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DOES THE EFFECT OF MATERNAL SCHOOLING ON INFANT MORTALITY VARY ACROSS DIFFERENT SETTINGS?

An Empirical Analysis Using Demographic and Health Surveys for Sub-Saharan Africa

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Abstract
The study reveals that the effect of maternal schooling on infant mortality varies between countries and tends to diminish over time within countries in Sub-Saharan Africa. These results imply that country level determinants affect the link between inequalities in socio-economic factors and inequalities in infant mortality rates. Previous research has mainly neglected country level determinants. Thus, future research should focus on understanding their role to provide a better knowledge base for policy makers trying to decrease infant mortality. We used nationally representative samples from the Demographic and Health Surveys for 28 different countries and employed a linear regression estimation strategy.

Keywords: maternal schooling, infant mortality, Sub-Saharan Africa, country level determinants, socio-economic determinants, Demographic and Health Surveys

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1. Introduction

A literature review on the effect of maternal schooling on child mortality revealed that previous research is mainly country-specific and that research results are non-existent for many countries. Hence, policy makers often have to base their decisions on research results from other countries although the external validity of these results is highly at doubt. The theoretical model by Houweling and Kunst (2010) suggests, that country level determinants are likely to change the relationships between socio-economic factors and child health. Although a thorough understanding of the effect of country level determinants is important for policy makers to make optimal decisions, research on these determinants is merely non-existent.

Our research questions are directly linked to the identified research gap. As research did not focus on country level determinants in explaining the effect of maternal schooling on child health, the intention of this paper is to increase the awareness of the necessity to focus on these determinants by answering the following two questions:

1) *Does the effect of maternal schooling on infant mortality differ between countries in Sub-Saharan Africa?*

2) *Does the effect of maternal schooling on infant mortality change over time within countries in Sub-Saharan Africa?*

We find that the effect of maternal schooling on infant mortality varies between countries as well as within countries over time in Sub-Saharan Africa. In Kenya and Burundi one additional year of maternal schooling is associated with a decrease of the probability that a child dies within the first year by more than 0.3 percentage points. In contrast, the effect is estimated to be only 0.1 percentage points in Benin and for about half of the countries the effect is economically or statistically insignificant. Furthermore, the effect of maternal schooling on infant mortality seems to decrease over time. We find this tendency for all but one country being studied and the effect is significant in one third of the countries. Thus, our results indicate that the effect of maternal schooling on infant mortality depends on certain characteristics of the environment. Country level determinants seem to alter the link between socio-economic determinants, such as maternal schooling, and infant mortality.

A greater understanding of the role of country level determinants is thus of utmost importance and deserves a greater focus by researchers. We believe that our results can contribute in directing future research towards this topic. Moreover, we suggest that important country level determinants are political and economical institutions, health care provision and disease prevalence.

For studying whether the effect of maternal schooling on infant mortality varies both between countries in Sub-Saharan Africa and also over time within countries, we use data from the Demographic and Health Surveys (DHS) and perform multivariate linear regressions. The datasets are collected by the United States Agency for International Development, which incorporate complete maternity histories as well as information on the socio-economic background of mothers. In total we use 46 datasets from 28 different Sub-Saharan countries in our analysis, ranging from 1996 to 2012. Many other researchers and institutions such as the WHO frequently rely on and use DHS data, thus indicating this data source to be reliable.

In order to answer the first research question, we regress infant mortality on maternal schooling while controlling for maternal age at the time of the interview and regional fixed effects. Moreover we explicitly account for the stratified multi-stage survey design of the DHS surveys. After performing this regression for 28 Sub-Saharan countries we use a seemingly unrelated regression post-estimation test in order to check whether the effect of maternal schooling on infant mortality differs between countries. In order to shed light on how the effect varies over time within countries, we pool two datasets from different time periods for 18 different countries. By including an interaction term of the survey wave and maternal schooling in each country regression we are able to check whether the effect has changed over time.

The analysis at hand shifts the research frontier outwards for three reasons. It is the first study that tests whether the effect of maternal schooling on infant mortality differs between countries on a large scale. Moreover we are not aware of any study that tries to explain the change of the effect of maternal schooling on infant mortality over time. Also, this study uses the most recent datasets that were available for the countries being studied.

We cannot reject the possibility of omitted variable bias and sample-selection bias, limiting the internal validity of our results. Nevertheless, we do not doubt the robustness of our general conclusions regarding the variation of the effect of maternal schooling on infant mortality between different settings. Moreover, this conclusion is likely to be externally valid for other regions throughout the world as well.

The severeness of child mortality throughout the developing world is common knowledge. Thus, underlining the importance of contributing to the literature aiming at reducing the deaths of children should not be necessary. Nevertheless, we give a brief overview of recent developments that indicate that Sub-Saharan Africa deserves special attention.

Every day 18,000 children die worldwide, mainly due to causes that are easily preventable (UNICEF, WHO, World Bank, UN-DESA Population Division, 2013). The United Nations Millennium Development Goal number four states that the child mortality (under five mortality rate) rate should be reduced by two thirds between 1990 and 2015. Worldwide, child mortality has dropped from 90 deaths per 1000 live births in 1990 to 48 in 1000 in 2012 (UNICEF et al., 2013). In absolute terms, the number of child deaths decreased from 12.6 million in 1990 to 6.6 million in 2012. This is however not sufficient to reach the MDG goal by 2015.

Especially in Sub-Saharan Africa, the decline has been very slow over the past decade. In 2000 the difference in child mortality between the regions Sub-Saharan Africa and industrialized countries was 175 in 1000 versus six in 1000 deaths. This shows how uneven child mortality is distributed across the world and the importance of tackling the problem with a special focus on the poorest regions.

Sub-Saharan Africa accounts for almost 50% of all under-five child deaths and even though the overall trend in this region is looking promising, there have been a dozen countries where the absolute number of under-five child deaths has increased between 2000 and 2010 (Bryce, Victora & Black, 2013, UNICEF et al., 2012). 70% of all deaths occur in the first year of children’s life, making it the most critical and important period that policies need to tackle.

The paper proceeds as follows. After reviewing the existing literature on the links between maternal schooling and child health, we introduce our research questions. Thereafter we outline our data and its specifications that need to be taken into account in the statistical analysis. After presenting our estimation strategy, we describe our main findings for the two different models. Before concluding we interpret our results and discuss them at length in the light of existing research, potential future research and limitations.

2. Literature Review

Our literature review aims at giving an elaborate overview of previous research findings regarding the links between maternal schooling and children's health. The conceptual framework by Mosley and Chen (Mosley & Chen, 1984) will serve as guidance throughout this section and will be introduced in the next paragraph. The literature review will conclude by pointing out research gaps that are directly linked to our proposed research questions.

2.1 Theoretical background

The conceptual framework by Mosley and Chen provides a theoretical basis to study the effect of socio-economic determinants, such as maternal schooling, on child mortality. The framework explicitly takes the pathways of socio-economic determinants into account because it is based on the premise that all socio-economic determinants of child mortality affect mortality through more proximate determinants, which affect the risk of disease and the outcome of disease processes. This approach allows the inclusion of both biological causes (proximate) and socio-economic factors (distal causes). The framework argues that inequalities with respect to socio-economic determinants lead to inequalities in proximate determinants and hence to inequalities in child mortality. The authors grouped the proximate factors into five categories: Maternal factors (age, parity, birth interval), environmental contamination (air, food/water/fingers, skin/soil/inanimate objects, insect vectors), nutrient deficiency (calories, protein, micronutrients), injury (accidental, intentional) and personal illness control (personal preventive measures, medical treatment) (Mosley & Chen, 1984).

The view that socio-economic determinants influence child mortality through more proximate or direct determinants of mortality has become generally accepted and the framework of Mosley and Chen (2010) is probably most widely used in the context of child mortality in lower and middle-income countries (LMIC).

Although the framework has shaped the research on child mortality determinants, it is criticized for emphasizing the proximate determinants too much and thus encouraging the focus on individual-level decision-making (Macassa, Hallqvist & Lynch, 2011). The authors state that health inequalities in Sub-Saharan Africa are caused by national and international physical, economic and political conditions – factors that have often been neglected. Thus they propose a new framework that emphasizes relevant distal factors such as political governance, civil war, globalization or gender discrimination as determinants of disparities in child mortality.

Houweling & Kunst developed an adequate representation (Figure I) of the reasons for socio-economic inequality in childhood mortality that is based on the Mosley and Chen framework but also considers more distal factors on the country and global level (2010). The relationships depicted in Figure I work as follows: The level and interrelationship of social and geographic stratification (A) have an effect on the inequality in proximate determinants (B), which in turn affect the inequality in childhood mortality (C). Moreover ill health negatively impacts the socio-economic status (D). Furthermore country and global level determinants (E,F,G,H,I) are assumed to modify the relationships mentioned above. The framework as displayed in Figure I will serve as a theoretical basis for the analysis of this paper and as a structure for the review of empirical findings in the following paragraphs.

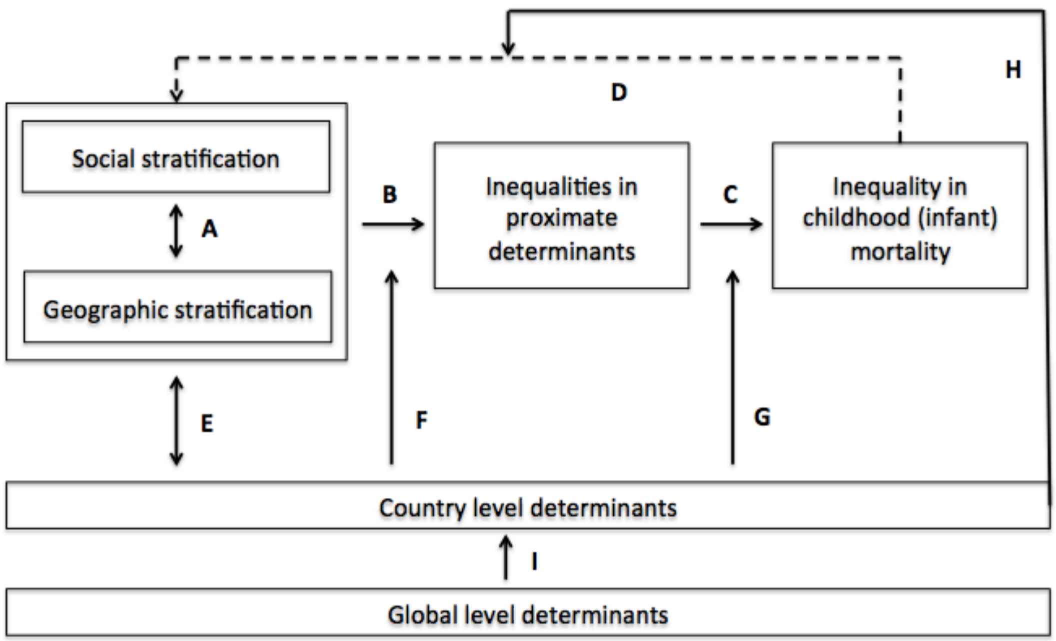

Figure I. Conceptual framework used as a theoretical basis

It shows the relationship between social and geographic stratification and inequality in childhood mortality. Reproduced from "Socio-economic inequalities in childhood mortality in low-and middle-income countries: a review of the international evidence" by Houweling, T. A., & Kunst, A. E. (2010). *British Medical Bulletin*, *93*(1), 7-26.

2.2 Maternal education and child mortality

In the past decades a growing amount of research on socio-economic determinants of health and specifically their effect on child mortality has been published. Maternal education has been identified as an important factor, which influences inequalities in child mortality through several different proximate determinants. The paper will summarize the main research findings on maternal education in this context in the following paragraphs. The framework displayed in Figure I will serve as guidance. Thus this paper first comments on the relationship between social and geographic stratification. Then the five main pathways through which maternal education affects inequalities in child mortality are reviewed. Finally, an evaluation on the current status with regard to the research about country level determinants is given.

Parental education as a socio-economic factor at the individual level has been shown to play an important role. It is important to consider the effect of mothers' and fathers' education separately, since their relationship towards their children differs substantially. Thus their behavior and characteristics affect child mortality through different proximate factors (Mosley & Chen, 1984). In most cases the father is responsible for generating income. This means that the fathers' education mainly affects child mortality through the income effect, implying that higher educated fathers generally have a better paying job and thus more monetary resources to spend on preventive care and health services. Mosley and Chen (1984) argue that skills, time and health of the mother operate directly on proximate determinants – at least to a higher degree than for men – rather than working through the income effect. This is due to the biological link of mothers with their children and the role of the mother within the household. Frost, Forste and Haas (2005) argue that there are at least five pathways that explain the effect of maternal education on child health and thus mortality – improved socio-economic status, health knowledge, modern attitudes towards health care, female autonomy and reproductive behaviors. The empirical evidence is reviewed for each pathway in turn.

2.2.1 Different pathways

Studies indicate that socioeconomic status is the most important pathway of the effect of maternal education on child mortality (Cleland & Van Ginneken, 1988; Desai & Alva, 1998; Bicego & Boerma, 1993). It has been shown that more education is linked to higher consumption of goods and services that impact health care (Cleland & Van Ginneken, 1988; Defo, 1997). Higher maternal education is correlated with higher income through a better job for the woman herself or through the marriage of a more educated husband with a higher paying job (Barrett & Browne, 1996; Cleland & Van Ginneken, 1988). Thus more educated women have more resources on average to spend on amenities such as housing, latrine facilities, piped water and electricity. These features are associated with lower child mortality (Barrett and Browne 1996; Defo, 1997; Martin, Trussell, Salvail & Shah, 1983).

Improved knowledge about health through education improves women's understanding about the causality between diseases and preventive behavior as well as about indices of ill health and available cure (Frost, Forste & Haas, 2005; Caldwell, 1979; Cleland & Van Ginneken, 1988, Defo 1997). Gleewe indicates from a study in Morocco that schooling affects health knowledge only indirectly through the use of literacy and numerical skills gained in school (1999). This is in line with Streatifield, Singarimbun and Diamond who argue that better education leads to an increased understanding of health messages through various sources such as mass media (1990). This understanding can lead to improved choices with regard to nutrition, hygiene and health care decisions, which are all important proximate determinants of child mortality (Defo, 1997; Guerrant, Oriá, R., Moore, Oriá, M. & Lima, 2008). These factors not only influence child health directly, but also through a better health status of the mother because maternal nutritional status is linked to child health through pregnancy for example (Mosley & Chen, 1984). Empirical evidence also emphasizes the importance of hygiene as Curtis and Cairncross showed that washing hands with soap decrease the incidence of diarrhea, a major cause of child deaths (2003). Moreover Curtis, Cairncross and Yonli emphasize the importance of the disposal of fecal material (2000).

Another reason why educated women have healthier children is a different attitude that makes them more likely to use modern medical treatments, use adequate preventive measures and send their kids to a medical center in case of illness (Bicego & Boerma, 1993). It is reasoned that such a behavior is influenced by education because it leads people to being more open minded to new methods and to being more trustful in rational explanations for diseases rather than keeping traditional beliefs (Barrett & Browne, 1996; Caldwell & Caldwell, 1993; Cleland & Van Ginneken, 1988; Defo, 1997). Zeitlin, Ghassemi and Mansour (1990) further find that attitude – being an optimistic and enterprising mother – positively affects child nutrition status.

Caldwell (1990) argues that a higher educational level enables a woman to being the primary decision maker with regard to health issues of her children. Thus, higher maternal education level shifts the responsibility to detect illness from traditional authority figures to the mother, who would identify illness at an earlier stage (Caldwell et al. 1990). Saraswathi (1992) provide empirical evidence that higher maternal education status is associated with a better nutritional status for female infants. Kishor (1995) implies that higher level of female autonomy leads to a lower rate of child mortality and Jejeebhoy (1995) argues that higher education leads to more autonomy leading to lower child mortality.

There is some empirical evidence that education influences reproductive behavior. Cleland and Van Ginneken (1988) found a link between higher educated women and lower fertility, childbearing at low-risk ages and longer birth intervals. This indicates that education leads to a more conscious decision-making when it comes to reproductive activities (Frost, Forste and Haas, 2004). For example Joshi (1994) finds that more educated women make greater use of contraceptive methods. There is empirical evidence that children's health is associated with the age of the mother at birth (Gubhaju, 1986; Martin et al., 1983; Tagoe-Darko, 1995). Forste (1998) finds that higher maternal age is associated with the child being less healthy in Bolivia whereas Sommerfelt and Stewart (1994) could not identify this relationship. Rustein (2005) comes to the conclusion that child survival decreases as birth intervals decrease and that lower birth intervals are associated with chronic and general under-nutrition. The association between birth intervals of less than two years and childhood mortality has also been reported (Sullivan et al., 1994; Tagoe-Darko, 1995; Curtis and Steele, 1996; Gubhaju, 1986).

Houweling and Kunz (2010) state that socio-economic differences with regard to child mortality can also be caused by a reversed effect of ill health on economic status. Due to out-of pocket expenditures for health services or lower wages due to less productivity at work, households might have to sell assets or decrease the expenditure on other things that affect health. The authors point out that this reversed effect can only partly explain socio-economic inequalities of child mortality because it cannot explain differences by education or ethnicity.

2.2.2 Country level determinants

According to the underlying framework in Figure I above, country level determinants affect inequalities in child mortality through four pathways. First, they influence the social stratification in a country and its relationship with geographic stratification. Moreover it alters the effect of social stratification on the inequality in proximate factors and the effect of the inequality in proximate factors on the inequality in child mortality. Last, it affects the reversed relationship of ill health and socio-economic status. Houweling und Kunst (2010) state that there is a lack of evidence with regard to country level determinants on child mortality disparities. This lack can mainly be attributed to the methodological difficulties with such research or the focus on more proximate factors encouraged by the Mosley and Chen framework (Macassa, Hallqvist and Lynch, 2011).

The literature research along this study could also not identify studies that shed light on country level determinants of socio economic inequalities with regard to child mortality. Moreover, frameworks or theories that would try to explain this linkage could not be found. Houweling und Kunst (2010) mention some possible pathways, which are summarized in the following. First, according to the authors social stratification is influenced by the government through, among others, taxation, social protection and education policies. For example, taxation can be flat or progressive, countries have different levels of social protection and thus income distribution and education policies have an effect on the quality in different regions or absenteeism of pupils. There may also be a reverse causality. Second, variables at the country level affect the relationship between social stratification and inequality in proximate determinants through for example the health care financing arrangements, incorporating the access of different socio-economic groups. Third, the relationship between inequalities in proximate factors and child mortality inequalities may be dependent on the quality of health care. Finally, the reversed effect of ill health on social status is influenced by public policies. An example is the reliance on out of pocket expenditures by the health system.

There have been some cross-country studies that analyzed the relationship between social, economic and political aspects at the country or global level and child mortality (Shandra, Nobles, London & Williamson, 2004). It is important to note that their results do not give an indication of how country level determinants alter the effect of maternal schooling on child mortality. The authors performed a cross-national analysis with 59 developing countries. The study reveals that child mortality is negatively correlated with the intra national variables economic development, the level of gross secondary school enrollment and female secondary school enrollment. The levels of political democracy and health expenditures do not have a significant effect. With regard to 'international variables' the authors find that a higher level of foreign direct investment is associated with a higher level of child mortality. This is in line with dependency arguments (Gereffi, 1989; Wallerstein, 1974) and previous research, indicating that trade dependency is positively correlated with child mortality.

Although the level of democracy is not significant on its own, it seems to affect child mortality by influencing the relationship between measures of dependency - such as commodity concentration, multinational corporate concentration and International Monetary Fund conditionality – and the level of child mortality. The positive relationship between measures of dependency and child mortality seems to be higher at lower levels of political democracy.

2.3 Research Gap

The previous paragraphs demonstrate that there exist many research results with regard to the link of maternal education on child and infant health. Nevertheless most research findings are country specific and differ with regard to their focus, for example the pathway being studied. Hence the outcome is a map with research results that are spread across countries and spread across topics. Putting all results together leads to a broad picture of the effect of maternal education on child health. Due to the lack of research results for all countries, policy makers have to draw conclusions from country-specific research results, although the external validity can be questioned since countries differ with regard to culture, political system, institutions, climate or conflicts. But referring to the theoretical framework by Houweling and Kunst (2010), country level determinants are likely to change the relationships between socio-economic factors and child health. Knowing the impact of country level determinants would have important implications for policy makers since resources could be directed more efficiently to those measures that promise the highest impact given country characteristics. Moreover these characteristics could also be altered in order to enhance the effect of certain policies that are supposed to lower child mortality. For example, by improving a country's education system, the positive effect of maternal schooling on child mortality is likely more pronounced.

Although the understanding of country level determinants seems to be important, research is merely non-existent due to methodological difficulties in finding causal relationships. A first step to increase the interest in this field would be the demonstration that the effect of socioeconomic determinants on child health varies across different settings. This can be the case both between countries but also within countries if certain characteristics have changed over time. If statistically significant and economically relevant variations were found, the awareness of the importance of country level determinants would be increased. The challenge to explain these variations would still remain.

3. Research Questions

As discussed in the previous section, it is important to include country level determinants into the discussion of socio-economic determinants and their effect on child health. This paper illustrates that these determinants are relevant by showing that the effect of the socioeconomic determinant maternal schooling on child mortality differs between settings. As mentioned before, settings can differ with regard to culture, the political system, institutions or climate among many others. These differences can occur between countries but also within countries over time. Therefore the goal of this paper translates into the following two research questions.

1) *Does the effect of maternal schooling on infant mortality differ between countries in Sub-Saharan Africa?*

2) *Does the effect of maternal schooling on infant mortality change over time within countries in Sub-Saharan Africa?*

We believe that the effect of maternal schooling on child health differs between countries and that the effect changes over time within countries as different country characteristics develop. Differences can stem from both the overall magnitude of the effect of maternal schooling on infant mortality, but also from differences in the relative importance of different pathways. This paper focuses on the former one and tries to estimate the difference in the overall effect of maternal schooling. If our assumptions are proven correct, we hope to have built a bridge from country-specific research to research about country and global level determinants. Both research areas should complement each other in order to optimize policy recommendations. The answer of the causes for these differences is outside of the scope of the paper at hand. Nevertheless the discussion section will shortly comment on potential linkages.

4. Estimation Strategy

In order to answer the research questions we needed data about complete maternal histories, schooling of mothers and their socio-economic background. We decided to take cross-sectional data of household surveys as a basis for a quantitative research approach. For the purpose of this study, we needed data for many different developing countries in order to carry out a cross-country analysis. The most appropriate data source are the Demographic and Health Surveys (DHS) by the United States Agency for International Development (USAID), both available for various countries in sub-Saharan Africa and also available for different time periods, called waves.

This section will first introduce the DHS surveys by focusing on their suitability for the analysis at hand, their reliability and their survey design. Moreover an overview of the used datasets is given. Afterwards, the data processing with special attention to survey specific modifications and our estimation strategy are outlined.

4.1 Demographic and Health Surveys

Data from the DHS is superior compared to other household surveys since it is available for more countries, provides many details and is also used by the World Health Organization to calculate official child mortality rates (UNICEF, WHO, World Bank & UNPD, 2007). Moreover the variables in the DHS fit well to our research strategy.

4.1.1 Complete maternity histories

Hill (1991) wrote a popular paper on the different approaches with respect to the measurement of child mortality and reviewed different types of data collection systems. The most accurate system is a vital registration of all newborns but these systems are hardly in place in developing countries and thus only few numbers of children are captured by vital registration in our countries of interest. According to Hill (1991), the next best system is the system of complete maternity histories, where both the date of birth and date of death, if applicable, are registered. DHS data provides such complete maternity histories and is therefore a very good base for calculating child mortalities as well as infant mortalities.

However this system poses some potential problems and biases. A critical bias is the “tendency […] to round ages at death of children to exact numbers or convenient fractions of years” (Hill, 1991). This means many deaths accumulate at age of death at 12 or 18 months, thereby underestimating for example infant mortality rates because infant mortality covers only dead children between 0 and 11 months. One other potential bias is the fact that dead mothers and their children are not included in the DHS data, since only living mothers were interviewed. This means we cannot capture the true effect of maternal characteristics on child health, which might be especially problematic in countries that have high rates of HIV.

4.1.2 Sample and data exploitation

First, we want to focus on infant mortality as opposed to under-five or neonatal mortality. We base this decision on the trade-off between two factors, i.e. capturing a high share of child deaths and the inclusion of relatively recent birth cohorts. Taking under-five mortality ensures a higher capturing of deaths but excludes the most recent data since children born within five years before the interview date have to be taken out of the sample. Taking infant mortality means that more recent data can be used as only children born within the last 12 months need to be excluded and since 70% of all child deaths occur within the first year, we would still provide a suitable database. Another option would have been to take neonatal mortality as dependent variable. This would have allowed us to use even more recent cohorts but would have lowered the deaths captured in our regressions to about 40%.

There have been six rounds of data collection with DHS, starting in 1984, with one round normally taking five years, overlapping partly with the previous period. The basic questionnaires stay constant between the different rounds to ensure compatibility for many important indicators. The objectives of the DHS are mainly to provide decision makers in participating countries the necessary information and tools to deliver the right policies and transfer the skills to conduct these types of survey to local authorities. Until now, about 260 surveys have been carried out in over 90 countries. For our analysis, we use a wide range of available datasets for all countries of interests. This means we draw data from DHS rounds II through VI, ranging from 1996 to 2012.

Table I lists the 46 datasets from 28 different countries that are included in our analysis. Moreover Table I gives an overview of each dataset including samples taken, number of clusters and number of strata. In order to test our first research question that the effect of maternal schooling on child health varies across countries, we use the newest available dataset of each country. Column '*wave 2*' in Table I indicates which datasets are used for the analysis of this effect. The surveys were conducted between 2006 (Benin and Mali) and 2012 (Gabon, Guinea and Niger) and each entry refers to a child of an interviewed mother in the survey. We restrict the sample to only those children that were born between twelve months and five years before the exact date of the interview. Since we are analyzing infant mortality, all children born within the 12 months before the survey are excluded from the sample. This ensures that all children have lived at least one year at the date of the survey and thus were fully at "risk" of dying within their first year. The upper boundary for calculating infant mortality is set at five years in order to avoid too much variation in country-specific settings. Sample size is lowest in Swaziland with 2,205 entries and highest in Nigeria with 22,468 entries.

Table I   Data overview

Country	Year	Delta years	Wave 1	Wave 2	Sample size	# Clusters	# Strata
Benin	1996		x		4 066	200	12
Benin	2006	10		x	12 604	750	23
Burkina Faso	2010	-		x	11 990	273	26
Burundi	2010	-		x	6 238	376	33
Cameroon	1998		x		3 118	203	3
Cameroon	2011	13		x	9 261	578	24
Congo	2011	-		x	7 299	384	15
Cote D'Ivoire	1999		x		1 583	140	3
Cote D'Ivoire	2011/12	12-13		x	6 071	351	21
Ethiopia	2000		x		8 779	539	21
Ethiopia	2011	11		x	9 264	596	23
Gabon	2000		x		3 475	249	9
Gabon	2012	12		x	4 690	334	20
Ghana	1998		x		2 637	400	20
Ghana	2008	10		x	2 316	408	20
Guinea	1999		x		5 532	293	9
Guinea	2012	13		x	5 532	300	15
Kenya	1998		x		4 500	530	19
Kenya	2008/09	10-11		x	4 731	398	15
Lesotho	2009	-		x	3 103	399	20
Liberia	2007	-		x	4 580	298	11
Madagascar	1997		x		4 862	269	13
Madagascar	2008/09	11-12		x	9 869	594	43
Malawi	2000		x		9 256	559	24
Malawi	2010	10		x	15 985	849	54
Mali	1996		x		8 073	300	13
Mali	2006	10		x	11 279	407	17
Mozambique	2011	-		x	8 725	610	21
Namibia	2006/07	-		x	4 041	495	26
Niger	1998		x		6 311	268	11
Niger	2012	14		x	9 913	476	8
Nigeria	2008	-		x	22 468	886	37
Rwanda	2000		x		6 110	443	13
Rwanda	2010	10		x	7 414	492	30
Senegal	1997		x		5 864	320	8
Senegal	2010/11	13-14		x	9 721	391	28
Sierra Leone	2008	-		x	4 244	352	32
Swaziland	2006/07	-		x	2 205	274	8
Tanzania	1999		x		2 539	176	5
Tanzania	2010	11		x	6 363	475	8
Uganda	2000		x		5 640	297	8
Uganda	2011	11		x	6 216	404	19
Zambia	1996		x		5 785	312	18
Zambia	2007	11		x	5 051	319	18
Zimbabwe	1999		x		2 928	230	18
Zimbabwe	2010/11	11-12		x	4 172	406	18

Notes: Overview of DHS datasets used, including year of survey, wave identifiers, sample size, number of clusters and number of strata.

Column '*wave 1*' displays the additional datasets of 18 countries that were used in order to estimate possible changes over time of the effect of maternal schooling on infant mortality. For those 18 countries, we thus had two different datasets at two points in time. These datasets in '*wave 1'* range from 1996 (Benin, Mali and Zambia) to 2000 (Ethiopia, Gabon, Malawi, Rwanda and Uganda) and were chosen on the basis of several criteria. First, the number of regions often varied between older and newer datasets. In order to use and pool the datasets, the information in the respective DHS final country reports needed to be sufficient in order to correctly align the number of regions for both waves in each country. Second, we tried to keep the variation of the time difference between the two waves in each country at a minimum. The smallest difference between two surveys is ten years and the largest difference is fourteen years (column '*delta years'*). Furthermore, the number of clusters and strata is displayed in the table. Both are part of the complex survey design of the DHS datasets and will be explained in section 4.2.

Table II shows an overview of the infant mortality rates calculated based on the DHS data for all datasets. It shows that the highest rates were found in Niger 1998 with 123 per 1000 deaths and the lowest rates in Gabon 2012 with 43 per 1000 deaths. Comparing within country changes, it can be observed that in Madagascar, Rwanda and Tanzania infant mortality decreased by at least 50%. Reductions in infant mortality rates are observed across the whole sample, with some countries experiencing higher reductions than others. Furthermore, summary statistics of maternal schooling are displayed including both the average over the whole dataset as well as a split by total years of schooling in five different groups. In each country, the data corresponds to the year of the survey. It can be seen that the average years of maternal schooling greatly varies across the countries, as well as the composition of the different groups. For a better visualization, Figure II shows all countries in the sample with their respective average of maternal schooling, colored in four different shades to represent averages of 0-2 years, 2-4 years, 4-6 years and more than 6 years.

Table II Summary statistics

Country	Year	Infant Mortality (per 1,000 births)	Mean years of maternal schooling	Total years of maternal schooling				
				0	1-4	5-7	8-10	11+
Benin	1996	94	0.95	80%	10%	6%	3%	1%
Benin	2006	67	1.34	76%	11%	8%	4%	2%
Burkina Faso	2010	65	0.96	85%	5%	7%	3%	1%
Burundi	2010	59	2.44	54%	18%	24%	2%	3%
Cameroon	1998	77	4.34	37%	13%	28%	14%	8%
Cameroon	2011	62	4.93	29%	13%	32%	16%	9%
Congo	2011	66	7.11	8%	13%	32%	34%	14%
Cote D'Ivoire	1999	112	2.03	65%	10%	18%	5%	1%
Cote D'Ivoire	2012	68	2.20	64%	12%	15%	5%	3%
Ethiopia	2000	97	0.82	83%	10%	5%	2%	1%
Ethiopia	2011	59	1.32	72%	17%	6%	3%	2%
Gabon	2000	57	6.43	8%	15%	43%	25%	10%
Gabon	2012	43	7.70	7%	9%	33%	33%	18%
Ghana	1998	57	4.77	39%	12%	15%	29%	6%
Ghana	2008	50	5.54	33%	11%	18%	28%	9%
Guinea	1999	98	0.98	87%	4%	5%	2%	2%
Guinea	2012	67	1.43	79%	6%	7%	4%	4%
Kenya	1998	74	6.71	12%	11%	35%	24%	18%
Kenya	2009	52	7.19	11%	8%	29%	36%	17%
Lesotho	2009	91	7.55	2%	7%	51%	28%	12%
Liberia	2007	71	2.98	51%	20%	17%	7%	5%
Madagascar	1997	96	3.39	27%	47%	13%	10%	3%
Madagascar	2008/09	48	3.24	27%	48%	13%	8%	4%
Malawi	2000	104	3.36	34%	30%	23%	10%	3%
Malawi	2010	66	4.72	19%	30%	28%	17%	6%
Mali	1996	122	0.74	85%	7%	5%	3%	0%
Mali	2006	96	0.93	86%	6%	5%	2%	1%
Mozambique	2011	64	3.03	38%	31%	20%	8%	3%
Namibia	2006/07	46	7.56	11%	11%	17%	38%	22%
Niger	1998	123	0.68	89%	3%	7%	2%	1%
Niger	2006	51	1.18	83%	5%	7%	3%	2%
Nigeria	2008	75	4.65	47%	5%	20%	8%	20%
Rwanda	2000	107	3.70	35%	23%	25%	14%	3%
Rwanda	2010	50	3.80	22%	38%	30%	8%	3%
Senegal	1997	68	1.42	78%	6%	11%	3%	2%
Senegal	2010/11	47	1.71	72%	7%	15%	4%	3%
Sierra Leone	2008	89	1.58	78%	6%	8%	5%	3%
Swaziland	2006/07	85	7.82	10%	9%	26%	33%	22%
Tanzania	1999	99	4.72	27%	10%	59%	1%	2%
Tanzania	2010	51	4.93	26%	10%	57%	4%	3%
Uganda	2000	88	3.83	26%	32%	31%	7%	4%
Uganda	2011	54	5.12	16%	28%	36%	11%	9%
Zambia	1996	109	5.38	16%	22%	42%	16%	5%
Zambia	2007	70	5.41	14%	24%	40%	16%	6%
Zimbabwe	1999	65	7.53	8%	9%	37%	21%	25%
Zimbabwe	2010/11	57	8.80	2%	4%	29%	27%	38%

Notes: Summary of DHS data per country, including infant mortality per 1000 deaths, mean years of maternal schooling and total years of maternal schooling in five different groups.

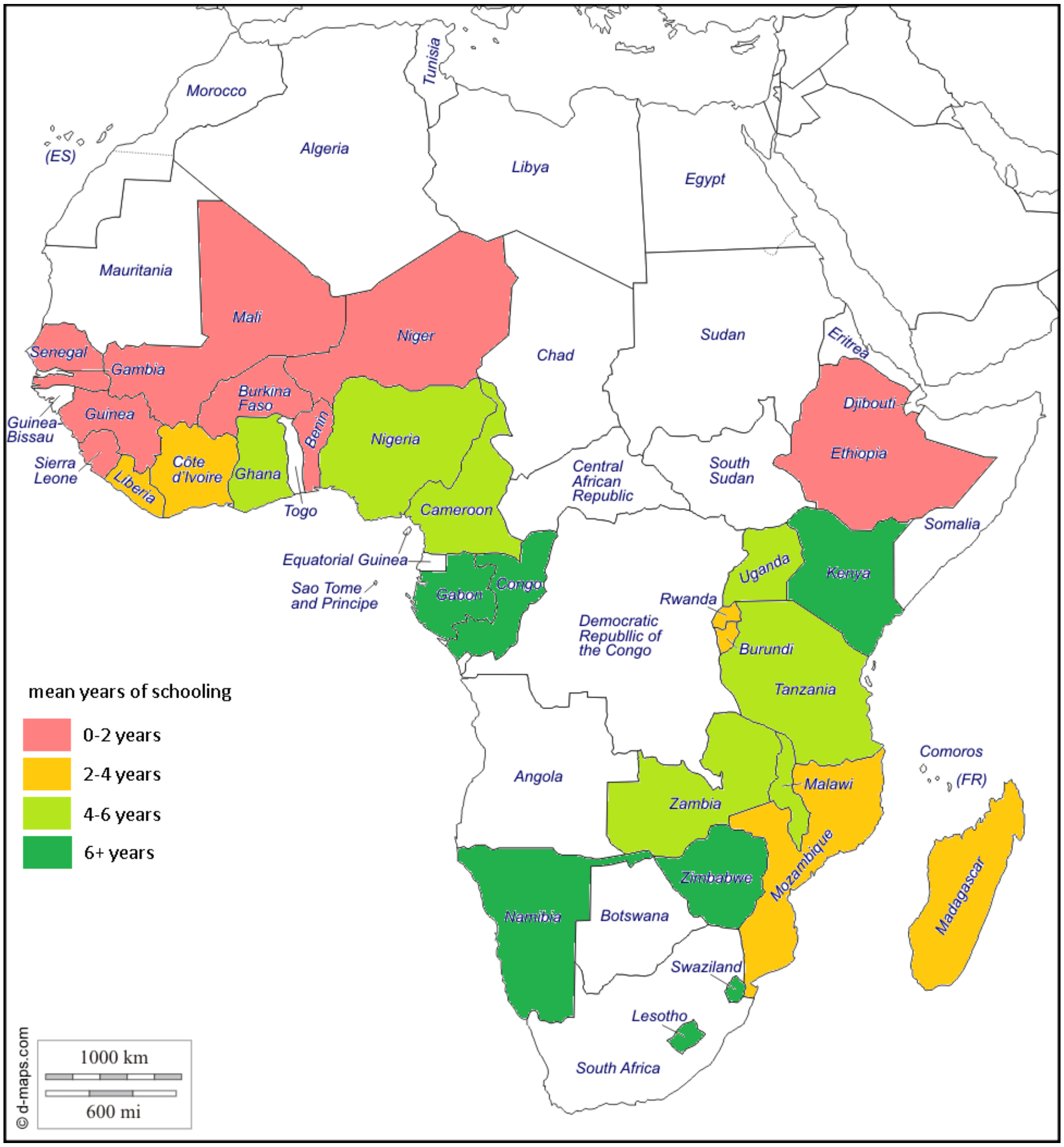

Figure II. Country overview and mean years of maternal schooling

This map shows all countries that we use for our analysis. They are shaded in different colors according to their mean years of maternal schooling.

4.2 Dealing with survey data

The general approach by which data is collected is a simple random sampling. This is however not very efficient when carrying out surveys since researchers normally want to ensure that specific groups or regions of the population are represented in the sample. Furthermore it can be both financially and statistically disadvantageous to employ a simple random sampling design for survey data. There are three distinct features that make survey data and survey data estimations special, namely weighting, clustering and stratification (Kreuter & Valliant, 2007). Thus, special attention needs to be paid to those features in order to achieve a high precision level for all estimations carried out.

Weighting

Weighting for survey data is done to be able to mirror survey estimates back to the whole population. Sample weights, or probability weights, can differ for different subgroups of the population, e.g. over gender or region. Within DHS sample weights correct for unit non-response biases and are calculated at the stratum level (a certain region) by taking the ratio of the population total of that specific group in the country and the number of individuals actually interviewed from that specific group. This ratio is the inverse of the selection probability, the probability of being included according to the sample design (Kreuter et al., 2007). The three reasons to use weights for analyses on DHS data are as follows (DHS Sampling Manual, 2012):

1. Ensure that statistical inference is valid
2. Decrease potential biases from non-response or other non-sampling errors
3. Ensure that the distribution of the sample stays similar to that of the whole population, especially critically in the instance of oversampling of some subgroups

Stratification

All the DHS data is stratified, meaning that the total survey population is split up into a number of strata (subgroups) based on certain criteria to make them as homogeneous as possible (DHS Sampling Manual, 2012). In every stratum, the sample is set up and chosen independently of the other strata. This means for "different samples […] drawn in replications of the survey, the strata will be held fixed while the particular households selected from each will vary from sample to sample" (Deaton, 1997). Using stratification has the main objectives of reducing the sample errors. This can be achieved because the sampling errors only depend on the population variance within each stratum and not across the different strata. It is important to note that stratification should be done at the first stage of a sample design where the stratification itself can either be single-level or multi-level. DHS survey are generally stratified with a multi-level approach, which means that the population is being divided by two characteristics, e.g. by region and then by an urban/rural identifier (Rutstein & Rojas, 2006).

Clustering

The first units that are being sampled in surveys are called primary sampling units (PSUs). Instead of sampling individuals as PSUs within each stratum, a technique called clustering is used for the DHS surveys, where the clusters act as the PSUs. Clusters are connected groups of households, mostly geographically located close to each other, that are used to increase the overall efficiency of the survey, mainly in financial terms, as travel costs are greatly reduced. Clusters used for DHS surveys are mostly employed with two-stage designs (DHS Sampling Manual, 2012).

For the two-stage sampling, the first stage involves selecting a certain number of stratified clusters according to probability proportional to size. Clusters need to be analyzed accurately and have to be up to date before they are used to ensure that the whole survey area is covered without any overlap or omission (DHS Sampling Manual, 2012). In the second stage of sampling a selection of households within each cluster is drawn from a complete list of all households in the given area. In general, all women aged 15-49 are eligible to fill out the DHS surveys.

This multi-level stratification and multi-stage clustering create a complex survey design, demanding cautious and precise treatment within Stata, especially since countries can differ from each other with regards to their design. If using the incorrect specifications, the point estimates and standard errors will likely be incorrectly estimated and thus it is important to follow the DHS documentations and apply the correct survey settings for the different countries. Survey settings include identification and application of stratification variable, cluster identification and survey weights. They are listed in Appendix A.

4.3 Preparation of datasets

In order to test our second research question we needed to pool datasets from two waves for a particular country to be able to measure whether the effect of maternal schooling on infant mortality changes over time. In the case of the DHS, the standard questions remain the same across several waves, thus making it convenient to compare changes over time. There are certain characteristics that change from round to round and from survey to survey, which have to be adapted in order to pool the two rounds. These characteristics include the number of different regions employed in each survey wave, the stratification variable and the survey weights. For these alignments to be properly executed, the final reports of the respective DHS rounds had to be used to identify the correct specifications. A detailed description of the pooling procedure is described in Appendix A.

For both the pooled as well as the normal datasets we restricted the sample to include only children born within the previous five years of the interview. This ensures that we are using the most recent data. This is a common practice carried out by many other researchers.

In our case it makes the results more accurate. If we were including all children, we would have a dataset covering more than 10 – 15 years. In such a long time span, political systems of a country or other economic and social factors could have changed and affected the health of children or maternal schooling.

4.4 Variables and models

In order to analyze the difference of the effect of maternal schooling on infant mortality between countries and within countries over time, we established two multivariate regression models. We will refer to 'Model I' as the model that we used to test our first research question and to 'Model II' for our second research question. We ran the respective models for all relevant countries. This means we performed 28 regressions for Model I and 18 regressions for Model II.

The previous section discussed the design of DHS datasets. By using DHS data, Madise, Stephenson, Holmes and Matthews (2007) demonstrated that conclusions drawn from regressions that do not take into account complex survey designs and hierarchical structure of surveys, could lead to misleading results. In particular we encountered three elements that may affect our regression results - weights, stratification and clustering. Weights are important due to the sample selection procedure. In the multistage survey design of the DHS surveys some domains such as urban regions are often oversampled, leading to unequal probabilities of selection into the sample. Hence treating the data as if it were collected using simple random sampling could lead to wrong conclusions.

Not considering the stratification or clustering of our data would affect the standard errors, resulting in false conclusions regarding the significance of estimated coefficients. According to Madise et al. (2007), taking into account the stratification leads to smaller standard errors and thus higher precision if the observations within the different strata are similar. Ignoring clustering can also have an effect on the standard errors, as individuals within a certain cluster might be similar to each other. Not accounting for this would violate the independence assumption and lead to standard errors that are too small. The Kreuter and Valliant (2007) states that using software packages that directly estimates standard errors that account for complex survey design is superior to other methods. Thus in order to get robust results we used the survey data commands in Stata that takes the survey design into account to estimate our linear regressions.

In order to show that taking the design of the survey into account is necessary, we also performed basic OLS regressions for a comparison of the resulting coefficients. In addition we calculated design effects and misspecification effects of the survey regressions to further demonstrate the usefulness of taking the survey design into account.

The dependent variable of both Models I and II is a dichotomous variable whether a child has died before the age of one or not. The variable takes the value zero if the child was either still alive at the date of the interview or died after its first year of life. It takes the value one if the child died within the first year. Note that only children that were born between one and five years before the exact survey date were taken into account.

The independent variable of interest in Model I is *maternal schooling*. The DHS data provides different measures of maternal schooling, including the total years of schooling, the highest degree attained and whether a person has started a degree, but dropped out. Since the number of years to finish primary, secondary or tertiary education varies between countries, we used the total years of schooling as our measure of maternal schooling to ensure a high degree of comparability between the different datasets. The variable total years of schooling is coded in equal steps, 0 meaning no schooling, 1 meaning one year of schooling and so forth. We expect the coefficient of the variable *maternal schooling* to be negative, as additional years of schooling for the mother tend to lower the probability of infant mortality.

In order to analyze the effect of maternal schooling over time for our second research question, two additional variables were added to Model II compared to Model I. First, the dummy variable '*wave*' was added. It is equal to one if the sample unit is drawn from the newer dataset and zero if it is drawn from the older dataset. We expect that the variable wave will have a negative sign, indicating that the rate of infant mortality has decreased throughout the last decades in most countries. Furthermore, Model II contains an interaction term of *wave* and *maternal schooling*. Through this, we are able to see whether the marginal effect of an additional year of schooling on child mortality differs between the earlier and the later wave in each country. Thus, the interaction term is our variable of interest in Model II to answer our second research question.

The selection of control variables for both Model I and Model II had to be done very carefully. Since our goal was to get an indication of the effect of maternal schooling on infant mortality, any variable that is a pathway of the effect of interest should not be included in the model. If pathway variables such as household wealth or husbands' profession were included in the model, part of the effect of maternal schooling would have been captured by these control variables.

Therefore we decided to leave our model rather simple and just control for maternal age as well as for unobserved regional fixed effects. We include age to control for the quality of schooling and a mothers life experience. Since mothers experience schooling at different points in time, the quality of their education might also vary. Hence the same number of schooling of an old and a young mother might not be comparable. Maternal age is measured in years. Furthermore we controlled for regional fixed effects by separating each region into rural and urban and then adding them as dummy variables to the regression. It is crucial to control for regional differences to prevent our model from omitted variable bias. Regional effects might affect maternal education through for example variations in access to school. Additionally regional effects might affect infant mortality directly through infrastructure at the community level or through provided health services. Furthermore, one has to be aware that the place of residence is not exogenous but underlies migration selectivity. This could likely lead to an endogeneity bias and an underestimation of the effect of maternal schooling on infant mortality. Table III gives an overview of the variables used in our regressions.

Table III Variable overview

Variable label	Variable name	Explanation
Infant mortality rate	*InfantMortality*	Dichotomous variable that takes the value 0 if the child is either still alive, or died after its first year. It takes the value 1 if the child died within the first year.
Maternal schooling	*schooling*	Total number of years of schooling for mothers measured in completed years.
Maternal age	*age*	Age of the mother in years at the time of the interview.
DHS round identifier	*wave*	Dichotomous variable that takes the value one if the sample unit is drawn from the newer dataset and zero when it is drawn from the older dataset.
Interaction term between schooling and wave	*schooling_wave*	Maternal schooling multiplied with the wave identifier.
Regional dummies	*(not shown in regression outputs)*	Dummies created from the interaction terms between the regional variable and the rural-urban identifier.

Notes: Summary of the variables used in the regressions, including variable label, the actual name plus a detailed explanation.

4.4.1 Model for between country variations

The regression to test our first research question whether the effect of maternal schooling on infant mortality differs between countries has the following specification

$$InfantMortality_j = \beta_0 + \beta_1 * schooling_j + \beta_2 * age_j + \boldsymbol{R_j} + u_j,$$

where

- j denotes country with $j = 1, \dots, 28$
- β_0 is the intercept,
- R_j denotes a vector for regional dummy variables
- n denotes regions
- $\beta_0 - \beta_2$ are the coefficients of the independent variables and
- u_j is the error term.

The null and alternative hypotheses that we tested are stated as follows:

$$H_0\colon\ \beta_{1,1} = \beta_{2,1} = \cdots = \beta_{28,1}$$
$$H_A\colon\ \beta_{1,1} \neq \beta_{2,1} \neq \cdots \neq \beta_{28,1}$$

In order to test whether the coefficients for schooling differ significantly between countries, we performed a seemingly unrelated regression (SUR) model. This method is normally used for systems of equations and leads to more precise estimators by employing sample information from other regressions, for example when the error terms of the different regressions are correlated (Zellner, 1962). Since we use the same independent variables in all country regressions, the estimated coefficients will not differ between the survey regression technique and the generalized least square estimators employed by the SUR model. By using a SUR model we can account for the survey design[1] and are able to test whether the coefficients of maternal schooling are significantly different from each other by using a wald test. We will reject the null hypothesis if the resulting F-statistics corresponds to a p-value smaller or equal to 0.10. For this hypothesis, we will only use on the newest datasets for each country (refer to Table I).

4.4.2 Model for over time within country variations

In order to test the second research question that the effect of maternal schooling on child mortality varies over time within countries we performed the following regression for each of the 14 countries.

$$(2) \quad InfantMortality_j = \beta_0 + \beta_1 * schooling_j + \beta_2 * wave_j + \beta_3 * (schooling * wave)_j + \beta_4 * age_j + \boldsymbol{R_j} + u_j$$

where

---

[1] For this, we are using the -suest- post-estimation command in Stata, which is compatible with survey data commands.

[2] It should be noted that the model presented in the previous section is not comparable in terms of magnitude to the model in this section. This is due to the special pooling procedure. For each country we aligned the two waves that were used and aligned them in terms of regions. Thus, the regressions used are not the same anymore

- j denotes country with $j = 1, \dots, 18$
- β_0 is the intercept,
- R_j denotes a vector for regional dummy variables (interaction term if regions and rural-urban identifier)
- β_i $(\mathrm{i} = 1, 2, \dots, 4)$ are the coefficients of the independent variables and
- u_j is the error term.

The null and alternative hypotheses that will be tested are stated as follows:

$$H_0\colon\ \beta_{j,3} = 0$$

$$H_A\colon\ \beta_{j,3} \neq 0$$

We expect the marginal effect of additional years of schooling to change over time, thus the alternative hypothesis states that β_3 is unequal to zero. We tested this hypothesis by means of a t-test. For this model, we use both old and new datasets for a selection of 18 countries (refer to Table I).

4.4.3 Underlying assumptions

The regression analysis is based on several assumptions that must hold in order to get estimators that are unbiased for the population parameters. The following paragraphs discuss assumptions that could be partially violated in our models, which are the zero conditional mean assumption, the selection bias and measurement errors.

The zero conditional mean assumption states that the error term, containing unobserved factors, has an expected value of zero for all values of the independent variables. If this assumption holds, the independent variables can be described as exogenous and the estimators are unbiased for the population parameters. On the other hand, if a factor is omitted that is both a determinant of the dependent variable and also correlated with one or more independent variables, our estimators will be biased. The estimated model will not be entirely free from omitted variable bias. We believe that our point estimate of maternal education could be slightly overestimated due to omitting the household wealth of the mothers' parents. Their household wealth is likely to be positively correlated with maternal education but also with infant mortality due to the potential provision of financial resources. Hence, parts of the correlation between maternal schooling and infant mortality result from the wealth of the parent's households. Since the DHS dataset did not provide any information about the mothers' parents, we were not able to test for that.

A selection bias that we encountered is the omission of dead mothers and their, potentially alive, children. One can assume that children of dead mothers have a below average health status given a certain level of maternal schooling. This would imply that our model underestimates the effect of maternal schooling on infant mortality.

A measurement error of the dependent variable is an additional source for a potential bias of our estimators. However as long as a measurement error with a mean unequal to zero is not correlated with the independent variables, only the intercept will be changed. But when there exists a correlation between the error term and the independent variables, the estimators will be biased. As mentioned earlier, some survey participants round the age at death of their children to convenient fractions of months or years. The important question that remains is whether people with certain characteristics are more likely to round this number than others. By looking at the datasets we did not identify a tendency that less educated mothers, mothers in a lower wealth percentile or mothers living in a rural area round more or less often. Hence, we conclude that the measurement error at hand is not a source of bias for our estimators.

5. Results

This section presents the test results for both the first research question, whether the effect of maternal schooling on infant mortality differs between countries, and the second research question, whether the effect of maternal schooling changes over time within countries.

5.1 Between country variations

Does the effect of maternal schooling on infant mortality differ between countries?

We find that the effect of maternal schooling on infant mortality varies strongly between countries with regard to magnitude and significance. The variation of the point estimates and their confidence intervals can be seen in Figure III on the next page. First of all we note that most point estimates are negative, which indicates that maternal schooling decrease the probability that a child dies within the first year. Further we see that the top four countries from Kenya to Ethiopia have point estimates between -0.004 and -0.003 and are three to four times as large as the point estimates of the bottom eleven countries (Cameroon to Ghana). A point estimate of -0.001 implies that maternal schooling decreases the probability of infant mortality by 0.1 percentage points. This means that, ceteris paribus, about three additional years of maternal schooling in Kenya, Burundi or Ethiopia (Lesotho has an insignificant coefficient) result in the reduction of the probability of infant mortality by one percentage point, thus the survival of one additional child out of one hundred.

In order to answer the question whether the coefficients of maternal schooling differ statistically between the countries, we performed seemingly unrelated regressions followed by a Wald test. The test yields a F-statistic of 1.52 and an associated p-value of 0.041 (Appendix B). Hence we reject the null hypothesis and conclude that the impact of maternal schooling on child mortality does indeed differ between the 28 countries in our sample.

We present an overview of all regression outputs in Table IV. For 12 out of 28 countries, maternal schooling has a coefficient, which is statistically significant at the ten percent level. Among these, the highest marginal effect of an additional year of schooling can be observed in Kenya. There, an additional year of maternal schooling is estimated to lower infant mortality by 0.37 percentage points. The lowest significant marginal effect can be found in Benin with a 0.1 percentage point reduction. The coefficients of the 12 countries with significant coefficients are also a lot larger in magnitude compared to the rest of the sample. For these other countries, many of the coefficients are also economically insignificant with coefficients below -0.001. However, a few of those countries such as Lesotho (-0.32 percentage points) and Zambia (-0.23 percentage points) have a rather large magnitude and are thus economically significant. Furthermore the effect of maternal schooling on child mortality is estimated to be -0.0013 and significant for the regression including all countries. This means that one additional year of maternal schooling lowers the probability of infant mortality by 0.13 percentage points. This coefficient serves as a general benchmark for the results of the country regressions.

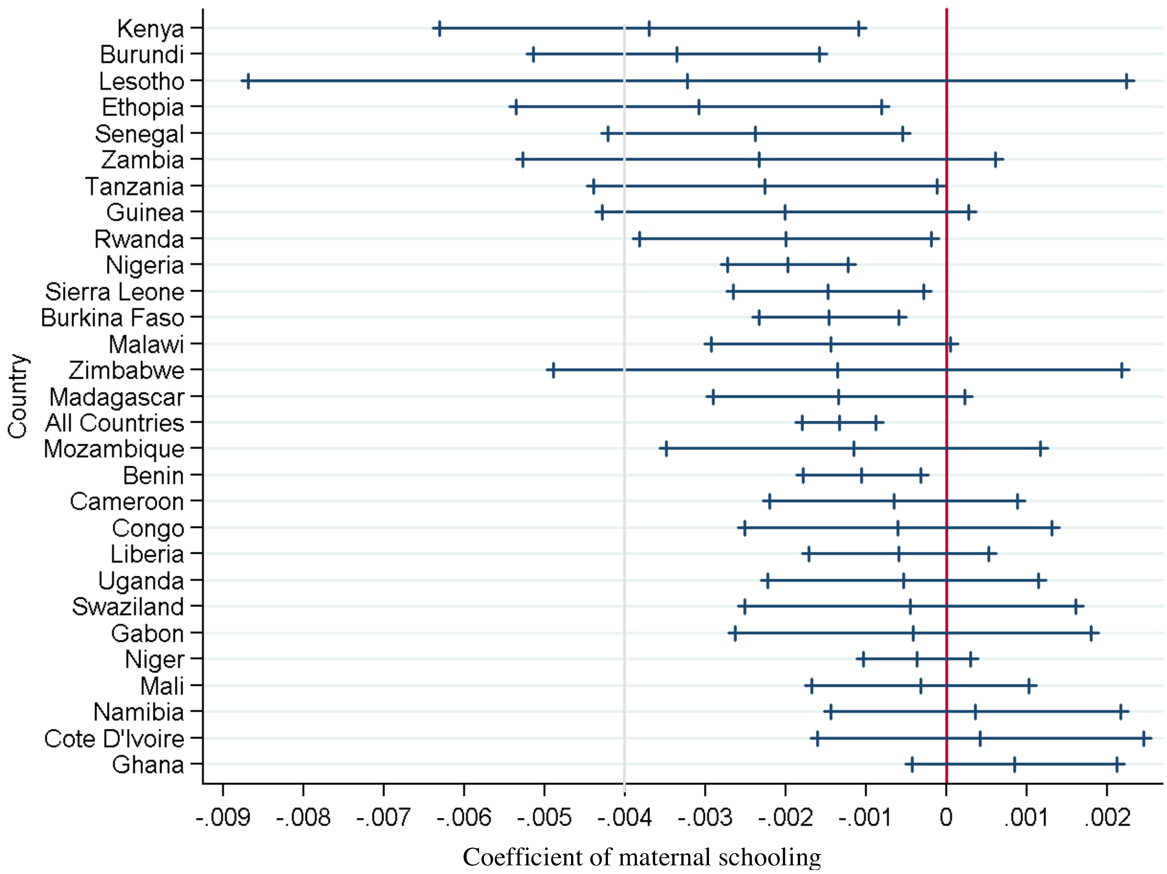

Figure III. Graphical overview of the point estimates for maternal schooling
This figure displays the point estimates and their respective 95% confidence intervals for all countries in the sample. They are generated by regressing maternal schooling, maternal age and regional dummies on infant mortality. Countries are sorted by point estimates, from largest to smallest.

Age as the control variable is low in magnitude for most countries and only significant for Mali (-0.0012) and Mozambique (-0.0016). This effect could either stem from biological factors such as maternal age at child's birth or from differences in the quality of schooling that the mothers received.

Appendix C shows the comparison between the survey design used for our analysis and a normal OLS model, comparing both point estimates as well as standard errors. Included in this table are also design effects (DEFT) and misspecification effects (MEFT). Since magnitude and significance levels vary between the two models, we conclude that using an estimation strategy that account for the complex survey design is superior.

Table IV Regression outputs of between country analysis (Model I)

VARIABLES	(1) All Countries	(2) Benin	(3) Burkina Faso	(4) Burundi	(5) Cameroon	(6) Congo	(7) Cote D'Ivoire	(8) Ethiopia	(9) Gabon	(10) Ghana
schooling	-0.00133***	-0.00105***	-0.00147***	-0.00336***	-0.000658	-0.000604	0.000422	-0.00308***	-0.000414	0.000847
	(0.000233)	(0.000373)	(0.000442)	(0.000905)	(0.000785)	(0.000972)	(0.00103)	(0.00116)	(0.00112)	(0.000649)
age	-8.64e-05	-0.000481	-0.000602	-0.000460	-0.000531	0.000133	0.000291	-0.000430	-0.000392	0.000577
	(0.000139)	(0.000377)	(0.000433)	(0.000574)	(0.000389)	(0.000501)	(0.000577)	(0.000578)	(0.000491)	(0.000748)
Constant	0.0224***	0.0700***	0.0377**	0.0805***	0.0794***	0.0337**	0.0236	0.0542**	0.0508**	0.0216
	(0.00858)	(0.0167)	(0.0148)	(0.0208)	(0.0188)	(0.0163)	(0.0255)	(0.0231)	(0.0204)	(0.0369)
Observations	222,186	12,604	11,990	6,238	9,261	7,299	6,071	9,264	4,690	2,316
R-squared	0.007	0.004	0.007	0.005	0.007	0.002	0.010	0.002	0.004	0.011
Regional FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES

VARIABLES	(11) Guinea	(12) Kenya	(13) Lesotho	(14) Liberia	(15) Madagascar	(16) Malawi	(17) Mali	(18) Mozambique	(19) Namibia	(20) Niger
schooling	-0.00200*	-0.0037***	-0.00322	-0.000594	-0.00134*	-0.00144*	-0.000323	-0.00115	0.000365	-0.000367
	(0.00116)	(0.00133)	(0.00278)	(0.000570)	(0.000798)	(0.000759)	(0.000686)	(0.00118)	(0.000919)	(0.000337)
age	-0.000830	0.00138	0.00128	-0.000990	0.000828*	-0.000546	-0.00120**	-0.00162***	0.000353	0.000190
	(0.000615)	(0.000926)	(0.00105)	(0.000875)	(0.000422)	(0.000421)	(0.000574)	(0.000513)	(0.000592)	(0.000386)
Constant	0.0831***	0.0500	0.0525	0.0774***	0.0197	0.0423***	0.0761***	0.0876***	0.0549	0.0182
	(0.0256)	(0.0340)	(0.0522)	(0.0274)	(0.0159)	(0.0159)	(0.0268)	(0.0231)	(0.0348)	(0.0131)
Observations	5,532	4,781	3,103	4,580	9,869	15,985	11,279	8,725	4,039	9,913
R-squared	0.011	0.012	0.010	0.005	0.008	0.003	0.004	0.008	0.009	0.003
Regional FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES

VARIABLES	(21) Nigeria	(22) Rwanda	(23) Senegal	(24) Sierra Leone	(25) Swaziland	(26) Tanzania	(27) Uganda	(28) Zambia	(29) Zimbabwe
schooling	-0.00197***	-0.00200**	-0.00238**	-0.00147**	-0.000450	-0.00226**	-0.000537	-0.00233	-0.00136
	(0.000381)	(0.000923)	(0.000932)	(0.000604)	(0.00105)	(0.00109)	(0.000856)	(0.00149)	(0.00180)
age	0.000129	0.000542	-7.70e-05	-0.000291	-0.000784	-0.000135	3.78e-05	-0.000791	0.000547
	(0.000330)	(0.000493)	(0.000323)	(0.000683)	(0.000928)	(0.000572)	(0.000579)	(0.000653)	(0.000703)
Constant	0.0625***	0.0455**	0.0430***	0.0867***	0.103**	0.0547*	0.0408**	0.0825***	0.0440
	(0.0127)	(0.0184)	(0.0131)	(0.0247)	(0.0425)	(0.0291)	(0.0206)	(0.0295)	(0.0362)
Observations	22,468	7,414	9,721	4,244	2,205	6,363	6,216	5,051	4,172
R-squared	0.004	0.002	0.005	0.002	0.003	0.013	0.004	0.006	0.005
Regional FE	YES	YES	YES	YES	YES	YES	YES	YES	YES

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Notes: These outputs are generated by regressing maternal schooling, maternal age and regional dummies on infant mortality. Coefficients and standard errors are presented for all 28 countries separately as well as for a regression that contains the full sample of countries.

5.2 Over time within country variations

Does the effect of maternal schooling on infant mortality change over time within countries?

The interaction term of schooling and wave is significant for six out of 18 countries, thus indicating a change of the effect of maternal schooling over time. The significant interaction terms are positive and large in magnitude, ranging from 0.0028 (Uganda) to 0.0062 (Mali). For five of those six countries (except Rwanda), the interaction terms have almost the same magnitude in absolute terms as the coefficient of maternal schooling. Thus the effect of maternal schooling is reduced to an economically insignificant level in the newer time period. With the exception of Guinea, the other 17 interaction terms are positive, indicating that the effect of maternal schooling on infant mortality has decreased over time in Sub-Saharan Africa.

We show the regression results of this multivariate model in Table V. It reveals that the effect of maternal schooling is significant at the ten percent level for 13 out of 18 countries. Thus, the share of countries with a significant coefficient of maternal schooling is higher when pooling two datasets compared to the previous results where only the newest dataset of each country was used[2]. This can have two reasons. Either, the larger sample led to smaller standard errors or the effect of maternal schooling was stronger and more significant in the older datasets, thus compensating for the insignificant coefficient in some of the newer datasets. The dummy variable wave is negative for all countries and significant at the ten percent level for 14 out of 18 countries. This dummy lowers the y-intercept of the regression, indicating that infant mortality has significantly decreased in Sub-Saharan Africa over time.

We conclude that the results point in the hypothesized direction, but in the majority of countries the difference between the effects of maternal schooling in the two waves is not significantly different from zero.

[2] It should be noted that the model presented in the previous section is not comparable in terms of magnitude to the model in this section. This is due to the special pooling procedure. For each country we aligned the two waves that were used and aligned them in terms of regions. Thus, the regressions used are not the same anymore and no inferences should be drawn across the two models.

Table V Regression outputs for over-time within country analysis (Model II)

VARIABLES	(1) Benin	(2) Cameroon	(3) Cote D'Ivoire	(4) Ethiopia	(5) Gabon	(6) Ghana	(7) Guinea	(8) Kenya	(9) Madagascar
schooling	-0.00135	-0.00340***	-0.00562**	-0.00480**	-0.00151	-0.000547	-0.00114	-0.00380***	-0.00404***
	(0.00193)	(0.00126)	(0.00250)	(0.00227)	(0.00122)	(0.00111)	(0.00122)	(0.00117)	(0.00102)
wave	-0.0223***	-0.0163	-0.0515***	-0.0365***	-0.0228*	-0.0150	-0.0319***	-0.0145	-0.0631***
	(0.00580)	(0.0103)	(0.0114)	(0.00632)	(0.0127)	(0.00973)	(0.00678)	(0.0156)	(0.00781)
schooling_wave	0.000197	0.00217	0.00596**	0.00153	0.00116	0.00129	-0.000302	1.20e-05	0.00357***
	(0.00197)	(0.00135)	(0.00264)	(0.00226)	(0.00164)	(0.00120)	(0.00158)	(0.00176)	(0.00126)
age	0.000190	-0.000240	-0.000528	-0.000782*	-5.23e-06	-0.000382	-0.000390	0.00105	0.000273
	(0.000364)	(0.000472)	(0.000689)	(0.000428)	(0.000437)	(0.000570)	(0.000477)	(0.000637)	(0.000402)
Constant	0.0864***	0.0976***	0.0974***	0.110***	0.0632***	0.0347	0.0864***	0.0640**	0.0865***
	(0.0169)	(0.0191)	(0.0236)	(0.0268)	(0.0149)	(0.0320)	(0.0179)	(0.0269)	(0.0161)
Observations	16,670	10,950	7,654	18,043	8,165	4,953	10,160	8,817	14,693
R-squared	0.005	0.004	0.020	0.007	0.004	0.008	0.009	0.018	0.016
Regional FE	YES	YES	YES	YES	YES	YES	YES	YES	YES

VARIABLES	(10) Malawi	(11) Mali	(12) Niger	(13) Rwanda	(14) Senegal	(15) Tanzania	(16) Uganda	(17) Zambia	(18) Zimbabwe
schooling	-0.00226**	-0.00650***	-0.00361**	-0.00567***	-0.00365***	-0.00152	-0.00319***	-0.00268*	-0.00267***
	(0.00115)	(0.00162)	(0.00177)	(0.00128)	(0.00101)	(0.00205)	(0.00106)	(0.00138)	(0.000979)
wave	-0.0398***	-0.0312***	-0.0757***	-0.0680***	-0.0268***	-0.0457***	-0.0456***	-0.0384***	-0.00933
	(0.00679)	(0.00576)	(0.00629)	(0.00901)	(0.00782)	(0.0133)	(0.00929)	(0.0119)	(0.0189)
schooling_wave	0.00141	0.00620***	0.00357**	0.00383**	0.00154	0.000700	0.00283**	0.000573	0.000627
	(0.00129)	(0.00174)	(0.00178)	(0.00155)	(0.00130)	(0.00229)	(0.00135)	(0.00184)	(0.00211)
age	-0.00106***	-0.00117***	-0.000587*	-0.000166	-0.000141	-0.000850	-0.000206	-0.00186***	-0.000767
	(0.000351)	(0.000418)	(0.000351)	(0.000399)	(0.000300)	(0.000685)	(0.000465)	(0.000485)	(0.000504)
Constant	0.0798***	0.103***	0.117***	0.131***	0.0697***	0.140***	0.0883***	0.175***	0.0918***
	(0.0168)	(0.0174)	(0.0136)	(0.0160)	(0.0120)	(0.0375)	(0.0167)	(0.0250)	(0.0306)
Observations	25,241	19,350	16,224	13,521	15,585	8,902	11,853	10,835	7,100
R-squared	0.006	0.007	0.022	0.014	0.006	0.018	0.008	0.011	0.005
Regional FE	YES	YES	YES	YES	YES	YES	YES	YES	YES

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Notes: These outputs are generated by regressing maternal schooling, the survey wave identifier, the interaction term of schooling and wave, maternal age and regional dummies on infant mortality. Coefficients and standard errors are presented for all 18 countries. Our variable of interest is the interaction term, which indicates whether the effect of maternal schooling on infant mortality has changed over time.

6. Discussion

The literature review reveals that previous research on maternal education does not shed light on country level determinants that modify the relationship between inequalities in maternal education and inequalities in child mortality. Moreover, studies about this relationship on the household level do only exist for a subset of countries. This means that policy makers in some countries often have to rely on research results from other countries. Since the external validity of country specific findings is questionable, this could lead to sub-optimal decision-making, as pathways and strength of relationships are likely to differ between countries. The same reasoning also implies for other socio-economic factors besides maternal education.

6.1 Interpretation of results

Our results clearly point in the direction that the relationship between socioeconomic determinants and infant mortality varies across different setting. Hence, conclusions drawn from research that results of other countries can be misleading and cause ineffective policy recommendations. This is shown by means of the socioeconomic determinant maternal schooling, whose effect on infant mortality seems to vary both across countries and within countries over time. We observe that an additional year of schooling is estimated to significantly decrease the probability of child death by 0.37 percentage points in Kenya but only by 0.1 percentage points in Benin. In other words, the association of an additional year of schooling with infant mortality in Kenya is almost four times higher than in Benin. For many of the countries being studied, no significant association between maternal schooling and infant mortality is found and also the size of the coefficients is often economically negligible. From these large variations we conclude that country level determinants that differ across countries play an important role in influencing the effect of socio-economic determinants such as maternal schooling on infant mortality. This is in line with the conceptual framework by Houweling and Kusnt (2010) depicted in Figure I.

Regarding the change of the effect of maternal schooling on infant mortality over time, we could observe a general tendency that the effect seems to decrease within countries. This means that maternal schooling has less of an impact on child health nowadays than it used to have a decade ago. This result is significant at the ten percent level for six out of 18 countries. For most of the other countries, while not statistically significant, the effect was still economically relevant and pointed in the same direction. It is interesting to contemplate about why the impact of maternal schooling on infant mortality has decreased over time in certain countries. It could be the case that the average level of maternal schooling has improved to a point where an additional year of schooling is less relevant than a decade ago. However as shown in Table II, the average level of schooling is still very dispersed across the countries. Out of the countries where the effect of maternal schooling significantly decreased over time, Mali and Niger have very low base levels of schooling and thus this explanation does not fully hold.

There must be other reasons as to why the effect of maternal schooling and infant mortality is smaller today than it used to be for certain countries. Another potential factor could be the overall improvement of countries in Sub-Saharan Africa with regard to the health status of the population. This means that it becomes more difficult over time for maternal schooling to have an effect on the health of children. Since the health status is still very low in Sub-Saharan Africa we believe that this cannot be the full explanation. We think that the explanation for our result can be explained by a similar reasoning used to explain the varying effect across countries. There we argued that country level determinants that differ between countries influence the causal chain from maternal schooling to infant mortality. We suggest that similar country level determinants that change over time are responsible for altering the effect of maternal schooling on infant mortality within countries.

We understand the results of our paper as an emphasis of the importance to study country level determinants in the context of the effect of socio-economic determinants on infant mortality. This research should be seen as a complement to the research at the household level. A better understanding of the link between country level determinants and the causal chain from socio-economic determinants to infant mortality will help policy makers to carry out better decisions. First, policy makers would be able to distribute resources to those activities that are most likely to be beneficial for the health of children given certain country characteristics and the relative importance of certain pathways. Secondly, countries might be able to alter country-level determinants in a way that the effect of certain socio-economic factors, such as maternal schooling, on child health is positively stimulated. Also Macassa, Hallqvist and Lynch (2011) state that health inequalities in Sub-Saharan Africa are caused by physical, economic and political conditions. Therefore they call for a larger focus on more distal factors as well in order to explain disparities in child mortality. They mention political governance, civil war, globalization and gender discrimination as potential relevant factors.

6.2 Potential relevant country level determinants

The following paragraphs will suggest potential country level determinants that cause the identified differences with regard to the effect of maternal schooling on infant mortality – both across countries and within countries over time. We have identified the following categories: culture, government spending, educational system, health care provision, labor market institutions and disease burdens. We will shortly comments on each of them.

The prominent role of mothers in households of a country could be a relevant cultural aspect. Even though culture can differ within countries as well, we believe there are also strong culture variations present on a country level. As we already mentioned in the literature review, Caldwell (1990) has shown that a higher educational level of mothers increases their authority in households. This leads to her being the primary decision maker when it comes to health care issues. As the role and level of authority of women in households is likely to differ across cultures, the effect of maternal schooling on the role is also likely to differ. This means that in cultures where the role of mothers in a household is already very strong, schooling will not have a large effect anymore. This would imply that maternal schooling has a stronger effect on infant mortality in countries with relatively strong gender discrimination or low level of female authority in households. Also, Macassa, Hallqvist and Lynch (2011) point out that the degree of gender discrimination in a certain region might affect the link between maternal schooling and more proximate factors.

Government spending is expected to be an important country level determinant as well. First, the absolute resources spent on health and educational services will be important. Second, the distribution or target regions for government spending are essential, as the marginal effect of additional spending differs between regions. In relatively poor regions, the effect of maternal schooling on infant mortality could be stimulated to a higher degree than in wealthier regions.

Furthermore, we believe that the overall quality of the educational system and thus the resources invested in education has a strong influence on the effect of maternal schooling on infant mortality. In countries with less qualified teachers, worse study materials and higher absenteeism of teachers the marginal effect of an additional year of schooling might be lower compared to a country with a well-established educational system.

Another reason why we observed different effects of maternal schooling on infant mortality across settings could be health care provision and the health care system of a country. The literature review revealed that improved knowledge about health through education increases the awareness of preventive care. Furthermore, it was found that women are more open to modern health services. These beneficial effects can only translate into improved health of children, if the gained knowledge could be used to alter their behavior – meaning that services also need to be available for people. For example, physicians and nurses could have higher barriers to work in rural regions in one country than in another country. Thus, we believe that in countries that assure the availability of basic health services to everyone, the effect of maternal schooling on infant mortality is bigger. Moreover, whether a country has a national health insurance or not could play an important role. In countries where also relatively poor people are insured by a national health insurance, increased knowledge about the benefits of health services could lead to a direct improvement of the health status of children. In countries where such a health insurance is not existent, improved knowledge has to be paired with the income effect in order to affords health services and improve children's health. Therefore, in countries that keep the costs of health services for relatively poor people low, the effect of maternal schooling on infant mortality is likely to be more pronounced.

Labor market institutions and labor market conditions are also likely to influence the effect of maternal schooling on infant mortality. Unemployment benefits would ensure that families have a basic income, which enables them to buy nutrition or health services. In countries with relatively high unemployment benefits, people are ensured a minimum income to afford nutrition and health services. Therefore, people might be able to retain a certain living standard and thus lowering the probability of infant deaths. On the other hand, in countries with no such institutions, the disadvantages of being unemployed due to a low level of education are more severe, which can translate into a worse health level of infants. Thus, additional years of maternal schooling are likely to have a larger impact on infant mortality in countries, where institutions such was unemployment benefits are not present. Furthermore, the marginal effect of schooling on wages might also vary between countries. Hence, the income effect through additional years of maternal schooling might vary between countries due to labor market institutions and labor market conditions.

The level of disease burden and thus the risk of dying if certain preventive measures are not taken might be another important country level determinant. For example, additional knowledge gained through maternal schooling is likely to have a larger effect on infant mortality in countries suffering from a high burden of HIV. There, a more intensive use of contraceptive methods can prevent more children from getting HIV than in countries where the risk of infection is lower. A similar argument can be made for countries that are highly vulnerable to Malaria. The awareness of the benefits when using bed nets potentially lead to larger decreases of infant deaths than in countries where the problem of malaria is not as severe.

6.3 Limitations and validity

We cannot reject the possibility of having biased estimators, due to potential omitted variable bias, sample-selection bias and endogeneity bias. More specifically, we did not control for the wealth of the mothers' parents and their background, which potentially have a direct effect on infant mortality and also on maternal schooling. If these omitted factors were positively correlated with both the dependent and independent variable, we would encounter an upward bias of the coefficient of maternal schooling. Furthermore we encounter a sample selection bias because children of dead mothers are not part of the sample. This would potentially lead to a downward bias of our test results if infants of dead mothers have a below average health status given a certain level of maternal schooling. Endogeneity bias potentially arises from migration selectivity, as mothers with more years of schooling tend to live in areas with advantageous living conditions. Since we controlled for regional fixed effects, the coefficient of maternal schooling might be underestimated. We believe that the biases mentioned above do not influence the main implications of our analysis.

6.4 Research frontier and future research

Our study shifts the research frontier outwards with regard to three aspects. First, this paper has been the first in testing whether the effect of maternal schooling on infant mortality differs between countries on a large scale. Second, to our knowledge no study has analyzed the change of the effect of maternal schooling on infant mortality over time so far. Third, the study has used the most recent datasets that were available for Sub-Saharan Africa.

The relevance of specific country level determinants in explaining the variations in the effect of maternal schooling on infant mortality has not been quantified so far. Furthermore it is important to identify the effect of country level determinants on other socio-economic determinants that affect infant mortality as well. Through this, policy makers will be able to make policy recommendations that use the optimal pathway in lowering infant mortality given the special characteristics of the respective country. Moreover, a better understanding of the relevance and working of country level determinants, would allow policy makers to deliberately change country level determinants such that they enhance the effect of measures at the household level. Ultimately, the proposed future research would help to lower infant mortality rates and thus to save the lives of many children throughout the developing world.

7. Conclusion

This paper demonstrates the need to direct research to country level determinants that potentially alter the effect of socio-economic determinants on infant mortality. We draw this conclusion from showing that the effect of maternal schooling on infant mortality varies across settings in Sub-Saharan Africa. By using the most recent data, we know that these variations are currently in place. In the discussion we identify cultural and institutional factors as well as disease burdens as potential determinants. Future research should build on our study by trying to test for the relevance of our proposed country level determinants. Moreover, scholars need to analyze in how far these results hold for other socio-economic factors and other regions as well.

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Appendix

A. Working with DHS Data in Stata

Table A.1 Survey specific variables

Variable label	Variable name	Explanation
Strata variable for each wave	*strata*	Generated from the original stratum variable for each DHS round that is based on the information in the final reports.
PSU variable for each wave	*v001*	Variable already specified in each dataset, one PSU equals one cluster.
Strata variable for the pooled data set	*strat_id*	Stratum variable that is used for the pooled data set by multiplying *strata x wave*.
PSU variable for the pooled data set	*wave_psu*	PSU variable that is used for the specifications in the pooled data set by multiplying *v001 x wave*. v001 contains all clusters within a dataset.
Sampling weight	*pweight*	De-normalized weight variable for the pooled dataset.

As a first step we used the newest dataset of a country, adapted the regions if necessary and changed the variable names according to the list above. The same naming convention was done for the older dataset and then we appended the newer dataset to the older one. This way we were sure that variables, which are not used in both rounds are being dropped.

Pooling the datasets
For pooling we first aligned the regions between the two waves. If exactly the same regions are used, no further action had to be taken except. In all other cases, we took the dataset with the fewer number of regions as the base and matched the regions from the other dataset on the base structure.

Second, an important consideration when pooling the data of two surveys is the de-normalization of the standard weights. All weights employed in DHS surveys are relative weights and adjusted by normalization so that the total number of weighted cases equals the total number of unweighted cases. This procedure however is survey and gender specific and thus when pooling two surveys from one country, the weights have to be de-normalized before pooling to correctly analyze the data afterwards (DHS Sampling Manual, 2012).

This procedure requires calculating the total sampling fraction, which is calculated by dividing the total number of women aged 15-49 interviewed in the survey (we are using women since we are working with the birth recode data file) by the total number of women aged 15-49 in the country. The de-normalized weight is then computed by dividing the normalized weight with this sampling fraction, separately for each country and survey. Since the total number of women aged 15-49 in a given country is not within the DHS data, we downloaded those numbers from the United Nations Population Division website (http://esa.un.org/wpp/unpp/panel_indicators .htm). The figures are only available in five-year steps and were thus interpolated for the years in between. For the number of women aged 15-49 interviewed in the survey, the numbers were taken individually from the final reports of each respective DHS survey.

While appending the two rounds, we created the *wave* variable that helps separating the two rounds. Once appended, we created new strata and PSU variables by interacting the *wave* identifier with *strata* respectively *v001.* By doing so we kept the correct survey specifications because all strata and PSUs are then unique in each dataset and do not appear twice.

Finally, all the regressions were computed using the *svy, subpop(eligible):* prefix. This achieves two things. First, by putting *svy* in front of the regress command, Stata knows how to apply the correct survey settings. Second, the data is restricted to a certain subsample of the population, that is only the children that have been born at least one year prior to the survey. By doing so, all children in the subsample are fully at "risk" for the mortality period of dying in their first year. This can be achieved by using the *svy, subpop(eligible)* option in Stata, instead of using an -if- command after the regression. An *-if-* command is essentially equivalent to deleting all other observations. *Subpop* on the other hand estimates the variance of the subpopulation by using both included and excluded observations, thus having "unconditional" variance estimators (Cochran, 1977).

When using these survey commands, a more complex formula can be adapted in order to calculate the standard errors for the models. Since DHS surveys are based on multi-stage stratified designs, the regular formulas for simple random sampling are no longer safe to use (DHS Sampling Manual, 2012). Instead, the Taylor Linearization Method of variance estimations for survey estimates needs to be applied (Woodruff, 1971). This is incorporated when using the *svy* commands and is also known as the Huber/White/robust sandwich variance estimator. The Taylor Linearization Method ensures a robust overall model (Kreuter et al., 2007).

B. Adjusted Wald Test

Stata output:

(1)	[Ben]schooling -	[Bfa]schooling	=	0
(2)	[Ben]schooling -	[Bur]schooling	=	0
(3)	[Ben]schooling -	[Cam]schooling	=	0
(4)	[Ben]schooling -	[Cng]schooling	=	0
(5)	[Ben]schooling -	[Cot]schooling	=	0
(6)	[Ben]schooling -	[Eth]schooling	=	0
(7)	[Ben]schooling -	[Gab]schooling	=	0
(8)	[Ben]schooling -	[Gha]schooling	=	0
(9)	[Ben]schooling -	[Gui]schooling	=	0
(10)	[Ben]schooling -	[Ken]schooling	=	0
(11)	[Ben]schooling -	[Les]schooling	=	0
(12)	[Ben]schooling -	[Lib]schooling	=	0
(13)	[Ben]schooling -	[Mad]schooling	=	0
(14)	[Ben]schooling -	[Maw]schooling	=	0
(15)	[Ben]schooling -	[Mal]schooling	=	0
(16)	[Ben]schooling -	[Moz]schooling	=	0
(17)	[Ben]schooling -	[Nam]schooling	=	0
(18)	[Ben]schooling -	[Nig]schooling	=	0
(19)	[Ben]schooling -	[Nia]schooling	=	0
(20)	[Ben]schooling -	[Rwa]schooling	=	0
(21)	[Ben]schooling -	[Sen]schooling	=	0
(22)	[Ben]schooling -	[Sie]schooling	=	0
(23)	[Ben]schooling -	[Swa]schooling	=	0
(24)	[Ben]schooling -	[Tan]schooling	=	0
(25)	[Ben]schooling -	[Uga]schooling	=	0
(26)	[Ben]schooling -	[Zam]schooling	=	0
(27)	[Ben]schooling -	[Zim]schooling	=	0

F(27, 12358) = 1.52
Prob > F = 0.0408

C. Survey Regression vs. Simple OLS

Table C.1 Comparison between Survey Regression and Simple OLS

Country	Year	SVY Design		Simple OLS		DEFT	MEFT
		schooling coefficient	standard error	schooling coefficient	standard error		
Benin	2006	-0,00105***	-0,00037	-0,00095**	-0,00041	1.09	0.59
Burkina Faso	2010	-0,00147***	-0,00044	-0,0012***	-0,00031	1.07	0.62
Burundi	2010	-0,00336***	-0,00091	-0,0026**	-0,00088	1.08	1.12
Cameroon	2011	-0,000658	-0,00079	-0,0011	-0,00081	1.30	1.12
Congo	2011	-0,000604	-0,00097	0,00063	-0,0011	1.15	1.53
Cote D'Ivoire	2012	0,000422	-0,0010	0,00025	-0,00064	1.10	1.37
Ethiopia	2011	-0,00308***	-0,0012	-0,0017*	-0,00091	1.52	1.31
Gabon	2012	-0,000414	-0,0011	-0,0005	-0,00099	1.49	1.62
Ghana	2008	0,000847	-0,00065	0,00053	-0,00079	0.85	0.98
Guinea	2012	-0,00200*	-0,0012	-0,0028***	-0,0008	1.30	1.02
Kenya	2009	-0,00370***	-0,0013	-0,0028***	-0,00074	1.31	1.45
Lesotho	2009	-0,00322	-0,0028	-0,0021	-0,0025	1.48	1.43
Liberia	2007	-0,000594	-0,00057	-0,00065*	-0,000322	1.58	0.86
Madagascar	2008/09	-0,00134*	-0,000798	-0,00085	-0,000642	1.14	1.12
Malawi	2010	-0,00144*	-0,000759	-0,0012	-0,000607	1.29	1.26
Mali	2006	-0,000323	-0,000686	-0,00041	-0,000733	1.00	1.20
Mozambique	2011	-0,00115	-0,00118	-0,00077	-0,0013	1.26	1.29
Namibia	2006/07	0,000365	-0,000919	0,00049	-0,000964	1.09	1.02
Niger	2006	-0,000367	-0,000337	-0,00037	-0,000268	1.19	0.82
Nigeria	2008	-0,00197***	-0,000381	-0,0021***	-0,000412	1.11	0.96
Rwanda	2010	-0,00200**	-0,000923	-0,002**	-0,000739	1.04	1.07
Senegal	2010/11	-0,00238**	-0,000932	-0,0023***	-0,000588	1.42	1.10
Sierra Leone	2008	-0,00147**	-0,000604	-0,0015**	-0,000487	1.10	0.74
Swaziland	2006/07	-0,00045	-0,00105	-0,00038	-0,000587	1.05	0.84
Tanzania	2010	-0,00226**	-0,00109	-0,0017*	-0,00097	1.20	1.29
Uganda	2011	-0,000537	-0,000856	-0,00049	-0,000791	1.10	1.00
Zambia	2007	-0,00233	-0,00149	-0,0018	-0,0015	1.20	1.23
Zimbabwe	2010/11	-0,00136	-0,0018	-0,0016	-0,00134	1.32	1.35

Notes: The table displays the coefficient and respective standard error of maternal schooling generated by two different models. On the left are the numbers for our preferred model that takes the complex survey specifications into account. On the right are the numbers for a normal OLS model that assumes simple random sampling. Additionally the design and misspecification effect are displayed in the last two columns.

Table C.1 displays the coefficients of maternal schooling and the respective standard errors for both the model that takes into account the complex survey design and a basic OLS model. The OLS model is clustered by region plus urban/rural identifier. The results reveal that the models do not differ much with regard to the significance of the coefficient of maternal schooling at the ten percent level. Magnitude of the coefficients and standard errors vary however, indicating the need to correctly specify our model with the survey data specifications. This is shown in the last two columns of Table C.1, in which we present design (DEFT) and misspecification (MEFT) effects. The DEFT is slightly larger than one for most countries, implying that the true standard errors using the survey regression are larger than the ones calculated by normal OLS. Thus, OLS would have possibly underestimated standard errors and falsely increased the significance of some coefficients. We find a similar pattern for the results of the MEFT with most of values being larger than one. A MEFT value of more than one means that we would have underestimated the confidence intervals if the survey design were not taken into account. We conclude that it was correct to use the survey commands in Stata in order to account for the complex survey design and prevent drawing false conclusions.

D. Extended Regression Outputs Model I

For completeness Tables D.1 and D.2 present the coefficients of maternal schooling for each country and for each of the three models that we performed. For those countries where the coefficient of maternal schooling is significant in the first model (column 1), the magnitude changes within an acceptable range as age (column 2) and regional fixed effects (column 3) were added to the model. Thus, our coefficients of interest can be seen as robust. For Cameroon, Liberia and Niger the coefficient of maternal schooling becomes insignificant as regional fixed effects are added to the model. This suggests that the association between maternal schooling and infant mortality in these countries is actually driven by regional differences with regard to socio economic characteristics and are thus cancelled out when accounting for these differences. It should be noted that the point estimate of maternal schooling decreases from model 2 to 3, not only for the three countries mentioned above, but also for a variety of other countries. This strengthens the claim that the relationship between maternal schooling and infant mortality is partly driven by regional fixed effects.

Table D.1 Extended regressions for between country analysis (a)

Countries	(1)	(2)	(3)
	Dependent variable: Infant mortality		
All countries	-0.00148***	-0.00148***	-0.00133***
	(0.000189)	(0.000190)	(0.000233)
Benin	-0.00178***	-0.00178***	-0.00105***
	(0.000432)	(0.000432)	(0.000373)
Burkina Faso	-0.00219***	-0.00226***	-0.00147***
	(0.000544)	(0.000549)	(0.000442)
Burundi	-0.00350***	-0.00359***	-0.00336***
	(0.000860)	(0.000857)	(0.000905)
Cameroon	-0.00229***	-0.00231***	-0.000658
	(0.000705)	(0.000704)	(0.000785)
Congo	-0.000387	-0.000386	-0.000604
	(0.000791)	(0.000791)	(0.000972)
Cote D'Ivoire	8.46e-06	4.41e-05	0.000422
	(0.00102)	(0.00102)	(0.00103)
Ethiopia	-0.00312***	-0.00325***	-0.00308***
	(0.00101)	(0.00103)	(0.00116)
Gabon	-0.0004	-0.000409	-0.000414
	(0.00108)	(0.00109)	(0.00112)
Ghana	0.000481	0.000504	0.000847
	(0.000694)	(0.000677)	(0.000649)
Guinea	-0.00297***	-0.00329***	-0.00200*
	(0.000988)	(0.00107)	(0.00116)
Kenya	-0.00286**	-0.00279**	-0.00370***
	(0.00125)	(0.00125)	(0.00133)
Lesotho	-0.00313	-0.00293	-0.00322
	(0.00234)	(0.00236)	(0.00278)
Liberia	-0.000942*	-0.00102*	-0.000594
	(0.000541)	(0.000549)	(0.000570)
Madagascar	-0.00136*	-0.00156**	-0.00134*
	(0.000734)	(0.000729)	(0.000798)
	Variables		
Maternal schooling	Yes	Yes	Yes
Age	No	Yes	Yes
Regional fixed effects	No	No	Yes

Notes: The table above shows the coefficients and standard errors for maternal schooling for three different models, in which we added the covariates age and regional dummies step-wise.

Table D.2 Extended regressions for between country analysis (b)

Countries	(1)	(2)	(3)
	Dependent variable: Infant mortality		
Malawi	-0.000203	-0.000464	-0.00144*
	(0.000687)	(0.000739)	(0.000759)
Mali	-0.000716	-0.000755	-0.000323
	(0.000740)	(0.000730)	(0.000686)
Mozambique	-0.000831	-0.00178*	-0.00115
	(0.000891)	(0.00101)	(0.00118)
Namibia	-5.52e-05	-1.82e-05	0.000365
	(0.000775)	(0.000780)	(0.000919)
Niger	-0.000688**	-0.000679**	-0.000367
	(0.000344)	(0.000342)	(0.000337)
Nigeria	-0.00223***	-0.00223***	-0.00197***
	(0.000331)	(0.000332)	(0.000381)
Rwanda	-0.00185**	-0.00187**	-0.00200**
	(0.000878)	(0.000879)	(0.000923)
Senegal	-0.00289***	-0.00289***	-0.00238**
	(0.000781)	(0.000780)	(0.000932)
Sierra Leone	-0.00117*	-0.00119*	-0.00147**
	(0.000607)	(0.000605)	(0.000604)
Swaziland	-0.000482	-0.000521	-0.00045
	(0.00106)	(0.00106)	(0.00105)
Tanzania	-0.000829	-0.000827	-0.00226**
	(0.00108)	(0.00109)	(0.00109)
Uganda	-0.00127	-0.00125	-0.000537
	(0.000866)	(0.000852)	(0.000856)
Zambia	-0.00148	-0.00163	-0.00233
	(0.00131)	(0.00132)	(0.00149)
Zimbabwe	-0.00179	-0.00167	-0.00136
	(0.00185)	(0.00189)	(0.00180)
	Variables		
Maternal schooling	Yes	Yes	Yes
Age	No	Yes	Yes
Regional fixed effects	No	No	Yes

Notes: The table above shows the coefficients and standard errors for maternal schooling for three different models, in which we added the covariates age and regional dummies step-wise.

E. Extended Regression Outputs Model II

Table E.1 Extended regressions for over-time within country analysis (a)

Countries	Independent Variables	(1)	(2)	(3)
		Dependent variable: Infant Mortality		
Benin	schooling	-0,00285 (0.00193)	-0,00283 (0.00194)	-0,00135 (0.00193)
	wave	-0.0249*** (0.00590)	-0.0247*** (0.00589)	-0.0223*** (0.00580)
	schooling*wave	0,00108 (0.00198)	0,00105 (0.00198)	0,000197 (0.00197)
Cameroon	schooling	-0.00429*** (0.00113)	-0.00437*** (0.00114)	-0.00340*** (0.00126)
	wave	-0.0177* (0.0102)	-0.0180* (0.0102)	-0,0163 (0.0103)
	schooling*wave	0,00201 (0.00133)	0,00207 (0.00134)	0,00217 (0.00135)
Cote D'Ivoire	schooling	-0.00704** (0.00290)	-0.00714** (0.00285)	-0.00562** (0.00250)
	wave	-0.0616*** (0.0154)	-0.0617*** (0.0154)	-0.0515*** (0.0114)
	schooling*wave	0.00705** (0.00307)	0.00712** (0.00304)	0.00596** (0.00264)
Ethiopia	schooling	-0.00453** (0.00196)	-0.00487** (0.00196)	-0.00480** (0.00227)
	wave	-0.0361*** (0.00630)	-0.0363*** (0.00630)	-0.0365*** (0.00632)
	schooling*wave	0,00141 (0.00221)	0,00152 (0.00221)	0,00153 (0.00226)
Gabon	schooling	-0,00147 (0.00123)	-0,00147 (0.00123)	-0,00151 (0.00122)
	wave	-0.0226* (0.0127)	-0.0227* (0.0128)	-0.0228* (0.0127)
	schooling*wave	0,00107 (0.00164)	0,00107 (0.00164)	0,00116 (0.00164)
Ghana	schooling	-0,00137 (0.00104)	-0,00138 (0.00105)	-0,00037 (0.00111)
	wave	-0,0161 (0.00990)	-0,0161 (0.00990)	-0,0148 (0.00971)
	schooling*wave	0,00185 (0.00125)	0,00186 (0.00125)	0,00123 (0.00119)
	Variables			
schooling		Yes	Yes	Yes
wave		Yes	Yes	Yes
schooling * wave		Yes	Yes	Yes
age		No	Yes	Yes
regional fixed effects		No	No	Yes

Notes: The table above shows the coefficients and standard errors for maternal schooling, the wave identifier and the interaction term of schooling and wave for three different models in which we added the covariates age and regional dummies step-wise.

Table E.2 Extended regressions for over-time within country analysis (b)

Countries	Independent Variables	(1)	(2)	(3)
		Dependent variable: Infant Mortality		
Guinea	schooling	-0,00187	-0,00186	-0,00114
		(0.00126)	(0.00126)	(0.00122)
	wave	-0.0290***	-0.0290***	-0.0319***
		(0.00711)	(0.00712)	(0.00678)
	schooling*wave	-0,00109	-0,00127	-0,000302
		(0.00160)	(0.00163)	(0.00158)
Kenya	schooling	-0.00417***	-0.00382***	-0.00380***
		(0.00119)	(0.00120)	(0.00117)
	wave	-0,0248	-0,023	-0,0145
		(0.0161)	(0.0161)	(0.0156)
	schooling*wave	0,00131	0,00102	1.20e-05
		(0.00182)	(0.00180)	(0.00176)
Madagascar	schooling	-0.00452***	-0.00452***	-0.00404***
		(0.00112)	(0.00112)	(0.00102)
	wave	-0.0608***	-0.0606***	-0.0631***
		(0.00750)	(0.00751)	(0.00781)
	schooling*wave	0.00316**	0.00310**	0.00357***
		(0.00134)	(0.00134)	(0.00126)
Malawi	schooling	-0.00206*	-0.00255**	-0.00226**
		(0.00113)	(0.00114)	(0.00115)
	wave	-0.0415***	-0.0402***	-0.0398***
		(0.00675)	(0.00681)	(0.00679)
	schooling*wave	0,00185	0,00178	0,00141
		(0.00132)	(0.00132)	(0.00129)
Mali	schooling	-0.00901***	-0.00903***	-0.00650***
		(0.00164)	(0.00164)	(0.00162)
	wave	-0.0327***	-0.0334***	-0.0312***
		(0.00572)	(0.00570)	(0.00576)
	schooling*wave	0.00829***	0.00827***	0.00620***
		(0.00180)	(0.00179)	(0.00174)
Niger	schooling	-0.00558***	-0.00572***	-0.00361**
		(0.00174)	(0.00174)	(0.00177)
	wave	-0.0763***	-0.0762***	-0.0757***
		(0.00636)	(0.00634)	(0.00629)
	schooling*wave	0.00490***	0.00502***	0.00357**
		(0.00178)	(0.00178)	(0.00178)
		Variables		
schooling		Yes	Yes	Yes
wave		Yes	Yes	Yes
schooling*wave		Yes	Yes	Yes
age		No	Yes	Yes
regional fixed effects		No	No	Yes

Notes: The table above shows the coefficients and standard errors for maternal schooling, the wave identifier and the interaction term of schooling and wave for three different models in which we added the covariates age and regional dummies step-wise.

Table E.3 Extended regressions for over-time within country analysis (c)

Countries	Independent Variables	(1)	(2)	(3)
		Dependent variable: Infant Mortality		
Rwanda	schooling	-0.00573***	-0.00585***	-0.00567***
		(0.00125)	(0.00123)	(0.00128)
	wave	-0.0684***	-0.0689***	-0.0680***
		(0.00898)	(0.00895)	(0.00901)
	schooling*wave	0.00388**	0.00401***	0.00383**
		(0.00153)	(0.00152)	(0.00155)
Senegal	schooling	-0.00413***	-0.00414***	-0.00365***
		(0.000891)	(0.000890)	(0.00101)
	wave	-0.0241***	-0.0243***	-0.0268***
		(0.00545)	(0.00543)	(0.00782)
	schooling*wave	0,00123	0,00126	0,00154
		(0.00118)	(0.00118)	(0.00130)
Tanzania	schooling	-0,000434	-0,000928	-0,00152
		(0.00205)	(0.00207)	(0.00205)
	wave	-0.0411***	-0.0427***	-0.0457***
		(0.0143)	(0.0145)	(0.0133)
	schooling*wave	-0,000395	0,000111	0,0007
		(0.00232)	(0.00237)	(0.00229)
Uganda	schooling	-0.00403***	-0.00407***	-0.00319***
		(0.00105)	(0.00106)	(0.00106)
	wave	-0.0445***	-0.0441***	-0.0456***
		(0.00932)	(0.00934)	(0.00929)
	schooling*wave	0.00276**	0.00274**	0.00283**
		(0.00136)	(0.00136)	(0.00135)
Zambia	schooling	-0,00211	-0.00231*	-0.00268*
		(0.00130)	(0.00129)	(0.00138)
	wave	-0.0416***	-0.0395***	-0.0384***
		(0.0119)	(0.0119)	(0.0119)
	schooling*wave	0,000633	0,000472	0,000573
		(0.00184)	(0.00184)	(0.00184)
Zimbabwe	schooling	-0.00232**	-0.00261**	-0.00267***
		(0.000991)	(0.00102)	(0.000979)
	wave	-0,00868	-0,00966	-0,00933
		(0.0190)	(0.0191)	(0.0189)
	schooling*wave	0,000532	0,000654	0,000627
		(0.00210)	(0.00211)	(0.00211)
		Variables		
schooling		Yes	Yes	Yes
wave		Yes	Yes	Yes
schooling*wave		Yes	Yes	Yes
age		No	Yes	Yes
regional fixed effects		No	No	Yes

Notes: The table above shows the coefficients and standard errors for maternal schooling, the wave identifier and the interaction term of schooling and wave for three different models in which we added the covariates age and regional dummies step-wise.