



Incidence and prevalence of orphanhood in Rakai, Uganda: a population-based cohort study, 1995–2022

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Summary

Background The introduction and scale-up of HIV treatment and prevention programmes have resulted in steady declines in orphanhood prevalence in sub-Saharan Africa, but orphanhood incidence and its associated factors are less understood. We aimed to describe the incidence and prevalence of orphanhood after HIV treatment and prevention programmes became available in Rakai, Uganda.

Methods In this population-based cohort study, we used data from all children and adolescents younger than 18 years with censused parents residing in 28 continuously surveyed Rakai Community Cohort Study (RCCS) communities from 1995 to 2022 (N=92 441), to calculate maternal, paternal, and double orphanhood prevalence by census round. Orphanhood incidence was estimated by use of a non-parametric hierarchical Bayesian model over time among children whose parents were alive during their first census interview and who were censused at least twice without missing more than two consecutive census visits (N=54 411). Poisson regression models estimated incidence rate ratios of orphanhood and 95% CIs by time period (pre-antiretroviral therapy [ART; 1995–2003], ART partial availability [2004–14], and ART full availability [2015–22]), age at orphanhood, and socioeconomic status of the household. Population attributable fractions of incident orphanhood due to parents' HIV-positive status were estimated among those with surveyed parents who were tested for HIV.

Findings Orphanhood prevalence declined considerably over the study period, with steepest declines after ART became available; from 21·5% (3421 of 15 941 individuals) in 2003–04 to 6·3% (1449 of 23 082 individuals) in 2020–22. In adolescents aged 15–17 years, orphanhood prevalence declined from 49·4% (1057 of 2138) in 2002–03 to 14·4% (526 of 3661 individuals) in 2020–22. Incidence rates declined sharply; double orphanhood declined from 5·13 (95% CI 4·02–6·45) per 1000 person-years in 2003–04 to 0·68 (0·42–1·05) per 1000 person-years in 2020–22. The proportion of new cases of orphanhood attributed to parental HIV status declined from 67% in 2004 to 11% in 2022 for paternal orphanhood and from 71% to 12% for maternal orphanhood.

Interpretation Scale-up of ART in this Ugandan setting drove substantive declines in orphanhood incidence. Yet, a considerable burden of orphanhood persisted in 2022, particularly among adolescents. To consolidate these gains, sustained investment and adaptation of HIV programmes are crucial to mitigate the ongoing risk of orphanhood for this vulnerable population.

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Introduction

An estimated 57·9 million children younger than 18 years in sub-Saharan Africa have lost one or both parents; about 10·3 million of them have lost a parent to HIV-related causes, representing 75% of the world's HIV-related orphans.¹ This high burden of HIV-related orphanhood continues despite the success of HIV interventions such as treat-all antiretroviral therapy (ART) policies, in which all people living with HIV are eligible to receive ART.^{2,3} Since research is limited to orphanhood prevalence, trends in orphanhood incidence are poorly understood, including the extent to which the expansion of HIV treatment programmes has reduced

the number of new orphans.⁴ This knowledge gap is especially crucial as recent gains in HIV control in sub-Saharan Africa are not guaranteed: an additional 2·8 million children could lose their parents due to HIV/AIDS if programmes such as the President's Emergency Plan for AIDS Relief (PEPFAR) are halted.⁵

Orphanhood is a key concern for child and adolescent development, with many adverse social and health consequences.² In addition to leaving school at younger ages, children who lose a parent due to HIV/AIDS face consequences different from those faced by other orphaned children, including higher risk of mental health disorders and unstable living arrangements.⁶

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Research in context

Evidence before this study

We searched PubMed using the terms (“HIV” OR “AIDS”) AND (“Orphan”*) AND (“Africa”*) NOT (“editorial”) OR (“case report”) for articles in English from database inception to Feb 2, 2025. Several studies identified marked declines in orphanhood after scale-up of HIV treatment and prevention interventions. One simulation study, by Masquelier and Timæus, showed marked declines in orphanhood prevalence across 16 African countries with high HIV prevalence from 1970 to 2020, but these estimates used data of varying quality. The most recent longitudinal analysis was our study from Rakai, Uganda, showing a decline in orphanhood prevalence from 53% in 2003, to 23% in 2018, among adolescents after the introduction of antiretroviral therapy (ART) in 2004. However, this study was limited to adolescents aged 15–19 years and only assessed orphanhood prevalence. Few studies have assessed trends in orphanhood incidence in Africa, and in HIV-related orphanhood since 2015.

Added value of this study

To our knowledge, this is the first study to provide long-term, population-based estimates of orphanhood incidence in the contemporary context of sustained ART scale-up and HIV prevention interventions in a high-burden, rural African setting.

Our findings show a dramatic decline in orphanhood incidence among children and adolescents in Rakai, Uganda, between 2004 and 2022, corresponding to expanded ART access and reduced parental HIV-related mortality. Notably, the proportion of orphanhood attributable to parental HIV infection fell sharply—from 67% for paternal orphanhood and 71% for maternal orphanhood during the pre-ART era (1995–2003) to 12% for maternal orphanhood and 11% for paternal orphanhood in the era of universal ART (2015–22). Despite these gains, the absolute number of children experiencing orphanhood remains high due to demographic growth. These findings provide important insights into the long-term population-level impact of HIV treatment programmes on child wellbeing and family structure in sub-Saharan Africa.

Implications of all the available evidence

In Rakai, Uganda, prevalence and incidence of orphanhood declined since 1995, and the decline accelerated after 2004, coinciding with the availability and expansion of ART and HIV prevention programmes. Uninterrupted continuation of HIV treatment and prevention efforts in sub-Saharan Africa remains essential to prevent the adverse health and social outcomes related to orphanhood, which include school dropout and HIV infection.

Together, these social consequences can bring about behaviours that put orphans at increased risk of contracting HIV.⁷ Furthermore, orphanhood can place constraints on household wellbeing. For example, higher youth dependency ratios often result in greater economic burdens and food insecurity.⁸

Most studies in sub-Saharan Africa have described the prevalence of orphanhood only, including our previous analyses of data from the Rakai community in Uganda.² Longitudinal studies in rural South Africa and Uganda have observed declines in orphanhood prevalence since the early 2000s.^{3,9} Although prevalence can help quantify overall need, it is a cumulative indicator that does not reflect the immediate impact of population-level interventions that improve parental survival. Incidence can assist in monitoring changes in orphanhood over time, especially in contexts with high population growth and migration. Furthermore, previous analyses from Rakai included either exclusively children younger than 15 years,³ or adolescents aged 15–19 years.² Although these age groups are important to investigate independently, analysing age groups in isolation reduces the ability of researchers and policy makers to compare estimates of orphanhood prevalence with global or national orphanhood estimates among all children and adolescents younger than 18 years. Also, few studies have analysed orphanhood incidence in the context of ART scale-up in high-burden HIV settings such as Uganda.

For a complete understanding of the burden, risks, and consequences of orphanhood in a contemporary

sub-Saharan Africa population, incidence and prevalence estimates are required.¹⁰ In countries with insufficient vital statistics systems, such as Uganda, population-based orphanhood surveillance is a crucial tool to inform targeted interventions for timely linkage of orphans to social services. In the current study, we used census data from a closely monitored longitudinal cohort study among children younger than 18 years in southern Uganda to describe trends in orphanhood incidence and prevalence, and to identify factors associated with orphanhood incidence, including parental HIV status. This study quantifies the impact of ART programmes on child welfare and informs efforts to reduce the burden of orphanhood.

Methods

Study design

This population-based cohort study used data from 28 agrarian and trading communities that were continuously surveyed in the Rakai Community Cohort Study (RCCS) from 1995 to 2022 (census rounds 2–20; appendix 1 p 3), to describe trends in orphanhood incidence and prevalence, and to identify factors associated with orphanhood incidence. The RCCS is a population-based open cohort of consenting individuals residing in communities in Rakai, Uganda and surrounding districts in southern Uganda.¹¹ Rounds of RCCS data collection occurred approximately 1–2 years apart. Each RCCS round included a household census and a survey for all individuals aged 15–49 years who

See Online for appendix 1

were present at the time of the census. The census involved collecting demographic information (including gender [as reported in the census by the head of household and self-reported by individuals included in the survey], age, relationship to the head of household, duration of residence, and the status of each parent [ie, co-resident, alive but not co-resident, or deceased]) on every household member from the head of household. Household socioeconomic status was derived from data collected on household assets and categorised into quartiles.¹² RCCS participation rates are similar to or higher than those of similar community cohort studies done in Africa, and previous research indicates that the population structure and HIV transmission dynamics are consistent with the larger south-central region of Uganda.^{13,14} Institutional review board approvals for the current analysis and RCCS were obtained from Uganda Virus Research Institute's Science and Ethics Committee (GC/127/1013), Uganda National Council for Science and Technology, and the institutional review board at Columbia University, USA (IRB-AAAU7723). Further information on the RCCS data collection and field methods has been provided elsewhere.³

Survey participants

The RCCS census interview, which covered most household residents, was completed by the head of household. However, a subset of the censused population (those aged 15–49 years) were eligible for individual participation in the full RCCS survey. The present study used the census population for the primary study population, assessing all-cause orphanhood incidence and prevalence estimates overall, and the survey population (ie, children whose parents participated in both the census and the RCCS survey) for the secondary study population, assessing HIV-attributed orphanhood. For individuals younger than 18 years, both written minor assent and parental or guardian permission were obtained; individuals younger than 18 years who met the definition of emancipated minors provided their own written informed consent. Community-wide HIV education, HIV counselling and testing, and referral for voluntary medical male circumcision and ART were offered free of charge to consenting participants. Overall, the RCCS survey enrolls over 85% of eligible residents present at the time of survey. Among consenting participants, about 99% respond to the full questionnaire and over 95% agree to HIV testing.^{15,16} HIV tests were first assessed with a validated rapid test in the field, and a laboratory-based enzyme immunoassay was used to confirm people with newly identified HIV positivity.

Procedures

Orphanhood prevalence for each census round was defined as the number of children (aged 0–17 years) whose mother, father, or both parents was reported to have died in the household census divided by the total

number of children at the time of the census. The RCCS orphanhood cohort comprised all household census participants younger than 18 years with complete information on age, gender, and orphanhood status at the time of the census. Children and adolescents with parents for whom no parental survival information was available at the time of the census were excluded. Round-specific orphanhood prevalence was described over time for non-mutually exclusive orphanhood categories, by type of orphanhood identified at the time of the census. Maternal orphans were those whose mother had died (whether or not their father was alive), paternal orphans were those whose father had died (whether or not their mother was alive), and double orphans were those where both of whose parents had died.

An incident orphan was defined as a child (age 0–17 years) whose parent had died since the last census round. Incident orphanhood was described by type of orphanhood identified since the previous census (maternal, paternal, or double). Incident maternal, paternal, and double orphanhood categories overlapped; therefore, we created three incidence cohorts as the analytical samples for incidence estimates (appendix 1 p 4). All orphanhood incidence cohorts comprised censused individuals younger than 18 years who were non-orphans at baseline (defined as their first census survey during the study period). Individuals in the incidence cohorts were followed up until the date they were first identified as an orphan, or the date they turned age 18 years, died, or out-migrated from the RCCS surveillance area. Hence, individuals were required to have completed at least two rounds of the census to be included in the incidence cohort. We also excluded individuals with two or more missing consecutive census rounds since the round of their orphaning was uncertain (N=3021; appendix 1 p 6). Further exclusions included those with missing information on age, gender, and orphanhood status (N=158; appendix 1 p 6).

Incidence rates per census round were calculated as the number of incident cases of orphanhood divided by the total number of person-years at risk (defined as the number of years between the current and last census dates for all children and adolescents who were not yet orphaned). Years of observation time ranged from 1–2 years depending on the dates of each person's current and previous census date. For visualisation, empirical rates were plotted at the midpoint of each census round.

Statistical analysis

The primary statistical objective was to describe the longitudinal orphanhood incidence across discrete census rounds for each type of orphanhood. We used random-effects Bayesian negative binomial regression models in a Bayesian hierarchical framework with one-dimensional smooth random functions to capture time trends. The functions were specified as

one-dimensional Gaussian processes with radial basis function kernel with midpoint census rounds as inputs. In the primary analysis, we did not consider incidence trends in continuous calendar time because study communities were visited consecutively; therefore, the incidence data within each round were structured by communities. The model was fitted with Stan version 2.33.1 with four chains, each with 500 warm-up iterations followed by 800 iterations.¹⁷ Additional details on the model setup and assumptions are provided in appendix 1 (p 7).

Associations between orphanhood incidence and individual-level or household-level factors were estimated by use of Poisson regression. For each type of orphanhood, incidence rate ratios (IRRs) and 95% CIs were used to compare incidence rates by age of the individual at the time of orphaning (age 0–4 years, age 5–9 years, age 10–14 years, and age 15–17 years), parental HIV status for those with parents who were tested for HIV in the RCCS survey (ie, those in the secondary study population), and socioeconomic status quartiles. Furthermore, to assess the potential influence of HIV treatment policy on orphanhood trends, IRRs were compared across time periods roughly approximating population-level access to ART: before ART availability (pre-ART period; 1995–2003), initial ART rollout in Uganda (ART partial availability period; 2004–14), and the ART treat-all strategy (under the universal test-and-treat strategy), under which all people living with HIV are eligible to receive ART regardless of their viral load or CD4 count (ART full availability period; 2015–22).

The percent orphanhood attributed to parent's positive HIV status was estimated with population attributable fractions (PAFs; percentage) among children and adolescents whose biological parents were surveyed and tested for HIV before their death (ie, those in the secondary study population). The PAF of incident maternal and paternal orphanhood due to parents living with HIV was estimated with

$$\text{PAF} = \text{pd} \times \frac{\text{IRR} - 1}{\text{IRR}}$$

where *pd* is the proportion of incident orphans exposed to the risk factor (HIV-positive parent).

To assess the potential effect of selection bias on the primary findings, we conducted sensitivity analyses by comparing the characteristics of participants against those who were excluded from the analysis with χ^2 tests for heterogeneity. As a quality control check, we assessed the consistency of orphanhood across subsequent rounds.

Role of the funding source

The funders of the study had no role in study design, data collection, data analysis, data interpretation, or writing of the report.

Results

Of 92 599 children and adolescents younger than 18 years who were censused at least once between 1995 and 2022, 99·8% (92 441) had censused parents with survival information (appendix 1 p 4). 58·9% (54 411 of 92 441) of these individuals were included in the incidence analysis since they were censused at least twice without missing more than two consecutive censuses (appendix 1 p 4). From these individuals, three cohorts were constructed to measure the incidence of each type of orphanhood: 50 508 with a living mother at baseline, 48 535 with a living father at baseline, and 52 177 with both parents alive at baseline. For all types of orphanhood, incident orphans were generally older at the time of first census, recruited during earlier time periods, and resided in households of lower socioeconomic status than non-orphans (table). A greater proportion of paternal orphans (69·6%; 1923 of 2764 individuals) lived with their other parent (ie, their mother) compared with maternal orphans (52·9%; 832 of 1574 individuals).

Orphanhood prevalence declined substantially over the study period (figure 1) from 27·7% (3645 of 13 173 individuals) in 1995–96 to 6·3% (1449 of 23 082 individuals) in 2020–22 (appendix 1 p 9). We observed a steady decline in single orphanhood after ART rollout in 2004 (from 21·5% [3421 of 15 941 individuals] in 2003–04 to 6·3% [1449 of 23 082 individuals] in 2020–22), and among children who experienced the death of both parents (from 6·6% [1045 of 15 941 individuals] in 2003–04 to 0·6% [137 of 23 082 individuals] in 2020–22). However, compared with incidence, the decline in orphanhood prevalence was less notable (figure 1). In adolescents aged 15–17 years, orphanhood prevalence declined from 49·4% (1057 of 2138 individuals) in 2002–03 to 14·4% (526 of 3661 individuals) in 2020–22. Paternal orphanhood remained the most common type of orphanhood identified over the study period, despite declining from 22·2% (2928 of 13 173 individuals) in 1995–96 to 4·6% (1064 of 23 082 individuals) in 2020–22 (figure 1; appendix 1 p 9). The prevalence of double orphanhood declined from 9·1% (1200 of 13 173 individuals) in 1995–96 to 0·6% (137 of 23 082 individuals) by the end of the study period in 2022.

Among children and adolescents who were not orphans at baseline, 2764 (5·7%) of 48 535 lost a father, 1574 (3·1%) of 50 508 lost a mother, and 891 (1·7%) of 52 177 lost both a mother and a father over the study period (table). Overall, declines in orphanhood incidence rate were greatest after 2004 (ie, initial rollout of ART in Uganda). From 20·5 (95% CI 17·3–24·1) cases per 1000 person-years in 1995–96 to 5·9 (5·0–6·8) cases per 1000 person-years in 2020–22 for paternal orphanhood, and from 8·6 (6·6–10·9) cases per 1000 person-years in 1995–96 to 2·3 (1·9–2·9) cases per 1000 person-years in 2020–22 for maternal orphanhood (figure 2). Double orphanhood declined from 5·13 (95% CI 4·02–6·45) per

	Mother alive at baseline		Father alive at baseline		Both parents alive at baseline	
	Incident maternal orphan (n=1574)	Non-maternal orphan (n=48 934)	Incident paternal orphan (n=2764)	Non-paternal orphan (n=45 771)	Incident double orphan (n=891)	Non-double orphan (n=51 286)
Gender						
Male	844 (53.6%)	23 887 (48.8%)	1334 (48.3%)	22 408 (49.0%)	451 (50.6%)	25 058 (48.9%)
Female	730 (46.4%)	25 047 (51.2%)	1430 (51.7%)	23 363 (51.0%)	440 (49.4%)	26 228 (51.1%)
Age at first census						
Median, years	5 (0–9)	3 (0–7)	4 (1–8)	2 (0–7)	7 (4–10)	3 (0–8)
0–4 years	685 (43.5%)	30 175 (61.7%)	1486 (53.8%)	29 017 (63.4%)	245 (27.5%)	30 848 (60.1%)
5–9 years	516 (32.8%)	9884 (20.2%)	768 (27.8%)	8982 (19.6%)	359 (40.3%)	10 551 (20.6%)
10–14 years	321 (20.4%)	6744 (13.8%)	436 (15.8%)	5933 (13.0%)	241 (27.0%)	7485 (14.6%)
15–17 years	52 (3.3%)	2131 (4.4%)	74 (2.7%)	1839 (4.0%)	46 (5.2%)	2402 (4.7%)
Age at orphanhood						
Median, years	11 (7–14)	NA	10 (6–14)	NA	12 (9–15)	NA
0–4 years	173 (11.0%)	NA	412 (14.9%)	NA	33 (3.7%)	NA
5–9 years	594 (37.7%)	NA	984 (35.6%)	NA	389 (43.7%)	NA
10–14 years	366 (23.3%)	NA	562 (20.3%)	NA	250 (28.1%)	NA
15–17 years	441 (28.0%)	NA	806 (29.2%)	NA	219 (24.6%)	NA
Socioeconomic quartile						
Lowest	376 (23.9%)	7203 (14.7%)	649 (23.5%)	6398 (14.0%)	224 (25.1%)	7725 (15.1%)
Middle-low	406 (25.8%)	9675 (19.8%)	644 (23.3%)	8915 (19.5%)	235 (26.4%)	10 199 (19.9%)
Middle-high	374 (23.8%)	14 455 (29.5%)	724 (26.2%)	13 595 (29.7%)	230 (25.8%)	15 042 (29.3%)
Highest	385 (24.5%)	16 793 (34.3%)	663 (24.0%)	16 137 (35.3%)	181 (20.3%)	17 464 (34.1%)
Unknown	33 (2.1%)	808 (1.7%)	84 (3.0%)	726 (1.6%)	21 (2.4%)	856 (1.7%)
Time period						
Pre-ART (1995–2003)	1200 (76.2%)	20 865 (42.6%)	2009 (72.7%)	18 696 (40.8%)	736 (82.6%)	22 403 (43.7%)
ART partial availability (2004–14)	315 (20.0%)	17 462 (35.7%)	632 (22.9%)	16 762 (36.6%)	138 (15.5%)	18 092 (35.3%)
ART full availability (2015–22)	59 (3.7%)	10 607 (21.7%)	123 (4.5%)	10 313 (22.5%)	17 (1.9%)	10 791 (21.0%)
Cohabitation						
Parent	832 (52.9%)	35 278 (72.1%)	1923 (69.6%)	33 187 (72.5%)	NA	36 310 (70.8%)
Adopted family	15 (1.0%)	1274 (2.6%)	42 (1.5%)	1060 (2.3%)	11 (1.2%)	1291 (2.5%)
Grandparent	497 (31.6%)	7266 (14.8%)	532 (19.2%)	6847 (15.0%)	394 (44.2%)	7934 (15.5%)
Sibling	14 (0.9%)	255 (0.5%)	22 (0.8%)	210 (0.5%)	15 (1.7%)	298 (0.6%)
Other relative	179 (11.4%)	3586 (7.3%)	205 (7.4%)	3322 (7.3%)	154 (17.3%)	4055 (7.9%)
Unrelated	23 (1.5%)	937 (1.9%)	28 (1.0%)	857 (1.9%)	392 (44.0%)	1024 (2.0%)
Unknown	14 (0.9%)	338 (0.7%)	12 (0.4%)	288 (0.6%)	15 (1.7%)	374 (0.7%)

Data are n (%) or median (IQR). ART=antiretroviral therapy. NA=not applicable. RCCS=Rakai Community Cohort Study.

Table: Baseline characteristics of analytic sample included in the incidence population estimates of the RCCS, 1995–2022

1000 person-years in 2003–04 to 0.68 (0.42–1.05) per 1000 person-years in 2020–22. Paternal orphanhood had the highest incidence across study years. The highest incidence of new orphans across all three types of orphanhood was observed in 1999–2000. However, after 2000–01, orphanhood incidence plateaued and eventually declined across all three types, most noticeably for paternal orphanhood. Paternal orphanhood incidence increased slightly ($p < 0.05$; appendix 1 p 15) during the final two census rounds (2018–20 and 2020–22).

Children and adolescents in the ART partial availability and ART full availability periods were less likely to lose either parent than those in the pre-ART period (figure 3). Individuals in the highest socioeconomic status quartile had the lowest orphanhood incidence rates. Among

children and adolescents with known parental HIV status, parental HIV-positive status was associated with almost ten times higher orphanhood incidence (maternal orphanhood IRR 9.98, 95% CI 8.58–11.60; paternal orphanhood 8.94, 7.96–10.10; figure 4) compared with those with parental HIV-negative status. The IRR for maternal orphanhood where the mother was HIV positive declined substantially over time, from 19.09 (95% CI 15.34–23.93) in the pre-ART period to 2.04 (1.25–3.23) in the ART full availability period. Similar patterns were observed for incident paternal orphanhood over the same time periods.

Among children with known parental HIV status in the pre-ART period, HIV-positive status accounted for more than two-thirds of paternal and maternal orphans

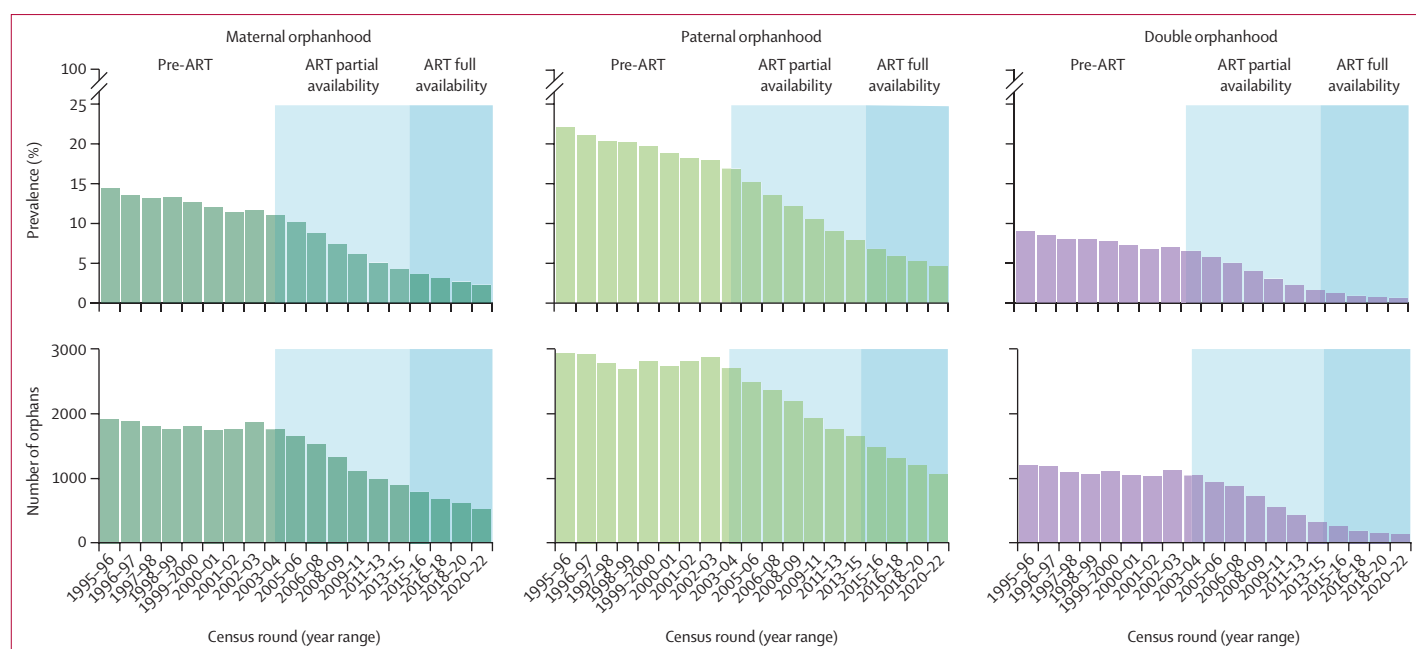


Figure 1: Prevalence and numbers of orphanhood among children and adolescents aged 0–17 years in the RCCS, 1995–2022

ART=antiretroviral therapy. RCCS=Rakai Community Cohort Study.

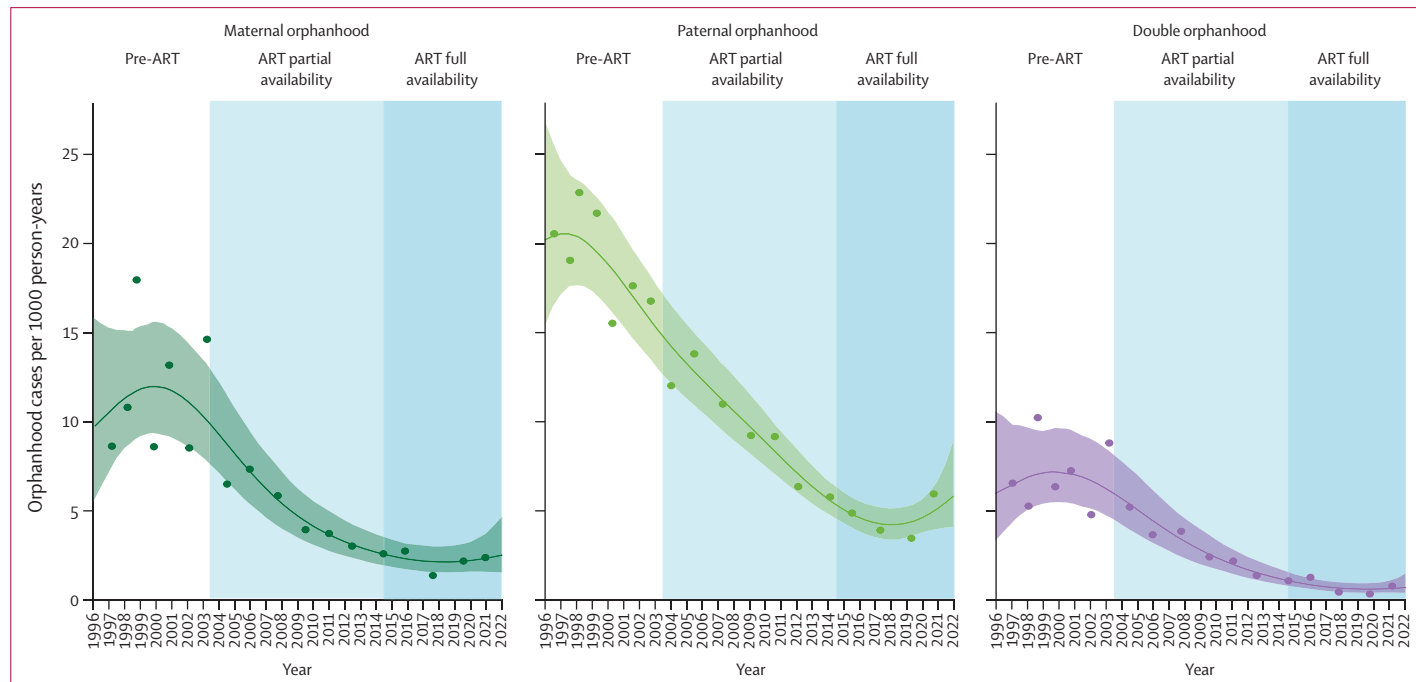


Figure 2: Incidence rate of orphanhood among children and adolescents aged 0–17 years in the RCCS, 1995–2022

Point estimates are plotted at the midpoint of the census round; for the first census round, the midpoint was in 1996. Incidence rate estimates and 95% CrIs were calculated from a Bayesian negative binomial distribution with a log-link mixed-effects regression model (shaded areas show CrIs). Baseline fixed effect and further random effects on time space in the regression model with individual-level exposure times specified as offset on the log scale (appendix 1 p 7). Children and adolescents with two or more missing census rounds were excluded. ART=antiretroviral therapy. CrI=credible interval. RCCS=Rakai Community Cohort Study.

(figure 5). Thereafter, the proportion of orphanhood attributed to parent's HIV-positive status declined from 67% for paternal orphanhood and 71% for maternal

orphanhood in the pre-ART period to 12% (maternal orphanhood) and 11% (paternal orphanhood) during the ART full availability period.

Discussion

By use of comprehensive longitudinal data, this study describes the considerable decline in orphanhood incidence and prevalence in southern Uganda between 1995 and 2022, particularly after the rollout of ART began in 2004. Orphanhood incidence was highest among those living in the lowest socioeconomic quartile and there were more adolescents who were incident orphans than younger children. The proportion of incident orphanhood attributed to the deceased parent's HIV-positive status declined markedly between the pre-ART and ART full availability. The likely impacts of these declines include reduced stress on extended families, increased duration of schooling, and possibly reduced risk of HIV infection among orphans. However, despite these improvements, the absolute burden of orphanhood remains high in this region.

Our study confirms the decline in orphanhood after periods of ART scale-up observed elsewhere in sub-Saharan Africa, including previous work in Rakai,³ other parts of Uganda,⁴ Botswana,¹⁸ South Africa,⁹ and a combined analysis of 16 African countries.¹⁹ Together, these findings show that widespread availability of HIV treatment has made a profound contribution to reversing mortality among parents.²⁰ Building on the findings presented in a previous RCCS analysis,³ the current analysis extends to 2022, showing that HIV treatment and prevention programmes continue to reduce rates of HIV-related orphanhood. In particular, the declines in orphanhood incidence observed during ART scale-up (ie, ART partial availability and ART full availability periods) and in the proportion of orphanhood incidence attributable to parental HIV-positive status show the specific benefits of HIV prevention programmes, and hence the urgent need for their continuation to avoid the health and social consequences of orphanhood,⁵ including the potential increase in HIV risk among orphans.⁷

Despite this clear progress, two trends warrant specific attention. First, we observed declines in orphanhood incidence started from around 2001, which is slightly earlier than the rollout of ART in 2004. Other evidence shows an earlier peak in HIV incidence in Uganda (in the 1990s) compared with other African countries;²¹ since HIV mortality tends to peak approximately 10 years after incidence, this earlier peak in HIV incidence potentially explains the earlier decline in orphanhood incidence in southern Uganda shown in this study. Uganda being further ahead than other African countries in the implementation of HIV control efforts, particularly in the pre-ART period, is thought to be related to funding efforts and intensive educational awareness programmes.²² Hence, the decline in orphanhood incidence before 2004 could be the result of behavioural change, as communities had greater awareness of HIV and risk behaviours. Furthermore, overall life expectancy increases were observed in Uganda because of other health

improvements not related to HIV, such as improvements in food security or tuberculosis and malaria prevention. However, as expected, the decline in orphanhood

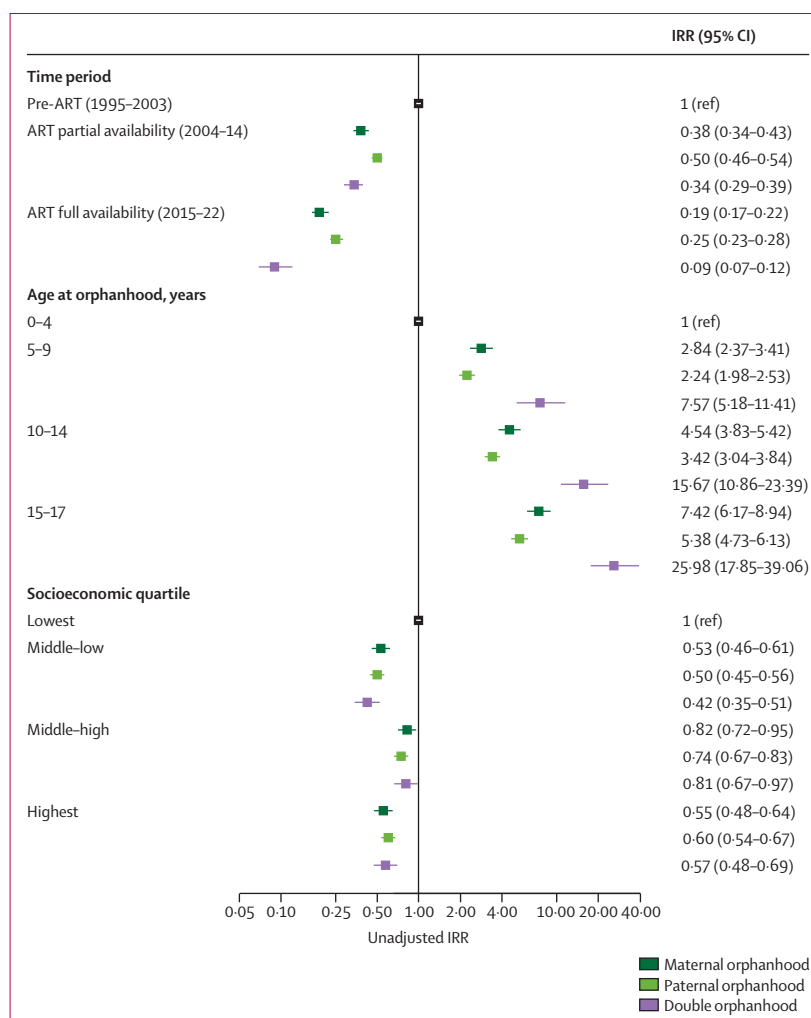


Figure 3: IRRs of incident orphanhood by time period, age, and socioeconomic status in the RCCS, 1995–2022. ART=antiretroviral therapy. IRR=incidence rate ratio. RCCS=Rakai Community Cohort Study.

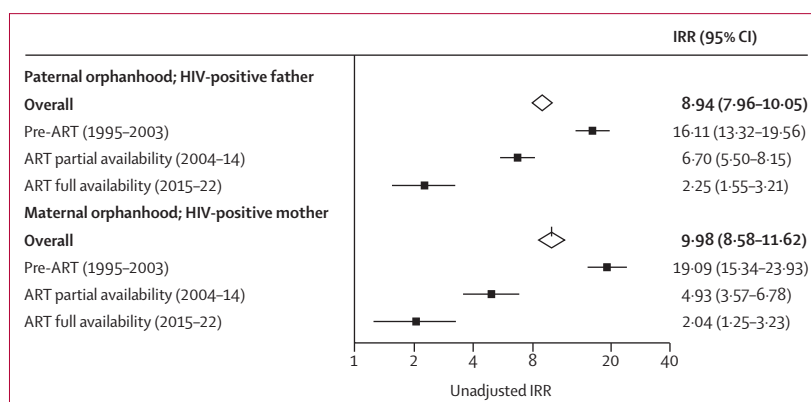


Figure 4: IRRs of incident orphanhood by parental HIV status and time period in the RCCS, 1995–2022. ART=antiretroviral therapy. IRR=incidence rate ratio. RCCS=Rakai Community Cohort Study.

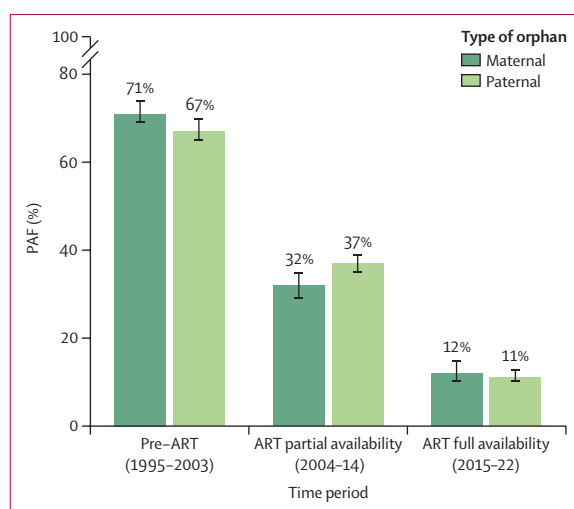


Figure 5: PAFs of incident maternal and paternal orphanhood due to parent's HIV-positive status, by time period, in the RCCS, 1995–2022

ART=antiretroviral therapy. PAF=population attributable fraction. RCCS=Rakai Community Cohort Study.

incidence accelerated after 2004, particularly for maternal and double orphanhood ($p < 0.05$; appendix 1 p 15), which was likely due to the implementation and scale-up of HIV treatment and prevention programmes. Second, although all types of orphanhood declined throughout the study period, paternal orphanhood was consistently higher than maternal orphanhood, and even increased slightly during the COVID-19 pandemic (2020–22). This increase has been observed elsewhere.²³ The reason for higher paternal orphanhood than maternal orphanhood is unclear but could in part be due to differing parental ages between mothers and fathers. In addition, although COVID-19 is known to result in increased adult mortality and hence orphanhood,^{3,23} future studies should examine the mechanisms underlying these apparent epidemic-related shocks to adult mortality by gender.²⁴ For example, men could have been more likely to die as a direct result of SARS-CoV-2 infection or due to enhanced susceptibility to the indirect effects of the pandemic.²⁵

Parental HIV-positive status was a main contributing factor underlying high rates of new orphanhood and adult mortality during the pre-ART period.²⁶ At the community level, HIV treatment programmes have an even larger impact on reducing orphanhood. Universal test-and-treat strategies—including differentiated service delivery models—can also improve the overall quality of life for people living with HIV, reducing not only their HIV-related mortality but other causes of mortality, such as severe mental health problems.²⁷ These findings underscore the need for sustained access to high-quality, effective care and treatment programmes for people living with HIV in sub-Saharan Africa,²⁸ including those funded by PEPFAR.²⁹ Without PEPFAR programmes, an estimated 2.8 million additional children will become orphans due to AIDS by 2030.⁵

Findings should be interpreted alongside several potential limitations. First, 35 009 children and adolescents were excluded because they were only present in one census round and 3021 were excluded because they were missing more than two consecutive rounds. Compared with the sample of included individuals, the excluded individuals represented older age groups (age 15–17 years at the time of first census round) and later census rounds; therefore, we might have underestimated orphanhood incidence in the ART full availability period. Second, parental HIV status was unknown for approximately half of the analytical sample for orphanhood incidence estimates, so the subanalysis of HIV attribution might not be fully representative of the entire population. However, cross-sectional associations with baseline age and socioeconomic status characteristics of the population of non-consenting parents suggests that individuals with missing HIV status were more likely to reside in households with lower socioeconomic status, which typically correlates with higher sexual risk behaviours (such as having sex at a young age or having multiple sexual partners) compared with consenting adults (appendix 1 p 14), and hence the likely impact of this bias would have been an underestimation of HIV-attributed orphanhood. Third, the study was restricted to households within the RCCS catchment areas and did not include orphanages. Hence, the orphanhood incidence estimates in this study could underestimate the true incidence, since orphans could have been systematically undercounted. This underestimation could be particularly true for double orphans, who are more likely to reside in an orphanage after the death of both parents. Lastly, direct causal effects of HIV programmes on orphanhood incidence could not be discerned with the given data. Indeed, Ugandan health-system improvements over the same period could have contributed to the observed reduction in orphanhood. Although modelling studies³⁰ aim to estimate the percent contribution of different diseases to adult mortality, future empirical research could incorporate vital statistics or verbal autopsy data to identify specific causes of maternal and paternal orphanhood. These studies could provide important insights into strategic programmes to support children and families.³¹

We observed substantive declines in the prevalence and incidence of orphanhood after the availability and expansion of HIV treatment and prevention programmes in southern Uganda. Although the proportion of orphanhood attributed to HIV declined substantially, the absolute burden of orphanhood remains high due to the growing child and adolescent population. These findings have several important public health implications. First, by observing the marked declines in orphanhood incidence, this study provides further evidence for the success and importance of HIV treatment and prevention interventions in sub-Saharan Africa. The recent abrupt

changes to USA foreign assistance, including widespread interruption of HIV treatment for people living with HIV, underscore the crucial importance of continued monitoring and evidence-based programming to protect children from orphanhood and its lifelong consequences.

Contributors

AK did the analyses, provided scientific input on the analysis plan, and assisted in writing the manuscript. DEM drafted the analysis plan and the initial version of the manuscript. AS, AK, and DEM verified the data. All authors had full access to all the data in the study. AK, DEM, FM, and JSS provided scientific oversight. AK, OR, YC, MKG, LWC, FN, GK, TL, NKS, AN, PK, DS, RS, AS, HN, SH, and JSS contributed to writing and provided scientific input. All authors contributed to the writing and had final responsibility for the decision to submit for publication.

Equitable partnership declaration

The authors of this paper have submitted an Equitable Partnership Declaration (appendix 2). This statement allows researchers to describe how their work engages with researchers, communities, and environments in the countries of study. This statement is part of The Lancet Group's broader goal to decolonise global health.

Declaration of interests

OR has received grants or contracts from Moderna Charitable Foundation, Engineering and Physics Science Research Council, Novo Nordisk Foundation, London Mathematical Society, and UK Health Security Agency (UKHSA). OR serves as a member of the UKHSA Genomics Database Steering Committee. JSS participates as a member of the Institutional Review Board at the Population Council and as a member of the Board of Directors for the Sexuality Information and Education Council of the USA. MKG, LC, and PK have received funding from the National Institutes of Health for research outside of the present study. All other authors declare no competing interests.

Data sharing

Individual-level data are available on reasonable request to Rakai Health Sciences Program. Interested collaborators can email info@rhsp.org for more information.

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References

- UNICEF. HIV/AIDS data. <https://data.unicef.org/topic/hiv/aids/global-regional-trends/#data> (accessed Nov 24, 2025).
- Santelli JS, Chen IS, Nabukalu D, et al. HIV combination prevention and declining orphanhood among adolescents, Rakai, Uganda, 2001–18: an observational community cohort study. *Lancet HIV* 2022; 9: e32–41.
- Makumbi FE, Nakigozi G, Sekasanvu J, et al. Incidence of orphanhood before and after implementation of a HIV care programme in Rakai, Uganda. *Trop Med Int Health* 2012; 17: e94–102.
- Mugenyi L, Nanfuka M, Byawaka J, et al. Effect of universal test and treat on retention and mortality among people living with HIV-infection in Uganda: an interrupted time series analysis. *PLoS One* 2022; 17: e0268226.
- Cluver L, Makangila G, Hillis S, et al. Protecting Africa's children from extreme risk: a runway of sustainability for PEPFAR programmes. *Lancet* 2025; 405: 1700–12.
- Sherr L, Hensels IS, Skeen S, Tomlinson M, Roberts KJ, Macedo A. Exposure to violence predicts poor educational outcomes in young children in South Africa and Malawi. *Int Health* 2016; 8: 36–43.
- Chae S. Timing of orphanhood, early sexual debut, and early marriage in four sub-Saharan African countries. *Stud Fam Plann* 2013; 44: 123–46.
- Rivers J, Mason JB, Rose DD, et al. The impact of orphanhood on food security in the high-HIV context of Blantyre, Malawi. *Food Nutr Bull* 2010; 31 (suppl): S264–71.
- Mejia-Pailles G, Berrington A, McGrath N, Hosegood V. Trends in the prevalence and incidence of orphanhood in children and adolescents <20 years in rural KwaZulu-Natal South Africa, 2000–2014. *PLoS One* 2020; 15: e0238563.
- Chiimba CM. Experiences of young orphans who transition into extended families in Zimbabwe. PhD Thesis, University of Pretoria, 2020.
- Wawer MJ, Sewankambo NK, Serwadda D, et al, and the Rakai Project Study Group. Control of sexually transmitted diseases for AIDS prevention in Uganda: a randomised community trial. *Lancet* 1999; 353: 525–35.
- Santelli JS, Chen I, Makumbi F, et al. Household wealth and HIV incidence over time, rural Uganda, 1994–2018. *AIDS* 2021; 35: 1835–43.
- Chang LW, Grabowski MK, Ssekubugu R, et al. Heterogeneity of the HIV epidemic in agrarian, trading, and fishing communities in Rakai, Uganda: an observational epidemiological study. *Lancet HIV* 2016; 3: e388–96.
- Lamarange J, Mossong J, Bärnighausen T, Newell ML. Participation dynamics in population-based longitudinal HIV surveillance in rural South Africa. *PLoS One* 2015; 10: e0123345.
- Santelli JS, Edelstein ZR, Mathur S, et al. Behavioral, biological, and demographic risk and protective factors for new HIV infections among youth in Rakai, Uganda. *J Acquir Immune Defic Syndr* 2013; 63: 393–400.
- Sewankambo NK, Wawer MJ, Gray RH, et al. Demographic impact of HIV infection in rural Rakai district, Uganda: results of a population-based cohort study. *AIDS* 1994; 8: 1707–13.
- Stan Toolkit. <https://mc-stan.org/users/interfaces/cmdstan> (accessed April 24, 2025).
- Stover J, Fidzani B, Molomo BC, Moeti T, Musuka G. Estimated HIV trends and program effects in Botswana. *PLoS One* 2008; 3: e3729.
- Masquelier B, Timæus IM. Estimating adult mortality based on maternal orphanhood in populations with HIV/AIDS. *Popul Stud (Camb)* 2025; 79: 337–57.
- Cluver L, Imai-Eaton JW, Sherr L, Mahy M, Flaxman S. Reauthorise PEPFAR to prevent death, orphanhood, and suffering for millions of children. *Lancet* 2023; 402: 769–70.
- Nabukalu D, Reniers G, Risher KA, et al. Population-level adult mortality following the expansion of antiretroviral therapy in Rakai, Uganda. *Popul Stud (Camb)* 2020; 74: 93–102.
- Slutkin G, Okware S, Naamara W, et al. How Uganda reversed its HIV epidemic. *AIDS Behav* 2006; 10: 351–60.
- Unwin HJT, Hillis S, Cluver L, et al. Global, regional, and national minimum estimates of children affected by COVID-19-associated orphanhood and caregiver death, by age and family circumstance up to Oct 31, 2021: an updated modelling study. *Lancet Child Adolesc Health* 2022; 6: 249–59.
- Hillis SD, Unwin HJT, Chen Y, et al. Global minimum estimates of children affected by COVID-19-associated orphanhood and deaths of caregivers: a modelling study. *Lancet* 2021; 398: 391–402.
- Zarull V, Kashnitsky I, Vaupel JW. Death rates at specific life stages mold the sex gap in life expectancy. *Proc Natl Acad Sci USA* 2021; 118: e2010588118.
- Sewankambo NK, Gray RH, Ahmad S, et al. Mortality associated with HIV infection in rural Rakai District, Uganda. *AIDS* 2000; 14: 2391–400.
- Havliir DV, Balzer LB, Charlebois ED, et al. HIV testing and treatment with the use of a community health approach in rural Africa. *N Engl J Med* 2019; 381: 219–29.
- Rautenbach SP, Whittles LK, Meyer-Rath G, et al. Future HIV epidemic trajectories in South Africa and projected long-term consequences of reductions in general population HIV testing: a mathematical modelling study. *Lancet Public Health* 2024; 9: e218–30.

See Online for appendix 2

- 29 The Lancet. American chaos: standing up for health and medicine. *Lancet* 2025; **405**: 439.
- 30 GBD 2021 Causes of Death Collaborators. Global burden of 288 causes of death and life expectancy decomposition in 204 countries and territories and 811 subnational locations, 1990-2021: a systematic analysis for the Global Burden of Disease Study 2021. *Lancet* 2024; **403**: 2100–32.
- 31 Villaveces A, Chen Y, Tucker S, et al. Orphanhood and caregiver death among children in the United States by all-cause mortality, 2000–2021. *Nat Med* 2025; **31**: 672–83.