Decentralization of Pediatric HIV Care and Treatment in Five Sub-Saharan African Countries

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Background: In resource-limited settings, decentralization of HIV care and treatment is a cornerstone of universal care and rapid scale-up. We compared trends in pediatric enrollment and outcomes at primary (PHFs) vs secondary/tertiary health facilities (SHFs).

Methods: Using aggregate program data reported quarterly from 274 public facilities in Kenya, Lesotho, Mozambique, Rwanda, and Tanzania from January 2008 to March 2010, we examined trends in number of children younger than 15 years of age initiating antiretroviral treatment (ART) by facility type. We compared clinic-level lost to follow-up (LTFU) and mortality per 100 person-years (PYs) on ART during the period by facility type.

Results: During the 2-year period, 17,155 children enrolled in HIV care and 8475 initiated ART in 182 (66%) PHFs and 92(34%) SHFs. PHFs increased from 56 to 182, whereas SHFs increased from 72 to 92 sites. SHFs accounted for 71% of children initiating ART; however, the proportion of children initiating ART each quarter at PHFs increased from 17% (129) to 44% (463) in conjunction with an increase in PHFs during observation period. The average LTFU and mortality rates for children on ART were 9.8/100 PYs and 5.2/100 PYs, respectively, at PHFs and 20.2/100 PYs and 6.0/100 PYs, respectively, at SHFs. Adjusted models show PHFs associated with lower LTFU (adjusted rate ratio = 0.55; $P = 0.022$) and lower mortality (adjusted rate ratio = 0.66; $P = 0.028$).

Conclusions: The expansion of pediatric services to PHFs has resulted in increased numbers of children on ART. Early findings suggest lower rates of LTFU and mortality at PHFs. Successful scale-up will require further expansion of pediatric services within PHFs.

Key Words: decentralization, HIV, pediatrics, primary health facilities

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INTRODUCTION

Approximately 1200 new pediatric infections occur each day, of which 90% occur in sub-Saharan Africa (SSA).[1] Despite rapid scale-up of HIV care and treatment, only 28% of the 1.27 million children in need of treatment received antiretroviral therapy (ART) compared with 54% of adults in 2009.[2] This huge gap between number estimated to be in need of treatment and the number on ART is expected to increase with the revised 2010 World Health Organization (WHO) guidelines.[3,4] There are multiple factors contributing to this gap between number in need and on ART including complexity of early infant diagnosis, problems related to pediatric ART formulations, personal/family challenges, health care system and human resource constraints, lack of funds, and political leadership.[5–7]

Historically in most low resource setting (LRS), pediatric HIV care has been provided at urban secondary and tertiary health facilities (SHFs), where there are pediatric specialists, better diagnostic resources, and higher level of provider comfort with caring for children. To achieve universal access and reduce unmet need in children, there is a clear need to expand services geographically from large urban facilities to small rural primary health facilities (PHFs) where most of the basic care for children in LRS is provided.[8] This process of decentralization of services to the lowest level of the health care delivery structure is considered one of the cornerstones of successful HIV scale-up.[9] There are reports of increased scale-up with successful decentralization of adult HIV services.[10–12] However, there are conflicting results on the impact of decentralization on outcomes, such as lost to follow-up (LTFU) and death in the adult literature. Some have reported lower rates of LTFU and mortality at PHFs,[11–13] whereas others have found higher rates among adults with HIV receiving care at PHFs.[14]

Progress in decentralizing pediatric HIV care to lower level facilities has been slow, and there are few published reports assessing outcomes of children receiving ART at PHFs. Reports from South Africa,[15,16] Zambia,[17,18] and Thailand[19] demonstrate successful decentralization of pediatric services

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to PHFs. In Zambia, children receiving ART in PHFs had comparable clinical and immunological outcomes to those in western countries.[18,20]

We used routinely collected data from 274 facilities in 5 countries in SSA to evaluate the impact of decentralization of pediatric HIV services. The objective of this analysis was to compare trends in pediatric enrollment and ART initiation and compare mortality and LTFU as measures of program quality among pediatric patients enrolled at PHFs and SHFs.

METHODS

Study Design and Study Population

We conducted a retrospective analysis using quarterly aggregated service delivery data from 274 health facilities in Kenya, Lesotho, Mozambique, Rwanda, and Tanzania. All health facilities received support from ICAP, a President's Emergency Plan for AIDS Relief (PEPFAR) implementing partner that has been supporting HIV care and treatment in SSA since 2005. Aggregate data is manually tallied from paper-based systems (pre-ART and ART registers and national reporting forms) that are maintained by health facility (site) staff. Data are reported per site per quarter on cohorts of patients enrolled and initiating ART in a given 3-month period. Information on each cohort includes number of patients initiating ART, median CD4 count at ART initiation for children aged 6 years or older, number transferred out, LTFU, or died. Subjects included in this analysis were HIV-infected children aged younger than 15 years enrolled in HIV care and started on ART from January 2008 to March 2010. Children who were initiated on ART at the facility before the study period or who were initiated at another facility and transferred into a facility included in the study were not included in the analysis.

Data on program and site characteristics were gathered through an annual facility survey using observations and interview of facility staff. Variables included geographic setting (urban or rural), facility type (primary, secondary, tertiary), laboratory services (availability of CD4 testing on site or off site), and staffing characteristics [number/type of full-time equivalent (FTE) providers]. Full-time equivalency was defined as working 2 shifts a day from Monday through Friday. Other clinic- and program-level characteristics included patient load (median number of patients enrolled in care), median CD4 cell count at ART initiation for patients aged 6 years or older, and program maturity (median number of quarters the facility submitted data reports). Because site surveys were repeated at different time points, latest available program-level variables were used for the present analysis. Other services available varied by country and include nutrition support, outreach services, support groups, peer educator program, and adherence counseling services.

There were a total of 526 health facilities in the 5 countries being supported by ICAP between January 2008 and March 2010. We excluded data from private health facilities (n = 20), designated pediatric centers of excellence (n = 6), inactive clinics as of March 2010 (n = 25), clinics that do not enroll pediatric patients by policy (n = 29), and new facilities that had reported for less than one year (n = 136) resulting in inclusion of 310 facilities for this analysis. In the analysis stage, we excluded an additional 36 facilities (12%) due to incomplete outcome data. Our final sample included 274 facilities.

The use of data for this study was approved as nonhuman subject research by the US Centers for Disease Control and Prevention (CDC) and the Institutional Review Board of Columbia University Medical Center.

Statistical Methods

The main variable of interest was facility type, PHF, and SHF as defined by the Ministry of Health (MOH) for each country. PHFs included health centers and clinics, whereas SHFs included district, sub-district, and provincial hospitals. We used trend analysis to compare the proportion of children younger than 15 years enrolled and initiating ART during the reporting quarter at PHFs and SHFs. For the analysis comparing outcomes by facility type, we defined LTFU as not having made a clinic visit or pharmacy pick up visit for at least 90 days and mortality as documented death based on clinic records. The average quarterly LTFU and mortality rates over the study period were calculated using clinic-level observation time for ART patients over the 9 reporting quarters as the denominator.[21] The clinic-level observation time accounts for different observation times for ART patients who were already on ART in previous quarters during the study period, newly initiating patients, and those who died, were LTFU, or transferred out of the clinic.

We used generalized linear mixed models to examine the program-level factors that were independently associated with LTFU and mortality. Chi-squared tests were used to analyze categorical data and Wilcoxon rank sum tests were used to analyze continuous variables comparing patient and facility characteristics by facility type. A log-linear generalized estimating equation regression model adjusting for clustering due to repeated measures was used to assess facility and patient characteristics associated with relative clinic-level LTFU and mortality per 100 person-years (PYs) on ART. We included the following variables in the bivariate analysis: patient load, program maturity, proportion children aged younger than 24 months initiating ART, median CD4 count at ART initiation for patients aged older than 6 years at the facility, availability of CD4 machines (on site or off site), and number of full-time equivalent (FTE) pediatrician, medical doctor, and nurses. Variables with significance at $\alpha < 0.25$ level in the bivariate analyses were included in the multivariate models.[22] Final models included variables significant at $\alpha < 0.05$ level and variables that could not be considered mediators of the effect of facility type on LTFU and mortality rates. Statistical analyses were performed using SAS software (version 9.2, SAS, Cary, NC).

RESULTS

A total of 17,155 children enrolled in HIV services and 8475 (49%) children initiated ART at 274 sites between January 2008 and December 2010 (Table 1). Over the 2-year period, the number of PHFs increased threefold, from 56 to

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TABLE 1. Characteristics of Children With HIV Infection, Aged Younger Than 15 Years, Initiating ART (N = 17,155) Enrolling in PHFs and SHFs (N = 274) in Rwanda, Tanzania, Mozambique, and Lesotho, January 2008 to March 2010

Variable	PHFs, N (%)	SHFs, N (%)	Total	*P*
Total sites (January 08 to March 10)	182 (66%)	92 (34%)	274	
Total no. children newly enrolled in care	6254 (36%)	10,901 (64%)	17,155	<0.0001
Proportion of children newly enrolled in care* (IQR)	7 (4–11)	9 (7–12)		<0.0001
Male: Female ratio	0.89	0.97		
Age at enrollment, y				
0–1	1879 (38%)	3069 (62%)	4948	
2–4	1712 (38%)	2769 (62%)	4481	
5–14	2612 (36%)	4620 (64%)	7232	
Unknown	51(10%)	443 (90%)	494	
Total no. children newly initiated ART	2443 (29%)	6032 (71%)	8475	<0.0001
Proportion of children newly initiating ART*(IQR)	6% (0–14)	9% (4.5–15)		<0.0001
Age at ART initiation, y				
0–1	663 (31%)	1510 (69%)	2173	
2–4	674 (29%)	1645 (71%)	2319	
5–14	1058 (28%)	2745 (72%)	3803	
Unknown	48 (27%)	132 (73%)	180	
Proportion of children < 24 newly enrolled in care who are initiated on ART† (IQR)	11 (IQR:0–75)	40 (IQR:0–75)		<0.001
No. children newly initiating ART per site per quarter	13.4	65.6		<0.001

*Numerator: children aged younger than 15 years newly initiated on ART during January 2008-March 2010; Denominator: adults and children newly initiated on ART during January 2008-March 2010.

†Numerator: children 0–1years newly initiated ART during January 2008-March 2010; Denominator: children 0–1 years newly enrolled in care during January 2008-March 2010.

182, accounting for 66% of all sites reporting, whereas the number of SHFs increased by 30%, from 72 to 92 (34%). The median number of children initiating ART during each quarter at PHFs increased from 129 at the beginning of the observation period to 463 at the end (Fig. 1), whereas it declined slightly in SHFs from 619 to 598. This increase in number of children initiating ART per quarter at the PHFs was primarily driven by the increase in number of sites over the 2-year period. This trend was consistent across all countries.

Despite the rapid increase in number of PHFs offering pediatric care, the total number of children newly enrolled in care at PHFs over the study period was far less than the number enrolled in SHFs; 6254 vs 10,901, $P < 0.001$ (Table 1). Similarly, among children initiating ART, the majority, 6032 (71%), were at SHFs compared with 2443 (29%) in PHFs. Overall, children accounted for 6% of clients initiating ART at PHFs, which was significantly lower than at SHFs (9%; $P = 0.0001$).

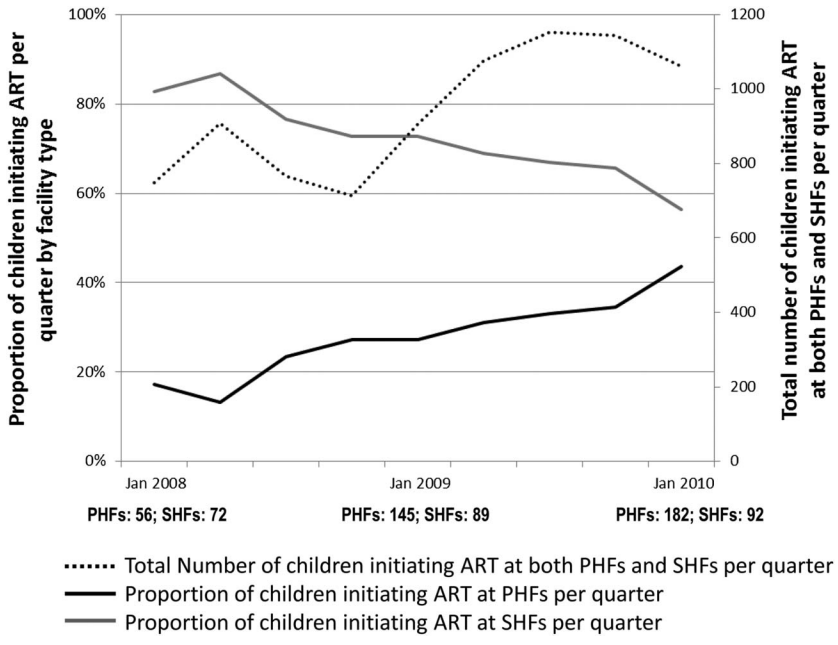

FIGURE 1. Number and proportion of children aged younger than 15 years (N = 8475) initiating ART per quarter at 274 primary and secondary health facilities in Rwanda, Tanzania, Mozambique, Kenya, and Lesotho between January 2008 and March 2010.

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SHFs had a significantly higher proportion of children aged younger than 24 months enrolled in care and initiating ART when compared to PHFs (Table 1). Among the 48% of facilities that disaggregated their data by age groups, the median proportion of children aged younger than 24 months initiated on ART at SHFs was 40% compared with 10% at PHFs ($P = 0.001$). Furthermore, more than half of PHFs did not have any children aged younger than 24 months on ART.

The characteristics of the PHFs and SHFs are summarized in Table 2. Of the 274 facilities, 182 (66%) were PHFs and 92 (34%) were SHFs. Sixty-four percent of the PHFs were in rural settings, whereas only 32% of the SHFs were rural. The SHFs were larger with a median of 536 [interquartile range (IQR): 213–1079] adult and pediatric patients on ART compared with the PHFs, 136 (IQR: 63–242; $P < 0.001$), and had been providing HIV services for a median of 3.5 years (IQR: 2.5–4.5) compared with a median of 2 years at PHFs (IQR: 1.25–2.25; $P < 0.0001$). The PHFs had more limited human and laboratory diagnostic resources compared with SHFs: PHFs were less likely to have a full-time medical doctor or pediatrician on site, and few had a CD4 machine on site (8% vs 59% at SHF; $P = 0.0001$).

During the 2-year period, 825 children on ART were reported to have died (151 in PHFs and 674 in SHFs) and 1556 children were LTFU (282 from PHFs and 1274 from SHFs). The average quarterly mortality rate and LTFU per 100 PYs on ART were significantly higher in SHFs compared with PHF (6.0/100 PYs on ART vs 5.2/100 PYs on ART, respectively; $P = 0.0013$, and 20.2/100 PYs vs 9.8/100 PYs, respectively; $P = 0.003$) (Table 3). There was no significant difference in average quarterly transfer out rates (12.7/100 PYs at SHFs and 9.4/100 PYs at PHFs; $P = 0.785$). Unadjusted and adjusted models were fit to examine facility and patient characteristics that were associated with LTFU and death (Table 4). Documented death and LTFU were lower at PHFs compared with SHFs (adjusted rate ratio = 0.66, $P = 0.028$; and adjusted rate ratio = 0.55, $P = 0.022$, respectively) (Table 4).

Among the 5 countries, Rwanda had the lowest rates of LTFU and mortality at both PHFs and SHFs (LTFU 0.92 vs 0.88; $P = 0.054$, mortality 3.1 vs 2.5; $P = 0.052$) (Table 3). Overall, LTFU was lower in the PHFs compared with SHFs across the 5 countries (Table 4). However, there was no significant difference in reported mortality per 100 PYs on ART between PHFs compared with SHFs in Rwanda, Kenya, and Mozambique (3.1 vs 2.5; $P = 0.052$; 6.1 vs 5.6, $P = 0.81$; and 6.8 vs 6.0, $P = 0.69$, respectively).

TABLE 2. Characteristics of the 274 Primary and Secondary Health Facilities in Rwanda, Tanzania, Mozambique, Kenya, and Lesotho

Characteristic	PHF	SHF	*P*
Total no. sites	182 (64%)	92 (36%)	
Patient load* (IQR)	136.5 (63–242)	536 (213–1079)	<0.0001
Program maturity† (IQR)	8 (5–9)	14 (10–18)	<0.0001
Mean no. full-time medical doctors (range)	0.3 (0–6)	0.9 (0–5)	<0.0001
Mean no. full-time nurses (range)	1.6 (0–13)	2.1 (0–24)	0.1107
Mean no. full-time pediatricians/pediatric specialists (range)	0 (0–0.4)	0.2 (0–5)	0.0017
CD4 machine on site (%)	14 (8%)	54 (59%)	<0.0001
Nurses initiating ART (%)	79 (43%)	39 (42%)	0.8727

*Patient load: median number of patients on ART.
†Program maturity: median number of quarters in operation.

TABLE 3. Unadjusted Outcomes by Facility Type, Overall and by Country for Children Aged Younger Than 15 Years (N = 8475) on ART in Rwanda, Tanzania, Mozambique, Kenya, and Lesotho, January 2008 to March 2010

	Lost to Follow-up/100 PYs on ART			Mortality Rate/100 PYs on ART		
	PHF*	SHF†	*P*	PHF	SHF	*P*
Overall	9.8	20.2	0.003	5.2	6.0	0.001
Rwanda	0.92	0.88	0.054	3.2	2.5	0.055
Tanzania	2.5	16.4	0.077	6.4	7.5	0.225
Mozambique	14.1	23.0	0.519	6.8	6.0	0.069
Kenya	18.1	29.4	0.001	6.1	5.6	0.811
Lesotho	12.9	47.3	0.003	3.5	12.5	0.222

*Primary health facility.
†Secondary health facility.

DISCUSSION

To our knowledge, this is the largest report comparing pediatric enrollment, ART initiation, and early outcomes at PHFs and SHFs in different countries in SSA. A threefold increase in the number of PHFs providing HIV services over the 2-year period resulted in a modest increase in the number of children enrolled in HIV care and initiating ART. This is consistent with the data from other LRSs that show increasing enrollment with increasing number of facilities providing pediatric HIV care and treatment.[12–16] However, SHFs still accounted for over two thirds of children in care and on ART during the study period.

Most pediatric programs in SSA have low proportions of children aged younger than 24 months enrolled and initiating ART because of the difficulty diagnosing HIV infection in infants and limited capacity and comfort to initiate ART in infants and young children.[23–25] The median proportion of children aged younger than 24 months initiated on ART at PHFs was low (11%), and more than half of PHFs did not have any children aged younger than 24 months on ART. The low proportion of children aged younger than 24 months initiating ART is concerning given the high rates of morbidity and mortality if left untreated.[26–28] A multifaceted approach is needed to address this if PHFs are to support scale-up pediatric services. This will include expansion of access to DNA polymerase chain reaction for early identification of infected infants, availability of easy-to-use ART

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TABLE 4. Bivariate and Multivariate Analysis of Lost to Follow-up and Mortality Among Children Aged Younger Than 15 Years (N = 8475) Initiating antiretroviral Therapy From January 2008 to March 2010 in 274 Facilities in Rwanda, Tanzania, Mozambique, Kenya, and Lesotho

	Lost to Follow-up				Mortality			
	Unadjusted		Adjusted		Unadjusted		Adjusted	
	RR*	*P*-value	ARR**	*P*-value	RR*	P-value	ARR**	*P*-value
Facility type								
SHF	1.00		1.00		1.00		1.00	
PHF	0.36	0.003	0.55	0.022	0.53	0.001	0.66	0.028
Country								
Rwanda	1.00		1.00		1.00		1.00	
Tanzania	5.38	<0.001	4.16	<0.0001	2.94	<0.001	2.70	0.001
Mozambique	8.75	0.0007	7.33	<0.0001	2.27	0.0007	2.21	<0.0001
Kenya	15.50	<0.0001	12.08	<0.0001	2.66	<0.0001	2.00	0.0009
Lesotho	19.49	0.0005	16.13	<0.0001	3.12	0.0005	2.42	<0.0001
Program maturity								
For every quarter maturity	1.01	0.829			0.99	0.761		
Program size								
>549	1.00				1.00			
194–548	0.79	0.292			1.00	0.998		
71–193	0.60	0.033			1.07	0.735		
<71	1.18	0.575			1.25	0.423		
Median CD4 count								
>190	1.00				1.00			
149–189	1.76	0.085			1.23	0.429		
118–148	2.46	0.001			1.47	0.084		
<118	2.85	<0.0001			1.62	0.626		
CD4 machine								
Off site	1.00				1.00			
On site	1.91	0.006			1.30	0.152		
% of children 0–1 y								
≥12.5%	1.00				1.00			
<12.5%	1.20	0.391			0.92	0.585		
FTE providers								
Every FTE physician	1.04	0.843			1.05	0.622		
Every FTE nurse	0.98	0.708			0.97	0.577		

ARR, adjusted rate ratio; RR, rate ratio.

formulations for infants (dispensing, prescribing and storage), training and mentorship of site staff to improve pediatric expertise, and access to advanced pediatric expertise to inform management of difficult cases.

Our overall programmatic outcomes are consistent with that reported in the literature for children receiving HIV care and treatment in similar settings; mortality rate of 5.2–6/100 PYs and LTFU of 9.8–20/100 PYs.[19,29,30] Overall both LTFU and mortality were lower at PHFs compared with SHFs. These findings are similar to studies from South Africa, Thailand, and Zambia that compared outcomes of children initiating ART at PHFs and SHFs.[12−15]Although we were unable to measure and control for all facility- and patient-level factors that could confound the difference in mortality, we controlled for facility characteristics (patient load, program maturity, FTE nurses and physicians, and on-site CD4 machine), patient characteristics (median CD4 at enrollment for children aged older than 6 years and proportion of children aged younger than 24 months on ART) and still found outcomes to be superior at PHFs compared with SHFs. This observed difference could be due to uncontrolled confounding because sicker children go to SHF. Further research is needed to look at patient-level factors that could account for this difference. Additionally, we cannot rule out the possibility of differential misclassification of true deaths as LTFU by facility type. We believe that given the disproportionately high LTFU rates found in SHFs, some may be true deaths that are misclassified as LTFU. If this is the case, the observed association between PHFs and lower mortality rates will be a conservative estimate. However, the lower LTFU rates in PHFs is not surprising and might be related to shorter distance between home and PHFs with reduced transportation costs, and the fact that smaller lower volume facilities may facilitate community and individual relationships, which may improve retention and adherence.[13]

Despite the large differences in LTFU rates across the 5 countries, the trend was consistent with PHFs having lower

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LTFU compared with SHFs, except in Rwanda where rates of both LTFU and death were substantially lower than in the other countries. These low rates are consistent with other adult and pediatric studies from Rwanda. This could be attributed to national leadership, progressive guidelines, and relatively low burden of disease. Furthermore, the Rwanda program has a much smaller case load that has been associated with lower rates of LTFU.[11,31] The differences in the other countries probably reflect underlying differences in health systems, maturity of HIV programs, local governance, and leadership.

STRENGTHS AND LIMITATIONS

The strength of this analysis is that it pools data from 5 countries with over 17,000 children enrolled and almost 50% initiated on ART. The large sample size and variety of facilities (urban, rural, large, and small) allows for robust interpretation and generalization of the findings. We were also able to examine a large number of program characteristics and control for these in our multivariate analysis.

The main limitation of the study is that we were unable to control for patient-level factors that could affect outcomes because we used aggregate data. We attempted to control for this by adjusting for factors known to be associated with mortality or LTFU (proportion of children aged younger than 24 months of age and median CD4 for clients aged older than 6 years at enrollment). Furthermore, because we limited our analysis to government-run health facilities, our results may not be generalizable to non–government-run facilities. ICAP-supported health facilities included in the analysis undergo routine data quality checks, which is standardized across ICAP-supported programs. Despite our efforts, incomplete and discrepant information are not uncommon at our facilities. However, we have not found any evidence of bias as a result of systematic misclassification or missing information during our data quality assurance activities. The errors are random and non-differential. Furthermore, the findings are only considered representative of ICAP-supported health facilities that were part of the analysis. Notably, we excluded 36 (12%) of the facilities that met the eligibility criteria due to incomplete outcome data. Although characteristics of these facilities were similar to characteristics of the facilities included in the analysis, the findings should not be generalized to those facilities.

In summary, our findings provide evidence of successful decentralization of pediatric HIV care in 5 African countries and demonstrate that pediatric HIV care and treatment is feasible in PHFs with equally or more effective outcomes than in SHFs. This article tries to highlight the importance of PHFs in the scale-up of pediatric care and treatment. SHFs continue to account for the majority of children engaged in HIV services. We have demonstrated, however, the increasing importance of PHF for pediatric care in the context of decentralization reaching more children without jeopardizing health outcomes. However, children aged younger than 24 months remain vulnerable and are less likely to be initiated on ART. To ensure equity and access to high-quality HIV care and treatment for infants and children, particular attention must be paid to identify the challenges faced by both PHFs and SHFs so that innovative programs can be implemented in response to their different needs. Although cost-effective analysis is beyond the scope of this article, further research into this critical area can aid in providing information on the optimal approach to service delivery for HIV-infected children.

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REFERENCES

1. WHO. Towards Universal access: scaling up priority HIV/AIDS interventions in the health sector. Progress Report 2010. Available at: http://whqlibdoc.who.int/publications/2010/9789241500395_eng.pdf. Accessed on January 15, 2012.
2. UNAIDS Global Report: UNAIDS report on the global AIDS epidemic. 2012. Available at: http://www.unaids.org/en/media/unaids/contentassets/documents/epidemiology/2012/gr2012/20121120_UNAIDS_Global_Report_2012_en.pdf. Accessed December 23, 2012.
3. WHO. Antiretroviral therapy of HIV infection in infants and children: towards universal access: recommendations for a public health approach-2010 revision. Available at: http://whqlibdoc.who.int/publications/2010/9789241599801_eng.pdf. Accessed on January 15, 2012.
4. WHO, UNICEF, UNAIDS: Global HIV/AIDS response: epidemic update and health sector progress towards universal access. Progress Report 2011. Available at: http://www.who.int/hiv/pub/progress_report2011/hiv_full_report_2011.pdf. Accessed May 13 2012.
5. De Baets A, Bulterys M, Abrams E, et al. Care and treatment of HIV-infected children in Africa: issues and challenges at the district hospital level. *Pediatr Infect Dis J.* 2007;26:163–173.
6. Braitstein P, Brinkhof MW, Dabis F, et al. Mortality of HIV-1-infected patients in the first year of antiretroviral therapy: comparison between low-income and high income countries. *Lancet*. 2006;367:817–824.
7. O'Brien DP, Sauvageot D, Zachariah R, et al. In resource-limited settings good early outcomes can be achieved in children using adult fixed-dose combination antiretroviral therapy. *AIDS*. 2006;20:1955–1960.
8. Kline MW. Perspectives on the pediatric HIV/AIDS pandemic: catalyzing access of children to care and treatment. *Pediatrics*. 2006;117:1388–1393.
9. Chan AK, Mateyu G, Jahn A, et al. Outcome assessment of decentralization of antiretroviral therapy provision in a rural district of Malawi using an integrated primary care model. *Trop Med Int Health*. 2010;15:90–97.
10. Boyer S, Eboko F, Camara M, et al. Scaling up access to antiretroviral treatment for HIV–infection: the impact of decentralization of healthcare delivery in Cameroon. *AIDS*. 2010;24:S5–S15.
11. Fatti G, Grimwood A, Bock P. Better antiretroviral therapy outcomes at primary healthcare facilities: an evaluation of three tiers of ART services in four South African provinces. *PLoS One*. 2010;5:e12888.
12. Mutevedzi PC, Lessells RJ, Heller T, et al. Scale-up of a decentralized HIV treatment program in rural Kwazulu-Natal, South Africa: does rapid expansion affect patient outcomes? *Bull World Health Organ*. 2010;88:593–600.
13. Bedelu M, Ford N, Hilderbrand K, et al. Implementing antiretroviral therapy in rural communities: the Lusikisiki model of decentralized HIV/AIDS care. *J Infect Dis*. 2009;S3:S464–S468.
14. Massaquoi M, Zachariah R, Manzi M, et al. Patient retention and attrition on antiretroviral treatment at district level in Malawi. *Trans R Soc Trop Med Hyg*. 2009;103:594–600.
15. Bock P, Boulle A, White C, et al. Provision of antiretroviral therapy to children within the public sector of South Africa. *Trans R Soc Trop Med Hyg*. 2008;102:905–911.
16. Janssen N, Ndirangu J, Newell M-L, et al. Successful pediatric HIV treatment in rural primary care in Africa. *Arch Dis Child*. 2010;95:414–421.

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17. Sutcliffe CG, Bolton-Moore C, van Dijk JH, et al. Secular trends in pediatric antiretroviral treatment programs in rural and urban Zambia: a retrospective cohort study. *BMC Pediatr.* 2010;10:54.
18. Bolton-Moore C, Mubiana-Mbewe M, Cantrell R, et al. Clinical outcomes and CD4 cell response in children receiving antiretroviral therapy at primary health care facilities in Zambia. *JAMA*. 2007;298: 1888–1899.
19. McConnell MS, Chasombat S, Sianghoe U, et al. National scale up and patient outcomes in a Pediatric Antiretroviral Treatment program, Thailand, 2000-2007. *J Acquir Immune Defic Syndr.* 2010;54:423–429.
20. McConnell MS, Byers RH, Frederick T, et al. Trends in antiretroviral therapy use and survival rates for a large cohort of HV infected children and adolescents in the United States, 1989-2001. *J Acquir Immune Defic Syndr.* 2005;38:488–494.
21. Lamb MR, El-Sadr WM, Geng E, et al. Association of adherence support and outreach services with total sttrition, loss to follow-up, and death among ART patients in Sub-Saharan Africa. *PLoS One* 2012;7:e38443.
22. Hosmer DW, Lemeshow S. Applied logistic regression. New York, NY: Wiley; 1989.
23. Reddi A, Leeper SC, Grobler AC, et al. Preliminary outcomes of a pediatric highly active antiretroviral therapy cohort from KwaZulu Natal, South Africa. *BMC Pediatr.* 2007;7:13.
24. Davies M-A, Egger M, Keiser O, et al. Pediatric antiretroviral treatment programs in sub-Saharan Africa: a review of published clinical studies. *Afr J AIDS Res.* 2009;8:329–338.
25. Barth RE, Templeman HA, Smelt E, et al. Long-term outcome of children receiving antiretroviral treatment in Rural South Africa: substantial virologic failure on first-line treatment. *Pediatr Infect Dis J.* 2011;30:53–56.
26. Newell ML, Coovadia H, Cortina-Borja M, et al. Mortality of infected and uninfected infants born to HIV-infected mothers in Africa: a pooled analysis. *Lancet*. 2004;364:1236.
27. Violari A, Cotton M F, Gibb D M, et al. Early antiretroviral therapy and mortality among HIV-infected infants. *N Eng J Med.* 2008;359:2233–2244.
28. Dunn D. Short-term risk of disease progression in HIV-1-infected children receiving no antiretroviral therapy or zidovudine monotherapy: a meta-analysis. *Lancet*. 2003;362:1605–1611.
29. Leyenaar J, Novosad PM, Ferrer KT, et al. Early clinical outcomes in children enrolled in human immunodeficiency virus infection care and treatment in Lesotho. *Ped Infect Dis J.* 2010;29:340–345.
30. Eley B, Davies M, Appoles P, et al. Antiretroviral treatment for children. *S Afr Med J.* 2006;96:988–993.
31. Lambdin BH, Micek MA, Koespell TB, et al. Patient volume, human resources levels, and attrition form HIV treatment programs in central Mozambique. *J Acquir Immune Defic Syndr.* 2011;57:e33–e39.

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