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TRACnet Internet and SMS Technology Improves Time to Antiretroviral Therapy Initiation among HIV-Infected Infants in Rwanda

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Abstract

Background—Delays in testing HIV-exposed infants and obtaining results in resource-limited settings contribute to delays for initiating antiretroviral therapy(ART) in infants. To overcome this challenge, Rwanda expanded its national mobile and internet-based HIV/AIDS informatics system, called TRACnet, to include HIV PCR results in 2010. This study was performed to evaluate the impact of TRACnet technology on the time to delivery of test results and the subsequent initiation of ART in HIV-infected infants.

Methods—A retrospective cohort study was conducted on 380 infants who initiated ART in 190 health facilities in Rwanda from March 2010 to June 2013. Program data collected by the TRACnet system was extracted and analyzed.

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Author contributions:

Study conception: KK, SN, AB, PJ, JC. Data acquisition: KK, JR, ER.

Data analysis and interpretation: KK, SN, ER, PM, VN, DJR, JC.

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Results—Since the introduction of TRACnet for processing PCR results, the time to receive results has significantly decreased from a median of 144 days[IQR 121-197] to 23 days[IQR 17-43]. The number of days between PCR sampling and health facility receipt of results decreased substantially from a median of 90 days[IQR 83-158] to 5 days[IQR 2-8]. After receiving PCR results at a health facility, it takes a median of 44 days[IQR 32-77] before ART initiation. Result turnaround time was significantly associated with time to initiating ART(P<0.001). An increased number of staff trained for HIV care and treatment was also significantly associated with decreased time to ART initiation(P=0.004).

Conclusions—The use of mobile technology for communication of HIV PCR results, coupled with well-trained and skilled personnel, can reduce delays in communicating results to providers. Such reductions may improve timely ART initiation in resource-limited settings.

Keywords

Rwanda; HIV; TRACnet; Infants; Cascade; Antiretroviral therapy initiation

Despite significant progress in expanding antiretroviral treatment(ART) availability for prevention-of-mother-to-child HIV transmission(PMTCT) over the last decade, vertical transmission of HIV remains a main route of HIV spread in sub-Saharan Africa.[1,2] Early identification of perinatally infected infants followed by rapid ART initiation is an important intervention to promote child health and survival.[3,4] Without ART, half of HIV-infected infants will die before their second birthday.[2,3]

In many African countries, delays in obtaining HIV PCR results and then in initiating ART in infected infants remain a serious concern.[3,4] An “Early Infant Diagnosis(EID) cascade” has been described in the care of HIV-exposed infants, from birth to identification of infected infants to initiation of ART.[5] Delays in testing exposed infants, in transporting samples to centralized laboratories, and in transmitting positive results to remote sites have compromised the timely initiation of ART in HIV-infected infants.[6,7] Delays in receiving test results necessarily lead to delays in ART initiation, likely contributing to the high mortality experienced in HIV-infected children.[5] Some countries have begun to explore innovations in mobile technology to handle this critical problem.[3,4,8]

As part of a national effort to understand and address the EID cascade in Rwanda,[5] three main sources of HIV PCR results delays were identified in 2009: 1) sample transport to the National Reference Laboratory(NRL) in the capital, Kigali; 2) laboratory processing of specimens, including reagent stock outs and equipment requirements (e.g. waiting for a full batch of samples); and 3) returning PCR results to health facilities. Previously, returning PCR results to sites relied on staff from each facility to pick up completed paper results when visiting Kigali (e.g. to drop off another sample). Total delays in receiving PCR results at the sending health facility could exceed 4 months after the initial blood draw.

To address these delays, the Ministry of Health(MOH) and National AIDS Control Commission(CNLS) asked Voxiva (an American information technology firm specializing in mobile health) in 2010 to build a Short Message Service(SMS) and internet-based component onto the existing TRACnet system to speed delivery of PCR results from NRL to

health facilities. TRACnet started in Rwanda in 2004 and involves reporting either by mobile phone via interactive voice response or by Internet, depending on availability.[9,10]

This initiative was part of a broader MOH plan to improve the treatment of HIV-infected infants, which also included training nurses in ART to expand qualified staff at health facilities, improving dried blood spot(DBS) sample transportation, and improving laboratory procedures at NRL.[5] The present study was designed to evaluate the impact of the introduction of SMS- and internet-based technology on the time to delivery of test results and subsequent initiation of ART in HIV-infected infants.

METHODS

Rwanda has a prevalence of HIV estimated at 3% in the general population and 4.3% among pregnant women.[11,12] By the end of the study period, all 475 health facilities in Rwanda were using TRACnet for PCR results transmission.

In Rwanda, national PMTCT guidelines mandate the first HIV test (DBS PCR) for children born to HIV-infected mothers be administered at 6 weeks. In all, 23,985 tests utilized the TRACnet system during the study period of March 2010 to June 2013. Infants of HIV-infected mothers registered in the PMTCT program under the HIV-exposed infant follow-up program were included if they had a positive HIV PCR test during the study period and had complete information on all collected variables (corresponding facilities were automatically selected).

Analysis was restricted to infants recorded in the system with positive PCR results to assess the turnaround time and the effects of using the TRACnet system on time to ART initiation. Positive HIV PCR tests for 712 infants were obtained (out of 23,985 total tests). Results from the first PCR test were considered for this study (275 second tests excluded). We analyzed data for HIV PCR-positive infants whose results were sent from NRL to health facilities and who initiated ART during the study period. 57 (13%) infants were excluded due to not starting ART or having missing data on ART initiation (14 were confirmed deaths). The final sample included 380 infants.

Data from the TRACnet EID system was collected starting in March 2010. Procedures from initial blood draw at the health facility through receipt of PCR result at the health facility are described in Figure 1. Variables included infant date of birth, clinical status (using 2006 WHO criteria[13]), and ART prophylaxis; ART prophylaxis of the mother; dates of sample collection, reception at NRL, result availability at NRL, and receipt at health facility; and date of ART initiation. Facility-related data were also collected, including facility type, clinical partner for HIV services, and staff. Pre-TRACnet baseline data were obtained from a previous national study.[5]

Data were exported from TRACnet to Microsoft Excel and STATA 10.1 (StataCorp LP, College Station, Texas, USA) for analysis. Descriptive statistics were performed using frequencies to describe demographic and clinical characteristics of participants. The T-test or ANOVA and Pearson correlation were applied in bivariate analysis. The dependent variable was time to initiation of ART, defined as the number of days between the dates of ART

initiation and DBS collection. In multivariate analysis, multiple linear regression models were applied to examine the independent predictors of the time to initiation of ART. Predictor variables included health facility type, partner, and location; number of nurses at the health facility and number trained for HIV care and treatment; and PCR result turnaround time. PCR results turnaround time represents the number of days from DBS sample collection to receipt at the health facility (Figure 1). PCR results turnaround time and time to ART initiation were expressed in days and were described using medians and interquartile ranges (IQR) as the distributions were non-normal. Confounding factors were controlled for in the multivariate analysis.

This study analyzed routine data collected by the national HIV care program, and so the Rwanda Biomedical Center considered this activity routine program evaluation. TRACnet data collection was approved by the Centers for Disease Control and Prevention(CDC) as program evaluation and a non-research determination was provided.

RESULTS

The median age at DBS sample collection for the first HIV PCR testing was 7.4 weeks[IQR 5-25] for the 380 infants included in the study(Table). The median age at ART initiation was 24.5 weeks[IQR 17-42].

The median turnaround time from DBS sample collection to results delivery at the health facility was 23 days[IQR 7-43]. This time included a median of 6 days[IQR 2-13] for the sample transportation from health facility to NRL, 8 days[IQR 6-18] for laboratory processing, and 5 days[IQR 2-8] for the results to be communicated to the health facility(Figure 1). Prior to initiation of the TRACnet program for EID in 2010, the median total turnaround time was 144 days[IQR 121-197]. The total time decreased 84% to 23 days[IQR 7-43] by the end of the study period(Figure 2). The number of days between PCR analysis and health providers receiving results decreased 94% from a median of 90 days in 2009 to 5 days. The median time to initiation of ART after receipt of PCR results at a health facility was 44 days[IQR 32-77]. The overall median time from DBS sample collection to ART initiation was 75 days[IQR 56-121].

Health centers (78 days) had a longer median time to ART initiation than district hospitals (54 days) or referral hospitals (47 days) (P=0.031; Table). As health centers are the most geographically remote components of the system, sample transport delays likely contributed to delays in ART initiation. Similarly, facilities located in Kigali had the shortest times to ART initiation (P=0.035) compared to the rest of the provinces. The time to ART initiation was shorter for health facilities with >5 staff trained in HIV compared to those with ≤5 staff trained in HIV (P=0.0015). Similarly, health facilities with >14 nurses and >27 total staff had shorter times to ART initiation (P=0.0011 and P=0.035, respectively). The Pearson correlation analysis showed a positive correlation between the time to initiation of ART and the turnaround time of PCR results (r=0.55; P<0.001).

In multivariable analysis, the T-test statistic for “trained staff for HIV care” was highly correlated with time to ART initiation (P=0.004), suggesting that for an increase of one

person in number of staff trained, a 3.3 day decrease in the time to infant ART initiation would be expected. The “PCR results turnaround time” was significantly associated with time to ART initiation (P<0.001), suggesting that for a one-day increase in PCR results turnaround time, a 1.1 day increase in time to infant ART initiation would be expected. Other variables tested (including the number of nurses or total staff at the facility, geographic location, facility type or partner, and child's sex or clinical status) were not significantly associated with time to ART initiation.

DISCUSSION

This study identified significant reductions in PCR turnaround times and in the total time to ART initiation in HIV-infected infants in Rwanda after implementation of an SMS- and internet-based technology system to deliver HIV PCR results directly to health facilities. The overall time for this EID cascade step was substantially reduced, from greater than four months to less than one month.

Prior to use of TRACnet for returning PCR results to facilities, the process could exceed four months. This was similar to findings reported from Zambia, where the median time from sample collection to return of results to the caregiver was 92 days[14] but much longer than that reported from Uganda, which found a median turnaround time of 38 days.[15] A pilot study using an SMS-based system to transmit HIV PCR results in Zambia also found a significant reduction in turnaround time between pre- and post-implementation of this system.[16] The use of TRACnet technology likely substantially contributed to the reduced time for this process in the present study. However, the 94% decrease in total turnaround time after TRACnet initiation may not have been attributable exclusively to the use of TRACnet since improvements in sample transportation systems and in sample processing speed may also have contributed to the improvement.

Closing the gap between reception of positive results at the health facility and ART initiation for infected infants should be a national priority. The findings also show that even after receiving PCR results, it takes a median of 44 days before initiating ART in the infected infant. Ideally, this time should be as short as possible in order to reduce potential morbidity and mortality, although it is dependent on several sequential, required steps before ART can be initiated. First, the mother is contacted with the results and is requested to bring the infant for care. Since appointments for HIV-exposed infant follow-ups are scheduled only once per month, delays can occur here. After presenting to clinic, the infant needs pre-ART bloodwork for kidney/liver function. Finally, the mother must be convinced of the value of ART and actively collaborate, which may require extended counseling sessions by skilled personnel. Future work should investigate all means to reduce the length of time between these steps. One such method to support this process could be SMS from the health facility to remind mothers to return for appointments, since nearly 65% of Rwandans have mobile phones.

The study has several limitations. Routine program data were analyzed and only subjects with complete information were included in the study. Since subjects with missing data were excluded, this could lead to selection bias that in turn could have underestimated the time to

receipt of results and ART initiation. As facilities were not selected randomly, certain facility-specific factors (e.g., inclusion of high-volume or high-performing sites) may have altered the results. Additionally, other concurrent factors in Rwanda may have also contributed to the decreased turnaround time; potential confounding variables included guideline changes with further healthcare worker training and improvements in sample transportation systems.

In conclusion, after introduction of an SMS- and internet-based technology system in Rwanda, delays in elapsed time from DBS PCR testing to result receipt at health facilities were substantially reduced. Reducing delays can lead to prompt ART initiation, which likely can decrease infant morbidity and mortality. In resource-limited settings where mobile phones are widespread but travel and transport may be difficult, use of mobile phone and internet-based technologies could help to enhance both HIV and general healthcare systems. In the HIV EID cascade, this study illustrates one way to close the gap between testing and ART initiation. Further studies of ways to use technology to improve healthcare should be prioritized.

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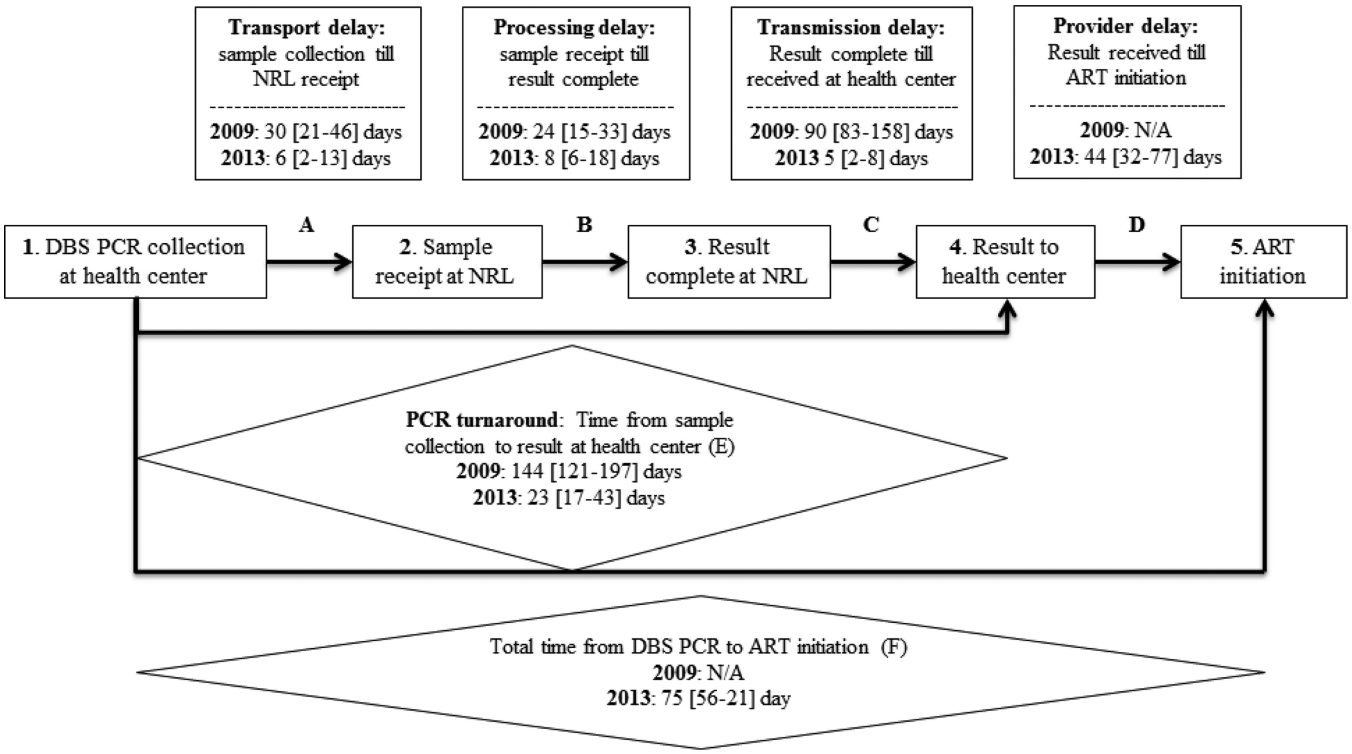

Figure 1.

Outline of Early Infant Diagnosis (EID) process (numbers) and potential delays (letters) from initial sampling to antiretroviral therapy (ART) initiation. 1) Facility collects the sample and fills in the DBS form; 2) sample receipt and coding at National Reference Laboratory (NRL); 3) NRL processes sample and results are added to the DBS form and TRACnet; 4) TRACnet triggers and sends an SMS with PCR results under the associated code to the 2 contact persons at the health facility (automatic report is generated for the PMTCT service); 5) facility contacts match the results to infants using the code and enter the results into the medical record. They then follow up with all infants testing positive to start on ART. Sources of potential delay include: A) sample collection at health facility till receipt at NRL (transport); B) sample receipt till result complete (processing); C) result complete till received at health facility (transmission); and D) result received till ART initiation (provider). The total time from sample collection to result receipt at health facility is the PCR turnaround (E), and the total time from DBS to ART initiation is denoted as (F).

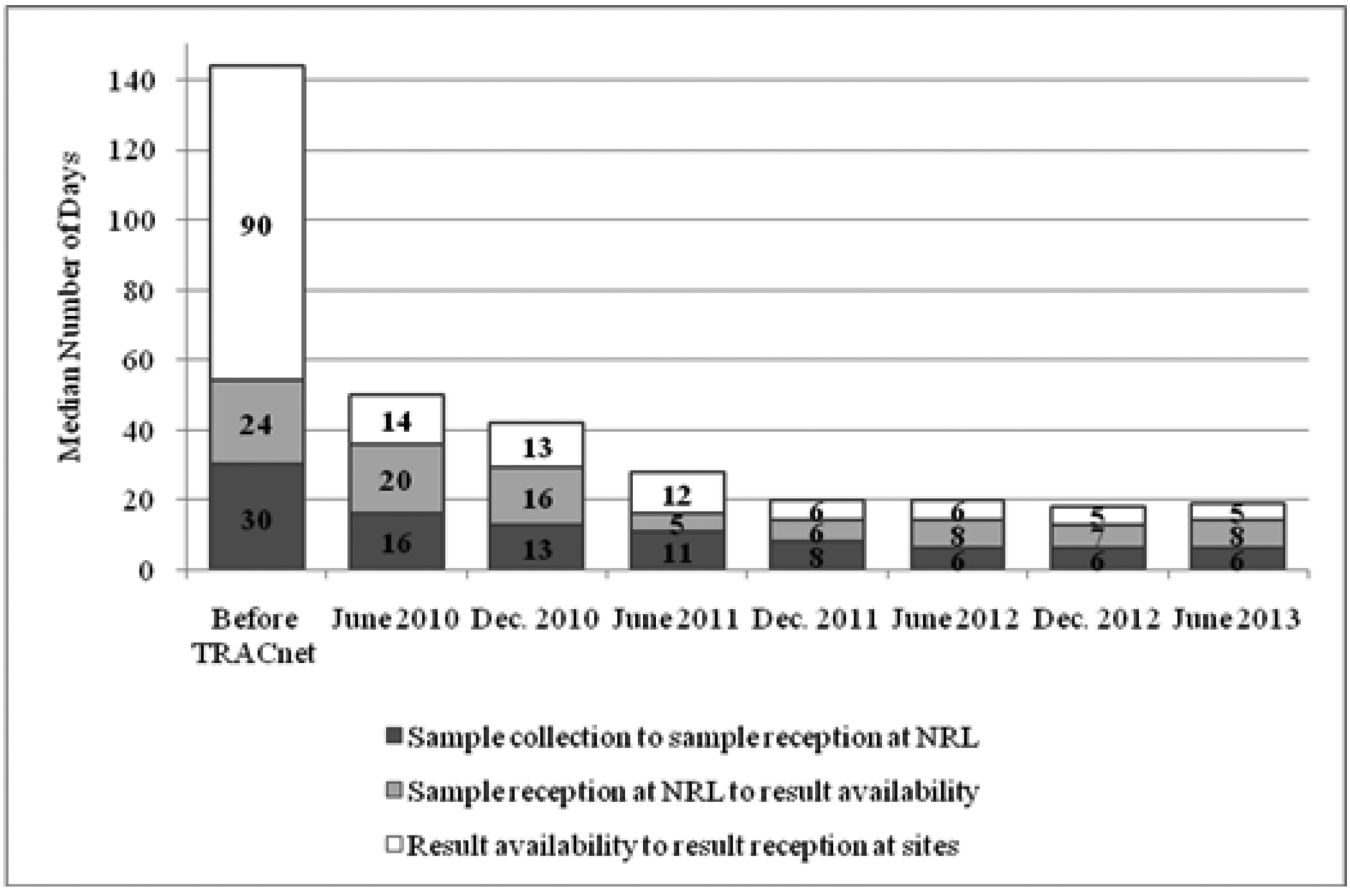

Figure 2.
Trends for HIV PCR results turnaround time (2010-2013)

Table Demographic and clinical characteristics of infants and their mothers and their health facilities with associated time to ART initiation.

Variables (N=380)	**N (%)**	**Median (IQR) days to ART initiation**	**P-value**
Sex[a]			
Female	199 (52.4%)	76 (55-117)	0.138
Male	181 (47.6%)	73.5 (57.5-126.5)	
Age[a]			
≤ 6 weeks	163 (42.9%)	80 (58-141)	0.120
>6 weeks	217 (57.1%)	70.5 (54-104.5)	
Child clinical status[1a]			
Asymptomatic	311 (82.0%)	76 (56.5-119,5)	0.925
Symptomatic	47 (12.3%)	70 (56-133)	
ART Prophylaxis of Child[b]			
Old (Single dose NVP + AZT)	161 (42.4%)	71 (55-127)	0.088
New (NVP for 6 weeks)	176 (46.3%)	73 (54-107)	
Old (Single dose NVP)	43 (11.3%)	91 (64-183)	
ART Prophylaxis of Mother[b]			
Triple therapy treatment	22 (5.8%)	76 (46-159)	0.170
AZT based dual therapy	148 (38.9%)	78(57.5-128.5)	
New TDF-based regimen	210 (55.3%)	73(55-117)	
Facilities (N=194)			
Facility location[b]			
Eastern province	38 (19.6%)	70 (49-121.5)	0.035
Kigali city	28 (14.4%)	60 (50-93)	
Northern province	29 (15.0%)	74 (57-120)	
Southern province	52 (26.8%)	86 (63-132)	
Western province	47 (24.2%)	82.5 (60.5-133.5)	
Facility ownership[a] (N=380)			
Faith based/Private	69 (35.6%)	73 (57-117)	0.707
Public	125 (64.4%)	76 (53-122)	
Type of health facility[b]			
Health Center	175 (87.8%)	78 (59-124)	0.031
District Hospital	15 (7.7%)	54 (46-88)	
Referral Hospital	4 (4.5%)	47 (40-53)	
Number of nurses at health facility[a]			
≤14	114 (58.8%)	80 (60-143)	0.0011
>14	80 (41.2%)	65.5 (51-98)	

Variables (N=380)	N (%)	Median (IQR) days to ART initiation	P-value
Staff trained for HIV Care[a]			
≤5	122 (62.9%)	84 (65-133)	0.0015
>5	72 (37.1%)	59.5 (49-94)	
Total staff at Health Facility[a]			
≤27	115 (59.3%)	81 (61-135)	0.035
>27	79 (40.7%)	63 (51-100)	

Abbreviations: *ART*, antiretroviral therapy; *AZT*, zidovudine; *NVP*, nevirapine; *TDF*, tenofovir

[a] T-test

[b] ANOVA test

[1] Missing information on 22 children (5.7%)