

Missed Opportunities for Early Infant HIV Diagnosis: Results of A National Study in South Africa

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Background: Services to diagnose early infant HIV infection should be offered at the 6-week immunization visit. Despite high 6-week immunization attendance, the coverage of early infant diagnosis (EID) is low in many sub-Saharan countries. We explored reasons for such missed opportunities at 6-week immunization visits.

Methods: We used data from 2 cross-sectional surveys conducted in 2010 in South Africa. A national assessment was undertaken among randomly selected public facilities (n = 625) to ascertain procedures for EID. A subsample of these facilities (n = 565) was revisited to assess the HIV status of 4- to 8-week-old infants receiving 6-week immunization. We examined potential missed opportunities for EID. We used logistic regression to assess factors influencing maternal intention to report for EID at 6-week immunization visits.

Results: EID services were available in >95% of facilities and 72% of immunization service points (ISPs). The majority (68%) of ISPs provide EID for infants with reported or documented (on infant's Road-to-Health Chart/booklet—iRtHC) HIV exposure. Only 9% of ISPs offered provider-initiated counseling and testing for infants of undocumented/unknown HIV exposure. Interviews with self-reported HIV-positive mothers at ISPs revealed that only 55% had their HIV status documented on their iRtHC and 35% intended to request EID during 6-week immunization. Maternal nonreporting for EID was associated with fear of discrimination, poor adherence to antiretrovirals, and inadequate knowledge about mother-to-child HIV transmission.

Conclusions: Missed opportunities for EID were attributed to poor documentation of HIV status on iRtHC, inadequate maternal knowledge about mother-to-child HIV transmission, fear of discrimination, and the lack of provider-initiated counseling and testing service for undocumented, unknown, or undeclared HIV-exposed infants.

Key Words: EID service, PICT, missed opportunities, HIV-exposed infants, mother-to-child HIV transmission

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BACKGROUND

HIV is a significant contributor to child morbidity and mortality in sub-Saharan countries.^{1,2} HIV progresses more rapidly in children, especially in infants acquiring infection in utero.^{3,4} Early initiation of antiretroviral (ARV) treatment substantially reduces the risk of death and disease progression and is standard of care in South Africa.^{3,5} Without treatment, 48% of perinatally infected and 22% of infants infected through breastfeeding dies before their first birthday.⁶ HIV-exposed uninfected infants also have a higher risk of morbidity and mortality than HIV-unexposed infants.⁷

Identifying HIV-exposed infants is the first critical step in the provision of early infant HIV diagnosis (EID) services and linkage to care. In many developing countries, including South Africa, despite substantial improvement in antenatal testing and maternal enrolment into prevention of mother-to-child transmission (PMTCT) programmes, identifying HIV-exposed infants postnatally for early testing and follow-up services has proven to be challenging.^{8–10}

Following the introduction of HIV DNA polymerase chain reaction (PCR) testing on dried blood spots, which

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simplified the collection and transportation of infant blood samples, many sub-Saharan countries have made significant progress in scaling-up EID services to lower level health care facilities.¹¹ The World Health Organization (WHO) recommends that EID services be offered at 6-week immunization visits.¹² Many sub-Saharan countries have high coverage for 6-week immunizations.¹³ The high 6-week immunization coverage, however, has not yet translated into high EID rates for HIV-exposed infants.^{11,14} In 2012, only 39% of children in low- and middle-income countries received HIV testing by 2 months postdelivery.¹⁵ In South Africa, a national review of 2008–2010 laboratory data for 8 of 9 provinces (excluding KwaZulu-Natal) indicated 69% and 45% of known HIV-exposed infants, respectively, missed opportunities for testing by the age of 2 months.¹⁴

The 2008 WHO guidelines recommended what is referred to as “the Targeted testing approach,” offering PCR testing to known HIV-exposed infants identified by maternal self-report or documentation of infant HIV exposure status on the infant’s Road-to-Health Chart/booklet (iRtHC).¹⁶ This approach focuses only on infants for whom maternal HIV infection status is already known. The revised 2010 guideline promotes early identification of all HIV-exposed infants, including infants whose maternal HIV infection status is unknown. This revised guideline recommend that the HIV exposure status of all infants be determined at 6-week immunization visits either from maternal reporting or from the iRtHC or by offering provider-initiated counseling and testing (PICT) of maternal HIV with same-day infant blood draw for HIV PCR testing if mother tests HIV-positive.^{12,17} If a mother refuses or is unavailable for HIV testing, an infant rapid test is recommended with same-day PCR testing for HIV-exposed infants. Currently, countries are at various stages of adopting the revised WHO guideline. At the time of this study, most facilities in South Africa were still implementing the 2008 EID guidelines, although South Africa was meant to be transitioning from the 2008 to the 2010 EID guideline.

Few studies have gathered national data to assess services for identifying HIV-exposed and infected infants.^{11,18} Several challenges to implementing EID services (including structural challenges, geographical accessibility, maternal knowledge, and psychosocial barriers) have been reported in previous studies.^{11,18–22} However, no study has explored the impact of approaches used at facility level for identifying HIV-exposed and infected infants.

We explored how HIV-exposed infants are identified and diagnosed at immunization service points (ISPs) and investigated factors associated with missed opportunities for EID.

METHODS

Study Design

We conducted 2 national surveys: the National Facility Assessment (NFA) preceded the National PMTCT Effectiveness (SAPMTCTE) survey. From January to May 2010, we conducted the NFA by interviewing 3–5 clinic nurses per facility to assess algorithms and systems for EID at 625

randomly selected facilities nationally. Subsequently, from June to December 2010, we revisited a subsample (N = 565) of facilities visited for NFA to conduct the SAPMTCTE survey. The SAPMTCTE survey was a cross-sectional survey that aimed to assess the effectiveness of the national PMTCT program. During this survey, we assessed maternal intention to request for EID service at 6-week immunization visits and potential predictors thereof. After interviews, each woman (regardless of previous HIV status) was offered infant HIV testing using PICT. The national PMTCT Effectiveness survey has been described in detail somewhere else.²³

Facility Sampling

The number of facilities needed per province for the NFA was guided by the sample size for the SAPMTCTE survey. The following parameters were taken into account to determine provincial SAPMTCTE sample size: the 2009 antenatal HIV prevalence data,²⁴ transmission rate estimates from 2 previous regional surveys,^{25,26} and the coverage of ARV prophylaxis in each province from district health information system report.²⁷ A precision-based sample size was calculated using nQuery Advisor Version 7 software for specified precision levels (+1% to +2%), and a design effect of 2. All (3390) public community health centres and clinics were included in the sampling frame.²⁷ These facilities were stratified into 4 groups based on their annual (2007) 6-week immunization coverage and antenatal HIV prevalence: small [<130 annual diphtheria–tetanus–pertussis-1 (DTP1) coverage], medium (130–300 annual DTP1 coverage), large (≥ 300 annual DTP1 coverage) with below the 2009 national average antenatal HIV prevalence ($<29\%$), and large with above the 2009 national average antenatal HIV prevalence ($\geq 29\%$).²⁷ Based on the above calculation, we needed 580 medium- and large-size facilities. These facilities were sampled using probability proportional to size sampling method within each stratum.

For the NFA, an additional 100 facilities (a convenient sample of 10–20 facilities per province) were selected from small (<130 annual immunization number) facilities using the probability proportional to size sampling method. Thus, in total, 680 facilities were selected for the NFA. Small facilities (n = 100) were not included in the SAPMTCTE survey because of logistic feasibility. A detailed description of sampling frame, sampling, and sample size is presented elsewhere.²³

Data Collection Procedures: NFA

Trained field workers used structured questionnaires to conduct face-to-face interviews with clinic managers and nurses providing immunization, PMTCT, and sick-child services in each selected facility and with district health information officers. We used hard copy questionnaires (with both open-ended and close-ended questions) to collect data on implementation of EID-related policies and procedures, staff attitudes toward EID, and the use of the iRtHC at ISPs to identify HIV-exposed infants. The questionnaire was piloted in 2 clinics that were not sampled for the main study. Field workers underwent standardized training.

Data Collection Procedures: SAPMTCTE Survey

Trained nurse data collectors approached mother/caregiver–infant pairs visiting 6-week immunization services and screened their eligibility. Consenting mothers, with infants aged 4–8 weeks with no emergency illnesses were enrolled and interviewed face-to-face. Data were gathered on reasons for the visit, antenatal and peripartum PMTCT services received, and knowledge about PMTCT using hand-held device (cell phone questionnaire). The iRtHC was checked for documentation of maternal and infant HIV status. The questionnaire was translated into all 11 South African official languages and piloted in 3 languages before the survey.

After the interview, infant HIV testing was offered using PICT. Mothers were given individual pretest counseling; thereafter, they were asked to consent to infant heel prick blood sampling. Mothers who agreed to infant testing were given confidential linked testing and infant results were returned to mothers through the health facility.

Data Analysis

The NFA data on EID services availability (i.e. EID availability within the health facility and at ISPs) and approaches for identifying HIV-exposed infants for EID services were analyzed using descriptive methods. A weighted analysis (weighting accounted for the different sampling design across provinces, sample size realization, and population live birth) was performed in the SAPMTCTE survey data to calculate the proportion of known HIV-positive mothers who brought their child for HIV testing at 6-week immunization visit, documentation of infant or mother HIV status (or documentation of maternal/infant prophylaxis) on iRtHC among both known HIV-exposed and unexposed infants, and acceptance of PICT offered as part of the survey.

Variable Created for Assessing Potential Missed Opportunities for EID

In the SAPMTCTE survey, we could not directly measure missed opportunities for EID (in the routine service) as we offered PICT to all 4- to 8-week-old infants visiting 6-week immunization services. However, the NFA and the SAPMTCTE data were combined and we used data on approaches to EID from the NFA and maternal request for infant testing/documentation on iRtHC from the SAPMTCTE survey to assess potential missed opportunities for EID that could have occurred in the absence of the universal PICT offered in the SAPMTCTE survey. We assumed that facility policy in the given year would have dictated current EID practice. Therefore, HIV-exposed infants who attended health facilities that reported using the targeted testing approach (i.e. testing self-reported/documented HIV-exposed infants) for EID would miss opportunities of early (6-week) testing unless their HIV status was documented on the iRtHC or their mothers requested infant testing at 6-week immunization visit. With this assumption, potential missed opportunities for EID was assessed among HIV-exposed infants attending facilities that provided targeted testing.

Survey logistic regression model was fitted to examine factors influencing maternal intention to request for EID service at the 6-week visit among known HIV-positive mothers. Covariates that are likely to be associated with EID based on literature review and clinical knowledge were included in univariable analysis. Variables that were significant using the conventional significance cut off point of 0.05 and variables that alter the estimate of other significant variables in the model by $\geq 10\%$ were kept in the final multivariable model. Based on this, the final multivariable model was adjusted for maternal age, education, socioeconomic score, infant feeding type (exclusive formula feeding vs. any breastfeeding), and knowledge of availability of the PMTCT program. All data analysis was conducted using STATA SE (version 12; StataCorp LP, Texas, USA).

The Medical Research Council Ethics Committee approved the final protocol for both surveys. The Centers for Disease Control and Prevention approved the SAPMTCTE survey. Informed consent was obtained verbally from all participating clinic nurses, and written consent was obtained from participating mother/caregivers.

RESULTS

NFA Profile

Of the 680 sampled facilities, 625 (92%) were visited for the NFA. Fifty-five (8%) of the sampled facilities could not be visited because of time constraints, temporary closure, or reported absence of main staff members needed for the interviews (Table 1).

The SAPMTCTE Survey Profile

In the SAPMTCTE survey, 10,820 mothers/caregivers from 565 of the 580 sampled facilities were screened for eligibility. Ninety-nine percent (10,735) of screened mother/caregiver–infant pairs were eligible and agreed to be interviewed. Ninety-six percent (96%, 10,357) of participants were mothers; 4% (378) were caregivers.

EID Service Availability Reported in the NFA

More than 95% of facilities in the NFA reported availability of EID (PCR testing) service within the facility. The majority (72%) of the facilities reported providing EID services at ISPs. Five percent reported that EID services are provided at 6-week immunization visits in conjunction with PMTCT/voluntary counseling and testing services and 15% reported that ISPs are not involved in the provision of EID services. The rest (8%) did not respond to this question.

Within the facilities that offered EID services at ISPs, 76% immunization nurses reported that offering EID services during routine immunization visits is feasible.

Testing Approaches Reported in the NFA

More than half (68%) of ISPs provide EID services to infants with reported or documented HIV exposure (targeted approach) (Fig. 1). Facility level data showed only 9% of

TABLE 1. Sampled Facilities for the National Facility Assessment in Total and by Province

Province	Total Number (n) PHCs + CHCs (DHIS 2007)	Number Sampled (% Provincial PHCs + CHCs)	Number Visited (% Sampled in Province)	Facility Stratum		
				Small* n (Column %)	Medium* n (Column %)	Large* n (Column %)
Eastern Cape	714	87 (12)	87 (100)	10 (10)	38 (17)	39 (13)
Free State	266	83 (31)	73 (88)	13 (14)	28 (12)	32 (11)
Gauteng	340	76 (22)	76 (100)	16 (17)	14 (6)	46 (15)
KwaZulu-Natal	562	74 (13)	71 (96)	10 (10)	23 (10)	38 (13)
Limpopo	438	84 (19)	56 (67)	10 (10)	23 (10)	23 (8)
Mpumalanga	267	87 (33)	87 (100)	12 (13)	25 (11)	50 (17)
Northern Cape	138	43 (31)	42 (98)	10 (10)	24 (11)	8 (3)
North West	338	79 (23)	74 (94)	7 (7)	34 (15)	33 (11)
Western Cape	327	67 (20)	59 (88)	8 (8)	18 (8)	33 (11)
Total	3390	680 (20)	625 (92)	96 (100)	227 (100)	302 (100)

*Small includes facilities with <130 annual DTP1 coverage, per 2007 district health information system report; medium includes facilities with 130–300 annual DTP1 coverage per 2007 district health information system report; large includes large (facilities with ≥300 annual DTP1 coverage per 2007 district health information system report) with below the 2009 national average antenatal HIV prevalence (<29%) and large with above the 2009 national average antenatal HIV prevalence (≥29%).

CHCs, community health care; DHIS, district health information system; PHCs, primary health care.

ISPs reported offering HIV testing for infants with undocumented and unknown HIV status per the WHO 2010 guideline. Nationally, 15% of facilities reported that ISPs are not involved in the provision of EID services. The rest (8%) did not respond to this question.

Maternal Acceptability of PICT Reported in the SAPMTCTE Survey

Twenty-nine percent of mothers self-reported having an HIV-positive status. Only 35% of self-reported HIV-positive mothers reported that they had intended to request infant HIV testing during the 6-week immunization visit (Fig. 2).

When PICT was offered to all infants at the 6-week immunization visit, 95% agreed to infant testing and receipt of results, and 32% of infants tested were HIV-exposed (Fig. 2). Almost all (97%) self-reported HIV-positive mothers who had no intention to request infant testing agreed to infant testing after PICT was offered in our study.

doses of maternal, infant, or both ARV regimens—AOR: 1.7; CI: 1.2 to 2.5) were also significantly associated with no intention to request EID service (Table 2).

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Patient Held Records Review in the SAPMTCTE Survey

Of 10,612 (99%) mother–infant pairs who brought the iRtHC, only 34% had maternal or infant HIV status indicated on the iRtHC. Among infants born to self-reported HIV-positive mothers, 49% had iRtHC with documentation of either a confidential code indicating maternal HIV status or maternal

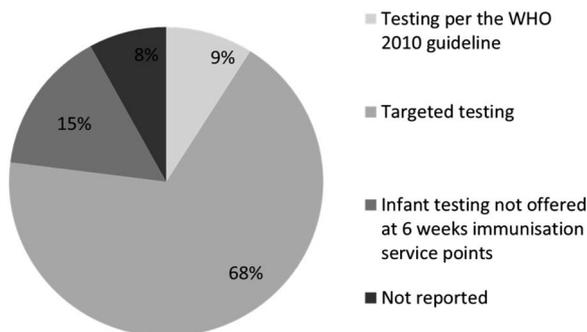
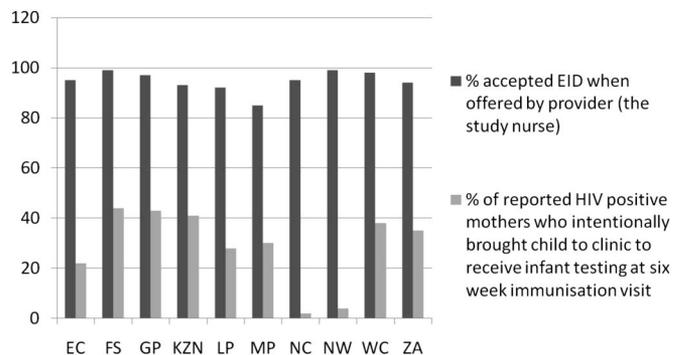


FIGURE 1. Reported % of facilities using the WHO 2010 EID guideline and the 2008 targeted infant HIV testing guideline to offer HIV testing at 6-week postpartum (n = 625).



EC-Eastern Cape, FS - Free State, GP- Gauteng, KZN - KwaZulu-Natal, LP-Limpopo, MP- Mpumalanga, NC- Northern Cape, NW-North West, WC-Western Cape, **ZA -South Africa**

FIGURE 2. Increase in EID coverage achieved by offering provider-initiated testing versus relying on a maternal request for EID among women aware of their HIV-positive status.

TABLE 2. Factors Associated With Mother not Intending to Request EID Service, Among HIV-Positive Mothers Who Know Their HIV Status

Factors Associated with Mother not Intending to Request EID	Unadjusted OR (95% CI), <i>P</i>	AOR (95% CI), <i>P</i>
Maternal age less than 20 yrs	1.5 (1.1 to 2.1) 0.012	1.3 (0.9 to 1.9) 0.130
Mothers who felt discrimination by the community	1.9 (1.2 to 3.0) 0.009	1.8 (1.1 to 2.9) 0.025
Socioeconomic status score*	0.9 (0.9 to 0.99) 0.035	0.9 (0.9 to 1.0) 0.139
Maternal education†	0.9 (0.7 to 1.1) 0.321	0.9 (0.7 to 1.2) 0.475
Unplanned pregnancy	1.1 (0.9 to 1.4) 0.351	1.0 (0.8 to 1.3) 0.722
Missed doses of one or both of maternal and infant ARV regimens	1.8 (1.3 to 2.6) 0.001	1.7 (1.2 to 2.5) 0.004
Exclusive formula feeding vs. any breastfeeding	0.9 (0.7 to 1.2) 0.442	1.0 (0.8 to 1.2) 0.742
Limited knowledge of modes of MTCT	2.0 (1.03 to 3.9) 0.041	2.1 (1.07 to 4.1) 0.032
Mother unaware of the PMTCT programme	1.5 (1.0 to 2.4) 0.060	1.4 (0.8 to 2.2) 0.205

Additionally sick child, facility delivery, postnatal visit, and number of pregnancy (classification of 4: 1 pregnancy, 2 pregnancies, 3 pregnancies, 4 and above pregnancies) were considered in the logistic regression but were not influential (had <0.10 confounding effect with *P* > 0.05). Significant associations (in both univariable and multivariable models) are indicated in bold.

*Socioeconomic score was a continuous variable constructed from availability of the following working items in the house: stove, refrigerator, radio, television, and car.

†Education categories: none, grade 1–7, grade 8–12, above grade 12.

OR, odds ratio; AOR, adjusted odds ratio.

Significant associations (in both univariable and multivariable models) are indicated in bold.

or infant ARV prophylaxis documented on the iRtHC, 6% had a maternal HIV test result documented on the iRtHC, and 45% had no documentation of HIV status on the iRtHC.

Potential Missed Opportunities in the Targeted Testing Approach

Of the 2856 HIV-exposed infants attending facilities that reported providing targeted testing, 1815 (62%) either had a documentation of HIV status on iRtHC or their mothers were intending to request EID services at the 6-week immunization visit (Table 3). The remaining 1041 (38%) HIV-exposed infants who attended facilities that provided targeted testing had neither a documentation of HIV status on iRtHC nor were their mothers intending to request EID services at the 6-week immunization visit, thus these children would have potentially missed opportunities for EID. Because our study offered PICT and EID to all

infants, to identify HIV-exposed and infected infants at ISPs, none of the HIV-exposed infants missed HIV testing.

DISCUSSION

We found that, EID services are available in >95% of public primary healthcare facilities in South Africa, with 72% of facilities offering EID services at ISPs. Despite this progress in delivering decentralized EID services, our study indicates that substantial missed opportunities for EID occur at 6-week immunization visits, posing significant challenges for early initiation of HIV treatment.

Despite the high attendance rate of 6-week immunization services in South Africa,¹³ potential missed opportunities for EID were very high in this study. Facilities that use targeted approaches potentially missed opportunities for early testing on significant numbers (38%) of HIV-exposed infants. Our assessment of infant HIV testing services at ISPs identified several gaps related to the approaches used for identifying HIV-exposed infants at 6-week immunization visits. The majority (68%) of facilities offered targeted testing, which relies on maternal reporting or documentation (on iRtHC) of HIV exposure, even though both the iRtHC and the maternal reporting were poorly used for conveying the HIV exposure status of infants to health workers responsible for EID.

Close to half (45%) of self-reported HIV-positive mothers had an iRtHC that had no documentation of HIV status. Poor communication between antenatal, delivery, and postnatal facilities and lack of good information systems have been reported as important barriers for continuity of postnatal PMTCT services in developing countries.^{9,28} Several efforts in sub-Saharan countries to improve the utilization of patient-held cards for documenting HIV status have had varying outcomes.^{29–31} In South Africa, the iRtHC coding system, MTCT stickers, stamps, and the new road-to-health booklet (RtH booklet) were introduced at various stages of the

TABLE 3. Potential Missed Opportunities for EID When the Targeted Approach is Used*

Documentation of HIV Status on iRtHC and Mothers Intention—Among Infants Attended Facilities That use the Targeted Approach*	HEI, n (%)
Infants' HIV exposure status documented on iRtHC and/or mothers intentionally brought child for EID (i.e. access to EID)	1815 (62)
Infants' HIV exposure status not documented on iRtHC and mothers had no intention to request EID (i.e. potential missed opportunities)	1041 (38)
Total HIV-exposed infants who attended facilities that use the targeted approach	2856 (100)

*Targeted approach refers to the offer of testing to infants who have documentation of HIV exposure on iRtHC or whose mothers request HIV testing. Value indicated in bold indicates potential missed opportunities for EID.

HEI, HIV-exposed infants.

implementation of the PMTCT programme. Health care providers seldom used the coding system because it required complex and time-consuming decoding.^{31,32} At the time of the PMTCT survey, the new RtH booklet, revised to include maternal and infant HIV information, was being implemented (April 2010). Although meticulous documentation of HIV status using this new RtH booklet might improve identification of HIV-exposed infants, the reliance on iRtHC to identify HIV-exposed infants has several limitations, including the dependence on mothers to bring the iRtHC to all postnatal visits and the inability to track infants who drop out at the 6-week visit.³³ This sole dependence on patient-held cards exacerbated by the lack of an internal mechanism for exchange of client records between antenatal and postnatal facilities has resulted in lack of clear accountability for tracing infants lost to follow-up during the early postnatal period and contributed to a high early postnatal attrition rate.³⁴

A number of pilot studies in less developed countries indicate the introduction of technology such as web-based medical recording systems could be more effective for identifying and tracking HIV-exposed infants.^{35,36} The use of electronic medical records could provide the postnatal health care personnel access to antenatal PMTCT mothers' information and enables tracing infants lost to follow-up during the early postnatal period. However, Web-based medical recording systems are rarely available in developing countries because of the cost and infrastructure requirements of setting-up this technology.

In this study, a small percentage (35%) of mothers reported that they had intention to self-report/request for infant HIV testing at 6-week immunization visits. Limited knowledge of the mode of MTCT, missed doses of 1 or both maternal and infant ARV regimens, and fearing discrimination were significant factors associated with increased maternal intention to not to request 6-week infant HIV testing services at 6-week immunization visits. Our study findings are supported by several studies that indicate PMTCT knowledge, adherence to treatment, and discrimination as main determinants of uptake of EID.^{21,22,37} A study in rural Kenya that assessed reasons for dropout from EID services indicated that most mothers are unsure of the number, exact time points, or type of tests to be done for EID services,³⁷ which suggests that lack of awareness about EID service could be one of the reasons why mothers do not self-report for testing. Reports from other similar studies conducted in rural areas of sub-Saharan countries indicate lack of privacy at immunization rooms, and fear of stigma and discrimination as important barriers for maternal disclosure of HIV status at immunization visits.^{38,39}

The 2010 WHO EID guidelines recommend improving early identification of undocumented and unknown HIV-exposed infants through the use of PICT. South Africa adopted this new EID guideline in 2010, in the same year as this study was conducted. This EID guideline recommends that all infants with undocumented/unknown HIV status be offered maternal or infant rapid test screening at their 6-week visit. The latest revision (2013) to this guideline in South Africa further recommends PICT for mothers tested HIV negative during pregnancy to detect HIV exposure because of

maternal infection late in pregnancy or during breastfeeding.⁴⁰ In implementing PICT, one of the challenges is lack of adequate human resource. Clear policy guidelines are needed in the use of lay counselors and community health workers for performing infant HIV testing so that the human resource problems of implementing PICT can be addressed.

Similarly, the suitability of the setup of immunization units for implementing the new guidelines should be assessed. Assessing (asking) maternal antenatal HIV testing histories in immunization rooms with inadequate privacy may result in false reporting, high refusal rate, and tendency to avoid immunization services because of fear of stigma.^{30,41} South Africa is a better resourced country compared to other African countries but insufficient space and inadequate privacy at immunization visits are reported as one of the challenges for providing infant HIV testing services in some areas of the country.²⁶

The results from this study are based on reports from service providers and caregivers. In this study, we were not able to directly measure the link between approaches for identifying HIV-exposed infants for EID service and uptake of EID service because the study offered PICT to all infants. Thus far, the only data source for routine EID uptake rate is the National Health Laboratory System data. The National Health Laboratory System data uses the antenatal HIV prevalence survey to indirectly estimate the expected HIV-exposed infants who should have received EID and estimates EID uptake from the number of specimens received for infant HIV testing. Although this method may not give an accurate estimate of EID uptake, it has been used as the only source of data for assessing trend in EID uptake nationally.

In conclusion, our findings suggest that improving the EID service uptake requires efforts to improve the identification of HIV-exposed infants at the 6-week immunization visit. If facilities continue to use the targeted testing approach, more than one-third of known HIV-exposed infants will not be offered EID, and opportunities to reduce MTCT, and HIV-related infant morbidity and mortality will be curtailed. The high uptake of HIV testing, when offered as part of the 6-week immunization services, suggests that the immunization setting provides an ideal opportunity for attaining high coverage of EID. Missed opportunities for EID were attributed to poor documentation of HIV status on iRtHC, inadequate maternal knowledge and fear of discrimination to disclose HIV status, and the lack of PICT service to undocumented/unknown HIV-exposed infants. Hence, improvement is needed in the following areas: documentation of HIV status on iRtHC, educating mothers about infant testing, reduction of stigma and discrimination through community-level educational campaigns, improving privacy at immunization facilities, introducing early infant HIV testing services into all immunization services, and ensuring PICT is offered to infants with undocumented or unknown HIV status.

REFERENCES

1. UNICEF. *Committing to Child Survival: A Promise Renewed Progress Report*. Available at: http://apromiserevnewed.org/files/APR_Progress_Report_2012_final_web3.pdf. Accessed January 12, 2013.

2. Liu Li, Johnson HL, Cousens S, et al. Global, regional, and national causes of child mortality: an updated systematic analysis for 2010 with time trends since 2000. *Lancet*. 2012;379:2151–2161.
3. Violari A, Cotton MF, Gibb DM, et al. Early antiretroviral therapy and mortality among HIV-infected infants. *N Engl J Med*. 2008;359:2233–2244.
4. Kuhn L, Abrams EJ, Weedon J, et al. Disease progression and early viral dynamics in human immunodeficiency virus-infected children exposed to zidovudine during prenatal and perinatal periods. *J Infect Dis*. 2000;182:104–111.
5. Department of Health. The South African antiretroviral treatment guidelines. Available at: http://www.doh.gov.za/docs/policy/2013/ART_Treatment_Guidelines_Final_25March2013.pdf. Accessed October 15, 2013.
6. Marston M, Becquet R, Zaba B, et al. Net survival of perinatally and postnatally HIV-infected children: a pooled analysis of individual data from sub-Saharan Africa. *Int J Epidemiol*. 2011;40:385–396.
7. Landes M, van Lettow M, Chan AK, et al. Mortality and health outcomes of HIV-exposed and unexposed children in a PMTCT cohort in Malawi. *PLoS One*. 2012;7:1–8.
8. Early Infant Diagnosis IATT Laboratory and Child Survival Working Group. GSG mid term review meeting, December 6–7, 2012. Available at: <http://www.emctt-iatt.org/wp-content/uploads/2012/12/EID-GSG.pdf>. Accessed January 11, 2013.
9. Horwood C, Haskins L, Vermaak K, et al. Prevention of mother to child transmission of HIV (PMTCT) programme in KwaZulu-Natal, South Africa: an evaluation of PMTCT implementation and integration into routine maternal, child and women's health services. *Trop Med Int Health*. 2010;15:992–999.
10. Cook RE, Ciampa PJ, Sidat M, et al. Predictors of successful early infant diagnosis of HIV in a rural district hospital in Zambézia, Mozambique. *J Acquir Immune Defic Syndr*. 2011;56:e104–e109.
11. Chatterjee A, Tripathi S, Gass R, et al. Implementing services for early infant diagnosis (EID) of HIV: a comparative descriptive analysis of national programs in four countries. *BMC Public Health*. 2011;11:553.
12. WHO recommendations on the diagnosis of HIV infection in infants and children 2010: strengthening health services to fight HIV/AIDS. Available at: http://whqlibdoc.who.int/publications/2010/9789241599085_eng.pdf. Accessed November 12, 2012.
13. WHO/UNICEF estimates of national immunisations: estimated coverage by country, year and vaccine. Available at: http://www.who.int/immunization_monitoring/data/zaf.pdf. Accessed February 17, 2013.
14. Sherman G, Lilian R. Early infant diagnosis of HIV infection in South Africa: 2008 to 2010. Available at: http://www.nhls.ac.za/assets/files/EID_HIV_PCR_2008-2010.pdf. Accessed December 18, 2012.
15. United Nations Children's Fund, *Towards an AIDS-Free Generation—Children and AIDS: Sixth Stocktaking Report, 2013*, UNICEF, New York, 2013.
16. NDOH. National Department of Health policy and guidelines for the implementation of the PMTCT programme, February 2008. Available at: <http://southafrica.usembassy.gov/root/pdfs/2008-pmtct.pdf>. Accessed November 13, 2012.
17. NDOH. *Guidelines for the Management of HIV in Children*. 2nd ed. Pretoria, South Africa: National Department of Health; 2010. Available at: http://familymedicine.ukzn.ac.za/Libraries/Guidelines_Protocols/2010_Paediatric_Guidelines.sflb.ashx. Accessed January 14, 2013.
18. Khamadi S, Okoth V, Lihana R, et al. Rapid identification of infants for antiretroviral therapy in a resource poor setting: the Kenya experience. *J Trop Pediatr*. 2008;54:370–374.
19. Peltzer K, Mlambo G. Factors determining HIV viral testing of infants in the context of mother-to-child transmission. *Acta Paediatr*. 2010;99:590–596.
20. Geelhoed D, Lafor Y, Chissale É, et al. Integrated maternal and child health services in Mozambique: structural health system limitations overshadow its effect on follow-up of HIV-exposed infants. *BMC Health Serv Res*. 2013;13:1–8.
21. Donahue MC, Dube Q, Dow A, et al. “They have already thrown away their chicken”: barriers affecting participation by HIV-infected women in care and treatment programs for their infants in Blantyre, Malawi. *AIDS Care*. 2012;24:1233–1239.
22. Berendes S, Rimal RN. Addressing the slow uptake of HIV testing in Malawi: the role of stigma, self-efficacy, and knowledge in the Malawi BRIDGE Project. *J Assoc Nurses AIDS Care*. 2011;22:215–228.
23. Goga A, Dinh T, Jackson D; for the SAPMTCT study group. Evaluation of the effectiveness of the national prevention of mother-to-child transmission (PMTCT) programme measured at six weeks postpartum in South Africa, 2010. Available at: <http://www.info.gov.za/view/DownloadFileAction?id=165280>. Accessed August 17, 2012.
24. *National Antenatal Sentinel HIV and Syphilis Prevalence Survey in South Africa*. Pretoria, South Africa: Department of Health; 2009. Available at: <http://www.health-e.org.za/documents/85d3dad6136e8ca9d02cceb7f4a36145.pdf>. Accessed October 14, 2012.
25. Rollins N, Little K, Mzolo S, et al. Surveillance of mother-to-child transmission prevention programmes at immunization clinics: the case for universal screening. *AIDS*. 2007;21:1341–1347.
26. Rollins N, Mzolo S, Moodley T, et al. Universal HIV testing of infants at immunization clinics: an acceptable and feasible approach for early infant diagnosis in high HIV prevalence settings. *AIDS*. 2009;23:1851–1857.
27. DHIS. District health information system 2007. Available at: <http://www.hst.org.za/publications/841>. Accessed January 22, 2011.
28. Reithinger R, Megazzini K, Durako SJ, et al. Monitoring and evaluation of programmes to prevent mother to child transmission of HIV in Africa. *BMJ*. 2007;334:1143–1146.
29. Manzi M, Zachariah R, Teck R, et al. High acceptability of voluntary counselling and HIV-testing but unacceptable loss to follow up in a prevention of mother-to-child HIV transmission programme in rural Malawi: scaling-up requires a different way of acting. *Trop Med Int Health*. 2005;10:1242–1250.
30. Dube Q, Dow A, Chirambo C, et al. Implementing early infant diagnosis of HIV infection at the primary care level: experiences and challenges in Malawi. *Bull World Health Organ*. 2012;90:699–704.
31. Braun M, Kabue MM, McCollum ED, et al. Inadequate coordination of maternal and infant HIV services detrimentally affects early infant diagnosis outcomes in Lilongwe, Malawi. *J Acquir Immune Defic Syndr*. 2011;56:e122–e128.
32. Mugwagwa R. The child health card as a linkage tool: experiences from Zimbabwe. Paper presented at: International AIDS Society 19–22 July 2009; Cape Town, South Africa.
33. Fraser HS, Allen C, Bailey C, et al. Information systems for patient follow-up and chronic management of HIV and tuberculosis: a life-saving technology in resource-poor areas. *J Med Internet Res*. 2007;9:e29.
34. Cherutich P, Inwani I, Nduati R, et al. Optimizing paediatric HIV care in Kenya: challenges in early infant diagnosis. *Bull World Health Organ*. 2008;86:155–160.
35. Jazayeri D, Farmer P, Nevil P, et al. An electronic medical record system to support HIV treatment in rural Haiti. *AMIA Annu Symp Proc*. 2003:878.
36. Allen C, Jazayeri D, Miranda J, et al. Experience in implementing the OpenMRS medical record system to support HIV treatment in Rwanda. *Stud Health Technol Inform*. 2007;129:382–386.
37. Hassan AS, Sakwa EM, Nabwera HM, et al. Dynamics and constraints of early infant diagnosis of HIV infection in Rural Kenya. *AIDS Behav*. 2012;16:5–12.
38. Michaels D, Eley B, Ndhlovu L, et al. Exploring current practices in paediatric ARV rollout and integration with early childhood programs in South Africa: a rapid situational analysis—horizons final report (population council/horizons Washington, DC) 2006. Available at: <http://www.popcouncil.org/pdfs/horizons/sapedssa.pdf>. Accessed February 23, 2013.
39. Bwirire LD, Fitzgerald M, Zachariah R, et al. Reasons for loss to follow-up among mothers registered in a prevention-of-mother-to-child transmission program in rural Malawi. *Trans R Soc Trop Med Hyg*. 2008;102:1195–1200.
40. NDOH. The South African antiretroviral treatment guidelines, PMTCT guidelines: revised March 2013. Available at: http://web.up.ac.za/sitefiles/file/45/1335/877/PMTCT%20guidelines_March%202013_DoH.pdf. Accessed October 12, 2012.
41. Goodson JL, Finkbeiner T, Davis NL, et al. Evaluation of using routine infant immunization visits to identify and follow-up HIV-exposed infants and their mothers in Tanzania. *J Acquir Immune Defic Syndr*. 2013;63:e9–e15.