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The Complementarity of MDG Achievements

The Case of Child Mortality in Sub-Saharan Africa

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Abstract

This paper analyzes complementarities between different Millennium Development Goals, focusing on child mortality and how it is influenced by progress in the other goals, in particular two goals related to the expansion of female education: universal primary education and gender equality in education. The authors provide evidence from eight Sub-Saharan African countries using two rounds of Demographic and Health Surveys per country and applying a consistent micro-econometric methodology. In contrast to the mixed findings of previous studies, for most countries the findings reveal strong complementarities between mothers' educational achievement and child mortality. Mothers' schooling lifts important demand-side constraints impeding the use of health services. Children of mothers with primary education are much more likely to receive vaccines, a crucial proximate determinant of child survival. In addition, better educated mothers tend to have longer birth intervals, which again increase the chances of child survival. For the variables related to the other goals, for example wealth proxies and access to safe drinking water, the analysis fails to detect significant effects on child mortality, a finding that may be related to data limitations. Finally, the study carries out a set of illustrative simulations to assess the prospects of achieving a reduction by two-thirds in the under-five mortality rate. The findings indicate that some countries, which have been successful in the past, seem to have used their policy space for fast progress in child mortality, for example by extending vaccination coverage. This is the main reason why future achievements will be more difficult and explains why the authors have a fairly pessimistic outlook.

This paper—a product of the Development Economics Prospects Group—is part of a larger effort in the group to do forward-looking analyses of development strategies, including strategies for achieving the Millennium Development Goals. Policy Research Working Papers are also posted on the Web at http://econ.worldbank.org. The author may be contacted at lay@giga-hamburg.de and robilliard@dial.prd.fr.

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The Complementarity of MDG Achievements: The Case of Child Mortality in Sub-Saharan Africa[†]

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Introduction

The instruments and means needed to achieve the Millennium Development Goals (MDGs) have been subject to an intensive debate in academic and policy circles in the past decade. A wide variety of approaches and models have been proposed that have yielded a number of important insights into the key mechanisms, resource requirements, and the main bottlenecks for achieving the MDGs (see Website of the UN Development Group; Sachs and McArthur, 2005; Bruns, 2003; Glewwe and Zhao, 2006). This paper contributes to this debate by examining complementarities between different MDGs.

More specifically, its overall objective is to analyze the effect of progress in other MDGs, in particular the expansion of female education (MDG2 & MDG3), on child mortality (MDG4).[2] Several studies have analyzed the contribution of specific factors to the attainment of the MDGs or a subset of them, for example infrastructure (Fay et al., 2005) or population growth (Potts and Fotso, 2007). Complementarities between different MDGs are difficult to study because of the complex nature of interactions that exist between 'inputs' and 'outputs'. For example, less income poverty may allow more people to send their children to school, which in turn reduces household income in the short run due to lost child labor but increases income prospects in the medium run. From this perspective, child mortality seems a particularly suited MDG outcome to study complementarities because there is no or little (immediate) feedback from child mortality to other MDGs.

Numerous studies have analyzed child mortality determinants in Sub-Saharan Africa (e.g. Brockerhoff and Derose, 1996; Brockerhoff and Hewett, 2000; Hill et al., 2001) with mixed outcomes in terms of socio-economic determinants, such as education and income. Unfortunately, many of these studies examine child mortality in one point in time and often for only one country. Most studies hence rely entirely on the cross-sectional within-country variation between households, mothers, and children typically using Demographic and Health Surveys (DHS). Moreover, they lack a common framework, which makes findings difficult to compare and to generalize. Finally, most studies spend little time at examining the transmission channels of socio-economic factors.

In this paper, we attempt to overcome some of these weaknesses by conducting a multi-country study using two rounds of DHS per country and a consistent micro-econometric methodology. We hence combine rigorous micro-econometric work and a comparative

[2] MDG 4 calls for a reduction of the under-five (child) mortality (U5M) rate by two thirds between 1990 and 2015.

perspective. We do so by investigating the following pairs of Sub-Saharan African countries: Madagascar – Mozambique, Uganda – Kenya, Senegal – Guinea, and Mali – Niger. The selected countries exhibit both important similarities, in particular countries of a pair, and marked differences, e.g. in child mortality reductions. To analyze and compare the determinants of child mortality, we estimate dicrete-time hazard models of survival for children under 5 for each country. The transmission channels are analyzed by regressions that link socio-economic variables, such as education, with so-called proximate child mortality determinants, for example birth spacing. In a final step, the hazard models are used to simulate the effects of expanding mother's education on child mortality.

In contrast to the mixed findings of the previous literature, we find strong complementarities between mothers' educational achievement and child mortality in most countries. While the direct effect of education in child mortality models is not particularly robust, we show that mothers' schooling lifts important demand side constraints in terms of the use of health services: Children of mothers with primary education are much more likely to receive vaccines. This effect on the demand for health services is not the only positive effect of mothers' education. Better educated mothers tend to have longer birth intervals, which again considerably increases the chances of child survival. For other MDG-related variables, e.g. wealth proxies and access to safe drinking water, we fail to detect significant effects on child mortality, a finding that may however to a large extent be related to data limitations.

Despite its importance, our simulations show that achieving universal primary education will not suffice to achieve the child mortality reduction targets, at least without other relevant conditions changing substantially. The comparison across countries suggests that there are important variations in the effectiveness of policies aimed at reducing child mortality. Since some countries, which have been successful in the past, seem to have used their policy space, for example by extending vaccination coverage, future reductions will be more difficult to attain. This is also the main reason why our simulation exercises yield a fairly pessimistic outlook for the prospects of achieving MDG4: Even an overly ambitious policy scenario that combines universal primary education with universal vaccination coverage and an elimination of short birth intervals falls short of the envisaged goals in seven out of eight of the country cases.

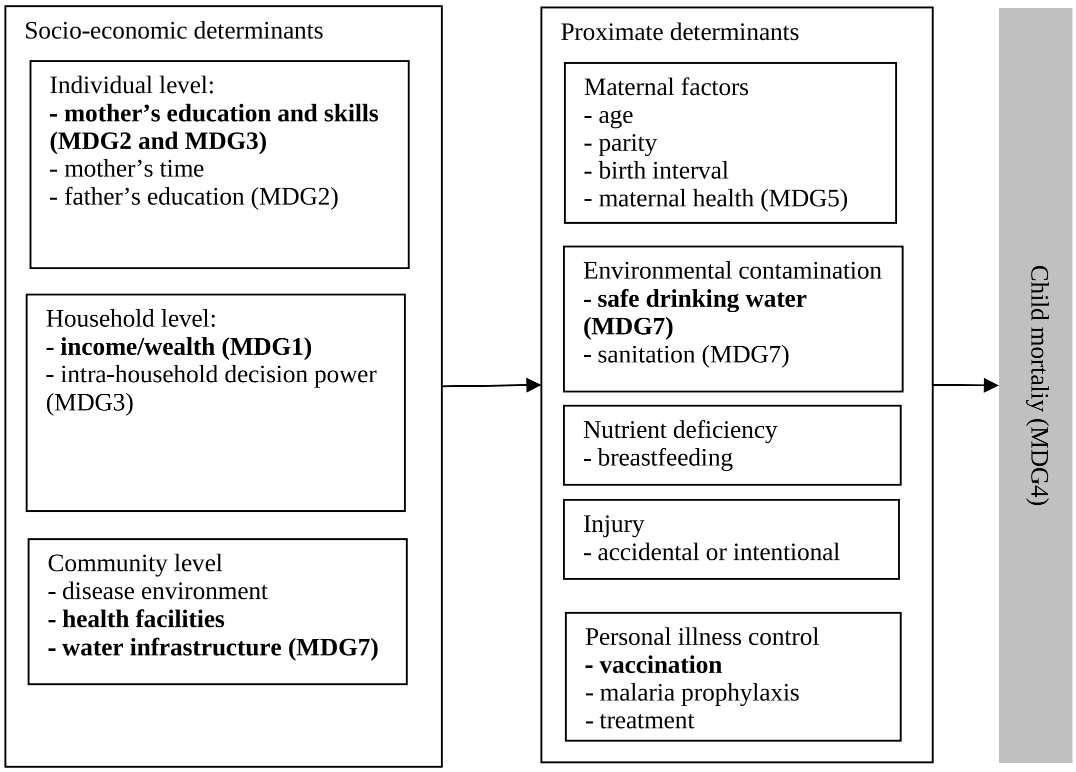
The paper first sets out the analytical framework for the study of child mortality determinants and briefly reviews existing empirical evidence from SSA. We then present the results of our empirical analysis. The empirical part of the paper starts with an outline of the main trends in child mortality outcomes and changes in some major determinants in the country case studies, and proceeds by presenting the estimation results of the survival models. This is followed by the MDG achievement simulations based on the former estimates. The final section concludes.

Child Mortality Determinants and Complementarities with Other MDGs

Analytical Framework

Our analysis follows the analytical framework for the study of child mortality proposed by Mosley and Chen (1984). In fact, most empirical studies on child mortality implicitly or explicitly rely on the Mosley-Chen-framework (Hill, 2003) that distinguishes between proximate and socio-economic determinants of child mortality. Proximate determinants (or intermediate variables) directly affect child mortality risk, such as maternal factors (age, parity, and birth interval), environmental contamination (hygienic factors, water, and sanitation), nutrition, injuries, and personal illness control. In contrast, all socio-economic variables have to operate through these proximate determinants and thus indirectly affect child mortality risk. Without trying to provide great detail, Figure 1 below summarizes the Mosley-Chen framework.

Figure 1: Socio-economic and proximate determinants of child mortality



Source: Authors' elaboration based on Mosley and Chen (1984).

Mosley and Chen (1984) group socio-economic determinants into individual level, household level and community level variables.[3] On the individual level, parents' skills, health and time are important determinants of child mortality. Skills are typically measured by formal educational achievement although 'child-raising skills' may also be acquired in different ways. While the father's education may often work primarily through its effect on household income, i.e. by affecting employment and income of the main income earner (in most households), it also plays an important role in household decision-taking (e.g. on household expenditure pattern) and for the father's personal illness control. Yet, the mothers' characteristics are of primary importance to child survival. During pregnancy and lactation the mother's and child's health are of course directly linked. Mother's health and nutritional status, her reproductive behavior and knowledge of child health care practices (vaccination, hygiene, disease treatment etc.) will be influenced by her educational attainment. Finally, the

[3] The following short summary of transmission channels from socio-economic factors to proximate determinants and relationships between those factors is by no means exhaustive. It mainly draws on Mosley and Chen (1984) where much more detail is provided.

mother's time for health care, food preparation, washing clothes etc. is important, but time for child care competes with other time uses, in particular income-generating activities. Whether this competition for mother's time becomes a threat to child health obviously depends on household income. For richer households, it may be easier to reallocate time to child care. Not only with regard to time use household income matters for child survival. Sufficient income allows the household to provide the child with food in adequate quantity and quality, drinking water, clothing, housing, energy, hygienic articles and health care (etc.).

All the mentioned individual and household choices that matter for child survival also have an important socio-cultural dimension. Social norms influence power relationships within households and therefore affect the intra-household allocation of resources both with regard to time use and expenditure allocation. Furthermore, these power relationships affect fertility and reproductive choices. In addition, some traditions or rules often directly guide certain decisions, for example with regard to nutrition choices or health practices, which, in some instances, can be harmful to the child. Norms and traditions are typically not specific to a single household, but shared by all the members of a community, tribe, or society. Yet, the extent to which the norms translate into individual or household behavior may well differ across households. Household and individual characteristics hence interact with those external determinants. This also holds for other community-level factors that include the ecological setting (climate, food availability, disease environment), the political economy (infrastructure and political institutions), and the availability of health services. The presence of a health facility (and its quality) as well as the availability of vaccines can be crucial for child survival. How far community health infrastructure will eventually affect child survival however depends on both the willingness to use and the ability to pay for child and mother health services.

We now want to discuss child mortality determinants focusing on MDG complementarities. Figure 1 highlights the MDG-related determinants that will be at the centre of our analysis: Mother's educational achievement (MDG2 & MDG3), household income/wealth (MDG1), and the delivery of two types of public services that matter for child survival – access to safe drinking water (MDG7) and child vaccinations (a proximate determinant of child mortality). As is evident from the above discussion, expanding parents' education and reducing income poverty is likely to improve child rearing through a number of channels. Wealthier and/or better educated parents, in particular mothers, can afford more and better food, make better informed fertility and reproductive choices, and may be able to dedicate more time to their children. Regarding the use of public services, education and income growth can relieve demand side constraints of their use, thereby reducing child mortality: Better educated mothers make sure that their children are being vaccinated. Wealthier households can pay for the fare to get to the health clinic or pay for the vaccine if not provided for free. Educated mothers may be much more aware of the risks associated to water from unprotected sources and wealthier households may be able to dedicate more resources to get safe drinking water. These examples illustrate that the willingness to use and ability to pay for public services are key links between child mortality and other MDGs.

Of course, there are other important links between different socio-economic determinants, which again eventually affect child mortality. It is a well established fact that educational attainments are an important determinant of income, even in poor agricultural contexts. Furthermore, mother's education determines her intra-household decision power (possibly also through increasing her contribution to household income). Yet, although these relationships will not be ignored, we will not address them explicitly in our empirical analysis that broadly follows the strategies that have been proposed in the literature on child mortality.

The conceptual framework of Mosley and Chen (1984) has triggered three types of empirical approaches to the analysis of child mortality (Hill, 2003): First, the analysis of the effects of socio-economic factors on proximate determinants, for example the analysis of factors associated with child immunization; second, studies that link an outcome variable, i.e. typically mortality, with both socio-economic and proximate determinants; and, third, reduced-form models that illustrate 'gross effects' associated with single socio-economic variables.

The first approach suffers from the obvious shortcoming that it does not establish a relationship between the socio-economic determinants and the outcome that we are ultimately interested in, child mortality. The second approach can provide interesting insights into how socio-economic variables affect child survival through proximate determinants. In theory, in a fully-specified model including all proximate determinants, the coefficients of the socio-economic variables should be zero, as, by definition, all variation in mortality should be captured by the former. In practice, however, we will not be able to include the entire set of proximate determinants because of measurement problems. A prominent candidate for such typically missing proximate determinant is e.g. the nutritional intake of the child, at least in large scale surveys. Not including this variable implies that the socio-economic determinants associated to nutrition, e.g. income, should show an effect that is however difficult to interpret since it is likely to reflect more than just the 'nutrition effect'. Finally, the third approach – although it does not provide any information on the mechanisms at work – can be very useful when combined with the second and first approach. As we will later describe in more detail, we opted for combining the three approaches in the current study. Yet, before we present our empirical results, the next section tries to summarize what is known about child mortality determinants, in particular with regard to those related to other MDGs in the Sub-Saharan context.

Evidence on Child Mortality Determinants in SSA

The literature on the determinants of child mortality, whether infant or under five, is relatively abundant. A number of single- and multiple country regression-based studies have been carried out in the last twenty years, most of them taking advantage of DHS data. It is indeed difficult to collect data suitable for mortality/survival analysis and DHS surveys are among the few surveys that permit this type of analysis since they collect information on the reproductive history of women. More specifically, they gather data on dates and survival status of all births, information that is obviously crucial for child and infant mortality analysis. Furthermore, being in large part conceptualized centrally by Macro International, the DHS surveys use a framework that allows the estimation of country-level models relying on the same set of variables. Given the characteristic of the dependent variable, hazard models are typically used to estimate mortality/survival models. The selection of variables is very often based on Mosley and Chen’s conceptual framework presented in the previous section. It usually includes child level (like gender and birth order), mother level (like birth spacing, age at birth, education, ethnicity) and household level information (like wealth and access to water). In the following, we review a number of empirical infant and child mortality studies that have been conducted in the SSA context. In addition, our literature review includes Charmarbagwala et al.’s (2004) world-wide meta-analysis of mortality, health and nutrition studies that only contains a couple of studies carried out on SSA datasets. This compilation of the results from 38 papers reveals, not surprisingly, a certain degree of consistency in the determinants of child mortality. However, as we will see, there is also quite some heterogeneity in the results – even within the SSA – suggesting that policies need to be adapted to the country-specific context.

In the reviewed micro-econometric studies, child characteristics typically show the expected influence on mortality. Boys are often found to be significantly more likely to die than girls and the same holds for first born children (see for example Lavy et al., 1996; Ssewanyana and Younger, 2007). In terms of maternal proximate determinants, the studies in general confirm the important influence in particular of mother’s age and birth intervals (for example Mturi and Curtis, 1995; Brockerhoff and Derose, 1996; Lavy et al., 1996; Lalou and LeGrand, 1997). Similarly, maternal health conditions can also be shown to be a key determinant of child survival (for example, as in Brockerhoff and Derose, 1996; Lavy et al., 1996).

In contrast, the evidence on the effect of mother's education, one of the socio-economic factors of primary interest in this study, is mixed. While quite a few studies only find a rather small and often insignificant effect (for example, Lavy et al., 1996; Brockerhoff and Derose, 1996; Lalou and LeGrand, 1997), others do detect the expected mortality-reducing effect (for example, Derose and Kulkarni, 2005; Ssewanyana and Younger, 2007; Omariba et al., 2007). For Kenya, Derose and Kulkarni (2005) do not only find a direct beneficial effect of mother's education on child survival, but, on top of this, an indirect community-level effect: The proportion of women in the community completing primary school significantly augments infant survival in addition to the individual-level effect. A positive effect of mother's education is also identified in Charmarbagwala et al.'s (2005) meta-analysis, supported by joint significance of variables measuring schooling and literacy. However, according to the authors, it is not clear if education by itself has any effect, or if education is only useful if it leads to a higher knowledge about health and nutrition. Finally, we would like to add, such knowledge may only be useful if it can be applied. For example, a mother may not be able to put her knowledge about nutritional requirements into practice, as her and the child's diet is determined by largely unchangeable agricultural and economic conditions. These two aspects may partly explain the variation in the findings on the effects of mother's education.

Another socio-economic factor of particular interest in this paper is material well-being, typically measured by consumption, income, and/or wealth. In fact, as almost all the reviewed studies rely on DHS data, researchers are forced to resume to an asset indicator as a proxy for material wealth. This asset indicator is typically computed using principal components analysis on the basis of a list of assets, as suggested by Filmer and Pritchett (2001). When included, wealth, as expected, tends to increase the chances of child survival (for example Hill et al., 2001) or infant survival (for example Ssewanyana and Younger, 2007) – independent of other factors included in the regression. Yet, for infant mortality however, this does not turn to be out a universal finding. The meta-study by Charmarbagwala et al. (2005) suggests that, although there can be little doubt that household income is a crucial factor in determining child health, it appears that income is not a significant determinant of infant mortality in the majority of cases. This can partly be explained by the fact that as mortality falls, the bulk of under-five-mortality is infant rather than child death, and these deaths are more sensitive to health provision than socio-economic conditions (White, 2004). The latter is for example shown by Omariba, Beaujot and Rajulton (2007) using the 1998 Kenyan DHS: While demographic factors are more important in explaining infant (under 12 months) mortality, socioeconomic, socio-cultural and hygienic factors are more important in explaining child (under five) mortality.

According to Charmarbagwala et al. (2005), a third important determinant of child health and nutrition outcomes appears to be the availability of clean drinking water and sanitation. By preventing infections and diarrhea these two factors lead to better nutritional outcomes for a given nutrition supply and so reduce mortality. While this logic certainly applies, the difficulties of operationalizing access to safe water in (DHS-based) empirical studies may explain why the results on clean water and sanitation in the reviewed studies tend to be mixed. Ssewanyana and Younger (2007), for example do not find significant effects of variables related to the quality of drinking water and of sanitation on infant mortality. Similarly, Lavy et al. (1996) only find the expected positive effect on child health only for rural areas. Brockerhoff and Hewett (2000) do find a positive effect of piped water access, but their regression does neither include income variables nor an urban dummy (only a dummy for the largest city).

While the above child, maternal, and certain household-level proximate as well as socio-economic explanatory variables are common to most studies (albeit operationalized in different ways), most studies tend to focus on a particular set of determinants or context factors. The studies can be grouped into those that focus on health infrastructure and vaccination (often in terms of rural-urban disparities), differential mortality between socio-economic (and/or ethnic or racial) groups, as well as the impact of HIV/AIDS, respectively.

Unfortunately, estimating the effects of the provision of health services on child mortality is not a straightforward exercise. One of the main reasons is the lack of data that would allow linking (individual) child mortality data, one the one hand, with the availability and quality of health services, on the other. Only few DHS surveys, for example, provide information on health infrastructure through a specially designed community module. Brockerhoff and Derose (1996) examine the impact of preventive health care on child survival determinants in five east African countries (Kenya, Madagascar, Malawi, Tanzania, and Zambia) using available DHS since 1992. For that purpose, they estimate child mortality models for three time intervals (0, 1-11, 12-23 months) including variables on the use of preventive health care, immunization coverage (individual and cluster info) and fertility regulation by mother. They conclude that preventive health measures are a key determinant of child mortality rates. In particular, they show that universal immunization could have reduced rates of mortality under age two by as much as one-third in these countries. A strong effect of vaccination is also shown by Ssewanyana and Younger (2007) who study the determinants and trends of infant mortality in Uganda using three rounds of DHS surveys. They estimate logit models and include district-level proxies for health infrastructure. District-level vaccination rates, in particular for childhood diseases, turn out to be one major determinant of (infant) mortality; mothers' educational achievement another.

Harttgen and Misselhorn (2006) use a multilevel approach to explain child mortality and malnutrition in South Asia and Sub-Saharan Africa on the basis of DHS data for South Asia and four Sub-Saharan Africa countries (Mali 2001, Nigeria 1999, Uganda 1995 and Zimbabwe 1994). Their special covariates include a health facility index (whether mother received tetanus vaccination before birth, whether mother received prenatal care, whether child was born at home without assistance of a doctor or a nurse, average number of vaccination per child within a household). Their results indicate that determinants of child mortality differ significantly from those of under-nutrition: access to health infrastructure appears to be more important for child mortality, while individual features (e.g. wealth and educational and nutritional characteristics of mothers) play a larger role for anthropometric shortfalls.[4] In their study on Zambia, Derose and Kulkarni (2005) identify similar mechanisms. They find that full immunization considerably improves infant survival chances, although material resources appear to become more crucial beyond infancy.

Differences in health infrastructure between rural and urban areas have also been under scrutiny of empirical research. Using Ghana's Living Standard Survey of 1988, Lavy et al. (1996) find big urban-rural disparities concerning health status, which they show to mainly stem from differences in the quality and accessibility of health services. Examining survival and health outcomes of children born during the ten years preceding the survey, they use non-parametric Kaplan-Meier methods to estimate hazard functions while time-dependent hazard rate Weibull models measure the rate at which the hazard rate changes. Investigating the same question for three Sahel countries (Burkina Faso, Mali and Senegal), Lalou and LeGrand (1997) reach a somewhat different conclusion. Similar to Lavy et al. (1996), they find child mortality rates to be substantially higher in rural than in urban areas using a special survey on infant mortality. According to their analysis, this is not only due to a lack of health infrastructure, but also a result of under-usage of health services in rural areas.

[4] However, the use of the health facility index masks the precise transmission channel of different components of health infrastructure and services that may have very different effects on child mortality, such as vaccination (programs) and the availability of a basic health services, respectively.

Results by Brockerhoff (1990, 1994) point in a similar direction, but also suggest a role for other socio-economic factors that may condition the use of health services. Brockerhoff (1990) focuses on the impact of rural-to-urban migration on child survival in Senegal. Using data from the DHS survey carried out in 1998, he estimates both infant (0-15 months) and child mortality (16-59 months) proportional-hazard models including migration variables. His results indicate that children's survival chances improve when migrating from rural to urban areas, but that children of rural-to-urban migrants continue to experience a much higher under-five mortality risk than urban non-migrants. Brockerhoff (1994) extends this analysis to four regions (Sub-Saharan Africa, North Africa, Latin America and Southeast Asia), using pooled regional samples of DHS surveys for 17 countries over the 1986-1990 period. Migrating from rural to urban areas appears to increase the risk of dying within the time of moving, but significantly reduces the risk afterwards in the late 1970s and 1980s. In Mali and Senegal the use of modern health services clearly increased after migration.

A second set of empirical studies focuses and differences in child mortality between socio-economic and ethnic groups. The reviewed literature reaches different conclusions as regards the magnitude of such differences. Mturi and Curtis (1995), for example, investigate the determinants of infant and child mortality in Tanzania using the 1991/92 Tanzania Demographic and Health Survey. They find a remarkable lack of infant and child mortality differentials by socioeconomic subgroups of the population, which they posit may reflect post-independence health policy and development strategies. This results stands in stark contrast to findings from other countries in SSA.

Brockerhoff and Hewett (2000) examine inequality of child mortality among ethnic groups in 11 Sub-Saharan Africa countries (Central African Republic, Côte d'Ivoire, Ghana, Kenya, Mali, Namibia, Niger Rwanda, Senegal, Uganda, Zambia) using DHS data. Their multivariate analysis takes into consideration the effects of ethnic affiliation as well as additional variables, to determine whether infant mortality differentials among ethnic group members are related to a combination of differences in household economic conditions, women's status, demographic behavior, and preventive health care practices, as well as residence in the largest city of the country. Their results indicate that there exist large disparities in early child survival chances among ethnic groups in a wide range of African countries. They also suggest that these differentials are closely linked with ethnic inequalities in household economic status, education of women, access to and use of health services, and degree of concentration in the largest city.

In South Africa, Burgard and Treiman (2004) examine racial differences in child mortality using data from two rounds of DHS surveys. They estimate piecewise exponential hazard models with shared frailty including as special covariates five age intervals, a dummy indicating whether the child preceding the index child died, and mother's race. They show that inequalities in the personal and household resources of South Africa's four main racial groups substantially account for racial differences in child survival rates. This suggests that the dismantling of the apartheid system cannot eradicate the racial disparity in child mortality unless persisting racial inequities in basic levels of living are radically reduced.

Recently, child mortality studies have also examined the impact of HIV-AIDS. Using two DHS surveys carried out in Kenya in 1993 and 1998, Hill et al. (2001) examine the trends and determinants of child mortality in Kenya in the late 1980s to mid 1990s. They show that rising child mortality in the 1990s cannot be explained by changes in socioeconomic, demographic or health service utilization factors and that the HIV epidemic hence appears to be the most probable cause of the recent increases in child mortality in Kenya. Derose and Kulkarni (2005), who estimate the effect of HIV prevalence and other community characteristics on childhood mortality, come to similar conclusions for Zambia. They find that community HIV rates significantly elevate the risk of child death. Yet, this does not hold for infant death, indicating that own or parental infection matters more than indirect mechanisms like a high dependency ratio.

In sum, the review of infant and child mortality studies with a focus on evidence from Sub-Saharan Africa yields the following main insights: (1) Child and maternal proximate determinants do have the expected important impact on child survival. (2) The evidence with regard to socio-economic factors, in particular with respect to maternal education, is mixed. (3) When included, access to health infrastructure, in particular access to vaccination, turns out to have a strong impact on infant and child mortality outcomes. (4) In Sub-Saharan Africa in particular, infant and child mortality differ substantially between urban and rural areas as well as ethnic/racial groups; this being rooted in major socio-economic differences. (5) In high prevalence countries, HIV-AIDS may be an important, but difficult to observe, factor in explaining changes in child and infant mortality.

Yet, this brief review of empirical studies on child mortality in SSA also reveals some gaps and shortcomings of the existing literature. An important shortcoming of almost all the reviewed studies, and, indeed, the present one, is their reliance on DHS data. While these datasets certainly have their merits and are among the few datasets suitable for child mortality analyses, they also have some deficiencies. The most pertinent example of these deficiencies, which may at least partly explain some of the mixed findings with regard to socio-economic determinants, is the inadequacy of the commonly used wealth index as a proxy for income/material well-being, in particular in the rural areas of Sub-Saharan Africa. We will discuss this issue at quite some length in our empirical analysis below. In our view, quite a few of the reviewed studies fail to discuss this possible source of error sufficiently.

A second shortcoming of the presented studies is their mere focus on reduced-form mortality equations that directly links socio-economic plus proximate determinants and child survival. Although the Mosley-Chen framework, as laid out above, also suggests examining the link between socio-economic and proximate determinants, we found very few examples for this type of exercise. This implies that the transmission channels (Are more educated mothers more likely to have their children vaccinated?) are often left in the dark.

Finally, the empirical literature is dominated by studies that examine a single country at a single point in time. Notable exceptions include the multi-country (not cross-country) studies by Lalou and LeGrand (1997), Brockerhoff and Hewett (2000), and Harttgen and Misselhorn (2006). Changes over time are only addressed in Hill et al. (2001) and Burgard and Treiman (2004). Although the use of multiple cross-sections (instead of panel data) does not allow for dynamic econometric analysis, these analyses do provide important insights into the factors that shape changes in child mortality. Therefore, the subsequent empirical analysis uses data from two years for each country in a multi-country comparison, attempts to address the difficulties with regard to the DHS wealth proxy, and stresses the transmission channels through which socio-economic factors eventually affect child mortality outcomes.

New Evidence from DHS: Comparing Country Experiences in SSA

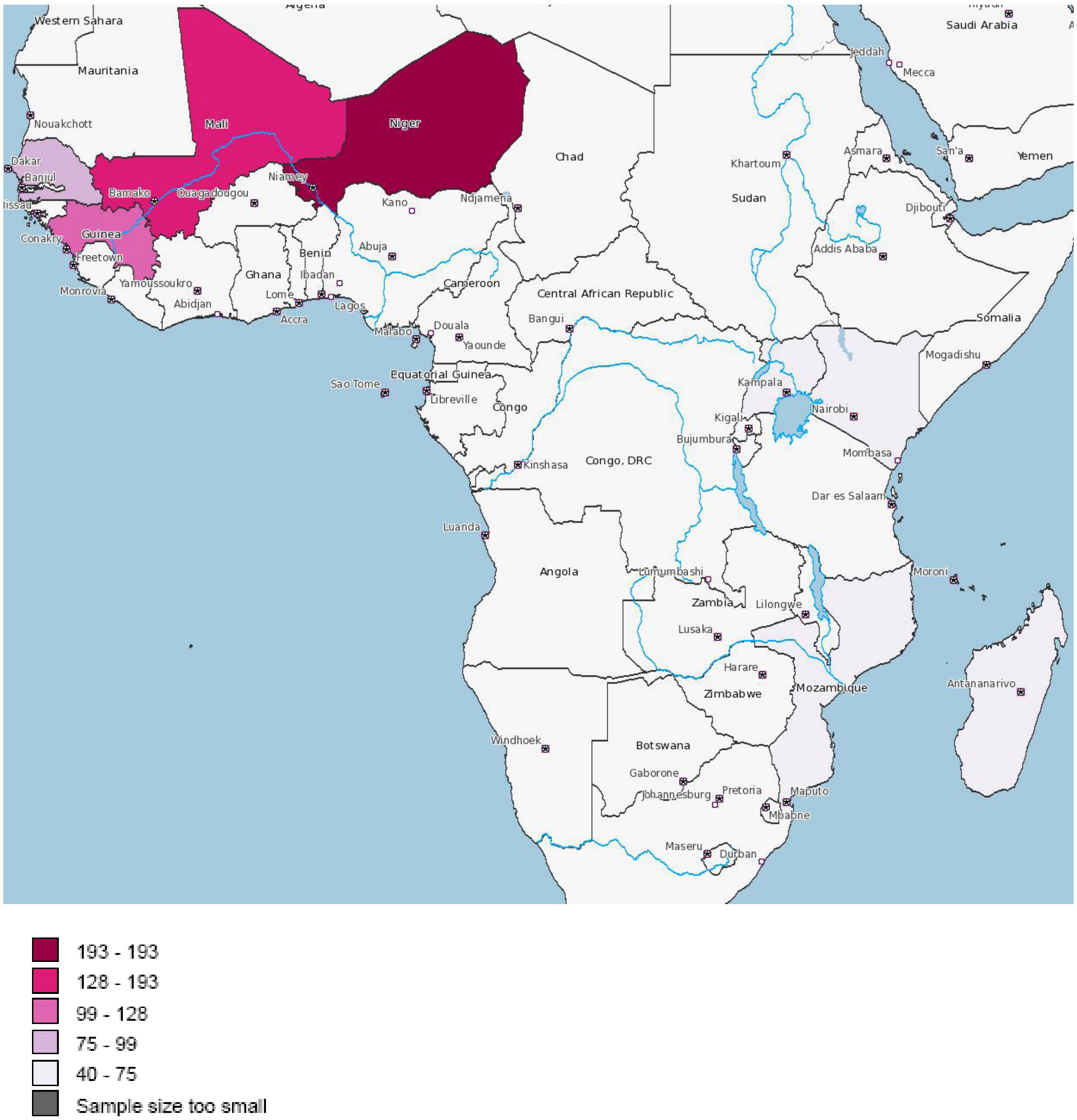
For our empirical analyses, we have selected four country pairs from different SSA regions: Guinea-Senegal and Mali-Niger in West Africa as well as Madagascar-Mozambique and Kenya-Uganda in East Africa. For all these countries, two relatively recent DHS from the late 1990s and early 2000s are available that we use for the statistical analyses. We opted for using two cross-sections for each country because this allows us to examine possible changes in child mortality determinants. Data availability has hence been one criterion for country selection. The selected countries with their respective child mortality levels are highlighted in Figure 2.

Before we present the empirical results, we shortly want to discuss the motivation, merits and shortcomings of our multi-country approach that will combine quantitative and qualitative elements. Although the quantitative analysis of child mortality determinants that broadly follow the studies presented above is at the core of the following empirical work, the cross-country comparisons will entail important qualitative components. Obviously, the findings from the estimates of child survival functions can be compared across countries. If we find effect ‘A’ to hold for all (or most) countries, then we can have quite some confidence in generalizing this result at least to other Sub-Saharan countries. Hence, one advantage of using a multi-country framework is the opportunity to generalize the results. Yet, if we can observe effect ‘A’ for all but one country (or a subset of countries) it would be interesting to find out why this is the case. In this paper, we will try to answer this type of question by resuming to a qualitative approach. Although the factors that cause effect ‘A’ to disappear for one of our countries could in principle be identified, quantified and tested statistically, many candidate factors will be difficult to observe (at least to quantify) and/or they are (quasi-) fixed for each country. Examples for such variables include the disease environment and the quality of public health centers. A qualitative approach however will possibly allow us to identify missing or context factors that can explain inter-country differences in the determinants of child mortality.

These considerations eventually motivate our country choices. The selected countries, typically the pairs, share some important characteristics, e.g. geographic and climatic conditions and/or income levels, but differ in other dimensions, e.g. infant mortality levels and changes therein, recent economic performance, or vaccination levels. Evidence from contexts that differ in unobserved or country-fixed characteristics – in our case from different SSA regions – enhances the opportunity to generalize the findings. If countries share many characteristics – as do the country pairs – this may allow isolating (unobserved, country-invariant) factors that may explain the differences in child mortality and its determinants, respectively. Alternatively, countries can be grouped according to certain criteria, for example the existence of user fees, and difference between those groups examined.

Conducting detailed micro-econometric work on 16 country-year cases while trying to keep results comparable implies losing some country-specificity. For example, we use a common set of explanatory variables for the estimates of the survival function although we could have used more variables in some of the country-year cases. Although DHS data use a common questionnaire there are some differences in questionnaires and data availability both between countries and over time. In our view, the results that we discuss in the following suggest that a cross-country approach that keeps individual country cases identifiable is indeed an adequate methodological framework for the study of child mortality. While the biological determinants of child mortality are fairly similar among the selected countries, the differences in their relationship to socio-economic determinants (as well as the effect of these through unobserved proximate determinants) vary considerably between countries or country groups. The next section discusses some basic characteristics of the case country pairs and highlights some of the major similarities and differences in both child mortality outcomes and some of the major determinants.

Figure 2: Levels of U5M in country case studies



Notes: U5M rates (Deaths per 1000 children) for the ten-year period preceding the survey (excludes month of interview from analysis). Source data includes surveys from: Guinea 1999, Kenya 2003, Madagascar 2003/04, Mali 2001, Mozambique 2003, Niger 1998, Senegal 1997, Uganda 2000/01.

Source: STATMapper, available at www.dhsmeasure.org.

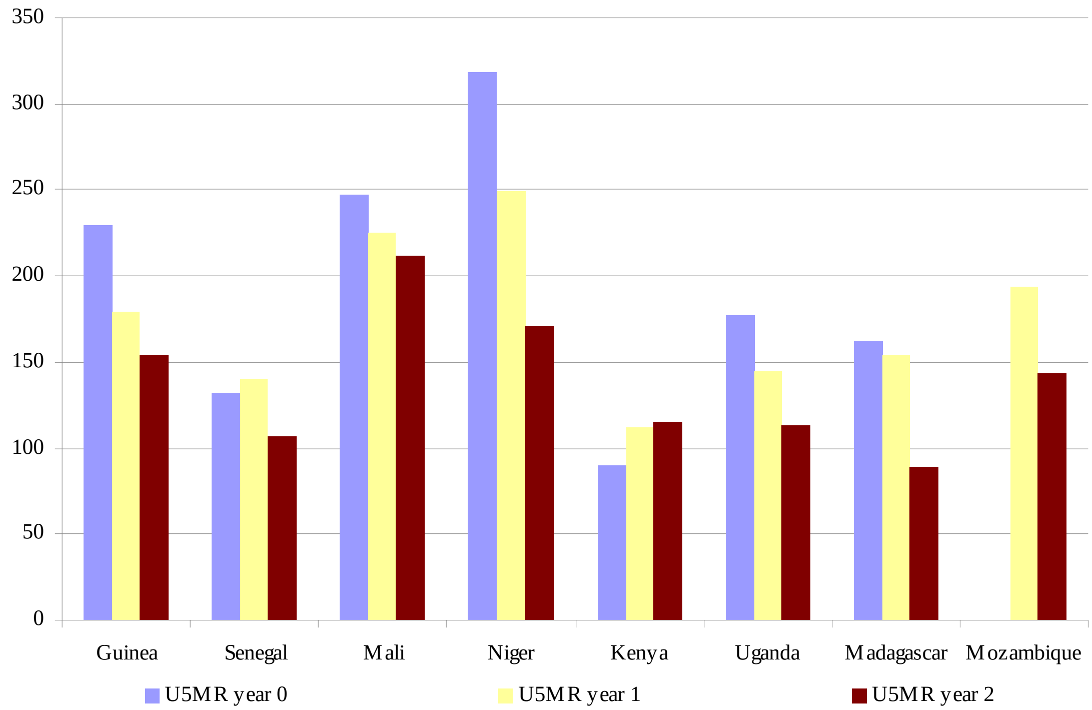
An Explorative Analysis of Trends and Determinants

Infant and child mortality levels in Sub-Saharan Africa are the highest in the world. In the median African country, more than 15 of 100 children die before their fifth birthday (Jameson et al., 2006). This compares to less than 25 out of 1,000 in the richer parts of the world. Not only are U5M levels very high; in addition, progress in reducing child mortality is very slow. Hence, Sub-Saharan Africa as a whole is seriously off track in terms of reaching MDG4. The latest report on MDG achievements by the United Nations (2008) puts U5M rate estimates for 1990, 2000, and 2006 at 184, 167, and 157 out of 1,000, respectively, for Sub-Saharan Africa.

Within the African continent however there is quite some variation in child mortality. This also holds for our sample of countries. As can be seen in Figure 3, U5M rates in our sample that covers the late 1990s to the early 2000s vary between 100 and 250.[5] In both the initial and the final year, the Sahel countries of Niger and Mali exhibit the highest U5M rates, initially considerably higher than 200. Only conflict or post-conflict countries, such as Angola, Sierra Leone, or the Democratic Republic of Congo, have similar or higher rates. In addition to the Sahel countries, Guinea and, despite quite a considerable reduction in recent years, Mozambique, stand out with U5M levels of around 150 in the final year.

[5] We have produced our own estimates of child and infant mortality for each country/year and in some instances these figures differ slightly from those that a query on the DHS-website (http://www.measuredhs.com/) gives. The years when the Demographic and Health Surveys (DHS), which we use for our all subsequent statistics and analyses, were conducted are given in Table 1 in the Appendix. The shortest time span is covered by the Kenyan surveys between 1998 and 2003 with 5 years; in all other cases the time that had passed between the first and the second survey lies between 6 and 8 years.

Figure 3: Infant and U5-child mortality in the country case studies



Source: Authors' calculation from DHS surveys.

Note: Year 0 refers to the initial value (taken from DHS surveys as close as possible to the year 1990), year 1 to the first survey used in our analysis and year 2 to the second survey used in our analysis (for the respective years refer to Table A1).

Yet, there are not only stark differences in U5M levels. While some countries have achieved considerable child mortality reductions in the respective periods under investigation, progress in other countries has been limited. In one country, Kenya, the U5M rate has even increased. To put achievement and failures into the context of the MDGs, the fourth column of Table 1 reports the hypothetical reduction in the U5M rate, had the country experienced the same point change reduction observed in the interim period between the two surveys for a period of 15 years. This "actual rate" can then be compared to the reduction of the U5M rate by two thirds in the initial year, which is reported in the second column. Although this is not precisely the MDG target for each of the countries, it is in most cases very close to it.

Table 1: Observed reduction in child mortality, simple projection, and reduction needed to achieve MDG4

	Most recent U5M rate	Target	Observed annual per thousand points change	Projected 2015 U5M rate	Status with regard to MDG 4 on current trends
Guinea	154.2	76.3	-3.2	122.2	off track
Senegal	107.3	43.9	-4.1	66.3	off track
Mali	211.7	82.4	-2.3	179.5	seriously off track
Niger	170.5	106.1	-9.8	82.3	on track
Kenya	115.6	29.9	0.7	124	seriously off track
Uganda	112.8	59.0	-5.4	64.2	almost on track
Madagascar	88.9	54.3	-8.1	-8.3	on track
Mozambique	143.8	64.8	-6.3	68.2	on track

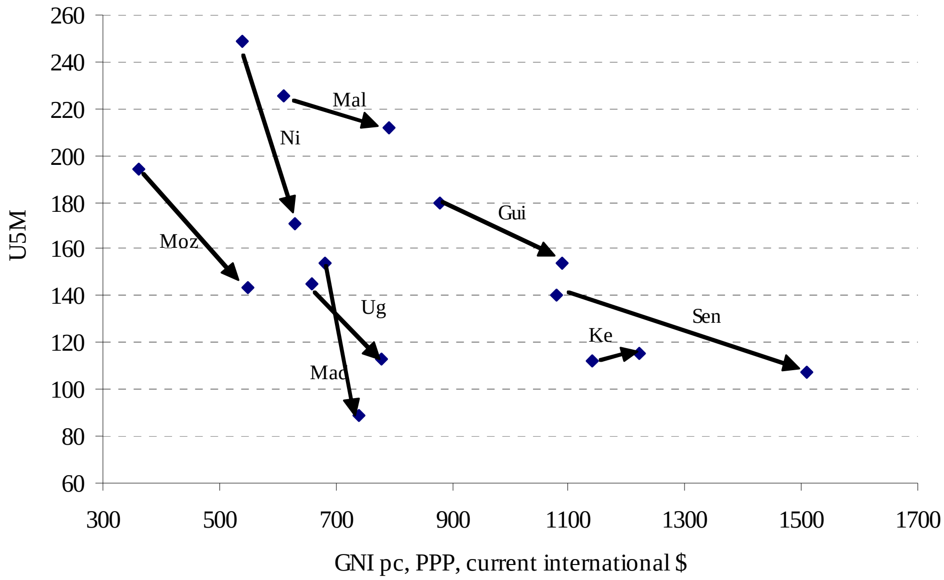
Source: Authors' calculation from DHS surveys.
Note: The target for U5M is computed based on the initial level taken from DHS reports for the following DHS surveys: Guinea, 1992; Senegal, 1992/93; Mali, 1987; Niger, 1992; Kenya, 1989; Uganda, 1988; and Madagascar, 1992. No survey close to 1990 is available for Mozambique. We make the assumption that U5M has remained constant in Mozambique between 1990 and 1997. Projections start from the most recent U5M observation and add the respective observed annual change times the number of years between the latest observation and 2015.

Among the countries with very high initial levels of child mortality, two have achieved considerable reductions. Of the eight countries, three are on track (Niger, Madagascar and Mozambique) and one is almost on track (Uganda). These countries could achieve MDG4 on current trends. Accordingly, half of the studied countries have a chance to make it, while the other half is off-track, very seriously in two of four cases. As already mentioned, child mortality was on the rise in Kenya between the last two surveys. Mali would not even reach a fifth of the necessary reduction; Guinea not half of it. Finally, Senegal is an intermediate case, and would be able to reach two thirds of the required reduction.

From a regional perspective, it appears that the East African countries in our sample have been more successful than West African ones, with the notable exception of Niger. In terms of the country pairs, we have one East African pair, where the worst performer, Kenya, meets one of the best performers, Uganda. The second East African pair compares two countries that both have performed fairly well. In West Africa, the Sahel country pair exhibits extreme differences in reductions, with Niger's strong reduction in sharp contrast to Mali's very limited achievements. The contrast of Guinea's slow reduction from high-levels with Senegal's reduction from somewhat lower levels completes the pair wise comparisons.

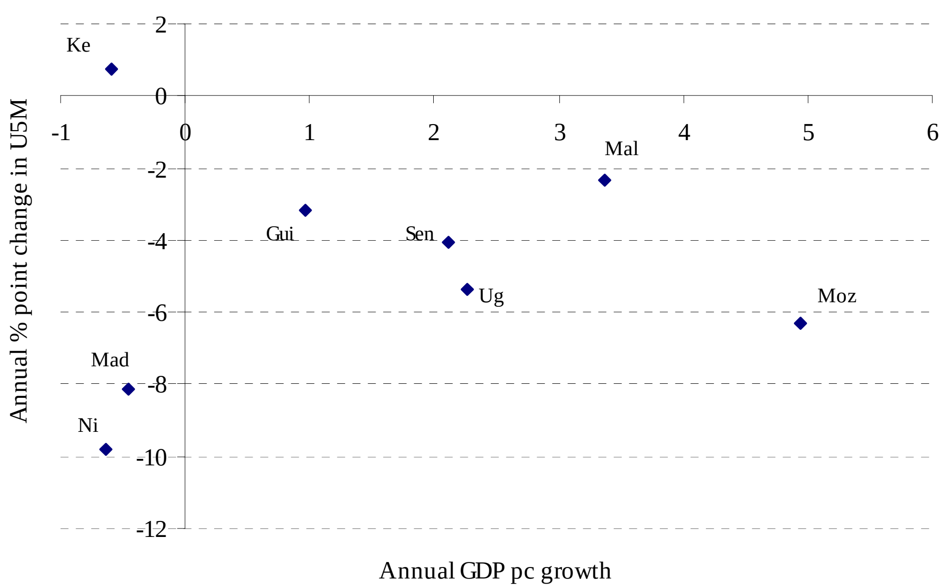
In the subsequent discussion we try to link child mortality levels and changes to some of their main determinants. The analysis illustrates that not only is there great heterogeneity in child mortality outcomes between the selected countries, it also suggests that the drivers of child mortality tend to be very different. First, we examine the relationship between income and child mortality. Not surprisingly, Figure 4 illustrates that there is indeed a negative correlation between per capita income levels (measured in PPP adjusted current international dollars) and child mortality. For example, the countries with the highest initial U5M rates were the poorest three at this time. Yet, much poorer countries can exhibit lower child mortality rates than richer countries, as demonstrated by one of the country pairs. Uganda's child mortality rate in the early 2000s was very close to Kenya's although income per capita was more than 30 percent lower. Even less clear is the relationship between income growth in the period under observation and child mortality reductions. While this can also be seen in Figure 4, this comes out even clearer in Figure 5 that relates the annual point reduction in U5M rates and growth of real GDP per capita in local currency, which is more useful than the above PPP-adjusted measure for computing growth rates. Based on these statistics, three countries experienced negative GDP per capita growth rates in the respective observation period: Kenya, Madagascar, and Niger. Yet, only in the case of Kenya has economic decline been associated with an increase in child mortality. Both Madagascar and Niger, in contrast, belong to the best performers in terms of child mortality reduction. If one removes the observations corresponding to Madagascar and Niger from Figure 5, higher growth rates are typically associated with higher reduction in child mortality.

Figure 4: Income per capita and U5M rates



Source: Authors' calculation from DHS surveys. GNI per capita comes from the World Development Indicators.
Note: The arrows point from the first survey year to the second for each country.

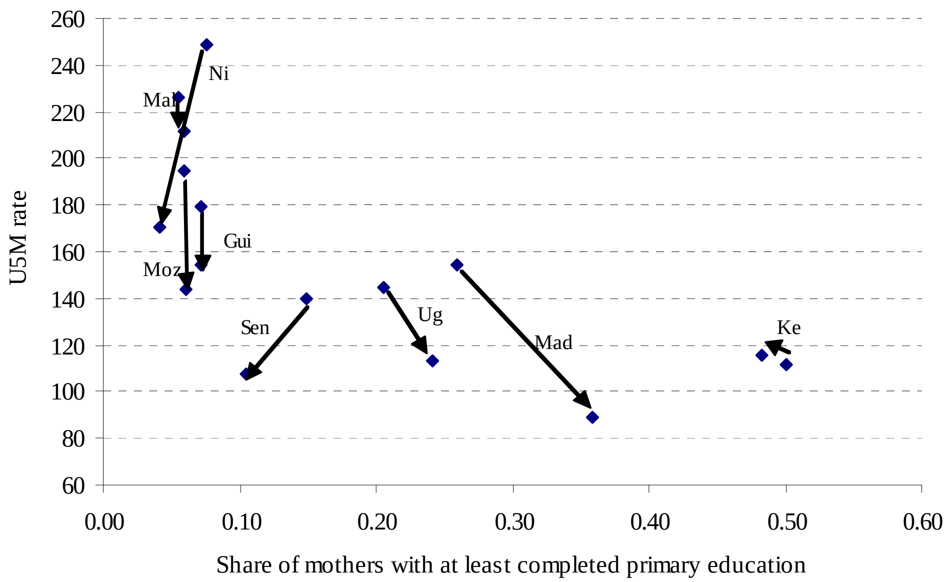
Figure 5: Income per capita growth and U5M rates



Source: Authors' calculation from DHS surveys. GDP per capita comes from the World Development Indicators.

The second major socio-economic determinant of child mortality, which we quickly assess here in a descriptive way, is mother's education. As can be seen in Figure 6, the share of mothers who completed at least primary education seems to show little correlation with child mortality rates. Except for Senegal, all West African countries tend to have very low rates of primary completion while mortality levels as well as performance vary greatly within this group. No country in West Africa has significantly expanded mothers' education in the respective period covered by the surveys. Yet, we have seen above, this has not prevented Niger from achieving a considerable reduction in child mortality. This also holds for Mozambique. In the remaining two fairly successful countries, Uganda and Madagascar, child mortality improvements have been accompanied by improvements in mothers' educational endowments.

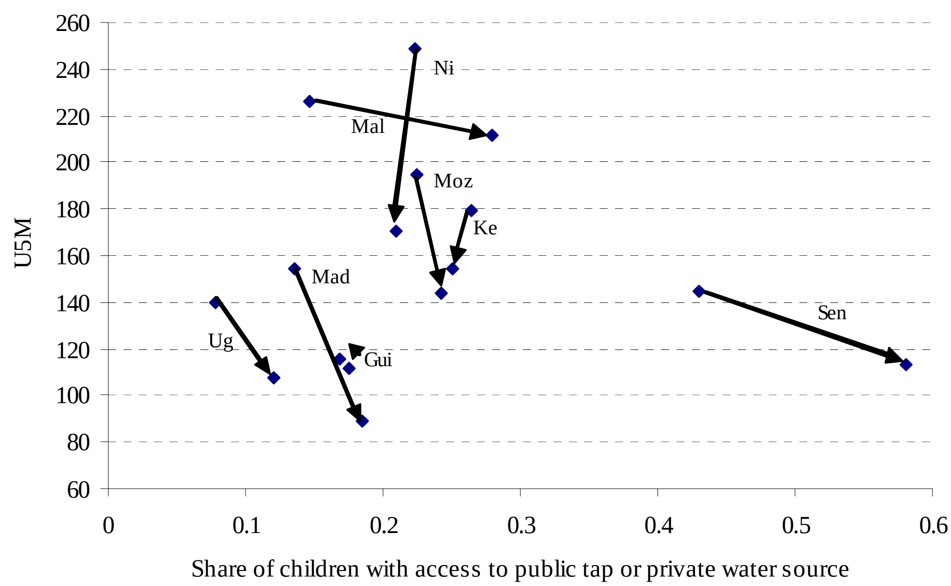
Figure 6: Mothers with at least primary education and U5M rates



Source: Authors' calculation from DHS surveys.
Note: The arrows point from the first survey year to the second for each country.

With regard to access to tap water (including both private and public access), the aggregate figures also hardly reveal any systematic pattern. Figure 7 illustrates that this holds in particular for the variation between countries, while some within-country changes show the expected pattern, i.e. that better access to safe drinking water is accompanied by child mortality reductions. Yet, the largest expansions in terms of access to tap water were recorded in Mali and Senegal, i.e. countries without major successes in child mortality reduction. In most successful countries expansions were minor or non-existent. We should note that the data available in the DHS surveys on water sources are hardly satisfactory and the choice of tap water as a proxy for safe drinking water is far from a perfect choice. While most DHS surveys offer a variety of possible water sources, the way the question is phrased make it very difficult or in most cases impossible to distinguish between safe and unsafe sources. This holds for comparisons between countries as well as over time.

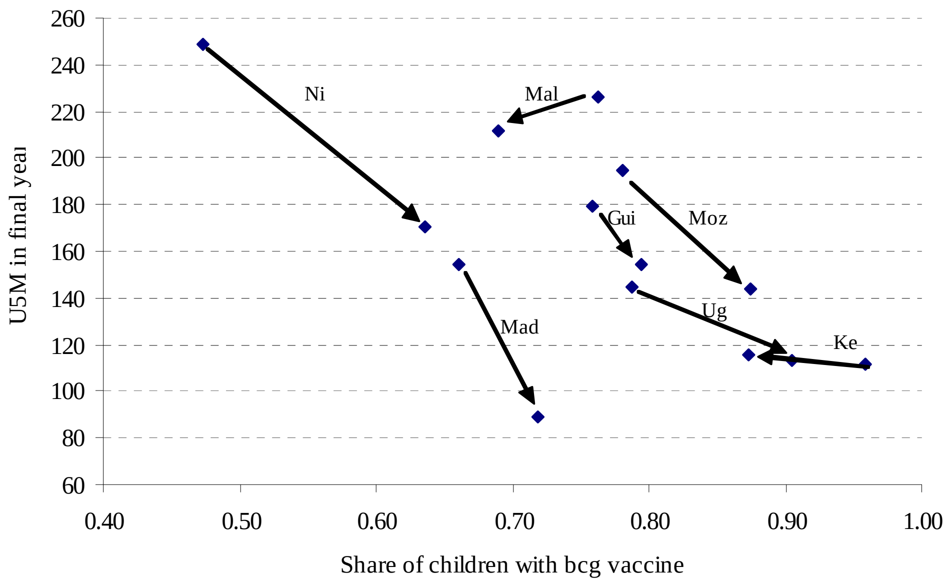
Figure 7: Access to tap water and U5M rates



Source: Authors' calculation from DHS surveys.
Note: The arrows point from the first survey year to the second for each country.

Data constraints also complicate the analysis of supply side factors. As mentioned above, only very few DHS surveys contain information on the availability and quality of health facilities. This is why we did not use these datasets in our comparative analysis. Beyond the DHS surveys, it is extremely difficult to find general information on the health system or to construct variables. There is some information on the use of services, but for many of the cases studied this information is incomplete. Because of these constraints, this paper focuses on the role of vaccination as the best available proxy. Of course, vaccination rates only partially reflect general health service coverage and quality, as vaccination campaign may be implemented as part of international health campaigns. Yet, the effectiveness of such campaigns may depend to some extend on the health infrastructure in the respective country. As Figure 8 shows there is a fairly strong positive relationship between vaccination coverage – here the share of children with a BCG vaccine[6] – and the reduction of child mortality. This holds roughly across time as well as across countries. All countries that are (almost) on track in terms of U5M reduction (Niger, Madagascar, Mozambique, and Uganda) have been considerably extended BCG vaccination coverage (somewhat less in Madagascar). In two of the countries that are seriously off-track, Kenya and Mali, the share of vaccine children has declined.

Figure 8: Share of children with BCG vaccine and U5M rates



Source: Authors' calculation from DHS surveys.
Note: The arrows point from the first survey year to the second for each country.

In sum, the preceding descriptive analysis certainly tells us that the pathways to achieving child mortality reductions are very different across countries. While income growth often goes along with reduction in child mortality, it does not seem to be a necessary condition for reductions in child mortality. Despite the well-documented beneficial effect of mother's education on child survival, this relationship can hardly be recovered from the aggregate data. The effect of access to tap water on child mortality is even less clear from our cross-country comparison. This would suggest rather weak complementarities between MDGs 1, 2, 3, and 7, on the one hand, and 4, on the other. In contrast to all these rather weak correlations, the aggregate figures suggest that expanding vaccinations is a key factor for

6 Bacillus Calmette-Guérin (or Bacille Calmette-Guérin, BCG) is a vaccine against tuberculosis.

reducing child mortality: There is no country that has made major progress in reducing child mortality without considerably expanding vaccination coverage.

Evidence from Survival Analysis

Despite these interesting insights and the illustration of some broad tendencies, these country comparisons based on aggregate data may hide more than they show. The determinants of child mortality however can only be understood by analyzing the relevant processes within households. In the following, we therefore use different types of micro-econometric models estimated on the DHS datasets to uncover the relationship between socio-economic and proximate determinants and how they affect child mortality outcomes. As pointed out above, we combine the three typical approaches to the study of child mortality determinants, i.e. the joint analysis of socio-economic and proximate determinants, the empirical assessment of 'gross effects' of socio-economic determinants, and the analysis of the relationship between socio-economic and proximate determinants. More specifically, we proceed by estimating the following models and specifications. In the first step, we estimate a discrete time survival model including both socio-economic – for example mother's education and wealth – and proximate determinants – for example gender of the child and birth intervals (Table A4). In this specification we restrict the set of explanatory variables to those common to all surveys from all countries in all years. The estimates should inform us about major structural breaks over time, the robustness of the results across different datasets, and highlight possible differences in mortality patterns between the country cases. The second specification (Table A5) estimates the same survival model using only the latest survey for each country. This allows us to include information on a child's vaccination status, which, unfortunately, is not available for earlier years. This model is also estimated with community-level fixed-effects (Table A6). These fixed-effect estimations should not only be seen as a robustness check. As supply-side factors, for example the presence of a health facility, can be assumed to be similar for all households within the same community, the coefficients, for example of education and wealth, can be interpreted as "pure" demand-side effects. Comparing the regular with the fixed-effects estimation results is of course a fairly indirect way to prove the importance of demand-side constraints. Yet, the interplay between demand- and supply-side factors could only be examined with detailed supply-side information, which, as mentioned earlier, is available for only very few countries.

The next specification again uses the survival model but includes only child characteristics that cannot be influenced by the parents (gender, first born) plus one of two key socio-economic variables, wealth and education (Tables A7 and A8). These estimates give an approximation to the 'gross effects' of wealth and mother's educational attainment. Finally, we relate socio-economic variables and proximate determinants in an attempt to quantify the influence of mother's educational attainment and income/wealth on proximate determinants. More specifically, we examine the effects on reproductive behavior (short birth interval, Tables A9 and A10) as well as on the use of public health services, more specifically BCG vaccination (Tables A11 and A12). These models are also estimated with a community fixed-effect (Tables A 10 and A12) with the same intention as above. These estimations hence examine the transmission channels through which possible complementarities between MDGs may work.

The subsequent section discusses the estimation method and the results. It also assesses the changes in observables that might explain the observed success or failure in terms of child mortality reduction in the selected countries. After this backward-looking exercise, we illustrate possible complementarities in MDG achievement by simulating the effect of universal primary education of mothers on child mortality – a scenario that is within reach for some of the selected countries in a reasonable period of time.

Empirical model

The core model of the subsequent analyses is a discrete time survival-model. Jenkins (1995) shows that discrete survival models can be estimated based on the application of standard binary dependent variable models to reorganized data. We estimate discrete logistic (proportional odds) model where child survival by month (up to the 60^{th} month) is the explained variable. This survival variable is constructed from the birth history section of the DHS. To avoid recall bias we only include births from the last five years preceding the survey. The estimates that link proximate and socio-economic determinants rely on logit-models since the right-hand side variables, short birth interval, access to safe drinking water and vaccination are coded as dichotomous variables. As noted above, both the survival and the logit models are also estimated with a community-level fixed effect. All the coefficients reported in Tables A4 to A12 are odds ratios. For the child mortality estimates, odds ratios larger than one imply that mortality is more likely than survival. For all estimations, we report robust standard errors that are corrected for clustering at the household level.

To facilitate the interpretation of the results, we quickly would like to illustrate the meaning of the reported odds ratios, as some readers might not be familiar with this type of model. Say a child's probability to die is 5 percent when the mother does not have primary education. Then the odds of dying are 0.05/0.95 = 0.053 to 1, or, 18.86 (1/0.053) to 1 in favor of survival. Assume now that the probability goes down to 4 percent if the mother has gone to school. Now the odds of dying are 0.04/0.96 = 0.042 to 1. The odds ratio in this case would be 0.042/0.053 = 0.79, i.e. mother's primary education decreases the odds of dying by 21 percent. Note that the relative risk, i.e. the ratio of the probabilities of dying, 0.04/0.05 = 0.8 is very close to the odds ratio. For many people, relative risk is more intuitively to grasp (but not straightforward to compute in our proportional odds model). In our specific datasets however, relative risk and odds ratio will always be of similar size, because of the relatively low probabilities of child death (this is meant in a mathematical sense).

Our choice of explanatory variables in the survival models follows similar studies based on DHS data (e.g. Omariba et al., 2007; Ssesewanya and Younger, 2007). They include child characteristics (the child's gender and whether it is the first-born), mother's characteristics (a dummy for mothers younger than 18 years and mothers' educational achievement), a dummy for short-birth interval (less or equal to 24 months), household size, dummies for private or public access to tap water, and wealth groups by rural and urban areas. Furthermore, we include regional dummies on a similar level of aggregation (approx. 5 regions per country) and controls for the birth year (since the children in the sample are born over a time span of 5 years). The more recent surveys also allow us to include the vaccination status, although we have to rely on an imputation method for dead children.

Some additional remarks on the wealth groups are required. Households are categorized into rural poor (the first two rural quintiles), rural rich (rural quintiles three to five), urban poor (the first two urban quintiles), and urban rich (the remaining three upper urban quintiles) based on a wealth index that we compute separately for rural and urban areas using principal component analysis following Filmer and Pritchett (2001). In our specification, poor rural households will serve as the reference category[7]. This implies that the urban wealth dummies also capture the effect of an urban dummy. The variables used for the wealth index include a range of assets, for which ownership is reported in the DHS (for example housing characteristics, bicycle, car, radio, television, fridge etc.). The correlation of the asset ownership with the underlying wealth concept may however differ considerably between rural and urban areas. While owning a bicycle in rural areas may classify one as a rich person, this is certainly not the case in urban areas. A similar reasoning applies to certain housing characteristics, such as iron sheets on the roof or cement floor. Therefore, we prefer our own

[7] In the fixed effects estimation, since each cluster is either rural or urban, only the dummy for being rich is used to control for wealth.

wealth proxy over the wealth proxy given in the DHS dataset. Finally, most assets that are part of the DHS questionnaire are owned by only a very small fraction of the rural population in the very poor contexts that we analyze. It is difficult to understand why the wealth-related questions chosen for the DHS have such a strong urban bias.

Descriptive statistics

Summary statistics for the share of children who died in the five years preceding the survey and selected explanatory variables are provided in Table A2. The share of children who died of course reflects the child mortality rate estimates reported above, with the highest share in Niger in 1998 and the lowest in Madagascar in 2003. Mean mother's age at birth is surprisingly similar across countries fluctuating around 27 with the lowest average for Uganda in 2000 with 25.9 years and the highest for Senegal with 27.9 in 1997. In terms of mother's education however there are considerable differences between the countries that we have already discussed above. Birth intervals of less than 2 years are fairly common in most of the countries and the share of births with short intervals is around one fifth with quite some variation between countries, but also over time. Madagascar and Uganda exhibit high shares of more than 27 percent in the early survey year, while this share stands at around 15 percent in Mozambique, Guinea, and Senegal. Average household size varies considerably between countries from around 6 members in Madagascar and Kenya to more than 13 in Senegal. Households are generally larger in Western than in Eastern Africa, certainly reflecting socio-cultural differences in the formation of households, as defined by the DHS. Finally, the descriptive statistics again show the deficiencies of the water supply variables in the DHS survey, as somewhat implausible variations appear over time for example for Mali, Niger, and Senegal. The corresponding results should hence be taken with caution.

Table A3 reports summary statistics for the vaccination rates. These statistics originate from the STATcompiler of http://www.measuredhs.com/ and are averages of (surviving) children aged 12-23 months who had received a specific vaccine at any time survey. Earlier DHS surveys only record vaccination information for children up to the age 2 years. The recent ones collect this information also for older children up to the 60th month and can hence be used in the micro analysis.[8] Table A3 shows considerable variation in vaccination rates.

[8] As just mentioned, the statistics are computed only for surviving children, since the surveys do not have vaccination records for dead children. Hence, the reported figures only partially reflect the averages of the relevant 'true' vaccination rates. While these average rates among surviving children can provide a reasonable approximation about actual vaccination rates among all children, we do need the child-level vaccination information for our analysis. We achieve this by a very simple imputation procedure: We assume that each (dead) child has received the same vaccinations as other children (at least one other child) in the same household.

This does not only hold for BCG-vaccination that we have briefly discussed above, but also for DPT (diphtheria, pertussis (whooping cough) and tetanus), polio and measles vaccinations. Niger and Mali stand out with very low vaccination rates in the early survey year (except for BCG in Mali). Yet, Niger is also the country that has achieved the highest increase between the two years in all rates. In general, the countries with increases in BCG coverage have also been successful in expanding other vaccines. We will discuss the role of improving vaccination coverage later in more detail. In general, we comment in more detail on the changes over time and their implications for the observed reductions or increases in child mortality once we have discussed the regression results.

Results

The first set of results based on the discrete time survival model is reported in Table A4. The underlying specification includes a number of socio-economic determinants, such as the wealth categories and mother's education, as well as proximate determinants, in particular maternal factors. Yet here, we restrict the set of explanatory variables to those that are available for all surveys from all countries for all years.

Overall, the findings reported in Table A4 correspond to expectations, but only few variables turn out to be consistently significant across countries and years. Among those 'robust' determinants are all the proximate determinants included in the regression. Boys are more likely to die than girls in almost all the countries in all years. The odds of dying are about 30 percent higher for boys in some cases (Uganda and Madgascar in the recent year), but in most cases the odds ratios fluctuate around 10 percent. With the exception of Kenya, the first born child is always more likely to die and this effect can be very large. In Senegal and Mozambique, we find an increase in the odds of dying by approximately 50 percent. The standard errors of these estimates are however fairly high. The coefficients of the dummy for mothers aged 17 years or less have the expected sign for all the countries, but do not turn out to be significant. Finally, the dummy for short birth intervals is significant in all country-year cases with the exception of Kenya in 1998. Typically, the effect is also very strong: If a child is born less than two years after its brother or sister, its odds of survival can be reduced by more than 50 percent in some countries (for example Madagascar, Mozambique).

The results on the socio-economic determinants are much less robust. Children of mother's with primary education are significantly (at least at the 10 percent level) less likely to die in 9 out of 16 estimations. For secondary education this is the case for only 4

Such an imputation yields average vaccination rates among dead children that are similar to those of survivors.

estimations. This latter result can however be easily rationalized by the very small share of mothers with secondary education and the corresponding large errors in the estimates. Only taking into account the significant results, the odds ratio of primary education fluctuates around 70 percent. A somewhat surprising finding is the consistently significant negative and fairly large effect of household size on child mortality. A positive relationship between mortality and household size may be expected since household size is typically inversely related to wealth or income per capita. In the case of Madagascar – where we observe the largest effect in the recent survey – each additional household member decreases the odds of child death by almost 25 percent. The results for the water access variables are weak. Children from households with private water access have significantly lower odds of dying in only 3 cases; for water from public taps in 2 cases. The point estimates of the effects vary widely and the odds ratios are sometimes even larger than one – albeit not significant in these instances. These results together with irregularities in the descriptive statistics reported above certainly suggest that access to water is measured with large errors and difficult to compare over time and between countries. They may however also reflect that there is no equivalence between access to tap water and access to safe drinking water.

Measurement problems are also likely to contaminate our results on the effects of wealth. The reference category is the rural poor, i.e. the effects of the other dummies have to be interpreted vis-à-vis belonging to the poorest two rural quintiles. Notably, the only country where all wealth dummies have the expected (and significant) child mortality reducing effect is Senegal, by far the richest country in the sample. We think that this finding rather reflects the deficiencies of the (widely used) wealth index rather than the fact that wealth does not play a role for child mortality outcomes in other, poorer countries. Because of the urban bias in the list of assets included in the DHS, the wealth index is likely to capture fairly well wealth difference in urban areas, or more generally richer countries. For rural areas however, significant assets like livestock and land are not included and the index probably reflects ‘urban lifestyle’ more than it reflects wealth.

With these caveats in mind, we still can detect some interesting patterns from the results. There is, for example, not much reason to believe that the wealth index should work better in Mali than it does in Kenya and Uganda. Nevertheless, differences in the odds between rural and urban areas are significant for the former country, but not for the latter. In general, urban-rural differences seem to be more pronounced in former French colonies. For Niger and Madagascar the effects are of similar size albeit not significant. In addition, the effect can be important. In Senegal, Mali, and Niger, belonging to the three richest urban wealth quintiles increases the odds of child survival by around 35 percent. Overall, these findings confirm the general perception of pronounced rural-urban disparities in many West-African countries, while East African urban agglomerations are often considered as poor as the rural areas in the respective country. A surprising finding – and one that is difficult to resolve – is the lack of significantly lower odds of dying for children from rich urban households in Guinea, Uganda, Kenya, and Mozambique.

In sum, the findings from this first specification confirm findings from other studies. We can identify some robust proximate determinants of child mortality, with birth spacing as an important choice variable of parents with a very strong effect on child survival. With the exception of mother's education, socio-economic variables present ambiguous results. This is likely to be related to measurement problems. Based on this rudimentary specification, we are not able to detect any considerable changes in coefficients over time. Thus, the candidates for explaining the observed changes in child mortality rates are changes in the observables (and/or unobservables). Finally, the stability of estimates gives us some confidence in using cross-sectional parameter estimates for some illustrative forward-looking simulations.

The estimation results of the specification that includes proxies for BCG, DPT, polio and measles vaccination are reported in Table A5. As mentioned earlier, this specification can only be estimated on data from the final survey year. The results demonstrate the potentially large beneficial effect of vaccines for small children. Having received a BCG vaccine consistently reduces the odds of dying. The reduction ranges from around one third in Niger to more than 60 percent in Kenya. It should be noted that these estimates appear to be fairly precise judged by their standard errors. In half of the countries, the measles vaccination is associated with similar reductions; yet, the effects of this vaccination are smaller and/or not significant for Senegal, Mali, Niger, and Madagascar. For the other two vaccines, our results suggest that DPT and polio never significantly increase the chances of survival. On the contrary, they actually often appear to increase mortality risk – in three cases significantly. These results are difficult to interpret and certainly deserve more scrutiny. A review of the medical literature on the impact of DPT and polio vaccines in West-Africa, suggests that there are indeed doubts with regard to their beneficial effects on child health (Kristensen et al., 2000; Aaby et al., 2004).[9]

The odds ratios and the corresponding standard errors for the other explanatory variables hardly change with the inclusion of the vaccination proxies. In some countries, for

[9] There is some evidence for so-called 'non-specific' adverse or beneficial effects of vaccinations in low-income countries. See e.g. Folb et al. (2004) and the literature cited therein.

example Kenya and Uganda, the odds ratios for children with primary educated mothers increase and get closer to 1, i.e. the 'direct' beneficial effect of education becomes smaller. We would expect this effect to arise from the inclusion of mortality-reducing variables that are correlated with mother's education. It should be noted that, similar to earlier studies, the effect of mother's education is not significant (with the exception of Uganda).

All the above results remain valid when the survival model is estimated including a community-level fixed-effect (see Table A6). In fact, almost all the coefficients are very close the model without this fixed effect. This is not necessarily what we would have expected, as the beneficial effect of vaccinations, for example, might be expected to stem mainly from inter- rather than intra-community variation.

As explained above, the possible correlation of socio-economic and proximate determinates, for example between mother's education and vaccination, rationalizes the next specification that only includes child characteristics, regional and birth year dummies, and mother's education. The results are reported in Table A7. If other controls are excluded, the 'gross' effect of primary completion is now significant in 5 out of 8 cases in the recent survey (compared to only one, Mali, in the former specification – see Table A6). The effect of secondary education is always very large, and significant in five cases. For selected effects in some countries, for example primary education in Senegal, Mali, and Niger, the differences in the gross and net effects can be substantial, which suggests that education influences some of the here excluded observables favorable to child survival, e.g. through better birth spacing. We examine these channels in more details below.

We now repeat the same exercise for wealth, including the wealth group dummies instead of mother's education. The patterns of wealth effects observed above now even come out clearer. In all former French colonies, urban children have significantly lower odds of dying than rural children. Senegal and Mali are the only countries where we can observe significant difference in children's odds of survival within rural areas. The 'gross' effects in the other countries are now in line with expectations although the differences are relatively small and not significant.

The 'gross effect' results are eventually driven by the links between some of the observables, in particular between socio-economic and proximate determinants. This becomes apparent in Table A9 that presents the results of a logit regression of short birth intervals on mother's education, the wealth group dummies, and controls for regional and year effects. For most countries, mother's education has indeed a very strong impact on birth spacing. In Mali, Niger, and Mozambique the odds of a short birth interval are around 30 percent lower for a mother with primary education compared to a mother with none. For the other countries the reduction in the odds is around 20 percent. The effects of secondary education are even stronger. Interestingly, most wealth dummies are not significant in this estimation, even in the countries where they had a significant effect on child survival. Yet, the sign of the effects is typically as expected. Community-fixed effects estimations yield similar results, but the coefficient on primary education loses its significance in three cases. A possible reason could be a community-level externality of other mother's education on birth spacing.

We now analyze the determinants of a child's vaccination status (Table A11). More specifically, we look at the BCG-vaccine, the only vaccine consistently beneficial to the child (at least in our estimates). We find a very strong positive effect of the socio-economic determinants on the probability of vaccination. In five countries, primary education of the mother more than doubles the odds of receiving the BCG-vaccine. For Uganda, Senegal, and Mozambique the odds for children are increased by about 40 percent. The effect of higher education is typically even stronger. Somewhat unexpectedly in light of the preceding results, we find a significant influence of the wealth group proxies in all the countries. Except for Kenya and Uganda, even the rural rich are significantly more likely to have their children vaccinated than the rural poor. Yet, this result again may not reflect a pure wealth effect, but also an 'urban lifestyle' effect. Where typical urban assets are more readily available, accessibility to vaccines may also be easier. Uganda and Kenya stand out as countries where only children in rich urban households have a significantly higher probability of vaccination. The odds ratios for rural rich and urban poor are not significantly different from one. Rural-urban disparities in vaccination are very pronounced in Guinea, Mali, Niger, and Mozambique where the odds ratios for poor urban households are two times larger than those of rural rich households. As regards the unequal vaccination probabilities within urban areas, in more than half of the countries – Guinea, Senegal, Niger, Kenya and Madagascar – the odds of being vaccinated approximately double in comparison to their poor urban counterparts.

Again, we also estimate this model with a community-level fixed-effect. As one may expect vaccination coverage to vary little within a community, but rather between communities, this specification may render very different results. And indeed the effects of education become smaller when the fixed effect is included. Yet, they are still strikingly high. The odds of receiving a BCG-vaccine are still more than 40 percent higher for a child whose mother has received primary education for all countries (except Guinea and Mozambique). While vaccination coverage of the individual child hence indeed has a community-level component, mothers' (and households') individual characteristics also have an important role to play. In other words, individual demand-side factors are a key factor for translating supply-side interventions in the health sector, here vaccinations, into child health improvements. This relationship hints at fairly large complementarities between female education and child mortality reduction that would not be obvious from the existing literature (and, in fact, our first sets of results).

Finally, the failures in terms of child mortality reduction are easily rationalized by our regression results combined with the descriptive statistics on changes in the explanatory variables provided in Table 3. For none of the countries that are off-track any of the observables that we find to be significant determinants of child mortality have improved considerably. Maybe somewhat surprisingly, this almost holds for the success countries as well. In these countries, progress in the observable determinants has also been limited with one notable exception: Vaccination rates improved dramatically in all the success countries. One of these countries is Niger and this country's experience illustrates an important point. The finding that demand-side factors, here mothers' education, are important in determining the use of public services, here child vaccination, does not mean that the provision of vaccinations will be ineffective. The importance of demand-side constraints that we find to be particularly strong in the case of Niger (and to decline little after the inclusion of the community-level fixed effect) rather implies two things: First, the intervention might have been more effective had fewer households been demand-side constrained, i.e. better educated; and, second, that the intervention's impact will be selective, i.e. better educated (and very likely better off) households will benefit more from it than others.

Simulations

We conclude our empirical analysis by a number of illustrative micro-simulations, which try to establish the order of magnitude of the impact of various policy interventions on mortality rates at the country level (as opposed to the effects on individual child survival probabilities). Specifically, the simulations attempt to quantify the effect of expanding mother's education on child mortality. Furthermore, we consider two 'policy interventions' that we have shown to be closely related to the education of the mother: BCG vaccination and short birth intervals. The objective of this exercise is to illustrate and compare the leverage of these policies and combinations thereof in different country contexts. On the basis of the simulation exercise, we finally want to judge the feasibility of achieving MDG4 for each of the country cases.

We use the estimation results from the full specification including vaccination proxies (reported in table A5) for the first set of simulations. The procedure is straightforward. In the first simulation we assume that all mothers complete at least primary schooling (which means that the schooling status of uneducated mothers is "upgraded" in the data base), then we re-compute the mortality risk for each child using the estimated coefficients of the survival models and finally derive the corresponding U5M rate at national levels. The child mortality reductions obtained through this procedure are driven both by the values of the coefficient related to mother's education in the survival models and by the initial rates of primary education completion, i.e. the number of uneducated women who, in the simulation, are endowed with primary schooling. In other words, policy leverage depends on the effectiveness of the intervention in each individual case as well as the (additional) number of mothers and children who benefit from the respective intervention. We repeat the same exercise for the full elimination of short birth intervals and full BCG vaccination coverage. Table A13 in the appendix illustrates the scope of the respective simulated policy changes. The results of the three simulations are reported in Table 2 alongside the reduction needed to achieve MDG4 to put those simulated reductions in perspective.[10]

While descriptive statistics show that both levels and progress in mothers' education across our sample countries are very uneven, our estimation results certainly indicate that it is an important determinant of child mortality through its impact on birth intervals and vaccination status. With renewed efforts in the area of primary education, improvements are expected to be larger in the course of the next 10 to 20 years in most of the countries. Nevertheless, we are of course aware that Guinea, Mali, Niger, and Mozambique are unlikely to reach 100 percent completion rates among young mothers. Yet, considerable improvements have been made recently in most countries. In Guinea, Mali, and Mozambique the enrollment rate now stands between 50 and 60 percent. In this group, only in Niger enrollments remains comparatively very low with only around 30 percent. Current enrollment rates in the other countries also suggest considerable improvement in mothers' education although full achievement of MDG 2 might not be reached.

[10] As the residual in the underlying binary choice model (logit) cannot be observed, this exercise involves the simulation of a residual that is consistent with the observed value of the left-hand side variable, i.e. 0 for survival and 1 for death.

Table 2: The impact of various policy interventions on U5M levels

Country	U5M Base values	Universal primary completion for mothers	Elimination of short birth interval	Universal BCG vaccination coverage	Needed to reach target
Guinea	155.2	-5.7	-12.4	-24.8	-77.9
Senegal	107.2	-23.7	-6.2	-7.6	-63.4
Mali	211.4	-48.8	-28.0	-31.1	-129.3
Niger	169.6	-44.1	-19.4	-19.4	-64.4
Kenya	116.6	-11.5	-9.6	-26.9	-85.7
Uganda	111.7	-16.8	-11.5	-15.9	-53.8
Madagascar	89.2	-0.6	-14.3	-18.0	-34.6
Mozambique	144.4	11.5	-14.3	-20.2	-79.0

Source: Authors' calculation from DHS surveys and simulations.

With the current trends in terms of primary schooling in mind, the potential effects of expanding education of mothers look impressive for some countries. In Mali and Niger, the simulated reduction in the U5M rate exceeds 40 per thousand points. These results are mainly driven by very low base completion rates in combination with odds ratios of the primary education variable around 0.75. For Guinea, the odds ratio being close to one explains why the simulation yields only a small effect despite a major expansion in education. For Madagascar, the underlying mechanism is the same, although, in this case, the simulated expansion is also smaller. The case of Mozambique appears puzzling but can be explained by the fact that the estimation of the survival model for that country actually yields a small positive – albeit insignificant – impact of mothers' education on child mortality. Kenya, Uganda, and Senegal represent intermediate case with quite substantial simulated reductions, the differences in outcomes mainly resulting from differences in base completion levels (and not in coefficients).

Before we proceed with further results, let us quickly reflect on the assumptions behind this simulation. The exercise assumes that mothers and children remain the same in all their observed characteristics (all explanatory variables of the specification reported in Table A5), but change their educational endowment to completed primary schooling if they were not educated. The corresponding coefficient however may be biased due to omitted variables, for example due to some type of ability bias. Another possible source of bias would arise if more educated mothers lived in communities with better the supply of health infrastructure, which we can only partially control for with our vaccination proxies. The fixed-effects estimations indeed suggest that there may be some bias of this type (Table A6). Finally, it has to be noted that most coefficients that eventually drive the effects of expanding education are not significant (see Table A5).

Despite these caveats, we think that this and the subsequent exercises do have significant empirical content. This holds even more so for the next two experiments since the effects of both short birth intervals and BCG-vaccination turned out to be large and highly significant in the survival model estimations. The simulated policy changes correspond to all children receiving the BCG vaccine and that preceding birth intervals never fall below 24 months. Obviously, the results are driven by the same forces as above. First, the strength of the effect, which varies much more for short birth intervals than for the BCG-vaccine; and, second, the differences in the scope of the policy change. Here, the differences are smaller with regard to short birth intervals (ranging from a minimum reduction of 12.1 percent for Guinea to a maximum reduction of 25.4 percent for Uganda) than they are for BCG where current coverage varies between 56.7 percent in Niger and 86.9 in Uganda.

Results from these two policy experiments are reported in the third and fourth column of Table 2 and indicate that the impact is significant but varies somewhat across countries. Concerning the elimination of short birth intervals, the impact on U5M varies from -6.2 per thousand points for Senegal to -28.0 per thousand points for Mali. This difference is explained to some extent by the fact that the incidence of short birth intervals is higher in Mali (see Table A2) but mainly by the fact that its effect on child survival appears to be very strong in this country (Table A5). This effect is also fairly strong for Niger and Guinea, where the elimination of short birth interval would reduce U5M by 19.4 and 12 per thousand points, respectively. In Madagascar and Mozambique, the policy would have similar effects with a corresponding decrease in U5M rates by 14 per thousand points. Finally, in Kenya and Uganda, the reduction would be close to 10 per thousand points.

Universal BCG vaccination would also permit a significant reduction of U5M in most countries, with impacts ranging from -7.6 per thousand points for Senegal to -31.1 per thousand points for Mali. Again, policy leverage depends on the estimated effect and the prevalence of the problem in each country. In Kenya, for example, the large reduction of 26.9 per thousand points is driven by a strong coefficient[11], while the effect in Mali is due to the relatively strong expansion of BCG coverage of almost 35 percentage points.

We have seen above that these three policies that we have simulated separately are, in fact, closely related. More precisely, better educated mothers are less likely to give birth in very short intervals and more likely to have their children being vaccinated. In order to

[11] A possible reason for the differences in coefficients in the case of vaccines could be the capacity of the health system to deliver vaccines safely and timely.

account for these effects, we have also simulated the effect of universal primary education of mothers using the coefficients estimated in the survival model that includes only child characteristics and mother's education (Table A7). As we have argued above, this model can be considered to capture the 'gross' effect of education on child mortality. In addition, we provide the results of a simulation that implements the three policies from above, universal mothers' education, elimination of short birth intervals and BCG-vaccination simultaneously. These two simulations should yield similar results if mothers with primary education in the underlying sample also tend to have adequate birth spacing and vaccinated children. The results are reported in Table 3.

Table 3: Comprehensive policy interventions

Country	U5M Base values	Universal primary education (gross effect)	All 3 policies	Needed to reach target
Guinea	155.2	-25.7	-39.2	-77.9
Senegal	107.2	-31.2	-33.6	-63.4
Mali	211.4	-96.9	-96.8	-129.3
Niger	169.6	-76.9	-76.4	-64.4
Kenya	116.6	-20.5	-44.8	-85.7
Uganda	111.7	-23.9	-38.0	-53.8
Madagascar	89.2	-10.1	-27.7	-34.6
Mozambique	144.4	-13.2	-23.6	-79.0

Source: Authors' calculation from DHS surveys and simulations.

In Mali, Niger, and Senegal, the two simulations indeed yield very similar impacts. This hence reflects that the small share of mothers with primary (or higher) education in these countries is indeed much more likely to have short birth intervals and their children vaccinated, as also indicated in the above analysis of these proximate determinants. In all the other countries, the simultaneous implementation of all three policies has a considerably larger effect. Here, levels of primary education are typically higher (Kenya, Uganda, Madagascar) and less strongly associated with the other policies (in particular Guinea and Mozambique where levels of primary education are also low).

The most striking result from these simulations, however, is that simultaneously achieving universal primary schooling completion for mothers, universal BCG vaccination and eliminating short birth intervals would not suffice to achieve MDG4 in 7 out of 8 countries of our sample. In Table 4, we summarize our assessments based on the simulations and compare then with the official UNDP judgment on the feasibility of achieving MDG4 by 2015.

Table 4: Summary of assessments on the feasibility of MDG4 by 2015

	On current trends	On simulations	UNDP judgement
Guinea	off track	Policy package not enough	Possible to achieve if some changes are made
Senegal	off track	Policy package not enough	Very likely to be achieved, on track
Mali	seriously off track	Achievement close with policy package	Possible to achieve if some changes are made
Niger	on track	Achievement possible with policy package	Very likely to be achieved, on track
Kenya	seriously off track	Policy package not enough	Possible to achieve if some changes are made
Uganda	almost on track	Achievement close with policy package	Off track
Madagascar	on track	Achievement close with policy package	Very likely to be achieved, on track
Mozambique	on track	Policy package not enough	Very likely to be achieved, on track

Source: Authors' calculation from DHS surveys.
Note: UNDP judgment taken from http://www.mdgmonitor.org (April 27, 2009).

Niger is the only country where the simulated policy package would achieve more than is needed to reach MDG4 in 2015. Since it is the country with the second highest U5M in our sample, this could be explained the fact that there is still a lot of scope for improvement and, hence, strong policy leverage. Niger is also the only country where all three judgments converge to say that achievement of MDG4 is within reach. The other Sahel country, Mali, would achieve the highest reduction of almost 100 per thousand points, but would still come short of meeting the 2015 target. . Yet, the remaining gap would not be too large if it were to implement the full policy package, the underlying mechanism being similar to the Niger case. However, recent trends are not particularly encouraging or indicating that the country moves into the right direction.

In contrast to Niger, the other three of the four fairly successful countries in the past, Mozambique, Madagascar, and Uganda, would only make little additional progress. This is particularly worrying in the case of Mozambique where the U5M rate – despite recent progress – still stands at fairly elevated levels. All three countries seem to have used quite some of the policy space to reduce U5M in recent years, such that future reductions or a continuation of past trends would come only with more effort in improving other conditions relevant for the reduction of child mortality. Among such unobserved conditions, health infrastructure and the quality of health services are likely to figure most prominently. This holds in particular for Mozambique, where households seem to be less demand-side constrained (more supply-side constrained) than in other countries. For this country, our assessment stands at odds with UNDP who judges MDG4 to be very likely to be achieved. UNDP arrives at the same judgment for Madagascar, where we are a bit more pessimistic although some further improvement seems to be possible (however, less likely to be obtained under the current political and economic circumstances). In contrast, we are more optimistic than UNDP concerning Uganda.

In Guinea and Senegal the effects of the simultaneous interventions are close to the extrapolation of the current trend (see Table 1), which falls short of the reduction needed to achieve MDG4. In Guinea and Senegal, the assessments based on recent observed trends and on simulations converge to indicate that these two countries are unlikely to achieve MDG4 by 2015. This assessment contrasts with the UNDP judgment which is more encouraging for both countries.

Finally, Kenya, would only get half way to the target. For this comparably rich country, the simulated policy scenario do not appear to be overly ambitious. For Kenya, our assessments (based on recent observed trends and on simulations) converge and point to a very worrying situation although the UNDP judgment is more optimistic.

Conclusion

This paper investigates the determinants of child mortality with a focus on MDG complementarities. More specifically, we examine how progress in other MDGs – in particular the expansion of female education, corresponding to MDG2 & MDG3 – would affect child mortality (MDG4). In particular, we analyze how so-called proximate determinants such as universal BCG vaccination and the elimination of short birth intervals are associated with mother’s education. The analysis is carried out on 16 DHS surveys collected in eight Sub-Saharan countries (Guinea, Senegal, Mali, Niger, Kenya, Uganda, Madagascar, and Mozambique) over the last 15 years and relies on the estimation of dicrete-time hazard models of survival for children under five.

We show that mother’s education is indeed an important determinant of child survival. The effect of mother’s education runs through a number of channels. Our analysis shows that more educated mothers have larger birth intervals and that their children are more likely to be vaccinated. These findings suggest that complementarities between achieving MDG2 & MDG3, on the one hand, and MDG4, on the other, could be substantial. This is confirmed by our simulation results: The results illustrate that the impact of mother’s education expansion on child mortality is considerable but varies markedly across countries. In countries with considerable room for improvement, notably in the Sahel zone, the simulated reductions are largest. However, despite their importance, the effects of universal primary completion of mothers alone would not suffice to achieve MDG4 by 2015. Yet, the results certainly underline the importance of demand side factors, as educational achievements, which constrain the use of public services. Achieving MDG4 hence obviously calls for both demand side and supply side interventions.

Complementary results show that simultaneously achieving universal primary schooling completion, universal BCG vaccination and eliminating short birth intervals would not suffice either to achieve MDG4 in seven out of eight countries of our sample. This is all the more worrying since these three policy achievements already represent extremely amibitious – and for most countries certainly quite unrealistic – targets.

The analysis carried out in this paper – as well as in most of the reviewed papers dealing with child mortality - indicates that the DHS initiative can be regarded as a great success for monitoring health outcomes in developing countries on an internationally comparable basis. Yet, the present study also reveals some limitations of this outstanding effort. In order to improve both the accuracy and policy relevance of this type of analysis, supply side data should be collected more consistently, water access variables should be made easier to harmonize between countries, and agricultural assets should be collected. Indeed, we found that the assets considered in the questionnaire are poor proxies to assess the wealth of rural households, making it difficult to convincingly estimate the link between the economic situation of the household and health outcomes.

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Appendix: Additional Tables

Table A1: Countries and survey years

	Survey years		
Country	0	1	2
Guinea	1992	1999	2005
Senegal	1992/93	1997	2005
Mali	1987	1995	2001
Niger	1992	1998	2006
Kenya	1989	1998	2003
Uganda	1988	2000	2006
Madagascar	1992	1997	2003
Mozambique	1997	1997	2003

Table A2: Descriptive statistics

	Guinea		Senegal		Mali		Niger		Kenya		Uganda		Madagascar		Mozambique	
	1999	2005	1997	2005	1995	2001	1998	2006	1998	2003	2000	2006	1997	2003	1997	2003
Share of children who died	13.6%	11.4%	9.8%	7.8%	17.0%	15.7%	17.8%	12.3%	8.8%	9.0%	11.4%	9.0%	12.0%	7.1%	15.3%	11.6%
Male	52.4%	51.6%	50.5%	51.5%	50.0%	50.8%	50.4%	51.2%	51.0%	50.8%	49.8%	49.6%	50.5%	48.9%	49.6%	49.4%
First born	17.8%	17.2%	17.6%	21.7%	16.5%	17.2%	17.0%	15.4%	24.8%	23.9%	18.0%	17.2%	21.2%	23.0%	22.0%	21.5%
Mother's age at birth	26.8	27.5	27.9	27.3	27.0	26.9	26.5	26.6	26.2	26.3	25.9	26.7	26.4	26.6	26.1	26.1
Mother’s education																
Primary completed	5.9%	4.9%	12.9%	9.6%	5.3%	5.3%	7.3%	3.7%	34.3%	35.8%	18.5%	21.6%	24.5%	32.0%	5.6%	5.6%
Higher than primary	1.3%	0.7%	2.0%	0.8%	0.1%	0.6%	0.3%	0.4%	15.7%	12.1%	1.9%	2.6%	1.4%	3.8%	0.3%	0.4%
Short birth interval	16.1%	12.1%	17.0%	17.7%	24.4%	20.7%	23.1%	20.1%	20.7%	20.7%	27.2%	25.4%	27.8%	21.6%	17.0%	14.8%
Household size	9.1	8.4	13.6	13.4	7.5	5.7	8.1	8.2	6.1	6.0	6.4	6.7	6.2	6.0	6.6	6.7
Private water access	7.0%	6.0%	26.3%	37.7%	4.6%	8.2%	9.6%	5.6%	17.0%	15.0%	1.1%	2.4%	4.0%	2.8%	11.3%	10.3%
Water from public tap	10.5%	10.9%	16.6%	20.2%	9.8%	19.0%	11.2%	14.7%	9.1%	9.6%	6.3%	9.1%	9.3%	15.7%	11.1%	14.0%
Number of recorded birth	5,834	6,311	7,329	10,604	10,215	13,135	7,959	9,160	5,639	6,019	7,205	8,365	6,109	5,414	7,071	10,321

Source: Authors’ calculation from DHS surveys.

Table A3: Vaccination rates

	BCG			DPT			Polio			Measles		
	Year 1	Year 2	Change	Year 1	Year 2	Change	Year 1	Year 2	Change	Year 1	Year 2	Change
Guinea	75.8	79.4	5%	46.2	51.1	11%	43.1	50.1	16%	52.1	50.2	-4%
Senegal		91.7			78.3			72.9			73.5	
Mali	76.3	69.0	-10%	37.5	39.6	6%	39.1	39.4	1%	50.8	48.7	-4%
Niger	47.3	63.6	34%	25.0	39.3	57%	24.0	54.6	128%	34.9	47.0	35%
Kenya	95.9	87.3	-9%	79.2	72.2	-9%	74.4	66.8	-10%	79.2	72.5	-8%
Uganda	78.7	90.5	15%	46.1	16.7	-64%	54.1	59.3	10%	56.8	68.1	20%
Madagascar	66.0	71.8	9%	48.4	61.4	27%	47.7	63.2	32%	46.0	59.0	28%
Mozambique	78.1	87.4	12%	59.6	71.6	20%	55.3	69.6	26%	57.5	76.7	33%

Note: Percentage of children 12-23 months who had received specific vaccines at any time before the survey. DPT, (sometimes DTP) is a mixture of three vaccines, to immunize against diphtheria, pertussis (whooping cough) and tetanus. Bacillus Calmette-Guérin (or Bacille Calmette-Guérin, BCG) is a vaccine against tuberculosis (Wikipedia.org).

Table A4: Survival model for child mortality for all years (no vaccination variables)

	Guinea		Senegal		Mali		Niger	
	1999	2005	1997	2005	1995	2001	1998	2006
Boy	1.102	1.211**	1.031	1.171*	1.125*	1.091	0.984	1.141*
	(0.08)	(0.09)	(0.08)	(0.08)	(0.05)	(0.05)	(0.06)	(0.07)
First born	1.144	1.090	1.462**	1.588***	1.421***	1.393***	1.367**	1.238*
	(0.14)	(0.13)	(0.17)	(0.15)	(0.12)	(0.10)	(0.14)	(0.13)
Mother under 18	1.165	1.202	1.205	1.119	1.152	1.100	1.124	1.165
	(0.15)	(0.18)	(0.19)	(0.13)	(0.10)	(0.09)	(0.12)	(0.15)
Primary completed	0.588*	0.900	0.689**	0.781	0.617**	0.736*	0.896	0.747
	(0.12)	(0.20)	(0.10)	(0.14)	(0.09)	(0.10)	(0.11)	(0.15)
Higher completed	0.450	0.198	0.126*			0.402	0.322	0.318
	(0.25)	(0.20)	(0.13)			(0.25)	(0.32)	(0.22)
Short birth interval	1.347**	1.736***	1.500***	1.437***	1.502***	1.833***	1.482***	1.601***
	(0.13)	(0.18)	(0.14)	(0.14)	(0.09)	(0.10)	(0.10)	(0.12)
Household size	0.927***	0.907***	0.991	0.983*	0.900***	0.898***	0.927***	0.926***
	(0.01)	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Private water	0.614*	0.876	0.896	0.751*	0.952	1.139	0.598**	1.017
	(0.13)	(0.20)	(0.12)	(0.09)	(0.16)	(0.15)	(0.10)	(0.23)
Public tap	0.890	1.042	1.040	0.891	1.041	1.082	0.798	1.032
	(0.12)	(0.20)	(0.13)	(0.09)	(0.10)	(0.08)	(0.10)	(0.16)
Rural rich	1.053	1.107	0.721***	0.710***	0.997	0.971	0.961	0.957
	(0.09)	(0.10)	(0.07)	(0.07)	(0.06)	(0.05)	(0.06)	(0.07)
Urban poor	0.779	0.941	0.739*	0.695**	0.793*	0.813*	0.958	0.779
	(0.11)	(0.18)	(0.09)	(0.08)	(0.07)	(0.08)	(0.14)	(0.15)
Urban rich	1.164	0.976	0.603**	0.665**	0.704***	0.670***	0.741	0.623*
	(0.19)	(0.21)	(0.11)	(0.10)	(0.07)	(0.08)	(0.12)	(0.13)
North	1.278	1.111	1.185	0.850	0.948	1.063	0.653***	0.880
	(0.17)	(0.13)	(0.14)	(0.10)	(0.15)	(0.11)	(0.06)	(0.11)
West	0.926	1.025	0.947	0.932	1.187*	1.077	0.571***	1.025
	(0.12)	(0.12)	(0.12)	(0.12)	(0.10)	(0.08)	(0.06)	(0.12)
South	1.177	1.364*	1.252*	1.258*	0.988	0.995	0.569***	1.131
	(0.15)	(0.20)	(0.14)	(0.15)	(0.07)	(0.08)	(0.06)	(0.13)
East					1.714***	0.924	0.723***	0.846
					(0.19)	(0.13)	(0.06)	(0.11)
Birth year 2	0.597**	1.027	0.928	0.962	0.866*	0.999	0.888	1.014
	(0.09)	(0.12)	(0.10)	(0.12)	(0.06)	(0.07)	(0.07)	(0.10)
Birth year 3	0.659**	0.830	0.866	1.039	0.889	1.132	0.739***	0.994
	(0.11)	(0.10)	(0.10)	(0.13)	(0.07)	(0.08)	(0.06)	(0.11)
Birth year 4	0.667*	0.851	0.910	0.709**	0.811*	0.904	0.568***	0.778*
	(0.11)	(0.11)	(0.11)	(0.09)	(0.07)	(0.07)	(0.06)	(0.09)
Birth year 5	0.670*	0.722*	0.856	0.717*	0.687***	0.882	0.514***	0.768*
	(0.11)	(0.11)	(0.12)	(0.09)	(0.06)	(0.07)	(0.05)	(0.10)
Birth year 6	0.664	0.812	0.790	0.827				
	(0.14)	(0.19)	(0.24)	(0.18)				
logt	0.389***	0.380***	0.406***	0.344***	0.422***	0.406***	0.497***	0.478***
	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Constant	0.074***	0.043***	0.031***	0.036***	0.062***	0.051***	0.084***	0.031***
	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Pseudo R^2	0.110	0.106	0.091	0.119	0.096	0.104	0.070	0.065
N	152,801	166,356	201,487	282,806	268,043	337,462	202,900	246,619

Source: Authors' calculation from DHS surveys.
Note: Robust standard errors in parentheses. * Significant at 10%, ** at 5%; *** at 1% level.

Table A4 (cont.): Survival model for child mortality for all years (no vaccination variables)

	Kenya		Uganda		Madagascar		Mozambique	
	1998	2003	2000	2006	1997	2003	1997	2003
Boy	1.061	1.292**	1.125	1.314***	1.153*	1.283*	1.125	1.066
	(0.10)	(0.12)	(0.08)	(0.10)	(0.08)	(0.15)	(0.08)	(0.06)
First born	0.803	0.809	1.121	1.006	1.099	1.063	1.522***	1.500***
	(0.11)	(0.12)	(0.13)	(0.12)	(0.13)	(0.17)	(0.15)	(0.13)
Mother under 18	1.964***	1.037	1.032	1.019	1.234	1.049	1.127	1.201
	(0.30)	(0.19)	(0.13)	(0.16)	(0.15)	(0.21)	(0.11)	(0.12)
Primary completed	0.750*	0.733**	0.692**	0.746**	0.667***	0.890	0.744	1.050
	(0.08)	(0.08)	(0.08)	(0.08)	(0.07)	(0.13)	(0.16)	(0.15)
Higher completed	0.559**	0.435***	0.734	0.636	0.258*	0.619	0.517	0.422
	(0.10)	(0.10)	(0.21)	(0.20)	(0.15)	(0.22)	(0.33)	(0.31)
Short birth interval	1.110	1.424**	1.298**	1.359***	1.616***	1.737***	2.026***	1.767***
	(0.13)	(0.17)	(0.11)	(0.12)	(0.13)	(0.25)	(0.17)	(0.14)
Household size	0.820***	0.812***	0.843***	0.801***	0.863***	0.774***	0.836***	0.845***
	(0.02)	(0.03)	(0.03)	(0.02)	(0.02)	(0.03)	(0.02)	(0.02)
Private water	1.050	0.853	0.618	0.533	1.145	0.556	0.759	0.914
	(0.19)	(0.17)	(0.24)	(0.22)	(0.29)	(0.22)	(0.13)	(0.15)
Public tap	0.706	0.969	0.678*	0.907	1.176	1.160	0.781	0.784*
	(0.15)	(0.15)	(0.12)	(0.14)	(0.18)	(0.22)	(0.11)	(0.09)
Rural rich	0.888	1.010	0.940	1.056	0.804*	0.894	1.324***	1.112
	(0.10)	(0.10)	(0.08)	(0.09)	(0.07)	(0.18)	(0.10)	(0.09)
Urban poor	1.238	1.129	0.778	1.051	0.837	0.606*	1.321	1.304*
	(0.28)	(0.19)	(0.12)	(0.21)	(0.14)	(0.14)	(0.21)	(0.16)
Urban rich	0.955	1.347	0.814	1.019	0.759	0.709	1.328	1.171
	(0.27)	(0.25)	(0.17)	(0.21)	(0.13)	(0.19)	(0.25)	(0.18)
North	1.654*	1.054	1.246	1.388**	0.628**	1.242	0.945	0.841*
	(0.39)	(0.19)	(0.16)	(0.17)	(0.09)	(0.34)	(0.10)	(0.07)
West	3.681***	1.971***	0.981	1.198	1.086	1.566*	0.838	0.910
	(0.84)	(0.32)	(0.13)	(0.14)	(0.14)	(0.34)	(0.13)	(0.11)
South					0.799	1.983**	0.935	0.727**
					(0.13)	(0.44)	(0.11)	(0.07)
East	2.108**	1.347	0.944	1.046	1.000	1.680*		
	(0.50)	(0.23)	(0.13)	(0.12)	(0.13)	(0.40)		
Birth year 2	1.046	1.052	1.000	1.021	0.891	2.057	1.063	0.788
	(0.16)	(0.18)	(0.10)	(0.14)	(0.21)	(2.12)	(0.11)	(0.16)
Birth year 3	0.822	1.277	0.996	0.990	0.756	2.581	0.418***	0.908
	(0.14)	(0.21)	(0.10)	(0.13)	(0.18)	(2.65)	(0.05)	(0.18)
Birth year 4	1.026	1.253	0.799*	0.891	0.861	2.422	0.522***	0.873
	(0.16)	(0.21)	(0.09)	(0.13)	(0.20)	(2.50)	(0.06)	(0.17)
Birth year 5	0.970	1.023	0.844	1.062	0.601*	2.134	0.585***	0.886
	(0.16)	(0.19)	(0.11)	(0.16)	(0.14)	(2.20)	(0.08)	(0.18)
Birth year 6		0.626		0.889	0.548*	2.553	0.774	0.742
		(0.18)		(0.19)	(0.15)	(2.63)	(0.15)	(0.16)
logt	0.379***	0.345***	0.438***	0.421***	0.385***	0.351***	0.371***	0.376***
	(0.02)	(0.02)	(0.01)	(0.01)	(0.02)	(0.02)	(0.01)	(0.01)
Constant	0.026***	0.036***	0.048***	0.038***	0.071***	0.014***	0.072***	0.067***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)	(0.01)
Pseudo R^2	0.129	0.139	0.086	0.097	0.111	0.139	0.134	0.121
N	155,051	167,736	197,568	232,249	163,724	155,683	186,079	275,910

Source: Authors' calculation from DHS surveys.
Note: Robust standard errors in parentheses. * Significant at 10%, ** at 5%; *** at 1% level.

Table A5: Survival model for child mortality for recent year (including vaccination variables)

	Guinea 2005	Senegal 2005	Mali 2001	Niger 2006	Kenya 2003	Uganda 2006	Madagascar 2003	Mozambique 2003
Boy	1.220**	1.169*	1.097*	1.146*	1.300**	1.289***	1.282*	1.057
	(0.09)	(0.08)	(0.05)	(0.07)	(0.12)	(0.10)	(0.15)	(0.06)
First born	1.081	1.604***	1.396***	1.247*	0.814	1.047	1.108	1.478***
	(0.13)	(0.15)	(0.10)	(0.13)	(0.12)	(0.12)	(0.18)	(0.13)
Mother under 18	1.207	1.118	1.097	1.146	1.064	1.008	1.001	1.244*
	(0.18)	(0.13)	(0.09)	(0.14)	(0.20)	(0.15)	(0.21)	(0.12)
Primary completed	0.949	0.777	0.764	0.742	0.841	0.774*	0.979	1.080
	(0.21)	(0.14)	(0.11)	(0.15)	(0.10)	(0.08)	(0.14)	(0.15)
Higher completed	0.206		0.415	0.311	0.509**	0.675	0.687	0.434
	(0.21)		(0.25)	(0.22)	(0.11)	(0.21)	(0.25)	(0.32)
Short birth interval	1.653***	1.441***	1.828***	1.611***	1.354*	1.347***	1.696***	1.712***
	(0.17)	(0.14)	(0.10)	(0.12)	(0.16)	(0.12)	(0.25)	(0.14)
Household size	0.908***	0.983*	0.899***	0.926***	0.810***	0.803***	0.775***	0.848***
	(0.02)	(0.01)	(0.01)	(0.01)	(0.03)	(0.02)	(0.03)	(0.02)
Private water	0.894	0.753*	1.150	1.005	0.912	0.561	0.607	0.936
	(0.20)	(0.09)	(0.16)	(0.23)	(0.19)	(0.22)	(0.25)	(0.15)
Public tap	1.060	0.899	1.089	1.050	1.021	0.905	1.254	0.820
	(0.20)	(0.10)	(0.08)	(0.16)	(0.16)	(0.14)	(0.24)	(0.10)
Rural rich	1.164	0.716***	1.000	0.970	1.057	1.043	1.013	1.129
	(0.10)	(0.07)	(0.05)	(0.07)	(0.11)	(0.09)	(0.20)	(0.09)
Urban poor	1.042	0.697**	0.897	0.790	1.133	1.106	0.669	1.466**
	(0.19)	(0.08)	(0.09)	(0.15)	(0.19)	(0.23)	(0.15)	(0.18)
Urban rich	1.099	0.675**	0.756*	0.626*	1.386	1.096	0.808	1.286
	(0.24)	(0.10)	(0.09)	(0.13)	(0.26)	(0.23)	(0.21)	(0.20)
bcg	0.442***	0.398***	0.509***	0.667***	0.351***	0.372***	0.412***	0.444***
	(0.05)	(0.05)	(0.03)	(0.06)	(0.05)	(0.04)	(0.07)	(0.04)
dpt	1.106	1.900***	1.164	1.681***	0.741	0.780	0.780	0.980
	(0.24)	(0.33)	(0.13)	(0.20)	(0.15)	(0.11)	(0.28)	(0.17)
polio	1.246	1.185	1.291**	1.090	1.355	1.194	0.780	1.348
	(0.28)	(0.20)	(0.12)	(0.13)	(0.31)	(0.16)	(0.27)	(0.23)
measles	0.687*	0.786	0.800*	0.874	0.402***	0.521***	0.932	0.350***
	(0.11)	(0.12)	(0.08)	(0.11)	(0.08)	(0.07)	(0.28)	(0.04)
north	1.150	0.850	1.049	0.877	1.084	1.637***	1.007	0.789**
	(0.14)	(0.10)	(0.12)	(0.11)	(0.20)	(0.21)	(0.27)	(0.07)
west	1.076	0.928	1.034	1.048	1.955***	1.339*	1.292	0.987
	(0.12)	(0.12)	(0.08)	(0.12)	(0.32)	(0.16)	(0.29)	(0.12)
south	1.514**	1.311*	1.057	1.150			1.741*	0.807*
	(0.22)	(0.15)	(0.08)	(0.14)			(0.38)	(0.08)
east			0.965	0.840	1.194	1.150	1.616*	
			(0.13)	(0.11)	(0.22)	(0.13)	(0.38)	
Birth year 2	1.073	0.964	1.010	1.002	1.183	1.036	2.277	0.810
	(0.13)	(0.13)	(0.07)	(0.10)	(0.20)	(0.14)	(2.35)	(0.17)
Birth year 3	0.857	1.043	1.154*	0.982	1.408*	1.017	2.937	0.952
	(0.11)	(0.13)	(0.08)	(0.11)	(0.23)	(0.14)	(3.03)	(0.20)
Birth year 4	0.905	0.725*	0.934	0.770*	1.438*	0.919	2.846	0.945
	(0.12)	(0.10)	(0.07)	(0.09)	(0.25)	(0.13)	(2.95)	(0.19)
Birth year 5	0.761	0.752*	0.895	0.773*	1.156	1.090	2.506	0.958
	(0.11)	(0.10)	(0.07)	(0.10)	(0.22)	(0.17)	(2.58)	(0.20)
Birth year 6	0.807	0.792			0.679	0.875	3.011	0.782
	(0.19)	(0.17)			(0.20)	(0.19)	(3.12)	(0.17)
logt	0.462***	0.391***	0.452***	0.485***	0.524***	0.631***	0.465***	0.535***
	(0.02)	(0.03)	(0.01)	(0.02)	(0.04)	(0.03)	(0.03)	(0.02)
constant	0.040***	0.038***	0.050***	0.032***	0.030***	0.034***	0.012***	0.057***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Pseudo R^2	0.114	0.127	0.110	0.068	0.158	0.111	0.152	0.136
N	166,356	282,806	337,462	246,619	167,736	232,249	155,683	275,910

Source: Authors' calculation from DHS surveys.
Note: Robust standard errors in parentheses. * Significant at 10%, ** at 5%; *** at 1% level.

Table A6: Survival model for child mortality for recent year with fixed effects (including vaccination variables)

	Guinea 2005	Senegal 2005	Mali 2001	Niger 2006	Kenya 2003	Uganda 2006	Madagascar 2003	Mozambique 2003
Boy	1.192*	1.208**	1.108*	1.135	1.348**	1.305***	1.250	1.076
	(0.09)	(0.09)	(0.05)	(0.07)	(0.13)	(0.10)	(0.15)	(0.07)
First born	1.097	1.676***	1.433***	1.289*	0.801	1.108	1.163	1.601***
	(0.14)	(0.16)	(0.10)	(0.14)	(0.11)	(0.13)	(0.20)	(0.13)
Mother under 18	1.214	1.012	1.107	1.117	1.199	0.955	1.123	1.201
	(0.18)	(0.13)	(0.09)	(0.14)	(0.24)	(0.16)	(0.24)	(0.12)
Primary completed	0.930	0.807	0.693**	0.778	0.845	0.820	0.995	1.066
	(0.20)	(0.15)	(0.10)	(0.15)	(0.10)	(0.09)	(0.15)	(0.15)
Higher completed	0.185	0.000	0.369	0.434	0.667	0.817	0.899	0.418
	(0.19)	(0.00)	(0.22)	(0.32)	(0.15)	(0.27)	(0.35)	(0.43)
Short birth interval	1.511***	1.315**	1.755***	1.551***	1.201	1.331***	1.600***	1.701***
	(0.16)	(0.12)	(0.10)	(0.12)	(0.14)	(0.11)	(0.22)	(0.14)
Household size	0.899***	0.984*	0.898***	0.930***	0.820***	0.807***	0.773***	0.845***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)	(0.03)	(0.01)
Private water	1.089	0.887	1.243	0.835	0.636	0.892	0.937	1.198
	(0.36)	(0.15)	(0.19)	(0.20)	(0.18)	(0.38)	(0.51)	(0.25)
Public tap	1.267	0.834	1.097	0.924	0.694	1.017	1.676	0.808
	(0.26)	(0.12)	(0.09)	(0.15)	(0.17)	(0.23)	(0.60)	(0.11)
Rich	1.150	0.767**	1.149**	0.970	1.082	0.956	1.152	1.118
	(0.09)	(0.06)	(0.06)	(0.07)	(0.11)	(0.08)	(0.14)	(0.07)
bcg	0.450***	0.416***	0.510***	0.687***	0.347***	0.372***	0.453***	0.412***
	(0.05)	(0.05)	(0.03)	(0.06)	(0.04)	(0.04)	(0.08)	(0.03)
dpt	1.168	1.991***	1.227	1.606***	0.691	0.780	0.805	0.959
	(0.23)	(0.33)	(0.13)	(0.19)	(0.16)	(0.12)	(0.31)	(0.15)
polio	1.242	1.203	1.246*	1.185	1.379	1.234	0.739	1.338
	(0.24)	(0.20)	(0.13)	(0.13)	(0.33)	(0.16)	(0.30)	(0.21)
measles	0.653**	0.814	0.808*	0.867	0.406***	0.518***	1.037	0.338***
	(0.10)	(0.11)	(0.08)	(0.10)	(0.08)	(0.07)	(0.34)	(0.04)
Birth year 2	1.073	0.900	0.994	0.957	1.124	1.094	2.184	0.933
	(0.13)	(0.11)	(0.07)	(0.10)	(0.20)	(0.16)	(2.24)	(0.19)
Birth year 3	0.850	0.988	1.131	0.957	1.330	0.976	2.856	1.107
	(0.11)	(0.11)	(0.08)	(0.10)	(0.23)	(0.14)	(2.92)	(0.22)
Birth year 4	0.888	0.673**	0.898	0.722**	1.347	0.914	2.698	1.081
	(0.12)	(0.09)	(0.07)	(0.08)	(0.24)	(0.14)	(2.76)	(0.22)
Birth year 5	0.776	0.698**	0.883	0.739*	1.089	1.084	2.386	1.060
	(0.11)	(0.09)	(0.07)	(0.09)	(0.20)	(0.17)	(2.44)	(0.22)
Birth year 6	0.826	0.717			0.629	0.857	2.782	0.884
	(0.19)	(0.15)			(0.19)	(0.18)	(2.85)	(0.19)
logt	0.471***	0.383***	0.458***	0.487***	0.549***	0.640***	0.461***	0.573***
	(0.02)	(0.02)	(0.01)	(0.02)	(0.03)	(0.03)	(0.03)	(0.02)
Pseudo R^2	0.122	0.134	0.111	0.066	0.165	0.116	0.159	0.146
N	144,058	234,794	322,350	219,329	111,940	198,163	95,858	229,556

Source: Authors' calculation from DHS surveys.
Note: Robust standard errors in parentheses. * Significant at 10%, ** at 5%; *** at 1% level.

Table A7: Survival model including only child characteristics and mother's education

	Guinea 2005	Senegal 2005	Mali 2001	Niger 2006	Kenya 2003	Uganda 2006	Madagascar 2003	Mozambique 2003
Boy	1.204* (0.09)	1.163* (0.08)	1.082 (0.05)	1.144* (0.07)	1.285** (0.12)	1.304*** (0.10)	1.291* (0.15)	1.068 (0.06)
First born	1.148 (0.11)	1.457*** (0.12)	1.405*** (0.08)	1.255** (0.10)	0.891 (0.10)	1.150 (0.11)	1.116 (0.14)	1.564*** (0.10)
Primary completed	0.817 (0.17)	0.666* (0.12)	0.546*** (0.07)	0.566** (0.11)	0.742** (0.08)	0.734** (0.08)	0.775 (0.12)	0.883 (0.12)
Higher completed	0.173 (0.17)		0.247* (0.15)	0.238* (0.17)	0.446*** (0.10)	0.526* (0.16)	0.438* (0.15)	0.336 (0.24)
North	1.132 (0.13)	0.878 (0.11)	1.256* (0.14)	0.794 (0.11)	0.961 (0.18)	1.339* (0.15)	1.413 (0.40)	1.064 (0.09)
West	0.984 (0.11)	0.798 (0.10)	1.088 (0.09)	0.814 (0.10)	1.935*** (0.33)	1.114 (0.13)	1.633* (0.38)	1.165 (0.15)
South	1.270 (0.18)	1.444** (0.16)	0.945 (0.08)	1.020 (0.13)			1.997** (0.43)	0.677*** (0.07)
East			0.919 (0.13)	0.870 (0.12)	1.135 (0.21)	0.980 (0.12)	1.769* (0.43)	
Birth year 2	0.963 (0.11)	0.931 (0.12)	0.956 (0.07)	1.026 (0.10)	1.047 (0.18)	0.957 (0.14)	2.123 (2.18)	0.736 (0.14)
Birth year 3	0.770* (0.09)	1.002 (0.12)	1.075 (0.08)	0.967 (0.11)	1.297 (0.21)	0.959 (0.13)	2.591 (2.65)	0.820 (0.16)
Birth year 4	0.758* (0.10)	0.680** (0.09)	0.842* (0.06)	0.759* (0.09)	1.302 (0.22)	0.892 (0.13)	2.512 (2.59)	0.784 (0.15)
Birth year 5	0.652** (0.09)	0.683** (0.09)	0.826* (0.06)	0.744* (0.09)	1.030 (0.19)	1.039 (0.16)	2.287 (2.35)	0.775 (0.15)
Birth year 6	0.730 (0.17)	0.820 (0.17)			0.633 (0.18)	0.866 (0.18)	2.473 (2.55)	0.622* (0.13)
logt	0.379*** (0.01)	0.344*** (0.01)	0.404*** (0.01)	0.477*** (0.01)	0.343*** (0.02)	0.419*** (0.01)	0.349*** (0.02)	0.374*** (0.01)
constant	0.032*** (0.00)	0.024*** (0.00)	0.038*** (0.00)	0.023*** (0.00)	0.019*** (0.00)	0.019*** (0.00)	0.005*** (0.01)	0.040*** (0.01)
Pseudo R^2	0.096	0.113	0.090	0.054	0.125	0.079	0.115	0.104
N	166,356	282,806	337,462	246,619	167,736	232,249	155,683	275,910

Source: Authors' calculation from DHS surveys.
Note: Robust standard errors in parentheses. * Significant at 10%, ** at 5%; *** at 1% level.

Table A8: Survival model including only child characteristics and wealth

	Guinea 2005	Senegal 2005	Mali 2001	Niger 2006	Kenya 2003	Uganda 2006	Madagascar 2003	Mozambique 2003
Boy	1.207**	1.168*	1.085	1.138*	1.280**	1.307***	1.293*	1.072
	(0.09)	(0.08)	(0.05)	(0.07)	(0.12)	(0.10)	(0.15)	(0.06)
First born	1.146	1.495***	1.404***	1.262**	0.838	1.091	1.145	1.555***
	(0.10)	(0.12)	(0.08)	(0.10)	(0.10)	(0.11)	(0.14)	(0.10)
Rural rich	0.988	0.651***	0.890*	0.919	0.898	0.962	0.826	0.969
	(0.09)	(0.06)	(0.05)	(0.07)	(0.10)	(0.09)	(0.18)	(0.08)
Urban poor	0.835	0.632***	0.792*	0.773	1.124	0.935	0.626*	1.110
	(0.13)	(0.07)	(0.08)	(0.11)	(0.17)	(0.18)	(0.14)	(0.13)
Urban rich	0.738	0.479***	0.525***	0.505***	0.932	0.738	0.556**	0.780*
	(0.13)	(0.06)	(0.05)	(0.06)	(0.16)	(0.15)	(0.12)	(0.08)
North	1.140	0.859	1.176	0.827	1.137	1.376*	1.407	1.047
	(0.13)	(0.10)	(0.13)	(0.11)	(0.21)	(0.17)	(0.39)	(0.09)
West	1.028	0.902	1.055	0.876	2.225***	1.130	1.673*	1.159
	(0.12)	(0.12)	(0.08)	(0.10)	(0.37)	(0.13)	(0.36)	(0.15)
South	1.284	1.339*	0.915	0.992			1.975**	0.714***
	(0.19)	(0.15)	(0.07)	(0.13)			(0.44)	(0.07)
East			0.872	0.868	1.357	0.968	1.703*	
			(0.12)	(0.12)	(0.24)	(0.12)	(0.42)	
Birth year 2	0.978	0.955	0.956	1.010	1.033	0.958	1.967	0.732
	(0.11)	(0.12)	(0.07)	(0.10)	(0.18)	(0.14)	(2.02)	(0.14)
Birth year 3	0.780*	1.013	1.076	0.957	1.298	0.948	2.386	0.811
	(0.09)	(0.13)	(0.08)	(0.11)	(0.21)	(0.13)	(2.44)	(0.16)
Birth year 4	0.767*	0.692**	0.849*	0.760*	1.281	0.890	2.324	0.775
	(0.10)	(0.09)	(0.06)	(0.09)	(0.22)	(0.13)	(2.40)	(0.15)
Birth year 5	0.657**	0.695**	0.821**	0.721**	1.021	1.026	2.091	0.768
	(0.09)	(0.09)	(0.06)	(0.09)	(0.19)	(0.15)	(2.15)	(0.15)
Birth year 6	0.736	0.810			0.629	0.855	2.277	0.615*
	(0.18)	(0.17)			(0.18)	(0.18)	(2.34)	(0.13)
logt	0.379***	0.344***	0.404***	0.477***	0.343***	0.418***	0.349***	0.374***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.01)	(0.02)	(0.01)
Constant	0.032***	0.033***	0.043***	0.026***	0.015***	0.018***	0.007***	0.041***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)
Pseudo R^2	0.096	0.116	0.091	0.056	0.121	0.078	0.117	0.105
N	166,356	284,889	337,462	246,619	167,736	232,249	155,683	275,910

Source: Authors' calculation from DHS surveys.
Note: Robust standard errors in parentheses. * Significant at 10%, ** at 5%; *** at 1% level.

Table A9: Determinants of short birth intervals

	Guinea 2005	Senegal 2005	Mali 2001	Niger 2006	Kenya 2003	Uganda 2006	Madagascar 2003	Mozambique 2003
Primary completed	0.650	0.859	0.707**	0.687**	0.812*	0.840**	0.811*	0.695**
	(0.16)	(0.10)	(0.08)	(0.09)	(0.07)	(0.06)	(0.07)	(0.09)
Higher completed	1.037	0.388*	0.289**	0.387*	0.649**	0.647*	0.502***	
	(0.48)	(0.17)	(0.14)	(0.17)	(0.09)	(0.12)	(0.10)	
Rural rich	0.811	1.068	1.156*	1.044	1.021	1.085	0.951	1.109
	(0.09)	(0.07)	(0.07)	(0.07)	(0.08)	(0.06)	(0.11)	(0.09)
Urban poor	0.755	1.002	0.974	1.121	1.061	1.018	0.939	1.013
	(0.15)	(0.10)	(0.09)	(0.12)	(0.13)	(0.13)	(0.12)	(0.11)
Urban rich	0.890	0.960	0.883	1.036	1.099	0.749*	0.637***	0.873
	(0.15)	(0.09)	(0.08)	(0.10)	(0.17)	(0.11)	(0.09)	(0.10)
North	2.122***	1.062	1.403**	0.839	1.366*	0.916	0.710*	1.295**
	(0.38)	(0.08)	(0.15)	(0.09)	(0.18)	(0.08)	(0.10)	(0.11)
West	1.592**	1.108	0.961	0.764*	1.632***	0.838*	1.087	1.418**
	(0.26)	(0.09)	(0.07)	(0.08)	(0.19)	(0.07)	(0.14)	(0.16)
South	1.701**	0.910	0.916	0.812			1.324**	0.638***
	(0.33)	(0.08)	(0.07)	(0.10)			(0.14)	(0.06)
East	0.778*	0.842	0.760***	0.840*	1.251	0.839	1.361	0.823
	(0.09)	(0.08)	(0.05)	(0.07)	(0.16)	(0.09)	(0.37)	(0.16)
Birth year 2	0.524***	0.750**	0.630***	0.561***	1.300*	0.837	1.024	0.777
	(0.07)	(0.07)	(0.04)	(0.06)	(0.17)	(0.09)	(0.27)	(0.15)
Birth year 3	0.360***	0.734***	0.546***	0.597***	1.189	0.820	1.113	0.660*
	(0.05)	(0.07)	(0.04)	(0.06)	(0.15)	(0.09)	(0.30)	(0.13)
Birth year 4	0.313***	0.689***	0.381***	0.392***	0.918	0.776*	1.075	0.518***
	(0.04)	(0.06)	(0.03)	(0.04)	(0.12)	(0.08)	(0.29)	(0.10)
Birth year 5	0.371***	0.775*			1.127	0.672**	0.816	0.338***
	(0.07)	(0.09)			(0.18)	(0.08)	(0.22)	(0.07)
Birth year 6			1.340**	1.026	1.321*	1.079	0.849	
			(0.13)	(0.11)	(0.16)	(0.08)	(0.12)	
constant	0.179***	0.264***	0.409***	0.446***	0.187***	0.451***	0.307***	0.253***
	(0.03)	(0.02)	(0.03)	(0.05)	(0.03)	(0.05)	(0.08)	(0.05)
Pseudo R^2	0.036	0.004	0.022	0.021	0.011	0.006	0.022	0.032
N	6,311	10,604	13,063	9,160	6,019	8,365	5,415	10,270

Source: Authors' calculation from DHS surveys.
Note: Robust standard errors in parentheses. * Significant at 10%, ** at 5%; *** at 1% level.

Table A10: Determinants of short birth intervals with fixed effects

	Guinea 2005	Senegal 2005	Mali 2001	Niger 2006	Kenya 2003	Uganda 2006	Madagascar 2003	Mozambique 2003
Primary completed	0.693	0.880	0.686**	0.702*	1.008	0.853*	0.907	0.785
	(0.17)	(0.10)	(0.08)	(0.10)	(0.09)	(0.06)	(0.08)	(0.12)
Higher completed	1.043	0.434	0.308*	0.281*	0.943	0.641*	0.592*	0.000
	(0.54)	(0.21)	(0.16)	(0.14)	(0.13)	(0.13)	(0.13)	(0.00)
Rich	0.882	1.037	1.038	1.106	1.089	0.964	1.004	0.988
	(0.07)	(0.06)	(0.05)	(0.06)	(0.07)	(0.05)	(0.07)	(0.06)
Birth year 2	0.774*	0.834	0.756***	0.855	1.145	0.884	1.289	0.825
	(0.10)	(0.08)	(0.05)	(0.08)	(0.15)	(0.09)	(0.37)	(0.17)
Birth year 3	0.517***	0.762**	0.627***	0.574***	1.242	0.866	0.978	0.790
	(0.07)	(0.07)	(0.05)	(0.05)	(0.16)	(0.09)	(0.28)	(0.16)
Birth year 4	0.356***	0.730***	0.545***	0.610***	1.106	0.836	1.042	0.685
	(0.05)	(0.07)	(0.04)	(0.06)	(0.15)	(0.09)	(0.30)	(0.14)
Birth year 5	0.321***	0.690***	0.390***	0.408***	0.886	0.840	1.084	0.553**
	(0.05)	(0.06)	(0.03)	(0.04)	(0.12)	(0.09)	(0.31)	(0.11)
Birth year 6	0.374***	0.817			1.138	0.697**	0.794	0.354***
	(0.07)	(0.10)			(0.18)	(0.08)	(0.23)	(0.08)
Pseudo R^2	0.032	0.003	0.020	0.020	0.003	0.003	0.006	0.017
N	5,308	10,335	12,926	8,950	5,465	8,224	5,060	9,051

Source: Authors' calculation from DHS surveys.
Note: Robust standard errors in parentheses. * Significant at 10%, ** at 5%; *** at 1% level.

Table A11: Determinants of child's bcg vaccination status

	Guinea 2005	Senegal 2005	Mali 2001	Niger 2006	Kenya 2003	Uganda 2006	Madagascar 2003	Mozambique 2003
Primary completed	2.001**	1.447*	2.095***	3.753***	2.609***	1.403**	2.297***	1.351
	(0.46)	(0.26)	(0.29)	(0.84)	(0.31)	(0.17)	(0.26)	(0.26)
Higher completed	6.055	1.435	2.768	4.965*	3.533***	2.194*	4.761***	0.728
	(6.31)	(0.94)	(1.49)	(3.61)	(0.64)	(0.70)	(1.29)	(0.41)
Rural rich	1.861***	1.671***	1.447***	1.524***	1.212	0.992	2.266***	1.193*
	(0.18)	(0.18)	(0.11)	(0.12)	(0.16)	(0.10)	(0.35)	(0.09)
Urban poor	3.206***	1.351	3.854***	3.053***	1.136	1.377	2.261***	2.864***
	(0.78)	(0.23)	(0.55)	(0.49)	(0.24)	(0.29)	(0.43)	(0.42)
Urban rich	4.954***	2.378***	7.788***	8.003***	1.677*	2.131***	4.231***	3.125***
	(1.01)	(0.33)	(1.11)	(1.26)	(0.36)	(0.47)	(0.75)	(0.54)
North	1.396*	0.942	0.790	1.298	0.962	2.934***	0.223***	0.693*
	(0.24)	(0.12)	(0.24)	(0.26)	(0.21)	(0.52)	(0.05)	(0.10)
West	1.581**	0.839	0.708*	1.270	0.637**	1.956***	0.270***	1.652*
	(0.27)	(0.13)	(0.12)	(0.24)	(0.11)	(0.34)	(0.06)	(0.40)
South	2.507***	1.543**	2.155***	1.686**			0.385***	3.701***
	(0.67)	(0.25)	(0.29)	(0.34)			(0.09)	(0.65)
East			1.494*	0.661*	0.417***	2.089***	0.725	
			(0.28)	(0.13)	(0.07)	(0.34)	(0.18)	
Birth year 2	1.471**	1.120	1.072	0.921	1.593***	1.056	6.092***	0.863
	(0.18)	(0.13)	(0.07)	(0.09)	(0.20)	(0.16)	(1.61)	(0.19)
Birth year 3	1.157	1.096	1.053	0.971	1.378*	1.088	6.248***	0.873
	(0.13)	(0.11)	(0.07)	(0.08)	(0.18)	(0.16)	(1.68)	(0.19)
Birth year 4	1.473***	1.313*	1.051	1.149	1.609***	1.012	7.502***	1.055
	(0.16)	(0.15)	(0.08)	(0.11)	(0.21)	(0.15)	(2.09)	(0.24)
Birth year 5	1.200	0.825	0.593***	0.804*	1.585***	0.900	7.203***	1.035
	(0.13)	(0.08)	(0.04)	(0.07)	(0.22)	(0.13)	(1.96)	(0.23)
Birth year 6	0.488***	0.186***			0.675*	0.303***	5.648***	0.678
	(0.07)	(0.02)			(0.11)	(0.05)	(1.50)	(0.15)
Constant	0.995	5.064***	1.020	0.905	2.882***	3.807***	0.273***	2.896***
	(0.15)	(0.72)	(0.11)	(0.15)	(0.57)	(0.72)	(0.08)	(0.77)
Pseudo R^2	0.076	0.070	0.094	0.104	0.091	0.052	0.161	0.102
N	6,311	10,604	13,063	9,160	6,019	8,365	5,415	10,321

Source: Authors' calculation from DHS surveys.
Note: Robust standard errors in parentheses. * Significant at 10%, ** at 5%; *** at 1% level.

Table A12: Determinants of child's bcg vaccination status with fixed effects

	Guinea 2005	Senegal 2005	Mali 2001	Niger 2006	Kenya 2003	Uganda 2006	Madagascar 2003	Mozambique 2003
Primary completed	1.347	1.410*	1.695***	3.197***	1.673***	1.501***	1.697***	1.026
	(0.30)	(0.22)	(0.23)	(0.62)	(0.18)	(0.15)	(0.17)	(0.18)
Higher completed	6.157	1.134	2.462	4.831*	2.313***	1.967*	3.508***	0.974
	(6.48)	(0.64)	(1.33)	(3.70)	(0.41)	(0.57)	(0.99)	(0.68)
Rich	1.199**	1.395***	1.295***	1.246***	0.992	1.303***	1.481***	1.065
	(0.08)	(0.09)	(0.06)	(0.07)	(0.08)	(0.10)	(0.12)	(0.06)
Birth year 2	1.323*	1.125	1.045	0.940	1.997***	1.076	7.850***	0.946
	(0.17)	(0.14)	(0.08)	(0.09)	(0.30)	(0.17)	(2.13)	(0.23)
Birth year 3	1.140	1.071	0.996	0.923	1.698***	1.005	7.622***	0.951
	(0.14)	(0.13)	(0.08)	(0.09)	(0.25)	(0.16)	(2.04)	(0.23)
Birth year 4	1.486**	1.291*	0.988	1.123	1.971***	0.985	9.183***	1.153
	(0.19)	(0.16)	(0.08)	(0.11)	(0.29)	(0.16)	(2.48)	(0.29)
Birth year 5	1.128	0.782*	0.492***	0.734***	1.912***	0.852	9.319***	1.142
	(0.13)	(0.09)	(0.03)	(0.07)	(0.28)	(0.13)	(2.51)	(0.28)
Birth year 6	0.378***	0.148***			0.692*	0.227***	6.961***	0.725
	(0.05)	(0.02)			(0.11)	(0.04)	(1.86)	(0.18)
Pseudo R^2	0.028	0.080	0.025	0.014	0.034	0.060	0.042	0.005
N	5,549	9,539	12,429	8,574	4,741	6,942	4,591	7,955

Source: Authors' calculation from DHS surveys.
Note: Robust standard errors in parentheses. * Significant at 10%, ** at 5%; *** at 1% level.

Table A13: Base values and target in simulated changes in socio-economic and proximate determinants

	Universal primary completion for uneducated mothers	Elimination of short birth interval	Universal BCG vaccination coverage
Target	100%	0%	100%
	Base value	Base value	Base value
Guinea 2005	4.9%	12.1%	73.9%
Senegal 2005	9.6%	17.7%	86.1%
Mali 2001	5.3%	20.7%	65.4%
Niger 2006	3.7%	20.1%	56.7%
Kenya 2003	35.8%	20.7%	81.8%
Uganda 2006	21.6%	25.4%	86.9%
Madagascar 2003	32.0%	21.6%	68.2%
Mozambique 2003	5.6%	14.8%	78.5%

Source: Authors' calculation from DHS surveys.
Note: Mothers with secondary or higher education are not downgraded.