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Are adolescent orphans more likely to be HIV positive? A pooled data analyses across 19 countries in sub-Saharan Africa

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Abstract

Background—Despite extensive resources and numerous programs directed towards orphans in sub-Saharan Africa, evidence of their disadvantage is surprisingly limited. While initial research suggests that orphans are at greater risk of being HIV-positive, the evidence suffers from important methodological and geographic limitations.

Methods—To rigorously test disparities in HIV prevalence related to orphanhood and parental HIV status in sub-Saharan Africa, we used Demographic and Health Survey data from 19 countries in sub-Saharan Africa. We conducted pooled multilevel logistic regression on adolescents aged 15–17 with HIV test results (N=22,837 girls and 20,452 boys).

Results—Regardless of their gender, orphans who lost their mother, lost both parents or had an HIV-infected mother were two to three times more likely to test positive for HIV infection (ORs 1.87–3.17). The loss of a father was also associated with HIV infection risk for females, but of slightly lower magnitude (OR 1.63).

Conclusion—To better inform interventions, future research is needed to quantify the relative contribution of perinatally- and sexually-acquired infections, and to investigate the specific mechanisms that may account for disparities in the latter. In the meantime, programs serving HIV-infect adults as well as those serving orphaned and vulnerable children should invest in family-based HIV testing in order to identify adolescents in need of treatment.

Keywords

HIV Infections; Adolescent; Orphans; Africa South of the Sahara; Risk Factors

INTRODUCTION

Over the past two decades, both research and programs have increasingly focused on the adverse consequences of orphaning in the context of the HIV/AIDS epidemic. One area of particular concern is whether orphans are more likely to be HIV-infected than their non-

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orphaned counterparts [1], and may thus perpetuate the epidemic in the next generation. Recent evidence seems to support an association, and specifically suggests a two-fold risk of HIV among select orphan populations compared to their non-orphaned peers [2].

Numerous hypotheses have been generated to explain orphan HIV disparities, including socioeconomic vulnerability, psychosocial distress, poor family functioning, and sexual abuse [1]. After the death of a parent, for example, many orphans experience depression [3 4] and may turn to unhealthy sexual partnerships for comfort [5]. Likewise, orphans may be more vulnerable to sexual victimization, which is known to heighten HIV risk via both direct and indirect pathways (i.e., subsequent risky behaviors and coping mechanisms) [6–8]. An association between orphanhood and sexual victimization has not been definitively established, however, with a recent meta-analysis citing poor methodological quality as one explanation for the ambiguity [9]. Moreover, while the above mechanisms are largely untested, others do not withstand basic critique: while some orphans demonstrate lower socioeconomic status [e.g., 10 11], evidence suggests that higher socioeconomic groups are most vulnerable to HIV in Africa [12–16].

What many of the above pathways have in common is an assumption that HIV is acquired during adolescence. Another possibility is that orphaned adolescents were infected at birth. While once considered rare, research now recognizes that a substantial proportion of HIV-infected infants may survive into adolescence [17 18]: a 2006 study predicted that 17% of perinatally-infected infants would reach their 15th birthday without intervention [18]. Prior to widespread access to ART, it was expected that most perinatally-infected children wouldn’t survive to adolescence; however this may have changed over the past decade. Empirical support for longer survival of perinatally-infected orphans is building: a study of HIV-positive adolescents in Zimbabwe found that most had a mother who was either HIV-positive or deceased, implying a strong role for vertical transmission [19].

Given the empirical uncertainty surrounding the potential mechanism, it’s not surprising that the evidence around orphanhood and HIV remains equally equivocal. While three notable studies use nationally-representative data to provide evidence of greater risk of HIV infection among female maternal orphans, the geographic scope is limited to two countries, South Africa and Zimbabwe [20–22]. A closer examination reveals substantial limitations in the existing research in this area. Several studies include non-representative convenience samples [23]; samples that vary widely in age and developmental group (e.g., combining children aged 0–15 years) [24]; few controls for confounding socio-demographic characteristics [23–25]; or are conducted in distinctly different geo-political climates (e.g., street youth in Russia [26]). Only one study examined orphan HIV disparities across multiple countries: they report null findings, which the authors attribute to a lack of statistical power [27]. Another notable limitation is the predominant focus on female orphans, as few studies analyze the HIV disadvantage among male orphans (exceptions are [20 21 27]). Several of the studies above are included in a widely-cited meta-analysis [2] that asserts greater HIV risk among orphans based on questionable or limited evidence.

With limited research on the relationship between HIV status and orphanhood, more research is needed to test their generalizability across epidemiological, political, and cultural contexts. Moreover, research suggests that adolescents living with HIV-positive or AIDS-sick parents may suffer similar or more intense disadvantage [28–30], which may extend to HIV risk [31]. Many adolescents will be both orphaned and living with an ill surviving parent. To date, studies of orphanhood and HIV have not recognized the potential vulnerability of this sub-population. Including parental HIV enables the evaluation of this experience as an important independent predictor and allows for a less biased assessment of orphanhood impact.

This research extends the above evidence base by simultaneously testing the association between orphanhood and HIV across 19 countries in sub-Saharan Africa. In doing so, we also control for potential confounding characteristics that may impact the relationship between orphanhood and HIV infection. Our approach broadens the geographic generalizability of earlier findings, examines its relevance to males as well as females, and explicitly tests the role of parental HIV in creating similar disparities.

METHODS

Data

We use data from Demographic and Health Surveys (DHS), a collaboration between the United States Agency for International Development and 85 host countries [32]. The DHS are cross-sectional, nationally-representative household surveys. A multistage sampling methodology is used: communities are randomly selected within defined strata (usually a combination of region and rural/urban location), households are randomly sampled within these communities, and face-to-face interviews are conducted with all individual residents aged 15–49 years. In addition to implementing standardized core modules, countries have had the option of offering HIV testing since 2001 [33]. This study uses data from both the standard DHS and more specialized AIDS Indicator Surveys. Analyses are restricted to 26 surveys from 19 countries in sub-Saharan Africa conducted in 2003 or later; all of which were publically available at the time of analyses and contain both HIV and parental survival data (see Tables 1 and 2). Multiple surveys from the same country are included, where available. Within the selected surveys, we use data for adolescents aged 15–17, which is the only group with both orphanhood and HIV testing information. Analyses were restricted to adolescents with HIV test results (22,464 females and 20,012 males). Further information regarding DHS is available at dhsprogram.com. Secondary research on this data source was exempted from the need for human subjects review by Stony Brook University.

Measures

In all DHS surveys, HIV testing is anonymous, informed, and voluntary. Blood spots are typically collected for household members aged 15–49 years and seropositivity determined by ELISA tests [33]. The DHS also collect data on parental survival for individuals under age 18; this information was used to create three mutually exclusive categories of orphanhood (maternal = death of a mother only; paternal = death of a father only; double = death of both parents) and a reference group whose parents were both living. Using household roster information, we also created an indicator of whether the index adolescent had an HIV-positive mother or father living in the home (coded 1; coded 0 if that the parent tested negative, was deceased or was not living in the home; coded as missing if the parent lived in the home but was not tested). Finally, we extracted data on the adolescent's age, education (classified as none, some or completed primary, and completed secondary), marital status (dichotomized into currently married or co-habitating versus all other), area of residence (rural or urban), and the household's wealth quintile (as provided by the DHS [34]).

Analyses

All analyses are stratified by gender, which has been shown to modify the relationship between orphanhood and sexual health in other studies [e.g., 27 35]. Weighted descriptive statistics are presented by survey; weights accounts for both sampling design and testing non-response. Since HIV infection is a relatively rare outcome, data were pooled across countries to create sufficient power to examine parental risk factors. HIV infection was modeled using multilevel logistic regression with random intercepts at three levels: survey, strata (a combination of region and urban/rural location), and community (approximated by the primary sampling unit).

Models are built sequentially: model 1 contains only the orphanhood and parental HIV predictors; model 2 adds controls for sociodemographic factors that may confound these relationships. Thus, the final model is specified as:

$$\ln\left(\frac{1-\pi_{\mathrm{ijkl}}}{\pi_{\mathrm{ijkl}}}\right)=\mathrm{Y}_{\mathrm{ikc}}=\beta_0+\beta_1\mathrm{X}_{\mathrm{ijkl}}+\beta_2\mathrm{O}_{\mathrm{ijkl}}+\mu_{\mathrm{jkl}}+\mu_{\mathrm{kl}}+\mu_{0\mathrm{l}}+\varepsilon_{\mathrm{ikl}}$$

where Y is the outcome of interest which varies between individuals (i), communities (j), strata (k), and survey (l); X is a set of confounders; O is a categorical variable indicating type of orphanhood; μ is the random intercept; and ε is the individual level residual. Missing data were handled by listwise deletion.

Country variation in culture, family structure, and epidemiologic context provide an important backdrop and may alter the relationship between parental status and HIV. To examine the heterogeneity in the effect of orphanhood and parental HIV infection, we had hoped to test country-level random slopes for these variables; however these models did not converge. We thus took an alternative approach: we used the posterior predicted values from the original model to calculate country-level orphanhood estimates, and then tested heterogeneity using the I^2 statistic, defined as: $I^2 = 100\% \times (Q - \mathrm{df})/Q$ where Q is Cochran's heterogeneity statistic and df are the degrees of freedom [36]. Negative values are set to zero, such that resulting values range from 0 to 100%. Values below 25% represent low heterogeneity, with higher values representing greater heterogeneity [36]. To examine heterogeneity visually, we created a forest plot of the beta coefficient of orphanhood in each country.

RESULTS

Sample description

Overall, a quarter of the adolescents in our pooled sample were orphaned; paternal orphaning was more common than either maternal or double orphaning (15% versus 5% for each of the latter orphan types). A much smaller proportion of adolescents resided with an HIV+ mother or father (4% and 2% respectively). Table 1 presents additional sociodemographic characteristics.

Tables 2 and 3 present the weighted HIV prevalence by individual survey for girls and boys respectively. There was considerable variation in adolescent HIV prevalence by survey, as expected given the difference in HIV prevalence across countries and over time. Among girls, HIV prevalence ranged from zero (no cases of HIV among sampled adolescents) to over 6% (Swaziland 2006); among boys the prevalence peaked at 3.5% (Zambia 2007). Orphanhood ranged from 13–44% among girls and 17–47% among boys; the loss of a father was far more common than the loss of a mother in every survey (Tables 2 and 3).

The association between orphanhood and adolescent HIV infection

Table 4 presents the distribution of HIV prevalence among sample adolescents by orphan status and by the HIV-status of residential parents. Across all 26 surveys, the unweighted HIV prevalence was approximately 1.4%; slightly higher for adolescent girls (1.7%) than adolescent boys (1.0%). The raw distribution shows a higher HIV prevalence among all orphan types, peaking at 5% among female double orphans. A similar pattern is observed for parental HIV status: HIV prevalence is two to three times greater among adolescents residing with an HIV-infected parent than among their counterparts.

Table 5 presents the results of the multilevel models regressing orphanhood and parental HIV on adolescent HIV infection by gender. In the crude model containing only orphanhood and parental HIV status (model 1), female paternal, maternal and double orphanhood all exhibited a strong and significant association with HIV infection (ORs 1.63, 2.62, and 3.11 respectively), as did maternal HIV status (OR 1.87). These associations remained robust and changed little in magnitude with additional controls (model 2).

Models 3 and 4 present the same analyses using the male adolescent sample. Similar to their female counterparts, male maternal and double orphans were more likely to test positive for HIV infection (ORs 2.64, 3.17 respectively), as did maternal HIV status (OR 2.55). These associations persisted in the fully-adjusted models. However, the association with paternal orphaning and paternal HIV status is non-significant across both models. We find no association between socioeconomic status (measured both through education and wealth) and HIV infection for either gender. Further, the addition of sociodemographics did not meaningfully change the coefficients for orphanhood or parental HIV infection, indicating they are likely not important confounders or mediators in this sample. Of note, the odds of HIV infection rise significantly with age for females; this pattern is not observed among males, reflecting the later age at which males acquire HIV.

Finally, we examined the extent of heterogeneity in the above the associations between orphanhood and HIV between countries for both genders. Supplement 1 displays the beta coefficient of orphanhood in each country, by orphan type and gender. We use this information to calculate the I^2 values. These were all negative (rescaled to zero) regardless of orphan sub-type, indicating no evidence of heterogeneity between countries. We note, however, that the low number of HIV cases in any individual country creates large confidence intervals, likely masking much of the real heterogeneity.

DISCUSSION

This study found robust associations between orphanhood and HIV infection among an adolescent sample pooled from 19 countries in sub-Saharan Africa. Regardless of their gender, orphans who had lost their mother had two to three times greater odds of testing positive for HIV infection. These findings provide greater weight to recent evidence on orphanhood and heightened HIV risk among females [20–22], and begin to tip the balance of evidence with regard to HIV disparities among male orphans. Our findings also extend this evidence base substantially by demonstrating that adolescents living with an HIV-positive mother are also more likely to be infected themselves.

It is important to note that the above findings represent associations; the cross-sectional nature of the data prohibits causal interpretation. Thus, the primary contribution of the current study is in clearly establishing the high burden of HIV among orphans and children living with HIV-infected mothers. Further studies can build from this foundation to better distinguish between transmission pathways. This is critical: the mechanisms underlying HIV risk in orphans have not clearly been established in research, and have very different implications for intervention. As mentioned in the introduction, many explanations have been proposed [1], which largely focus on distal risk factors (e.g., socioeconomic status, psychosocial distress, abuse) that are assumed to influence more proximal sexual risk factors (e.g., number, type and concurrency of sexual partnerships). We do control for wealth and education and find no change in orphan disparities, and find little support for a pathway involving socioeconomic disadvantage. This finding emphasizes that vulnerability in orphans most likely stems from factors unique to losing parents, rather than from structural disadvantage, and is consistent with past work examining similar pathways to fertility [37]. With this one exception, however, our study does not seek to evaluate the pathways, and thus can only hypothesize about alternative explanations. In particular, it is possible that greater HIV prevalence among orphaned adolescents reflects long-term survival of perinatally-infected infants, as has been suggested by a number of recent studies [19 38 39]. Our data cannot differentiate between the above pathways. For example, we found that maternal death and HIV status were stronger and more consistent predictors of adolescent HIV status than paternal indicators. While this could be taken as evidence of perinatal infections in the case of maternal death, we find perinatal transmission a less convincing argument for the association between maternal HIV status and adolescent HIV status. For all cohorts included in our analyses, treatment was not widely available during early childhood (and for earlier cohorts, not at all); thus it is unlikely that both parent and child would be long-term survivors. New approaches, such as structural equation modeling and/or longitudinal data analyses, are needed to tease apart the dual contributions of perinatal and sexual HIV transmission, and to better identify the distal pathways.

Moreover, future studies may be able to overcome several other limitations inherent in the current study. For example, the DHS data do not capture the age at which respondents were orphaned, which likely moderates the impact of parental death. Similarly, we do not have information on HIV-related illness among parents. While we do capture parental HIV status, this alone does not allow us to discern whether their HIV infection affects their health status. Similarly, we are only able to examine adolescents within a narrow age range (15–17), as these are the only ages for which the DHS collects both HIV status and parental survival. Finally, we used multilevel regression because it enables us to better account for country-level variation in the model [40]. However, this technique assumes that the sample of higher level units (in this case surveys) was chosen at random, which does not hold for DHS surveys.

While there are inherent limitations, this study also had several notable strengths. We use nationally-representative data from 19 countries in sub-Saharan Africa to provide the most comprehensive analysis of orphanhood and HIV risk to date. The multi-country approach taken ensures relevance of the above findings across a range of resource-poor settings in Africa where orphanhood and HIV are common, though we also acknowledge that pooled analyses could obscure important heterogeneity in the relationship between individual countries. Moreover, our pooled analyses provide the power necessary to disaggregate both by orphan type and gender. The unique nature of the DHS household survey also enables us to consider the role of parental HIV, acknowledging that a substantial period of distress and disadvantage may precede a parent's AIDS-related death. While nationally-representative data on orphanhood has long been reported by UNAIDS and others, we know of only one other study to quantify the proportion residing with HIV-infected parents [41]. Finally, our study focuses on adolescents – a high risk population at the beginning of their sexual trajectories.

In sub-Saharan Africa, an estimated that 56 million children have experienced parental death, of which approximately a quarter are due to the HIV/AIDS epidemic [42]. The number living with an HIV-positive mother is harder to estimate, but clearly measures in the tens of millions. Given that youth account for almost half of all new HIV infections [43], the strength of the disparities, and the sheer magnitude of this population, adolescents who are orphaned or live with an HIV-positive mother may have the potential to shape the course of the HIV/AIDS epidemic in the years to come. Regardless of whether they were born with HIV or acquired the virus sexually, we need to ensure that this high risk population of adolescents has access to testing and lifesaving treatment. While WHO recommends that all adolescents in generalized epidemics be tested for HIV, currently only 10–15% of youth in sub-Saharan Africa know their status [44] and pediatric treatment reaches few than a third of those in need [45]. Counter to trends among adults, AIDS-related mortality actually rose 50% from 2005–2012 among adolescents [42]. Clearly, extending HIV-services to adolescents, particularly key populations such as those affected by parental HIV, is essential. Programs serving orphaned and vulnerable children should invest in family-based HIV testing, either through their own HIV testing campaigns or through better linkages with existing HIV services. Programs that serve HIV-positive adults should likewise adopt a family-centered approach and ensure all children – regardless of their age – are tested for HIV. Identifying HIV-positive adolescents in need of immediate clinical services can both ensure their health and reduce onward HIV transmission to their sexual partners.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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What was already known about this subject

Previous research suggests an association between orphanhood and HIV risk in sub-Saharan Africa. However, such evidence is mixed; suffers from important methodological limitations; is limited in geographic scope; and only rarely considers male orphans. Moreover, and the impact of living with an HIV-positive parent had not been assessed.

What this study adds

This study found that, regardless of their gender, adolescent orphans who had lost their mother were two to three times more likely to test positive for HIV infection across 19 countries in sub-Saharan Africa. These findings provide greater weight to recent evidence on orphanhood and heightened HIV risk among females, and begin to tip the balance of evidence with regard to HIV disparities among male orphans. Our findings also extend this evidence base substantially by demonstrating that adolescents living with an HIV-positive mother are also more likely to be infected themselves, and suggest greater surveillance of and intervention with these populations is necessary to reduce transmission among adolescents.

Table 1

Unweighted sample descriptives among adolescents aged 15–17 years and tested for HIV in 19 African countries (26 DHS surveys), by sex

	Females N=22,464 %	Males N=20,012 %
Orphanhood		
Paternal orphan	15.2	15.1
Maternal orphan	5.1	5.1
Double orphan	5.4	5.6
Parental HIV		
Mother HIV+	3.7	3.9
Father HIV+	1.7	2.1
Age		
15 years	34.7	33.7
16 years	33.9	34.8
17 years	31.4	31.5
Married	10.1	0.4
Education		
None	11.4	7.4
Some or completed primary	88.1	92.1
Completed secondary	0.5	0.5
Wealth Quintile		
Poorest	18.0	18.1
Poor	17.9	19.3
Middle	18.8	20.6
Richer	20.8	21.0
Richest	24.6	20.9
Rural Residence		
Urban	36.0	29.5
Rural	66.0	70.5

Table 2

Weighted sample descriptives by survey, females aged 15–17 years tested for HIV

Country (year)	Unweighted N	HIV Prevalence (%)	Maternal Orphanhood Prevalence (%)	Paternal Orphanhood Prevalence (%)	Double Orphanhood Prevalence (%)	Proportion living with an HIV+ Mother (%)	Proportion living with an HIV+ Father (%)
Burkina Faso (2010)	1001	0.0	4.5	6.6	2.8	0.9	0.6
Cameroon (2011)	1020	1.3	5.6	12.2	3.5	2.7	1.5
Congo (2009)	767	2.1	5.9	11.7	1.6	1.7	0.1
Cote d'Ivoire (2005)	591	0.6	3.2	13.4	2.0	9.2	3.6
Cote d'Ivoire (2011)	547	0.1	5.2	12.8	3.1	1.6	1.2
DRC (2007)	550	0.2	4.5	8.2	4.1	1.9	0.0
Ethiopia (2011)	2191	0.1	4.6	13.7	2.0	0.5	0.3
Gabon (2012)	732	1.5	2.9	7.0	2.7	5.4	4.3
Lesotho (2004)	464	6.1	3.7	26.0	9.8	9.4	2.1
Lesotho (2009)	562	2.7	5.6	22.0	16.7	11.1	3.9
Liberia (2007)	734	0.9	2.0	9.9	2.5	0.4	0.4
Malawi (2004)	298	0.9	5.9	15.5	12.2	4.5	3.0
Malawi (2010)	1115	3.4	4.6	16.2	5.9	5.9	3.4
Mozambique (2009)	525	4.6	5.4	21.1	2.6	7.0	2.7
Rwanda (2005)	830	0.3	7.3	24.7	9.7	1.0	0.6
Rwanda (2010)	988	0.6	5.5	24.2	6.6	1.9	0.8
Senegal (2010)	795	0.1	4.9	11.3	0.9	0.2	0.7
Sierra Leone (2008)	311	0.7	3.1	20.0	2.8	0.0	0.2
Swaziland (2006)	739	6.5	7.3	21.5	9.2	9.6	3.8
Tanzania (2003)	750	1.1	5.3	14.7	3.1	3.2	0.9
Tanzania (2007)	1335	0.6	5.4	12.4	2.6	3.5	0.9
Tanzania (2011)	1369	1.0	4.9	12.7	3.2	4.0	2.2
Uganda (2011)	1403	2.0	3.4	16.0	6.0	4.3	1.8
Zambia (2007)	780	4.6	6.8	15.0	9.3	6.2	3.8
Zimbabwe (2005–6)	1062	3.5	6.0	20.1	11.7	6.6	3.5
Zimbabwe (2010–11)	1005	3.7	6.4	21.9	14.7	7.4	3.5

Table 3

Weighted sample descriptives by survey, males aged 15–17 years tested for HIV

Country (year)	Unweighted N	HIV Prevalence (%)	Maternal Orphanhood Prevalence (%)	Paternal Orphanhood Prevalence (%)	Double Orphanhood Prevalence (%)	Proportion living with an HIV+ Mother (%)	Proportion living with an HIV+ Father (%)
Burkina Faso (2010)	959	0.7	3.8	7.4	2.1	0.4	0.4
Cameroon (2011)	938	0.1	4.6	13.9	3.1	1.5	0.6
Congo (2009)	639	0.7	5.4	11.2	2.2	0.9	0.7
Cote d’Ivoire (2005)	526	0.1	3.5	12.0	1.5	7.3	5.7
Cote d’Ivoire (2011)	474	0.2	5.6	11.1	0.1	1.2	2.7
DRC (2007)	507	1.9	4.1	12.5	4.9	1.9	0.1
Ethiopia (2005)	1582	0.0	4.9	13.2	2.3	1.2	0.5
Gabon (2012)	725	0.1	5.6	9.7	2.5	3.9	10.2
Lesotho (2004)	407	1.2	7.6	27.0	9.7	9.2	2.9
Lesotho (2009)	490	2.6	7.1	23.7	16.4	10.2	2.5
Liberia (2007)	606	0.7	2.8	11.1	0.5	0.3	0.0
Malawi (2004)	262	0.7	5.3	15.2	8.9	6.7	3.9
Malawi (2010)	1037	2.0	4.2	16.9	7.4	7.3	3.0
Mozambique (2009)	541	1.7	6.2	20.0	4.3	8.7	4.2
Rwanda (2005)	680	0.0	4.6	25.0	9.8	2.5	0.6
Rwanda (2010)	919	0.4	5.6	23.9	5.9	3.1	1.2
Senegal (2010)	707	0.0	6.0	11.7	1.5	0.5	0.1
Sierra Leone (2008)	266	0.0	3.6	13.1	2.7	0.3	1.0
Swaziland (2006)	778	1.4	8.1	22.3	7.8	10.6	3.6
Tanzania (2003)	837	1.9	6.6	13.0	3.1	3.3	2.8
Tanzania (2007)	1174	1.0	5.3	15.0	3.2	3.2	0.4
Tanzania (2011)	1174	0.6	5.6	11.1	3.4	4.9	3.0
Uganda (2011)	1312	1.5	5.0	15.7	6.3	3.8	3.2
Zambia (2007)	679	3.5	5.7	14.6	10.6	7.5	5.1
Zimbabwe (2005–6)	1018	3.0	6.2	21.0	11.6	6.8	2.3
Zimbabwe (2010–11)	923	3.0	7.1	21.1	14.9	5.8	3.8

Table 4

Unweighted HIV status among adolescents aged 15–17 years in 19 African countries (26 DHS surveys), by parental survival and HIV-status

	HIV among females		HIV among males	
	n	**(%)**	**n**	**(%)**
Total	393	1.8	208	1.0
Orphanhood				
Both parents alive	211	1.3	118	0.8
Paternal orphan	84	2.5	36	1.2
Maternal orphan	39	3.5	22	2.2
Double orphan	59	5.0	32	2.9
Parental HIV				
Not living with an HIV+ parent	328	1.7	178	1.0
Living with an HIV+ mother	36	4.6	22	3.0
Living with an HIV+ father	13	3.7	11	2.8

Table 5

Multilevel logistic regression models testing the association between orphanhood and HIV prevalence among adolescents aged 15–17 years tested for HIV in 19 African countries

	Females		Males	
	Model 1 OR (CI)	**Model 2 OR (CI)**	**Model 3 OR (CI)**	**Model 4 OR (CI)**
Orphanhood				
Both parents alive	*ref*	*ref*	*ref*	*ref*
Paternal orphan	1.63 **	1.60 **	1.37	1.40
	(1.23 – 2.17)	(1.20 – 2.13)	(0.90 – 2.07)	(0.92 – 2.11)
Maternal orphan	2.62 ***	2.59 ***	2.64 ***	2.61 ***
	(1.79 – 3.84)	(1.77 – 3.80)	(1.58 – 4.44)	(1.55 – 4.40)
Double orphan	3.11 ***	3.03 ***	3.17 ***	3.20 ***
	(2.24 – 4.31)	(2.18 – 4.21)	(2.00 – 5.02)	(2.02 – 5.07)
Parental HIV				
Neither HIV+	*ref*	*ref*	*ref*	*ref*
Mother HIV+	1.87 **	1.93 **	2.55 **	2.46 **
	(1.26 – 2.78)	(1.30 – 2.88)	(1.50 – 4.35)	(1.44 – 4.21)
Father HIV+	1.38	1.41	1.78	1.75
	(0.75 – 2.53)	(0.77 – 2.60)	(0.88 – 3.61)	(0.86 – 3.55)
Age				
15 years		*ref*		*ref*
16 years		1.22		1.03
		(0.93 – 1.60)		(0.72 – 1.47)
17 years		1.34 *		0.91
		(1.01 – 1.77)		(0.62 – 1.32)
Married		1.38 +		1.36
		(0.97 – 1.98)		(0.16 – 11.44)
Education				
None		*ref*		*ref*
Some or completed primary		0.71		2.11
		(0.42 – 1.20)		(0.73 – 6.11)
Completed secondary		0.45		1.52
		(0.10 – 2.07)		(0.14 – 16.54)
Wealth Quintile				
Poorest		*ref*		*ref*
Poor		1.11		1.1
		(0.76 – 1.62)		(0.64 – 1.90)
Middle		1.01		1.22
		(0.69 – 1.48)		(0.72 – 2.06)
Richer		1.03		0.99

	Females		Males	
	Model 1 OR (CI)	**Model 2 OR (CI)**	**Model 3 OR (CI)**	**Model 4 OR (CI)**
		(0.69 – 1.52)		(0.56 – 1.75)
Richest		0.9		1.48
		(0.58 – 1.39)		(0.81 – 2.70)
Residence				
Urban		*ref*		*ref*
Rural		0.60***		0.74
		(0.44 – 0.82)		(0.47 – 1.15)
Random Effects	**Variance (CI)**	**Variance (CI)**	**Variance (CI)**	**Variance (CI)**
Survey	1.27 (0.62 – 2.61)	1.43 (0.70 – 2.94)	0.83 (0.36 – 1.93)	0.80 (0.34 – 1.86)
Strata	0.06 (0.00 – 0.82)	0.00 (0.00 – 0.00)	0.16 (0.02 – 1.15)	0.09 (0.00 – 2.62)
Community	0.38 (0.10–1.49)	0.40 (0.11 – 1.49)	1.40 (0.64 – 3.03)	1.46 (0.68 – 3.12)
N	20,068	20,066	17,945	17,944

*** p<0.001,

** p<0.01,

* p<0.05,

+ p<0.10