

# Impact of Round-the-Clock, Rapid Oral Fluid HIV Testing of Women in Labor in Rural India

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**Abbreviations:** ART, antiretroviral therapy; CI, confidence interval; MGIMS, Mahatma Gandhi Institute of Medical Sciences; PMTCT, prevention of mother-to-child HIV transmission

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## ABSTRACT

### Background

Testing pregnant women for HIV at the time of labor and delivery is the last opportunity for prevention of mother-to-child HIV transmission (PMTCT) measures, particularly in settings where women do not receive adequate antenatal care. However, HIV testing and counseling of pregnant women in labor is a challenge, especially in resource-constrained settings. In India, many rural women present for delivery without any prior antenatal care. Those who do get antenatal care are not always tested for HIV, because of deficiencies in the provision of HIV testing and counseling services. In this context, we investigated the impact of introducing round-the-clock, rapid, point-of-care HIV testing and counseling in a busy labor ward at a tertiary care hospital in rural India.

### Methods and Findings

After they provided written informed consent, women admitted to the labor ward of a rural teaching hospital in India were offered two rapid tests on oral fluid and finger-stick specimens (OraQuick Rapid HIV-1/HIV-2 tests, OraSure Technologies). Simultaneously, venous blood was drawn for conventional HIV ELISA testing. Western blot tests were performed for confirmatory testing if women were positive by both rapid tests and dual ELISA, or where test results were discordant. Round-the-clock (24 h, 7 d/wk) abbreviated prepartum and extended postpartum counseling sessions were offered as part of the testing strategy. HIV-positive women were administered PMTCT interventions. Of 1,252 eligible women (age range 18 y to 38 y) approached for consent over a 9 mo period in 2006, 1,222 (98%) accepted HIV testing in the labor ward. Of these, 1,003 (82%) women presented with either no reports or incomplete reports of prior HIV testing results at the time of admission to the labor ward. Of 1,222 women, 15 were diagnosed as HIV-positive (on the basis of two rapid tests, dual ELISA and Western blot), yielding a seroprevalence of 1.23% (95% confidence interval [CI] 0.61%–1.8%). Of the 15 HIV test-positive women, four (27%) had presented with reported HIV status, and 11 (73%) new cases of HIV infection were detected due to rapid testing in the labor room. Thus, 11 HIV-positive women received PMTCT interventions on account of round-the-clock rapid HIV testing and counseling in the labor room. While both OraQuick tests (oral and finger-stick) were 100% specific, one false-negative result was documented (with both oral fluid and finger-stick specimens). Of the 15 HIV-infected women who delivered, 13 infants were HIV seronegative at birth and at 1 and 4 mo after delivery; two HIV-positive infants died within a month of delivery.

### Conclusions

In a busy rural labor ward setting in India, we demonstrated that it is feasible to introduce a program of round-the-clock rapid HIV testing, including prepartum and extended postpartum counseling sessions. Our data suggest that the availability of round-the-clock rapid HIV testing resulted in successful documentation of HIV serostatus in a large proportion (82%) of rural women who were unaware of their HIV status when admitted to the labor room. In addition, 11 (73%) of a total of 15 HIV-positive women received PMTCT interventions because of round-the-clock rapid testing in the labor ward. These findings are relevant for PMTCT programs in developing countries.

*The Editors' Summary of this article follows the references.*



## Introduction

Worldwide, about 18 (45%) of 40 million HIV-infected individuals are women [1]. The vast majority (60%) of new HIV infections occur in women of reproductive age and in infants and children [1]. With only 9% of pregnant women receiving antiretroviral therapy (ART) (as compared to the UNAIDS/WHO target of 80%), an urgent scaling up of HIV prevention efforts are needed to avert a pediatric HIV epidemic [1]. Controlling HIV infection in women and children is crucial for changing the trajectory of the global HIV epidemic.

Standard interventions for prevention of mother-to-child transmission (PMTCT) can significantly reduce HIV transmission in infants [2]. About 75% of perinatal HIV transmission occurs during labor and delivery [3]. To effectively administer PMTCT interventions, rapid and timely ascertainment of HIV serostatus is an absolutely critical step. In many developing countries, women frequently fail to get tested for HIV early in their pregnancy, leaving health care providers only a brief time window during labor and delivery in which to test and intervene. In such urgent situations, rapid, point-of-care, easy to use HIV tests may be extremely helpful, especially noninvasive formats such as oral fluid point-of-care tests [4,5]. For example, in a previous diagnostic study in India, we had shown that the oral fluid-based OraQuick HIV-1 & HIV-2 rapid test (OraSure Technologies, <http://www.orasure.com/>) was 100% sensitive and 100% specific [4]. Our recent systematic review of rapid HIV testing found sufficient evidence on their high accuracy and feasibility in pregnant women [6].

Worldwide, about one in eight women is deprived of adequate prenatal care, and one in nine is not tested for HIV [7]. In 2005, the global coverage of PMTCT interventions was estimated at only 8% [8]. Lack of knowledge of HIV serostatus has been identified as a key factor limiting the widespread implementation of PMTCT programs [8]. To address this issue, innovative approaches that help increase and improve acceptability, availability and feasibility of HIV testing and counseling services are the key to enhancing the implementation of available PMTCT interventions [8]. With this in mind, we set out to conduct this study in rural India, where we aimed to evaluate the impact of introducing rapid HIV testing in the labor room setting.

In India, according to the HIV Sentinel Surveillance Report 2005, of all estimated adults living with HIV infection, about 38.4% infected were women, and 57% were from rural areas [9]. Anecdotal reports estimate that nearly half (50%) of rural Indian women present for any antenatal care for the first time only during labor and delivery [10]. Hospitals in India often document these women as “unbooked” or “unregistered” cases. There may be several reasons for women presenting only at the time of delivery: (1) preference for home delivery; (2) inadequate access to healthcare services in rural areas; (3) inadequate antenatal care due to the low priority for women’s health; (4) poverty; (5) illiteracy [10]. Thus, lack of antenatal care, lack of knowledge of HIV serostatus coupled with late presentation to the hospitals in labor (often with obstetric complications) with an insufficient available time window for HIV testing and intervention can lead to mother-to-child HIV transmission. In 2005, 3.8% of HIV transmission (4,755 cases) in infants in India were

attributed to mother-to-child HIV transmission [9]. These data indicate that testing early in pregnancy may not be adequate in India, because a significant proportion of women present only during labor and delivery.

In this context, we set out to investigate in rural pregnant women in labor in India, the impact of introducing an innovative round-the-clock (24 h, 7 d a week) oral fluid-based, rapid HIV testing and counseling program. Our study objectives were: (1) to determine the prevalence of HIV infection in women presenting to the labor and delivery ward with incomplete or no knowledge of HIV serostatus; (2) to determine the impact of round-the-clock HIV testing in labor (i.e., detection of new HIV cases among women with no prior HIV testing, improvement in the uptake of HIV testing, preference for rapid testing); (3) to determine the feasibility of abbreviated prepartum and extended postpartum counseling sessions in a busy labor ward setting.

## Methods

### Study Setting

Our study was conducted between January and September 2006, in the Department of Obstetrics and Gynecology at the Mahatma Gandhi Institute of Medical Sciences (MGIMS), a rural, tertiary-care, teaching hospital in Sevagram, India with an estimated 3,500 deliveries each year. This hospital serves as a high-risk obstetric unit to several villages in Wardha district in central India. The study was jointly approved by the ethics committees at the University of California, Berkeley, United States, and the MGIMS hospital, Sevagram, India.

### Criteria for Recruitment

To be eligible for recruitment into our study, women had to be: aged 18–45 y, in active and/or early (incipient) labor according to the criteria used by attending obstetricians at the MGIMS hospital, willing to provide informed consent in the labor ward, and willing to undergo prepartum and postpartum counseling sessions. Women with unknown, unreported HIV serostatus and those presenting with poorly reported and poorly documented HIV test results with unclear HIV serostatus were also included. Women presenting at any gestational age were included.

Women were excluded if they were recipients of ART or were in poor general medical condition (including obstetric emergencies) or with severe mental health problems that precluded informed consent.

### Recruitment Process in the Labor Ward

All consecutive women admitted to the labor ward were identified by the project manager (an attending obstetrician) and her assistants (residents in training), using the labor ward register, maintained by the labor ward staff. This was done on a round-the-clock daily basis. The project manager evaluated women for eligibility, and those found to be eligible were approached for written informed consent. Women who consented were offered prepartum counseling and HIV testing. At any time, women were given the option to refuse testing and counseling.

### Written Informed Consent

The informed consent form explained the details of the study, the HIV testing procedure and interventions available for the patient, in two local languages (i.e., Hindi and

Marathi). This information was orally communicated to the women by a trained counselor, in the presence of the project manager after the patient was admitted in the labor ward. All women were encouraged to ask questions at any time during the consenting process.

### HIV Counseling Sessions

HIV counseling and testing were both conducted in the labor ward. Three trained counselors (all women) took turns in 8 h shifts to make themselves available round-the-clock to provide 24 h coverage to the labor room. This, however, was not the case prior to the start of the project. All counselors were previously trained as part of the Government of India's PMTCT program.

Because prior studies had reported significant challenges in implementing conventional HIV counseling in the labor ward setting, we decided to conduct counseling in two stages; first, an abbreviated prepartum counseling session and subsequently, an extended postpartum session [11,12]. Prior to conducting this study, the feasibility of the two-stage counseling process was assessed in a pilot study on 20 women. Based on the results of the pilot study and feedback from participants, the consent process, prepartum counseling, and postpartum counseling were modified.

**Prepartum abbreviated session.** In the prepartum abbreviated session (10–15 min), key messages conveyed included modes of transmission of HIV, importance and benefits of HIV testing, information on PMTCT, and interventions available for PMTCT. Flip charts and materials provided by the Government of India's National AIDS Control Organization (NACO) were used at all times for counseling. Questions and concerns regarding delivery of interventions and test procedures were addressed at the time of counseling. Information was conveyed in one of two local languages, Hindi or Marathi, depending on the preference of the patient. In general, prepartum counseling sessions were done in private, unless the women asked for the presence of family member(s). As far as it was possible in this busy labor ward, privacy was ensured by using screens/curtains to cover the area around the bed. In women who were in active labor, counseling was conducted between contractions.

During prepartum counseling sessions, women were provided with the option of knowing their result immediately after testing or after delivery during the postpartum counseling sessions. Thus, test results were reported depending on the preference of participants. Women were informed that, if they were found to be HIV-positive, further consent would be required for interventions to prevent transmission of HIV to the baby.

**Postpartum extended session.** Among women diagnosed with HIV infection, the postpartum session was used to provide details on what interventions were available, and the prognosis of treatments administered. This information was always conveyed in private by an attending obstetrician. No family member was allowed to be present unless the patient consented to his/her presence. Among women diagnosed with HIV, counselors provided additional information on steps to be taken to prevent further HIV transmission, information on HIV transmission through breast milk, and avoidance of mixed feeding. Social support available to the mother for implementing the recommendations on breast feeding was assessed. Information on ART and prophylaxis, including

referrals to the nearest free ART center, were provided. The importance of regular follow-up visits to the hospital for monitoring was emphasized. The extended postpartum counseling sessions typically lasted between 30–40 min among women diagnosed with HIV infection.

Among women who were HIV seronegative, the postpartum counseling sessions lasted about 15 min. In these sessions, women were counseled on risk reduction strategies by the counselors, and asked to return for repeat HIV testing in 3 mo when: (1) the couple was serodiscordant, or (2) the woman presented with a high-risk profile.

Risk factor, demographic, and test preference information were collected from all women in face-to-face interviews during prepartum and postpartum counseling sessions. In extended postpartum counseling sessions, additional information on various feeding options (e.g., exclusive breast milk, formula feed, top feed, mixed feed), time of weaning, and social support was also collected from seropositive women.

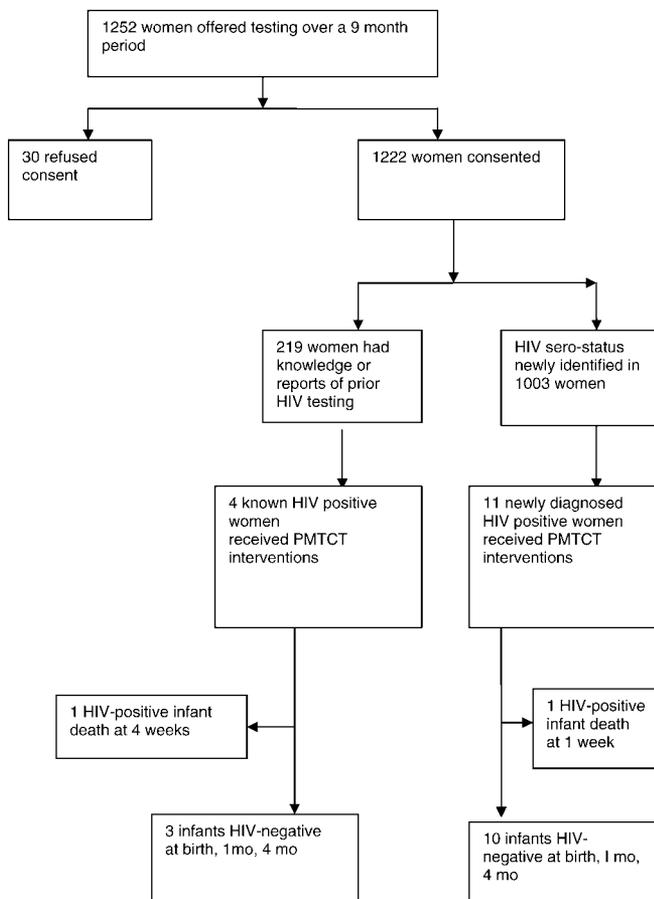
### HIV Testing Algorithm

Figure S1 demonstrates the HIV testing algorithm. HIV testing was performed by trained counselors in the labor ward. Women were informed that they could refuse testing at any time. Two rapid OraQuick tests were performed in parallel, one on oral fluid, and one on finger-stick blood, to ascertain HIV serostatus. Both tests have been validated in India previously [4], and were performed according to manufacturer's instructions, including use of external controls [13]. Although the oral-fluid test was the novel rapid test that was being evaluated for its convenience and feasibility in urgent settings, we chose a parallel testing strategy (i.e., two rapid tests) that is known to improve diagnostic accuracy.

Immediately after the two rapid tests were conducted, phlebotomy was performed to collect venous blood (5 ml of blood) for the reference standard tests: single ELISA (Vironostika HIV Uniform II Ag/Ab Plus O, Organon Teknika) alone for rapid test negative participants, and dual ELISA plus Western blot (Qualicode HIV1/2 Kit, Immunetics) for rapid test positive participants. As a quality control measure, all ELISA and Western blot positive samples were independently confirmed by an external reference laboratory (with 100% concordance) at regular intervals by sending random samples every month.

HIV seropositivity was diagnosed only when oral and finger-stick OraQuick tests were both reactive, and subsequently confirmed by dual ELISA and Western blot. However, for immediately decision making in the labor ward, a positive result by both oral fluid and finger-stick OraQuick was considered adequate, even if this meant potentially overtreating some participants. Women were considered HIV seronegative when both oral and finger-stick OraQuick were nonreactive and were subsequently confirmed negative by a single ELISA. We resolved any discordant test results (i.e., discordant OraQuick rapid tests, or discordance of rapid test results with ELISA tests) by repeating rapid OraQuick rapid tests, and confirmatory testing (dual ELISA and Western blot).

The results of the rapid OraQuick tests were available to the attending obstetricians within 20 min of completion of rapid testing. However, results of confirmatory tests (i.e., ELISA and Western blot) were available within 1–3 d postdelivery.



**Figure 1.** Flow of Participants Through the Study  
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### PMTCT Interventions for HIV-Positive Women

HIV-positive women were urgently referred for elective cesarean section and ART administration if they presented with unruptured membranes. For an elective cesarean section, a 3–4 h time window was required to deliver interventions and also allow ART drugs to attain peak levels in the maternal circulation. This time window varied with the patient's medical condition and stage of labor. For vaginal delivery, however, ART drugs were administered in established labor in the first stage.

The HIV-positive women who presented with ruptured membranes were administered ART and were delivered vaginally, if they did not consent to an emergent cesarean section. This decision was left to the women. In such cases, an elective cesarean section was not offered as its advantage was lost. In contrast, for all obstetric indications, an emergent cesarean section was conducted irrespective of HIV serostatus.

All HIV-positive women received standard doses of Nevirapine, Zidovudine, and Lamivudine at the time of labor (intrapartum), followed by Zidovudine and Lamivudine for one wk post delivery (postpartum) [14–17]. Infants received single dose Nevirapine and Zidovudine for one wk [17]. Infant HIV serostatus was assessed using HIV DNA polymerase chain reaction (PCR) within 48 h of delivery and at one mo and four mo after delivery. Infants are currently being followed for confirmatory HIV testing at 18 mo.

At time of discharge from the hospital, mothers were referred for free ART at the nearest government-supported ART center. Additionally, prophylaxis, and continuity of care was done at the Internal Medicine department of the MGIMS hospital. HIV infected infants were referred to the Pediatrics department of the MGIMS hospital for care and follow up.

### Sample Size and Data Analysis

Based on previous Indian studies and clinical experience at the study site, we a priori anticipated an overall HIV prevalence of 1.5% among women admitted to the labor ward at the MGIMS hospital. [10,11] To estimate this prevalence with a precision of about 0.5%, we planned to enroll 1,500 eligible women. However, because of lower than anticipated enrollment, we completed the study with a total sample size of 1,222.

Data were analyzed using Stata (Version 9.0, Stata Corp, <http://www.statacorp.com/>). Outcomes of the study included HIV seroprevalence, diagnostic accuracy of rapid tests, client preference for rapid tests, proportion of women whose HIV status was documented because of labor ward testing, proportion of new HIV cases that were picked up because of labor ward testing, and proportion of HIV-positive women who received PMTCT interventions because of labor ward testing. HIV seroprevalence was calculated along with 95% confidence intervals (CIs). Diagnostic accuracy was evaluated using sensitivity (true-positive rate) and specificity (false-positive rate), with 95% CI estimates. Agreement between test results was assessed using the *kappa* statistic.

## Results

### Description of Study Participants

Figure 1 demonstrates the flow of participants in the study. During the study period, of 1,252 eligible women approached for informed consent and participation in the study, 1,222 (98%) consented to testing. Due to round-the-clock availability of the counselors, none of the eligible women were missed. However, women with mental health problems and obstetric emergencies were excluded at the outset. Eligible women who refused testing ( $n = 30$ ) either perceived themselves to be not at risk, or claimed to have been tested in the past, and were confident that they were not HIV infected. Thus, excluding refusals, a total of 1,222 participants underwent rapid testing in the labor ward between January 2006 and September 2006.

The demographic and risk profile characteristics of the study participants, stratified by HIV serostatus, are shown in Table 1. The mean age of seronegative women was 24 y (range 18–38 y) and that of seropositive women was 22 y (range 20–28 y). About 79% of seronegative and 80% of seropositive women were educated up to high school. About 71% of seronegative and 93% of seropositive women were housewives. A majority of women were from low socioeconomic strata; the total monthly income per household was below Rs (Rupees) 5,000 (approximately US\$125) for 90% of seronegative and 86% of seropositive women.

Overall, about 99% of all study participants were married, monogamous, with less than 1% reported having engaged in sex outside marriage. About 5% of the participants reported that their husband used drugs and alcohol before sex. About 2% of the women reported have had blood transfusions in

**Table 1.** Demographic and Risk Factors in HIV Seronegative Women and Seropositive Women

Risk Factors	Category	Seronegative Women (n = 1,207)	Seropositive Women (n = 15)
<b>Marital status (married)</b>	—	99% (1196/1207)	100% (15/15)
<b>Age (mean and range)</b>	—	24 (18–38 y)	22 (20–28 y)
<b>Education</b>	Illiterate	2.5% (30/1,207)	6.7% (1/15)
	Primary School	5.3% (64/1,207)	6.7% (1/15)
	Middle School	30.5% (368/1,207)	26.7% (4/15)
	High School	43.5% (525/1,207)	47% (7/15)
	Diploma/Bachelor	16.5% (199/1,207)	13% (2/15)
	Professional	1.8% (21/1,207)	0% (0/15)
<b>Monthly household income</b>	Rs 1–1,000	11% (138/1,207)	6.7% (1/15)
	Rs 1,001–3,000	53% (636/1,207)	67% (10/15)
	Rs 3,001–5,000	26% (314/1,207)	13% (2/15)
	Rs 5,001–10,000	8% (98/1,207)	13% (2/15)
	Rs 10,001–25,000	1.5% (18/1,207)	0% (0/15)
	Rs 25,001–above	0.25% (3/1,207)	0% (0/15)
<b>Occupation (self)</b>	Laborer /factory/field worker	12% (146/1,207)	7% (1/15)
	Farmer	14% (172/1,207)	0% (0/15)
	Housewife	71% (852/1,207)	93% (14/15)
	Business	0.4% (5/1,207)	0% (0/15)
	Teacher	0.91% (11/1,207)	0% (0/15)
	Student	0.08% (1/1,207)	0% (0/15)
	Other	1.7% (20/1,207)	0% (0/15)
<b>Current STD symptoms</b>	No symptoms	84% (1,014/1,207)	40% (6/15)
	Vaginal discharge	9% (1,13/1,027)	47% (7/15)
	Burning during urination	6% (77/1,027)	13% (2/15)
	Genital ulcer	0.25% (3/1,027)	0% (0/15)
<b>Condom use</b>	—	95% (1,145/1207)	80% (12/15)
<b>Past blood transfusion</b>	—	2% (23/1207)	13% (2/15)
<b>Previous HIV testing</b>	—	31% (379/1,207)	27% (4/15)
<b>Spouse with TB</b>	—	1.2% (14/1,207)	27% (4/15)
<b>Lifetime number of sexual partners</b>	One	99.5% (1,201/1,207)	67% (10/15)
	Two	0.5% (6/1,207)	27% (4/15)
	Three	0% (0/1,207)	7% (1/15)

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the past. A vast majority (84%) of the women reported no symptoms of sexually transmitted diseases. Only about 2% of the women reported that their spouse/partner had been tested for HIV and only 1% reported that their spouse was HIV-positive.

### Results of HIV Testing

Of 1,222 study participants, 563 (46%) presented with some history of HIV testing during pregnancy. The remaining 659 participants (54%) were never tested during their pregnancy. Of 563 women who had claimed to have been tested, 367 (65%) reported being tested in private health facilities, 46 (8%) in government facilities, and 15 (3%) in nongovernment organizations, while the rest (24%) could not recall the site of testing.

Of 563 women, 327 (58%) were unaware of the results of the HIV test result, due to either failure in picking up test results or not receiving a report of HIV test from private facilities. The remaining participants, 3% (17/563) were unwilling to disclose the test result. About 39% (219/563) of the participants claimed to know the result, but their documentation of test result was of poor quality, perhaps due to the fact that many were tested in private settings, including unlicensed health professionals.

Of the 1,222 women who participated in the study, 15 women were found to be HIV-positive using the reference standard of dual ELISA and Western blot. Thus, the overall

HIV seroprevalence rate during the study period was 1.23% (95% CI 0.61%–1.8%)

Overall, of the 1,222 women who underwent testing in the labor ward, 1,003 (82%; 95% CI 79.8%–84.2%) had never been HIV tested, or had been tested but were unaware of their HIV status (Figure 1). Thus, the use of labor room rapid HIV testing resulted in the ascertainment of information on HIV serostatus in 82% of all women, who would not have known their HIV status otherwise. Of the 15 HIV-positive women, four presented with previously reported HIV test results. Thus, 11 of 15 HIV infected (73.3%; 95% CI: 47.5%–90.9%) women were newly diagnosed at point-of-care, resulting in substantially higher case detection of HIV positives due to the round-the-clock testing program.

### PMTCT Interventions

Of the 15 HIV-positive women, 14 (93.3%; 95% CI 71.3%–99.7%) received PMTCT interventions, both in the intrapartum and postpartum period. Only one HIV-positive woman was found nonreactive with both OraQuick rapid tests, but she was later found positive by ELISA (and confirmed by Western blot). This participant and the infant did not receive intrapartum interventions, but were administered ART postpartum, within 24 h of receiving the positive test results.

Of the 15 infants delivered by HIV-infected women, two infants were HIV DNA PCR positive within 48 h. Of these,

**Table 2.** Diagnostic Accuracy of OraQuick Oral Fluid Test

OraQuick Oral Test Results	EIA + Western Blot Positive	EIA Negative	Total
Positive	14	0	14
Negative	1	1,207	1,208
Total	15	1,207	1,222

Sensitivity = 93.3% (95% CI 71.3%–99.7%)  
 Specificity = 100% (95% CI 99.75%–100%)  
 Positive predictive value = 100% (95% CI 99.99%–100.0%)  
 Negative predictive value = 99.96% (95% CI 99.6%–99.98%)  
*Kappa* = 1.00 (95% CI 0.99–1.00)  
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one infant died within 1 wk, and the other died within 1 mo of delivery. The remaining 13 infants were HIV DNA PCR negative at 48 h, 1 mo and 4 mo after delivery.

### Turn Around Times for Testing and Interventions

The time interval between eligibility assessment and informed consent was 5–10 min. The time taken for pretest counseling on average was 15 min, and time taken for HIV rapid testing on average was 20 min. In sum, the total time from eligibility assessment of the study participant to referral for PMTCT intervention averaged 40–60 min.

### Diagnostic Accuracy of Rapid HIV Tests

Both oral fluid and finger-stick OraQuick rapid tests had similar diagnostic accuracy (Tables 2 and 3). The sensitivity of both tests was 93.3% (95% CI 71.3–99.7%) and specificity was 100% (95% CI 99.75–100%). One negative OraQuick rapid HIV test result (by both oral and finger-stick OraQuick) was later found to be positive by the reference standard of ELISA and Western blot. Thus, the false negative rate was 6.7%. Agreement between the oral fluid and finger-stick OraQuick results was perfect (*kappa* = 1.00). There were no discordant OraQuick rapid test results.

### Client Preference for Rapid Testing

Client preference for rapid testing was assessed during the postpartum counseling. When asked which HIV test participants would prefer for first time and repeat testing, most participants (70%) reported that the oral fluid-based OraQuick would be their preferred choice. When questioned as to which test would they recommend a friend for testing, 74% participants preferred oral fluid testing, 24% preferred finger-stick, and 1% preferred the venous blood draw. Minimum frequency of discomfort (76%) was reported by participants with the oral fluid test. With the finger-stick test, 63% reported no discomfort, while, with venous blood draw, discomfort was reported by 94% participants.

Other issues with finger-stick test were pain reported by 26% participants, fear of giving blood by 11% participants. With venous blood draw, 20% participants reported pain, 62% reported fear of giving blood, and 18% pain and swelling.

### Feasibility of Counseling in the Labor Room Setting

Anecdotally, based on the reports of the counselors, the postpartum counseling session was well received by the study participants. According to the counselors, women were

**Table 3.** Diagnostic Accuracy of OraQuick Finger-stick Test

OraQuick Finger-Stick Test Results	EIA + Western Blot Positive	EIA Negative	Total
Positive	14	0	14
Negative	1	1,207	1,208
Total	15	1,207	1,222

Sensitivity = 93.3% (95% CI 71.3%–99.7%)  
 Specificity = 100% (95% CI 99.75%–100%)  
 Positive predictive value = 100% (95% CI 99.99%–100.0%)  
 Negative predictive value = 99.96% (95% CI 99.6%–99.98%)  
*Kappa* = 1.00 (95% CI 0.99–1.00)  
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relaxed and were better able to question and comprehend information provided on care of their infant, including information on HIV transmission through breast milk.

### Disclosure of Test Results

Counselors had strict instructions to protect the confidentiality of test results. A majority (85%) of women preferred to know their results right after testing. Disclosure of results to the spouses was left to the discretion of the study participants. We do not have information on how many HIV-negative women disclosed their serostatus to their partner. We do have information on HIV-positive women. Of all HIV-positive women, 75% (12/15) discussed their serostatus with their husbands and the remainder (3/15) with their mothers.

## Discussion

HIV testing of pregnant women during labor and delivery is one of the last opportunities to prevent mother-to-child HIV transmission, especially in women who do not have access to antenatal care and HIV testing services early in pregnancy. In India, a sizeable proportion of rural women present to hospitals for delivery without any prior antenatal care [10,11]. Even those women who do receive some antenatal care do not always get tested for HIV for various reasons.

In this study, we assessed the impact of introducing round-the-clock, rapid, point-of-care HIV counseling and testing in a labor ward in rural India. Our results show that it is feasible to introduce a program of round-the-clock oral rapid HIV testing, including abbreviated prepartum and extended postpartum counseling sessions, even in a very busy labor room setting in an Indian village. In our study, all women who consented were successfully counseled and tested. Counseling in the labor room setting was highly feasible, even in a busy rural hospital setting. Our data suggest that the availability of round-the-clock rapid HIV testing resulted in successful documentation of HIV serostatus in a large proportion of women who were unaware of their HIV status when admitted to the labor ward. In addition, 11 of a total of 15 HIV-positive women received PMTCT interventions because they underwent rapid testing in the labor ward. Lastly, with regard to rapid test accuracy, both oral and finger-stick OraQuick tests had excellent specificity (100%), with one false negative result.

An important finding of our study was that of the 564

women who claimed to have been tested for HIV some time during pregnancy, only 219 were confident in reporting test results. A majority of the women had failed to pick up their test results from private providers or had not been adequately informed about test results. Of the 15 HIV-positive women, only four reported having been tested in pregnancy. In our study, a majority of women sought HIV testing from private practitioners (including unlicensed providers) and were unaware of the test results. These data suggest that there are several missed opportunities for HIV testing during pregnancy.

In India, HIV testing is not routinely offered by health care providers, especially in the private health care sector [18]. Further, several factors acting at individual, community, regional, and national levels prevent women from seeking voluntary HIV testing in pregnancy. Individual-level factors include poverty and difficulty in accessing health care, reluctance of rural women to seek hospital care as opposed to midwife-based home care, stigma, fear of obtaining a positive test result coupled with the fear of intimate partner violence and ostracism by the partner's family, and lack of awareness about the effectiveness of PMTCT interventions [18]. Community-level factors include stigma, discrimination by community and health care professionals, and lack of social support [18,19]. Regional- and national-level factors are: (1) lack of infrastructure (including availability of round-the-clock laboratory technicians); (2) irregular and insufficient supply of HIV rapid test kits; (3) cumbersome and time-consuming blood-based rapid tests; (4) lack of 24-h round-the-clock counseling services; and (5) women presenting late in labor (often within obstetric complications), which makes it difficult for obstetricians to arrange for urgent PMTCT interventions [4,10]. In our study, by offering round-the-clock rapid testing and two-stage counseling, we were able to deliver PMTCT interventions to women who presented late in labor with no prior history of HIV testing and/or antenatal care.

Acceptability of rapid testing in our study was 98%, as compared to 83%–85% reported elsewhere [20–22]. Preference for oral fluid-based tests over blood-based tests was 70%. This preference could be because oral fluid testing was convenient and did not elicit patients' fear of blood draw, or pain of needle stick and venipuncture. Our previous study in sexually transmitted disease clinic attendees in India documented a similarly high preference for the oral fluid-based rapid tests [4].

Effective counseling sessions can play a major role in the institution of PMTCT interventions worldwide. However, counseling women in labor is a challenging endeavor [11,12]. Besides, issues such as patient confidentiality, privacy of disclosure, and social support for the care of infant and mother all affect the emotional health of both mother and baby and need to be addressed [12,20]. In our study, an abbreviated counseling session during labor and an extended postpartum counseling session led to a better uptake of advice from counselors in comparison to a one stage counseling session in labor used previously in routine practice settings [6,11,12].

To our knowledge, our study is the first and largest study in a rural setting in the world, introducing round-the-clock rapid HIV testing and counseling in pregnant women in labor. The novel features of our study are: (1) use of an oral

fluid-based OraQuick Rapid HIV-1/HIV-2 test; (2) use of a parallel testing strategy with finger-stick OraQuick Rapid HIV-1/HIV-2 test; (3) round-the-clock availability of trained counselors, and use of a two-stage (i.e., abbreviated prepartum and extended postpartum) counseling sessions; (4) evaluation of this strategy in a rural population in a resource constrained setting.

In previous studies, blood-based rapid HIV tests have been used in pregnant women in both antenatal clinics and labor rooms [6,21,23,24]. The US Centers for Disease Control and Prevention (CDC)-funded Mother Infant Rapid Intervention at Delivery (MIRIAD) study evaluated the feasibility and performance of the blood-based rapid OraQuick Rapid HIV test in 4,849 pregnant women in labor across 16 hospitals in the US [21]. Of 7,381 potential participants, 4,849 women consented (84%) for testing [21]. In comparison, our consent rate was 98%.

Three studies have been conducted in pregnant women in antenatal clinics and delivery rooms in urban India [10,11,20]. In the first study, 1,258 consenting women were tested with blood-based rapid HIV and salivary brush OraQuick HIV tests. A lower sensitivity of 75% for OraQuick saliva test was detected due to inadequate salivary sample collection and use of inferior quality gold standard ELISA test [10]. In our study, an advanced version of oral fluid-based OraQuick Rapid HIV-1/HIV-2 in a parallel strategy with a reference standard of dual ELISA and Western blot improved our estimates of diagnostic accuracy. In the second Indian study, about 522 of 1,322 women (44%) consented to test with four rapid HIV tests (i.e., three rapid finger-stick and one rapid saliva test). Approximately, 61% women presented with a prior history of HIV testing, and four new cases of HIV were identified [11]. In our study, a majority (82%) of women presented with no history of HIV testing, and eleven new cases were identified. In the third study, 61% (417 of 613) women accepted testing and counseling, as compared to 98% in our study [20]. The higher acceptance rate in our study could be attributed to the use of an oral fluid HIV test and a two-stage counseling session that were not employed in earlier studies [20].

Our study has strengths and limitations. Strengths include a fairly large sample size, a high response rate, inclusion of several rural women with no prior antenatal care, and provision of round-the-clock two-stage counseling and point-of-care oral rapid HIV testing services even in a busy rural labor room setting.

With regard to limitations, our study was not designed to detect HIV seroprevalence in all pregnant women. Further, our sensitivity estimates of OraQuick tests were imprecise because of the relatively few HIV-positive women diagnosed during the study period. Our study was conducted in a rural, labor ward setting in India, and therefore our results may not be generalizable to all settings. Due to the fact that we utilized the existing hospital resources and rapid HIV test kits donated to us for the study, we were unable to precisely assess the total costs involved in setting and implementing our testing and counseling program. We are currently planning cost-effectiveness and cost-benefit analyses of introducing a round-the-clock rapid HIV testing program in the labor ward. Lastly, while we have demonstrated the feasibility and impact of introducing a round-the-clock rapid HIV testing program in the labor ward, the sustainability of such projects and their evaluation for implementation at the

country level will require involvement of government and international agencies.

## Conclusions

In a busy, rural labor ward setting in India, we demonstrated the feasibility and impact of introduction of a round-the-clock rapid HIV testing and two-stage counseling program. Our data suggest that this testing approach resulted in successful documentation of HIV serostatus in a large proportion of women who were unaware of their HIV status when admitted to the labor ward. Additionally, a high proportion of HIV-positive women received PMTCT interventions due to rapid testing in labor. These findings may inform existing PMTCT programs in similar settings worldwide to upgrade the current testing services in rural resource constrained settings. This includes incorporation of patient preferred oral rapid point-of-care HIV tests and patient-tailored two-stage counseling sessions that worked well in our setting. Such targeted initiatives may also help estimate burden of HIV infection in pregnant women with unknown serostatus in similar settings worldwide.

## Supporting Information

### Figure S1. HIV Testing Algorithm

Found at doi:10.1371/journal.pmed.0050092.sg001 (33 KB DOC).

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**Author contributions.** NPP: Conception and design, acquisition of data, analysis and interpretation of data, drafting of manuscript and statistical analysis. RB: Conception, conduct of the study, acquisition of data, interpretation of data, drafting of manuscript. JPT: Conception and design, interpretation of data, drafting of manuscript and technical support. PVS: Conception and design, acquisition of data, interpretation of data, drafting of manuscript. DC: Conception and design, interpretation of data, drafting of manuscript, critical revision of manuscript and technical support. SPK: Design, interpretation of data, drafting of manuscript, critical revision of manuscript. MP: Design, interpretation of data, technical support, critical revision of manuscript. MBK: Design, interpretation of data, technical support, supervision, drafting and critical revision of manuscript. SC: Conception and design, interpretation of data, drafting of manuscript, critical revision, technical support and overall supervision of the project.

## References

- UNAIDS (2006) 2006 report on the global AIDS epidemic: executive summary / UNAIDS. Geneva. Document Number UNAIDS/06.20E. Available at: [http://whqlibdoc.who.int/unaid/2006/9291735116\\_eng.pdf](http://whqlibdoc.who.int/unaid/2006/9291735116_eng.pdf). Accessed 31 March 2008.
- Brocklehurst P, Volmink J (2002) Antiretrovirals for reducing the risk of mother-to-child transmission of HIV infection. *Cochrane Database Syst Rev*: CD003510.
- Kourtis AP, Lee FK, Abrams EJ, Jamieson DJ, Bulterys M (2006) Mother-to-child transmission of HIV-1: timing and implications for prevention. *Lancet Infect Dis* 6: 726–732.
- Pant Pai N, Joshi R, Dogra S, Taksande B, Kalantri SP, et al. (2007) Evaluation of diagnostic accuracy, feasibility and client preference for rapid oral fluid-based diagnosis of HIV infection in rural India. *PLoS ONE* 2: e367.
- Pant Pai N (2007) Oral fluid-based rapid HIV testing: issues, challenges and research directions. *Expert Rev Mol Diagn* 7: 325–328.
- Pant Pai N, Tulsy JP, Cohan D, Colford JM Jr, Reingold AL (2007) Rapid point-of-care HIV testing in pregnant women: a systematic review and meta-analysis. *Trop Med Int Health* 12: 162–173.
- Merhi Z, Minkoff H (2005) Rapid HIV screening for women in labor. *Expert Rev Mol Diagn* 5: 673–679.
- Bolu OO, Allread V, Creek T, Stringer E, Forna F, et al. (2007) Approaches for scaling up human immunodeficiency virus testing and counseling in prevention of mother-to-child human immunodeficiency virus transmission settings in resource-limited countries. *Am J Obstet Gynecol* 197: S83–S89.
- NACO (2006) HIV/AIDS epidemiological surveillance and estimation report for the year 2005. NACO, Government India HSS-2006.
- Bhore AV, Sastry J, Patke D, Gupte N, Bulakh PM, et al. (2003) Sensitivity and specificity of rapid HIV testing of pregnant women in India. *Int J STD AIDS* 14: 37–41.
- Bharucha KE, Sastry J, Shrotri A, Sutar S, Joshi A, et al. (2005) Feasibility of voluntary counselling and testing services for HIV among pregnant women presenting in labour in Pune, India. *Int J STD AIDS* 16: 553–555.
- Jamieson DJ, O'Sullivan MJ, Maupin R, Cohen M, Webber MP, et al. (2003) The challenges of informed consent for rapid HIV testing in labor. *J Womens Health (Larchmt)* 12: 889–895.
- [No authors listed] (2006) Orasure Technologies OraQuick ADVANCE Rapid HIV1/2 Antibody Test (package insert). Orasure Technologies, Bethlehem, Pennsylvania: Orasure Technologies.
- Giuliano M, Guidotti G, Andreotti M, Pirillo MF, Villani P, et al. (2007) Triple antiretroviral prophylaxis administered during pregnancy and after delivery significantly reduces breast milk viral load: a study within the Drug Resource Enhancement Against AIDS and Malnutrition Program. *J Acquir Immune Defic Syndr* 44: 286–291.
- Marazzi MC, Germano P, Liotta G, Guidotti G, Loureiro S, et al. (2006) Safety of nevirapine-containing antiretroviral triple therapy regimens to prevent vertical transmission in an African cohort of HIV-1-infected pregnant women. *HIV Med* 7: 338–344.
- McIntyre JA, Martinson N, Gray GE, Hopley M, Kimura T, et al. (2003) Addition of short course combivir (CBV) to single dose zidovudine (sdNVP) for the prevention of mother to child transmission (pMTCT) of HIV-1 can significantly decrease the subsequent development of maternal and paediatric NNRTI-resistant virus. The 3rd IAS Conference on HIV Pathogenesis and Treatment. Rio de Janeiro. Abstract No: TuFo0204. Rio de Janeiro. Available: <http://www.iasociety.org/Default.aspx?pageId=11&abstractId=2176901>. Accessed 8 April 2008.
- World Health Organization G (2006) What's new in the PMTCT guidelines? Geneva: WHO. Available: [http://www.who.int/hiv/mediacentre/fs\\_2006guidelines\\_pmtct/en/index.html](http://www.who.int/hiv/mediacentre/fs_2006guidelines_pmtct/en/index.html). Accessed 31 March 2008.
- Samuel NM, Sriyayanth P, Dharmarajan S, Bethel J, Van Hook H, et al. (2007) Acceptance of HIV-1 education & voluntary counselling/testing by & seroprevalence of HIV-1 among pregnant women in rural south India. *Indian J Med Res* 125: 49–64.
- Steinbrook R (2007) HIV in India—the challenges ahead. *N Engl J Med* 356: 1197–1201.
- Shankar AV, Pisal H, Patil O, Joshi A, Suryavanshi N, et al. (2003) Women's acceptability and husband's support of rapid HIV testing of pregnant women in India. *AIDS Care* 15: 871–874.
- Bulterys M, Jamieson DJ, O'Sullivan MJ, Cohen MH, Maupin R, et al. (2004) Rapid HIV-1 testing during labor: a multicenter study. *JAMA* 292: 219–223.
- Webber MP, Demas P, Enriquez E, Shanker R, Oleszko W, et al. (2001) Pilot study of expedited HIV-1 testing of women in labor at an inner-city hospital in New York City. *Am J Perinatol* 18: 49–57.
- Melvin AJ, Alarcon J, Velasquez C, Rodriguez C, Piscocoy J, et al. (2004) Rapid HIV type 1 testing of women presenting in late pregnancy with unknown HIV status in Lima, Peru. *AIDS Res Hum Retroviruses* 20: 1046–1052.
- Nogueira SA, Lambert JS, Albuquerque AL, Rodrigues R, Reis S, et al. (2001) Assessment of a rapid HIV test strategy during labor: a pilot study from Rio de Janeiro, Brazil. *J Hum Virol* 4: 278–282.

## Editors' Summary

**Background.** Since the first reported case of AIDS (acquired immunodeficiency syndrome) in 1981, the number of people infected with the human immunodeficiency virus (HIV), which causes AIDS, has risen steadily. Now, more than 33 million people are infected, almost half of them women. HIV is most often spread through unprotected sex with an infected partner, but mother-to-child transmission (MTCT) of HIV is also an important transmission route. HIV-positive women often pass the virus to their babies during pregnancy, labor and delivery, and breastfeeding, if nothing is done to prevent viral transmission. In developed countries, interventions such as voluntary testing and counseling, safe delivery practices (for example, offering cesarean delivery to HIV-positive women), and antiretroviral treatment of the mother during pregnancy and labor and of her newborn baby have minimized the risk of MTCT. In developing countries, the prevention of MTCT (PMTCT) is much less effective, in part because pregnant women often do not know their HIV status. Consequently, in 2007, nearly half a million children became infected with HIV mainly through MTCT.

**Why Was This Study Done?** In many developing countries, women do not receive adequate antenatal care. In India, for example, nearly half the women living in rural areas do not receive any antenatal care until they are in labor. This gives health care providers very little time in which to counsel women about HIV infection, test them for the virus, and start interventions to prevent MTCT. Furthermore, testing pregnant women in labor for HIV and counseling them is a challenge, particularly where resources are limited. In this study, therefore, the researchers investigate the feasibility and impact of introducing round-the-clock, rapid HIV testing and counseling in a busy labor ward in a rural teaching hospital in Sevagram, India.

**What Did the Researchers Do and Find?** Women admitted to the labor ward between January and September 2006 were offered two rapid HIV tests—one that used a saliva sample and the other that used blood taken from a finger prick. Blood was also taken from a vein for conventional HIV testing. All the women were given a 15-minute counseling session about how HIV is transmitted, the importance of HIV testing, and information on PMTCT before their child was born (prepartum counseling), and a longer postpartum counseling session. HIV-positive women were given a cesarean delivery where possible and antiretroviral drug treatment to reduce MTCT. 1,222 women admitted to the labor ward during the study period (1,003 of whom did not know their HIV status) accepted HIV testing. Of 15 study participants who were

HIV positive, 11 learnt of their HIV status in the labor room. Two babies born to these HIV-positive women were HIV positive and died within a month of delivery; the other 13 babies were HIV negative at birth and at 1 and 4 months after delivery. Finally, the rapid HIV tests missed only one HIV-positive woman (no false-positive results were given), and the time from enrolling a woman into the study through referring her for PMTCT intervention where necessary averaged 40–60 minutes.

**What Do These Findings Mean?** These findings show the feasibility and positive impact of the introduction of round-the-clock pre- and postpartum HIV counseling and rapid HIV testing into a busy rural Indian labor ward. Few of the women entering this ward knew their HIV status previously but the introduction of these facilities in this setting successfully informed these women of their HIV status. In addition, the round-the-clock counseling and testing led to 11 women and their babies receiving PMTCT interventions who would otherwise have been missed. These findings need to be confirmed in other settings and the cost-effectiveness and sustainability of this approach for the improvement of PMTCT in developing countries needs to be investigated. Nevertheless, these findings suggest that round-the-clock rapid HIV testing might be an effective and acceptable way to reduce MTCT of HIV in many developing countries.

**Additional Information.** Please access these Web sites via the online version of this summary at <http://dx.doi.org/10.1371/journal.pmed.0050092>.

- Read a related *PLoS Medicine* Perspective article
- Information is available from the US National Institute of Allergy and Infectious Diseases on HIV infection and AIDS and on HIV infection in women
- HIV InSite has comprehensive information on all aspects of HIV/AIDS
- Women, Children, and HIV provides extensive information on the prevention of mother-to-child transmission of HIV in developing countries
- Information is available from Avert, an international AIDS charity, on HIV and AIDS in India, on women, HIV, and AIDS, and on HIV and AIDS prevention, including the prevention of mother-to-child transmission
- AIDSinfo, a service of the US Department of Health and Human Services provides health information for HIV-positive pregnant women (in English and Spanish)