (societal) perspective				Healthcare payer perspective			
		Costs (C)	QALY (E)	C/E	ICER	Costs (C)	QALY (E)	C/E	ICER
0.005	Proposed	64.50	65.03	0.99	Not cost saving	231.75	65.03	3.56	Cost saving
	Existing	45.50	65.02	0.69		318.51	65.02	4.89	
0.01	Proposed	64.90	65.03	0.99	Not cost saving	232.05	65.03	3.57	Cost saving
	Existing	48.14	65.02	0.74		325.91	65.02	5.01	
0.05	Proposed	67.73	65.03	1.04	Cost saving	234.47	65.03	3.61	Cost saving
	Existing	69.14	65.01	1.06		385.07	65.01	5.92	
0.1	Proposed	71.3	65.03	1.10	Cost saving	237.50	65.03	3.65	Cost saving
	Existing	95.4	64.99	1.46		459.02	64.99	7.06	
0.118 (current study)	Proposed	72.6	65.03	1.12	Cost saving	238.6	65.03	3.67	Cost saving
	Existing	104.84	64.99	1.61		485.6	64.99	7.47	
0.2	Proposed	78.48	65.03	1.21	Cost saving	243.57	65.03	3.75	Cost saving
	Existing	147.89	64.96	2.27		606.92	64.96	9.34	

HIV: Human Immunodeficiency Virus, INR: Indian Rupee (Rs), QALY: Quality Adjusted Life Years, ICER: Incremental Cost Effectiveness Ratio, C/E: Cost/effectiveness ratio

Table 3: Deterministic model comparing mean cost and quality adjusted life years of existing and proposed systems at different HIV positivity rates of HIV in pregnancy and probability of incident HIV in pregnancy=0.118 per 100 woman years

HIV positivity in pregnancy (%)	Strategy	Government (societal) perspective				Healthcare payer perspective			
		Costs in INR (C)	QALY (E)	C/E	ICER	Costs in INR (C)	QALY (E)	C/E	ICER
0.01	Proposed	69.29	65.01	1.07	Cost saving	235.84	65.01	3.63	Cost saving
	Existing	94.55	64.97	1.46		419.21	64.97	6.45	
0.025	Proposed	70.53	65.02	1.08	Cost saving	237.82	65.02	3.66	Cost saving
	Existing	98.41	64.98	1.51		428.42	64.98	6.59	
0.05	Proposed	72.60	65.03	1.12	Cost saving	238.60	65.03	3.67	Cost saving
	Existing	104.84	64.99	1.61		485.64	64.99	7.47	
0.1	Proposed	76.74	65.06	1.18	Cost saving	242.03	65.06	3.72	Cost saving
	Existing	117.70	65.02	1.81		568.67	65.02	8.75	
0.5	Proposed	109.88	65.32	1.68	Cost saving	269.55	65.32	4.17	Cost saving
	Existing	220.59	65.23	3.38		1232.93	65.23	18.9	
1	Proposed	151.31	65.64	2.30	Cost saving	303.94	65.64	4.63	Cost saving
	Existing	349.21	65.50	5.33		2063.25	65.50	31.5	

HIV: Human Immunodeficiency Virus, INR: Indian Rupee (Rs), QALY: Quality Adjusted Life Years, ICER: Incremental Cost Effectiveness Ratio, C/E: Cost/effectiveness ratio

number of undiagnosed HIV infected mothers and infection during pregnancy has stalled the progress toward EMTCT.[21] Of particular concern is adoption of strategy of universal repeat HIV screening for all pregnant women in late pregnancy, replacing the existing system of one routine screening test earlier in pregnancy. For instance, in South Africa, where there is generalized epidemic, the national guidelines in South Africa recommend repeat HIV tests are done every 3 monthly, during delivery, 6 weeks postpartum, and 3 monthly during breastfeeding.[22] On the other hand, The WHO does not recommend repeat screening routinely warranted in low prevalence settings, such as India, since the incidence of HIV infection is expected to be low.[6]

In this context, we chose to adopt a cross-sectional study design, since we wanted the study to represent the practical situation where the clinician receives a pregnant woman, who has already been screened negative elsewhere early in pregnancy, for the first time in their clinic. Incidentally, a follow-up study from India[23] found HIV incidence among pregnant women was 1.2 (95% CI: 0.32–2.97)/1000 women years, which is similar to that in the present study.

It is understandable that, as the antenatal HIV positivity declines, the marginal cost-effectiveness also declines. For instance, in this study, the existing system was 1.9 times costlier per QALY in a setting where ANC positivity was 0.05%,[4] when compared to settings with higher positivity.[23] We did one way sensitivity analysis for study settings with different ANC HIV positivity and found that, at HIV positivity of 0.5% (similar to study setting by Joshi *et al*.), the existing system was 4 times costlier per QALY compared to system of repeat testing. Even in Uganda where ANC HIV prevalence was considered as 0.1%,

repeat HIV antibody screening at delivery was found more cost effective than single screening test.[24]

Other studies recommended repeat HIV screening in pregnancy in settings with HIV incidence of 1/1000 women years or more.[25] The current study indicated that, when the incidence of HIV in pregnancy is 1.18/1000 woman years, even in settings with antenatal HIV positivity rates as low as 0.01%, repeat HIV screening is cost effective. Similarly, the current study showed that, even if the rate of incident HIV in pregnancy was as low as 0.5/1000 woman years, proposed system of repeat HIV screening can be cost saving per QALY gained in the government perspective. In a broader overall perspective and from the perspective of health payer, repeat HIV screening in pregnancy is cost saving at all rates of incident HIV.

Conclusion

Universal repeat HIV screening can be cost effective even when the probability of incident HIV is low or when the antenatal HIV positivity rate is low. Thus, repeat HIV screening in late pregnancy, if made available to all pregnant women through the national program, will help in ensuring linkage of infected pregnant women to ART and averting every possible transmission to the newborn, thus stepping closer to target of EMTCT of HIV. We recommend that further reduction in cost of repeat testing can be achieved by pooled sample testing, which would be ideal in a low prevalence setting like India.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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