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Child Mortality in Eastern and Southern Africa

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Abstract

High rates of infant mortality in Africa continue to be a major public health concern today, despite the fact that most deaths can be prevented from well known, relatively low cost technologies. Using multiple years of DHS from four countries, we estimate the change in the relative risk of death as well as the main contributions to the change in mortality over time. We find significant declines in the mortality hazard in each of the 4 countries, with the largest declines in Malawi (44 percent) and Tanzania (22 percent) between the mid 1990s to mid 2000s, although there is significant variation by age group in the hazard rate across time. In Zambia for example, the hazard increased for children ages 25-60 months in spite of on overall decline in mortality, while in Mozambique the largest decline in mortality was exactly among this age group. The decomposition analysis illustrates that some of the main correlates of mortality did not contribute to overall declines over time, because the levels of these correlates did not change during the study period. This is particularly true for birth spacing, attended births and breastfeeding. The analysis also demonstrates the overall lack of explanatory power of the individual and household level variables available for use in the DHS, indicating the need to collect complementary supply side information, through community questionnaires for example, that can be linked to DHS households and thus expand the set of covariates available for modeling child survival and other health outcomes.

Keywords

Child mortality, underlying causes, determinants, decomposition analysis, Eastern and Southern Africa

[1] This paper was initiated while Handa was UNICEF's Regional Social Policy Advisor for Eastern & Southern Africa. Thanks to Rumishael Shoo for intellectual encouragement and Chirayath Suchindran for useful guidance on the statistical model. Authors are listed in alphabetical order.

Introduction

Between 1990 and 2006, the number of child deaths globally was cut from 13 to just fewer than 10 million per year. The vast majority of these deaths occurred in developing countries and from preventable causes, and six of the largest developing countries accounted for roughly half of all child deaths globally. Despite the fact that 90 percent of these causes of death are preventable by known and affordable interventions (Black et al., 2003), the decline in infant and child mortality has slowed considerably in recent history, from an annual reduction of 2.2 percent between 1970 and 1985 to around 1.3 percent since then, with the slowest declines occurring in sub Saharan Africa (Murray, Laakso et al., 2007). This has lead to renewed efforts by the global community to support public health care services in poor countries. Several new global health initiatives have sought to draw attention to Millennium Development Goal 4 (MDG4), and to increase resources and partnerships to reduce infant and child mortality in developing countries—collectively these initiatives are known as the global campaign for the health MDGs.[2,3]

Among all child deaths, approximately 45 percent occur in sub-Saharan Africa (SSA) where mortality rates are the highest; 35 out of the 40 countries with the highest mortality rates are in this region. In Eastern & Southern Africa (ESA), the focus of this study, the under-5 Mortality Rate (U5MR) dropped by about 9 percent between 1990 and 2003, from 188 to 171 per 1000 live births over a 14-year period (UNICEF, 2008). This corresponds to an overall decline of nearly 0.7 percent each year, still far below the 4 percent annual reduction that is required to reach MDG4 and well below the global annual reduction of 1.3 percent. At current trends, the mortality rate in children under-5 will decline by less than 15 percent by 2015 from the base year 1990, compared to the MDG goal of 67 percent.

Extensive work on child mortality in developing countries indicates that most child deaths in SSA (and in the developing world in general) are from preventable causes such as diarrhea, pneumonia, measles, and malaria (Jones et al., 2003). Under-nutrition is the underlying cause of half the death among those aged 1-5, while among neonates, who represent about a third of all child deaths, mortality is overwhelmingly attributed to asphyxia, sepsis, tetanus and preterm delivery (UNICEF-ESARO, 2007). Given this etiology, there is consensus among experts that the goal of reducing child mortality by two-thirds by 2015 could be achieved if a few known and effective child survival interventions were made universally accessible.

Much of the recent research on child mortality has focused on documenting and verifying trends over time in order to establish whether countries are on-track towards fulfilling their obligations under the Millennium Declaration. Indeed there is currently an important discussion about the credibility of official mortality figures published by UNICEF and WHO, the replicability of these estimates, and the lack of uncertainty bounds associated with predictions used by these organizations when publishing official mortality estimates (The Lancet).[4] However, from a learning and policy perspective, what are needed are

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[2] MDG4 is to reduce infant and child morality by two-thirds between 1990 and 2015 (United Nations Development Programme, online).

[3] These major initiatives include the International Health Partnership (Government of the United Kingdom), the Global Business Plan for Maternal, Newborn and Child Health (Government of Norway), and the Catalytic Initiative to Save One Million Lives (Government of Canada) see Murray, Frenk and Evans (2007).

[4] In fact, an inter-agency working group was formed in 2004 specifically to define a common methodology for estimating comparable trends in child mortality in order to measure performance towards MDG4—see UNICEF, WHO, The World Bank and UN Population Division (2007). Murray et al. (2007) reanalyze existing data for 172

specific population level micro analyses of the causes of death, and more importantly, analyses of the changing importance of household and community level factors over time in determining deaths. A major challenge in performing such micro-level analyses is that the determinants of child mortality are multi-dimensional, and are not solely affected by the availability of specific child survival interventions. Insofar as child mortality is determined by individual behavior at the household level, both supply and demand side factors have the potential to bring about reductions in mortality—but gathering data at the micro-level on both these sets of factors is extremely difficult. Standard household survey instruments used for calculating national mortality rates, such as the Demographic and Health Surveys (DHS) and Multiple Indicator Cluster Surveys (MICS), do not routinely collect information on the availability of health services or specific interventions in a manner that can be linked with household level information. Consequently, studies must try and 'explain' changes in child mortality by describing overall changes in funding for the health sector, and the implementation of specific child survival interventions in a country (e.g., Masanja, et al 2008; Armstrong-Schellenberg et al. 2004; Bryce et al. 2006) without being able to explicitly link interventions with micro-level information on child survival.

However, the DHS and MICS do collect detailed household level and mother specific information which, when linked with individual birth histories and compared over time, can provide potentially useful information on the household level determinants of child survival, and the relative importance of these factors over time. At a minimum, this information can tell us which groups have shown the most improvement in child survival, and where resources should be targeted. In addition, some of these household level variables are susceptible to policy intervention, such as access to water and sanitation, age at first birth, and birth spacing. And comparisons across countries can tell us whether there are certain stylized determinants of mortality that exist across populations, which can further assist in identifying strategies that can be generalized across regions.

Consequently, the objective of this paper is to provide an in-depth analysis of the micro-level determinants of child survival in four Eastern and Southern Africa (ESA) countries over time: Malawi, Mozambique, Tanzania and Zambia. Two of these countries are thought to have made important gains in reducing mortality (Malawi and Mozambique), mortality increased in Tanzania in the late 1990s but then dropped in the early part of this decade, while in Zambia the pattern of child mortality during the 1990s is unclear.[5] Each of these countries has two comparable national household surveys (DHS) at least five years apart which provide a sufficiently long enough window to observe sustained changes if they occurred. For each country we provide three sets of analyses. First, we pool the data and estimate survival functions with cohort effects to test whether the probability of survival has changed significantly over time. This is a statistically more rigorous method of establishing the trend in mortality over time compared to the approach used by the inter-agency working group. This method provides direct estimates of the change in the relative risk of death over time (the death hazard) as well as statistical tests for differences over time and by age cohort. Second, we estimate full survival models by age group to assess whether there are patterns in the main determinants of child survival across the countries. Finally, we quantify the change in child survival over the study period that is attributable to each of the variables included in our regression model, thus providing a picture of some of the key drivers of mortality changes in the time period being studied. To our knowledge, this is the first study to present both formal statistical tests for changes in the mortality hazard over time across ESA countries and to quantify the relative contribution of various covariates on the mortality hazard across countries based on direct estimation from national micro-level data.

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countries and confirm the overall global trends since 1980 reported by UNICEF and WHO, though in some cases with significant country level differences in trends.

[5] Masanja et al. (2008) report significant reductions in child mortality for Tanzania in the 2000s using DHS data.

Data and variables

The data used for this analysis are derived from the Demographic and Health Surveys (DHS) conducted in Malawi (1992, 2004), Mozambique (1997, 2003), Tanzania (1996, 2004) and Zambia (1992, 2001).[6] The conceptual framework guiding the selection of analysis variables is the proximate determinants model of child health, first outlined by Mosley and Chen (1984). Within this framework, we restrict ourselves to variables that are measured consistently across survey years within countries, and that are also available in at least different two countries in order to allow for cross-national comparison. The majority of the variables included in our estimation are intermediate or proximate determinants of mortality in the Mosley and Chen framework, that is to say, their levels are determined by underlying or 'distal' socioeconomic characteristics. However three such underlying factors are also included directly in the model, household wealth, maternal education and the indicator of whether the pregnancy was wanted (capturing norms or preferences), and these may be expected to attenuate somewhat the effects of the proximate factors, though empirically this is not the case due to the wide range of other underlying factors which also affect the intermediate variables and are not included in the model.[7] We also include a self-reported measure of the size of the child at birth, which we interpret as an intermediate factor influenced by pre-natal norms and behaviors, but which might be also be considered an immediate cause in that very low birth size itself may lead directly to mortality.[8] On the policy side, Bryce, et al (2006) construct country and regional level profiles of coverage of child survival interventions to track policy effort in this area. We note that five of the indicators in their list are included in our regression models (birth size, breastfeeding, water, sanitation, and skilled attendant at delivery) so we are able to quantify the contribution of these 5 factors to overall changes in mortality in the 4 countries over the study period.[9] In the remainder of this section we provide a brief review of the evidence surrounding the main variables used in our analysis.

A number of researchers, including Benjamin and Pollard (1980) and Madise, et al. (2003), have noted increased frailty amongst male infants, although that frailty is mitigated as male infants grow older (Bicego & Ahmad, 1996). Unwanted pregnancies may have significant effects on child mortality particularly in societies where there is gender preference as infants or children of the desired sex may receive more attention, food, medical and other resources that improve their chances for survival (Scrimshaw, 1978). It is harder to sort out behavioral and biological factors in the relationship between mortality and birth order, since high birth order children are borne to older women who may have been

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6 The Malawi data was collected by the Malawi National Statistical Office (NSO) and Macro International, Inc. in 1992 and by NSO and OCR Macro,Inc. 2004. The Mozambique data was collected by the Instituto Nacional de Estatistica and Ministerio da Saude (National Institute of Statistics and Ministry of Health) and Macro International Inc. In 1997, and the Instituto Nacional de Estatistica and Ministerio da Saude and ORC Macro, Inc in 2003.The Tanzania data was collected by the Tanzania National Bureau of Statistics (NBS) and Macro International, Inc in 1996, while the 2004 data was collected by NBS and OCR Macro, Inc. The Zambia 1992 data was collected by the Zambian Central Statistics Office (CSO) and Macro International, Inc, in 1992, and by CSO and OCR Macro, Inc in 2001.

7 Pitt (1997) estimated the determinants of child mortality and child health, controlling for prior selective fertility and mortality behavior, and found fertility selection to be statistically significant in the estimation of the determinants of mortality in all 14 Sub-Saharan DHS data sets studied. However, most of the other parameters were little changed even when selection is accounted for.

8 We use self report rather than actual measured weight due to large numbers of missing values for the latter variable.

9 Note that Bryce et al. do not link intervention coverage with micro-level data in order to estimate the impact of such coverage on child survival.

physically depleted by earlier pregnancies, but who would also be more experienced at keeping children alive. Higher order children have to compete with older children who may receive more investments since they have already survived past a critical threshold (Scrimshaw, 1978), although it is also possible that all children in high parity household suffer due to the sharing of resources among more people. Indeed, Trusell and Pebley (1984) estimated that the elimination of fourth and higher order births would reduce infant and child mortality by about 8 percent.

Birth order and parity are related to birth spacing which is another important factor. In particular, birth spacing in excess of 24 months (Cleland & Sathar, 1984; Griffiths et al., 2001) has been recommended due to reduced ability of the mother to transfer nutrients to the unborn child (Madise et al., 2003).[10] A similar reduced ability to transfer nutrients is also likely to arise in the gestation of twins, as well as for very young mothers. Additional nutrition factors, such as breastfeeding, also matter (Rutstein, 2000), as it provides the critical nutrients and antibodies to infants and lowers exposure to potentially contaminated foods. In addition, some studies indicate that the use of birthing assistance by traditional midwives is negatively associated with infant mortality (Lawn et al., 2005; Smith et al., 2000)[11].

Moreover, Fotso, Ezeh, Madise and Ciera (2007) show, amongst other things, that urbanization is associated with a reduced quality of life, since urbanization without infrastructure investment means reduced access to drinking water and sanitation, which are both closely related to diarrhea, a major (preventable) cause of child mortality (Agha, 2000; Awasthi & Agarwal, 2003).

Economically, wealth and mother's education are expected to affect child survival in many ways. Wealth is expected to influence whether or not the family can adequately provide for the child, while mother's education is expected to influence the quality of the child's care. Counterintuitively, Das Gupta (1990) shows that mortality rises with the education of the mother in South Asia; however, Basu and Stephenson (2005) argue that the counterintuitive effect is more nuanced. By examining the relationship between mother's education and various proximate determinants of child mortality Mosley and Chen (1984), Basu and Stephenson show that most proximate determinants improve with mother's education, with the exception of birth interval, first age at birth, parity, or whether or not treatment is sought for various maternal and childhood illnesses.[12]

The means of the variables in each of the years for each of the countries and under-5 mortality are available in Appendix 2 Tables A8 – A11 (all subsequent tables are presented in Appendix 2). A brief summary is provided here, based on changes in excess of 0.1. In Malawi we observe that the total number of births per mother fell over the time period, the number of mothers observed amongst the wealthiest quintile and mothers from urban areas also decreased, as did the number of children who were ever breastfed, while the number of mothers with access to an improved water source increased over the period. In Mozambique, the observed differences are generally negligible, but of note is the increase in observed parity and urbanization and the decline in water and sanitation coverage.[13] In Tanzania, the

[10] Madise (2003) shows that the birth weight of children born before a 24 month window is much lower than for those born after a 24 month window.

[11] Lawn et al. (2005) found that skilled birth attendance and institutional delivery rates are consistently lowest in countries and regions with the highest neo-natal mortality rates in SSA and South Asian countries.

[12] Basu and Stephenson suggest that mother's education may increase illness reporting, as mother's become more adept at noticing illnesses; therefore, even if many of the more educated mothers seek treatment, the increase in reported illness may make treatment-seeking appear to be unrelated to mother's education.

[13] In Mozambique, 4 variables (desired pregnancy, assisted birth, breastfeeding and birth size) are only available in the 36 month birth history and not the full 5 year birth history.

observed differences are generally negligible, with the exception of access to improved sanitation, which decreased. Finally, in Zambia, the observed differences for parity, wealth and urbanization were similar to Malawi, although access to both an improved water source and to improved sanitation fell, as did the number of mothers with completed primary education.

Our dependent variable, the survival status of each child at each month, is derived from the 5 year birth interval. We use the 5 year rather than complete (15 year) birth history because many of our independent variables are contemporaneous measures which are unlikely to represent family circumstances more than 5 years ago; the full birth history is also subject to more recall error.

Empirical approach

We employ the Cox proportional hazard model to estimate the trend in mortality over time, and the main micro-level determinants of child mortality. The basic equation we estimate is as follows:

(1) $$h(t/X) = h_0(t)\exp\{\beta_1 X_C + \beta_2 X_M + \beta_3 X_H)$$

where

X_C is a vector of child specific variables such as age, sex and birth order;
X_M is a vector of mother specific variables such as age at first birth, education, and parity;
X_H is a vector of household level variables such as wealth, water and sanitation, and region.

The empirical approach is separated into three parts. In the first part, we present formal tests of whether the hazard rate has changed over time—in other words, whether there has been a statistically significant change in the relative risk of child survival across the two survey years. We do this by estimating a simple pooled proportional hazard model using monthly time intervals and including a dummy variable for survey year (or birth cohort). We also present age-specific models to test whether there are differences in hazard rates over time among particular age groups such as neonates or infants (this is equivalent to relaxing the proportionality assumption in the Cox model). In the second part, we estimate complete Cox proportional hazard models using a full set of covariates (household, mother and child level) and compare these effects across countries to look for patterns in the determinants of child survival during this period. Our final analysis consists of decomposing the change in the predicted probability of survival across time into that part attributable to changes in each of the variables included in the model. This allows for an assessment of the relative contribution of each of the observed covariates on child mortality, since a factor's relative contribution to the mortality hazard over time is both a function of its estimated coefficient as well as the degree of change in its actual value over time. Thus a quantitatively large and statistically significant association of a covariate with mortality can only induce an actual change in the overall mortality rate if the level of that covariate changes over time (perhaps due to public policy) in a way that benefits maternal and child health—the decomposition analysis is a way to attribute overall changes in child survival to changes in such underlying factors.

Descriptive analysis of child survival over time

We begin our analysis with a description of the trend in child survival and mortality hazards over the study period in each country. Figure 1 in Appendix 1 (all figures are in Appendix 1) depicts Kaplan-Meier Survival curves for under-5 mortality using child-month data for two points of time in each of the four countries. All countries show clear improvements in survival rates, with the older cohort curves falling below the earlier cohort curves at virtually all ages. The improvement is largest in Malawi where, at age 60 months, the probability of survival has increased from 79 to 89 percent. In all countries the pattern of the survival curve is the same, with steep drops at very young ages and then flattening out after 24 months of age. The largest differences across time also seem to occur in this same time-frame, with the possible exception of Malawi where the curves continue to diverge even out to 40 months.

Table A1 (all tables are in Appendix 2) presents hazard ratios derived from the Cox model using pooled data at the child-month level with a cohort dummy indicating if the observation is from the later sample. Panel A shows hazard ratios for the full sample of children 0-60 months, and these results are not only consistent with survival graphs but also provide quantitative estimates of the change in the hazard rate over time. The largest decline is in Malawi (44 percent), followed by Tanzania (22 percent) and then Mozambique and Zambia (13 percent).[14]

Based on the estimates in Panel A we derive the actual hazard rate for each cohort and graph these in Figure 2 in Appendix 1.[15] The hazard rates are generally declining over time as we would expect, which is consistent with the well known fact that the risk of death in Africa is high at very young ages and then declines rapidly beyond 1 and 2 years of age. The hazard function for the earlier cohort is higher than for the later cohort in all countries indicating reductions in mortality across cohorts. The most interesting feature of Figure 2 however is the non-monotonicity in the hazard rates. These jumps in the hazard occur at fairly consistent points in each country, at ages 24, 36 and 48 months, while up to 18 months of age the curves tend to be relatively smooth. This confirms the well-known 'heaping' of deaths at yearly intervals, particularly deaths for children who died at older ages (beyond 18 months). In Malawi and Tanzania the largest 'heaping' occurs at 36 months, while in Mozambique and Zambia it occurs at 48 months. In general the curves are smoothest for Malawi and least smooth for Mozambique, which might point to data quality concerns in Mozambique.

Panel B of Table A1 reports cohort effects for different age groups to see where the overall gains in survival came from.[16] Malawi displays the strongest declines in the hazard across cohorts; Panel B indicates that these declines came from all age groups, with the biggest improvement coming from the 25-60 months age group which experienced a 77 percent reduction in relative risk of death between 1992 and 2004. Tanzania also displays significant reductions in the hazard rate across cohorts (22 percent), but unlike Malawi, the reduction is driven by the 3-6 and 7-12 months age groups only. This in turn contrasts with Mozambique, where the (albeit much smaller) decline in mortality is driven by the youngest (0-2 month olds) and oldest (25-60 months) age groups. The age pattern is also unique in Zambia, where large improvements at 0-2 months are partially off-set by worsening mortality among 25-60 month olds. Thus the overall reduction in the mortality hazard in Zambia (by 13 percent) would have been larger had it not been for the 25-60 months age group where the hazard rate actually increased by 80 percent.

These simple descriptive analyses thus confirm a statistically significant reduction in child mortality in the four countries over the study period, but also highlight clear differences in how these gains were achieved. Among the four countries, only Malawi displays significant reductions in the relative risk of

[14] The estimates in Table A1 are hazard ratios, indicating the change in the relative hazard between the later cohort and the earlier cohort. Hence in Malawi the hazard for the later cohort is 56 percent that of the earlier cohort, or a 44 percent reduction in the hazard rate.

[15] The hazard rates are only estimated up to the age of last death in either data set.

[16] Note that in our data analysis, time and age of the child in months are exactly the same and all records are taken from the 5 year birth history. Hence a child in the 0-24 month sub-sample may have been born 5 years ago.

dying at all ages up to 60 months. In Tanzania and Mozambique the overall decline is driven by particular age groups, while Zambia actually had increasing mortality among children 25-60 months old.

Determinants of mortality

Tables A2 and A3 report hazard ratios for the full set of covariates linked to child survival. As before, data are pooled and coefficient estimates can thus be thought of as the average response of any particular covariate over the entire study period holding constant other variables in the model. The addition of this exhaustive set of covariates should dampen the overall cohort effects reported in Panel A of Table A1 since those cohort effects are supposedly capturing differences across time in the explanatory variables, but in fact this does not occur. In Mozambique and Zambia the relative hazard remains the same while in Malawi and Tanzania the cohort effect actually increases by 6 and 4 points respectively, indicating that the covariates in 2004 are in some sense 'worse' from a child survival perspective. The means in Table A9 indicate that the rate of breastfeeding might be driving the change in the cohort effect between Table A1 (Panel A) and Table A2 for Malawi; the rate of breastfeeding declined by 16 points between the surveys and breastfeeding has a large and statistically significant protective effect on child survival. In Tanzania both a decline in breastfeeding and a decline in the proportion of children in the richest quintile occurred in 2004. In general, the rather small changes in the hazard ratios (Mozambique, Zambia), or the increase in the cohort effects (Malawi, Tanzania) from Table A1 (Panel A) and Table A2 means that the covariates included in Table A2 do not explain much of the large changes across cohorts in hazard rates estimated in Table A1, or that the levels of explanatory variables became worse in terms of child health. We explore this point further in the next section.

Table A2 indicates several factors that significantly alter the hazard of dying across these ESA countries: twin birth (risk), higher birth order (protective), parity (risk), longer birth spacing (protective), larger birth size (protective) and household wealth (protective). Each of these is potentially affected by public policy. Among these variables birth spacing has the largest consistent protective effect on the hazard rate, decreasing the hazard by over 50 percent in Mozambique for example, and by around 40 percent in Malawi and Zambia. Among these important factors birth order is somewhat puzzling, the results indicating that higher birth order children (beyond 3) reduces the relative risk of death by 24-36 percent.[17] However this is controlling for maternal depletion through the parity variable, so in this case birth order can be viewed as an experience effect.[18] Also unusual is the general insignificance (with 2 exceptions) of the water and sanitation variables since these are thought to be key inputs into the production of children's health (Handa, 1999; Pongou et al., 2006). The lack of consistent significance of home births is also peculiar, particularly given the strong policy focus on improving the number of births attended by a skilled professional. Only in Malawi does this appear to be a strong risk factor, increasing the relative risk of death by 16 percent.

Table A3 replicates the analysis for children age 24 months and below, and the main risk and protective factors continue to be the same as those highlighted for the full sample, with birth spacing once again being the largest protective factor, along with birth order and wealth, and twin births, parity, small birth size and the male child associated with higher hazard rates. Improved water and sanitation also becomes statistically significant in some cases. Since the risk of death is highest at very young ages, we include replications of Table A2 for children 1 year and younger (Table A6), and then for children age 0-2 months only (Table A7). These show roughly similar results as those in Tables A2 and A3, although

[17] The high correlation between birth order and first born is also apparent in the data and leads to the insignificance of first born. When birth order is excluded from the model the hazard ratios for first born all become greater than 1 and significant in two countries.

[18] When parity is excluded, birth order becomes a risk factor.

fewer effects are significant for the 0-2 month age group due to the small sample sizes. One result that stands out is the relatively higher risk of death for boys in the first two months of life, with effect sizes ranging from 18 percent (Mozambique) up to 62 percent in Tanzania.

Decomposition of relative contributions to mortality over time

Tables A2 and A3 demonstrated that several key individual, mother and household factors have large and statistically significant associations with child mortality, and overall survival rates have improved significantly in three of the four study countries. What are the key explanatory factors driving these changes in hazard rates over time? Clearly the contribution to the overall change for any given factor will depend not only on the strength of the relationship between that factor and mortality (measured by the size of regression coefficient), but also on the extent of the change in the level of that factor over time. Hence a factor may be strongly related to survival, but may not have contributed to the decline in mortality because it did not become more pervasive over time.

We quantify the relative contribution of each of the covariates in our model by calculating the change in the value of each covariate over time, and multiplying the difference by the Cox regression coefficient. The exponential of the resulting value, minus 1, gives the proportional change in the hazard rate across cohorts due to the change in the prevalence of that factor. Illustrative calculations for the full sample for each country are shown in Tables A8 – A11. The main results of these calculations are summarized in Tables A4 (full sample) and Table A5 (under 25 months sample). The discussion below focuses on changes greater than 1 percent.

The salient feature of Table A4 is that the covariates as a whole account for very little of the change in hazard rates over time in these countries. The baseline cohort effects reported in Panel A of Table A1 are almost identical to the cohort effects at the bottom of Table A4; as noted earlier in the discussion around Tables A2 and A3, the coefficients of the cohort effects hardly move when the full set of covariates are included in the model. The exceptions to this are Malawi and Tanzania, where the cohort effect actually moves away from 1, or gets larger in absolute terms. Thus in Malawi and Tanzania, the values of the explanatory variables (contained in the model) have actually changed in a way that is worse for child survival; once we control for this, the 'unexplained' cohort effect becomes even larger, moving from about 46 to 52 percent in Malawi, and from 22 to 26 percent in Tanzania. In other words, once controlling for the change in the explanatory variables over time, the estimated mortality hazard is now 52 (26) percent lower in the later cohort relative to the earlier one in Malawi (Tanzania).

Tables A2 and A3 indicated that parity, birth order, birth spacing and wealth are consistently the most important determinants of mortality in this region, with the largest marginal effects associated with birth spacing. However, in only one case (Mozambique) is the change in the hazard over time explained by changes in birth spacing because in fact there was no change in birth spacing over this period (see Tables A8 – A11) in any of the countries except for Mozambique where the percentage of births occurring after 24 months increased by 3 percentage points (Table A9). Living in the richest wealth quintile has a strong protective influence on mortality based on the regression results, but in fact over this period, wealth led to an increase in the hazard mortality in 3 of the 4 countries, with a particularly large effect of 3.8 percent in Zambia. The underlying mean values reported in these tables illustrate that the number of young children coming from the richest quintile declined over the period.

The decomposition results for parity are also revealing. Parity is an important risk factor for mortality as demonstrated in Tables A2 and A3; in Malawi and Zambia parity declined significantly through the period (Tables A8 and A11) which in turn resulted in declines in the overall mortality hazard by 5.5 and 1.5 percent respectively. In Tanzania the parity decline was smaller thus leading to a much smaller decline in the overall hazard rate (0.7 percent). In Mozambique parity actually increased leading to a small increase in the overall hazard in the later period.

Increasing the number of births attended by a skilled professional is a major policy objective in the region yet the contribution of this factor to overall changes in the mortality hazard is 0. While this is due to the small marginal effect on mortality of this factor, especially in Zambia and Tanzania, it is important to note that home-births either stayed the same (Malawi) or actually increased (Tanzania, Zambia) during this period. Hence this policy objective has clearly not been associated with improvements in outcomes. Similarly, the rate of breastfeeding has declined in all three countries where such data is available for our study sample; in Malawi a 16 percentage point decline between 1992 and 2004 led to an increase in the mortality hazard of 8 percent.

Table A5 shows hazard contributions for the 0-24 month old age group and these are generally similar to the results in Table A4 for the full sample with a few exceptions. In this sample the contribution of improved water sources is somewhat larger, and leads to declines in the hazard in Malawi (1.1 percent) and an increase in Zambia (3.2 percent). These changes are of course driven by changes in the underlying means: in Malawi there were significant increases in access to clean water (21 percentage points) while in Zambia there was a 15 percentage point decline in access.[19]

Conclusion

High rates of infant mortality in Africa continue to be a major public health concern today, despite the fact that most deaths can be prevented from well known, relatively low cost technologies. This has led to a renewed focus on reducing child mortality in Africa and a call for a second child survival revolution similar to that spearheaded by UNICEF and other international agencies in the 1970s. Some success stories have recently been documented in the region, resulting in questions about whether outcomes are systematically improving in the region, and what the determinants of changes might be. Using DHS from four countries collected at least 5 years apart in the 1990s and 2000s, and thus representing the population of births over at least 10 years, we estimate the trends in mortality over time and then attribute changes over time into various observed factors at the child, mother and household level.

We find significant declines in the mortality hazard in Malawi (44 percent), Tanzania (22 percent), Mozambique and Zambia (13 percent each) (Table A1). The hazard of death generally declines with age, with the most significant declines in the first 6 months of age. But the data show strong jumps in the hazard at 2, 3 and 4 years of age, confirming rounding of deaths to the nearest year for mortality events sufficiently long ago, a fact that has important implications for population level estimates of age-specific child mortality rates based on long recall periods.

The changes in the mortality hazard are not constant across age groups. In Tanzania, the large improvements over time are driven by the 3-12 month age group while in Mozambique they are driven by the 0-2 and 25-60 month age groups. In Zambia, the entire reduction in under-5 mortality is driven by neonates, despite an increase in the relative risk of death for children 25-60 months old. Malawi was the only country that shows consistent and significant declines in the relative risk of death across all age groups.

The micro-level determinants of child survival during the study period are fairly consistent across the four countries, with the largest protective factors involving parity, birth spacing and to a lesser degree, household wealth, all of which can be influenced by public policy. However, these marginal effects must be combined with changes in the actual values of the underlying factors to assess the contribution of these

[19] These mean changes are for the 0-24 month sample and are available from the authors upon request.

factors to overall changes in mortality as well as to assess the success of public policy in this area. The results of such an analysis demonstrates that some of the most important factors for child survival have actually not improved over the study period, leading to virtually no contribution to the overall change in hazard rates. This is particularly true for birth spacing where there is hardly any improvement (increases in birth spacing) over the 10-15 year period examined here. Another major risk factor, parity, only changed significantly in Malawi and thus led to a 6 percent decline in the mortality hazard between 1992 and 2004. In Zambia on the other hand, parity actually increased, resulting in a 2 percent increase in the mortality hazard between 1992 and 2001. One factor that has traditionally been the focus of maternal and child health policy, attended births, does not contribute to mortality change in any of the study countries over this period. Indeed, the proportion of attended births actually decreased in Tanzania and Zambia but remained unchanged in Malawi. Meanwhile breastfeeding, another major focus of health policy, declined in all three countries where such data are available. The fact that there has been no significant improvement in these well-known correlates of child survival highlights the major challenge faced by policy makers and program managers in the health sectors in Africa.

This article has also demonstrated the limitation of current data collection initiatives for policy analysis on child health and mortality in Africa. The need for increased evidence based policy analysis around child survival has been highlighted as an urgent requirement by the Child Survival Countdown Committee (Bryce et al., 2006). The primary micro-level data sources for such analyses are the DHS and MICS. However, the range of policy relevant variables captured in these surveys, especially on the supply side, is minimal. There is no community or facility questionnaire at the cluster level to accompany the household survey, and thus no easy way to link household characteristics and outcomes (e.g., death or illness) to service access, provision or use. Consequently, even the comprehensive set of covariates used in this article cannot explain more than a few percent of the change in the mortality hazard across time; large changes in mortality over time remain unexplained by the models and are captured in the cohort dummy. As increased public resources become available for child health programs in Africa, critical attention must also be paid to designing and implementing appropriate data collection instruments to document the determinants of change in children's health status at the micro level, rather than to the simple counting of deaths at the aggregate level.

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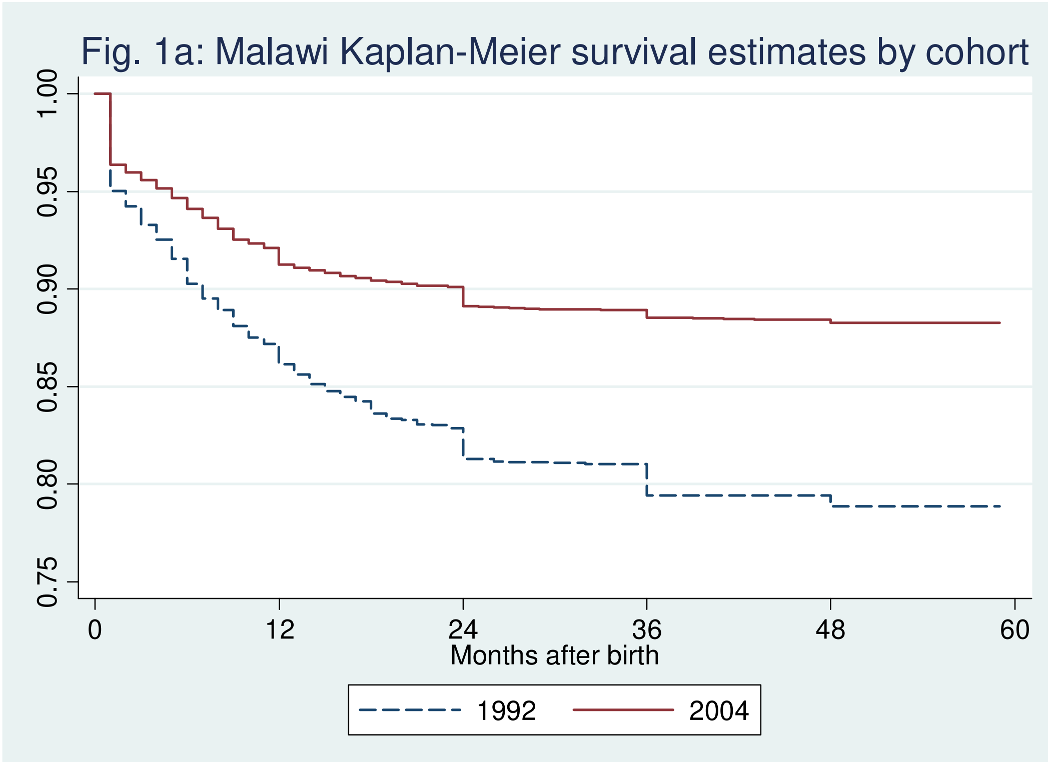
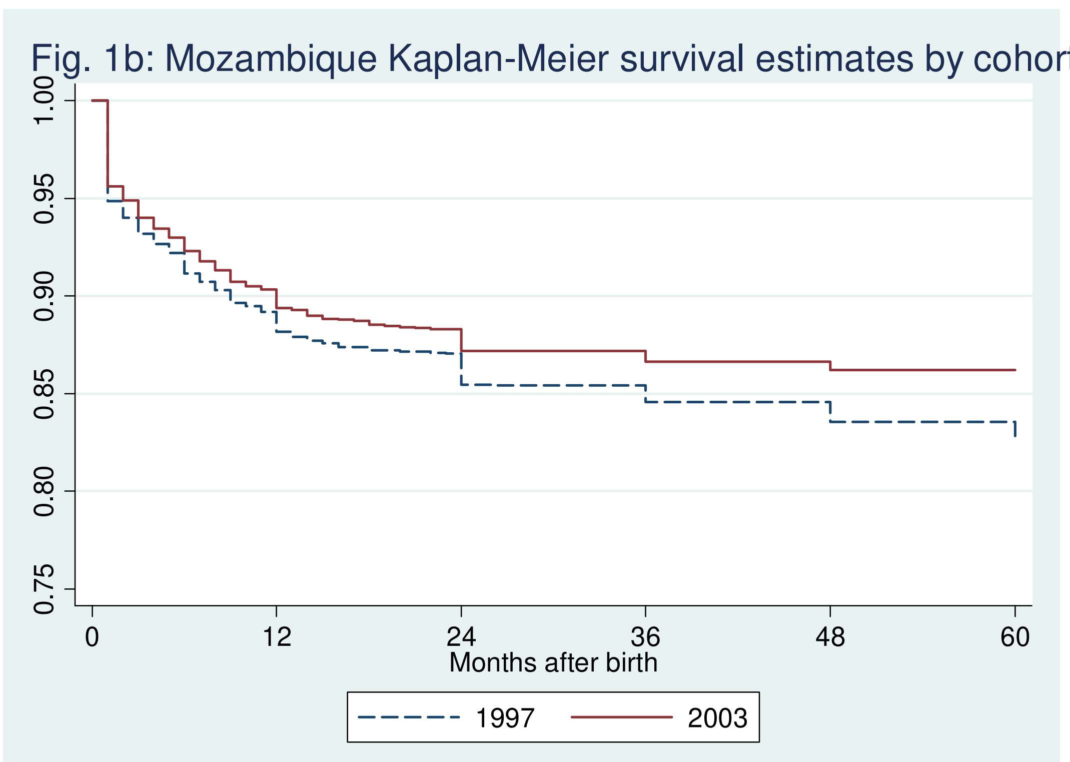
Appendix 1. Figures





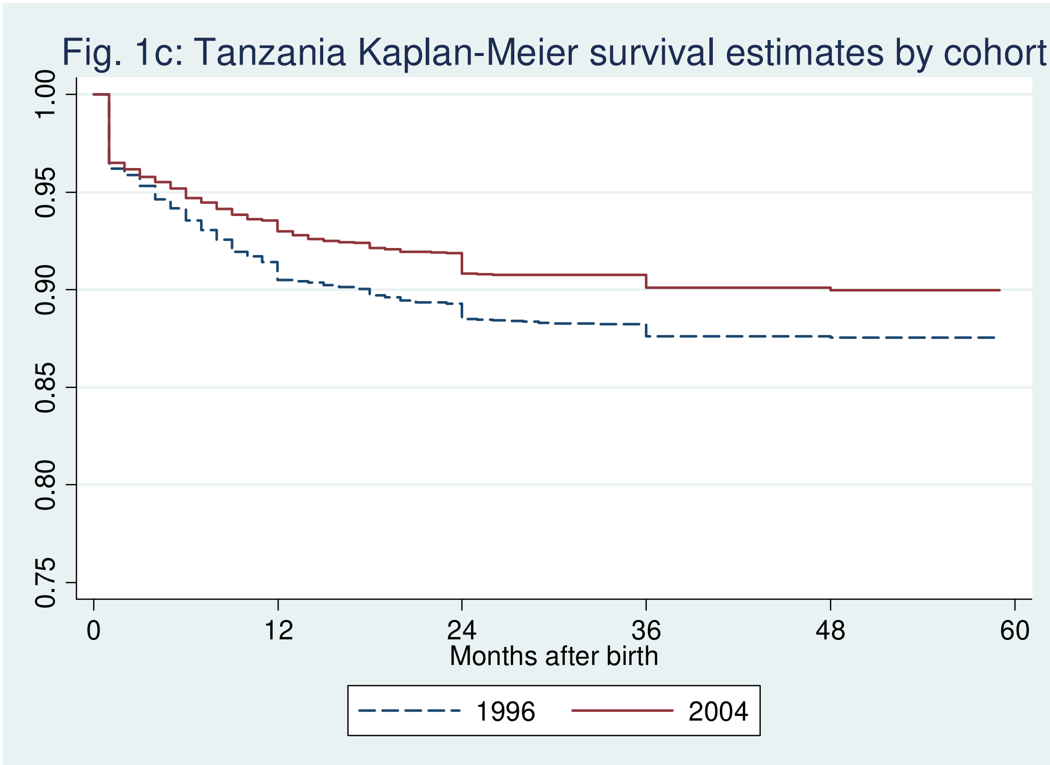


Fig. 1c: Tanzania Kaplan-Meier survival estimates by cohort
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0.90
0.85
0.80
0.75
0
12
24
36
48
60
Months after birth
1996
2004

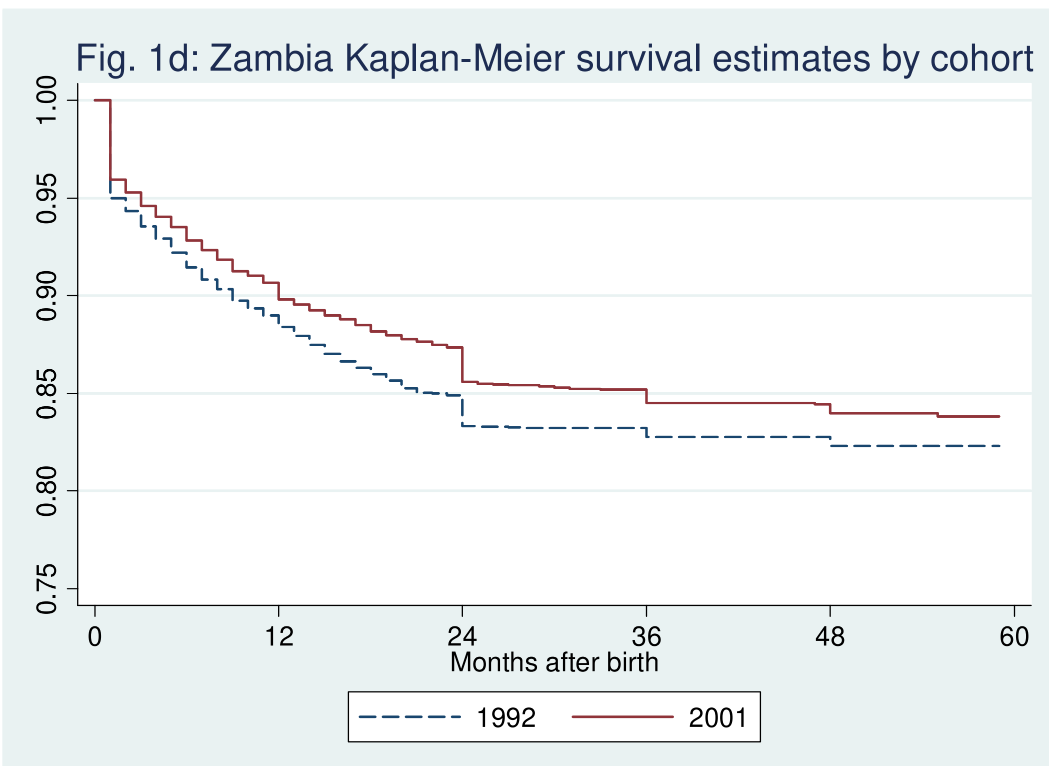
Fig. 1d: Zambia Kaplan-Meier survival estimates by cohort
1.00
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0.90
0.85
0.80
0.75
0
12
24
36
48
60
Months after birth
1992
2001

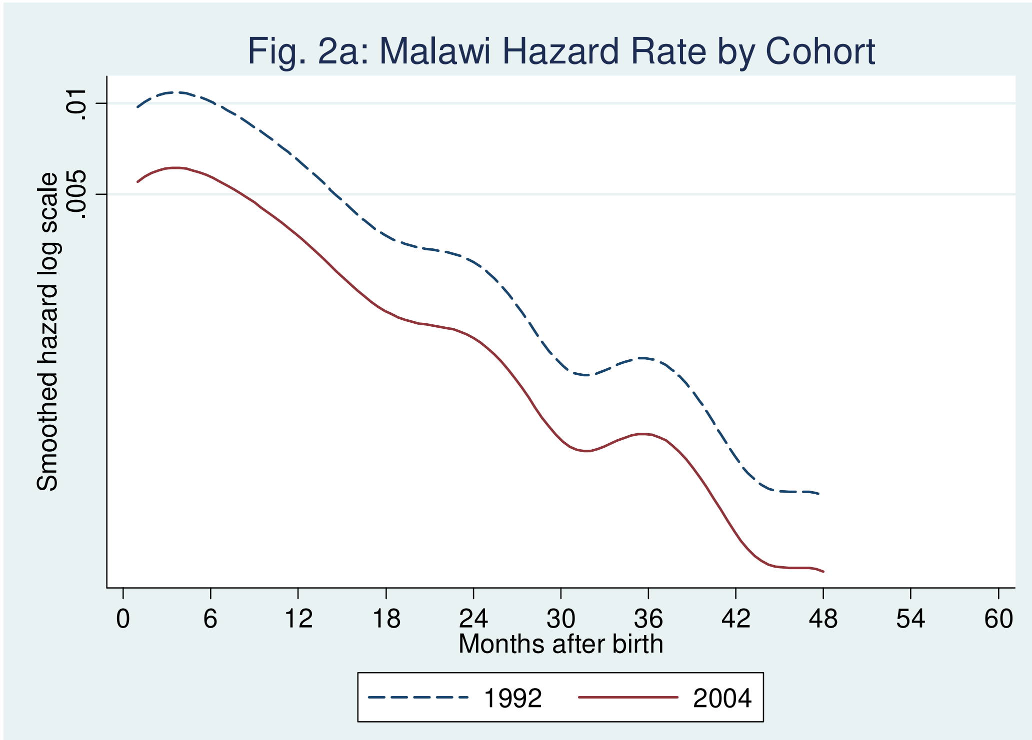
Fig. 2a: Malawi Hazard Rate by Cohort
Smoothed hazard log scale
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36
42
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54
60
Months after birth
1992
2004

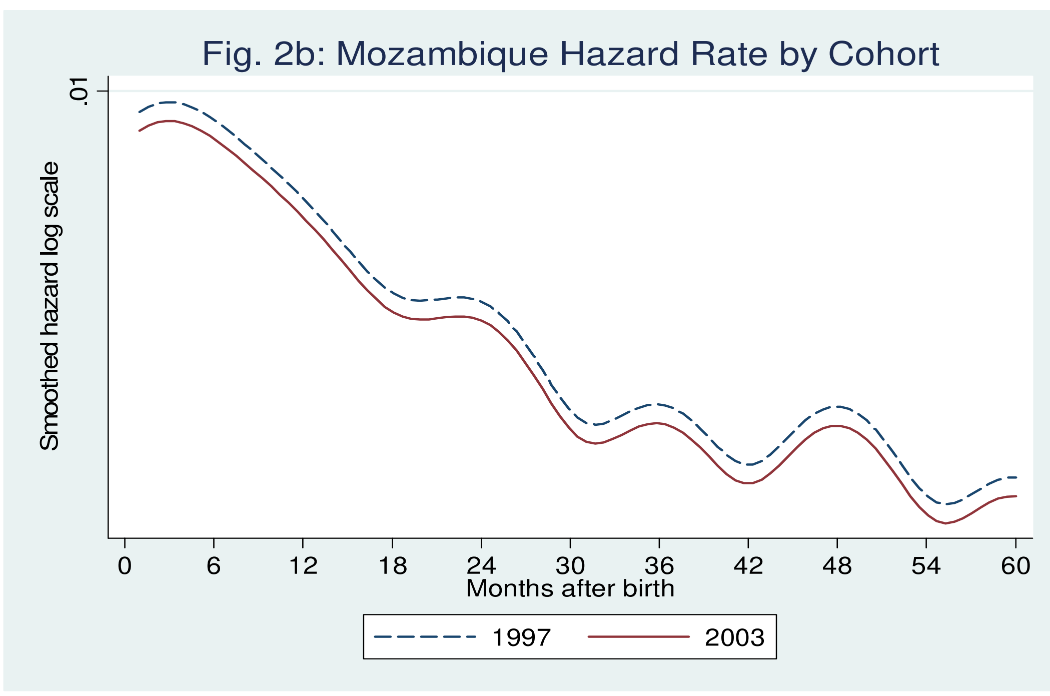
Fig. 2b: Mozambique Hazard Rate by Cohort
Smoothed hazard log scale
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42
48
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60
Months after birth
1997
2003

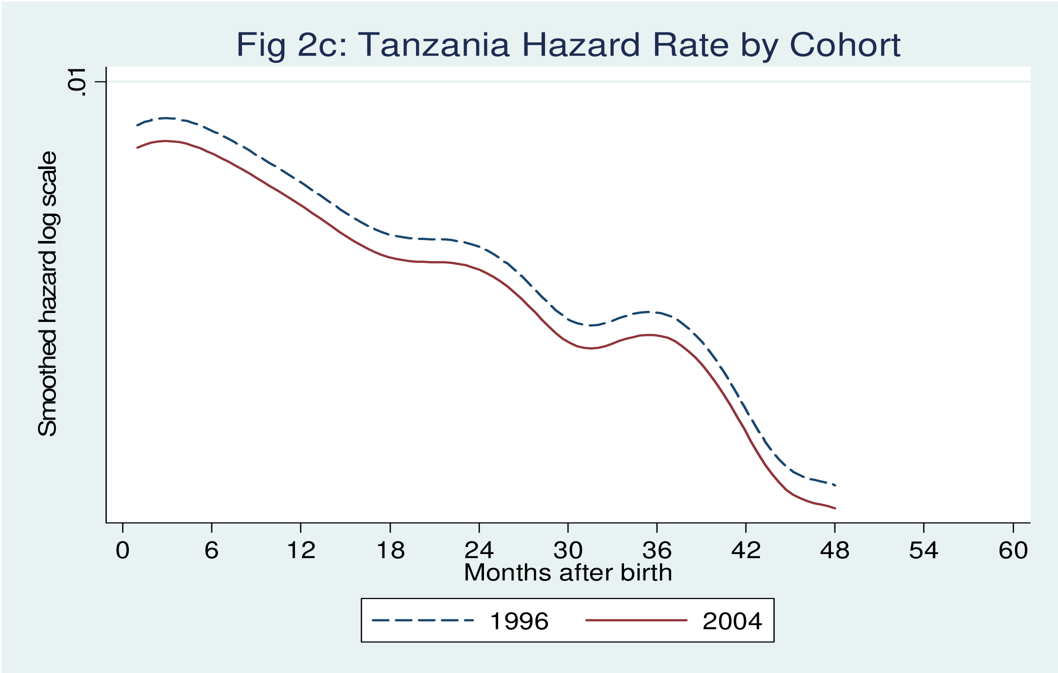
Fig 2c: Tanzania Hazard Rate by Cohort
Smoothed hazard log scale
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Months after birth
1996
2004

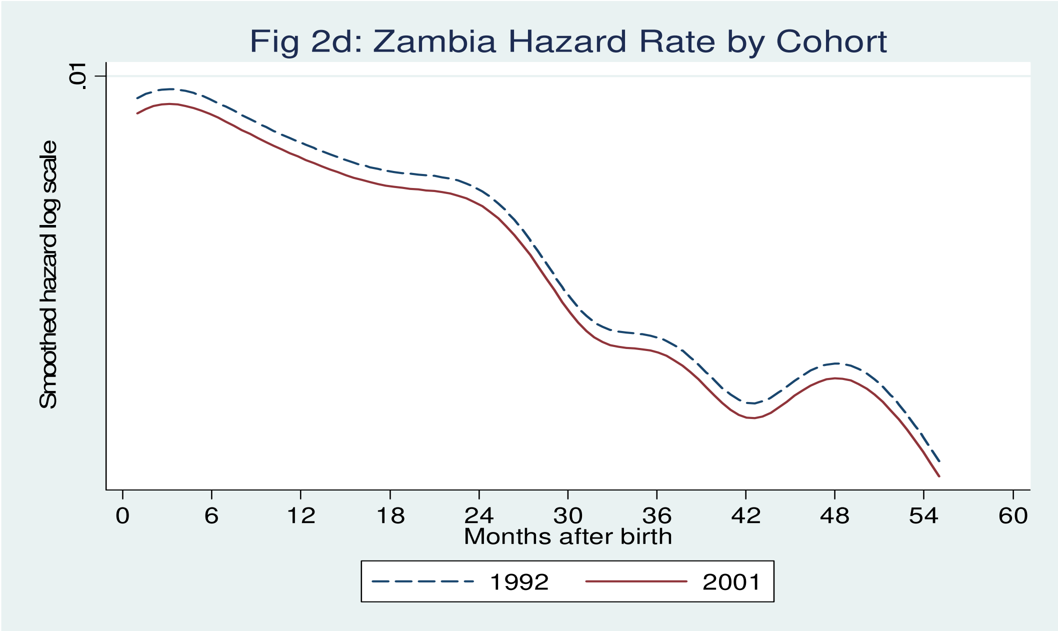
Fig 2d: Zambia Hazard Rate by Cohort
Smoothed hazard log scale
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42
48
54
60
Months after birth
1992
2001

Appendix 2. Tables

Table A1: Change in mortality hazard across cohorts by age

	Malawi (1)	Mozambique (2)	Tanzania (3)	Zambia (4)
	Panel A: Full sample			
0-60 months	0.5613**	0.8633**	0.7848**	0.8671*
	(-10.84)	(-2.77)	(-3.74)	(-2.54)
Observations	388,961	458,739	404,368	331,361
	Panel B: By age group			
0-2 months	0.6985**	0.8534*	0.9305	0.8306*
	(-4.24)	(-2.06)	(-0.74)	(-2.25)
3-6 months	0.4592**	0.9019	0.6147**	0.8386
	(-6.77)	(-1.02)	(-3.70)	(-1.42)
7-24 months	0.5309**	0.8995	0.7265**	0.8670
	(-7.71)	(-1.30)	(-3.29)	(-1.70)
25-60 months	0.3307**	0.5459**	0.7742	1.8051*
	(-4.52)	(-2.61)	(-0.88)	(2.01)
Cohort years	1992, 2004	1997, 2003	1996, 2004	1992, 2001

Table reports hazard ratio associated with cohort dummy from Cox proportional hazard models estimated on child-month observations from DHS using 5 year birth history. Z statistics in parentheses. ** $p<0.01$, * $p<0.05$

Table A2: Estimates of relative risk of death before 5 years by country

	Malawi	Mozambique	Tanzania	Zambia
	(1)	(2)	(3)	(4)
Sex of child is male	1.1361*	1.0774	1.2010**	1.1917**
	(2.57)	(1.72)	(3.02)	(3.43)
Twin birth	3.5751**	3.0683**	2.7539**	3.1162**
	(12.40)	(11.15)	(9.11)	(11.79)
First born	1.0760	0.9670	0.9889	0.8540
	(0.80)	(-0.44)	(-0.10)	(-1.81)
3rd birth or greater	0.7216**	0.7144**	0.6344**	0.7666**
	(-3.81)	(-4.45)	(-4.35)	(-3.32)
Mother finished primary education	0.7752**	0.9893	1.0264	0.8598*
	(-2.84)	(-0.09)	(0.39)	(-2.52)
Has first birth at 16 years old or older	0.8934	0.8222**	0.8421	1.1607
	(-1.52)	(-3.51)	(-1.74)	(1.79)
Number of live births for the mother	1.0781**	1.0795**	1.1099**	1.0404**
	(5.11)	(5.77)	(6.09)	(2.90)
Mother did not want to have any or more children	0.9290		0.7559*	0.7963**
	(-1.03)		(-2.11)	(-2.70)
Preceding birth was more than 24 months ago	0.6142**	0.4849**	0.6889**	0.6028**
	(-7.08)	(-13.54)	(-4.29)	(-7.88)
Small or very small at birth	1.4608**		1.3856**	1.6437**
	(5.94)		(3.51)	(8.13)
Birth- delivered at home or from traditional attendant	1.1641*		1.0373	1.0125
	(2.56)		(0.52)	(0.20)
Ever Breastfed	0.6201**		1.4260*	
	(-5.76)		(1.98)	
In the richest wealth quintile	0.9393	0.6613**	0.7190**	0.7513*
	(-0.74)	(-4.58)	(-2.77)	(-2.18)
Have access to improved water source §	0.9256	0.9465	0.9910	0.8678*
	(-1.31)	(-0.98)	(-0.13)	(-2.27)
Have access to improved sanitation ‡	0.6852	0.5813*	0.6978	0.9586
	(-1.92)	(-2.06)	(-1.46)	(-0.32)
Urban resident	1.0037	1.0718	0.9708	1.1359
	(0.04)	(0.98)	(-0.26)	(1.68)
Later Cohort Year $	0.4832**	0.8597**	0.7398**	0.8461**
	(-10.78)	(-2.99)	(-4.04)	(-2.88)
Observations	372922	449857	377511	323929
Log Pseudolikelihood	-14302.20	-19886.61	-9865.33	-15747.80
Cohort years	1992, 2004	1997, 2003	1996, 2004	1992, 2001

§ UN defines this as water that is safe to drink and available in sufficient quantities for hygienic purposes.
‡ UN defines this as the lowest-cost option for securing sustainable access to safe, hygienic and convenient facilities and services for excreta and sullage disposal that provide privacy and dignity while ensuring a clean and healthful living environment both at home and in the neighborhood of users. $ 2003 for Mozambique; 2004 for Malawi; 2004 for Tanzania; 2001 for Zambia.
Table reports hazard ratio associated with each variable in the first column, estimated from Cox proportional hazard models using child-month observations from DHS. Z statistics in parentheses. Breastfeeding variable not consistent across surveys in Zambia. Four variables not measured for full birth history in 1997 Mozambique survey. ** p<0.01, * p<0.05

Table A3: Estimates of relative risk of death before 2 years by country

	Malawi (1)	Mozambique (2)	Tanzania (3)	Zambia (4)
Sex of child is male	1.1333*	1.0629	1.2123**	1.1953**
	(2.43)	(1.38)	(3.08)	(3.40)
Twin birth	3.6098**	3.1344**	2.8420**	3.1857**
	(12.16)	(11.29)	(9.41)	(11.92)
First born	1.0787	0.9766	1.0225	0.8540
	(0.80)	(-0.31)	(0.19)	(-1.78)
3rd birth or greater	0.7204**	0.7105**	0.6373**	0.7515**
	(-3.71)	(-4.36)	(-4.17)	(-3.52)
Mother finished primary education	0.7907**	0.9864	1.0102	0.8628*
	(-2.58)	(-0.12)	(0.15)	(-2.45)
Has first birth at 16 years old or older	0.8884	0.8208**	0.8218*	1.1430
	(-1.58)	(-3.49)	(-1.96)	(1.58)
Number of live births for the mother	1.0817**	1.0774**	1.1131**	1.0430**
	(5.30)	(5.65)	(6.21)	(3.02)
Mother did not want to have any or more children	0.9037		0.7543*	0.7913**
	(-1.37)		(-2.07)	(-2.73)
Preceding birth was more than 24 months ago	0.6075**	0.4782**	0.6813**	0.5957**
	(-6.96)	(-13.65)	(-4.28)	(-7.87)
Small or very small at birth	1.4652**		1.3987**	1.6326**
	(5.87)		(3.51)	(7.91)
Birth- delivered at home or from traditional attendant	1.1766**		1.0719	1.0099
	(2.74)		(0.95)	(0.15)
Ever Breastfed	0.6038**		1.4079	
	(-6.07)		(1.88)	
In the richest wealth quintile	0.9562	0.6636**	0.7316*	0.7585*
	(-0.53)	(-4.51)	(-2.56)	(-2.10)
Have access to improved water source §	0.9284	0.9530	0.9880	0.8633*
	(-1.23)	(-0.85)	(-0.17)	(-2.33)
Have access to improved sanitation ‡	0.6307*	0.5382*	0.6380	0.9628
	(-2.37)	(-2.19)	(-1.71)	(-0.28)
Urban resident	1.0188	1.0558	0.9525	1.1279
	(0.22)	(0.75)	(-0.42)	(1.55)
Later Cohort Year $	0.4926**	0.8758**	0.7391**	0.8297**
	(-10.38)	(-2.59)	(-3.96)	(-3.18)
Observations	248626	294249	250572	218138
Log Pseudolikelihood	-13728.48	-19237.64	-9484.38	-15294.51
Cohort years	1992, 2004	1997, 2003	1996, 2004	1992, 2001

§ UN defines this as water that is safe to drink and available in sufficient quantities for hygienic purposes. ‡ UN defines this as the lowest-cost option for securing sustainable access to safe, hygienic and convenient facilities and services for excreta and sullage disposal that provide privacy and dignity while ensuring a clean and healthful living environment both at home and in the neighborhood of users. $ 2003 for Mozambique; 2004 for Malawi; 2004 for Tanzania; 2001 for Zambia.
Table reports hazard ratio associated with each variable in the first column, estimated from Cox proportional hazard models using child-month observations from DHS. Z statistics in parentheses. Breastfeeding variable no consistent across surveys in Zambia. Four variables not measured in 1997 Mozambique survey. ** p<0.01, * p<0.05

Table A4: Contribution to change in mortality hazard over time for 0-60 month old children

	Malawi (1)	Mozambique (2)	Tanzania (3)	Zambia (4)
Child's characteristics				
Male	0.01%	-0.01%	-0.07%	0.17%
Twin	-0.93%	0.10%	0.37%	-0.74%
First-born	0.39%	0.02%	0.00%	-0.22%
Third-born or higher birth order	3.27%	-0.38%	0.56%	0.88%
Mother's Characteristics				
Mother has primary education	-0.41%	-0.01%	0.02%	1.90%
Mother was >16 at first birth	-0.18%	-0.17%	-0.61%	0.65%
Parity (total # of births by mother)	-5.49%	0.18%	-0.69%	-1.47%
Birth situation				
Unwanted pregnancy	-0.29%		1.28%	-2.25%
>24 months between births	-0.27%	-2.44%	0.06%	-0.63%
Small at birth	-0.53%		0.36%	1.52%
Born at home or by traditional methods	-0.03%		0.25%	0.10%
Ever breast-fed	8.12%		-1.50%	
Household				
Richest	0.70%	1.39%	1.72%	3.81%
Community				
Have access to improved water source §	-1.18%	0.14%	0.15%	3.01%
Have access to improved sanitation ‡	0.64%	0.32%	-0.97%	0.52%
Urban	-0.06%	0.65%	0.11%	-2.18%
Cohort effect (unexplained change)	-51.67%	-14.03%	-26.02%	-15.39%

§ UN defines this as water that is safe to drink and available in sufficient quantities for hygienic purposes. ‡ UN defines this as the lowest-cost option for securing sustainable access to safe, hygienic and convenient facilities and services for excreta and sullage disposal that provide privacy and dignity while ensuring a clean and healthful living environment both at home and in the neighborhood of users.

Percentage change in hazard due to change in value of each covariate between time periods. See Tables A8-A11 for derivation and text for explanation.

Table A5: Contribution to change in mortality hazard over time for 0-24 month old children

	Malawi (1)	Mozambique (2)	Tanzania (3)	Zambia (4)
Child's characteristics				
Male	0.00%	-0.01%	-0.10%	0.16%
Twin	-1.02%	0.19%	0.42%	-0.64%
First-born	0.37%	0.02%	-0.01%	-0.12%
Third-born or higher birth order	3.21%	-0.48%	0.35%	0.77%
Mother's Characteristics				
Mother has primary education	-0.45%	-0.01%	0.00%	1.97%
Mother was >16 at first birth	-0.17%	-0.12%	-0.65%	0.57%
Parity (total # of births by mother)	-5.69%	0.36%	-0.35%	-1.43%
Birth situation				
Unwanted pregnancy	-0.39%		1.37%	-2.42%
>24 months between births	-0.38%	-2.63%	-0.16%	-0.75%
Small at birth	-0.58%		0.31%	1.39%
Born at home or by traditional methods	-0.11%		0.42%	0.09%
Ever breast-fed	8.69%		-1.43%	
Household				
Richest	0.49%	1.45%	1.60%	3.65%
Community				
Have access to improved water source §	-1.13%	0.11%	0.20%	3.19%
Have access to improved sanitation ‡	0.71%	0.47%	-1.18%	0.46%
Urban	-0.28%	0.51%	0.19%	-2.10%
Cohort effect (unexplained change)	-50.74%	-12.42%	-26.09%	-17.03%

§ UN defines this as water that is safe to drink and available in sufficient quantities for hygienic purposes. ‡ UN defines this as the lowest-cost option for securing sustainable access to safe, hygienic and convenient facilities and services for excreta and sullage disposal that provide privacy and dignity while ensuring a clean and healthful living environment both at home and in the neighborhood of users.

Percentage change in hazard due to change in value of each covariate between time periods. See Tables A8-A11 for derivation and text for explanation.

Table A6: Estimates of relative risk of death before 1 year by country

	Malawi (1)	Mozambique (2)	Tanzania (3)	Zambia (4)
Sex of child is male	1.1053	1.0595	1.2417**	1.1635*
	(1.69)	(1.25)	(3.13)	(2.50)
Twin birth	3.9836**	3.2943**	3.2434**	3.5538**
	(12.52)	(11.36)	(10.22)	(13.04)
First born	1.0649	0.9771	0.9394	0.8520
	(0.62)	(-0.28)	(-0.50)	(-1.59)
3rd birth or greater	0.6840**	0.6906**	0.6167**	0.8485
	(-3.86)	(-4.47)	(-4.03)	(-1.80)
Mother finished primary education	0.7640**	0.9610	0.9551	0.8370**
	(-2.60)	(-0.30)	(-0.57)	(-2.61)
Has first birth at 16 years old or older	0.8776	0.8114**	0.8318	1.1695
	(-1.62)	(-3.42)	(-1.59)	(1.62)
Number of live births for the mother	1.0877**	1.0877**	1.1200**	1.0392*
	(5.20)	(6.00)	(5.96)	(2.46)
Mother did not want to have any or more children	0.8594		0.7328*	0.7555**
	(-1.85)		(-2.08)	(-2.99)
Preceding birth was more than 24 months ago	0.5927**	0.4626**	0.5875**	0.5410**
	(-6.61)	(-13.23)	(-5.54)	(-8.88)
Small or very small at birth	1.5873**		1.4324**	1.7916**
	(6.45)		(3.52)	(8.66)
Birth- delivered at home or from traditional attendant	1.1958**		1.1103	0.9801
	(2.76)		(1.28)	(-0.27)
Ever Breastfed #	0.5626**		1.5301*	
	(-6.33)		(2.01)	
In the richest wealth quintile	1.0111	0.6686**	0.7863	0.8301
	(0.12)	(-4.00)	(-1.83)	(-1.23)
Have access to improved water source §	0.9191	0.9253	0.9485	0.8527*
	(-1.31)	(-1.32)	(-0.70)	(-2.31)
Have access to improved sanitation ‡	0.5736*	0.5723	0.6807	0.8862
	(-2.17)	(-1.81)	(-1.28)	(-0.75)
Urban resident	0.8965	1.0564	0.9111	1.0437
	(-1.12)	(0.73)	(-0.74)	(0.48)
Later Cohort Year $	0.5153**	0.8857*	0.6761**	0.8412**
	(-8.86)	(-2.15)	(-4.51)	(-2.65)
Observations	146356	170926	144764	127546
Log Pseudolikelihood	-11307.90	-16791.66	-7742.94	-11834.64
Cohort years	1992, 2004	1997, 2003	1996, 2004	1992, 2001

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$ 2003 for Mozambique; 2004 for Malawi; 2004 for Tanzania; 2001 for Zambia.
Table reports hazard ratio associated with each variable in the first column, estimated from Cox proportional hazard models using child-month observations from DHS. *z*-statistics in parentheses. Breastfeeding variable no consistent across surveys in Zambia. Four variables not measured in 1997 Mozambique survey. ** p<0.01, * p<0.05

Table A7: Estimates of relative risk of death at 0-2 months by country

	Malawi	Mozambique	Tanzania	Zambia
	(1)	(2)	(3)	(4)
Sex of child is male	1.2015*	1.1756*	1.6189**	1.2721**
	(1.97)	(2.52)	(4.76)	(3.05)
Twin birth	4.9664**	3.8520**	3.8312**	3.8182**
	(11.39)	(11.12)	(7.51)	(11.36)
First born	1.0145	0.9987	0.9592	0.8382
	(0.10)	(-0.01)	(-0.24)	(-1.37)
3rd birth or greater	0.6324**	0.7177**	0.5524**	0.7571*
	(-3.08)	(-3.00)	(-3.05)	(-2.23)
Mother finished primary education	0.7964	1.0302	1.0521	0.8247*
	(-1.54)	(0.18)	(0.42)	(-2.10)
Has first birth at 16 years old or older	0.7739*	0.7762**	0.7443	1.1641
	(-2.22)	(-3.03)	(-1.79)	(1.15)
Number of live births for the mother	1.0798**	1.1071**	1.1581**	1.0710**
	(2.92)	(5.81)	(5.39)	(3.20)
Mother did not want to have any or more children	1.0013		0.7945	0.6617**
	(0.01)		(-1.07)	(-2.87)
Preceding birth was more than 24 months ago	0.5449**	0.4015**	0.4811**	0.4463**
	(-5.31)	(-11.39)	(-5.58)	(-9.47)
Small or very small at birth	2.1643**		1.6782**	2.6315**
	(7.99)		(3.38)	(11.41)
Birth- delivered at home or from traditional attendant	1.2270		1.2373	1.0374
	(1.89)		(1.66)	(0.38)
Ever Breastfed	0.3764**		1.4930	
	(-7.91)		(1.35)	
In the richest wealth quintile	0.9612	0.6791**	0.7156	0.8940
	(-0.29)	(-2.92)	(-1.46)	(-0.50)
Have access to improved water source §	0.9980	0.9107	1.0062	0.8976
	(-0.02)	(-1.19)	(0.06)	(-1.20)
Have access to improved sanitation ‡	0.9305	0.4361	1.0079	0.9664
	(-0.22)	(-1.95)	(0.02)	(-0.14)
Urban resident	0.9605	1.1516	0.8715	0.9824
	(-0.28)	(1.40)	(-0.62)	(-0.15)
Later Cohort Year $	0.4707**	0.8282*	0.8236	0.8432*
	(-6.07)	(-2.49)	(-1.55)	(-2.13)
Observations	28172	33156	27337	24712
Log Pseudolikelihood	-4755.69	-8758.51	-3274.20	-5970.69
Cohort years	1992, 2004	1997, 2003	1996, 2004	1992, 2001

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$ 2003 for Mozambique; 2004 for Malawi; 2004 for Tanzania; 2001 for Zambia.
Table reports hazard ratio associated with each variable in the first column, estimated from Cox proportional hazard models using child-month observations from DHS. *Z*-statistics in parentheses. Breastfeeding variable no consistent across surveys in Zambia. Four variables not measured in 1997 Mozambique survey. ** p<0.01, * p<0.05

Table A8: Decomposing change in hazards of under-5yr death in Malawi

	Mean value of predictor			Cox regression coefficient	Net change in hazard	
	1992	2004	Difference		Absolute	%
	(1)	(2)	(3) = (2)-(1)	(4)	(5)=(4)*(3)	(exp(5)-1)
under-5yr Mortality	0.1640	0.0845	-0.0795			
Predictor						
Male	0.4996	0.5002	0.0006	0.1276	0.0001	0.008%
Twin	0.0305	0.0232	-0.0073	1.2740	-0.0093	-0.926%
First-born	0.1715	0.2249	0.0534	0.0733	0.0039	0.392%
Third-born or higher birth order	0.6687	0.5702	-0.0985	-0.3262	0.0321	3.265%
Mother has primary education	0.1602	0.1764	0.0162	-0.2546	-0.0041	-0.412%
Mother was >16 at first birth	0.8409	0.8570	0.0161	-0.1128	-0.0018	-0.181%
Parity (total # of births by mother)	4.7815	4.0304	-0.7511	0.0752	-0.0565	-5.492%
Unwanted pregnancy	0.1294	0.1688	0.0394	-0.0736	-0.0029	-0.290%
>24 months between births	0.6239	0.6295	0.0056	-0.4875	-0.0027	-0.273%
Small at birth	0.1608	0.1469	-0.0139	0.3790	-0.0053	-0.525%
Born at home or by traditional methods	0.2860	0.2841	-0.0019	0.1519	-0.0003	-0.029%
Ever breast-fed	0.9925	0.8291	-0.1634	-0.4779	0.0781	8.122%
Richest	0.2619	0.1502	-0.1117	-0.0626	0.0070	0.702%
Have access to improved water source §	0.4560	0.6090	0.153	-0.0773	-0.0118	-1.176%
Have access to improved sanitation ‡	0.0463	0.0294	-0.0169	-0.3780	0.0064	0.641%
Urban	0.2597	0.1107	-0.149	0.0037	-0.0006	-0.055%
Cohort effect (unexplained change)	0	1	1	-0.7272	-0.7272	-51.674%

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Table A9: Decomposing change in hazards of under-5yr death in Mozambique

	Mean value of predictor			Cox regression coefficient	Net change in hazard	
	1997	2003	Difference		Absolute	%
	(1)	(2)	(3) = (2)-(1)	(4)	(5)=(4)*(3)	(exp(5)-1)
under-5yr Mortality	0.1351	0.1150	-0.0201			
Predictor						
Male	0.4958	0.4938	-0.002	0.0745	-0.0001	-0.015%
Twin	0.0282	0.0291	0.0009	1.1211	0.0010	0.101%
First-born	0.2267	0.2219	-0.0048	-0.0335	0.0002	0.016%
Third-born or higher birth order	0.5793	0.5906	0.0113	-0.3363	-0.0038	-0.379%
Mother has primary education	0.0657	0.0748	0.0091	-0.0108	-0.0001	-0.010%
Mother was >16 at first birth	0.8059	0.8145	0.0086	-0.1958	-0.0017	-0.168%
Parity (total # of births by mother)	4.1167	4.1398	0.0231	0.0765	0.0018	0.177%
Unwanted pregnancy						
>24 months between births	0.5909	0.6250	0.0341	-0.7238	-0.0247	-2.438%
Small at birth						
Born at home or by traditional methods	Data not complete (not measured in 1997 Mozambique DHS)					
Ever breast-fed						
Richest	0.2306	0.1973	-0.0333	-0.4136	0.0138	1.387%
Have access to improved water source §	0.4327	0.4075	-0.0252	-0.0550	0.0014	0.139%
Have access to improved sanitation ‡	0.0273	0.0215	-0.0058	-0.5426	0.0031	0.315%
Urban	0.2641	0.3574	0.0933	0.0694	0.0065	0.650%
Cohort effect (unexplained change)	0.0000	1.0000	1	-0.1512	-0.1512	-14.032%

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Table A10: Decomposing change in hazards of under-5yr death in Tanzania

	Mean value of predictor			Cox regression coefficient	Net change in hazard	
	1996	2004	Difference		Absolute	%
	(1)	(2)	(3) = (2)-(1)	(4)	(5)=(4)*(3)	(exp(5)-1)
under-5yr Mortality	0.0882	0.0676	-0.0206			
Predictor						
Male	0.5070	0.5033	-0.0037	0.1831	-0.0007	-0.068%
Twin	0.0304	0.0340	0.0036	1.0130	0.0036	0.365%
First-born	0.2055	0.2058	0.0003	-0.0112	0.0000	0.000%
Third-born or higher birth order	0.6064	0.5941	-0.0123	-0.4551	0.0056	0.561%
Mother has primary education	0.5433	0.5509	0.0076	0.0260	0.0002	0.020%
Mother was >16 at first birth	0.8726	0.9085	0.0359	-0.1718	-0.0062	-0.615%
Parity (total # of births by mother)	4.3845	4.3181	-0.0664	0.1042	-0.0069	-0.689%
Unwanted pregnancy	0.0889	0.0434	-0.0455	-0.2799	0.0127	1.282%
>24 months between births	0.6615	0.6600	-0.0015	-0.3727	0.0006	0.056%
Small at birth	0.1026	0.1136	0.011	0.3261	0.0036	0.359%
Born at home or by traditional methods	0.4818	0.5503	0.0685	0.0366	0.0025	0.251%
Ever breast-fed	0.9742	0.9315	-0.0427	0.3549	-0.0152	-1.504%
Richest	0.2080	0.1564	-0.0516	-0.3299	0.0170	1.717%
Have access to improved water source §	0.5710	0.4002	-0.1708	-0.0090	0.0015	0.154%
Have access to improved sanitation ‡	0.0247	0.0519	0.0272	-0.3599	-0.0098	-0.974%
Urban	0.2110	0.1726	-0.0384	-0.0296	0.0011	0.114%
Cohort effect (unexplained change)	0	1	1	-0.3014	-0.3014	-26.022%

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Table A11: Decomposing change in hazards of under-5yr death in Zambia

Predictor	Mean value of predictor 1992 (1)	2001 (2)	Difference (3) = (2)-(1)	Cox regression coefficient (4)	Net change in hazard Absolute (5)=(4)*(3)	% (6)=Exp(5)-1
under-5yr Mortality	0.1431	0.1288	-0.0143			
Child's characteristics						
Male	0.4939	0.5038	0.0099	0.1547	0.0015	0.153%
Twin	0.0288	0.0223	-0.0065	0.9074	-0.0059	-0.588%
First-born	0.2072	0.2211	0.0139	-0.0969	-0.0013	-0.135%
Third-born or higher birth order	0.6236	0.5907	-0.0329	-0.3421	0.0113	1.132%
Mother has primary education	0.5221	0.3977	-0.1244	-0.1167	0.0145	1.462%
Mother was >16 at first birth	0.8447	0.8882	0.0435	0.1298	0.0056	0.566%
Parity (total # of births by mother)	4.6823	4.3096	-0.3727	0.0648	-0.0242	-2.386%
Unwanted pregnancy	0.0612	0.1610	0.0998	-0.2923	-0.0292	-2.875%
>24 months between births	0.6407	0.6532	0.0125	-0.4543	-0.0057	-0.566%
Small at birth	0.0996	0.1300	0.0304	0.4125	0.0125	1.262%
Born at home or by traditional methods	0.4937	0.5776	0.0839	0.0023	0.0002	0.019%
Ever breast-fed						
Richest	0.2483	0.1174	-0.1309	-0.2706	0.0354	3.606%
Have access to improved water source	0.6546	0.4456	-0.209	-0.1249	0.0261	2.645%
Have access to improved sanitation	0.2327	0.1098	-0.1229	-0.0387	0.0048	0.477%
Urban	0.4330	0.2597	-0.1733	0.1238	-0.0215	-2.123%
Cohort effect (unexplained change)	0	1	1	-0.1110	-0.1110	-10.506%

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