The Impact of AIDS Mortality on Indirect Estimates of Fertility

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The Impact of AIDS Mortality on Indirect Estimates of Fertility

This study investigates the impact of AIDS mortality on own-children fertility estimates in seriously affected countries.[1] Previous research has focused on the impact of AIDS mortality on direct and indirect estimates of child and adult mortality,[2] on the impact of AIDS epidemic-like regimes of rising child mortality and falling fertility,[3] and on the utility of own-children estimation of fertility in countries suffering from HIV/AIDS epidemics.[4] This study differs in that it investigates the bias in own-children estimates of total fertility rate (TFR) associated with the distortion in female adult mortality rates from AIDS. The study compares TFRs from Demographic and Health Surveys (DHS)[5] from 13 Sub-Saharan African countries calculated using life tables based on (1) estimated child mortality assuming a fixed level of life expectancy and North model mortality, (2) a trend in mortality level based on child mortality and North model mortality, and (3) a pattern of mortality incorporating AIDS. It concludes with a note about the sensitivity of own-children TFR estimates to differences between model mortality and with-AIDS mortality across three regions in Sub-Saharan Africa.

The Own-Children Technique

The own-children technique is an indirect technique for fertility estimation requiring the matching of children and their natural mothers from a census or survey data file followed by rejuvenation of both mothers and children to estimate age-specific fertility rates for the fifteen years prior to data collection (Cho 1973; Cho, Retherford and Choe 1986; Levin 2009). Assuming that the completeness of census enumeration is invariant across age groups, that there is no age misreporting, that the population is closed to migration, and that mortality levels are known, the rejuvenation process yields usable numerators and denominators for the calculation of age-specific and total fertility rates (ASFRs, TFRs). If the assumptions about coverage, age misreporting, and no migration are violated, the technique may provide some idea of past trend, if not accurate year-specific TFR levels. If past mortality pattern and levels are not available, ASFR estimates can still be generated but past levels of TFR and the general trend in fertility implied by the method may be biased.

The Impact of Age Pattern of Mortality on Own-Children Fertility Estimation

This study investigates the impact of misspecification of mortality level and pattern on own-children estimates of TFR for African countries affected by HIV/AIDS. That impact is estimated by comparing the estimated TFR time series from the own-children method using, as input, microdata files having relationship to head of household from recent Demographic and Health Surveys for three groups of countries and four alternative specifications of mortality.[6] The mortality specifications are:

(1A) Level of mortality determined by estimated under-5 mortality taken from the current life tables in the U.S. Census Bureau's International Data Base,[7] which are typically based on child survivorship from multiple censuses and surveys for sub-Saharan African countries. However, specification 1A assumes a fixed level of life expectancy (e(0)) for the 15-year period preceding data collection and

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[1] The term "seriously affected" countries refers to countries with HIV prevalence exceeding an estimated one percent of the general adult population.
[2] Timaeus and Nunn (1997), Ward and Zaba (1999), Mahy (2003), Hallett et al. (2010).
[3] Moultrie and Dorrington (2008).
[4] Avery et al. (2010).
[5] http://www.measuredhs.com/
[6] The most recent DHSs available for countries selected were used in the study. More recent DHSs either had not been completed (Cote d'Ivoire 2012, Uganda 2011, Mozambique 2011) or the datasets from these surveys were not available (Malawi 2010) when the work was conducted.
[7] http://www.census.gov/population/international/data/idb/informationGateway.php

North model mortality. For variant 1A, both-sexes e(0) is set equal to the level implied by the mean under-5 mortality rate for the 15-year period preceding the survey.

(1B) Level of mortality determined by estimated under-5 mortality taken from the current life tables in the U.S. Census Bureau's International Data Base, but with both-sexes e(0) set equal to the level implied by estimated under-5 mortality for the year of the DHS survey and North model mortality.

(2) A trend in mortality level, again based on Census Bureau estimates of child mortality and North model mortality, and

(3) The Census Bureau's actual age-specific mortality for each country, incorporating AIDS.

In general, patterns of mortality incorporating AIDS will be associated with larger numbers of rejuvenated women and lower past TFRs in the past than either the fixed e(0) or model mortality alternatives.

Series 2 has been generated by accepting the Census Bureau's sex-specific infant and under-5 mortality estimates for each of the 15 years preceding the DHS, then using North model mortality to complete sex-specific life tables for each year. Life table values q(x) and L(x) from these life tables were then used in the East-West Population Institute's program EASWESPOP[8] to reverse-survive women and their children and to calculate age-specific fertility and total fertility rates (ASFRs, TFR). Series 1A and 1B, which assume constant, North model mortality, are the least realistic of the listed models but are included to look at the sensitivity of TFR estimates to model specification. Estimated TFRs from these series have been generated by specifying either an average both-sexes e(0) or a survey year e(0) estimate taken from series 2 life tables, using EASWESPOP to rejuvenate women and children.. The EASWESPOP program itself suggests use of mortality for the survey year (series 1B) if only one life table (fixed mortality) is to be used. The third series has been generated by accepting with-AIDS q(x) and L(x) values from the Census Bureau's with-AIDS life tables (specifically modeled to reflect clinic-based and population-based estimates of HIV seroprevalence, country-specific anti-retroviral treatment (ART), and mother-to-child transmission rates. These are the life tables underlying the demographic indicators published in the Census Bureau's International Data Base. As with series 2, the q(x) and L(x) values are used to calculate rejuvenated women and children, and ASFRs, in EASWESPOP. Series 3 is the reference series for this analysis.

The countries used in the study are from Southern Africa, which has higher levels of HIV prevalence than other regions of Africa on average; East Africa, which has intermediate prevalence levels on average; and West Africa, which has lower prevalence levels on average. The countries, Demographic and Health Surveys used in the study, and HIV seroprevalence estimates for 2009 are shown in Table 1.

Table 1. Countries Used in This Study

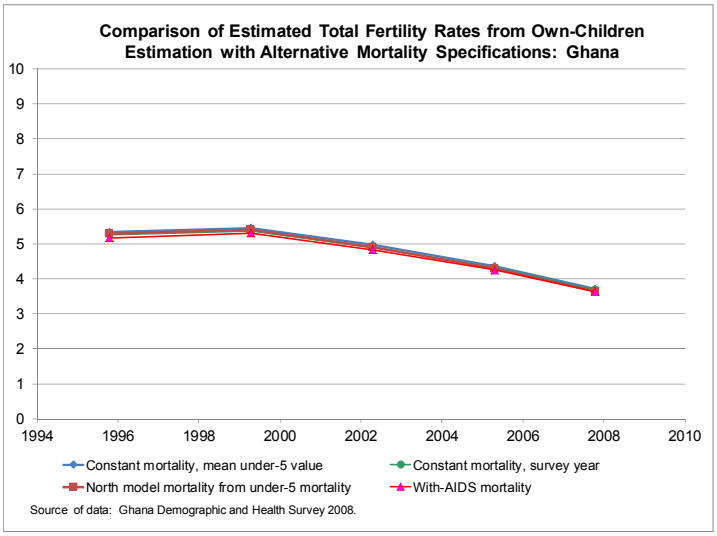
West Africa		East Africa		Southern Africa	
DHS	2009 Sero-prevalence*	DHS	2009 Sero-prevalence	DHS	2009 Sero-prevalence
Ghana 2008	1.8	Tanzania 2010	5.8	Mozambique 2003	11.5
Cote d'Ivoire 1998-99	3.4	Kenya 2008-09	6.3	Namibia 2006-07	13.1
Nigeria 2008	3.5	Uganda 2006	6.5	Zambia 2007	13.5
Cameroon 2004	5.3	Malawi 2004	11.0	Lesotho 2009	23.6
				Swaziland 2006-07	25.9

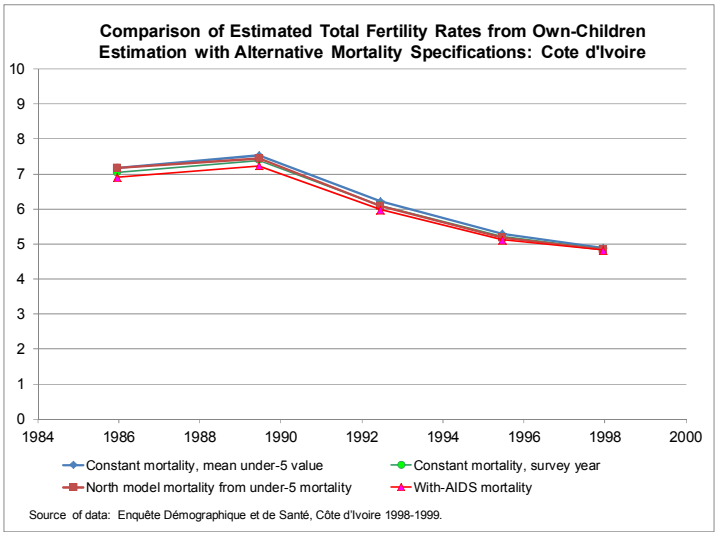
* Seroprevalence levels are from UNAIDS (2010: Annex 1).

Own-children estimates of total fertility incorporating alternative mortality specifications are shown in the following 13 charts (Figure 1) and in Table 2. The charts show average TFR estimates for 0 to 24 months prior to survey, 2 to 4 years, 5 to 7 years, 8 to 10 years, and 11 to 14 years prior to the survey using a

[8] http://www.eastwestcenter.org/research/research-program-overview/population-and-health/demographic-software-available-from-the-east-west-center/fertest.zip.

Figure 1. Own-children Estimates for Select West African Countries





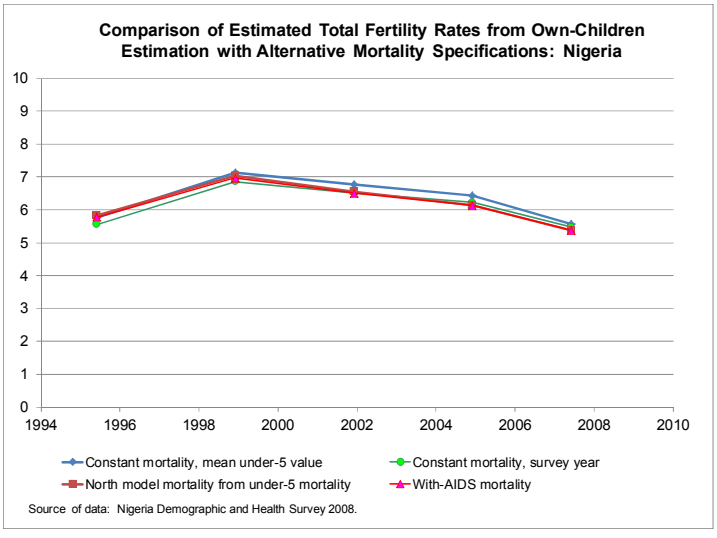


Figure 1. Own-children Estimates for Select West African Countries (cont.)

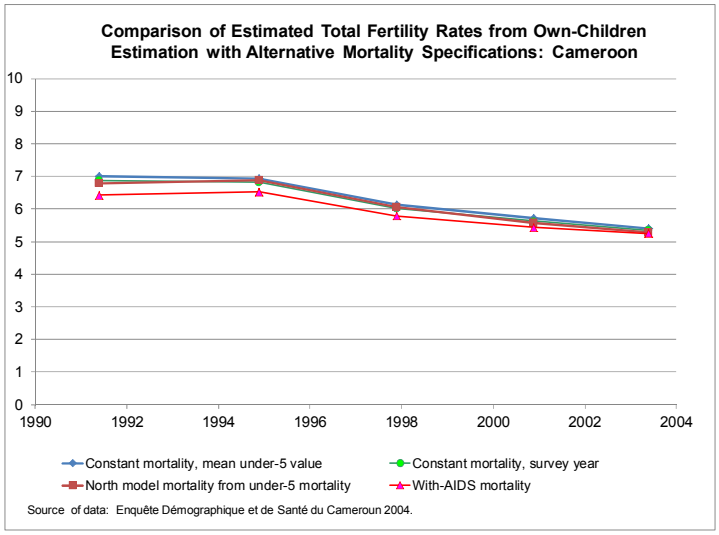
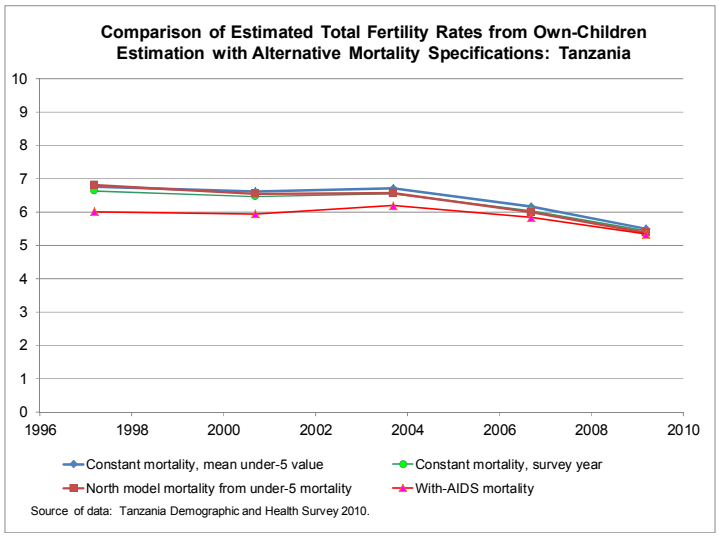


Figure 1. Own-children Estimates for Select East African Countries



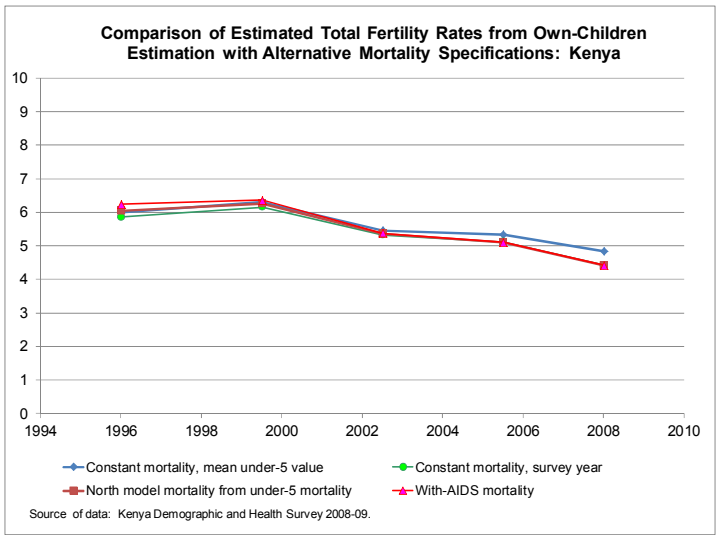
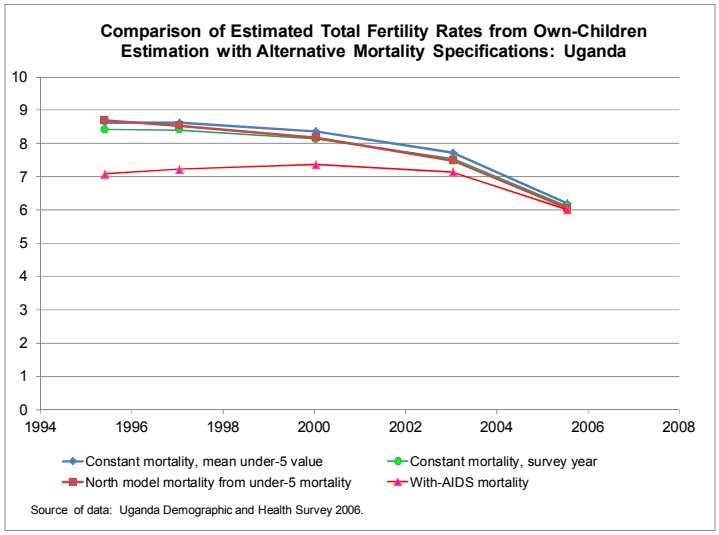


Figure 1. Own-children Estimates for Select East African Countries (cont.)



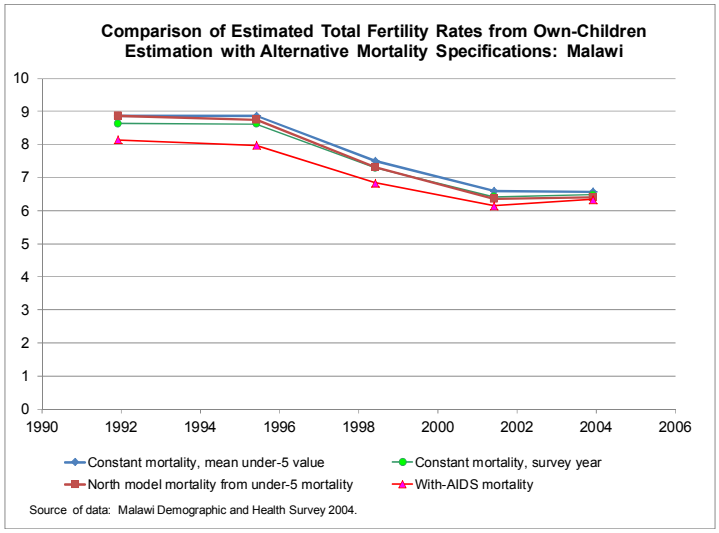


Figure 1. Own-children Estimates for Select Southern African Countries

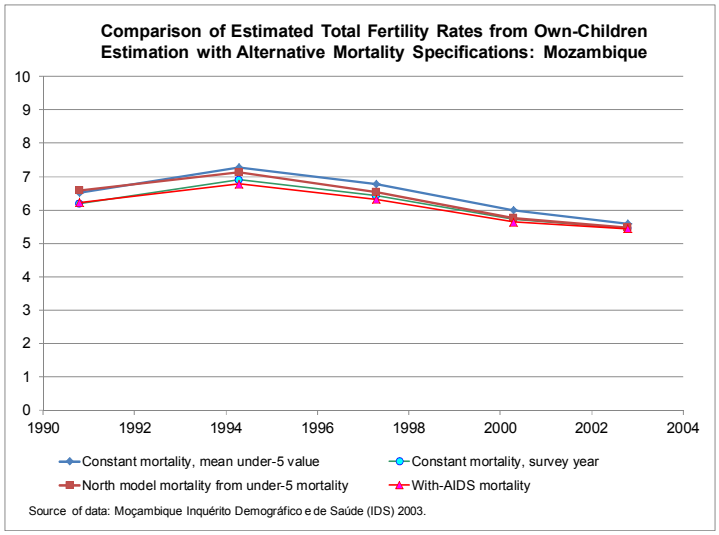
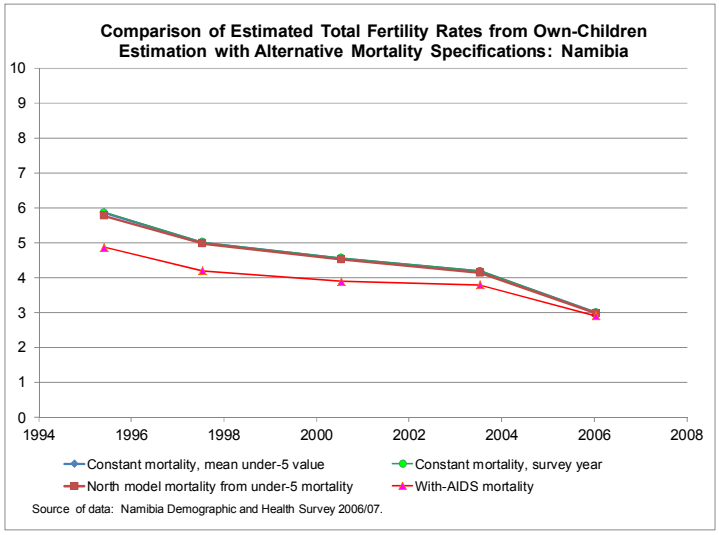
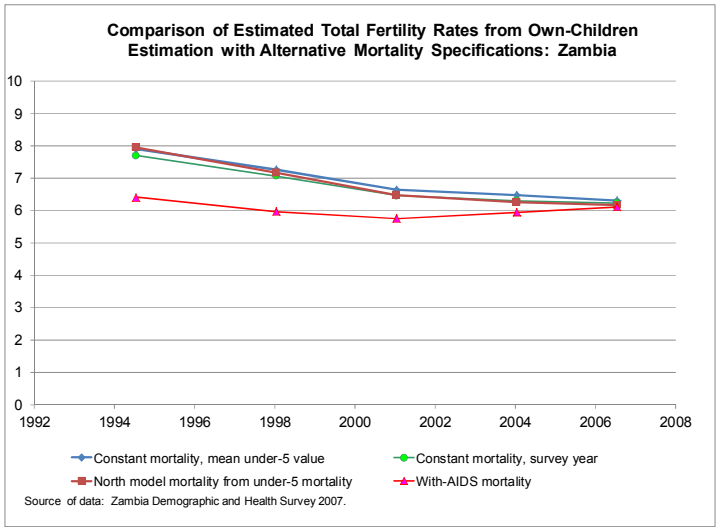


Figure 1. Own-children Estimates for Select Southern African Countries (cont.)





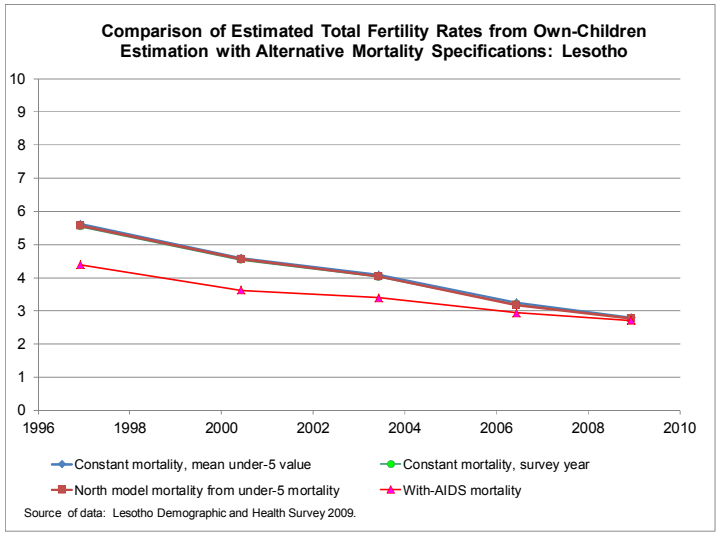
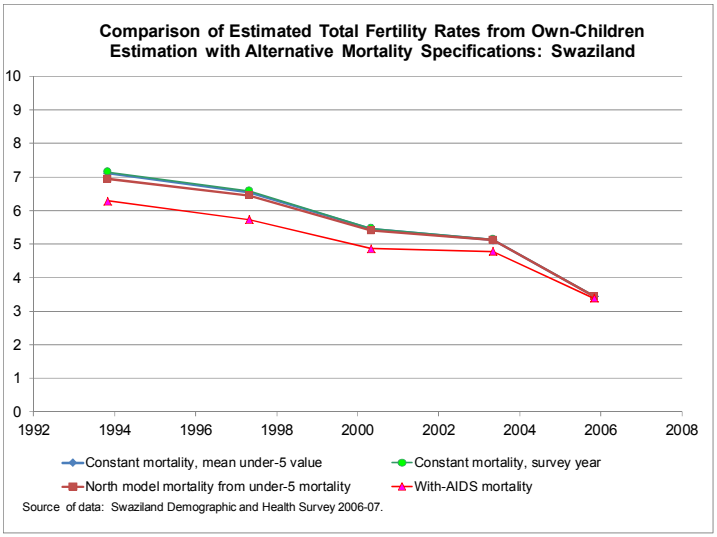


Figure 1. Own-children Estimates for Select Southern African Countries (cont.)



common set of under-5 mortality estimates for mortality level but alternative mortality patterns. Table 2 shows own-children estimates of TFR for the period 2 to 4 years prior to the survey based on estimated under-5 mortality levels and North model mortality patterns (series 1A, 1B, 2), as well as mortality based on both under-5 mortality and adult mortality incorporating the impact of HIV and AIDS (series 3). The differences between the four series are less than half a birth per woman on average: just under 0.2 births per woman for comparisons of series 2 and 3 for the 13 countries, 0.21 births per woman on average for comparisons of series 1B and 3, and 0.34 births per woman for comparisons of series 1A and 3. Biases (measured by the differences between series 1A, 1B and 2 vs. series 3) are larger for East and Southern Africa than for West Africa.

Figure 2 shows that the bias expressed in terms of the ratio for series 1B or 2 TFR estimates to series 3 TFR estimates varies directly with level of HIV seroprevalence: countries with higher HIV, and elevated young adult female mortality, have greater divergence between TFR estimated using a model and TFR estimated using a full mortality pattern, which incorporates the effect of AIDS. For the West African countries shown, the average ratio of TFRs, comparing series 2 and 3, is 0.99 (series 3 TFR being 1 percent lower than series 2 estimated TFR); for East Africa, 0.97; for Southern Africa, 0.94.

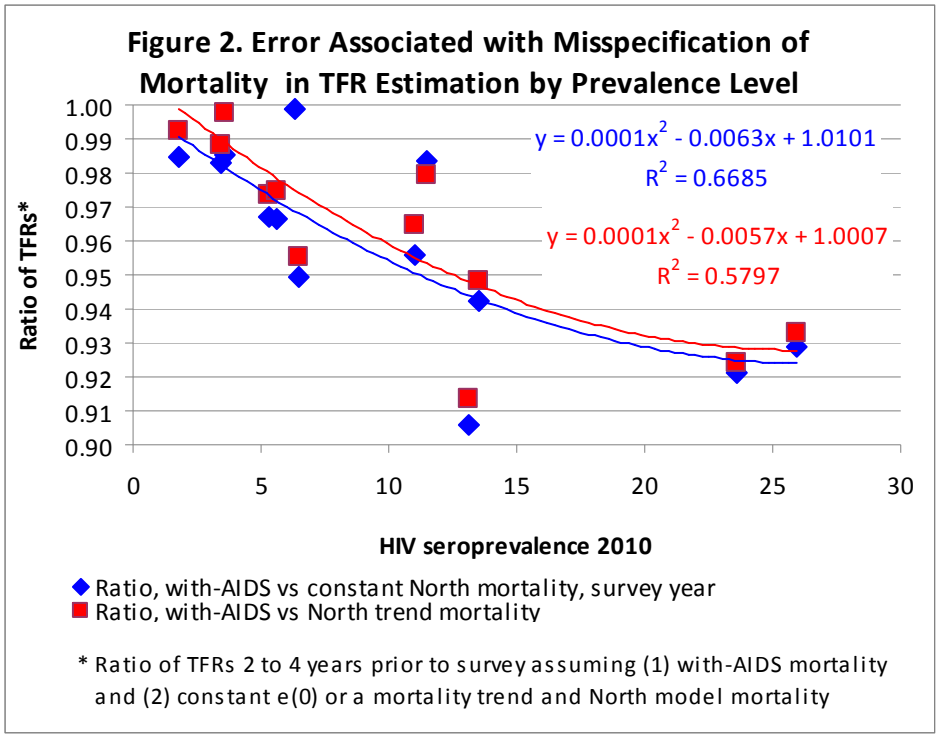
For the periods 5 to 7 years and 8 to 10 years prior to the survey, the differentials between the three TFR series estimated without AIDS mortality (1A, 1B, 2) and series 3 are larger (Figure 1). For the period 5 to 7 years prior to the survey, for example, the average ratios of TFRs, comparing series 2 and 3, is 0.98 for the four West African countries; 0.95 for East Africa; 0.89 for the Southern African countries.

Bias Associated with Specification of Mortality in Own-Children Estimates Compared with Uncertainty in TFR Estimates from Other Sources

One way of assessing whether the discrepancies found in TFR estimates for the 13 countries used in the study should be a concern is to compare the discrepancies with the 95-percent confidence intervals on the 3-year average direct estimates of TFR from the DHSs. The rationale for the comparison is this: If the difference between the first or second series and the reference series is less than the published 95 percent confidence interval (CI) for DHS direct estimates of TFR then perhaps the bias introduced by

Table 2. Comparisons of estimated TFRs for the period 2-4 years prior to survey for the series without AIDS mortality and the fourth series incorporating AIDS mortality

Country	Own-children TFR, 2-4 years prior to survey: (1A) Constant mortality, mean value	(1B) Constant mortality, survey year	(2) Trend, North model mortality	(3) With AIDS mortality	Absolute differences in TFRs for series: (1A) vs (3)	(1B) vs (3)	(2) vs (3)
West Africa					**0.22**	**0.11**	**0.06**
Ghana	4.37	4.32	4.28	4.25	0.12	0.07	0.03
Cote d'Ivoire	5.30	5.21	5.18	5.12	0.18	0.09	0.06
Nigeria	6.43	6.21	6.14	6.12	0.30	0.09	0.01
Cameroon	5.72	5.62	5.58	5.43	0.28	0.19	0.15
East Africa					**0.40**	**0.22**	**0.18**
Tanzania	6.16	6.04	5.99	5.84	0.32	0.20	0.15
Kenya	5.34	5.11	5.10	5.10	0.24	0.01	0.00
Uganda	7.72	7.53	7.48	7.15	0.58	0.38	0.34
Malawi	6.59	6.42	6.36	6.14	0.45	0.28	0.22
Southern Africa					**0.38**	**0.29**	**0.28**
Mozambique	6.00	5.73	5.75	5.64	0.37	0.09	0.12
Namibia	4.17	4.18	4.15	3.79	0.39	0.39	0.36
Zambia	6.47	6.31	6.28	5.95	0.53	0.36	0.33
Lesotho	3.24	3.20	3.18	2.94	0.29	0.25	0.24
Swaziland	5.11	5.14	5.12	4.78	0.34	0.37	0.34
Mean differences, 13 countries					0.34	0.21	0.18



misspecification of mortality in own-children fertility estimation should not be a major concern, because this source of error is overshadowed by sampling variability. Table 3 shows the comparison. For none of the 13 DHSs is the estimated bias (series 2,3) larger than the 95-percent confidence interval. Using the 95-percent confidence interval criterion for the series 2 vs. series 3 comparison suggests that the bias associated with specification of mortality in own-children fertility estimation is not, perhaps, an additional cause for concern.

Table 3. Comparison of DHS confidence intervals for TFR estimates (3-year averages) and series differences from with-AIDS TFR estimates (2-4 years prior to survey)

	95 percent confidence intervals for DHS direct estimates of TFR			Absolute differences in TFRs for series			Is CI larger than difference in series estimates		
Country	LB	UB	CI	(1A),(3)	(1B),(3)	(2),(3)	(1A),(3)?	(1B),(3)?	(2),(3)?
West Africa									
Ghana	3.78	4.28	0.50	0.12	0.07	0.03	Yes	Yes	Yes
Cote d'Ivoire	4.22	4.97	0.75	0.18	0.09	0.06	Yes	Yes	Yes
Nigeria	5.56	5.89	0.33	0.30	0.09	0.01	Yes	Yes	Yes
Cameroon	4.76	5.18	0.42	0.28	0.19	0.15	Yes	Yes	Yes
East Africa									
Tanzania	5.16	5.71	0.55	0.32	0.20	0.15	Yes	Yes	Yes
Kenya	4.22	4.90	0.68	0.24	0.01	0.00	Yes	Yes	Yes
Uganda	6.42	6.93	0.52	0.58	0.38	0.34	**No**	Yes	Yes
Malawi	5.84	6.25	0.40	0.45	0.28	0.22	**No**	Yes	Yes
Southern Africa									
Mozambique	3.07	3.20	0.13	0.37	0.09	0.12	**No**	Yes	Yes
Namibia	3.38	3.75	0.37	0.39	0.39	0.36	**No**	**No**	Yes
Zambia	5.84	6.50	0.66	0.53	0.36	0.33	Yes	Yes	Yes
Lesotho	3.07	3.53	0.46	0.29	0.25	0.24	Yes	Yes	Yes
Swaziland	3.63	4.07	0.44	0.34	0.37	0.34	Yes	Yes	Yes

An alternative metric involving comparison to DHS birth history-based direct estimates of TFR is not shown. This is the arguably obvious closeness of own-children estimates to the average birth history-based TFR estimate for the 3-year or 5-year period prior to the survey. This metric is not used for two reasons. First, birth history-based estimates of TFR have their own weaknesses, including birth date displacement,[9] and birth date displacement may affect TFR estimates for some of the countries used in this study. In the author's view, comparison of deviations of own-children TFR estimates to a questionable reference estimate would not add to the conclusions based on other metrics. Second, Avery et al. (2010) have suggested that own-children TFR estimates for some countries may be preferred to birth history-based estimates, which would argue against drawing conclusions based on a series of differences between own-children TFRs and birth history-based TFRs.

A second way of putting the mortality model-based bias into perspective is to compare the series differences to the range of fertility levels implied by the differences between direct and indirect estimates of fertility from the DHSs. The logic behind this comparison is like that presented in Table 3: If the difference between the series 2 and reference series TFR estimates for the period 2 to 4 years prior to survey are less than those between direct, birth-history-based estimates and indirect P/F ratio estimates, which already define the likely range for "true" TFR trend, then mortality pattern again may not represent

[9] Birth history displacement refers to the tendency, in some countries, for reported dates of birth for children to be transferred backward in time prior to interview. See Sullivan (2008).

a further source of concern. In Table 4, series 2 and 3 differences are compared with the differences between birth history-based direct estimates of TFR for the 3-year period prior to each survey and Brass P/F ratio estimates. This table shows that the estimated bias associated with using model mortality (column 2) is less than the range of TFR estimates based on birth history-based direct estimates and Brass P/F ratio indirect estimates (column 5) in 9 of 13 countries. The exceptions are Malawi and 3 of the 5 Southern African countries, where AIDS mortality is most severe and own-children-based TFR estimates are more affected by age pattern of mortality. This comparison, then, yields mixed results. For lower HIV prevalence countries in West Africa and East Africa, differences in estimated TFR associated with mortality misspecification are overshadowed by the range of uncertainty associated with direct and indirect estimates of TFR. However, for some countries in Southern Africa, where prevalence levels are higher, the impact of misspecification of mortality exceeds the range defined by estimation method.

Table 4. Indications of Bias in Own-children TFR Estimates

	95-percent confidence interval on DHS direct TFR estimates	Differences in TFR estimates, series 2 and 3	Direct TFR estimates, 3-year averages	P/F ratio adjusted TFR estimates*	Differences, direct and indirect TFRs**	Differences in extrapolated TFRs, series (2) and (3) ***
	(1)	(2)	(3)	(4)	(5)	(6)
West Africa		**0.06**			**0.38**	**-0.10**
Ghana	0.50	0.03	4.03	4.34	0.31	-0.07
Cote d'Ivoire	0.75	0.06	5.18	5.66	0.48	-0.09
Nigeria	0.33	0.01	5.72	6.00	0.28	-0.05
Cameroon	0.42	0.15	4.97	5.44	0.47	-0.19
East Africa		**0.18**			**0.55**	**-0.47**
Tanzania	0.55	0.15	5.44	5.96	0.53	-0.46
Kenya	0.68	0.00	4.56	5.15	0.59	0.08
Uganda	0.52	0.34	6.67	7.57	0.90	-1.00
Malawi	0.40	0.22	6.05	6.22	0.17	-0.51
Southern Africa		**0.28**			**0.22**	**-0.51**
Mozambique	0.13	0.12	5.54	6.12	0.58	-0.18
Namibi	0.37	0.36	3.57	3.63	0.07	-0.43
Zambia	0.66	0.33	6.17	6.59	0.43	-0.82
Lesotho	0.46	0.24	3.54	3.39	-0.15	-0.87
Swaziland	0.44	0.34	3.85	4.03	0.18	-0.23

* P/F ratio adjustment factors used were averages of ratios P2/F2 and P3/F3 based on reported child survivorship of women ages 20-24 and 25-29.
** Reference periods are ignored in this comparison. The DHS direct estimates refer to a 3-year period prior to the survey centered approximately 1.5 years before the midpoint of DHS fieldwork. The series 2 and 3 own-children point estimates are the average values for a period centered (after a half year offset) 3.5 years prior to the survey.
*** Extrapolations are linear, based on own-children average TFR estimates for the periods 2 to 4 years and 5 to 7 years prior to survey.

A third way of evaluating the differences between series 2 and series 3 estimates is to recognize the implied differences in TFR *trend* associated with choice of mortality pattern (Figure 1). That is, even if the difference between the TFR estimates for the period 2 to 4 years prior to survey are moderately small, trends in own-children TFR estimates based on alternate mortality patterns may imply quite different TFRs projected for 5 or 10 years into the future. Table 4 column 6 shows differences in TFR projected linearly to a point in time 5 years after survey, comparing series 2 and 3, for the 13 countries considered

in this study. The differences indicate that, by this metric, misspecification of mortality in own-children fertility estimation again matters for more seriously affected countries. The average bias for Southern African countries is half a birth in projected TFR just 5 years following the survey.

Summary and a Concluding Comment on Adjustment of Own-Children Estimates

Specification of mortality in own-children fertility estimation matters for countries seriously affected by HIV and AIDS as a group. Bias measured in terms of difference between estimates for the 2 to 4 years prior to survey are unacceptably large, on average, and would lead to large implied bias in projections, especially for countries with higher HIV prevalence levels.

As is true with some other estimation and projection procedures, the own-children fertility estimation technique benefits from the use of best available demographic inputs. For countries less affected by AIDS, the bias in TFR estimation from not using a pattern of adult mortality incorporating AIDS mortality may be comparable to that associated with misspecification of the level of mortality in other indirect estimation techniques, such as Rele's technique.[10] For more seriously affected countries, however, the advantage of using mortality pattern incorporating the impact of AIDS mortality in own-children fertility estimation is clearer.

Previous work on estimating biases associated with applying indirect estimation techniques to demographic data for populations affected by AIDS mortality has emphasized the potential impact of AIDS mortality, or of non-monotonically declining mortality, on resulting estimates (Ward and Zaba 1999, Moultrie and Dorrington 2008, Timaeus and Nunn 1997) but has avoided claiming that estimated bias for a single country or a simulated population could be extended to provide a generally applicable adjustment factor for other populations. The same disclaimer applies here even through thirteen rather than one or two countries are used in the analysis. It is tempting to suggest that the fitted equation from Figure 2,

$$y = 0.0001x^2 - 0.0057x + 1.0007$$

where y is the ratio of TFR estimated using with-AIDS mortality to TFR estimated using a level derived from under-5 mortality and North model mortality pattern, for the period 2 to 4 years prior to the survey, and
x is seroprevalence,

could be used to derive adjusted own-children TFR estimates for the period 2 to 4 years preceding a survey. However, it might be preferable to conclude, based on the evidence presented here, that the bias associated with failing to adjust is negligible at prevalence levels under 5 percent and that the bias for populations with prevalence levels above 5 percent may range from 3 percent (Malawi) to 9 percent (Namibia). The range of implied adjustment factors for two of the countries shown in Figure 2 – Namibia (13.1 percent seroprevalence, ratio of models 3 vs 2 being 91 percent) and Zambia (13.5 percent seroprevalence, ratio 95 percent) underscores the uncertainty involved and the need to use with-AIDS mortality when applying the own-children technique to census and survey data from seriously affected countries.

[10] Rele's technique (1967, 1989), which provides for estimation of gross reproduction rate (and TFR) given age structure, level of mortality, and the assumption of stability or near-stability, is considered to be relatively robust to misspecification of mortality level.

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