Rapid human immunodeficiency virus-1 testing on labor and delivery in 17 US hospitals: the MIRIAD experience

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The objective of the study was to evaluate the feasibility, acceptability, and accuracy of rapid human immunodeficiency virus (HIV) testing during labor. The Mother-Infant Rapid Intervention at Delivery (MIRIAD) study was a prospective, multicenter study that offered voluntary, rapid HIV testing to women with undocumented HIV status at 17 hospitals in 6 cities. Of 12,481 eligible women, 74% were approached for participation and 85.5% of those approached accepted rapid HIV testing. Among 7753 women tested, MIRIAD identified 52 (0.7%) HIV-infected women. The time between obtaining the blood sample for the rapid test and reporting the results to the health care provider was shorter for hospitals utilizing point-of-care testing than in hospitals utilizing laboratory-based testing (30 minutes vs 68 minutes; $P < .0001$), and point-of-care testing strategies were 14 times more likely to have a short turnaround as laboratory testing strategies. Routine rapid testing during labor provides a feasible, acceptable, and accurate way to identify HIV-infected women before delivery.

Key words: rapid human immunodeficiency virus testing

Approximately one quarter of human immunodeficiency virus (HIV)–infected persons in the United States are unaware that they are infected.[1] It is particularly important that pregnant women know their HIV status, both for their own health and to prevent transmission to their infant. Because of the implementation of several effective strategies, including the use of combination antiretroviral prophylaxis, elective cesarean delivery, and avoidance of invasive obstetric procedures and breast-feeding, perinatal HIV transmission rates have dramatically decreased in the United States over the past decade.[2,3] The problem is that to implement these strategies successfully, a pregnant woman and her health care provider must be aware of her HIV status.

Since 1995, there have been guidelines in place in the United States recommending HIV testing for all pregnant women.[4] These guidelines have evolved and now include routine opt-out testing, in which pregnant women are notified that HIV testing is included as a routine prenatal test to be performed unless they decline.[5] However, women who do not obtain prenatal care are unlikely to be tested for HIV during pregnancy.[6] Even women who receive prenatal care may not be offered or accept testing.[2] Because most women in the United States deliver in hospitals, rapid HIV testing on labor and delivery units is the last opportunity to identify HIV-infected women before delivery and to provide antiretroviral prophylaxis to prevent perinatal transmission during labor and delivery.[7]

The Mother-Infant Rapid Intervention at Delivery (MIRIAD) study was a large, prospective, multicenter project designed to evaluate the feasibility, acceptability, and accuracy of rapid HIV testing during labor. An earlier brief report included initial results from the study's first 2 years.[8] The present paper summarizes the final data from 17 hospitals during the entire 40-month study period. In addition, we present more extensive analyses by including variables and follow-up information not available when the earlier report was published.

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MATERIALS AND METHODS

The MIRIAD study, which was a prospective, multicenter study funded by the Centers for Disease Control and Prevention (CDC), offered voluntary, rapid HIV testing to women with undocumented HIV status late in pregnancy. The MIRIAD protocol, which enrolled patients from November 2001 through February 2005, was successfully implemented in 17 hospitals in 6 cities (Atlanta, GA; Baton Rouge, LA; Chicago, IL; Miami, FL; New Orleans, LA; and New York, NY). One Atlanta hospital was unsuccessful in implementing the MIRIAD protocol because of problems in coordinating multiple obstetric providers and private practice groups. Because only 1% of the eligible women there were tested, that hospital has been excluded from all analyses.

All women presenting to labor and delivery units were screened for eligibility for MIRIAD as either a "peripartum" or a "late presenter" participant. To be eligible, a woman had to have undocumented HIV status during her current pregnancy. Pregnant women with an estimated gestational age of 24 weeks or greater and in labor or with an indication for urgent delivery were eligible for the peripartum protocol. Labor was defined as ruptured membranes or cervical dilation of 4 cm or greater for pregnancies less than 34 weeks' gestation and as regular, painful uterine contractions accompanied by cervical dilation for those at gestation of 34 weeks or longer. For the late-presenter protocol, eligible women had to have an estimated gestational age of 34 weeks or longer and not be in labor. The initial eligibility requirement that the late presenter group also had to have no prenatal care visits was dropped in early 2003.

Women determined to be eligible were approached and asked whether they were interested in MIRIAD. If a peripartum woman expressed interest, a flip-chart with pictures was used to present information about the study and to review the relevant parts of the informed consent process.[9] Because the women eligible for the late-presenter protocol were not in labor, the flip-chart was not used for them and a standard consent process was followed. Toward the end of the study, the way women were approached for participation changed at 3 hospitals at which an opt-out approach for HIV testing during labor was evaluated as part of a substudy. Beginning in July 2004, all women eligible for MIRIAD at these 3 hospitals were consented for rapid testing using a standard institutional consent form, rather than the MIRIAD research consent form (opt-in approach). Then in October 2004, all women eligible for MIRIAD at the same 3 hospitals were given a 1-page information sheet listing the routine admission labor and delivery tests to be performed (eg, rapid plasma reagin, rapid HIV, complete blood count, blood type, and antibody screen) for all women. Those who did not want to be tested for HIV had to specifically decline the testing (opt-out approach). The findings from this substudy will be described more fully in a subsequent manuscript.

Information was collected on all eligible women, including the exact time (in minutes) when they arrived on the labor and delivery unit and when they were offered participation in MIRIAD, their reasons for declining participation (if applicable), and brief demographic and delivery information. One hospital, however, failed to collect the demographic and delivery information of eligible women who were not enrolled. All participants provided written informed consent, and the MIRIAD protocol was approved by the institutional review boards at the CDC and all participating hospitals.

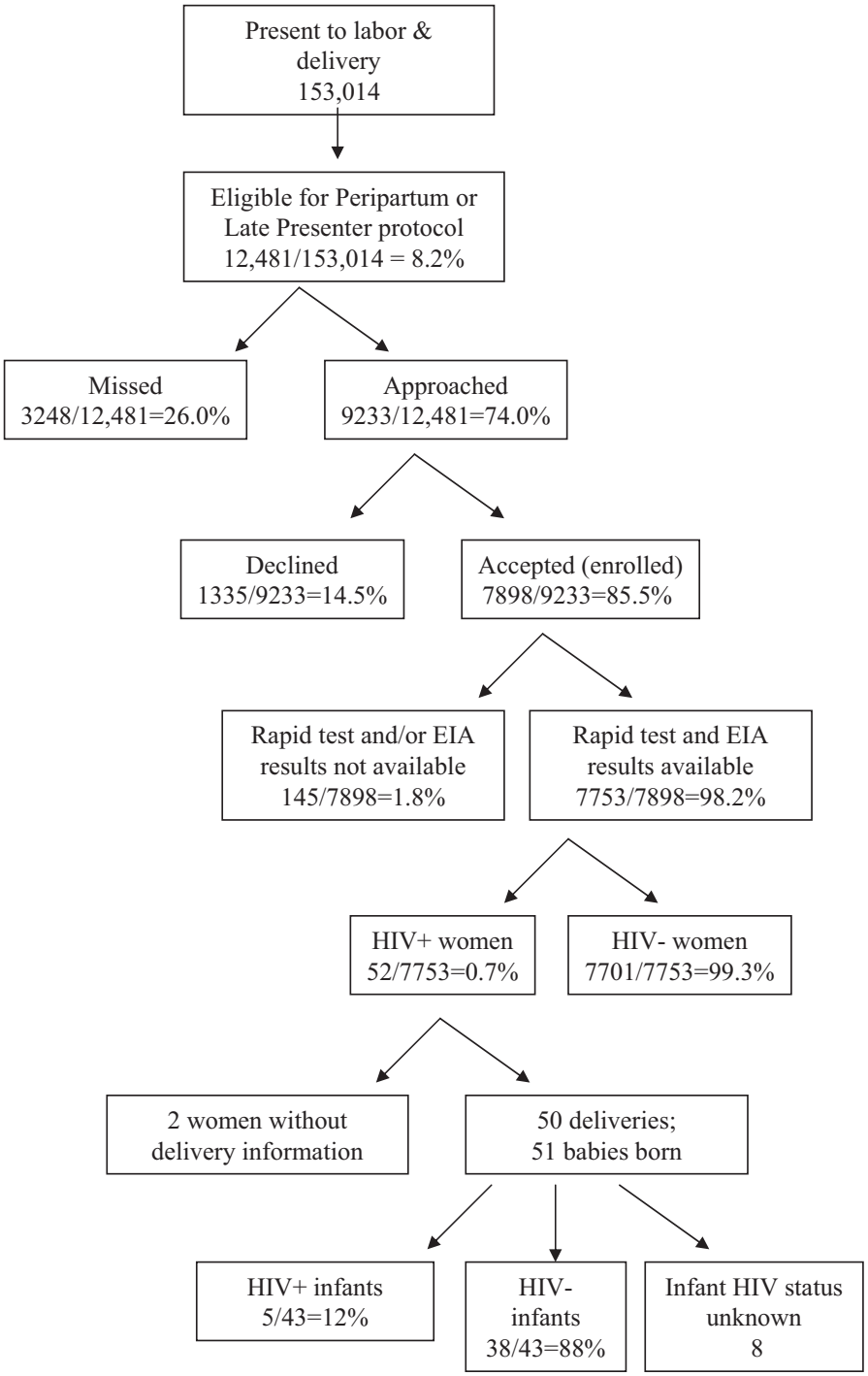
Once a participant consented to join the study, blood was collected for both rapid and conventional HIV testing (in some cases residual blood routinely collected on the labor and delivery unit at admission could be used for HIV testing). OraQuick rapid HIV-1 antibody test (OraSure Technologies Inc, Bethlehem, PA) was used for the rapid testing.[8] For the MIRIAD study, the US Food and Drug Administration (FDA) allowed the use of the OraQuick test under an investigational device exemption before the test was formally licensed in November 2002. In some hospitals, the rapid testing was performed on the labor and delivery unit by trained staff (subsequently described as point-of-care testing), whereas in other hospitals it was performed in a laboratory. Two hospitals switched from laboratory testing to point-of-care testing during the course of the study.[10]

All specimens were tested in parallel by conventional testing with enzyme immunoassay (EIA) and confirmatory Western blot. Seven institutions used the Abbott HIV-1/HIV-2 EIA (Abbott Laboratories, Abbott Park, IL), 7 institutions used the Genetic Systems HIV-1/HIV-2 peptide EIA (BioRad Laboratories, Hercules, CA), and 3 used the bioMerieux Vironostika HIV-1 ELISA kit (bioMerieux, Durham, NC). The bioMerieux EIA test is a second-generation test; the other EIA tests are third-generation tests. Initially, reactive rapid tests and EIAs were repeated in duplicate and a repeatedly reactive rapid test or EIA was confirmed using Western blot.

Most women were informed of the rapid test results as quickly as possible. Although there was an option on the informed consent form for peripartum women to indicate they did not want to be informed of the results until after delivery, only 136 women (2.3%) requested this option. When the rapid test result was positive, the woman was counseled that her test result was preliminarily positive and that the conventional testing results were still pending. These women were treated clinically as HIV infected and offered antiretroviral prophylaxis and other preventive obstetric care as appropriate, including avoiding invasive procedures during labor and delivery, such as the placement of fetal scalp electrodes.

An algorithm was designed to resolve discordant test results, when the results of rapid testing were not confirmed by conventional testing results. In these cases, the women and their infants were followed up at least 6 months to resolve the discrepancy. Infants born to HIV-infected women were tested using HIV deoxyribonucleic acid (DNA) polymerase chain reaction (PCR) at less than 48 hours, 2 weeks, 6 weeks, and 3 months,

FIGURE 1
Flow chart of MIRIAD participants, 2001-2005



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and if they were still indeterminate, at 6 months.

To assess the duration of each step in the testing process from arrival on the labor and delivery unit until the woman received her results, the staff recorded the time of each event. In addition, the MIRIAD staff reviewed medical records and conducted face-to-face interviews with both MIRIAD-identified HIV-infected women and a sample of uninfected eligible women.

Statistical analyses were performed using SAS software, version 9.1 (SAS Institute, Cary, NC). Odds ratios with 95% confidence intervals were estimated using unconditional logistic regression, adjusting for study site and other covariates. The sensitivity, specificity, and predictive values of the rapid tests and the EIAs were calculated. For each of these measures, confidence intervals were estimated using exact binomial methods. the median turnaround times were compared using the Wilcoxon rank-sum test.

RESULTS

During the 40-month study period, there were 153,014 labor and delivery visits at the 17 participating hospitals (Figure 1). Of these, 12,481 women (8.2% of all visits recorded) were eligible for either the late presenter or peripartum MIRIAD protocol. Approximately three quarters of eligible women were approached about enrollment in MIRIAD (and thus one quarter of the women were missed and never asked whether they wanted to participate).

Of the 9233 women who were approached for participation, approximately 15% declined, and the remaining 7898 women accepted. Among those who accepted, complete testing results were unavailable for 145 (1.8%) women. No rapid test results were available for 12 women, for 117 women conventional test results were not available, and both results were missing for 16 women. Conventional test results were missing largely because blood was inadvertently not sent for confirmatory testing or because specimens were lost. Among the 7753 women with available test results, 52 (0.7%) were HIV infected. In this group, 50 women delivered a total of 51 babies (1 set of twins); 2 women did not deliver at a MIRIAD hospital, and thus no delivery information was available for them. Eight infants were lost to follow-up, and therefore, their HIV status remains unknown. Of the 43 infants with known HIV infection status, 5 (12%) were HIV infected.

Among women eligible for MIRIAD, the majority were younger than 25 years of age, almost two-thirds were black, and

most had 12 years or less of education (Table 1). Thirty-eight percent of the women had no prenatal care. In adjusted analyses, compared with women who were approached for participation in MIRIAD, the women who were "missed" (not offered participation) were more likely to be eligible for the late presenter protocol, to be younger than 20 years of age, to belong to a racial group other than black or white, to be admitted on a weekend, to be admitted during the evening shift (4:00 PM to 12:00 AM), and to have more advanced cervical dilation (8-10 cm) upon admission. Conversely, "missed" women were less likely to be Hispanic and to arrive 3-12 hours before delivery (Table 2).

The most common reason a woman was missed was that no staff member was available (33%) to approach her about participation. Although the participating hospitals were strongly encouraged to have 24-hour-a-day, 7-day-a-week coverage of labor and delivery, some of them had difficulty achieving continuous coverage. In addition, there were times at which some hospitals had to temporarily halt MIRIAD study activities, such as during hurricanes in New Orleans and Miami and during a temporary staffing shortage in Atlanta. During these times, all eligible women presenting to labor and delivery were not offered participation in MIRIAD and had to be classified as "missed." When the periods when MIRIAD was not operating fully (eg, no night shift MIRIAD staff available or during hurricanes or staffing shortages) were excluded from the analysis, the risk factors for being missed were not appreciably changed. The only notable differences were that age younger than 20 years (adjusted odds ratio [AOR] 1.23; 95% confidence interval [CI] 0.95-1.60) and advanced cervical dilation (AOR 1.19; 95% CI 0.86-1.66) were no longer significant risk factors.

In adjusted analyses, factors significantly associated with having women decline participation in MIRIAD included older age (AOR 1.7; 95% CI 1.4-2.0 for age 25 years or older), nonblack race (AOR 1.8; 95% CI 1.4-2.4), non-Hispanic ethnicity (AOR 2.1; 95% CI 1.6-2.9), admission during the evening or

TABLE 1
Characteristics of the 12,481 women presenting to labor and delivery who were eligible for the MIRIAD study, 2001-2005

Characteristic	No.	%
Participant group		
Peripartum	8898	71.3
Late presenter	3583	28.7
Age, y		
Younger than 20	2030	18.5
20-24	3621	32.9
25-29	2414	22.0
30 or older	2924	26.6
Missing	1492	
Race		
White	3215	29.8
Black	6969	64.6
Other	595	5.5
Missing	1702	
Hispanic ethnicity		
Non-Hispanic	7372	66.3
Hispanic	3740	33.7
Missing	1369	
Years of education		
0-11	3312	43.9
12	2918	38.6
12 or more	1319	17.5
Missing	4932	
No. of prenatal care visits		
0	2691	38.0
1-5	1718	24.3
More than 5	2666	37.7
Missing	5406	
Gestational age, wks		
Less than 32	866	7.8
32-36	2732	24.6
More than 36	7495	67.6
Missing	1388	
Study site		
Atlanta, GA	647	5.2
Chicago, IL	3868	31.0
Miami, FL	5237	42.0
New Orleans/Baton Rouge, LA	1575	12.6
New York, NY	1154	9.2

Continued on page S76.

TABLE 1
Characteristics of the 12,481 women presenting to labor and delivery who were eligible for the MIRIAD study, 2001-2005

Continued from page S75.

Characteristic	No.	%
Admission on weekend*		
Yes	3860	30.9
No	8620	69.1
Missing	1	
Time of admission		
12:00 AM to 8:00 AM	3600	28.8
8:00 AM to 4:00 PM	5127	41.1
4:00 PM to 12:00 AM	3751	30.1
Missing	3	
No. of hours before delivery woman first arrived		
0-2	1813	19.7
3-6	1859	20.2
7-12	1680	18.2
More than 12	3869	42.0
Missing	3260	
Hospital rapid testing process		
"Point-of-care" testing	7309	58.6
"Laboratory-based" testing	5172	41.4
Membrane status		
Intact	7782	64.8
Ruptured	2773	23.1
Unknown	1463	12.2
Missing	463	
Cervical dilation		
0-4 cm	6782	70.7
5-7 cm	1750	18.3
8-10 cm	1057	11.0
Missing	2892	
MIRIAD study date		
11/16/01 to 3/15/02	633	5.1
3/16/02 to 7/15/02	814	6.5
7/16/02 to 11/15/02	1286	10.3
11/16/02 to 3/15/03	1352	10.8
3/16/03 to 7/15/03	1563	12.5
7/16/03 to 11/15/03	1723	13.8
11/16/03 to 3/15/04	1563	12.5
3/16/04 to 7/15/04	1540	12.3
7/16/04 to 11/15/04	1373	11.0
11/16/04 to 2/13/05	634	5.1

MIRIAD, Mother-Infant Rapid Intervention at Delivery.

* Weekend considered from Friday at 5 PM to Monday at 6 AM.

night shifts (4:00 PM to 8:00 AM) (AOR 1.3; 95% CI 1.1-1.6), and having attended at least 1 prenatal care visit (AOR 1.8; 95% CI 1.4-2.2). Women eligible for the late-presenter protocol were more likely to decline than were those eligible for the peripartum protocol (AOR 3.5; 95% CI 2.8-4.3). The lowest rates of acceptance were on Friday evenings, when less than 80% of women accepted testing (Figure 2). The acceptance rate was higher in hospitals that used residual blood from a routine blood collection that did not require an extra needle stick to obtain a blood sample for the study (87.2% vs 73.9%; $P < .0001$). Staff members recorded women's reasons for declining participation; more than 1 reason could be recorded. Among peripartum women, the most common reasons given included having already been tested for HIV during the current pregnancy (37%), refusing to participate in research (16%), not wanting to know their HIV status (12%), and a perception that they were not at risk for HIV (12%). Among late presenters, the most common reason was also already having been tested for HIV during the current pregnancy (65%); less common reasons were not wanting another blood draw (9%) and refusing to participate in research (8%).

Women who initially declined participation were asked whether they would agree to be reapproached for participation at a later time. Among the 374 women who said they would and were reapproached, 196 (52%) agreed to participate when asked a second time. Often the staff member reapproaching the woman was not the one who approached her initially. The median interval between the first and second approaches was 16.5 hours; in most cases the women were reapproached after delivery.

Among the peripartum participants, the median time from arrival on the labor and delivery unit until the woman was informed of her rapid test result was shorter for hospitals using point-of-care testing than for those using laboratory-based testing (242 minutes vs 295 minutes; $P < .0001$). More specifically, the time between obtaining the blood sample for the rapid test and the reporting of results to the health care provider was

TABLE 2
Odds of never being offered MIRIAD among women eligible for rapid HIV testing during labor, MIRIAD study, 2001-2005

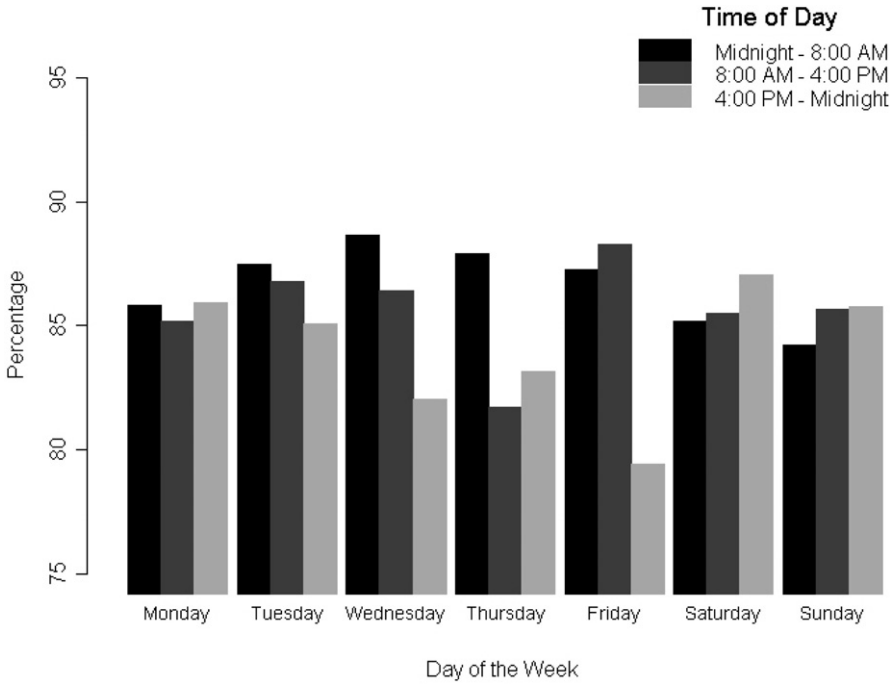
Characteristic	No.	MIRIAD never offered %	Odds ratio adjusted for study site (95% CI)	Odds ratio for full model* (95% CI)
Presentation				
Peripartum	8898	14.1	1.0	1.0
Late presenter	3583	55.6	10.8 (9.74-12.0)	10.1 (8.13-12.5)
Age, y				
Less than 20	2030	23.0	1.31 (1.13-1.51)	1.35 (1.07-1.70)
20-24	3621	22.1	1.12 (0.99-1.27)	1.00 (0.82-1.22)
25-29	2414	22.6	1.07 (0.94-1.23)	1.08 (0.87-1.33)
30 or older	2924	23.0	1.0	1.0
Missing	1492	51.2		
Race				
White	3215	26.5	1.0	1.0
Black	6969	17.3	1.07 (0.95-1.19)	0.84 (0.64-1.09)
Other	595	14.5	1.65 (1.25-2.19)	2.20 (1.43-3.40)
Missing	1702	64.8		
Hispanic ethnicity				
Non-Hispanic	7372	18.3	1.0	1.0
Hispanic	3740	29.1	1.11 (1.00-1.23)	0.71 (0.54-0.92)
Missing	1369	59.5		
Admission on weekend†				
Yes	3860	28.3	1.25 (1.14-1.37)	1.82 (1.55-2.14)
No	8620	25.0	1.0	1.0
Missing	1	100.0		
Time of admission				
12:00 AM to 8:00 AM	3600	19.3	0.70 (0.63-0.78)	1.03 (0.85-1.25)
8:00 AM to 4:00 PM	5127	26.4	1.0	1.0
4:00 PM to 12:00 AM	3751	32.1	1.46 (1.32-1.61)	1.39 (1.16-1.66)
Missing	3	33.3		
No. of hours prior to delivery woman first arrived				
0-2	1813	16.6	0.44 (0.38-0.52)	1.24 (0.95-1.63)
3-6	1859	11.0	0.28 (0.24-0.33)	0.73 (0.57-0.93)
7-12	1680	11.0	0.28 (0.23-0.33)	0.68 (0.53-0.87)
More than 12	3869	26.6	1.0	1.0
Missing	3260	46.9		
Cervical dilation				
0-4 cm	6782	24.0	1.0	1.0
5-7 cm	1750	13.1	0.38 (0.32-0.44)	0.92 (0.73-1.14)
8-10 cm	1057	14.8	0.55 (0.45-0.66)	1.37 (1.02-1.82)
Missing	2892	42.7		

CI, confidence interval; *MIRIAD*, Mother-Infant Rapid Intervention at Delivery.

* Logistic regression model containing study site, study date, and all variables listed in the table.

† Weekend considered from Friday at 5:00 PM to Monday at 6:00 AM.

FIGURE 2
Proportion of eligible women accepting participation in MIRIAD (2001-2005), by time of day and day of the week



Acceptance is lowest on Friday evenings (χ^2 P value = .0015).
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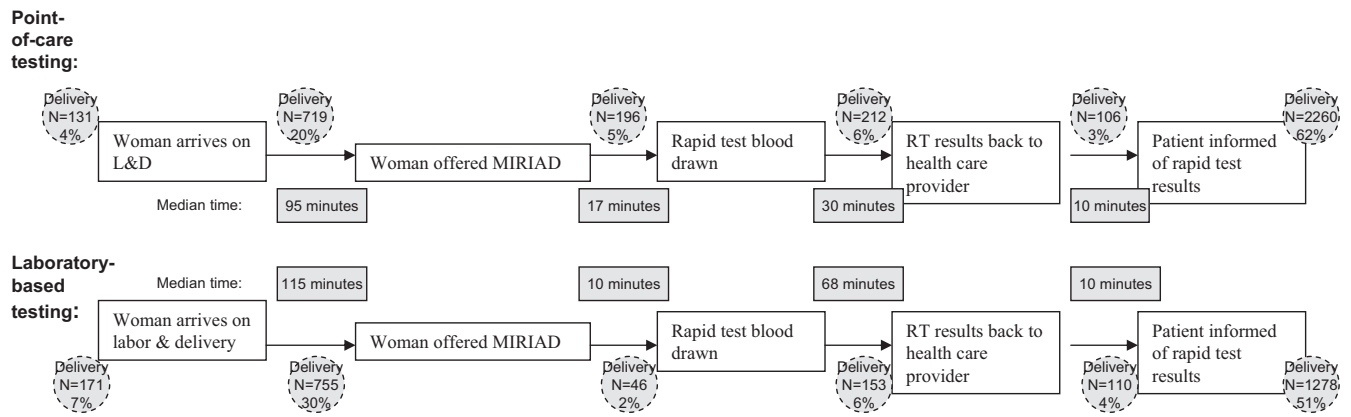
considerably shorter for hospitals using point-of-care testing than those employing laboratory-based testing (30 minutes vs 68 minutes; $P < .0001$; Figure 3). In addition, higher proportion of test results were reported back to the health care provider before delivery in point-of-care hospitals (65% vs 55%; $P < .0001$).

In analyses adjusted only by study site, women arriving more than 2 hours before delivery were more likely to have a rapid turnaround time, defined as less than 60 minutes from drawing of blood until the health care provider received the results (Table 3). However, the strongest predictor of a rapid test turnaround was the hospital rapid testing process; point-of-care testing strategies were 14 times as likely to have a short turnaround as those with laboratory-based testing strategies.

In analyses adjusted for both study site and hospital testing process (point of care vs laboratory based), admission on the weekend or during the night shift (12 AM to 8 AM) was associated with a longer turnaround (Table 3). When we examined predictors of the receipt of test results after, as opposed to before, delivery, several factors were associated with such delayed receipt, including a short time (2 hours or less) between arrival and delivery (AOR 83.4; 95% CI 61.8-113.0), having more than 5 prenatal care visits (AOR 1.3; 95% CI 1.1-1.5), nondaytime admission (AOR 1.6; 95% CI 1.3-2.0 for night shift and AOR 2.5; 95% CI 2.1-3.1 for evening shift), and admission on the weekend (AOR 1.8; 95% CI 1.5-2.2).

Using rapid testing, MIRIAD identified 52 HIV-infected women on labor

FIGURE 3
Testing timeline* for peripartum MIRIAD participants, 2001-2005



*Events on labor and delivery, from the woman's arrival until she is informed of the test results are described in unshaded boxes and ordered chronologically. Median times between events are reported in the shaded boxes. The proportion of women who deliver before, after, and between events is noted in the shaded circles; all circles for point-of-care and lab-based testing add to 100%.
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TABLE 3
Odds of short rapid test turnaround time (less than 60 minutes between blood draw and health care provider receiving test results) for 6719 peripartum women* enrolled in MIRIAD, 2001-2005

Characteristic	No.	Short turnaround time %	Odds ratio adjusted for study site (95% CI)	Odds ratio adjusted for study site and rapid testing process (95% CI)
No. of prenatal care visits				
0	1692	63.2	1.01 (0.86-1.19)	0.89 (0.74-1.07)
1-5	1186	62.3	0.95 (0.82-1.11)	0.97 (0.82-1.16)
More than 5	1853	63.9	1.0	1.0
Missing	1988	65.0		
Gestational age, wks				
Less than 32	623	64.5	1.01 (0.85-1.21)	0.95 (0.78-1.16)
32-36	1202	62.1	0.91 (0.80-1.04)	0.99 (0.85-1.15)
More than 36	4524	64.4	1.0	1.0
Missing	370	60.0		
Admission on weekend†				
Yes	2089	62.1	0.91 (0.82-1.01)	0.85 (0.75-0.96)
No	4630	64.5	1.0	1.0
Time of admission				
12:00 AM to 8:00 AM	2354	63.6	0.97 (0.87-1.09)	0.85 (0.75-0.97)
8:00 AM to 4:00 PM	2621	64.1	1.0	1.0
4:00 PM to 12:00 AM	1743	63.5	0.98 (0.86-1.11)	0.93 (0.80-1.07)
Missing	1	100		
No. of hours prior to delivery woman first arrived				
0-2	1321	61.0	1.0	1.0
3-6	1472	64.6	1.19 (1.02-1.38)	1.11 (0.93-1.32)
7-12	1315	64.9	1.21 (1.04-1.42)	1.06 (0.89-1.27)
More than 12	1874	66.3	1.26 (1.09-1.46)	1.05 (0.89-1.24)
Missing	737	58.8		
Hospital rapid testing process				
"Point-of-care" testing	3914	81.0	14.3 (12.3-16.6)	—
"Laboratory-based" testing	2805	39.8	1.0	—
MIRIAD study date				
11/16/01 to 3/15/02	358	55.0	1.0	1.0
3/16/02 to 7/15/02	546	54.4	0.97 (0.76-1.25)	0.87 (0.66-1.15)
7/16/02 to 11/15/02	769	50.6	0.79 (0.62-1.00)	0.73 (0.56-0.94)
11/16/02 to 3/15/03	894	55.9	0.99 (0.78-1.25)	0.83 (0.64-1.06)
3/16/03 to 7/15/03	746	56.6	0.99 (0.78-1.25)	0.83 (0.64-1.07)
7/16/03 to 11/15/03	854	69.1	1.75 (1.38-2.23)	1.03 (0.79-1.35)
11/16/03 to 3/15/04	831	70.4	1.95 (1.53-2.49)	0.79 (0.60-1.04)
3/16/04 to 7/15/04	791	77.1	2.88 (2.24-3.70)	1.18 (0.89-1.57)
7/16/04 to 11/15/04	656	76.2	2.99 (2.30-3.88)	1.23 (0.91-1.66)
11/16/04 to 2/13/05	274	71.2	2.13 (1.56-2.91)	0.89 (0.63-1.28)

CI, Confidence interval; *MIRIAD*, Mother-Infant Rapid Intervention at Delivery.

* Twenty peripartum women were missing turnaround times and were therefore not included.

† Weekend considered from Friday at 5:00 PM to Monday at 6:00 AM.

TABLE 4
HIV test results, by infection status, for 7753 women tested in the MIRIAD study, 2001-2005

	HIV infection status		
	Positive	**Negative**	**Total**
Rapid test results			
Positive	52 (100.0)	6 (0.08)	58 (0.75)
Negative	0 (0.00)	7695 (99.92)	7695 (99.25)
Total	52	7701	7753
EIA results			
Positive	52 (100.0)	18 (0.23)	70 (0.90)
Negative	0 (0.00)	7683 (99.77)	7683 (99.10)
Total	52	7701	7753
Performance of rapid tests (95% CI)			
Sensitivity	100% (93.15-100%)		
Specificity	99.92% (99.83-99.97%)		
Positive predictive value	89.66% (78.83-96.11%)		
Negative predictive value	100% (99.95-100%)		
Performance of EIA (95% CI)			
Sensitivity	100% (93.15-100%)		
Specificity	99.77% (99.63-99.86%)		
Positive predictive value	74.29% (62.44-83.99%)		
Negative predictive value	100% (99.95-100%)		

EIA, Enzyme immunoassay; *MIRIAD*, Mother-Infant Rapid Intervention at Delivery.

and delivery units. Neither OraQuick nor EIA produced false-negative results (Table 4). However, there were 6 false-positive OraQuick results and 18 false-positive EIA results. Sensitivity was 100% for OraQuick and EIA, and specificity was 99.92% and 99.77% for OraQuick and EIA, respectively.

Among 49 women identified as HIV infected who had their exact delivery time recorded (3 of the 52 women had missing delivery times), 32 (65%) were identified before delivery. Among the 43 women for whom data on delivery and intrapartum prophylaxis were available, 30 (69.8%) received intrapartum zivdovudine (AZT) prophylaxis and 12 (27.9%) received nevirapine intrapartum prophylaxis in addition to AZT. Of the 42 HIV-exposed infants with information on prophylaxis available in the newborn's hospital record, 41 (97.6%) received AZT, and of these, 21 (50%) also received nevirapine. On further investigation, 25 of the 52 HIV-infected women (48%) were found to have a previous positive HIV test, but this earlier testing was not documented in their medical records and was not known to the labor and delivery staff at presentation. None of these women had received antiretroviral prophylaxis during the current pregnancy. For women who presented in labor, the time from presentation to time of delivery was similar for HIV-infected and HIV-uninfected women (10 hours vs 7.8 hours; $P = .1$).

COMMENT

A variety of intrapartum antiretroviral regimens, when combined with neonatal antiretroviral prophylaxis, substantially reduce perinatal HIV transmission.[11] Because the vast majority of deliveries in the United States occur in hospitals, presentation to labor and delivery represents a critical opportunity to test women with undocumented HIV status and to provide antiretroviral prophylaxis for those women identified as HIV infected.

MIRIAD demonstrates that routine rapid intrapartum HIV testing for women whose HIV status is unknown can be implemented in a variety of labor and delivery settings using different models of implementation. MIRIAD hospitals ranged from large teaching facilities to smaller community hospitals. In some cases, dedicated MIRIAD staff were responsible for all aspects of counseling and testing, but in most settings preexisting staff, including nurses, midwives, obstetrics and gynecology residents, and attending physicians were responsible for carrying out the different aspects of the counseling and testing. In some settings, labor and delivery nurses, midwives, or obstetrics and gynecology residents were trained to perform rapid testing on the labor and delivery unit.

The MIRIAD model of rapid HIV testing was well accepted by the women, with approximately 85% of women ac-

cepting testing when offered. We note, however, that the MIRIAD study also found that acceptance rates for HIV testing were not uniform across different time periods during the day, most likely because of variability in staffing and other logistic factors at certain time periods. Acceptance rates were considerably lower during the evening and night shifts, with the lowest participation rate on Friday evenings. Rates of being approached about the study also varied by time of day and day of week, with admission on the weekend and admission during the evening shift associated with higher odds of being "missed" and thus not offered participation. Although labor and delivery units function 24 hours a day, 7 days a week, patterns of care may vary by day and time of week. A challenge for the widespread implementation of rapid testing will be to ensure that such testing is uniformly offered and available, regardless of the time of day, day of the week, or staff availability. In addition, women presenting with advanced cervical dilation were more likely to be "missed," perhaps because the staff was too busy preparing for the imminent delivery. Ideally, these women should be approached before delivery, but if this is not feasible, they should be approached immediately after giving birth.

The MIRIAD study also demonstrated that rapid testing on labor and delivery can provide accurate and timely results. In this study, OraQuick performed better than the EIA, with higher specificity and positive predictive value. Although some hospitals have used an expedited EIA as a preliminary testing strategy to provide prophylaxis to women in labor before the results of the Western blot, this test still takes longer than does the rapid test and does not perform as well. Furthermore, EIAs can not be used as a point-of-care test. MIRIAD demonstrates that use of a rapid test may be a better strategy than an expedited EIA testing strategy in terms of getting timely, accurate HIV results and intervening during the intrapartum period. With OraQuick, the majority of women received their test results before delivery, with point-of-care testing providing more rapid results than with laboratory-based testing.[10]

In the United States, rapid HIV testing on labor and delivery is increasingly being recommended[5] and implemented.[12,13] Expedited or rapid testing was initially recommended by the CDC for women on labor and delivery with unknown status in the 2001 recommendations,[14] which was strengthened in a "Dear Colleague" letter (www.cdc.gov/HIV/projects/perinatal/2003/letter.htm, accessed July 11, 2006) 2 years later. In addition, professional organizations are increasingly recommending rapid HIV testing on labor and delivery; the American College of Obstetricians and Gynecologists includes rapid testing on labor and delivery in their most recent guidelines for HIV testing.[5]

The CDC established a working group of experts, which developed a practical guide and model implementation protocol (www.cdc.gov/hiv/rapid_testing; accessed May 20, 2006) for HIV screening of women in labor. This guide, which was largely based on the MIRIAD experience, provides guidance and practical tips to clinicians, laboratorians, hospital administrators, and policymakers who are planning to implement a program for rapid HIV testing during labor. The guide, which is posted on the CDC website, is regularly reviewed and updated as additional experience and information become available.

Of the 17 MIRIAD hospitals, 13 have continued a rapid HIV testing program since completing the MIRIAD research study. Some hospitals found the transition to making rapid testing a standard practice to be challenging without the staff and resources provided by the MIRIAD study. MIRIAD investigators and project personnel played pivotal roles in expanding rapid HIV testing in hospitals in their regions. In Illinois, for example, the Chicago MIRIAD team partnered with the Illinois Department of Public Health to facilitate the development and adoption of a state law requiring that rapid HIV testing be offered to all women presenting in labor with undocumented HIV status. They also facilitated compliance with the law by providing resources and training to all birth hospitals in Illinois.

In Florida, 44 of the 124 hospitals that provide obstetric services have implemented rapid testing, and in July 2005 the governor signed an HIV testing bill that includes an opt-out approach to be implemented in all labor and delivery settings. New York has updated its regulations, requiring that women be offered testing and that results be available within 12 hours of admission to labor and delivery. In addition, MIRIAD investigators and project directors have been key technical experts during CDC-sponsored regional workshops to implement rapid testing in labor and delivery in US hospitals.

The findings from MIRIAD are also relevant for international settings. In these settings, in which the majority of HIV-infected pregnant women deliver worldwide, many pregnant women either do not access regular prenatal care or are not routinely offered HIV testing during prenatal care. As a result, many arrive at hospitals in labor with undocumented HIV status. A number of large hospitals including those in Kampala, Uganda (personal communication, M.G. Fowler) and St. Petersburg, Russia,[15] are now offering rapid HIV testing at labor and delivery based on the results from the MIRIAD study.

In terms of implementing a rapid HIV testing program, several lessons can be learned from the MIRIAD experience. First, point-of-care testing provides more timely results than does laboratory-based testing. Initially, some hospital laboratories were reluctant to use a point-of-care model, but MIRIAD demonstrated that it can work quite well. For a test to be used on the labor and delivery unit, it must be specifically "waived" by the Clinical Laboratory Improvement Act (CLIA) (Public Health 42 C.F.R. § 493, http://www.access.gpo.gov/nara/cfr/waisidx_04/42cfr493_04.html, accessed May 20, 2006), indicating that it is not too complex to be used in this way. Currently there are 6 HIV rapid tests approved for use in the United States, and 4 of them are CLIA waived.

Second, almost half of women identified in MIRIAD as HIV infected had a previous

positive HIV test. Unfortunately, this information was not available to the labor and delivery staff at the time of presentation, suggesting that women may be reluctant or fearful of disclosing such a result when they come to a hospital for obstetric services.[16] In addition, it suggests that results of prenatal testing and other medical records may not always be readily accessible on labor and delivery. Because medical records are increasingly stored and transmitted electronically, there may be opportunities for improving how and when prenatal and other medical records are communicated to labor and delivery staff.

Third, the MIRIAD study suggests that a routine opt-out approach to rapid HIV testing may increase testing rates. The considerable proportion of women (26%) who were "missed" by MIRIAD and thus never offered HIV rapid testing may represent the group of women who would most benefit by an opt-out approach, because these women were never given the opportunity to be tested.

Fourth, barriers to acceptance of HIV testing by women on labor and delivery should be eliminated. For example, some women reported not wanting another blood draw as a reason for declining testing, and acceptance rates were indeed lower when an additional blood draw was required. Making rapid HIV testing a routine part of intrapartum care and collecting blood at the time of other routine blood collection may improve testing rates.

As the number of women living with HIV in the United States continues to increase,[17,18] rapid HIV testing on labor and delivery for women with undocumented HIV status is an important last opportunity to identify HIV-infected women to not only provide preventive interventions for their infants but to also encourage women to seek the care needed for their own health.[19]

Ideally, all infected women would be identified before pregnancy. Preconception care should include HIV testing and should assure that future pregnancies are desired. For infected women, early antiretroviral prophylaxis with a regimen appropriate for pregnancy is recommended. If HIV-infected women are not identified before pregnancy, then prenatal care provides another, albeit later, opportunity to assess their status. If those who are infected are still not identified prenatally, then routine rapid testing at labor and delivery may provide the last good opportunity to identify them and may serve as a safety net to identify HIV-infected women and to institute measures to decrease the risk of perinatal HIV transmission. The MIRIAD study demonstrates that this last approach is feasible and acceptable and provides timely and accurate results. ■

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