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Estimates of the prevalence of undiagnosed HIV among children living with HIV in Eswatini, Lesotho, Malawi, Namibia, Tanzania, Zambia, and Zimbabwe from 2015 to 2017: an analysis of data from the cross-sectional Population-based HIV Impact Assessment surveys

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Summary

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Contributors

CAT, EJA, MM, and AL designed the analysis. AL, KS, and HN-B contributed to the study design and methodology, study implementation, data collection, and data cleaning. RZ did the analysis and created figures. CAT, EJA, MM, and AL reviewed the data. CAT wrote the original draft of the manuscript and all coauthors reviewed and provided input on the final manuscript. Data for the manuscript were verified by RZ and CAT. All authors had full access to all the data in the study and had final responsibility for the decision to submit for publication.

Declaration of interests

We declare no competing interests.

Background—In 2020, there were an estimated 1·7 million children younger than 15 years living with HIV worldwide, but there are few data on the proportion of children living with HIV who are undiagnosed. We aimed to estimate the prevalence of undiagnosed HIV among children living with HIV in Eswatini, Lesotho, Malawi, Namibia, Tanzania, Zambia, and Zimbabwe.

Methods—We conducted an analysis of data from the cross-sectional Population-based HIV Impact Assessment (PHIA) surveys from 2015 to 2017. PHIAs are nationally representative surveys measuring HIV outcomes. HIV rapid test data (with PCR confirmatory testing for children aged <18 months) were used to measure HIV prevalence among children in each country (Eswatini, Lesotho, Malawi, Namibia, Tanzania, Zambia, and Zimbabwe). Mothers or guardians reported previous HIV testing of children and previous results. Detection of antiretroviral medications was done using dried blood spots. Children who tested positive in the PHIA with previous negative or unknown HIV test results and without detectable antiretroviral medication blood concentrations were considered previously undiagnosed; all other children who tested positive were considered previously diagnosed. Survey weights with jackknife variance were used to generate national estimates of HIV prevalence and undiagnosed HIV in children aged 1–14 years. We also report the prevalence (weighted proportions) of antiretroviral therapy coverage and viral load suppression (<400 copies per mL).

Findings—Between 2015 and 2017, 42 248 children aged 1–14 years were included in the surveys, of whom 594 were living with HIV. Across the seven countries, the estimated weighted HIV prevalence was 0·9% (probability band 0·7–1·1) and we estimated that there were 425 000 (probability band 365 000–485 000) children living with HIV. Among all children living with HIV, 61·0% (n=259 000 [probability band 216 000–303 000]) were previously diagnosed and 39·0% (n=166 000 [128 000–204 000]) had not been previously diagnosed with HIV. Among previously diagnosed children living with HIV, 88·4% had detectable antiretroviral medication blood concentrations and 48·3% had viral load suppression. Among all children living with HIV (regardless of previous diagnosis status), 54·7% had detectable antiretroviral medication blood concentrations and 32·6% had viral load suppression.

Interpretation—Our findings show the uneven coverage of paediatric HIV testing across these seven countries and underscore the urgent need to address gaps in diagnosis and treatment for all children living with HIV.

Introduction

In 2020, there were an estimated 1·7 million children younger than 15 years living with HIV worldwide, and only about half (54%) were on antiretroviral therapy (ART).[1] Most new paediatric HIV infections are a result of vertical transmission and approximately 90% of children living with HIV live in sub-Saharan Africa.[2] Children living with HIV who are not on ART experience substantial morbidity and mortality,[3,4] and WHO guidelines have called for immediate treatment initiation at diagnosis for children living with HIV, regardless of age, to improve survival and development.[5] To identify children living with HIV and to ensure rapid ART initiation, prevention of mother-to-child transmission (PMTCT) services should include infant testing for all HIV-exposed infants, including early infant diagnosis by age 2 months and repeated testing throughout breastfeeding.[5]

Although coverage of paediatric HIV testing through PMTCT services has increased considerably over the past decade, progress has been slow and gaps remain across countries. In 2015, only an estimated 54% of HIV-exposed infants were tested at 2 months across the Start Free, Stay Free, AIDS Free focus countries comprised of the 21 countries (all in sub-Saharan Africa) with the highest burden of pregnant women living with HIV.[6] By 2020, early infant diagnosis had increased to approximately 63% overall, but remained at less than 50% in five countries.[7,8] Substantial challenges continue to contribute to missed diagnoses among children living with HIV, including retention of women living with HIV on ART throughout breastfeeding, identification of women who acquire HIV during breastfeeding (which poses high vertical transmission risk), and testing of children throughout and after cessation of breastfeeding.[7,9,10]

It is crucial to identify children living with HIV who are undiagnosed and ensure that they are initiated on ART because of the high mortality among children living with HIV who are not on treatment.[11] Finding older children living with HIV who were missed in PMTCT programmes is challenging.[7] Provider-initiated testing and counselling has been the primary approach to case finding; however, it has not been widely implemented, in part due to an absence of perceived need to test older children, as well as due to issues related to disclosure and consent.[12,13] Unfortunately, there are few available empirical studies that have estimated the proportions of undiagnosed children living with HIV in countries with a high HIV burden and these data are not part of routine reporting efforts. Information about the size and characteristics of this population is needed to design effective and targeted testing strategies.

We aimed to estimate the prevalence of undiagnosed HIV among children living with HIV, as well as the proportions of children living with HIV on ART and with viral suppression in Eswatini, Lesotho, Malawi, Namibia, Tanzania, Zambia, and Zimbabwe.

Methods

Study design and participants

We conducted an analysis of data from the cross-sectional Population-based HIV Impact Assessment (PHIA) surveys from 2015 to 2017 in Eswatini, Lesotho, Malawi, Namibia, Tanzania, Zambia, and Zimbabwe. The PHIA surveys measure HIV prevalence and incidence in multiple countries with a high HIV burden and are funded by the President's Emergency Plan for AIDS Relief (PEPFAR) through the US Centers for Disease Control and Prevention (CDC).[14] PHIAs are cross-sectional household surveys that use two-stage sampling to select representative samples of adults and children (appendix p 1). Households were randomly selected from primary sampling units comprised of census-derived enumeration units. Within all sampled households, all eligible adults aged 15 years or older were included. Within a random subgroup of half (in Eswatini, Lesotho, Malawi, Namibia, Zambia, and Zimbabwe) or one-third (in Tanzania) of sampled households, all eligible children (age 0–14 years) were included. Surveys were powered to achieve precision with a relative standard error of 30% around a national estimate of HIV incidence in adults aged 15–49 years.[14] The PHIA data included were collected in 2016–17 in Eswatini, 2016–17 in Lesotho, 2015–16 in Malawi, 2017 in Namibia, 2016–17 in Tanzania, 2016 in Zambia, and 2015–16 in Zimbabwe.[15] Inclusion of countries in this analysis was based on

public availability of data and a minimum sample size of children living with HIV (>25 individuals) needed to generate stable estimates.

Procedures

For the PHIA survey, in each country, heads of households completed questionnaires including household rosters identifying biological relationships between parents and children, and women confirmed biological relationships with children during individual adult interviews. Clinical data for children, including reports of previous HIV testing and results, were provided by adults.[14] The household response rate for the PHIA surveys ranged from 83·9% in Zimbabwe to 94·7% in Tanzania.[15]

As part of the survey, consenting eligible adults and children whose guardians provided consent underwent in-home rapid HIV testing according to the national testing guidelines and algorithms of each country (children aged 10 years or older provided assent in most countries). All survey participants who had an HIV-positive test in the field also received laboratory verification of results using the Geenius HIV 1/2 supplemental assay (Bio-Rad Laboratories; Hercules, CA, USA).[16] Blood samples from children younger than 18 months were screened using Determine HIV 1/2 (Abbott Molecular; Abbott Park, IL, USA), and those who were HIV-seropositive were also tested via DNA PCR at national or central laboratories in each country.[16] HIV-1 RNA viral load measures were based on plasma or dried blood spot samples using CobasTaqMan (Roche Diagnostics; Burgess Hill, UK) Abbott M2000 System (Abbott Laboratories; Abbott Park, IL, USA). Dried blood spot samples were screened for the presence of antiretroviral medications (efavirenz, nevirapine, and lopinavir in all countries, and atazanavir in Malawi and Zambia).[14] Screening was conducted using high-performance liquid chromatography with tandem mass spectrometry at the International Laboratory Branch of the CDC or at the University of Cape Town, Cape Town, South Africa.[16] Antiretroviral medication detection in infants younger than 12 months was only available in Namibia and Tanzania; therefore children younger than 1 year were excluded from our analysis.

Statistical analysis

Children aged 1–14 years who tested HIV-positive in the PHIA were included and were classified as having either known (previously diagnosed) or unknown (previously undiagnosed) HIV-positive status at the time of the survey using data reported by parents or guardians, and on the basis of detection of antiretroviral medication in children's blood samples. Children reported as having previously tested HIV-positive or who had detectable antiretroviral medication concentrations in blood samples were considered previously diagnosed; those reported to have previous negative or unknown HIV status and who did not have detectable antiretroviral medication concentrations were considered previously undiagnosed. We report characteristics of the household, child, and child's biological mother, including mother's ART status and viral load suppression (<50 copies per mL). Ethnicity data were not consistently collected across countries and are not reported; almost all participants were of Black African descent. Children's ART status was determined on the basis of antiretroviral medications detection and caregiver report. Most children had dried

blood spot samples rather than plasma samples, so we report viral load suppression as less than 400 copies per mL (lower limit of detection for dried blood spot).

To generate estimates of national HIV prevalence in children and numbers of diagnosed and undiagnosed children living with HIV from the survey samples, we calculated raw counts and weighted percentages adjusted to account for the two-stage probability sampling design and for non-response (at household, individual, and blood-test levels; appendix p 1). Person-level blood-test weights were derived from person-level interview weights with an added adjustment to account for non-response to blood draw, and with a post-stratification adjustment for non-convergence so that weighted count estimates were matched with the population control totals by 5-year age group, sex, and country.[14,17] We report raw frequencies and weighted percentages for the characteristics of children living with HIV and their ART and viral suppression status. For the population estimates of HIV prevalence and projections of children living with HIV overall and by diagnosis status, we include probability bands, estimated with fixed 25 df to avoid overstating precision for smaller subgroup analyses, and rounded to reflect uncertainty in estimates. We also examined the concordance between the child's reported HIV status at the time of the PHIA (reported to have previously tested HIV-positive *vs* previously tested negative, unknown results, or no previous test) and detection of antiretroviral medications in the blood as a proxy for known HIV-positive status. Weighted proportions and κ statistics of inter-rater reliability are presented with corresponding 95% CIs. The datasets used for the analyses were deidentified and are publicly available. Statistical analyses were done in SAS version 9.4.

Role of the funding source

There was no funding source for this study.

Results

Between 2015 and 2017, 42 248 children aged 1–14 years were included in the seven country surveys, of whom 594 were living with HIV. The estimated weighted prevalence of HIV among children aged 1–14 years from the PHIA surveys was 0·9% (probability band 0·7–1·1) overall, ranging from 0·4% in Tanzania to 2·7% in Eswatini (appendix p 2). In all of the countries except Tanzania and Zambia, HIV prevalence was higher among children aged 10–14 years than among children younger than 10 years.

The median age of children living with HIV was 6·8 years (IQR 3·9–10·4) and 39·5% were aged 5–9 years (table 1). 63·0% of children living with HIV across all countries had previously been tested for HIV before the survey. Among children living with HIV who had previously been tested, 80·3% were reported to have had HIV-positive results, 15·9% were reported as negative at most recent test, and 3·8% had indeterminate or no results received. The mothers of most children living with HIV (81·3%) were alive; 72·1% of mothers tested HIV-positive in the survey, 3·7% tested HIV-negative, and 24·2% had missing results or were not available to be tested. Using information reported by mothers about previous testing, we estimated that 10·6% of mothers were diagnosed with HIV before pregnancy, 20·7% were diagnosed during pregnancy (with the HIV-positive child), 41·4% were diagnosed after the child was born, and an additional 18·9% were newly identified in the PHIA survey.

Among mothers who reported HIV-positive status at the time of the survey, 88·6% had detectable antiretroviral medication blood concentrations and among all mothers who were HIV-positive in the survey, 49·2% had a viral load of less than 50 copies per mL (table 1).

Among children living with HIV, 61·0% were diagnosed and 39·0% were undiagnosed (table 1). 87·6% of diagnosed children living with HIV were reported to have been tested for HIV previously compared with only 24·5% of undiagnosed children living with HIV ($p<0·0001$). We estimated that 14·6% of mothers of diagnosed children were identified as having HIV before pregnancy, 30·2% were diagnosed during pregnancy, and only 2·1% were newly diagnosed in the PHIA survey (table 1). Among undiagnosed children living with HIV, 4·2% of mothers were diagnosed before pregnancy, 6·0% were diagnosed during pregnancy, and 44·9% were newly identified in the PHIA survey ($p<0·0001$). Slightly more than half (57·3%) of HIV-positive mothers of diagnosed children living with HIV had a viral load of less than 50 copies per mL, whereas 36·3% of HIV-positive mothers of undiagnosed children living with HIV had viral suppression ($p=0·027$). Characteristics of the samples from each country are shown in the appendix (pp 3–10).

Among diagnosed children living with HIV, 88·4% had detectable antiretroviral medication concentrations in their blood, 5·0% were reported to be on ART but had no detectable antiretroviral medication concentrations, and 6·6% were not on ART according to antiretroviral medication detection and caregiver reports (table 2). Namibia had the highest proportion of diagnosed children living with HIV with detectable antiretroviral medication concentrations (96·0%) and Zambia had the lowest (80·2%). Among diagnosed children living with HIV, 48·3% had a viral load of less than 400 copies per mL; the proportion ranged from 27·1% in children aged 1–4 years to 58·2% in those aged 10–14 years. Among all children living with HIV, including those without previous diagnosis, 54·7% had detectable antiretroviral medication concentrations, 3·0% were reported to be on ART but had no detectable antiretroviral medication concentrations, and 42·3% were not on ART according to antiretroviral medication detection and caregiver reports. Only one-third (32·6%) of all children living with HIV had a viral load of less than 400 copies per mL (table 2). Namibia had the highest proportion of all children living with HIV with detectable antiretroviral medication concentrations (81·0%) and Eswatini had the highest proportion with a viral load of less than 400 copies per mL (59·7%). Zambia had the lowest proportion of all children living with HIV with detectable antiretroviral medication concentrations (43·1%) and Tanzania had the lowest proportion of all children living with HIV with a viral load of less than 400 copies per mL (17·3%).

Across the seven countries, we estimated that—at the time of the PHIA surveys—there were 425 000 children aged 1–14 years living with HIV (probability band 365 000–485 000) and of these, 259 000 (216 000–303 000; 61·0%) were diagnosed and 166 000 (128 000–204 000; 39·0%) were undiagnosed (table 3). Around half (50·9%) of children living with HIV aged 1–4 years, 35·2% aged 5–9 years, and 34·4% aged 10–14 years were undiagnosed (figure). Zambia (51·5%) and Tanzania (50·0%) had the highest proportions of undiagnosed children living with HIV, while Namibia (15·6%) and Eswatini (16·6%) had the lowest. In Lesotho, Namibia, Tanzania, and Zimbabwe, children living with HIV aged 1–4 years were the age group with the highest proportion who were undiagnosed (table 3). In Malawi and

Zambia, 10–14 years was the age group with the highest proportion of undiagnosed children living with HIV (figure).

Examination of agreement between HIV status of children as reported by parents or guardians and detection of antiretroviral medications in the child's blood (as a proxy for diagnosis) showed only fair to good concordance (κ 0·61; 95% CI 0·55–0·68; table 4). Among children with detectable antiretroviral medication concentrations, 20·4% were reported by caregivers to be HIV-negative or have unknown HIV status and 15·2% of children who were reported by caregivers to have been diagnosed with HIV did not have detectable antiretroviral medication concentrations (table 4).

Discussion

Using data from PHIA surveys conducted across seven countries from 2015 to 2017, we estimate that 39% of children living with HIV had not been diagnosed at the time of the survey, amounting to an estimated 166 000 undiagnosed children living with HIV who were not yet on treatment. Among children living with HIV who were previously diagnosed, most had detectable antiretroviral medication concentrations but only about half had a suppressed viral load. In the total population of children living with HIV, including those who were previously undiagnosed, just more than half had antiretroviral medications detected in their blood and a third had a suppressed viral load. Overall, these findings highlight substantial gaps in paediatric HIV diagnosis services and underscore the urgent need to accelerate testing to identify undiagnosed children living with HIV and to ensure they initiate treatment. For the children with known HIV-positive diagnosis (most of whom were on ART), these findings are further evidence of suboptimal treatment outcomes among children living with HIV.

A key finding from our analysis is the uneven progress in HIV diagnosis and ART coverage among children at the time of the surveys across these seven countries, which reflects the severity of their HIV epidemics, as well as the performance of their PMTCT and adult ART programmes. Although our data do not provide direct information about specific gaps in PMTCT services and paediatric testing efforts, they do provide some indications. In the years before the surveys, there remained serious challenges with infant diagnosis in some of these countries, particularly Tanzania, as evidenced by high proportions of undiagnosed children living with HIV in the age group of 1–4 years. In addition, across the seven countries, two-thirds of undiagnosed children living with HIV had reportedly never been previously tested for HIV, and many mothers of children living with HIV were newly identified as HIV-positive through the surveys. If these women accurately reported knowledge of their HIV status, this indicates missed HIV testing in mothers, including identification of incident HIV infections during pregnancy and breastfeeding, which could account for unidentified children living with HIV. These data also suggest that provider-initiated HIV testing and counselling efforts had not been effectively implemented at the time of the surveys, given the high proportions of older children who remained undiagnosed, including more than 100 000 children living with HIV in the age group of 5–14 years. It is important to note that our data are from 2015 to 2017 and progress has been made since the time of the PHIA surveys. In Malawi, Namibia, Tanzania, and Zambia, for instance, early

infant diagnosis coverage increased from less than 50% in 2015 to between 65% (Zambia) and 99% (Namibia) by 2020.[6] However, despite improvements in early infant diagnosis, overall progress has been slow with only an estimated 54% of children living with HIV globally receiving ART in 2020.[6]

As previously reported by Saito and colleagues,[17] the PHIA data have been pivotal in validating existing UNAIDS estimates of ART coverage and further quantifying the number of children not on treatment. Our data provide further insights into the gaps in ART coverage and show that these are primarily driven by missed diagnosis. Based on detectable antiretroviral medication concentrations, ART coverage among previously diagnosed children living with HIV in most countries was high, but less than half of diagnosed children living with HIV had a suppressed viral load. These findings are further evidence of poor treatment outcomes previously identified among children living with HIV in sub-Saharan Africa, which are driven by late ART initiation, high pretreatment viral loads, suboptimal ART regimens, and pretreatment drug resistance.[18–20] ART coverage in children living with HIV varied by country and was consistent with our findings on previously undiagnosed children living with HIV. Eswatini and Lesotho, which had the lowest proportions of undiagnosed children, also had the highest ART coverage among all children living with HIV, whereas Zambia and Tanzania, where about half of all children living with HIV were undiagnosed, had the lowest ART coverage. These data are clear evidence that to address the paediatric treatment gap, we must do more to identify children living with HIV.

Despite improved coverage of PMTCT services, including ART for pregnant women and testing at age 6–8 weeks for HIV-exposed infants,[7] challenges remain in retaining women living with HIV on ART and ensuring early and continued infant testing throughout breastfeeding. Interventions that can improve retention of mothers and infants include integrated post-partum ART services for mothers within the maternal–child health platform, provision of additional training of health-care workers, and involvement of peer and other lay health workers.[21,22] Efforts should also include pre-exposure prophylaxis (PrEP) for pregnant and breastfeeding women to prevent new HIV infections,[23] along with retesting for previously HIV-negative mothers during breastfeeding to identify new maternal infections.[10] Many countries have introduced retesting guidelines for pregnant and breastfeeding women,[24] which should be coupled with testing for infants with mothers who have been identified as HIV-positive. Our finding that one-quarter of undiagnosed children living with HIV had been previously tested and that most were HIV-negative underscores the need to ensure all HIV-exposed infants receive a final status at the end of breastfeeding, which remains challenging in many countries.[7] Infant tracking systems, integrated maternal infant care throughout breastfeeding, and point of care testing could be considered to improve final status determination.[22,25,26]

While new innovations and testing interventions are needed to identify older children living with HIV, expansion of effective existing approaches is also urgently needed.[27] By our estimates, around half of undiagnosed children living with HIV had mothers who were diagnosed with HIV, most of whom were on treatment, which is evidence of missed index testing opportunities and low prioritisation of case finding in children. Provider-

initiated HIV testing and counselling in health-care settings, particularly malnutrition units, tuberculosis clinics, and inpatient wards, has shown high yield and often identifies children with acute health needs.[13,28] Index case finding and family testing, which identify children living with HIV through their HIV-positive parents, siblings, and other household members, are also effective strategies that should be offered through both facility or home-based testing.[29] An evaluation of index case finding in Malawi in 2014–15 found that 65% of adults living with HIV reported a child or young person in their household who had not been tested, and, in 10% of households with untested children, at least one new child living with HIV was identified.[30] Major initiatives, including PEPFAR's accelerating children's HIV/AIDS treatment initiative (2014–16), might have improved paediatric case finding; however, their impact has not been well characterised[29] and ART coverage among children remains low.[6]

To our knowledge, our analysis is unique in examining concordance between parent or guardian reports of HIV-positive status and detection of antiretroviral medications in the child's blood (as a marker of known HIV-positive status). We found only fair to good agreement between the report of a child's HIV-positive status and detectable antiretroviral medications, partly because 15% of children previously diagnosed with HIV were not on ART, which reflects poor treatment coverage even among known children living with HIV. In addition, we found that about 20% of children with detectable antiretroviral medication concentrations were reported as HIV-negative or to have unknown status, which could have resulted from respondents not knowing the child's HIV status but might also reflect hesitation among parents and guardians to report HIV-positive status of children, even for children on ART. These data indicate that surveys relying on parental reporting of children's HIV status (without testing) might underestimate the true proportions of children living with HIV, and suggest that caregivers might experience stigma associated with a child's HIV diagnosis.[31,32]

We believe these are the first national estimates of undiagnosed children living with HIV based on population-level data from sub-Saharan Africa and as such these findings provide new and important information. Routinely reported country indicators do not include data on undiagnosed children living with HIV. Our estimates are therefore an important contribution to efforts to estimate the magnitude of missed HIV diagnosis and to increase paediatric ART coverage. The rigour and high participation rates of the PHIA surveys are strengths of this study, as are the biological data collected, including testing of mothers and children and detection of antiretroviral medication blood concentrations which we used to identify children with known HIV-positive status. Our study has some limitations. We were not able to include infants younger than 12 months in our analysis due to missing antiretroviral medication drug concentrations from blood samples in most countries; therefore our conclusions are limited to children aged 1–14 years. There might also be some misclassification of HIV diagnosis status. It is possible that adults reporting children's HIV status were unaware of or refused to report HIV-positive status and, if these children were missing detectable antiretroviral medication concentrations due to non-adherence or not having started ART, we might have overestimated the number of undiagnosed children. Another limitation is the potential for misreporting of mother–child biological relationships (women might have been misidentified as biological mothers), which might be responsible

for a small number of serodiscordant mother–child pairs. In addition, our estimates of the timing of the mother's HIV diagnosis were imprecise as we did not have access to children's dates of birth and could therefore only roughly estimate the timing of the mother's HIV diagnosis in a window around the child's birth. Finally, the PHIAs were conducted from 2015 to 2017, providing evidence about PMTCT and HIV testing coverage for as long ago as the early 2000s for older children. There has been substantial progress in expanding access and coverage of PMTCT and paediatric testing initiatives over the past 15 years, including changes to guidelines to start all pregnant women living with HIV on lifelong ART in all of the countries included in this study, point of care testing, and provider-initiated testing for older children. Our findings describe challenges to PMTCT programmes in the past; however, the data on the youngest children in these surveys confirm that gaps have persisted in many countries, contributing to missed diagnosis and low treatment coverage among children living with HIV.

In conclusion, across seven countries with a high HIV burden, we estimate that in 2015–17, 39% or 166 000 children aged 1–14 years living with HIV had not been diagnosed and were not on treatment. Furthermore, due to missed diagnosis, only about half of children living with HIV in these countries were on ART and only a third had viral suppression. To close the paediatric treatment gap, urgent efforts are needed to accelerate HIV testing in these settings.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Data sharing

All data used in this analysis are publicly available at https://phia.icap.columbia.edu/.

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Research in context

Evidence before this study

Substantial progress has been made over the past two decades in expanding services to prevent vertical transmission of HIV and expand HIV testing for infants and children in countries with a high HIV burden. During the period of upscaling, however, many children living with HIV did not receive HIV testing, and gaps remain in efforts to test all HIV-exposed infants and children. Existing evidence on missed diagnoses in children living with HIV comes from UNAIDS data, which has shown that, in 2020, only 63% of infants born to mothers living with HIV in high-burden countries were tested within the first 2 months of life. In addition, studies evaluating programmes that aimed to identify older children living with HIV through targeted testing initiatives, including provider-initiated testing and counselling as well as index testing, have shown high yield indicating missed diagnoses. Although important, these data do not provide an understanding of the magnitude of the problem at a population level. We searched PubMed for peer reviewed articles published in English between Jan 1, 2006, and June 30, 2021, which measured missed diagnoses in populations of children living with HIV, with the search terms "("unknown status" OR "undiagnosed" OR "missed diagnosis")" AND "("HIV" OR "human immunodeficiency virus")" AND "("children" OR "pediatric")". No studies were identified that reported estimated prevalence of missed diagnosis among children living with HIV for any country or region.

Added value of this study

To our knowledge, our analysis provides the first national estimates of the prevalence of undiagnosed HIV in children living with HIV based on population-level data from sub-Saharan Africa. Using data from Population-based HIV Impact Assessment surveys conducted in Eswatini, Lesotho, Malawi, Namibia, Tanzania, Zambia, and Zimbabwe in 2015–17, we estimated that close to 40% of children (aged 1–14 years) living with HIV across these seven countries were undiagnosed, amounting to 166 000 children living with HIV. We also found that, among all children living with HIV (including those who were previously undiagnosed), only 55% were on antiretroviral therapy (ART) and 33% had a viral load of less than 400 copies per mL. Among children living with HIV with known HIV-positive diagnosis (most of whom were on ART), only 49% had a viral load of less than 400 copies per mL. There was substantial variation by country in the prevalence of undiagnosed HIV and paediatric ART coverage, and we found that the countries with the highest prevalence of missed diagnosis also had the lowest ART coverage among all children living with HIV. These data provide insight into the gaps in services that aim to prevent vertical transmission of HIV and testing initiatives for infants and children. Although the data were collected from 2015 to 2017, they provide new and previously unknown information about the first 90 (knowledge of HIV status) of the UNAIDS 90–90-90 HIV treatment outcomes for children, which have not been previously reported.

Implications of all the available evidence

Our findings highlight the substantial gaps in paediatric HIV testing services in these countries with a high HIV burden and underscore the urgent need to accelerate testing to identify undiagnosed children living with HIV and to ensure that treatment is initiated. These findings are further evidence of suboptimal treatment outcomes among diagnosed children living with HIV, half of whom were not virally suppressed. It has long been a goal to improve ART coverage among children living with HIV, which remains at only 50%—substantially lower than the coverage among adults. Our findings show that to address the treatment gap in children, we must improve paediatric testing coverage.

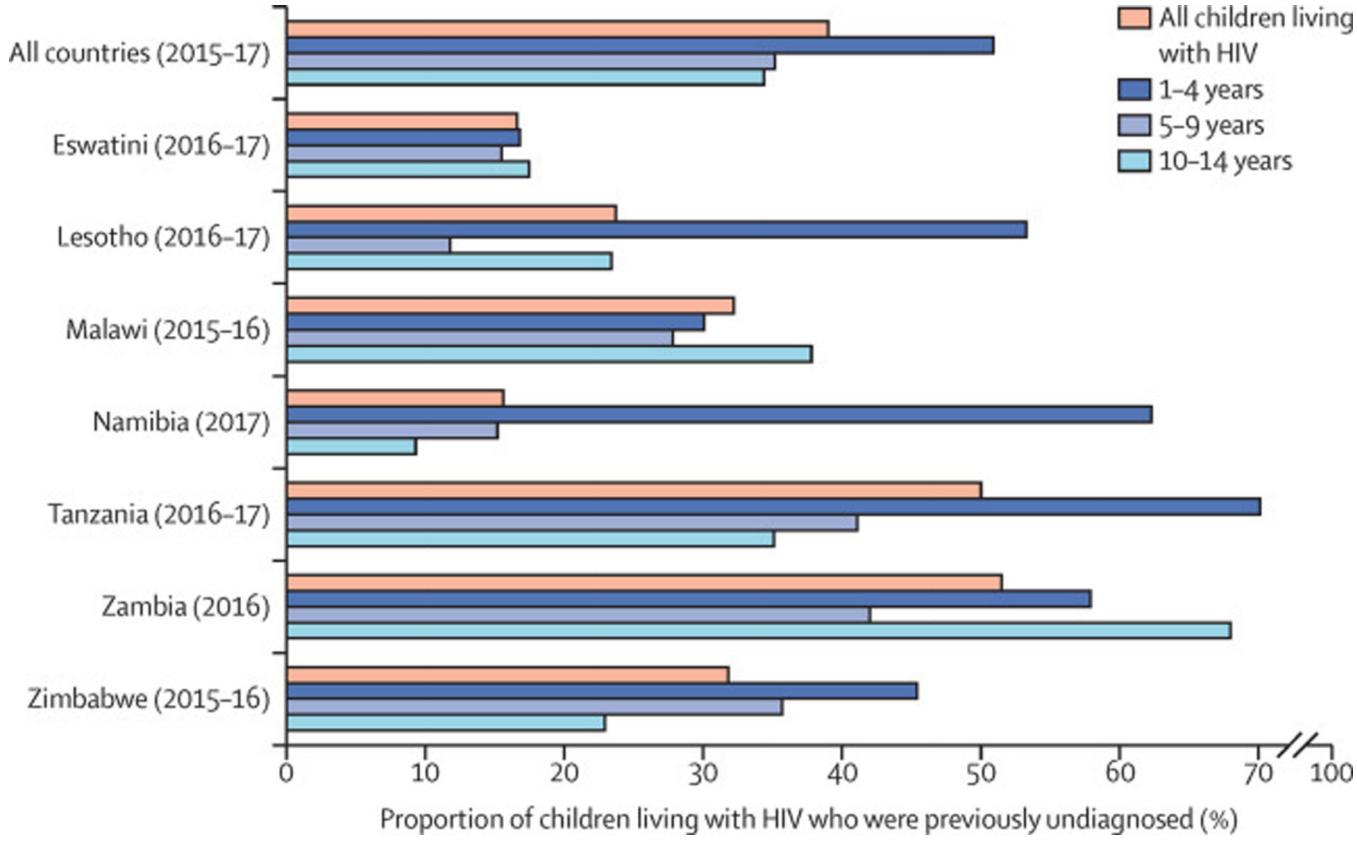

Figure:

Proportions of children living with HIV who were previously undiagnosed as measured in the PHIA surveys in 2015–17, by country and age group

PHIA=Population-based HIV Impact Assessment.

Table 1:

Characteristics of children aged 1–14 years living with HIV and their mothers in PHIA surveys in Eswatini, Lesotho, Malawi, Namibia, Tanzania, Zambia, and Zimbabwe from 2015 to 2017

	All children living with HIV*	Diagnosed children living with HIV	Undiagnosed children living with HIV	p value†
Total	594 (100·0%)	415 (61·0%)	179 (39·0%)	..
Household characteristics				
Respondent				
Mother	289 (56·0%)	201 (55·5%)	88 (56·9%)	0·24
Female guardian	166 (22·%)	126 (26·1%)	40 (157%)	..
Father or male guardian	85 (17·0%)	52 (14·3%)	33 (21·1%)	..
Unknown relationship	54 (4·9%)	36 (4·1%)	18 (6·3%)	..
Urban area indicator				
Urban or peri-urban (Lesotho)	169 (28·2%)	109 (29·3%)	60 (26·5%)	0·62
Rural	425 (71·8%)	306 (70·7%)	119 (73·5%)	..
Wealth quintile				
First (lowest)	154 (20·0%)	111 (19·2%)	43 (21·2%)	0·99
Second	133 (20·1%)	93 (19·7%)	40 (20·7%)	..
Third	122 (24·2%)	87 (24·2%)	35 (24·3%)	..
Fourth	102 (21·4%)	69 (22·6%)	33 (19·6%)	..
Fifth (highest)	81 (13·8%)	53 (13·5%)	28 (14·2%)	..
Missing	2 (0·5%)	2 (0·8%)	0	..
Characteristics of child				
Sex				
Male	290 (49·9%)	212 (53·9%)	78 (43·8%)	0·11
Female	304 (50·1%)	203 (46·1%)	101 (56·2%)	..
Age, years				
Median (IQR)	6·8 (3·9–10·4)	7·2 (4·4–10·7)	6·0 (3·3–9·8)	..
1–4	96 (26·0%)	47 (20·9%)	49 (33·9%)	0·13
5–9	234 (39·5%)	172 (42·0%)	62 (35·6%)	..
10–14	264 (34·5%)	196 (37·1%)	68 (30·5%)	..
Child previously tested for HIV				
Yes	409 (63·0%)	363 (87·6%)	46 (24·5%)	<0·0001
No	117 (27·7%)	16 (4·9%)	101 (63·3%)	..
Unknown	19 (4·8%)	2 (3·1%)	17 (7·5%)	..
Refused or missing	49 (4·5%)	34 (4·4%)	15 (4·7%)	..
Child's most recent HIV test result (among those ever tested)				
Positive	349 (80·3%)	349 (94·7%)	0	≠
Negative	50 (15·9%)	12 (4·0%)	38 (82·8%)	..
Unknown or indeterminate	4 (1·8%)	1 (0·3%)	3 (10·1%)	..
Did not receive results or missing	6 (2·0%)	1 (1·0%)	5 (7·1%)	..

	All children living with HIV*	Diagnosed children living with HIV	Undiagnosed children living with HIV	p value†
Child enrolled in school				
Yes	395 (60·0%)	293 (63·7%)	102 (54·2%)	0·40
Not enrolled	48 (7·7%)	30 (7·9%)	18 (7·6%)	..
Too young	104 (27·8%)	60 (24·1%)	44 (33 5%)	..
Missing	47 (4·5%)	32 (4·3%)	15 (4·7%)	..
Child's mother alive	470 (81·3%)	321 (77·4%)	149 (87·4%)	0·033
Child's father alive	412 (76·0%)	284 (73·7%)	128 (79·4%)	0·29
Characteristics of child's mother				
Age, years				
<20	143 (23·4%)	97 (20·7%)	46 (27·3%)	0·59
20–29	65 (19·4%)	39 (17·8%)	26 (21·6%)	..
30–39	144 (32·7%)	98 (36·2%)	46 (277%)	..
≥40	118 (24·5%)	87 (25·3%)	31 (23 4%)	..
Lives in same home as child	334 (79·2%)	227 (82·3%)	107 (74·9%)	0·23
Mother's highest level of school completed				
No formal education	24 (6·9%)	13 (5·1%)	11 (9·5%)	0·14
Primary	180 (49·6%)	123 (51·6%)	57 (46·8%)	..
Secondary	111 (18·9%)	77 (21·5%)	34 (15·4%)	..
Tertiary	12 (2·0%)	10 (2·9%)	2 (0·6%)	..
Missing	143 (22·6%)	98 (18·9%)	45 (27·7%)	..
Final HIV status of child's mother in PHIA survey				
HIV-positive	306 (72·1%)	213 (76·3%)	93 (66·2%)	0·25
HIV-negative	17 (3·7%)	9 (3·6%)	8 (4·0%)	..
Missing or not tested	147 (24·2%)	99 (20·1%)	48 (29·8%)	..
HIV testing history				
Ever tested	321 (74·1%)	222 (79·6%)	99 (66·5%)	010
Never tested	7 (3·3%)	2 (1·5%)	5 (5·8%)	..
Missing	142 (22·6%)	97 (18·9%)	45 (27·7%)	..
HIV status (self-reported)				
Positive	268 (78·6%)	208 (94·1%)	60 (52·7%)	<0·0001
Negative	32 (15·5%)	5 (1·7%)	27 (38·5%)	..
Never tested, results not received, or missing	21 (5·9%)	9 (4·2%)	12 (8·8%)	..
Estimated timing of mother's HIV diagnosis§				
Before pregnancy	29 (10·6%)	26 (14·6%)	3 (4·2%)	<0·0001
During pregnancy	50 (20·7%)	42 (30·2%)	8 (6·0%)	..
After child's birth	140 (41·4%)	99 (45·5%)	41 (35·2%)	..
PHIA survey	32 (18·9%)	3 (2·1%)	29 (44·9%)	..
Unknown	23 (8·4%)	14 (7·6%)	9 (9·7%)	..
Mother's ART status (among those self-reported HIV-positive)				

	All children living with HIV*	Diagnosed children living with HIV	Undiagnosed children living with HIV	p value†
Antiretroviral medications detected in bloody¶	236 (88·6%)	189 (90·2%)	47 (83·8%)	0·23
Reported to be on ART but no antiretroviral medications detected in blood	11 (2·5%)	9 (2·8%)	2 (1·7%)	..
Not on ART (no antiretroviral medications detected and no report of ART)	21 (8·9%)	10 (7·0%)	11 (14·5%)	..
Mother's viral load (mothers who tested positive in the PHIA survey)				
<1000 copies per mL	218 (63·9%)	172 (76·1%)	46 (44·5%)	0·0008
<50 copies per mL	188 (49·2%)	148 (57·3%)	40 (36·3%)	0·027
Missing	2 (0·8%)	1 (0·3%)	1 (0·5%)	..

Data are n (%) unless otherwise stated. All percentages are weighted. PHIA=Population-based HIV Impact Assessment. ART=antiretroviral therapy.

*Weighted percentages to reflect estimates for the total population of children living with HIV across the seven countries.

†Rao-Scott adjusted χ^2 tests used to compare characteristics of diagnosed with undiagnosed children living with HIV using survey weights; p values are presented for the comparison across all levels of multilevel categorical variables, with no cells excluded.

‡Rao-Scott adjusted χ^2 testing not appropriate due to the presence of no participants in one column, and exact tests were not available for weighted proportions. §Among HIV-positive mothers, we estimated the timing of mothers' awareness of their own HIV-positive status relative to the birth of the child on the basis of the mother's report of her first HIV-positive testing date and estimated date of birth for the child; mothers reporting being previously aware but missing testing date were coded as missing timing of awareness; mothers reporting being previously unaware before the survey were coded as testing HIV-positive in the PHIA survey; HIV-positive testing dates were estimated for mothers reporting being previously aware and reporting the month and year (or just year) of their first HIV-positive test; date of birth for children was not recorded in the PHIA survey and was estimated by subtracting age in days (derived from age in years for children >5 years and age in months for children <5 years) from the PHIA survey date; to estimate timing of mother's diagnosis relative to child's birth, we compared the estimated date of mother's diagnosis with the child's estimated date of birth; mothers diagnosed more than 1 year before the child's estimated date of birth were considered diagnosed before pregnancy, those diagnosed up to 1 year before or after the child's estimated date of birth were considered diagnosed during pregnancy, and those diagnosed more than 1 year after the child's estimated date of birth were considered diagnosed after the child's birth. Efavirenz, nevirapine, or lopinavir in all countries, plus atazanavir in Malawi and Zambia.

¶Efavirenz, nevirapine, or lopinavir in all countries, plus atazanavir in Malawi and Zambia.

Table 2:

ART status and viral load suppression among children aged 1–14 years living with HIV in PHIA surveys in Eswatini, Lesotho, Malawi, Namibia, Tanzania, Zambia, and Zimbabwe from 2015 to 2017, overall and by age group

	Diagnosed children living with HIV				All children living with HIV (diagnosed and undiagnosed)			
	Total	**1–4 years**	**5–9 years**	**10–14 years**	**Total**	**1–4 years**	**5–9 years**	**10–14 years**
All study countries								
ART status								
Antiretroviral medications detected in blood	370 (88·4%)	39 (90·0%)	150 (87·0%)	181 (89·0%)	375 (54·7%)	39 (44·1%)	152 (57·3%)	184 (59·7%)
Reported on ART but no antiretroviral medications in blood	24 (5·0%)	6 (6·3%)	8 (2·5%)	10 (7·1%)	24 (3·0%)	6 (3·1%)	8 (1·6%)	10 (4·7%)
Not on ART	21 (6·6%)	2 (3·7%)	14 (10·5%)	5 (3·9%)	195 (42·3%)	51 (52·8%)	74 (41·1%)	70 (35·6%)
Viral load <400 copies per mL	254 (48·3%)	22 (27·1%)	100 (50·0%)	132 (58·2%)	268 (32·6%)	23 (16·1%)	104 (34·2%)	141 (43·2%)
Eswatini								
ART status								
Antiretroviral medications detected in blood	68 (91·0%)	5 (71·5%)	27 (91·4%)	36 (95·2%)	68 (75·8%)	5 (59·5%)	27 (77·3%)	36 (78·5%)
Reported on ART but no antiretroviral medications in blood	5 (6·7%)	2 (28·5%)	2 (6·0%)	1 (2·2%)	5 (5·6%)	2 (23·7%)	2 (5·0%)	1 (1·8%)
Not on ART	2 (2·3%)	0	1 (2·6%)	1 (2·6%)	15 (18·6%)	1 (16·8%)	6 (17·7%)	8 (19·7%)
Viral load <400 copies per mL	53 (70·4%)	5 (69·2%)	21 (70·0%)	27 (71·0%)	54 (59·7%)	5 (57·6%)	22 (61·7%)	27 (58·6%)
Lesotho								
ART status								
Antiretroviral medications detected in blood	59 (93·6%)	4 (81·5%)	22 (96·4%)	33 (93·4%)	59 (71·4%)	4 (38·1%)	22 (85·0%)	33 (71·6%)
Reported on ART but no antiretroviral medications in blood	2 (3·3%)	1 (18·5%)	0	1 (3·3%)	2 (2·5%)	1 (8·6%)	0	1 (2·5%)
Not on ART	2 (3·1%)	0	1 (3·6%)	1 (3·3%)	21 (26·1%)	6 (53·3%)	4 (15·0%)	11 (25·9%)
Viral load <400 copies per mL	45 (69·5%)	3 (59·2%)	14 (57·9%)	28 (79·2%)	49 (59·3%)	3 (27·7%)	16 (59·9%)	30 (67·1%)
Malawi								
ART status								
Antiretroviral medications detected in blood	54 (82.3%)	10 (91·8%)	21 (75·8%)	23 (81·2%)	54 (55·8%)	10 (64·2%)	21 (54·8%)	23 (50·5%)
Reported on ART but no antiretroviral medications in blood	4 (3·8%)	1 (2·2%)	0	3 (9·1%)	4 (2·6%)	1 (1·5%)	0	3 (5·7%)
Not on ART	10 (13·9%)	1 (6·0%)	7 (24·2%)	2 (9·7%)	40 (41·6%)	8 (34·3%)	16 (45·2%)	16 (43·8%)
Viral load <400 copies per mL	36 (43·7%)	2 (9·9%)	17 (60·5%)	17 (54·3%)	41 (36·1%)	2 (7·0%)	18 (50·0%)	21 (45·1%)
Namibia								
ART status								

	Diagnosed children living with HIV				All children living with HIV (diagnosed and undiagnosed)			
	Total	**1–4 years**	**5–9 years**	**10–14 years**	**Total**	**1–4 years**	**5–9 years**	**10–14 years**
Antiretroviral medications detected in blood	57 (96·0%)	3 (100·0%)	22 (89·9%)	32 (100·0%)	57 (81·0%)	3 (37·7%)	22 (76·2%)	32 (90·7%)
Reported on ART but no antiretroviral medications in blood	3 (4·0%)	0	3 (10·1%)	0	3 (3·4%)	0	3 (8·5%)	0
Not on ART	0	0	0	0	13 (15·6%)	4 (62·3%)	5 (15·3%)	4 (9·3%)
Viral load <400 copies per mL	38 (68·0%)	1 (17·2%)	17 (68·6%)	20 (70·6%)	38 (57·4%)	1 (6·5%)	17 (58·2%)	20 (64·0%)
Tanzania								
ART status								
Antiretroviral medications detected in blood	21 (100·0%)	3 (100·0%)	9 (100·0%)	9 (100·0%)	21 (50·0%)	3 (29·9%)	9 (58·9%)	9 (64·9%)
Reported on ART but no antiretroviral medications in blood	0	0	0	0	0	0	0	0
Not on ART	0	0	0	0	22 (50·0%)	10 (70·1%)	6 (41·1%)	6 (35·1%)
Viral load <400 copies per mL	8 (28·5%)	1 (5·4%)	3 (35·3%)	4 (34·0%)	9 (17·3%)	2 (10·2%)	3 (20·8%)	4 (22·1%)
Zambia								
ART status								
Antiretroviral medications detected in blood	35 (80·2%)	6 (77·5%)	23 (79·7%)	6 (85·9%)	40 (43·1%)	6 (32·7%)	25 (49 7%)	9 (38·5%)
Reported on ART but no antiretroviral medications in blood	4 (10·8%)	1 (22·5%)	2 (6·3%)	1 (14·1%)	4 (5·2%)	1 (9·5%)	2 (3·6%)	1 (4·5%)
Not on ART	4 (9·0%)	0	4 (14·0%)	0	47 (51·7%)	12 (57·9%)	25 (46·7%)	10 (57·0%)
Viral load <400 copies per mL	19 (43·7%)	5 (76·4%)	9 (29·0%)	5 (61·9%)	22 (23·5%)	5 (32·2%)	9 (16·8%)	8 (30·4%)
Zimbabwe								
ART status								
Antiretroviral medications detected in blood	76 (89·7%)	8 (87·2%)	26 (93 8%)	42 (87·8%)	76 (61·2%)	8 (47·7%)	26 (60·3%)	42 (67·7%)
Reported on ART but no antiretroviral medications in blood	6 (7·1%)	1 (6·4%)	1 (3·0%)	4 (9·9%)	6 (4·8%)	1 (3·5%)	1 (1·9%)	4 (7·6%)
Not on ART	3 (3·2%)	1 (6·4%)	1 (3·2%)	1 (2·3%)	37 (34·0%)	10 (48·8%)	12 (37·8%)	15 (24·7%)
Viral load <400 copies per mL	55 (64·0%)	5 (44·0%)	19 (69·7%)	31 (66·4%)	55 (43·7%)	5 (24·1%)	19 (44·8%)	31 (51·2%)

Data are n (%). All percentages are weighted to reflect estimates for the total population of children living with HIV across the seven countries. Antiretroviral medications were efavirenz, nevirapine, or lopinavir in all countries, plus atazanavir in Malawi and Zambia. Not on ART was defined as not on ART according to report by caregivers and no antiretroviral medications detected in blood. Viral load data are reported for all children (not restricted to those on ART). ART=antiretroviral therapy. PHIA=Population-based HIV Impact Assessment.

Table 3:

Population estimates of children living with HIV and numbers and proportions who were diagnosed and undiagnosed in Eswatini, Lesotho, Malawi, Namibia, Tanzania, Zambia, and Zimbabwe in 2015–17, overall and by age group

	Estimates of total children living with HIV	Estimates of diagnosed children living with HIV	Estimates of undiagnosed children living with HIV
All study countries			
Overall	425 000 (365 000–485 000)	259 000 (216 000–303 000; 61·0%)	166 000 (128 000–204 000; 39·0%)
1–4 years	110 000 (75 000–146 000)	54 000 (29 000–80 000; 49·1%)	56 000 (31 000–81 000; 50·9%)
5–9 years	168 000 (130 000–206 000)	109 000 (82 000–136 000; 64·8%)	59 000 (34 000–67 000; 35·2%)
10–14 years	147 000 (120 000–174 000)	96 000 (74 000–118 000; 65·6%)	50 000 (33 000–67 000; 34·4%)
Eswatini (2016–17)			
Overall	10 000 (8100–13 000)	8600 (1000–6600; 83·4%)	1700 (600–2800; 16·6%)
1–4 years	1200 (300–2100)	1000 (200–1800; 83·2%)	200 (0–600; 16·8%)
5–9 years	4000 (2500–5500)	3400 (2100–4700; 84·5%)	600 (0–1400; 15·5%)
10–14 years	5100 (3700–6600)	4200 (2900–5600; 82·5%)	900 (300–1500; 17·5%)
Lesotho (2016–17)			
Overall	13 000 (9500–16 000)	9700 (7100–12 000; 76·3%)	3000 (1300–4700; 23·7%)
1–4 years	1800 (700–2800)	800 (50–1600; 46·7%)	900 (100–1700; 53·3%)
5–9 years	4200 (2600–5700)	3600 (2200–5100; 88·2%)	500 (0–1100; 11·8%)
10–14 years	6800 (4600–9100)	5200 (3400–7100; 76·6%)	1600 (500–2700; 23·4%)
Malawi (2015–16)			
Overall	119 000 (88 000–149 000)	81 000 (54 000–107 000; 67·8%)	38 000 (24 000–52 000; 32·2%)
1–4 years	33 000 (14 000–53 000)	23 000 (5300–41 000; 69·9%)	10 000 (1500–19 000; 30·1%)
5–9 years	40 000 (22 000–59 000)	29 000 (17 000–41 000; 72·2%)	11 000 (0–23 000; 27·8%)
10–14 years	45 000 (28 000–63 000)	28 000 (14 000–42 000; 62·2%)	17 000 (5600–28 000; 37·8%)
Namibia (2017)			
Overall	8900 (6700–11 000)	7500 (5300–9700; 84·4%)	1400 (500–2300; 15·6%)
1–4 years	700 (50–1300)	300 (0–700; 37·7%)	400 (0–900; 62·3%)
5–9 years	3500 (2200–4900)	3000 (1700–4300; 84·8%)	500 (0–1100; 15·2%)
10–14 years	4700 (3000–6400)	4300 (2500–6000; 90·7%)	400 (0–900; 9·3%)
Tanzania (2016–17)			
Overall	101 000 (59 000–143 000)	51 000 (23 000–78 000; 50·0%)	50 000 (22 000–79 000; 50·0%)

	Estimates of total children living with HIV	Estimates of diagnosed children living with HIV	Estimates of undiagnosed children living with HIV
1–4 years	36 000 (9200–63 000)	11 000 (0–26 000; 29·9%)	25 000 (3000–48 000; 70·1%)
5–9 years	40 000 (14 000–65 000)	23 000 (3700–43 000; 58·9%)	16 000 (300–32 000; 41·1%)
10–14 years	25 000 (11 000–40 000)	16 000 (4400–28 000; 64·9%)	8900 (1200–17 000; 35·1%)
Zambia (2016)			
Overall	80 000 (61 000–99 000)	39 000 (27 000–50 000; 48·5%)	41 000 (28 000–55 000; 51·5%)
1–4 years	19 000 (10 000–28 000)	8100 (1200–15 000; 42·1%)	11 000 (5400–17 000; 57·9%)
5–9 years	43 000 (30 000–56 000)	25 000 (15 000–35 000; 58·0%)	18 000 (10 000–26 000; 42·0%)
10–14 years	18 000 (9100–26 000)	5600 (2200–9000; 32·0%)	12 000 (4100–20 000; 68·0%)
Zimbabwe (2015–16)			
Overall	93 000 (70 000–116 000)	63 000 (47 000–80 000; 68·2%)	30 000 (13 000–46 000; 31·8%)
1–4 years	18 000 (9400–27 000)	9900 (3200–17 000; 54·6%)	8200 (2700–14 000; 45·4%)
5–9 years	33 000 (17 000–49 000)	21 000 (12 000–31 000; 64·3%)	12 000 (0–25 000; 35·7%)
10–14 years	42 000 (30 000–54 000)	32 000 (21 000–44 000; 77·1%)	9700 (4000–15 000; 22·9%)

Data are n (probability band) or n (probability band; %).

Table 4:

Concordance between children's reported HIV status and antiretroviral medications detected in blood (as a proxy for known HIV-positive diagnosis) among children living with HIV in PHIA surveys in Eswatini, Lesotho, Malawi, Namibia, Tanzania, Zambia, and Zimbabwe from 2015 to 2017

	Antiretroviral medications detected		Antiretroviral medications not detected		κ (95% CI)*
	Child reported as HIV-positive†	Child reported as HIV-negative or unknown†	Child reported as HIV-positive‡	Child reported as HIV-negative or unknown‡	
All countries	304 (79·6%)	69 (20·4%)	37 (15·2%)	163 (84·8%)	0·61 (0·55–0·68)
Eswatini	60 (90·4%)	6 (9·6%)	5 (26·1%)	12 (73·9%)	0·60 (0·39–0·81)
Lesotho	44 (74·8%)	15 (25·2%)	3 (15·2%)	17 (84·8%)	0·50 (0·31–0·69)
Malawi	38 (78·0%)	16 (22·0%)	12 (28·4%)	28 (71·6%)	0·40 (0·21–0·58)
Namibia	46 (83·5%)	11 (16·5%)	3 (17·8%)	13 (82·2%)	0·53 (0·31–0·74)
Tanzania	16 (64·8%)	5 (35·2%)	0	22 (100·0%)	0·77 (0·58–0·95)
Zambia	35 (90·1%)	5 (9·9%)	7 (16·9%)	39 (83·1%)	0·72 (0·57–0·87)
Zimbabwe	65 (87·2%)	11 (12·8%)	7 (16·3%)	32 (83·7%)	0·66 (0·52–0·80)

Data are n (%) unless otherwise stated. 573 children were included in this analysis; 19 with no antiretroviral medication detection results and two for whom their parent or guardian refused to give testing history or testing results were excluded. PHIA=Population-based HIV Impact Assessment.

*p values for all κ estimates were <0·0001.

†Percentages are weighted proportions of all children living with HIV with antiretroviral medications detected.

‡Percentages are weighted proportions of all children living with HIV with no antiretroviral medications detected.