Supplementary material

Estimating adult mortality based on maternal orphanhood in populations with HIV/AIDS

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In addition to the supplementary Tables and Figures in this appendix, a Github public repository (https://github.com/brunomasquelier/OrphanhoodAIDS) is available and contains the following folders:

- R code for microsimulations: R code to recreate the set of microsimulations. Users interested in conducting microsimulations need a local installation of SOCSIM, which is available here: https://lab.demog.berkeley.edu/socsim/. Socsim is also available through the rsocsim package in R, available here: https://github.com/MPIDR/rsocsim.
- Data: Mortality and fertility standards needed to generate the demographic rates that inform the microsimulations.
- Results: CSV data files containing estimates of ${}_np_{25}$ from the different orphanhood approaches.
- Workbook: An Excel workbook to facilitate the estimation of adult mortality from orphanhood in applications based on tabulated data.

Appendix A List of censuses conducted in Sub-Saharan Africa with orphanhood data

Western Africa	1970	1980	1990	2000	2010	2020
Benin	1979		1992	**2002**	**2013**	
Burkina Faso	1975	1985	**1996**	**2006**	**2019**	
Cabo Verde	1970	1980	1990	2000	**2010**	2021
Côte d'Iv.	1975	**1988**	**1998**		2014	2021(?)
Gambia	**1973**	**1983**	**1993**	**2003**	**2013**	
Ghana	1970	1984		2000	2010	2021
Guinea		1983	1996		**2014**	
Guinea-Bissau	1970 1979		1991	2009		
Liberia	1974	**1984**		**2008**		2022
Mali	1976	**1987**	**1998**	**2009**		**2022**
Mauritania	1976	1988		2000	2013	
Niger	1977	**1988**		**2001**	**2012**	
Nigeria	1973		1991	**2006**		

Senegal	1976	**1988**		2002	**2013**	**2023**
Sierra Leone	**1974**	**1985**		**2004**	2015	2021
Togo	1970	1981			**2010**	2022(?)

Middle Africa	1970	1980	1990	2000	2010	2020
Angola	1970				**2014**	
Cameroon	1976	**1987**		**2005**		
Central African Republic	1975	**1988**		**2003**		
Chad		**1989**	1993	**2009**		
Congo	**1974**	1984	1996	**2007**		
DR of the Congo		**1984**				
Equat. Guinea		1983	1994	2002	2015	
Gabon	1970	1980	1993	**2003**	2013	
Sao Tome and Principe		1981	1991		2012	

Eastern Africa	1970	1980	1990	2000	2010	2020
Burundi	1979		**1990**	**2008**		
Comoros		**1980**	**1991**	2003	**2017**	
Djibouti		**1983**		**2009**		
Eritrea		1984				
Ethiopia		1984	1994	**2007**		
Kenya	**1979**	**1989**	**1999**	**2009**	2019(?)	
Madagascar	1975		**1993**		2018	
Malawi	**1977**	1987	**1998**	**2008**	2018(?)	
Mauritius	1972	1983	1990	2000	2011	2022
Mozambique	1970	1980	**1997**	**2007**	2017(?)	
Rwanda	1978		**1991**	**2002**	**2012**	2022
Seychelles	1971;1977	1987	1994	2002	2010	2022
Somalia	1975	1987				
South Sudan	**1973**	1983	**1993**	**2008**		
Uganda		**1980**	**1991**	**2002**	**2014**	
United Republic of Tanzania	**1978**	**1988**		**2002**	**2012**	2022(?)
Zambia		1980	1990	2000	**2010**	2022(?)
Zimbabwe		**1982**	**1992**	**2002**	**2012**	2022

Southern Africa	1970	1980	1990	2000	2010	2020
Botswana	**1971**	1981	1991	**2001**	**2011**	**2022**
Eswatini	**1976**	**1986**	**1997**	**2007**	2017(?)	
Lesotho	**1976**	**1986**	**1996**	**2006**	**2016**	
Namibia	1970	1981	1991	**2001**	**2011**	2023(?)
South Africa		1980;1985	1991; **1996**	**2001**	**2011**	2022(?)

Table S1 – *Censuses conducted in Sub-Saharan Africa (censuses in which maternal orphanhood data were collected are in bold)*
Source: United Nations, Department of Economic and Social Affairs, Population Division 2021. Collected Data: List of selected demographic topics collected in specific data sources by country or area, Available from https://population.un.org/DataArchiveWeb/. Censuses for which it is unclear whether orphanhood questions were asked are identified with a question mark.

Appendix B Coefficients used to convert proportions of surviving mothers into survival probabilities

n	β_0	β_1	β_2	R^2	CV
10	-0.2894	0.00125	1.2559	0.997	0.0015
15	-0.1718	0.00222	1.1123	0.996	0.0031
20	-0.1513	0.00372	1.0525	0.995	0.0058
25	-0.1808	0.00586	1.0267	0.993	0.0088
30	-0.2511	0.00885	1.0219	0.992	0.0126
35	-0.3644	0.01287	1.0380	0.992	0.0172
40	-0.5181	0.01795	1.0753	0.992	0.0222
45	-0.6880	0.02342	1.1276	0.993	0.0271
50	-0.8054	0.02721	1.1678	0.992	0.0400

Table S2 – *Coefficients used to convert proportions of surviving mothers into survival probabilities - Sc: Timæus (1992)*

n	β_0	β_1	β_2
10	-0.3611	0.00125	1.2974
15	-0.4030	0.00222	1.3732
20	-0.2120	0.00372	1.1342
25	-0.2389	0.00586	1.1131
30	-0.2513	0.00885	1.0223

Table S3 – *Coefficients provided by Timæus and Nunn (1997) for converting proportions of surviving mothers into survival probabilities in HIV/AIDS-disrupted settings*

Appendix C Parametrization and calibration of the microsimulations

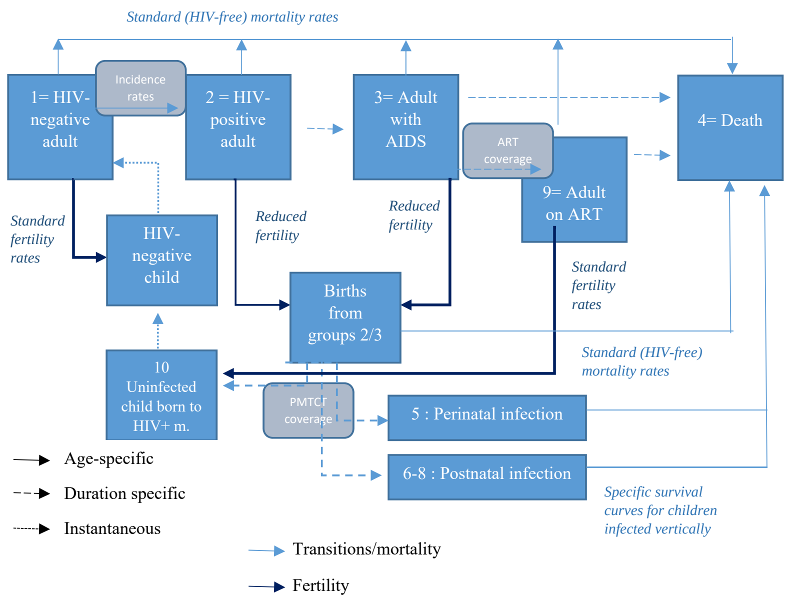

Figure S1 – *Flow chart of population subgroups identified in the microsimulations to incorporate HIV/AIDS*

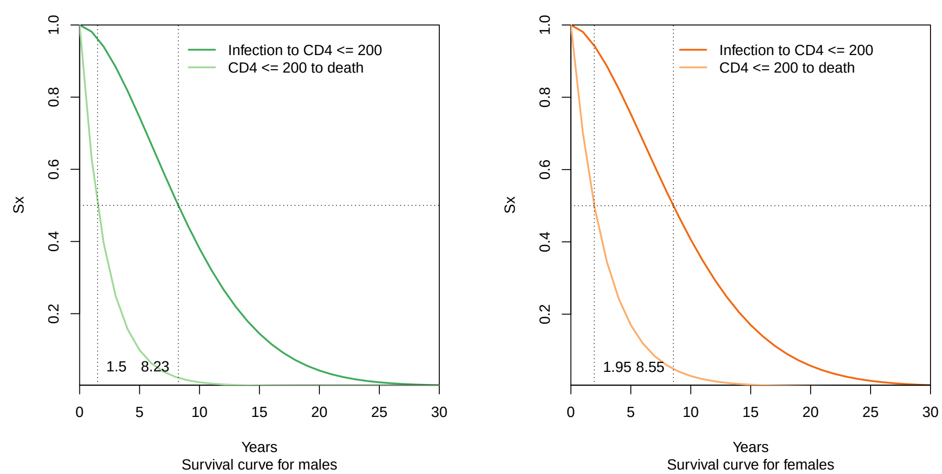

Figure S2 – *Survival curves for infected individuals progressing from infection to clinical stage, then from clinical stage to death, in the absence of treatment - Sc : Stover (2009)*

To build the ART and PMTCT uptake scenarios, we examined treatment coverage in 16 countries where HIV prevalence reached at least 5%. We distinguished between two groups: those where the maximum coverage of ART had reached 83% (9 countries), and those where it remained lower (7 countries). Trends in ART coverage for these countries are presented in Figure S3. A logistic growth curve fitted to these two sets of ART coverage trends helped to build the first two scenarios: rapid and slow increases in ART take-up. For these same countries, another logistic curve was fitted on PMTCT treatment coverage. This helps reflect the faster increase in

PMTCT coverage and the time lag between the two curves. In addition to the scenarios with rapid and slow scale-up of ART, a third scenario without any treatment was included.

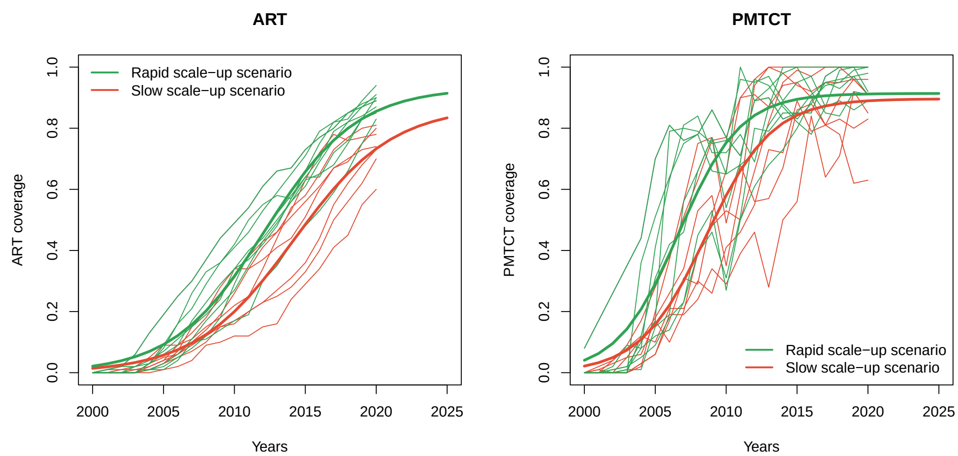

Figure S3 – *ART and PMTCT treatment coverage trends in 16 sub-Saharan African countries where prevalence has reached 5%.*
Sc: UNAIDS estimates extracted from `https://data.worldbank.org/`

Women were randomly recruited to the subgroup on ART at the beginning of each 5-year period, so as to achieve the desired coverage. To reflect the fact that historically pregnant women identified at antenatal clinics tended to initiate ART before other women, we prioritized women who were soon to give birth. Priority was given to women aged 15-49 who have reached the clinical stage and for whom SOCSIM has scheduled a birth as the next event. Women who have reached the clinical stage without a scheduled birth were second in the order of priority. They were followed by HIV-positive women who have not yet reached the clinical stage but have a birth scheduled in the next few months, and finally, other HIV-positive women aged 15-49, until we reached the expected ART coverage. This procedure ensures that PMTCT coverage increases faster than ART coverage.

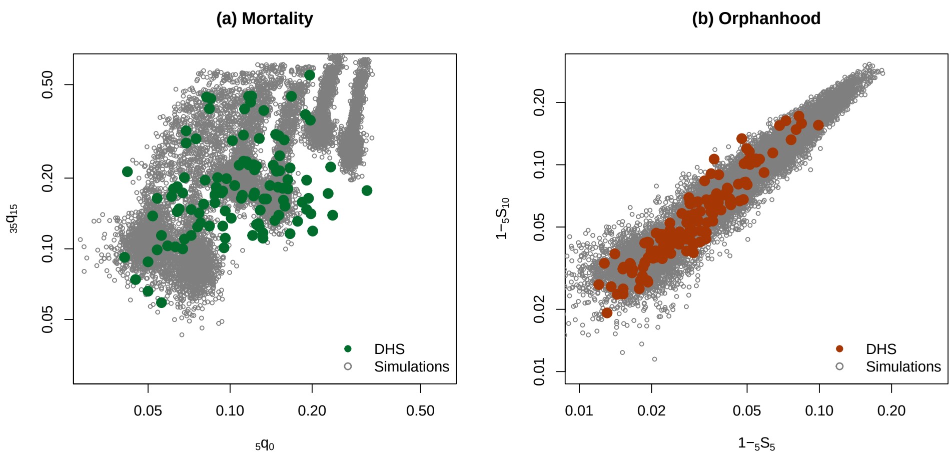

Figure S4 – *(a) Adult ($_{35}q_{15}$) and child ($_5q_0$) mortality in DHS surveys and in the set of simulations, (b) Orphanhood prevalence in DHS surveys and in the simulation set (in children aged 5-9 and 10-14).*

Appendix D Median ratios of estimated to true odds of surviving in simulations

	Pre-HIV		HIV epidemic								
Year	192	197	202	207	212	217	222	227	232	237	242
Coeff.: Timæus (1992) - Time location: Brass and Bamgboye (1981)											
${}_{10}p_{25}$	1.05	1.05	0.99	0.98	1.07	1.31	1.58	1.85	1.72	1.38	1.18
${}_{15}p_{25}$	1.02	1.01	0.98	0.94	0.98	1.12	1.41	1.77	1.68	1.35	1.18
${}_{20}p_{25}$	1.00	0.99	0.98	0.93	0.95	1.06	1.34	1.70	1.55	1.33	
${}_{25}p_{25}$	1.00	0.99	0.97	0.94	0.97	1.07	1.33	1.61	1.41	1.23	
${}_{30}p_{25}$	1.00	0.99	0.98	0.95	0.99	1.12	1.36	1.55	1.33	1.28	
${}_{35}p_{25}$	1.00	0.99	0.99	0.96	1.01	1.17	1.38	1.51	1.26		
${}_{40}p_{25}$	1.00	1.00	1.00	0.98	1.03	1.17	1.37	1.46	1.23		
${}_{45}p_{25}$	1.00	1.00	1.01	1.01	1.06	1.19	1.36	1.46	1.28		
Coeff.: Timæus and Nunn (1997) when HIV >= 5%, Timæus (1992) when HIV < 5% Time location: Brass and Bamgboye (1981)											
${}_{10}p_{25}$	1.05	1.05	0.99	0.98	1.07	1.15	0.97	1.04	0.90	0.69	0.59
${}_{15}p_{25}$	1.02	1.01	0.98	0.94	0.98	1.12	1.24	1.21	1.13	0.87	0.82
${}_{20}p_{25}$	1.00	0.99	0.98	0.93	0.95	1.06	1.34	1.51	1.22	0.95	
${}_{25}p_{25}$	1.00	0.99	0.97	0.94	0.97	1.07	1.33	1.61	1.31	0.96	
${}_{30}p_{25}$	1.00	0.99	0.98	0.95	0.99	1.12	1.36	1.55	1.33	1.32	
${}_{35}p_{25}$	1.00	0.99	0.99	0.96	1.01	1.17	1.38	1.51	1.26		
${}_{40}p_{25}$	1.00	1.00	1.00	0.98	1.03	1.17	1.37	1.46	1.23		
${}_{45}p_{25}$	1.00	1.00	1.01	1.01	1.06	1.19	1.36	1.46	1.28		
New coefficients on adjusted proportions Time location: synthetic cohorts											
${}_{10}p_{25}$	1.01	1.01	0.98	1.01	0.99	0.98	1.01	1.03	1.01	0.95	0.98
${}_{15}p_{25}$	1.00	1.00	0.99	1.03	1.01	0.98	0.99	1.04	1.02	0.95	1.00
${}_{20}p_{25}$	1.00	1.00	1.00	1.03	1.02	0.98	0.98	1.04	1.02	0.99	0.99
${}_{25}p_{25}$	1.00	0.99	1.00	1.02	1.01	0.99	0.98	1.03	1.02	1.00	1.00
${}_{30}p_{25}$	1.00	1.00	1.01	1.02	1.00	0.99	0.98	1.03	1.01	1.00	1.00
${}_{35}p_{25}$	1.00	1.00	1.01	1.02	1.00	0.99	0.98	1.03	1.01	0.99	0.99
${}_{40}p_{25}$	1.00	1.00	1.00	1.00	1.00	1.00	0.99	1.02	1.01	0.99	0.99
${}_{45}p_{25}$	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.03	1.01	1.00	0.99

Table S4 – *Median ratios of estimated to true odds of surviving in simulations with vertical transmission and reduced fertility*

Appendix E Prediction errors for models to correct bias in proportions

Model performance was evaluated using the root-mean-square error, and the maximum and minimum values of the median ratio of the estimated to the true odds of surviving. These metrics were first computed in a sample of 80% of all simulations, which served to obtain the coefficients. Then out-of-sample metrics were calculated based on values predicted from these coefficients in the remaining simulations.

	0-4 (n =5)		5-9 (n =10)		10-14 (n =15)	
RMSE	in-sample	out-of-sample	in-sample	out-of-sample	in-sample	out-of-sample
Model 1	0.00206	0.00207	0.00639	0.00667	0.01141	0.01038
Model 2	0.00186	0.00186	0.00429	0.00445	0.00555	0.00529
Model 3	0.00158	0.00157	0.00332	0.00346	0.00445	0.00418
Model 4	0.00157	0.00155	0.00333	0.00351	0.00465	0.00441
Model 5	0.00156	0.00155	0.00327	0.00343	0.00431	0.00406
Model 6	0.00148	0.00147	0.00309	0.00333	0.00462	0.00439
Model 7	0.00147	0.00146	0.00306	0.00330	0.00420	0.00399
	15-19 (n =20)		20-24 (n =25)		25-29 (n =30)	
RMSE	in-sample	out-of-sample	in-sample	out-of-sample	in-sample	out-of-sample
Model 1	0.01508	0.01419	0.01653	0.01460	0.01446	0.01471
Model 2	0.00548	0.00562	0.00552	0.00531	0.00574	0.00534
Model 3	0.00481	0.00496	0.00530	0.00515	0.00571	0.00535
Model 4	0.00548	0.00562	0.00552	0.00531	0.00574	0.00534
Model 5	0.00481	0.00496	0.00530	0.00515	0.00571	0.00535
Model 6	0.00548	0.00562	0.00552	0.00531	0.00574	0.00534
Model 7	0.00481	0.00496	0.00530	0.00515	0.00571	0.00535
	30-34 (n =35)		35-39 (n =40)		40-44 (n =45)	
RMSE	in-sample	out-of-sample	in-sample	out-of-sample	in-sample	out-of-sample
Model 1	0.01088	0.00996	0.00854	0.00917	0.01023	0.01005
Model 2	0.00652	0.00634	0.00782	0.00850	0.01023	0.01004
Model 3	0.00652	0.00634	0.00782	0.00849	0.01023	0.01004
Model 4	0.00652	0.00634	0.00782	0.00850	0.01023	0.01004
Model 5	0.00652	0.00634	0.00782	0.00849	0.01023	0.01004
Model 6	0.00652	0.00634	0.00782	0.00850	0.01023	0.01004
Model 7	0.00652	0.00634	0.00782	0.00849	0.01023	0.01004

Table S5 – *Prediction errors for candidate models for bias in proportions of mothers surviving*

Model 1: $\frac{{}_5S_n}{{}_5S_n^*} \sim \beta_0 + \beta_1\ HIV_t$

Model 2: $\frac{{}_5S_n}{{}_5S_n^*} \sim \beta_0 + \beta_1\ HIV_{t-n+2.5}$

Model 3: $\frac{{}_5S_n}{{}_5S_n^*} \sim \beta_0 + \beta_1\ HIV_{t-n+2.5} + \beta_2\ ART_{t-n+2.5}$

Model 4: $\frac{{}_5S_n}{{}_5S_n^*} \sim \beta_0 + \beta_1\ HIV_{t-n+2.5} + \beta_2\ PMTCT_{t-n+2.5}$

Model 5: $\frac{{}_5S_n}{{}_5S_n^*} \sim \beta_0 + \beta_1\ HIV_{t-n+2.5} + \beta_2\ PMTCT_{t-n+2.5} + \beta_3\ ART_{t-n+2.5}$

Model 6: $\frac{{}_5S_n}{{}_5S_n^*} \sim \beta_0 + \beta_1\ [\ HIV_{t-n+2.5} \times (1 - PMTCT_{t-n+2.5})]$

Model 7: $\frac{{}_5S_n}{{}_5S_n^*} \sim \beta_0 + \beta_1\ [\ HIV_{t-n+2.5} \times (1 - PMTCT_{t-n+2.5})\ ] + \beta_2\ ART_t$

Appendix F Prediction errors for models to convert proportions into life table survivorship probabilities

Model performance was again evaluated using the root-mean-square error, and the maximum and minimum values of the median ratio of the estimated to the true odds of surviving.

5-9 (n =10)	In-sample			Out-of-sample		
	RMSE	Max ratio	Min ratio	RMSE	Max ratio	Min ratio
Model 1	0.0110	1.1265	0.9063	0.0111	1.1236	0.9030
Model 2	0.0100	1.0781	0.8598	0.0101	1.0858	0.8635
Model 3	0.0090	1.0421	0.9226	0.0089	1.0449	0.9354
Model 4	0.0087	1.0555	0.9576	0.0087	1.0514	0.9570
Model 5	0.0100	1.0786	0.8609	0.0100	1.0884	0.8629
Model 6	0.0097	1.0825	0.8983	0.0097	1.0894	0.8979
Model 7	0.0093	1.0598	0.8724	0.0092	1.0679	0.8758
Model 8	0.0099	1.0682	0.8530	0.0099	1.0773	0.8536
Model 9	0.0086	1.0346	0.9475	0.0086	1.0352	0.9505
10-14 (n =15)	In-sample			Out-of-sample		
	RMSE	Max ratio	Min ratio	RMSE	Max ratio	Min ratio
Model 1	0.0134	1.1330	0.9272	0.0137	1.1125	0.9194
Model 2	0.0121	1.0852	0.8862	0.0125	1.0789	0.8809
Model 3	0.0108	1.0630	0.9172	0.0110	1.0548	0.9113
Model 4	0.0103	1.0621	0.9718	0.0105	1.0574	0.9692
Model 5	0.0120	1.0819	0.8828	0.0124	1.0725	0.8763
Model 6	0.0116	1.0804	0.9199	0.0121	1.0701	0.9116
Model 7	0.0108	1.0610	0.9002	0.0110	1.0525	0.8867
Model 8	0.0119	1.0763	0.8786	0.0123	1.0653	0.8732
Model 9	0.0100	1.0414	0.9547	0.0103	1.0365	0.9457
15-19 (n =20)	In-sample			Out-of-sample		
	RMSE	Max ratio	Min ratio	RMSE	Max ratio	Min ratio
Model 1	0.0150	1.1276	0.9499	0.0148	1.1300	0.9443
Model 2	0.0134	1.0843	0.9087	0.0136	1.0878	0.8931
Model 3	0.0128	1.0875	0.9160	0.0131	1.0848	0.9027
Model 4	0.0117	1.0584	0.9792	0.0120	1.0591	0.9583
Model 5	0.0133	1.0810	0.9061	0.0135	1.0844	0.8895
Model 6	0.0130	1.0770	0.9321	0.0133	1.0800	0.9284
Model 7	0.0120	1.0610	0.9390	0.0123	1.0612	0.9544
Model 8	0.0132	1.0742	0.9033	0.0134	1.0783	0.8875
Model 9	0.0113	1.0410	0.9806	0.0115	1.0402	0.9582
20-24 (n =25)	In-sample			Out-of-sample		
	RMSE	Max ratio	Min ratio	RMSE	Max ratio	Min ratio
Model 1	0.0168	1.1311	0.9670	0.0168	1.1446	0.9567
Model 2	0.0147	1.0752	0.9289	0.0148	1.0762	0.9143

Model 3	0.0144	1.0792	0.9309	0.0144	1.0800	0.9163
Model 4	0.0135	1.0520	0.9698	0.0135	1.0460	0.9535
Model 5	0.0147	1.0776	0.9288	0.0148	1.0771	0.9155
Model 6	0.0144	1.0730	0.9484	0.0146	1.0695	0.9455
Model 7	0.0139	1.0597	0.9562	0.0140	1.0583	0.9479
Model 8	0.0145	1.0686	0.9217	0.0146	1.0676	0.9081
Model 9	0.0131	1.0363	0.9706	0.0131	1.0272	0.9541
25-29 (n =30)	In-sample			Out-of-sample		
	RMSE	Max ratio	Min ratio	RMSE	Max ratio	Min ratio
Model 1	0.0190	1.1283	0.9713	0.0189	1.1299	0.9638
Model 2	0.0167	1.0667	0.9400	0.0168	1.0697	0.9376
Model 3	0.0165	1.0668	0.9401	0.0166	1.0688	0.9398
Model 4	0.0158	1.0437	0.9780	0.0159	1.0374	0.9789
Model 5	0.0167	1.0678	0.9411	0.0168	1.0697	0.9409
Model 6	0.0165	1.0615	0.9533	0.0167	1.0597	0.9538
Model 7	0.0161	1.0500	0.9606	0.0163	1.0474	0.9497
Model 8	0.0166	1.0603	0.9366	0.0167	1.0621	0.9377
Model 9	0.0156	1.0354	0.9790	0.0157	1.0317	0.9797
30-34 (n =35)	In-sample			Out-of-sample		
	RMSE	Max ratio	Min ratio	RMSE	Max ratio	Min ratio
Model 1	0.0209	1.1168	0.9748	0.0204	1.1032	0.9644
Model 2	0.0192	1.0527	0.9483	0.0188	1.0484	0.9374
Model 3	0.0192	1.0519	0.9480	0.0188	1.0477	0.9360
Model 4	0.0186	1.0348	0.9891	0.0182	1.0227	0.9736
Model 5	0.0192	1.0529	0.9488	0.0189	1.0479	0.9360
Model 6	0.0192	1.0486	0.9557	0.0188	1.0484	0.9438
Model 7	0.0187	1.0411	0.9672	0.0184	1.0288	0.9651
Model 8	0.0192	1.0502	0.9475	0.0188	1.0467	0.9355
Model 9	0.0185	1.0309	0.9855	0.0181	1.0139	0.9752
35-39 (n =40)	In-sample			Out-of-sample		
	RMSE	Max ratio	Min ratio	RMSE	Max ratio	Min ratio
Model 1	0.0220	1.0734	0.9717	0.0229	1.0821	0.9701
Model 2	0.0214	1.0348	0.9654	0.0221	1.0302	0.9668
Model 3	0.0214	1.0346	0.9654	0.0221	1.0300	0.9667
Model 4	0.0212	1.0245	0.9873	0.0218	1.0310	0.9775
Model 5	0.0214	1.0369	0.9672	0.0221	1.0313	0.9688
Model 6	0.0214	1.0367	0.9685	0.0221	1.0282	0.9727
Model 7	0.0213	1.0323	0.9634	0.0219	1.0353	0.9682
Model 8	0.0214	1.0331	0.9654	0.0220	1.0312	0.9646
Model 9	0.0211	1.0217	0.9880	0.0217	1.0296	0.9786
40-44 (n =45)	In-sample			Out-of-sample		
	RMSE	Max ratio	Min ratio	RMSE	Max ratio	Min ratio
Model 1	0.0240	1.0416	0.9574	0.0240	1.0363	0.9305

Model 2	0.0238	1.0314	0.9860	0.0237	1.0259	0.9709
Model 3	0.0238	1.0316	0.9860	0.0237	1.0258	0.9708
Model 4	0.0238	1.0320	0.9858	0.0237	1.0298	0.9709
Model 5	0.0240	1.0344	0.9571	0.0240	1.0294	0.9295
Model 6	0.0240	1.0361	0.9581	0.0239	1.0263	0.9299
Model 7	0.0240	1.0349	0.9562	0.0240	1.0298	0.9292
Model 8	0.0238	1.0288	0.9848	0.0237	1.0247	0.9693
Model 9	0.0237	1.0317	0.9902	0.0236	1.0267	0.9692

Table S6 – *Prediction errors for candidate models for converting proportions of mothers surviving into survival probabilities*

Model 1: ${}_np_{25} = \beta_0(n) + \beta_1(n)\ M + \beta_2(n)\ {}_5S(h)_{n-5}$

Model 2: ${}_np_{25} = \beta_0(n) + \beta_1(n)\ M + \beta_2(n)\ {}_5S(h)_{n-5} + \beta_3\ HIV_t + \beta_4\ ART_t$

Model 3: ${}_np_{25} = \beta_0(n)+\beta_1(n)\ M+\beta_2(n)\ {}_5S(h)_{n-5}+\beta_3\ HIV_t+\beta_4\ ART_t+\beta_5\ HIV_{t-n+2.5}+\beta_6\ ART_{t-n+2.5}$

Model 4: ${}_np_{25} = \beta_0(n) + \beta_1(n)\ M + \beta_2(n)\ {}_5S(h)_{n-5} + \beta_3\ HIV_t + \beta_4\ ART_t + \beta_5\ \Delta HIV + \beta_6\ \Delta ART$

Model 5: ${}_np_{25} = \beta_0(n) + \beta_1(n)\ M + \beta_2(n)\ {}_5S(h)_{n-5} + \beta_3\ [HIV_t \times (1 - ART_t)]$

Model 6: ${}_np_{25} = \beta_0(n) + \beta_1(n)\ M + \beta_2(n)\ {}_5S(h)_{n-5} \times [HIV_t \times (1 - ART_t)]$

Model 7: ${}_np_{25} = \beta_0(n)+\beta_1(n)\ M+\beta_2(n)\ {}_5S(h)_{n-5}+\beta_3\ [HIV_t\times(1-ART_t)]+\beta_4\ \Delta[HIV\times(1-ART)]$

Model 8 (two equations):

$\{{}_np_{25} = \beta_0(n) + \beta_1(n)\ M + \beta_2(n)\ {}_5S(h)_{n-5} + \beta_3\ HIV_t\}\ (ART_t = 0)$

$\{{}_np_{25} = \beta_4(n) + \beta_5(n)\ M + \beta_6(n)\ {}_5S(h)_{n-5} + \beta_7\ [HIV_t \times (1 - ART_t)]\}\ (ART_t > 0)$

Model 9 (two equations):

$\{{}_np_{25} = \beta_0(n) + \beta_1(n)\ M + \beta_2(n)\ {}_5S(h)_{n-5} + \beta_3\ HIV_t + \beta_4\ \Delta HIV\}\ (ART_t = 0)$

$\{{}_np_{25} = \beta_5(n) + \beta_6(n)\ M + \beta_7(n)\ {}_5S(h)_{n-5} + \beta_8\ [HIV_t \times (1 - ART_t)] + \beta_9\ \Delta[HIV \times (1 - ART)]\}\ (ART_t > 0)$

where

HIV_t or ART_t = HIV prevalence or ART coverage at the time of data collection (obtained as the average of estimates from each survey as we use two series to construct the synthetic proportion)

$HIV_{t-n+2.5}$ or $ART_{t-n+2.5}$ = HIV prevalence or ART coverage at the time of birth (average of estimates from each survey)

Δ HIV or Δ ART = difference between the two surveys in HIV prevalence or ART coverage at the time of data collection

Appendix G Data sources on maternal orphanhood prevalence

Proportions of orphans by age were calculated based on microdata in the IPUMS database, DHS and MICS, based on census reports available online, and on the DemoData database of the United Nations Population Division:

- Minnesota Population Center. Integrated Public Use Microdata Series, International: Version 7.3 [dataset]. Minneapolis, MN: IPUMS, 2020. https://doi.org/10.18128/D020.V7.3
- ICF. 2004-2017. Demographic and Health Surveys (various) [Datasets]. Funded by USAID. Rockville, Maryland: ICF [Distributor].
- Anna Bolgrien, Elizabeth Heger Boyle, Matthew Sobek, and Miriam King. IPUMS MICS Data Harmonization Code. Version 1.1 [Stata syntax]. IPUMS: Minneapolis, MN. , 2024. https://doi.org/10.18128/D082.V1.1
- United Nations DemoData: https://popdiv.dfs.un.org/DemoData/web/ - see Gerland, P. (2023, December). What's Beneath the Future: World Population Prospects. In Semaine Data-SHS, Dec 2023, Aix-en-Provence, France.

When the data could be disaggregated by gender of the respondent, we retained the proportions of surviving mothers computed from female respondents, as they were on average lower than in reports from males, possibly due to some age exaggeration in men (Ewbank 1981).

The mean age at childbearing was calculated based on the World Population Prospects which we used to make time-varying estimates (United Nations 2022).

Botswana	1971 Census, 2001 Census, 2007 Family Health Survey (MICS), 2011 Census, 2017 Survey
Cameroon	1960-1965 Enquête Démographique, 1978 World Fertility Survey, 1987 Census, 1991 DHS, 1998 DHS, 2000 MICS, 2004 DHS, 2005 Census, 2006 MICS, 2011 DHS, 2014 MICS, 2018 DHS
Central African Rep.	1988 Census, 1994-1995 DHS, 2000 MICS, 2006 MICS, 2010 MICS, 2018-2019 MICS
Côte d Ivoire	1978-1979 Enquête démographique à passages répétés, 1988 Census, 1994 DHS, 1998 Census, 2000 MICS, 2005 AIS, 2006 MICS, 2011-2012 DHS, 2016 MICS, 2021 DHS
Eswatini	1976 Census, 1986 Census, 1997 Census, 2000 MICS, 2006-2007 DHS, 2007 Census, 2010 MICS, 2014 MICS, 2021-2022 MICS
Kenya	1969 Census, 1973 Demographic Baseline Survey, 1977 National Demographic Survey, 1979 Census, 1983 National Demographic Survey, 1989 Census, 1993 DHS, 1998 DHS, 1999 Census, 2000 MICS, 2003 DHS, 2009 Census, 2014 DHS, 2022 DHS
Lesotho	1971-1973 Demographic Survey, 1976 Census, 1977 WFS, 1986 Census, 2000 MICS, 2001 Demographic Survey, 2004 DHS, 2006 Census, 2009 DHS, 2014 DHS, 2016 Census, 2018 MICS
Malawi	1966 Census, 1970-1972 Population Change Survey, 1977 Census, 1982 Demographic Survey, 1992 DHS, 1998 Census, 2000 DHS, 2004 DHS, 2006 MICS, 2008 Census, 2010 DHS, 2013-2014 MICS, 2015-2016 DHS, 2019-2020 MICS
Mozambique	1997 DHS, 1997 Census, 2003 DHS, 2007 Census, 2008 MICS, 2009 HIV-AIDS Indicator Survey, 2011 DHS, 2015 HIV-AIDS Indicator Survey
Namibia	1992 DHS, 2000 DHS, 2001 Census, 2006-2007 DHS, 2013 DHS
Rwanda	1991 Census, 1992 DHS, 1996 Socio-demographic Survey, 2000 DHS, 2000 MICS, 2002 Census, 2005 DHS, 2010 DHS, 2012 Census, 2014-2015 DHS, 2019 DHS
South Africa	1996 Census, 1998 DHS, 2001 Census, 2007 Community Survey, 2011 Census, 2016 Community Survey, 2016 DHS
Tanzania	1973 National Demographic Survey, 1978 Census, 1988 Census, 1991-1992 DHS, 1996 DHS, 1999 Reproductive and Child Health Survey, 2002 Census, 2003-2004 AIS, 2004-2005 DHS, 2007-2008 AIS/MIS, 2010 DHS, 2011 HIV-AIDS Indicator Survey, 2012 Census, 2015-2016 DHS, 2022 DHS
Uganda	1969 Census, 1988-1989 DHS, 1991 Census, 1995 DHS, 2000-2001 DHS, 2002 Census, 2006 DHS, 2011 DHS, 2014 Census, 2016 DHS
Zambia	1992 DHS, 1996 DHS, 1999 MICS, 2001-2002 DHS, 2007 DHS, 2010 Census, 2013-2014 DHS, 2018 DHS
Zimbabwe	1982 Census, 1992 Census, 1994 DHS, 1997 Inter-Censal Demographic Survey, 1999 DHS, 2002 Census, 2005-2006 DHS, 2009 MICS, 2010-2011 DHS, 2012 Census, 2014 MICS, 2015 DHS, 2019 MICS

Table S7 – *Data sources on maternal orphanhood prevalence used in this study*

Appendix H Trends in the probabilities ${}_{10}q_{25}$ based on orphanhood, using coefficients from Timæus and Nunn (1997)

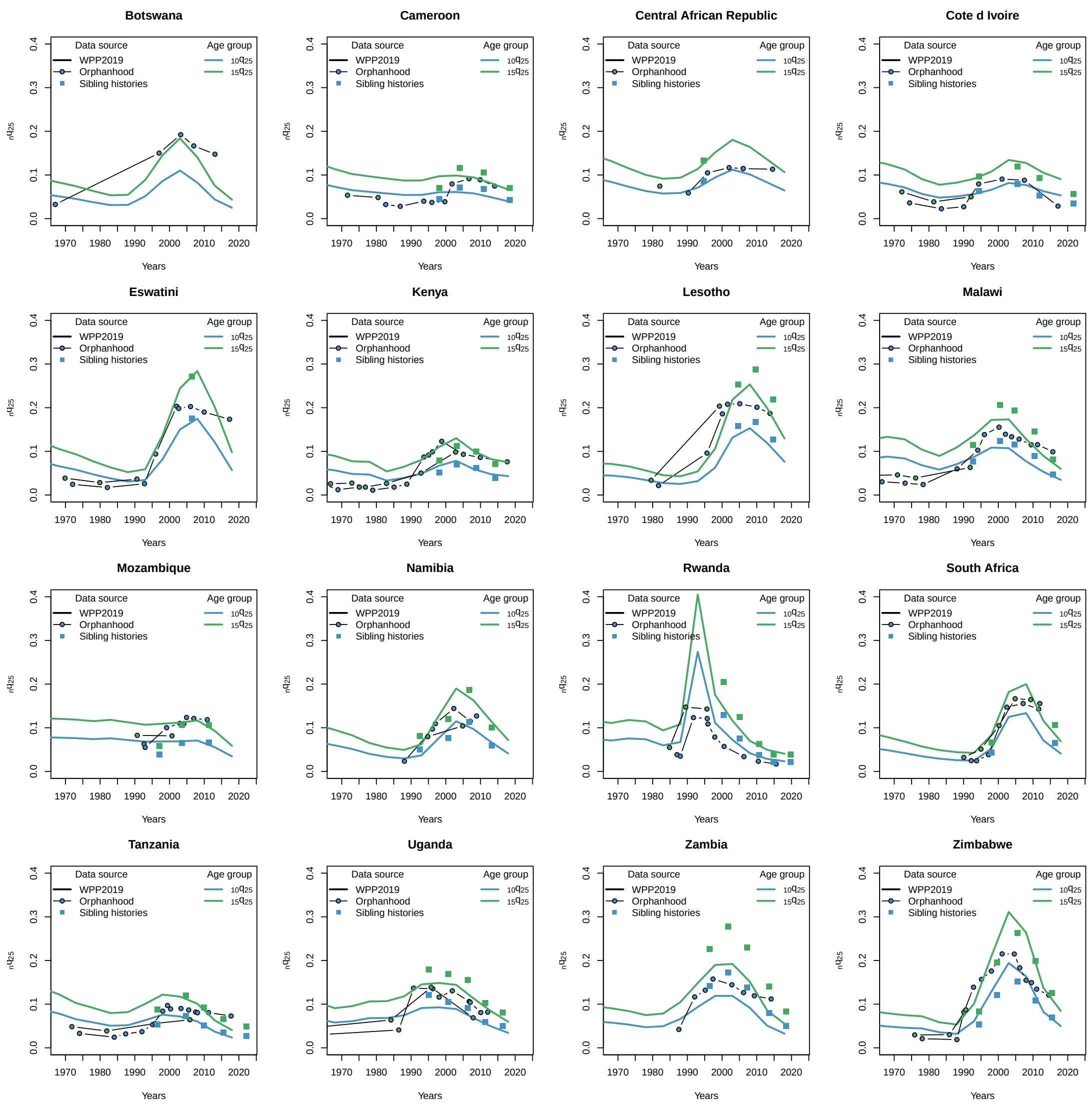

Figure S5 – *Trends in the probabilities ${}_{10}q_{25}$ based on orphanhood, using coefficients from Timæus and Nunn (1997) when HIV >= 5% and Timæus (1992) when HIV < 5%, from a single survey or census, estimates from WPP and sibling histories*

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Stover, J. 2009. AIM: A Computer Program for Making HIV/AIDS Projections and Examining the Demographic and Social Impacts of AIDS. Technical report, Washington, DC.

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