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THE EFFECT OF HIV ON CHILD MORTALITY
TRENDS IN SUB-SAHARAN AFRICA *

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INTRODUCTION

HIV has caused adult mortality rates to escalate rapidly in many countries of sub-Saharan Africa, and there is some indication that child mortality rates are also rising, possibly because of mother to child transmission. However, evidence for the causal role of HIV is relatively weak, for several reasons. First, background trends in child mortality from other causes may exacerbate or mask the deterioration in mortality due to HIV, making it difficult to detect changes attributable to HIV simply by monitoring time trends in overall child mortality. Secondly, methods of measuring child mortality that rely on retrospective reporting by mothers (either direct methods based on birth histories, or indirect methods using the Brass techniques) yield biased results in the presence of a strong correlation between the mortality of mothers and children. Finally, there are few community-based studies that measure the HIV status of infants and track their survival, because the persistence of maternal anti-bodies in the blood of infants makes the standard ELISA tests which are used for adults inappropriate for testing children. The alternative PCR tests that can detect the presence of the virus (as opposed to HIV antibodies) are very expensive and difficult to administer outside of a hospital setting.

This paper builds upon a series of investigations undertaken with funding from UNICEF to address these problems. It proposes a relatively simple method for estimating and projecting infant and child mortality levels in populations affected by HIV, given pre-epidemic trends in child mortality (or current estimates for mortality in uninfected children), an estimate of the mother to child transmission rate, and the widely available HIV prevalence data for pregnant women attending ante-natal clinics in sentinel surveillance sites.

The method is illustrated by applying it to six African countries with varying levels of background child mortality, and divergent experiences of HIV epidemics, described schematically in table 1. Results are presented in terms of estimates of infant and child mortality levels, and comparative statistics such as HIV attributable mortality which measures the excess mortality in the population as a whole due to HIV.

Previous attempts to make such estimates have been undertaken, notably by UNAIDS [Walker et al, 2002], but the methods presented in this paper represent an advance in terms of simplicity and transparency, as they do not rely on a knowledge of age-specific fertility rates of infected and uninfected mothers, and the dependency on models (as opposed to empirical data) is kept to a minimum.

TABLE 1: COUNTRIES CHOSEN TO ILLUSTRATE HIV CHILD MORTALITY IMPACT METHODOLOGY

Country	Child mortality pre-HIV	HIV epidemic characteristics
Botswana	Low, slow decline	Late start, explosive growth, v. high prevalence
Kenya	Moderate, little change	Mid- start, steady growth, high prevalence
Uganda	High, steady decline	Early start, now falling, moderate prevalence
Senegal	High, rapid decline	Early start, no growth, low prevalence
Zimbabwe	Low, slow decline	Early start, rapid growth, v. high prevalence
Malawi	Very high, rapid decline	Mid- start, steady growth, high prevalence

Methods

Empirical estimates of infant and child mortality rates by HIV status of the child are not generally available at a national level, and the methods described below explain how they can be estimated based on historical trends and a standard survival curve for "net" HIV mortality. However, countries which conduct DHS+ surveys in which the HIV status of adults is determined may soon be in a position to obtain reasonably up to date estimates of the mortality of uninfected children based on birth histories supplied by uninfected mothers. The reports of HIV negative women will not be biased by excessively high correlation between mother and child

mortality, although they will be unrepresentative for the population as a whole. If available, these should be used to estimate the mortality of uninfected children in preference to projected rates from before the start of the epidemic.

Mortality of HIV negative children – projection method

Published time series of national mortality estimates usually include the probabilities of dying by age 1 (infant mortality) and age 5 (child mortality). In order to make sure that these values are applicable for uninfected children, estimates from before or very early on in the epidemic must be used and projected to the year required. Changes in the burden of disease over time can change not only the overall level of mortality in childhood, but also the relationship between levels of mortality at younger ages compared to older ages. A flexible and sensitive projection method should allow for this. The method proposed below is a variant of a procedure that is widely used in official projections made by the UN Population Division [1989] and other institutions. Linear trends in the parameters that govern the level and shape of mortality are extrapolated using a relational logit model of mortality, since it has been shown (Brass, 1971) that mortality schedules are linearly related on the logit scale.

The logit transformation is defined as

$$Y(x) = \ln\left\{\frac{q(x)}{l(x)}\right\}$$

---(1)

Where $q(x)$ and its complement $l(x) = 1 - q(x)$ are the probabilities of dying before age x and surviving to age x respectively.

Comparing observed historical values to an appropriate reference standard (such as a UN model lifetable), the parameters of the linear relationship of the observed mortality schedule with respect to the reference are given by:

$$\text{slope} = \beta = \frac{Y_O(5) - Y_O(1)}{Y_S(5) - Y_S(1)}$$

$$\text{intercept} = \alpha = Y_O(5) - \beta \cdot Y_S(5)$$

---(2)

where the subscripts *O* and *S* denote observed and standard values respectively.

Evaluating α and β at two time points, t_1 and t_2 allows these parameters be projected linearly to the date required, e.g. at an arbitrary time point t in the future, we have:

$$\alpha(t) = \frac{t - t_1}{t_2 - t_1} \cdot [\alpha(t_2) - \alpha(t_1)]$$

$$\beta(t) = \frac{t - t_1}{t_2 - t_1} \cdot [\beta(t_2) - \beta(t_1)]$$

---(3)

Survival probabilities for uninfected children at any future time t are given by:

$$l_U(x,t) = \frac{1}{1 + \exp\{\alpha(t) + \beta(t) \cdot Y_S(x)\}}$$

---(4)

The illustrative examples presented in the results section use national estimates of infant and child mortality published by the UN Population Division [2002]. The time points, t_1 and t_2 chosen to evaluate pre-HIV

mortality levels and trends are shown in table 2, together with infant and child mortality rates observed in these years. The points were chosen 10 years apart to obtain a reasonable estimate of the long term trend, with the later point corresponding to the latest year in which UNAIDS estimates suggest that prevalence in the general adult population was still below 1 per cent.

TABLE 2: PRE-EPIDEMIC INFANT AND CHILD MORTALITY RATES (PER THOUSAND LIVE BIRTHS)

Country	year 1	IMR	CMR	year 2	IMR	CMR
Botswana	1981	56	83	1991	38	53
Kenya	1977	64	105	1987	61	90
Uganda	1976	133	222	1986	98	177
Senegal	1978	113	279	1988	88	195
Zimbabwe	1976	55	92	1986	49	71
Malawi	1980	138	259	1990	135	234

Source: UN Population Division, 2002

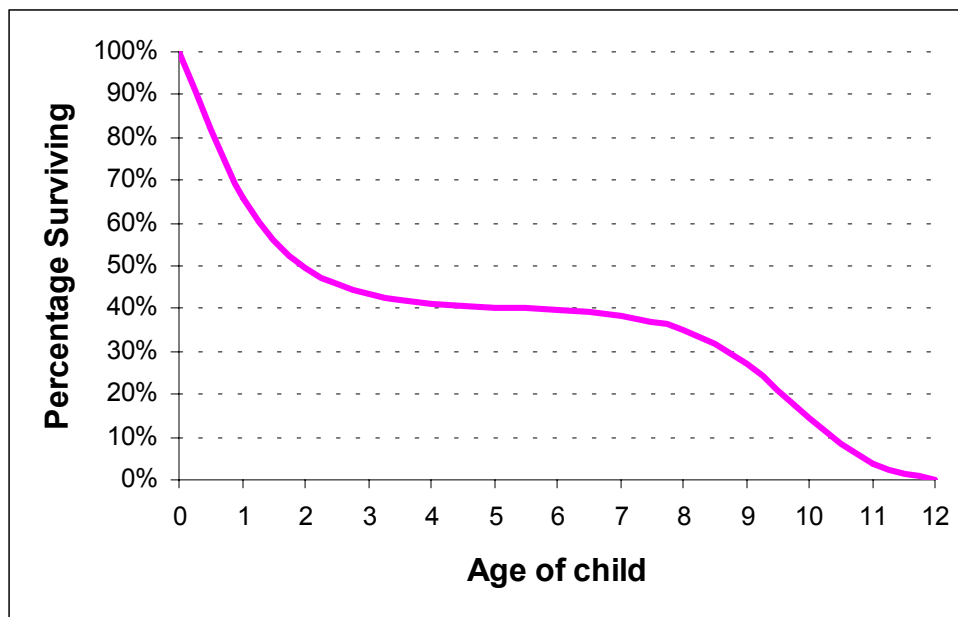*Net and gross mortality of infected children – the Weibull model*

Fewer HIV infected children will survive in a high mortality setting than in low mortality populations. A model pattern of "net" AIDS mortality has been constructed [Marston et al 2003], to represent the theoretical survival pattern observed if HIV related causes were the only ones operating for infected children. Age specific "net" mortality risks can be combined with mortality risks experienced by uninfected children to yield the "gross" overall mortality experienced by infected children.

It has been suggested [Spira et al, 1999; Peckham & Gibb, 1995; Kuhn et al, 1999] that HIV infected infants who acquired the infection in utero experience a more rapid progression through the disease stages leading to AIDS and death, than those acquiring the infection at parturition or during breastfeeding. The theoretical form of the survival curve for HIV mortality in paediatric infections embodying this frailty assumption has been described by Shearer et al [2000], and by the UNAIDS reference group [2002] as taking the form of a double Weibull:

$$l_N(x) = \pi \cdot \exp\left\{-\left[\lambda_1 \cdot x\right]^{\mu_1}\right\} + (1-\pi) \cdot \exp\left\{-\left[\lambda_2 \cdot x\right]^{\mu_2}\right\} \qquad \text{---(5)}$$

where λ_1, μ_1, λ_2 and μ_2, are parameters of the component Weibull curves describing mortality amongst rapid- and slow- progressors respectively; and π is the proportion of children who progress rapidly. The parameter values that were found to give the best fit to a wide range of net survival data measured in clinic- and community- based cohorts were: $\pi = 0.610$, $\lambda_1 = 0.830$, $\mu_1 = 1.140$, $\lambda_2 = 0.100$, $\mu_2 = 10.000$. The curve, shown in figure I, indicates that even if mortality from non-HIV related causes were negligible, over a third of infected children would die before their first birthday, nearly two thirds by age five and virtually none would be expected to live beyond age 12.

Figure I. The double Weibull representation of "net" mortality due to HIV

Gross survival probability to age x for HIV infected children, $l_I(x)$ or their cumulated mortality, $q_I(x)$, can be calculated from the net probability of HIV infected children surviving, $l_N(x)$, and the probability of uninfected children surviving, $l_U(x)$, using the usual relationships for cause deleted life tables:

$$l_I(x) = l_N(x) \cdot l_U(x)$$
$$q_I(x) = q_N(x) + q_U(x) - q_N(x) \cdot q_U(x)$$

---(6)

Child mortality in the population as a whole

To calculate child mortality in the whole population, we need to know the proportion of children infected, who experience the mortality schedule $q_I(x)$, whilst uninfected children, the complement of this proportion, experience the schedule defined by $q_U(x)$. The proportion of HIV infected children, h, is the product of prevalence among mothers, p, and the vertical (mother to child) transmission probability, v:

$$h = p \cdot v$$

---(7)

National estimates of HIV prevalence among mothers are widely available from sentinel surveillance in ante-natal clinics, though care must be taken to weight results from rural and urban clinics to ensure that the weighted average reflects the rural and urban population composition of the country. Prevalence levels shown in figure II are taken from national estimates published by UNAIDS [2003]. These have been smoothed by UNAIDS, using maximum likelihood techniques to fit a model of epidemic growth to weighted prevalence data from individual ANC clinics.

Figure II. Trends in HIV prevalence, 1990-2000
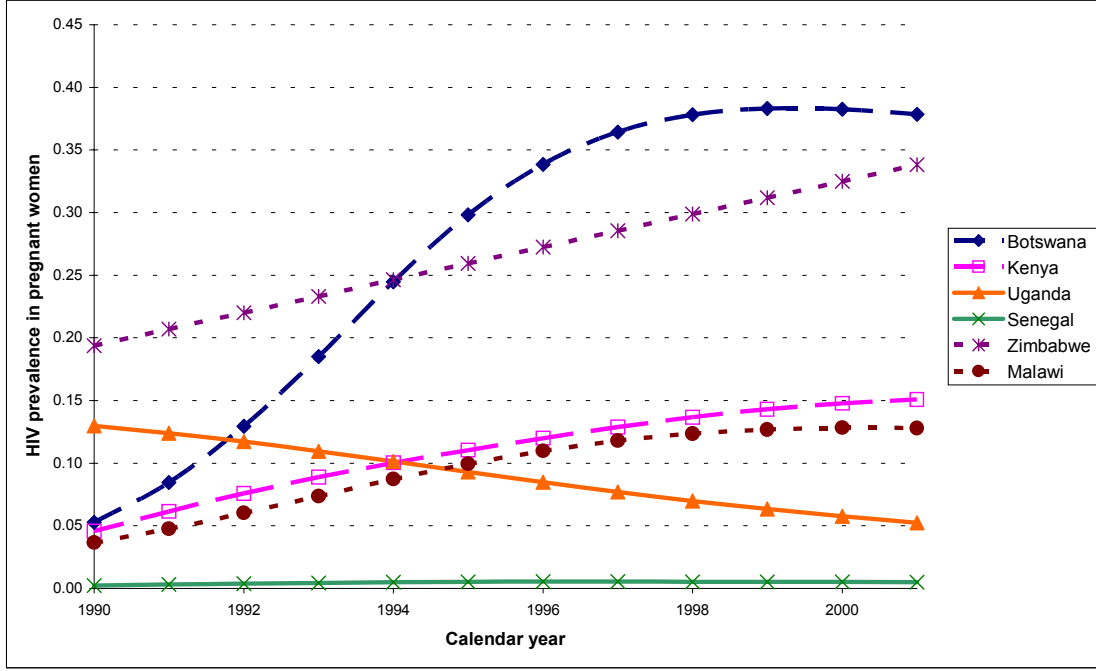
Source: UNAIDS, 2003 (data in appendix table 1).

Vertical transmission rates have been estimated to lie between 25 per cent and 45 per cent in breastfeeding populations, [Nicoll et al, 2000], an average value of 35 per cent is used in this paper. It is a simple matter to adapt the method to model a lower vertical transmission ratio to represent the effects of anti-retroviral therapy for prevention of mother to child transmission, but since this kind of intervention is not yet widely available such scenarios have not been constructed for the present application.

Allowing for the proportion of infected children in the cohort, the overall child mortality schedule is given by:

$$q_A(x) = (1-h) \cdot q_U(x) + h \cdot q_I(x)$$
$$= q_U(x) + hq_N(x) - hq_U(x) \cdot q_N(x) \qquad \text{---(8)}$$

where the second expression is obtained by substituting the formula for $q_I(x)$ derived in equation (6). We ignore the fact that infants infected through breast feeding initially experience the mortality risks of uninfected children, as an allowance for this has been built into the shape of the net mortality Weibull function.

Population attributable fraction of mortality

The HIV population attributable mortality fraction is the proportion by which mortality rates or probabilities would be reduced in the population as a whole if HIV/AIDS was eliminated. For infant and child mortality measures it is defined as:

$$Population\ Attributable\ Mortality = \frac{q_A(x) - q_U(x)}{q_A(x)} \qquad \text{---(9)}$$

6

This can be expressed in terms of net mortality from HIV among infected children and mortality of uninfected children, by substituting the expression for $q_A(x)$ from equation 8 into equation 9 and simplifying, then substituting for h from equation (6):

$$Population\ Attributable\ Mortality\ = \frac{h \cdot q_N(x) - h \cdot q_U(x) \cdot q_N(x)}{q_U(x) + h \cdot q_N(x) - h \cdot q_U(x) \cdot q_N(x)}$$

$$= \left[1 + \frac{q_U(x)}{p \cdot v \cdot q_N(x) \cdot (1 - q_U(x))}\right]^{-1} \qquad ---(10)$$

Results

The results below are presented graphically with reference to child mortality, cumulated to age 5, which captures more of the impact of HIV than infant mortality. Tables showing annual estimates of both infant and child mortality are provided in the appendix. Where an analysis of trends in infant mortality indicates substantial differences from the child mortality patterns this is noted in the explanatory text.

According to UN population division estimates, mortality in uninfected children was set to decline in all six countries, with the possible exception of Kenya, where it had been stagnating since the mid 1980s. Although the figure suggests that the steepest absolute decline was expected in Malawi, this is primarily a consequence of the historically very high child mortality rates in that country – the proportionate declines between 1990 and 2000 were in fact highest in Senegal and Zimbabwe. Infant mortality estimates showed a broadly similar pattern, except that Senegal was projected to have 20 per cent lower infant mortality among children born to uninfected mothers over the whole time period compared to Uganda – it is very high mortality among 1-4 year olds in Senegal that brings the estimates of child mortality for uninfected children in these two countries so close in figure III.

Figure III. Projected child mortality for uninfected children, 1990-2001
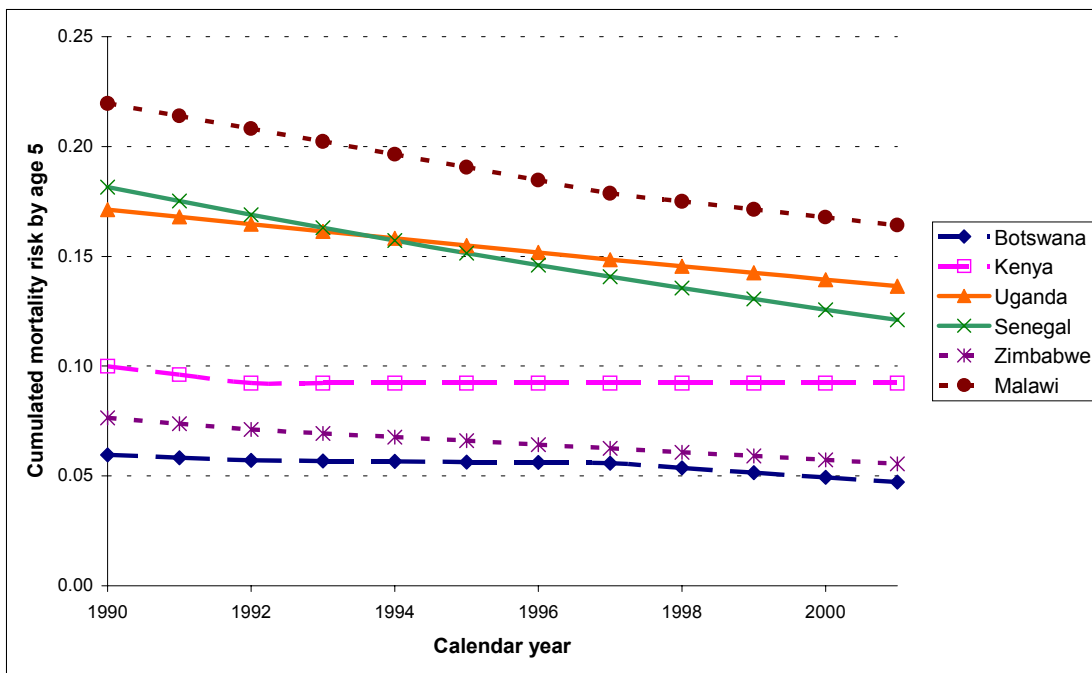
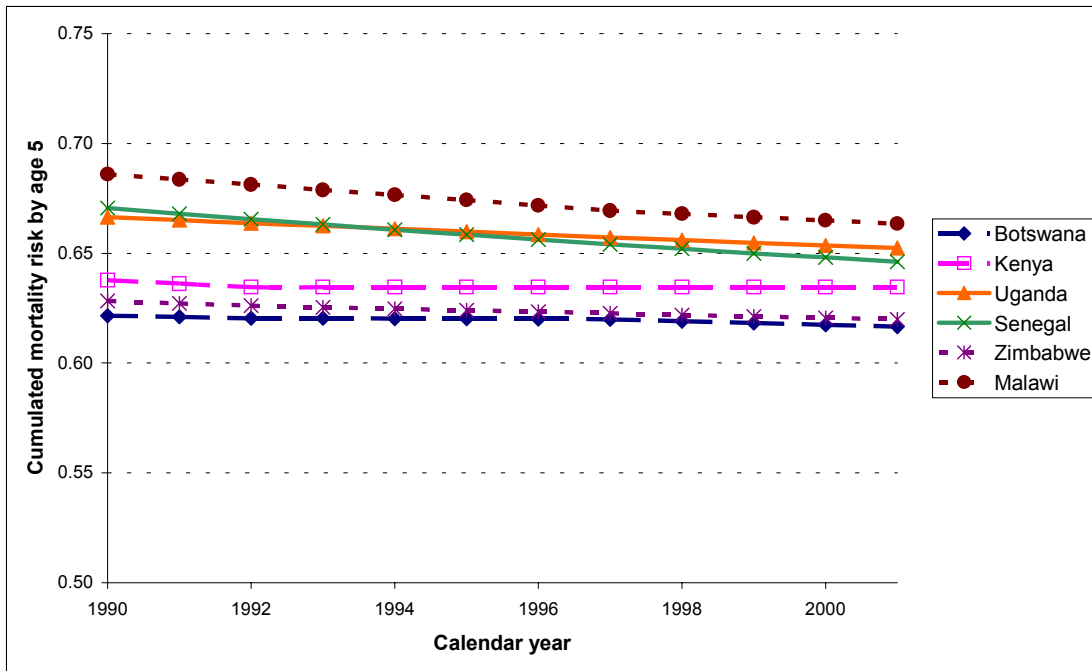**Figure IV. Estimated child mortality for infected children, 1990-2001**

Figure IV shows the estimated levels for child mortality in infected children over the same time period in these six countries. Clearly the mortality rates for infected children are much higher (four to ten times as high) than the rates for the uninfected. The country-specific rates are also much more narrowly distributed (range 5 per thousand) than the rates for uninfected children (range 150 per thousand), as the main determinant is the net mortality associated with HIV, other cause mortality plays a relatively minor role.

Figure V shows child mortality trends for the decade in the population as a whole, and provides the most vivid illustration of the reversals brought about in the relatively low mortality countries: Botswana, Zimbabwe and Kenya. In Botswana child mortality is estimated to have almost doubled from around 70 per thousand in 1990 to 130 per thousand in 1999. By contrast, high mortality countries such as Malawi, may continue to experience an overall decline in child mortality if they manage to sustain the rapid rate of decline in non-HIV related child mortality that was evident in the 1980s. In Uganda the overall decline is steeper than in Malawi, as the projected decline in other cause mortality coincides with an estimated decrease in the prevalence of HIV. In Senegal, the low prevalence of HIV means that at the population level there is virtually no difference between the overall mortality estimates and the projections for HIV negative children.

Figure V. Estimated child mortality for population as a whole, 1990-2001
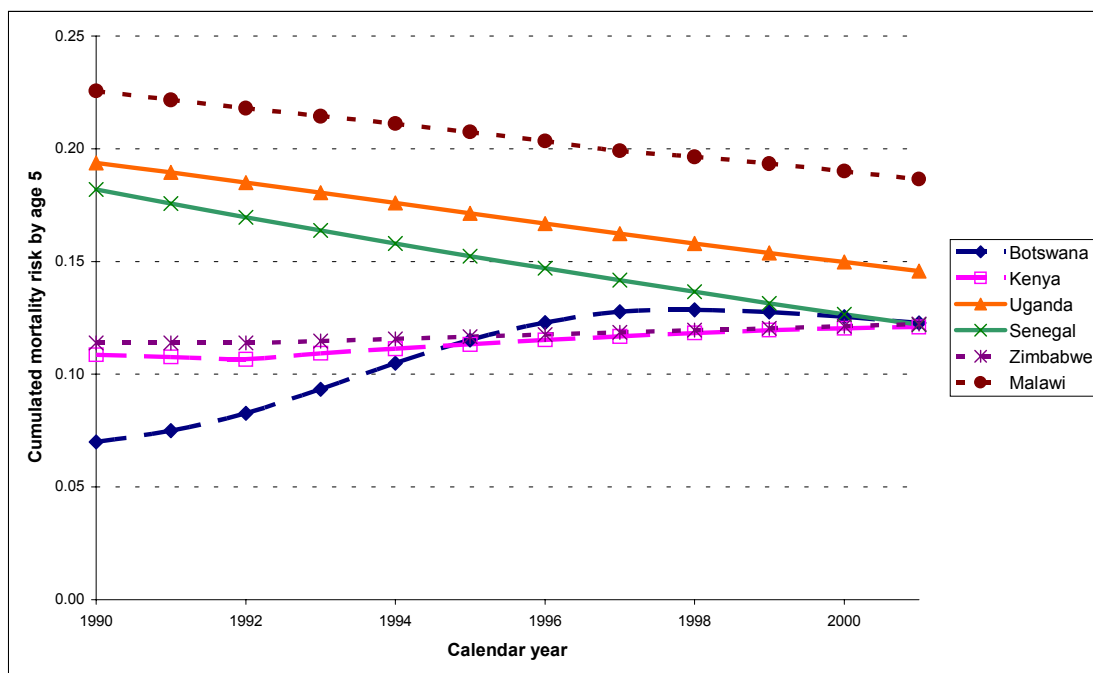

Figure VI displays the proportion of the overall mortality that is attributable to HIV: showing how much lower, proportionately, child mortality would be in the absence of HIV. Uganda, with declining HIV prevalence in this decade is the only country in which the fraction of child mortality attributable to HIV has declined. In Botswana and Zimbabwe where background mortality is low and prevalence is high, HIV attributable mortality is now over 50 per cent. The rise in PAF is most dramatic in Botswana, because of the relatively late start and explosive increase in the HIV epidemic in that country.   Malawi shows a steady increase in PAF in spite of the estimated overall decline in child mortality, as the projected rapid decline in mortality from other causes means that overall child mortality and mortality of HIV negative children diverge over time.

The importance of background mortality in determining PAF is made clear by comparing Uganda and Botswana. In 1992 these countries had approximately the same HIV prevalence, around 12 per cent (see fig 2), but figure 6 shows that PAF was already much higher in 1992 in Botswana (around 40 per cent) than in Uganda (around 10 per cent) because of higher background mortality in Uganda – 210 per thousand as opposed to 60 per thousand in Botswana.

Figure VI. HIV population attributable fraction of child mortality, 1990-2001
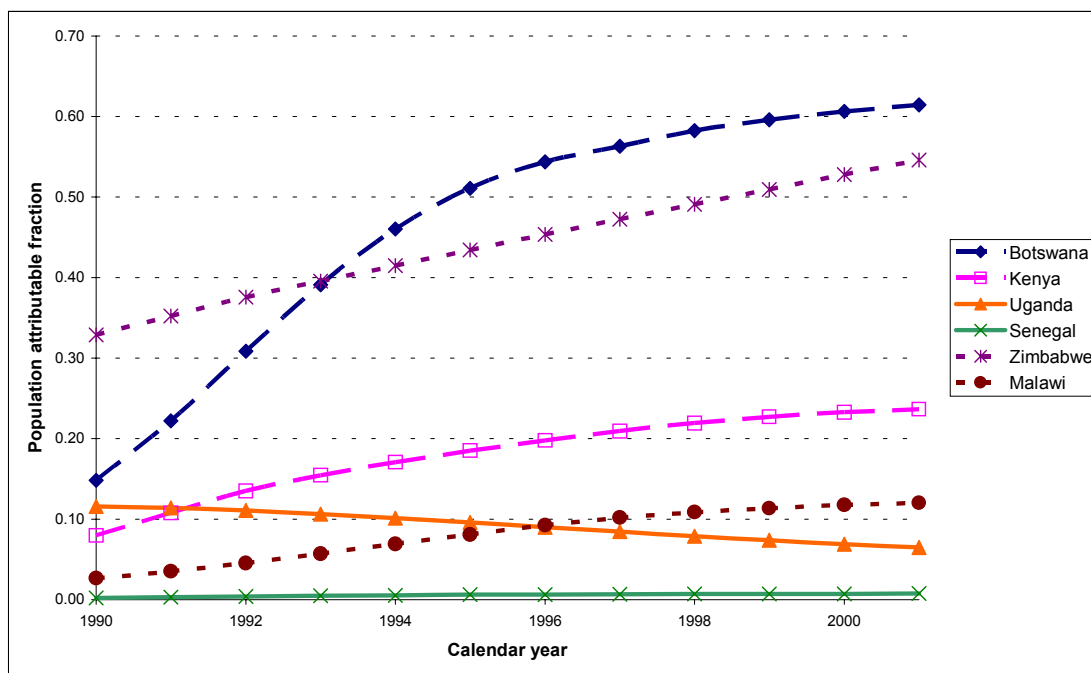
Discussion

The procedure above is easy to apply and the requisite data are readily available for most countries suffering generalised HIV epidemics. However, it is necessary to examine some of the assumptions and potential weaknesses of this approach, and to consider the margins of error associated with the results. It is also useful to examine the ways in which the same basic methodology can be used as a model to make projections into the future and to generate estimates of the scale of improvement in background mortality needed to offset the effects of HIV.

Projecting background mortality

Probably the weakest aspect of the proposed methodology for estimating child mortality in the presence of HIV is the forward projection of pre-epidemic trends in child mortality, since these trends may change over time in ways that would be expected to vary from one country to another. The projections used above are based on official UN Population Division estimates, which draw on a wide variety of sources: censuses, national surveys and where available, registration data, which should make them more robust than estimates based on a single source. However, DHS surveys are often regarded as a "gold standard" for demographic measurement, so it is useful to compare estimates based on UN projections with those based on projecting only DHS data on child mortality.

Figure VII. Absolute differences between UN and DHS estimates of child mortality
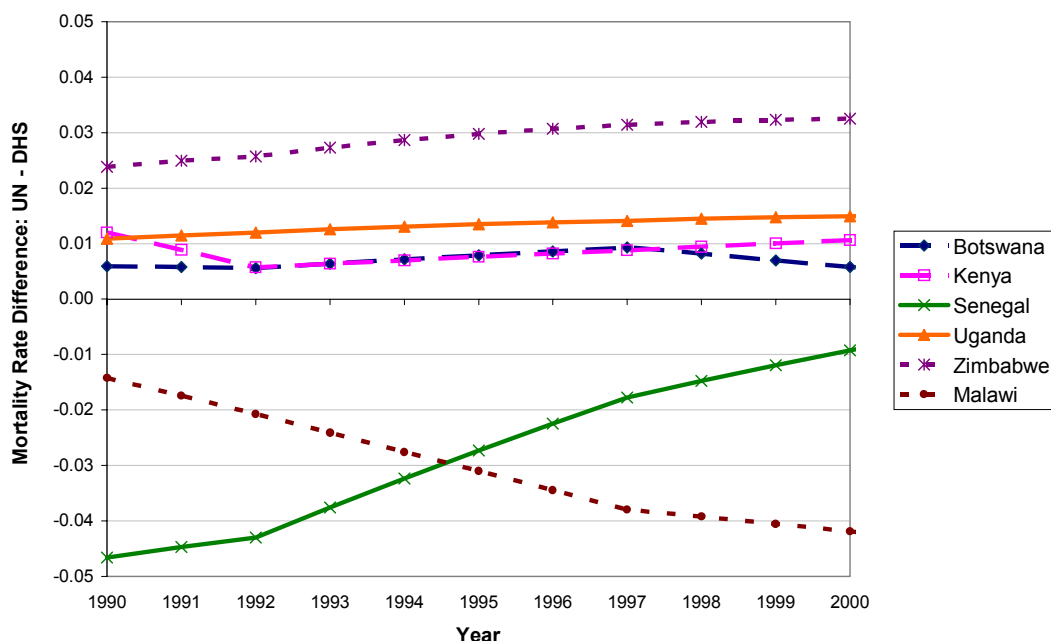

Figure VII illustrates such a comparison, and shows that projected child mortality based on DHS data alone differs from the UN projection by up to +/- 5 percentage points (50 per thousand). In Senegal and Malawi the DHS estimates suggest more severe child mortality than that implied by the UN projection, and a steeper mortality fall is implied for Senegal, a more gentle fall for Malawi. If the pattern implied by the DHS projection were correct, the population attributable fraction of child mortality in Malawi would be lower, and it would not rise as fast over time. The effect on the PAF estimate for Senegal would be negligible because of the low HIV prevalence in that country. In the remaining four countries, UN mortality estimates are slightly higher than those based on DHS data alone, but the trends are pretty much the same, so PAF estimates would be marginally higher throughout the period of estimation.

Uncertainties such as these make it advisable to compare the projected estimates with any relevant empirical data pertaining to HIV negative children. Such data may come from specialised cohort studies in which HIV status of mothers is ascertained, and the mortality of their children monitored. Of the six countries used to illustrate this procedure, two have cohort studies of this kind. In Uganda, the MRC cohort study [Nakiyingi et al, 2003] measured average child mortality for 2,800 children of HIV negative mothers in the Masaka district between 1989 and 2000 and found it to be 120 per thousand, which is a lot lower than the UN projected values which range from 170 to 130 per thousand. However, Masaka lies in the Central district, where overall child mortality is more favourable than for the country as a whole (about 20 per thousand lower [DHS, 2003]). In Malawi, the Karonga family health study [Crampin et al, 2003] measured the child mortality of 780 children born to HIV negative mothers between 1988 and 1999 as160 per thousand, also considerably lower than the projected values ranging from 220 to 170 per thousand. Again, the study site is located in a region with favourable mortality, which DHS estimates put at some 30 per thousand lower than the national average.

We can adapt this method to model what sort of trends in overall child mortality would be caused by steadily increasing HIV prevalence if background mortality and other factors such as vertical transmission are stable. The model indicates that if non-HIV child mortality is of the order of 150 per thousand, then every one percentage point increase in HIV prevalence will cause overall child mortality levels to increase by 1.8 per thousand. At lower background mortality levels the rate of increase is slightly higher: for a background child mortality level of 100 a one percentage point increase in HIV prevalence is associated with an increase in child mortality of 1.9 per thousand. If background mortality is 200 per thousand, overall mortality will increase by 1.7 per thousand for each percentage point increase in HIV prevalence among pregnant women. Conversely, to

retain overall child mortality at a pre-HIV level of 150 per thousand would require background mortality to decline steadily: a fall of 2 per thousand in mortality of HIV negative children would offset the effect of an increase of 1 per cent in HIV prevalence, leaving overall mortality unchanged.

Net and Gross mortality of HIV infected children

Underlying the "cause deleted" formulation of equation (6) is the implicit assumption that for an infected child the risk of dying from HIV associated causes is independent of the risk of death from other causes, which may not be strictly true. When it comes to deriving the "gross" mortality of infected children from a knowledge of the "net" mortality curve and mortality of their uninfected peers this is a conservative assumption, since repeated challenges to the immune system are believed to hasten the progression of HIV-related illnesses, and these would be more frequent in an environment in which infectious diseases of childhood are common. Since the Weibull model net survival curve was derived using the same "independence" assumptions with a large collection of clinical and community sources this assumption is unlikely to bias the "gross" mortality estimate in one or other direction.

Vertical transmission of HIV and the proportion of children affected

We used an "average" value of 35 per cent for the proportion of children of HIV positive mothers who become infected. In fact this proportion varies between 25 per cent and 45 per cent in breastfeeding populations, and may fall as a result of PMTCT interventions. By exploring the effects of higher or lower levels of vertical transmission we have found that with HIV prevalence at 20 per cent a change of 10 percentage points in vertical transmission is associated with a change of 10 per thousand in overall child mortality. Lower or higher HIV prevalence decreases or increases the effect proportionately (e.g. at a prevalence level of 10 per cent a change of 10 per cent points in vertical transmission is associated with a change of 5 per thousand in overall child mortality). The scale of this effect is not influenced by the level of background mortality.

However the community study analyses undertaken as part of the UNICEF study [e.g. NgWeshemi et al, 2003] have shown that it is not just the infected children who suffer increased mortality in the wake of the HIV epidemic. The death of a mother raises the mortality risks for all her children, particularly those under two, whether or not mother or child are HIV infected. Since HIV will cause a dramatic increase in the number of deaths among mothers, this indirect effect of child mortality may become significant, and is not captured by the vertical transmission rate or the double Weibull model for "net" HIV mortality of infected children. However, the proportion of HIV infected mothers who die before their children reach age 5 is much smaller than the proportion who transmit the virus to their children – so that the PAF associated with mother's death is of the order of two percent in populations in which the PAF associated with HIV infection is of the order of 20 per cent [Zaba et al, 2003].

Comparison with other estimation methods

The method currently used by UNAIDS starts with the same basic data that we have used here, but involves several extra steps [Ghys et al, 2003]. The measured HIV prevalence in pregnant women attending ANC at sentinel surveillance sites is first converted to an estimated age-specific distribution of HIV prevalence in all women, using the Futures' group SPECTRUM package [Stover et al, 2001] and allowing for the over-representation of infected women among pregnant women aged under 20, and the under-representation of infected women over 25. Age specific fertility rates estimated by the UN Population Division are then applied to the distribution of infected and uninfected women by age, allowing for lower fertility in infected women. An estimate of the vertical transmission rate is used to obtain the relative number of infected and uninfected children, who are then subject to the appropriate mortality schedules, with the gross mortality of infected children derived in a similar way to that explained above.

By using the prevalence data for pregnant women to estimate directly the proportion of infants born to HIV infected women the method presented in this paper simplifies the UNAIDS procedure. We do not attempt to allow for pregnancy losses that might disproportionately affect HIV infected women after they have been tested

in the ANC. Since foetal losses associated with HIV generally occur early in the first trimester [Gray, 1997], whereas in Africa women tend to come for ANC in the second or even third trimester [Slaymaker, 2003], this should not affect the validity of our estimate.

Direct estimates of the mortality of HIV negative children based on the birth history reports of uninfected mothers identified in DHS+ surveys which measure adult HIV status could provide powerful evidence of background child mortality levels. Infected mother's birth histories collected in the same kind of survey might appear to provide a data source for estimating the mortality of infected children. However, deriving estimates of mortality of infected children from retrospective reports of infected mothers is not a straightforward procedure, since the proportion of infected children borne by these women is determined not just by the vertical transmission ratio, but also by the duration of time since the woman became infected: recently infected women will have borne most of their children prior to infection; women infected further back in the past (who will be relatively under-represented in the survey because of HIV related mortality) will have borne a higher proportion of their children after becoming infected. Recent modelling work by Artzrouni and Zaba [2002] suggests that the bias caused by the high correlation of mother and child mortality would lead to retrospective reports underestimating the true child mortality among infected mothers by around 8 per cent in mature epidemics, this is confirmed by observation in the Kisesa cohort study [Ng'Weshemi et al, 2003]. Estimates of the mortality of infected children that ignored this selection effect would be even more biased.

However even at quite high prevalence levels, Artzrouni and Zaba show that the bias in retrospectively reported overall child mortality rarely exceeds 5 per cent, provided that the estimates are based on births occurring in the five years immediately preceding the survey. The bias in infant mortality measurement could be lower still (of the order of 1 per cent), if these estimates are based on births in the year or two before the survey. This means that ordinary DHS-type surveys which measure child mortality based on recent birth histories without measuring HIV status are unlikely to underestimate overall child mortality in the 5 years before the survey by more than 5 per cent, though selection effects would make comparisons with mortality rates up to 10 years before the survey unreliable. Ordinary DHS birth histories will therefore continue to be a useful guide to the general level of child mortality just before the survey, but will not be so useful, even in conjunction with information on HIV prevalence, in determining the contribution of HIV to the overall trend.

To put the information about the scale of the biases in perspective, it is worth noting that in these countries, at the national level, standard errors of DHS birth history based child mortality estimates range from 4.7 per thousand (Malawi 2000) to 6.8 per thousand (Zimbabwe 1999). This implies that confidence limits based on twice the standard error would amount to between +/- 5 per cent and +/-13 per cent of the overall child mortality estimate. On the other hand, UNAIDS warn that their published estimates of HIV prevalence should be viewed as having an accuracy of +/- 25 per cent.

Conclusion

Estimating the true contribution of HIV to trends in child mortality in countries affected by the epidemic is critically dependent on being able to assess the trend in child mortality among uninfected children. Although simple projection methods can be devised to do this, national level estimates obtained from birth histories of women uninfected with HIV would provide a better basis for such estimates. Nationally representative DHS surveys that collect data on HIV sero-status of adults have an important role to play in this respect. More traditional DHS surveys without bio-markers, that collected data on births in the five years preceding the survey could provide estimates of overall child mortality level which would be slightly biased downwards, but well within the range of sampling accuracy for such surveys.

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Appendix: detailed annual estimates, including data used for plotting figures

HIV prevalence in pregnant women attending ANC in sentinel surveillance clinics

Country	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Botswana	0.053	0.085	0.129	0.185	0.245	0.298	0.338	0.364	0.378	0.383	0.383	0.379
Kenya	0.046	0.061	0.076	0.089	0.100	0.110	0.120	0.129	0.137	0.143	0.148	0.151
Uganda	0.130	0.124	0.117	0.109	0.101	0.093	0.085	0.077	0.070	0.063	0.057	0.052
Senegal	0.002	0.003	0.004	0.004	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
Zimbabwe	0.194	0.207	0.220	0.233	0.246	0.259	0.273	0.286	0.299	0.312	0.325	0.338
Malawi	0.037	0.048	0.060	0.074	0.087	0.099	0.110	0.118	0.124	0.127	0.128	0.128

Infant mortality HIV negative

Country	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Botswana	0.052	0.050	0.048	0.046	0.044	0.043	0.041	0.039	0.038	0.036	0.035	0.033
Kenya	0.067	0.066	0.064	0.063	0.061	0.060	0.058	0.057	0.056	0.054	0.053	0.051
Uganda	0.109	0.107	0.105	0.103	0.102	0.100	0.099	0.097	0.095	0.093	0.091	0.089
Senegal	0.085	0.084	0.083	0.082	0.081	0.079	0.078	0.077	0.076	0.075	0.074	0.073
Zimbabwe	0.062	0.061	0.059	0.057	0.056	0.054	0.053	0.051	0.050	0.048	0.047	0.045
Malawi	0.143	0.141	0.139	0.136	0.134	0.131	0.129	0.126	0.124	0.122	0.119	0.117

Infant mortality HIV positive

Country	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Botswana	0.372	0.371	0.370	0.369	0.368	0.366	0.365	0.364	0.363	0.362	0.361	0.360
Kenya	0.383	0.382	0.381	0.380	0.379	0.378	0.377	0.376	0.375	0.374	0.373	0.372
Uganda	0.410	0.409	0.408	0.407	0.406	0.405	0.404	0.402	0.401	0.400	0.398	0.397
Senegal	0.395	0.394	0.393	0.392	0.392	0.391	0.390	0.389	0.389	0.388	0.387	0.386
Zimbabwe	0.379	0.378	0.377	0.376	0.375	0.374	0.373	0.372	0.371	0.370	0.369	0.368
Malawi	0.433	0.432	0.430	0.429	0.427	0.425	0.423	0.422	0.420	0.419	0.417	0.416

Infant mortality whole population

Country	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Botswana	0.058	0.059	0.063	0.067	0.072	0.076	0.079	0.080	0.081	0.080	0.079	0.077
Kenya	0.072	0.072	0.072	0.072	0.072	0.072	0.072	0.071	0.071	0.070	0.069	0.068
Uganda	0.122	0.120	0.117	0.115	0.113	0.110	0.108	0.105	0.102	0.100	0.097	0.095
Senegal	0.086	0.084	0.083	0.082	0.081	0.080	0.079	0.078	0.077	0.075	0.074	0.073
Zimbabwe	0.084	0.084	0.084	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.084
Malawi	0.147	0.146	0.145	0.144	0.143	0.141	0.140	0.138	0.137	0.135	0.133	0.131

HIV attributable fraction infant mortality

Country	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Botswana	0.103	0.160	0.233	0.312	0.384	0.442	0.485	0.515	0.534	0.547	0.557	0.565
Kenya	0.070	0.094	0.116	0.136	0.154	0.170	0.186	0.201	0.216	0.228	0.239	0.248
Uganda	0.112	0.109	0.106	0.101	0.096	0.090	0.084	0.078	0.073	0.068	0.064	0.060
Senegal	0.003	0.004	0.005	0.006	0.007	0.007	0.007	0.008	0.008	0.008	0.008	0.007
Zimbabwe	0.257	0.275	0.294	0.312	0.330	0.349	0.368	0.386	0.404	0.422	0.439	0.457
Malawi	0.025	0.033	0.042	0.052	0.063	0.072	0.081	0.088	0.094	0.098	0.101	0.103

Under five mortality HIV negative children

Country	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Botswana	0.073	0.070	0.067	0.064	0.061	0.059	0.056	0.053	0.051	0.049	0.046	0.044
Kenya	0.100	0.096	0.091	0.089	0.087	0.085	0.083	0.081	0.078	0.076	0.073	0.071
Uganda	0.167	0.165	0.162	0.159	0.156	0.152	0.149	0.146	0.143	0.140	0.136	0.133
Senegal	0.181	0.175	0.169	0.163	0.157	0.152	0.146	0.141	0.136	0.131	0.126	0.121
Zimbabwe	0.097	0.094	0.091	0.088	0.084	0.081	0.077	0.074	0.071	0.069	0.066	0.064
Malawi	0.219	0.215	0.211	0.207	0.203	0.198	0.194	0.190	0.186	0.182	0.178	0.174

Under five mortality HIV positive children

Country	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Botswana	0.635	0.634	0.633	0.632	0.631	0.630	0.628	0.627	0.627	0.626	0.625	0.624
Kenya	0.646	0.644	0.642	0.642	0.641	0.640	0.639	0.638	0.637	0.636	0.635	0.634
Uganda	0.672	0.671	0.670	0.669	0.668	0.666	0.665	0.664	0.663	0.661	0.660	0.659
Senegal	0.678	0.675	0.673	0.671	0.668	0.666	0.664	0.662	0.660	0.658	0.656	0.654
Zimbabwe	0.645	0.643	0.642	0.641	0.640	0.638	0.637	0.636	0.635	0.634	0.633	0.632
Malawi	0.693	0.691	0.690	0.688	0.686	0.685	0.683	0.681	0.680	0.678	0.677	0.675

Under five mortality whole population

Country	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Botswana	0.083	0.087	0.093	0.101	0.110	0.118	0.124	0.126	0.127	0.126	0.124	0.121
Kenya	0.109	0.107	0.106	0.106	0.106	0.106	0.106	0.106	0.105	0.104	0.102	0.100
Uganda	0.190	0.187	0.183	0.178	0.174	0.169	0.165	0.160	0.156	0.151	0.147	0.143
Senegal	0.182	0.176	0.170	0.164	0.158	0.152	0.147	0.142	0.137	0.132	0.127	0.122
Zimbabwe	0.134	0.134	0.133	0.133	0.132	0.131	0.131	0.130	0.130	0.130	0.131	0.131
Malawi	0.225	0.223	0.221	0.219	0.217	0.215	0.213	0.210	0.207	0.204	0.200	0.196

Under five mortality attributable fraction

Country	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Botswana	0.125	0.193	0.277	0.364	0.443	0.504	0.549	0.580	0.600	0.614	0.625	0.635
Kenya	0.080	0.110	0.139	0.162	0.182	0.201	0.220	0.237	0.254	0.270	0.284	0.297
Uganda	0.121	0.118	0.114	0.110	0.105	0.099	0.093	0.087	0.082	0.077	0.072	0.068
Senegal	0.002	0.003	0.004	0.005	0.006	0.006	0.007	0.007	0.007	0.007	0.007	0.008
Zimbabwe	0.278	0.298	0.318	0.340	0.363	0.385	0.408	0.431	0.452	0.473	0.493	0.514
Malawi	0.027	0.035	0.046	0.057	0.068	0.079	0.088	0.096	0.103	0.108	0.112	0.114