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## Growth and Survival

### Child Health Disparities and Early Life Adversity in Sub-Saharan Africa

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# Growth and Survival

## Child Health Disparities and Early Life Adversity in Sub-Saharan Africa

Omar Karlsson



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DOCTORAL DISSERTATION


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<p><b>Abstract</b></p> <p>Sound physical health is a critical component of the human development process, wherein early life and childhood are pivotal periods. Although child health in sub-Saharan Africa has been improving for the past few decades, the region still has the highest mortality rate for children under five as well as high levels of child morbidity. The most immediate causes of these poor health outcomes are infectious diseases and undernutrition, while more remote factors, such as resources available to parents, are also known to play a role in child health. Parents are further embedded in an economic, social and epidemiological environment, which commonly reflects the parent's own resources, as well as aiding them in or inhibiting them from ensuring the healthy development of their children.</p> <p>The primary aim of this dissertation is to first study the consequences of an adverse environment in infancy, such as exposure to infectious diseases, on human development; and secondly, to explore disparities in child health as they relate to several parental factors — maternal health, parental education, and religious affiliation. Specifically, the dissertation examines the overlap and interaction between these parental factors and contextual factors in determining child health. The results show that adversity in infancy negatively impacts subsequent human development, which is not mitigated in households with higher socioeconomic status. Secondly, contextual factors explain some of the differences in child health between different groups but do so to a varying degree. The relationship between child health and parental education and, especially, maternal health, appears to be persistent and strong, even independent of contextual factors and other measures of living standards. On the other hand, the link between religious affiliation and child health mostly reflects geographic clustering of religious groups and heterogeneity in living standards. As the contextual environment has improved, the association between parental education and maternal health and child health appears to have decreased. Specifically, the persistence of the intergenerational transmission of health from mother to child has attenuated as government spending on health care has increased, and the association between parental education and child health has diminished over time as the contextual environment has improved.</p> <p>Parental resources, health, and socioeconomic status are all vital components of human development in sub-Saharan Africa and other low and middle-income countries. The intergenerational transmission of disadvantage from parents to children is, however, reduced with improving environments.</p>		
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Omar Karlsson



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# List of papers

- I Karlsson, Omar (2018). Scarring and selection in sub-Saharan Africa: The effects of adverse environment in infancy on health and education. *Unpublished manuscript*.
- II Karlsson, Omar and Dribe, Martin (2018). Maternal height and child development in sub-Saharan Africa: Underlying mechanisms and the role of public spending on health. *Unpublished manuscript*.
- III Karlsson, Omar; De Neve, Jan-Walter; and Subramanian, S.V. (2018). Weakening association of parental education: analysis of child health outcomes in 43 low- and middle-income countries. *International Journal of Epidemiology*.
- IV Karlsson, Omar (2018). Child health disparities by religious affiliation in West and Central Africa. *Unpublished manuscript*.



# Introduction

## Motivation and aim

Individuals' well-being is related to what they are capable of being and doing. According to the capability approach pioneered by Amartya Sen (1990), development entails an expansion of capabilities that enable individuals to live good lives and achieve desirable outcomes. Capabilities are embedded in individuals in the form of skills and capacities, as well as in their living contexts, where capabilities manifest as opportunities and freedoms. Skills and capacities accumulate throughout an individual's life course with particularly important periods being those of early life, childhood, and adolescence (Barker, 2004; Case and Paxson, 2008; Gluckman et al., 2010). While survival, health, and primary education are fundamental capabilities of intrinsic value, they are also instrumental in acquiring further capabilities and achieving desirable outcomes (Heckman and Corbin, 2016; Nussbaum, 2011). Children born to parents with sufficient resources, in a food-secure environment with good public health, and access to health care and education, have opportunities to develop skills and capacities and to grow into healthy individuals.

There have been major improvements in well-being, globally, reflected in increased life expectancy, better health, and the availability of more opportunities (Deaton, 2013). Beginning in the eighteenth century, improved nutrition and reduced exposure to infectious diseases in Europe resulted in a significant reduction in the death rate of children, marking the onset of the mortality transition. The health of survivors also improved, reflected in better health in adulthood (Floud et al., 2011; Hatton, 2013). Improvements in well-being are also underway in the developing world, where under-five mortality rates have shown a decline since the 1950s, and nutrition and school enrollments have improved more recently (Deaton, 2013, 2007; Soares, 2007). However, large disparities in well-being persist between countries, with much of the developing world continuing to lag far behind the developed countries with regard to most fundamental capabilities (Victora et al., 2003).

The list of least-developed countries, compiled by the United Nations (UN), contains 47 countries, 33 of which are in sub-Saharan Africa (SSA) (UN, 2018,

2014). SSA has an under-five mortality rate of 78 deaths per 1,000 live births and accounts for half of the global deaths of children under 5 years old while, having one-fourth of global births (Liu et al., 2017, 2015; World Bank, 2017). Further, many surviving children are undernourished and unhealthy, as reflected in the high prevalence of stunted physical growth affecting 35% of the under-5 age group in this region (UN IGME, 2015; World Bank, 2018). The proportion of children out of school is 22%, which is higher than the corresponding percentage in any other part of the world (UNESCO, 2018; World Bank, 2017). Despite improvements, only a few countries achieved the Millennium Development Goal of reducing under-five mortalities by two-thirds during the period 1990–2015 (Way, 2015).

The main proximate determinants of child health in SSA are infectious diseases, although undernutrition and preterm birth complications also play substantial roles (Horton et al., 2008; Liu et al., 2017, 2015; Mosley and Chen, 1984; UNICEF, 2007). Within households, parents are often unable to provide sufficiently for their children because of a variety of factors associated with a lack of material means and other capabilities, such as health and education. Further, disadvantaged households are situated within environments where necessary infrastructure and services, such as health care and education, are lacking, and where the risk of exposure to harmful diseases and food insecurity is high (Fotso and Kuate-Defo, 2005; Griffiths et al., 2004; Kravdal, 2004; Stephenson et al., 2006).

The introduction of the Sustainable Development Goals (SDGs) led to renewed efforts to improve child health and human development, with the objectives of reducing the under-five mortality rate to 25 deaths per 1,000 live births, achieving universal primary and secondary education, and ending all forms of child malnutrition by 2030, and reducing stunting to less than 15% by 2025. The SDGs call for disaggregation of important indicators to combat inequalities associated with, for example, ethnicity and socioeconomic status (SES). Most countries in SSA need to accelerate their reduction rates relating to the above conditions and to tackle disparities in under-five mortality rates, stunting, and school enrolment to achieve the SDGs (UNICEF, 2018).

Significant disparities in child health between various groups within countries continue to be apparent, and many children inherit disadvantages from their parents. Studies have revealed an enduring association between child health and maternal health, parental education, and, to a less extent, religious affiliation, which respectively represent health, socioeconomic, and sociocultural factors (Caldwell, 1979; Gyimah, 2007; Monden and Smits, 2009). Poor maternal health, measured by height, has been found to negatively impact child health in most developing contexts, with the main suggested pathways being compromised human development in mother's early life (Perkins et al., 2016). Parental education has been widely studied as a determinant of child health, with causal

links posited to occur through various pathways, such as improved skills, and improved incomes (Mosley and Chen, 1984). It has been suggested that the relationship between religious affiliation and child health is rooted in differences in behaviors and attitudes prescribed by religious doctrines (Gyimah, 2007). However, other explanations lie in differential access to resources and living standards between these groups.

Although studies have found disparities in child health by maternal health, parental education, and religious affiliation, the extent to which group-level differences in child health overlap and interact with contextual factors is less well understood. Compared with lower-income households and their locations, those that are better-off are more likely to be found in places characterized by better living standards; better provision of services, such as healthcare and education; a less disease-prone environment, and more food security, with each of these factors independently influencing child development. Religious groups are also highly clustered geographically, which may explain observed differences in child health.

Further, parental factors may interact with the contextual environment in determining child health, given that many of the proposed pathways of parental factors, such as health and education, are related to contextual factors. For example, it has been suggested that maternal education impacts on child health by increasing the skills and knowledge of mothers regarding nutrition, hygiene, preventive care, and treatment of diseases (Mosley and Chen, 1984, p. 35). Therefore, the effectiveness of parental education, and, more broadly, parental resources in determining child health evidently varies according to the external environment, relating, for example, to economic development, underlying disease risks, and availability of health care, nutrition, contraceptives, and clean water (Jeong et al., 2018).

This dissertation is a compilation of four papers. The main aim of this thesis is to first, study the effect of early life adversity on human development, and second, examine broad relationships between parental factors and child health, in a large number of sub-Saharan African and other low- and middle-income countries (LMICs). Three out of the four papers further quantify the extent to which contextual factors, as well as various dimensions of living standards and demographic characteristics, account for the relationship between parental factors and child health.

The overarching research question is as follows:

To what extents do contextual factors explain the observed disparities in child health by maternal health, parental education, and religious affiliation?



Since parental factors also interact with contextual factors in their relationship with child health, the four sub-questions addressed in each paper are:

Are children in better-off households less affected by an adverse environment during infancy in SSA?

Does increased public spending on health reduce the intergenerational transmission of health from mother to child in SSA?

Does the association between parental education and child health change over time as contexts have improved in LMICs?

What are the implications of community-level religious composition for child health in West and Central Africa?

Considering the first sub-question, infants in better-off households may be less affected by adverse exposures as a result of greater investments in health before, during, and after they are exposed to an adverse environment. Considering the second sub-question, increased public spending on health may improve the public health environment and access to health care and therefore mitigate the negative consequences of poor maternal health. In relation to the third sub-question, the strength of the relationship between parental education and child health may change over time as education becomes less exclusive and other underlying factors change. Considering the last sub-question, the community-level religious composition may influence, for example, religiosity, and have implications for religious minorities, as well as reflecting living standards.

Measures of child health used in the dissertation are under-five mortality, neonatal, post-neonatal and child mortality, and anthropometric indicators, such as height-for-age and stunting. In addition to child health, two of the papers examine school attendance as an outcome. School attendance is a fundamental capability and an important dimension of the human development process (Nussbaum, 2011). It is also related to child health, as healthier children are more likely to attend school (Alderman et al., 2001; Brooker et al., 1999; Heckman, 2007; Heckman and Corbin, 2016). Three of the papers cover between 11–35 countries in SSA and one paper covers 43 LMICs, 25 of which are in SSA. The data used in these studies comprise pooled datasets extracted from the Demographic and Health Surveys (DHS) conducted between 1990 and 2016. In one paper, the DHS data have been supplemented with data from the Global Health Expenditure Database of the World Health Organization (WHO). Most analyses included children born up to five years prior to each survey, but in some of them, complete birth histories, beginning in the late 1950s, are used.

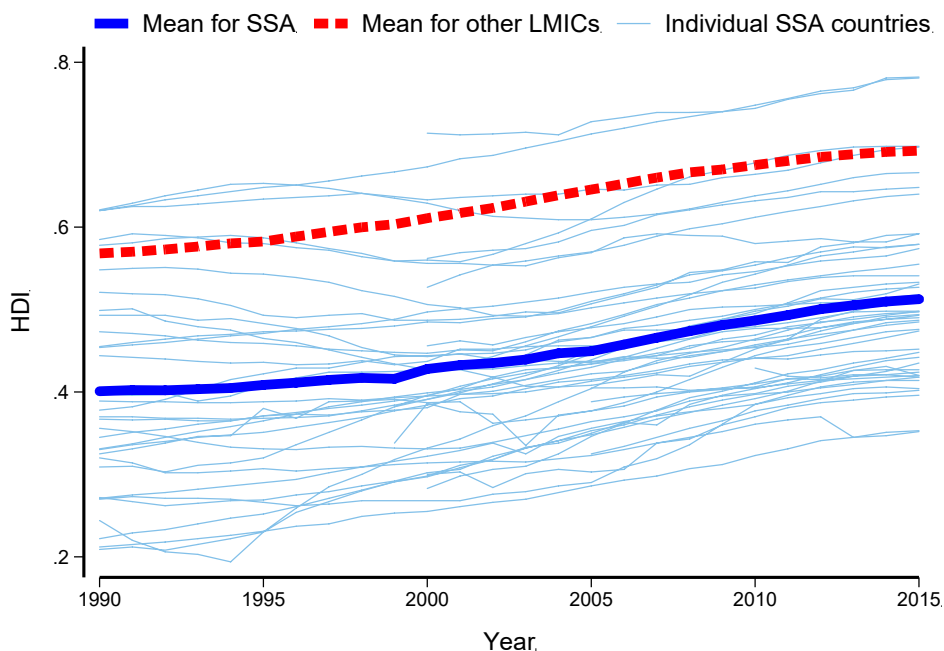
DHS data from 33 countries in SSA are used in the analysis presented in the first paper, which assesses the impacts of adversity experienced in infancy on child health, and school attendance. Because of data requirements, this analysis is confined to more densely populated and extensively surveyed areas. For the analysis of the association between maternal height, and under-five mortality and school attendance presented in the second paper, all available DHS surveys conducted in SSA are included to obtain a large sample size. Thus, the sample comprised 35 countries in SSA. The analysis of the association between parental education and child health, presented in the third paper, included all LMICs for which data from at least two DHS surveys are available to test for changes in the association over time. The analysis is based on 86 surveys from 43 countries. Finally, the analysis of differences in child health by religious affiliation, presented in the fourth paper, focuses on all religiously mixed countries in West and Central Africa for which data are available, or 11 countries. In all of the analyses, only children born to women who are respondents in the DHS surveys are included. Consequently, the substantial population of orphans in the region, especially in countries with a high prevalence of HIV/AIDS, such as southern Africa, and countries affected by civil wars, are excluded from the studies.

## Sub-Saharan Africa and the developing world

SSA is a vast region encompassing 48 countries and extending over an area of 21.2 million square kilometers, with a total population of about one billion people that accounts for 12% of the world's population. This region is ethnically, culturally, historically, and environmentally diverse. Over 2,000 languages are spoken in the region, of which French and English are widespread. There is usually an overlap between languages and ethnic groups, which number several thousand. Despite the ethnic and cultural diversity of the region, most people practice some form of either Christianity or Islam (Lugo and Cooperman, 2011, 2010). The majority of the countries were formerly under colonial rule, with most of these nations gaining independence in the 1960s (Hunziker, 2005). Political turmoil has characterized many of the countries in SSA, and there have been civil wars with high deaths tolls within the region (Ghobarah et al., 2004).

The region is also diverse regarding its geography and climate. The northern part of the subcontinent has vast deserts and a hot and arid climate. Highlands with a dry and cool climate are located in the southern and eastern parts. Tropical forests occur in the central part of the region, which along with the western part, is generally characterized by a hot and humid tropical climate. Countries in SSA also vary vastly in size, ranging from 2.2 million square kilometers (the Democratic

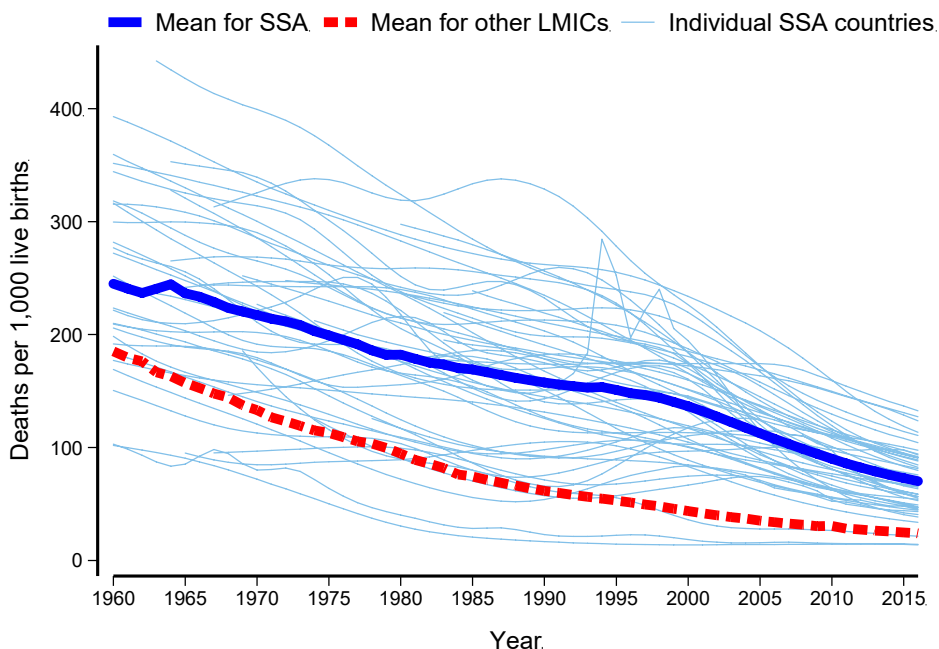
Republic of Congo) to 1,000 square kilometers (Sao Tome and Principe). The continent also includes Nigeria, which is one of the most populous countries in the world with 186 million inhabitants as well as some of the smallest countries, worldwide, such as the Sao Tome and Principe with 200,000 inhabitants.



**Figure 1. Human Development Index (HDI) in sub-Saharan Africa (SSA) and in other low- and middle-income countries (LMICs)**  
 Note: The mean value calculated for sub-Saharan Africa and low- and middle-income countries is at the country level for each year. Means are unweighted. Source: World Bank (2017).

For many decades, living standards in SSA have been deficient, with this region ranking among the lowest, globally, for most measures of development and well-being (Malik, 2014). The Human Development Index (HDI) prioritizes capabilities as a measure of development and is composed of life expectancy at birth, mean years of schooling, and gross national income per capita (UNDP, 2018). An HDI of under 0.55 is generally considered to indicate a low level of human development, whereas one between 0.55 and 0.7 indicates a medium level of human development. Figure 1 shows that the mean HDI has been increasing for countries in SSA as well as other LMICs. However, the mean for SSA is considerably lower than that for other LMICs, with most countries in the region demonstrating low HDIs. Figure 2 shows that the under-five mortality rate, which is another development indicator, had started decreasing in 1960 in SSA and other

LMICs. The under-five mortality rate has remained considerably higher in SSA than in other LMICs.



**Figure 2. Under-five mortality rate in sub-Saharan Africa (SSA) and other low- and middle-income countries (LMICs)**

Note: The mean value calculated for sub-Saharan Africa and low- and middle-income countries is at the country level for each year. Means are unweighted. Source: World Bank (2017).

The underlying cause of low HDI values is poverty. In many countries within the region, people are dependent on subsistence agriculture for their survival. Although a favorable climate for agriculture characterizes some parts of the region, food security is still a critical issue, with malnourishment being common among children and adults. A low level of technology within the agricultural sector reflected in primitive equipment and limited irrigation and fertilizer use undermine food security. Droughts and crop failures further complicate the situation. Integration of the region's markets with international markets is weak, and local markets are unstable. Poor infrastructure constrains the distribution of food, and inadequate storage facilities result in food spoilage and wastage (Devereux and Maxwell, 2001; Shively and Hao, 2012).

Governments in countries in SSA are generally weak leading to ineffective institutions, political instability, corruption, and in some cases, civil wars. Weak

states have limited capacities for raising revenue, which, in turn, results in limited financial support available for infrastructure programs, education, and healthcare. Unstable growth, large informal sectors, and high debt ratios, further constrain financing. Given minimal public expenditure on healthcare, facilities for the provision of health care are insufficient, inaccessible, and ineffective for many within the region, while infections and other health problems are common (Ghura, 1998). There is often an absence of safe water supplies and sewage plants to provide clean water and hygienic toilet facilities. Extensive exposure to infectious diseases, morbidity, and mortality among children in SSA may be primarily attributed to the lack of public initiatives by governments relating to the implementation, monitoring, and maintenance of facilities and infrastructure (Montgomery and Elimelech, 2007). Moreover, the hot and humid climate in some areas and the presence of jungles and rivers create ideal breeding grounds for pathogens (Kalluri et al., 2007).

Although the onset of a fertility transition is evident in SSA, this occurred later and proceeded more slowly than in other regions (Gerland et al., 2017). Whereas for most of the developing world the fertility decline began in the mid-1970s, it did not fully manifest until the mid-1990s in most countries in SSA. Further, differing from other regions, the shift in fertility in SSA began during stages of lower socioeconomic development lower incomes, less schooling, and less urbanization. Currently, however, fertility in SSA is higher than in other developing countries. Moreover, the level of fertility is higher than would be expected for the level of economic development. It appears that demand for children in SSA is higher than in other LMICs, given that contraceptive use is lower, and the desired family size is greater than in other regions (Bongaarts, 2017). There are, however, sub-regional differences. East African countries, such as Rwanda, Malawi, and Ethiopia, where family planning has been prioritized, have experienced a rapid uptake of contraceptives followed by a fertility decline. As a whole, western and central Africa lag behind southern and eastern Africa when it comes to the shifting fertility trend (Mbacké, 2017).

One consequence of declining mortality, with a lower decrease in fertility, is that Africa's population is growing at a fast pace and is predicted to rise from its current proportion of 13% of the global population to 17% in 2030 and 36% in 2100. The continent also has a large share (16%) of children under the age of 5 years, compared with the global share of this age group (9%) (UN, 2017). This youth bulge has led to hopes of a demographic dividend, which has historically contributed to economic growth and development in other regions in the world (Lee and Mason, 2006). Adequate investments in and care of children and youth through the provision of proper health care and education are necessary to ensure the development of human capital and to reap most of the benefits of a demographic dividend (Ahmed et al., 2016; Gribble and Bremner, 2012).

## Under-five mortality

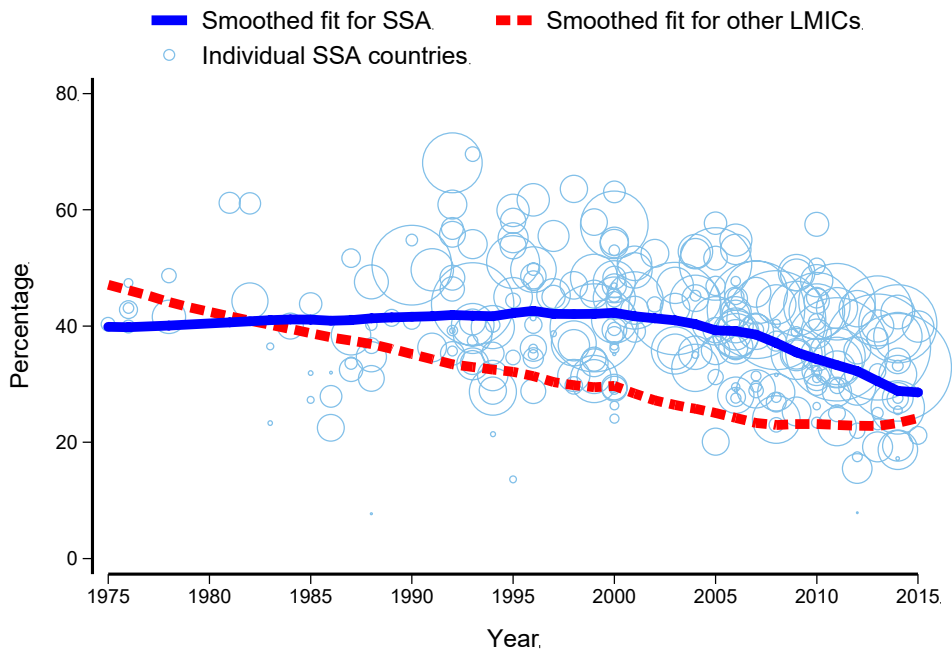
The year 2015 was an important year, as it marked the endpoint of the designated period (1990–2015) for achieving the Millennium Development Goal of reducing the under-five mortality rate by two-thirds (Unicef, 2015). This rate was reduced by 55%, globally, during the above period, thus falling short of the goal (WHO, 2015a). Figure 2 shows under-five mortality rates in SSA and other LMICs from 1960 onward. In SSA, the under-five mortality rate declined from 83 to 54 deaths per 1,000 births between 1990 and 2015, and the absolute number of deaths of children less than 5 years old decreased by 24%. In 2015, the region accounted for 50% of under-five deaths globally. After a setback caused by the HIV/AIDS epidemic in the 1990s was overcome after 2000, the declining trend in the mortality rate accelerated. Within SSA, Western and Central Africa have higher death rates for children less than 5 years old (99 per 1,000 births) compared with Eastern and Southern Africa (67 per 1,000 births). However, Angola (in southern Africa) had the highest under-five mortality rate at 157 per 1,000 births. All countries with an under-five mortality rate above 100 per 1,000 births are located in SSA: Angola, Chad, Somalia, the Central African Republic, Sierra Leone, Mali, and Nigeria. Moreover, all of the countries in these regions had under-five mortality rates above 25 deaths per 1,000 births. The SDGs for 2030 seek a reduction in the under-five mortality rate to fewer than 25 per 1,000 in all countries. To achieve this goal, 47 countries, of which 32 are in SAA, will need to accelerate their reduction rates (You et al., 2015).

The primary causes of under-five mortality are preventable diseases. WHO classifies the underlying cause of death according to its “International Classification of Diseases” (ICD-10) (WHO, 2015b). Globally, the causes of child death changed considerably as the rate declined between 2000 and 2015. In 2000, the leading causes of under-five deaths were pneumonia (17%), preterm birth complications (13%), and diarrhea (12%). The most significant reduction in deaths during this period occurred for deaths due to pneumonia, diarrhea, intrapartum-related events, malaria, and measles, all of which were reduced by over 30%, contributing to a 62% reduction in the under-five mortality rate. In 2015, the leading causes of death for children under the age of 5 years were preterm birth complications (18%), pneumonia (16%), and intrapartum-related events (12%) (Liu et al., 2017, 2015).

The share of deaths of children under 5 occurring in the neonatal period has been increasing over time, indicating a reduction in deaths due to infectious diseases. Neonatal deaths accounted for 45% of the deaths of children under 5 years in 2015, increasing from 38% in 2000. Consequently, preterm birth complications have become the leading cause of child mortality, not just among neonatal babies but also among children under 5. The leading causes of neonatal deaths are

preterm birth complications (16%), intrapartum-related events (11%), and meningitis or sepsis (7%). Pneumonia (13%), diarrhea (9%), injuries (6%), and malaria (5%) accounted for the highest proportions of post-neonatal deaths of children under 5 (Liu et al., 2017, 2015).

The mortality rate in SSA is not only higher than in other countries, but it also exhibits a different pattern. Through 2000 and 2015, the share of under-five deaths attributable to infectious diseases was considerably higher in SSA than the in other regions, whereas the percentage of deaths in the neonatal period was lower. Over 90% of global deaths from malaria and HIV/AIDS occur in SSA, resulting in a higher prevalence of deaths from infectious diseases in the region. In 2000, malaria was the leading cause of child deaths in SSA, responsible for 17% of under-five mortalities in the post-neonatal period. Over the period 2000–2015, reduced rates of malaria, diarrhea, and measles accounted for 22%, 17%, and 17%, respectively, of the reductions in under-five mortality rate in SSA. In 2015, the leading causes of under-five mortalities were pneumonia (17%), preterm birth complications (12%), and intrapartum-related events (12%) (Liu et al., 2017, 2015).



**Figure 3. Prevalence of stunting in children under the age of 5 years in sub-Saharan Africa (SSA) and other low- and middle-income countries (LMICs)**  
The smoothed fit is obtained using locally weighted scatterplot smoothing. Source: World Bank (2017).

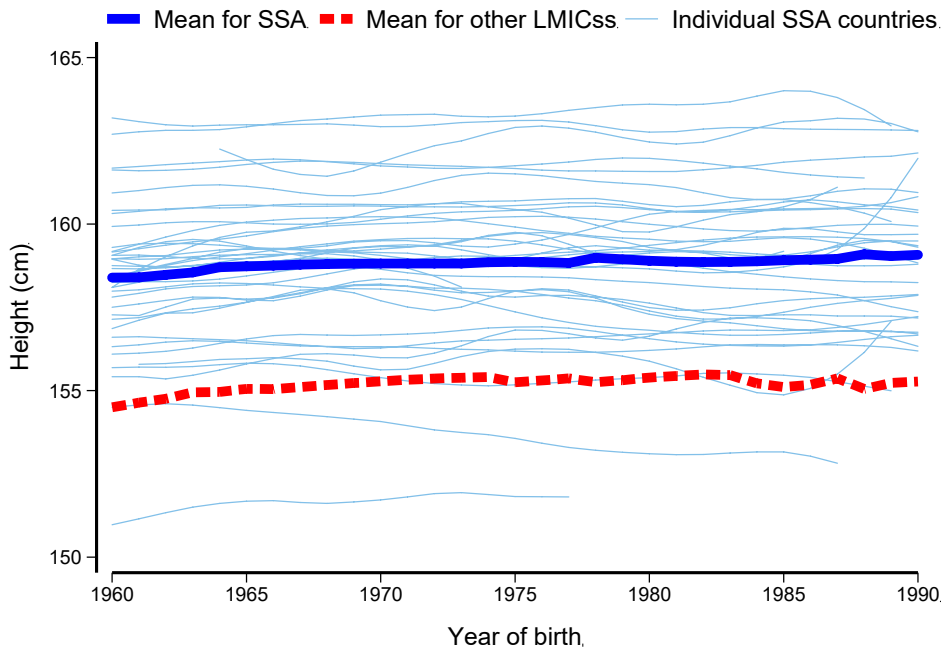
The HIV/AIDS epidemic has also had severe consequences for children in SSA. Mother-to-child transmission of HIV, which can happen during pregnancy, birth, and after delivery through breastfeeding, is the most common cause of HIV/AIDS infection among children. It has been estimated that about 60% of infected children die before the age of 5, and in 2002, HIV/AIDS may have caused up to 10% of deaths of children less than 5 years old in the region (Newell et al., 2004). The consequences of the HIV/AIDS epidemic for under-five mortality rate are apparent in Figure 2, reflected in a reduced pace in the mortality reduction from the 1990s up to 2000.

Although the WHO systematically selects a single cause of death, the reality is that under-five mortalities in developing countries are often caused by a sequence of infections and other types of harmful exposure, such as birth complications and undernutrition. Disease and nutrition are also interrelated. Malnourished children are more susceptible to infectious diseases, and infections, in turn, often prevent efficient absorption of nutrients (Ibrahim et al., 2017; Scrimshaw et al., 1968; Walson and Berkley, 2018). Malnutrition is believed to explain about 35% of diseases (Horton et al., 2008) and to be a significant contributing factor in about 50% of under-five mortalities (UNICEF, 2007).

### **Anthropometric outcomes**

Improved survival leads to an increasing focus on the morbidity and healthy development of children. Anthropometric measures are widely used as indicators of child development. Similar to mortality, cumulative exposure to malnutrition and disease determine anthropometric outcomes. Child stunting is a commonly used indicator of chronic undernutrition and exposure to infectious diseases. Figure 3 shows the stunting trend from 1975 to 2015, which decreased rapidly after 2000 in SSA, although it remains greater in SSA than other LMICs. In the 1990s, the global prevalence of stunting was 40%, but this figure dropped to 27% in 2010. In 1990, within SSA, Southern Africa had the lowest prevalence of stunting (35%), followed by West Africa (38%), Central Africa (45%), and East Africa (48%). In 2010, Southern Africa still had the lowest prevalence of stunting, slightly declining to 33%. Western Africa showed no decrease but had the second lowest prevalence in 2010. Central Africa evidenced the most significant reduction in stunting (to 39%) in 2010. Although the highest prevalence of stunting was still in East Africa, it decreased to 45% (De Onis et al., 2012).





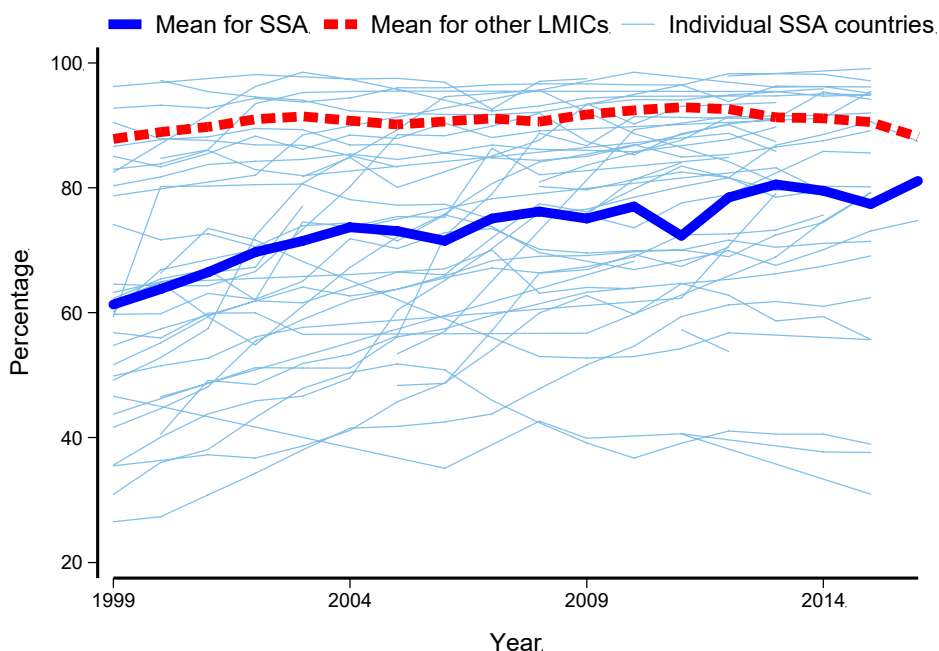
**Figure 4. Height (in cm) of women in sub-Saharan Africa (SSA) and in other low- and middle-income countries (LMICs)**

All available DHS data are used to calculate annual country-level means for SSA and LMICs. The means are weighted using sampling weights adjusted to sum up to one for each survey. Only women above the age of 21 are included. Source: DHS (2018).

Exposure to diseases and undernutrition in early life also impact on adult height, which is a widely used indicator of cumulative health and living standards in the field of economic history (Steckel, 1995a). Figure 4 shows height trends by birth cohorts for SSA and other LMICs. Although African women are shorter than women in developed countries, their heights exceed the predictions for the adverse environments in which they were raised, and they are considerably taller than women in other developing countries. The reasons for the surprisingly tall stature of African women remain unclear. Part of the explanation may be that their food is not predominantly vegetarian and is not as limited as that of women in developing countries in Asia. Infant mortality has been extremely high, indicating an environment with a high level of disease severity that has been suggested to lead to selection effects in early life, where children with lower health potential are more likely to die, leaving the surviving population taller. Countries in SSA are also less densely populated than many other developing countries, resulting in exposure to fecal germs that are not as chronic and reduced and slower human-to-human transmission of infectious diseases. The surprisingly tall stature of African

women may also be related to catch-up growth during adolescence since stunting rates are generally very high in childhood. A final suggested factor explaining the surprisingly tall stature of women in SSAs is genetic traits (Akachi and Canning, 2010; Deaton, 2013, p. 162, 2007; Moradi, 2010).

Overall, the heights of adult women belonging to all socioeconomic groups in SSA first increased and then decreased for cohorts born during the period 1940 to 1990. However, they varied slightly by region. On average, women in Southern Africa steadily grew taller and faster in urban as opposed to rural areas. Sahelian women showed no change over time in urban areas, but their heights decreased in rural areas. The heights of women in both Central and East Africa increased up to the 1970s but subsequently began to decline (Garenne, 2011; Moradi, 2010).



**Figure 5. Net primary school enrolments in sub-Saharan Africa (SSA) and other low- and middle-income countries (LMICs)**  
Annual country-level means are calculated for SSA and LMICs. Means are unweighted. Source: World Bank (2017).

## Education

Primary school enrolments have been increasing throughout the developing world, especially in the wake of initiatives such as the Millennium Development Goals

and Education for All. Many countries have abolished primary school fees, thereby making this level of education more accessible for all students. Figure 5 shows increases in net enrollments in primary education since 1999. Net adjusted enrolments in primary school increased from being just over 60% in 1999 to 77% in 2014. Although enrollment rates remain lower in SSA than other LMICs, the gap has been steadily decreasing. Increases in enrolment percentages have been higher for girls (76% in 2014 as opposed to 49% in 1990) than for boys. However, the increase over time in primary school completion rates was less marked (54% in 1990 and 69% in 2014).

The adult literacy rate showed a more modest increase from 57% in 1995 to 61% in 2014. Growing cohort sizes put pressure on the education system, and the rapid increase in the absolute number of students which was not met with sufficient increase in funding may have lowered the quality of education in some cases (UNESCO, 2011; World Bank, 2017). Although primary school attendance has generally reached high levels, school quality and outcomes remain poor and a minority of primary school students have acquired basic skills such as reading, writing, and basic arithmetic skills (ASER, 2015; Bietenbeck et al., 2018; Bold et al., 2017; Hungi et al., 2010; Malpel, 2016).

## **Interventions**

It has been suggested that initial steps toward better health in now developed countries were achieved through better nutrition, improved sanitation, and clean water in parallel with rising incomes (Cutler and Miller, 2005; Fogel, 2002; Kremer and Glennerster, 2011). Most of the subsequent improvements in health that occurred in the twentieth century were the outcome of technological advances rather than income growth (Jamison et al., 2001; Preston, 1975). A large proportion of the reduction in under-five mortalities in developing countries was achieved through transfers of low-cost technologies that were easy to implement. Consequently, life expectancies are significantly higher in the currently developing world than they were in the now developed countries at similar income levels. Sub-optimal investments in public goods, such as water infrastructure, as well behavioral factors related to the uptake of various interventions are the reasons for the continued high rates of infectious diseases in many developing countries (Kremer and Glennerster, 2011).

Different interventions are required to improve child health, depending on the sources of adversity. Tuberculosis, malaria, diarrhea, and lower respiratory tract infections require environmental changes, such as pest control, clean water, and better sanitation. Medical treatments provided within healthcare systems are not sufficiently effective for addressing these threats. However, childhood diseases,

such as whooping cough, diphtheria, polio, measles, and tetanus, as well as perinatal complications and malnutrition, could be improved through better childcare, the provision of guidance before and after delivery, monitoring and vaccinating children, and the availability of health facilities for dealing with emergencies. Solutions to these problems require effective clinics and healthcare systems (Deaton, 2013, p. 121). Parental training in proper nutrition is also essential because of the higher risk of children becoming malnourished after weaning, and the synergetic relationship between infectious diseases and undernutrition (Kwena et al., 2003).

Public health in developing countries has advanced through new inventions, programs, and initiatives, often initiated by non-governmental organizations. In the 1950s, campaigns to promote the provision of penicillin to treat yaws, for example, were instituted. Vector control, aimed at the chemical elimination of disease carriers, such as mosquitos, was also successful, at least initially (mosquitos later became resistant and more powerful agents deemed too harmful to the environment). In the late 1950s, the UN extended the reach of campaigns already implemented in Europe to the rest of the world, aimed at reducing the incidence of tuberculosis, yaws, leprosy, malaria, and trachoma and supported a project aimed at the provision of improved sanitation and clean water. This was followed by other campaigns, such as the WHO's promotion of the DPT vaccine covering diphtheria, whooping cough, and tetanus as well as vaccines for measles, polio, and tuberculosis in 1974. The most recent campaign was launched in 2000, aimed at reinvigorating previous efforts. Some discoveries have helped to reduce infant mortality, such as oral rehydration therapy, entailing oral administration of a mixture of salt, glucose, and water to treat diarrhea as well as the introduction of low-cost mosquito nets to prevent malaria (Deaton, 2013, p. 104).

## Theoretical background

### **Capabilities**

The focus on survival, health, and schooling can be attributed to their importance for individual well-being and human development. All of these are integral to the capability approach, which views development as the expansion of capabilities (Robeyns, 2005; Sen, 1990). A set of capabilities enables individuals to achieve various desirable outcomes, referred to as "functionings," which they "value and have a reason to value." The capabilities possessed by an individual constitute a space for potential actions, whereas functionings are the actions materialized by the individual, depending on her or his preferences and norms (Heckman and

Corbin, 2016). Functionings comprise states of “beings and doings,” such as being healthy, working, and being well nourished. Capabilities can be of intrinsic value (functionings that are valuable in and of themselves), of instrumental value (the means for achieving further capabilities) or both. Education and good health are examples of capabilities that are of intrinsic value but can also be instrumental in, for example, securing a job and raising healthy children. In the same way, a child's health is of intrinsic value but is also instrumental in relation to their school attendance and performance because healthier children are more likely to attend school and perform better than less healthy children (Miguel and Kremer, 2004; Mukudi, 2003). Internal capabilities comprise skills and capacities that are embedded in individuals, such as literacy and health, whereas external capabilities<sup>1</sup> are embedded in their living contexts that include, for example, healthy parents with sufficient resources, access to health care and education, and hygienic and disease-free environments with secure access to food. At birth, and throughout infancy and childhood, individuals have few internal capabilities and are dependent on external capabilities for their well-being and for developing internal capabilities. This dissertation is about the development of internal capabilities in the form of bodily health, survival, and education. External capabilities are considered as determinants that inhibit or aid the development of internal capabilities. Given that the full set of capabilities includes a vast array of skills, capacities, and opportunities, overlapping with individual preferences and needs, their measurement is inherently difficult. The outcomes considered in this dissertation, namely survival, health, and education, commonly feature in the human development literature, and scholars have argued that they are universal fundamental capabilities, independent of any preference (Nussbaum, 2011, 2001).

## **Human development and capabilities**

Heckman offers a framework for studying the accumulation of internal capabilities, or skills and capacities, such as good health (Heckman, 2007; Heckman and Corbin, 2016). A skill production function can demonstrate the

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<sup>1</sup> There is no standard definition for the concept of external capabilities (Jackson, 2014). The notion of capabilities as being either embedded in individuals or beyond the individual has been defined and conceptualized differently within the literature. In her earlier work, Nussbaum referred to internal and external capabilities (Nussbaum and Long, 1988). Others have used S-capabilities to denote skills embedded in individuals and O-capabilities to denote the options available to individuals to exercise these skills (Gasper, 1997; Otto and Ziegler, 2006). The idea of external capabilities, being abilities that individuals have to function with the help of interpersonal relations is conceptually different (Foster et al., 2008). However, a general notion of external capabilities as factors external to the individual that inhibit or aid the development or use of capabilities and outcomes (functioning) is well established (Heckman and Corbin, 2016).

process of accumulation of skills and capacities in childhood in relation to this dissertation, encompassing internal and external capabilities.

$$\theta_{t+1} = m_t(h, \theta_1, I_1, \dots, I_t)$$

In the above equation  $h$  denotes parents' instrumental capabilities for child rearing,  $\theta_1$  denotes the initial stock of internal capabilities (endowments at conception such as genes), and  $I_1, \dots, I_t$  denotes sets of investments at each stage, that determine the set of internal capabilities at a subsequent stage  $\theta_{t+1}$ . Investments are resources directed at children such as nutrition, schooling, health care, and illness control. Investments are provided by, for example, parents and governments. The instrumental capabilities for childrearing associated with the parents are, for example, knowledge about proper nutrition, hygiene and illness control. as well as health and material resources. Chronic exposure to diseases and malnutrition early in life has permanent negative effects on children's health and cognitive development (Barker, 1997; Gluckman et al., 2010; Steckel, 2008) and consequently affect their education and future incomes (Case and Paxson, 2006; Currie, 2008; Currie and Moretti, 2007). Because pregnancy and birth complications can also have long-term consequences (Van Handel et al., 2007), maternal health and abilities are of particular importance as they determine child health, in utero, during birth, as well as post-birth, because women are the primary caretakers of children in SSA (FAO, 2014).

Assuming that  $h$  is constant, the investments ( $I_1, \dots, I_{t-1}$ ) and the initial endowments ( $\theta_1$ ) can be replaced by the accumulated stock of internal capabilities ( $\theta_t$ ) and investments ( $I_t$ ) made at a previous stage  $t$ .

$$\theta_{t+1} = f_t(h, \theta_t, I_t)$$

$h$  and  $I$  are external capabilities signifying the extent to which a child's circumstances enable her or him to develop internal capabilities in the form of skills and capacities. The stock of capabilities,  $\theta_t$ , refers to internal capabilities that are instrumental in producing  $\theta_{t+1}$ . The accumulated stock of internal capabilities augments internal capabilities in subsequent periods through self-productivity. Further, internal capabilities produced at one stage will raise the productivity of investments at later stages; and investments at later stages will also increase the returns to investments made at earlier stages. This is referred to as dynamic complementarities. Self-productivity and dynamic complementarities imply that investments are most efficient in early life (Heckman, 2007). A child who has received sufficient investments in the form of nutrition and disease prevention during infancy will have a stronger immune system. A stronger immune system is an internal capability that allows the child to fight off infections more effectively during subsequent periods, enabling further development of the

child's internal capabilities regarding cognitive abilities and health. If a school-aged child has reached sufficient cognitive development and good health, as a result of adequate investments during previous periods, then investments in the form of primary schooling will be more efficient, as healthier more able children attend schools more regularly and learn more.

### **Early-life conditions, human development, and anthropometric measures of health**

The Heckman production function demonstrates synergistic accumulation of internal capabilities which is cross-fertilizing across periods, which implies that investments made early in life are the most efficient. Early life investments are also of major importance because adverse exposures in early life cause severe and irreversible biological and physiological damage. Consequently, other measures of well-being, such as health, income, and education are affected. Expressions of phenotypes, which influence health and cognition, are most sensitive to environmental impacts during critical periods of developmental plasticity<sup>2</sup>. Critical periods of particular importance are the fetal stage and the first two years after birth when rapid physical growth and development take place (Bateson et al., 2004; Kuh and Shlomo, 2004). The thrifty phenotype hypothesis suggests that nutritional deficiencies in early life lead to reduced growth and a slower metabolism to increase the chances of survival. This adaptation may, however, have detrimental consequences later in life. Limited nutrition may also need to be allocated selectively within the body to save vital organs at the cost of the development of other organs (Barker, 2004; Gluckman et al., 2010; Low et al., 2012). Diseases and malnutrition can operate interactively, and malnourished children are more vulnerable to diseases, and exposure to diseases can influence the ability of their bodies to absorb nutrients. Disease exposure can result in an inflammatory response that may similarly reduce physical growth and cause permanent physiological damage. Energy can also be diverted from growth and development to combatting infections (Finch and Crimmins, 2004; Katona and Katona-Apte, 2008).

Environmental factors, as well as genetics and hormonal factors, also influence physical growth and height (Coutant et al., 2001). In an optimal environment, entailing sufficient nutrition and a low degree of exposure to infectious diseases, different genotypes can give rise to the same stature. Conversely, in contexts of frequent exposure to infectious diseases and poor nutrition, these same genotypes

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<sup>2</sup> Developmental plasticity refers to the ability of genotypes to produce different phenotypes (observable traits) according to environmental ques.

may give rise to shorter but differing heights. In developed countries, it has been estimated that 10–20% of adult height is environmentally determined (Silventoinen, 2003). The environmentally determined component of height is likely to be higher in developing countries than in developed countries since standards of living are lower, and food scarcity and diseases are more severe, making height a good indicator of living standards in these countries (Fogel, 1994; Steckel, 1995b).

Exposure to diseases and undernutrition in early life reduces physical growth and is associated with low birth weight, growth restrictions during early childhood, and ultimately shorter adult height. In the context of early-life conditions, these anthropometric measures are related to human development, mortality, adult health, and consequently education and income (Case and Paxson, 2008; Currie, 2008; Deaton, 2007; Steckel, 1995b). Therefore, birth weight is a widely used indicator of fetal nutrition, growth, and stunting during childhood indicate childhood nutrition and exposures to diseases, and adult height indicates the cumulative health and the net nutritional history (Bozzoli et al., 2009; Currie and Moretti, 2007; Perkins et al., 2016; WHO, 1986).

In a context of impoverishment, children are born slightly below the growth standard set by World Health Organizations (WHO) and continue to diverge from this standard up to the age of 2. After this age, these children's growth is mostly parallel to, but below the growth standard, and ultimately, their adult height reached upon maturity is shorter (De Onis et al., 2006; Eckhardt et al., 2005). Even though deprivation in early life restricts growth, individuals can catch up in height during their adolescence, and as a result of an extended growth period, if nutrition is sufficient and exposures to infections rare. However, chronic and severe exposures in early life most likely always restrict growth and result in shorter adult height, which can be 10–15 cm in the most extreme conditions (Steckel, 1995b, 2009). Further, even though catch-up growth may occur, it is unclear whether it also leads to catch-up in relation to health and other negative consequences of early life adversity (Case and Paxson, 2008).

The negative effects of adverse exposures in early life and reduced physical growth may also have negative consequences across generations, which are examined in the second paper of this dissertation. One biological issue that is raised by these conditions is the growth of the fetus during pregnancy. There are indications that mothers whose birth weights were low, and who are of shorter stature, experience lower weight gain and a higher risk of developing hypertension during pregnancy which puts their children at risk of being born with low birth weights. Growth restrictions in utero also lead to the reduced size of the uterus and ovaries in a woman, which restricts the growth of the fetus, leading to lower birth weight (Ibáñez et al., 2000). Further, in general, the pelvises of shorter women are



narrower than those of taller women, increasing the risk of cephalopelvic disproportion and obstructed labor (Rush, 2000; Sokal et al., 1991). There have also been reports of the practice of “eating down,” or eating less during pregnancy, among smaller women in some cultures to keep the baby small and thereby avoid complications during delivery (Christian et al., 2006). Another potential biological mechanism is transgenerational epigenetic inheritance, entailing a process in which environmental influences on gene expressions are passed down generations (Heard and Martienssen, 2014).

Intergenerational transmission of attributes that can be influenced by conditions during early life appears to be more genetically determined in environments in which children have been able to live up to their genetic potential to a greater extent with less harm from exposures to infections and undernutrition. Turkheimer et al. (2003) found indications that variations in IQ were almost entirely genetically determined in well-off households, whereas they were contingent on the environment to a much greater extent among impoverished families. Similarly, the influence of genetic inheritance on a child’s birth weight was found to be reduced when fetal growth is restrained, for example in first pregnancies and when a pregnant mother smokes (Little and Sing, 1987).

It is unclear to what extent differences in height among distinct populations are environmentally or genetically determined. However, social classes that are economically advantaged within different populations and ethnic groups tend to have similar heights, and immigrants tend to reach similar statures to those of the original inhabitants within the United States and Europe within two generations (Malcolm, 1974; Martorell and Habicht, 1986; Steckel, 1995b). Regardless, the use of anthropometric measures is valid when comparing changes in living standards within populations over time. Genetic determinants of population height are mostly constant over relatively short periods because potential evolutionary changes act slowly, so observed changes in height over the past two centuries most likely reflect improved living conditions.

Numerous studies have linked adversity faced in early life to later life health outcomes, such as adult height. However, several different mechanisms have been suggested. Preston et al. (1998) suggest that the main mechanisms through which adversity in early life can impact on observed health outcomes are scarring, selective mortality, acquired immunity, and correlated environments. Scarring is a mechanism of primary interest as it captures the full extent of the negative health consequences of adversity in early life. Through scarring effects, the overall health of the surviving population, manifested, for example, in stature, shifts downward, resulting in a lower mean for health. Another mechanism is selective mortality, whereby individuals with underlying health problems and lower potential health, are more likely to die when exposed to adversity in early life, compared to

healthier individuals. When selective mortality dominates over scarring, the surviving population is observed to be healthier, as individuals from the lower end of the health distribution are not observed due to selective mortality. The third mechanism, acquired immunity, relates to individuals who survive adverse exposure to influenza, for example, for which immunity can be acquired. Such individuals have been observed to be healthier, as subsequent exposure does not have the same impact on their health. Last, the effect of exposure to adversity in early life may be exaggerated by correlated environments wherein individuals experience sustained exposure to adversity and deprivation over multiple periods and even across generations.

### **Measuring external capabilities**

Infectious diseases, undernutrition, and perinatal complications are the leading causes of mortality and morbidity, obstructing child development in LMICs. However, the extent to which children are exposed to undernutrition and infections is related to the characteristics of the parents, and the communities in which they reside. Mosley and Chen (1984) proposed a framework that is useful for examining the determinants of child health in developing countries. They identified a set of proximate determinants that directly affect mortality or morbidity, such as faltering growth, and all other determinants, such as socioeconomic determinants, must operate through in their effects on child health. There are five broad categories of proximate determinants: maternal factors (e.g., age, parity, birth intervals); injuries; nutrition; environmental contamination (transmission of infectious agents); and illness control (preventive controls such as immunizations and curative controls, such as oral rehydration and antibiotics). Importantly, specific disease states are not treated as causes of illness or death, but rather as indicative of the operation of specific proximate determinants. Faltering growth, and ultimately mortality, is an ideal outcome for modeling such a process as it reflects cumulative exposures to harm rather than an acute phenomenon. In this sense, illnesses are inherently transitory and either result in complete recovery or irreversible consequences for physical growth and survival. Although SES may cause acute events, it primarily affects child health through cumulative exposure to harm via proximate determinants.

Mosley and Chen further suggest specific socioeconomic determinants operating through proximate determinants. For example, they suggest that maternal education affects proximate determinants directly by increasing the capacities of mothers in relation to their feeding practices and skills in preventing and responding to diseases. By contrast, they suggest that paternal education mainly operates via household wealth, although they suggest it also influence attitudes toward reduced fertility and investments in children. Household incomes influence

resources available for the provision of adequate nutrition and health care as well as more sanitary living environments. Additionally, they suggest sociocultural factors, such as religion, impact on traditions, norms, and attitudes, which can affect the value ascribed to children, the use of modern medicine, hygiene, food preferences, and fertility (Mosley and Chen, 1984).

## A Review of the literature

### **Adverse exposures in early life and later life outcomes**

A variety of approaches have been applied to demonstrate the critical implications of exposure to diseases and undernutrition in early life for later life outcomes. Studies conducted in the UK have shown that children who had suffered from severe illness and respiratory infections were shorter on average (Kuh and Wadsworth, 1989; Rona and Florey, 1980; Tanner, 1962). A history of disease in early childhood may, however, be endogenous in relation to later outcomes, and would not, therefore, reveal causal effects. Unexpected exogenous events, such as outbreaks of disease and famine often feature in estimates of the causal effects of exposure to adversity in early life on later life outcomes. For example, individuals who were in utero during the Dutch “Hunger Winter” of 1944–1945 when food supplies were cut off for eight months, evidenced higher rates of obesity (Ravelli et al., 1999), type two diabetes (Lumey et al., 2009), schizophrenia (Susser et al., 1996), and schizoid personality disorder (Hoek et al., 1996). Moreover, studies showed that women who were exposed in early gestation had children with lower birth weight (Lumey, 1992), and women who were exposed to the famine during their childhood had increased risks of breast cancer (Elias et al., 2004). Almond (2006) studied the impacts of an outbreak of a short and unexpected influenza pandemic in 1918 that affected roughly two-thirds of mothers giving birth that year and found that those who were in utero during the period of the pandemic had worse health, education, and income.

Another approach that has been used to estimate the effects of early life conditions on later outcomes entails an assessment of temporal variations in ecological indicators that capture or proxy disease environments and nutritional availability. Temporal variations in malaria rates in early life were found to affect educational attainment in the United States (Barreca, 2010), the economic status of men in India (Cutler et al., 2010), men’s productivity in Colombia, the United States, Brazil, and Mexico (Bleakley, 2010), and female education and literacy rates in Sri Lanka and Paraguay (Lucas, 2010). Infant mortality rate is also a commonly used proxy for adverse environments. Finch and Crimmins (2004) found that a high

infant mortality rate in the year of an individual's birth lowered her or his life expectancy by several years. The effects of exposure to adversity later in childhood were not as strong as those experienced in infancy, indicating that exposure to harm is more critical during the period of infancy than during subsequent life phases. Using data from nineteenth-century Sweden, Bengtsson and Broström (2009) found that a high infant mortality rate in the year of birth had a substantial negative effect on wealth accumulation as well as old age mortality. They did not find any evidence that early life adversity affected old-age mortality through acquired wealth, suggesting that physiological damage from infections was the leading pathway. Bozzoli, Deaton, and Quintana-Domeque (2009) found that the prevalence of post-neonatal mortality at birth had a substantial negative impact on adult height in Western Europe and the United States. The post-neonatal mortality rate at birth accounted for as much as 60% of variations in adult height, and most of the increase in stature over the period was attributable to a decline in post-neonatal mortality.

These studies have revealed scarring effects, that is, worse health outcomes in the surviving population caused by exposure to adversity in early life. However, studies have also found that populations exposed to adversity had better health outcomes than those not exposed, indicating that those with worse health potential were more likely to die as a consequence of adverse exposures, resulting in a higher observed mean health value for the surviving population. For example, a study found that individuals exposed to the Chinese famine in early life were taller as adults than those not exposed (Gørgens et al., 2012). A study conducted on adult women in SSA found a positive association with child mortality in the year of birth and adult height (Deaton, 2007). These findings have been attributed to the severity of these adverse exposures, which results in the dominance of selective mortality over scarring effects.

## **Intergenerational transmission of health**

Adverse exposures in early life not only impact negatively on those who experience it but also on their descendants through intergenerational health transmission. Intergenerational transmission refers to the environment, conditions, and exposures undergone by one generation that influences the outcomes of the next, for example in the areas of health, growth, and development. Maternal health is a particularly important factor in determining the health outcomes of children, as it relates to pregnancy, birth, and childcare. As previously discussed, relatively short average heights in many developing countries reflect a history of disease and poor nutrition in early life. The protective role of maternal height on the outcomes of children has been widely reported in studies (Baird, 1964; Donnelly et al., 1964).

Many studies have examined the relationship between maternal health, as measured by height, and child health outcomes in contemporary developing countries. A large-scale study covering 54 LMICs found a robust inverse relationship between maternal height and child health outcomes. The association between maternal height and under-five mortality was strongest in the neonatal period, followed by infancy. This association was consistent, and it was statistically significant for mortality in 46 out of 56 countries studied (Özaltın et al., 2010). In a study entailing a large sample drawn from 38 developing countries, Bhalotra and Rawlings (2011) found a considerable level of intergenerational persistence in health outcomes. They reported that a standard deviation increase in mother's height decreased the risk of her child's mortality in infancy by 7.6% in relation to the average mortality rate in their sample. Adjusting for parental SES and demographic characteristics decreased the intergenerational correlation by 45%, indicating that much of the association is indirect.

Smaller-scale studies have also been conducted. For example, one study found that children of taller mothers are less likely to die before the age of 5 years in Nigeria (Enwerem et al., 2014). In India, maternal height was found to be associated with child mortality, stunting, wasting, and anemia (Subramanian et al., 2009). In Vietnam, Venkataramani (2011) found that a child's height increased by approximately 0.2 standard deviations for a single standard deviation in maternal height (while controlling for paternal height). Another study found an association between maternal height and both fetal growth and gestational age at birth in the Nordic countries (Zhang et al., 2015). The association between maternal height and birth weight was found to be primarily defined by genetics, whereas its association with gestational age at birth was not.

Several studies have examined the correlation between a woman's birthweight and that of her child. Currie and Moretti (2007) found a strong correlation between the birthweights of mothers born in California during the period 1970–1974 and those of their children. A woman born with a low birth weight (less than 2,500 grams) was 50% more likely to give birth to a child with low birth weight when compared to her non-low birth weight sister. Moreover, they found that both the intergenerational correlation in birth weight and the correlation between birth weight and future outcomes were stronger in disadvantaged areas. Thus, they concluded that early-life health shocks are more severe for mothers from economically disadvantaged backgrounds. Addo et al. (2015) found that both maternal and paternal birthweights and early childhood growth were associated with a child's birthweight in several LMICs. The association with maternal growth in early life was higher, indicating the importance of pregnancy-related pathways in accounting for the relationship with child's birthweight and growth.

Using a large sample of children born in the United States during the period 1989–2006, Almond et al. (2012) identified a direct linkage between the disease environment of a mother during her early life and growth and childhood outcomes of her children. They found that white children born to mothers who were exposed to a period of high post-neonatal mortality (a proxy for disease exposure in early life) had a lower birth weight than those born to mothers that were not exposed. The reverse was the case for black children. The authors suggested that this finding may reflect selection, due to greater severity of exposures for black mothers. In a study of a British cohort born in 1958, Palloni et al. (2009) examined the intergenerational persistence of poverty and how it could relate to health during early life. They found that intergenerational transmission of social class could partially be attributed to childhood health. These effects on childhood health also extend to the development of human capital. A further finding was that early-life health is related to the socioeconomic gradient observed in adulthood.

Two studies examined whether more favorable living standards reduced intergenerational health transmission in developing countries using maternal height as a health measure (Bhalotra and Rawlings, 2013; Monden and Smits, 2009). They found a substantially weaker association between maternal height and child mortality for educated mothers compared with less well-educated mothers. However, because maternal education, like height, is also influenced by living standards during early life and childhood, they may be determined simultaneously. Therefore, a more valid approach for testing the impacts of living standards is to explore how factors external to the household interact with maternal height. Monden and Smits (2009) adopted this approach by interacting maternal height with district- and national-level factors, such as GDP, female employment, and the prevalence of hospital deliveries. However, they found an absence of heterogeneity in the association. On the other hand, Bhalotra and Rawlings (2013) found that temporal variations in female education, immunization rates, and income at aggregate levels modified the association between maternal height and mortality. An increase in female education by one year attenuated the association by 17%, and a standard deviation increase in the log of GDP, and in immunization rates, decreased the association by 20%, and 19%, respectively.

## **Parental education and child health**

Intergenerational transmissions of disadvantage are not only observed as health and biological characteristics, such as maternal height but they can also operate through various measures of SES, such as parental education. Parental education reflects past and present living standards, in addition to indicating their attitudes, resources, and skills for childrearing. Several studies have found a strong positive association between maternal education and child health that exceeds associations

for other measures of SES. Caldwell (1979) found a strong association between maternal education and child mortality in Nigeria. Caldwell suggested that maternal education enhanced skills and knowledge and positively influenced attitudes, and receptivity and adaptation to beneficial changes within a modernizing society. More recent studies have shown that maternal education is related to various measures of child health such as under-five mortality (Grepin and Bharadwaj, 2015), and child nutrition (Makoka and Masibo, 2015; Strauss, 1990), independent of other measures of living standards. On a national level, increased female education was found to be associated with improved nutrition globally (Headey, 2013) and to have a stronger association with improved child nutrition than did economic growth in Africa (Harttgen et al., 2013), explaining much of the decrease in the under-five mortality rate (Murphy et al., 2009). Education of girls also appears to be associated with child health beyond the developing context, with studies in the UK and Sweden linking maternal education to child health (Lakshman et al., 2013).

The pathways through which maternal education affects child health have been attributed to a variety of factors, such as increased access to and use of health-related products and services (Onsomu et al., 2015); knowledge, skills, income and SES (Cleland and Van Ginneken, 1988); information use (Handa, 1999; Thomas et al., 1991); assortative mating (Breierova and Duflo, 2004); reduced fertility (Grepin and Bharadwaj, 2015); and female empowerment and attitudinal changes (Caldwell, 1979). The importance of different pathways appears to vary. In some contexts, there is an income pathway relating to parental education (Frost et al., 2005), whereas in others there is none (Handa, 1999). The association of parental education with child health can also vary through its interaction with contextual factors. For example, contextual factors, such as access to health services have been found to be complementary<sup>3</sup> to maternal education in one context (Barrera, 1990), substitutes<sup>4</sup> in another (Thomas et al., 1990), and having no significant interaction with maternal education in a third context (Strauss, 1990).

The particular importance of maternal education above other measures of living standards has been disputed. Desai and Alva (1998) found a much weaker association between maternal education and child nutrition after adjusting for households' living standards and unobserved spatial variations. In their final model, the association of maternal education with child nutrition was only statistically significant in a handful of developing countries. However, they noted

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<sup>3</sup> I.e., children of educated mothers benefit more from access to health care than children of non-educated mothers, possible due to greater uptake or better access for educated mothers.

<sup>4</sup> I.e., access to health service reduces the health disadvantage of children born to non-educated mothers compared to children born to educated mothers, because mothers are to a less extent on their own in securing the health of their children.

that their control variables were inadequate for capturing all aspects of living standards and other possible confounders, both individual and contextual.

Mosley and Chen's study (1984) suggested that paternal education mostly affects child survival through increased income, especially in an urban setting, but a more favorable attitude on the part of educated fathers may also play a role. The role of paternal education in child health has not received as much attention, but several studies have compared this with maternal education. Some studies found an association between child health and maternal education but no association with paternal education (Aslam and Kingdon, 2012), whereas others found an association with both maternal and paternal education, sometimes of similar magnitudes (Breierova and Duflo, 2004; Semba et al., 2008). A large-scale study found a similar association between maternal and paternal education, and child nutrition after adjusting for contextual factors, the educational composition of the household, and interactions between maternal and paternal education (Vollmer et al., 2017a). According to the authors, maternal education reflects living standards more systematically than does paternal education.

It is also unclear whether parental education has a causal effect on child health or whether it is merely a marker of subtle differences in living standards, innate ability (Card, 2001), or genetic and childhood endowments (Behrman and Wolfe, 1987). The results of small-scale causal studies have varied, often depending on the context or the outcomes used (Currie and Moretti, 2003; De Neve and Subramanian, 2017a; Grepin and Bharadwaj, 2015; Güneş, 2015; Lindeboom et al., 2009; McCrary and Royer, 2011). In two studies, the educational reform in Zimbabwe was considered as an exogenous variation allowing causal effects of maternal education on child health to be identified. One study, which used under-five mortality as an outcome, found that children born to women with secondary education were substantially less likely to die (Grepin and Bharadwaj, 2015). The second study found no effect on child stunting using the same natural experiment, (De Neve and Subramanian, 2017b).

Because of the multitude of pathways, confounders, and interactions, it is not surprising that the strength of the association between parental education and child health is context-dependent (Jeong et al., 2018). The association between parental education and child health has been observed to vary between different populations (Desai and Alva, 1998; Jeong et al., 2018), but it is also likely to vary within populations over time, as the context changes. Caldwell (1979) observed that in the 1970s, the association between maternal education and child survival lessened over time. Bado and Sathiya Susuman (2016) found reduced disparities in under-five mortalities in relation to maternal education for later-born children in several countries in SSA born 1990–2015. Between 1992 and 1995, undernutrition of children in urban India declined, whereas inequalities between socioeconomic



groups increased (Kumar et al., 2015). In the state of Sao Paulo in Brazil, disparities in under-five mortalities by household wealth decreased, whereas those related to maternal education increased (Sastry, 2004). Among Norwegian children born during the period 1968–1991, the association between neonatal mortality and maternal education increased over time (Arntzen et al., 1996). It is therefore apparent that the association between parental education and child health not only varies by country, but it also changes within countries over time, and not necessarily in the same way as other socioeconomic measures.

## **Religious affiliation and child health**

Studies on sociocultural factors, such as religion, and child health have been far fewer than those on maternal health and paternal education, and child health. Religion influences behaviors, traditions, and attitudes. Thus, religion and religious affiliation may directly influence proximate determinants, for example, through hygiene, feeding practices, and attitudes towards modern medicine, or through other determinants, such as parental education, productivity, or fertility. However, religious affiliation may also be unrelated to child health beyond merely reflecting social status and access to resources.

Studies have revealed that certain religious groups have significant health advantages over other groups, despite having lower living standards. This finding suggests that behaviors and attitudes that are rooted in religious doctrine may be beneficial for child health. In the nineteenth and early twentieth centuries, child mortality rates among Jews were lower than those of Christians despite Jews having lower living standards in Europe and the United States (Condran and Kramarow, 1991; Derosas, 2003). It has been suggested that these differences are related to the emphasis on personal hygiene in Judaism, which would be incidentally beneficial for child health outcomes (Preston and Haines, 2014). Others have suggested that social isolation of Jews reduced their exposure to infectious diseases, leading to reduced child mortality. Contemporary studies in India have similarly found lower child mortality among Muslims than among Hindus, despite Muslims having substantially worse living standards (Bhalotra et al., 2010). However, studies exploring differences based on community-level religious composition found that child mortality rates among Hindus and Muslims residing in communities with Muslim majorities were similar. It has been suggested that the reason for this finding is the lower rates of open defecation among Muslims, and in Muslim communities, which reduces mortality due to exposures to fecal germs (Geruso and Spears, 2018).

A study by Caldwell (1986) revealed an overlap between developing countries with mostly Muslim populations and those with high child mortality rates.

Caldwell attributed the poor outcomes in countries with significant Muslim populations to the role of women, who had lower levels of education, whose use of family planning was limited, and who had little access to employment outside of the home. It should be noted that Caldwell did not claim that these outcomes were inherent to Islam or that they were immutable; instead, Caldwell suggested that they were embedded in the contemporary cultural context of these regions. West Africa has large populations of both Muslims and Christians, but studies have found that children born to Muslims have worse health outcomes and that Muslim mothers are less likely to use health care. Two studies from Burkina Faso and Nigeria found that vaccination rates were lower among children born to Muslims than among those born to Christians (Antai, 2009; Soura et al., 2013). Utilization of maternal health services was found to be lower among Muslim mothers than among Christian mothers in Ghana. In both of these studies, SES only partially explained these differences, suggesting that they may be rooted in religious teachings. However, a study from Ghana found that SES entirely explained the lower survival of children born to Muslim women (Gyimah, 2007), suggesting that religion may merely reflect differences in living standards and access to resources.

## Summary

The theoretical framework guiding this dissertation and the terminology used for the relationships under investigation are those of the capabilities approach pioneered by Amartya Sen (1990). This approach posits that the value of health and education is more than intrinsic, and illustrates the enormous breadth of the determinants of human development. Capabilities determine functionings, that is, what individuals are able to be and do. Whereas internal capabilities are embedded in individuals in the form of skills and capacities, external capabilities, namely freedoms and opportunities, extend beyond individuals, enabling them to achieve functionings both in the present and in the future. For example, in early life, external capabilities, such as parental resources, disease-free environments, and access to health care, are important determinants of both current and future well-being. Heckman's skill production function emphasizes that internal capabilities are acquired through a cumulative process and points to the efficiency of investments in early life, as internal capabilities are self-producing and dynamically complementary, so that "skills beget skills" (Heckman, 2007; Heckman and Corbin, 2016). The importance of investments during the early phase of life is further supported by a large body of literature that documents the importance of early-life nutrition and disease control for human development (Barker, 2004; Gluckman et al., 2010).

Sound health is a critical component of the human development process. Undernutrition and infections along with perinatal factors are the most common proximate causes of child mortality and morbidity in developing countries (Liu et al., 2017, 2015). More remote socioeconomic and sociocultural factors are also widely acknowledged as influencing child development. Mosley and Chen (1984) formalized how socioeconomic factors, such as parental education and sociocultural factors, such as religion, are operationalized in ways that influence child health through nutrition, disease prevention, environmental contamination, maternal factors, and injuries, which are proximate determinants of child health.

Sub-Saharan Africa contains most of the world's least developed countries, where many fundamental capabilities, such as survival, bodily health, and primary education, are far from guaranteed (UN, 2018; UN IGME, 2015; World Bank, 2018, 2017). The opportunity to developed skills and capacities is inhibited by frequent exposures to infectious diseases, food insecurity, lack of services such as health care and education, and lack of infrastructure such as clean water provision. As a consequence, parents and communities in SSA are to a greater extent left on their own in ensuring the healthy development of their children, in an environment that is more hazardous, compared to parents in developed countries, where nutrition is abundant, infections less severe, and health care and education available for most parents. Obstacles to healthy human development persist across generation, and as underprivileged individuals grow up, the toll on their health and socioeconomic status negatively impacts the healthy development of their children.

Previous research has used infant mortality in the year of birth as a proxy for infectious diseases environment and other proximate determinants of child health and demonstrated negative, scarring effects, on the health outcomes of the survivors in adulthood (Bengtsson and Lindström, 2003; Bozzoli et al., 2009). Studies have also indicated that selective mortality may have a more significant impact on the observed health of the surviving population when adversity is severe, such as in many contexts in SSA, biasing downward, or in the most extreme cases, indicating a positive association between early life adversity and health (Deaton, 2007; Preston et al., 1998). The first paper in this dissertation contributes to this literature by testing the impact of a novel measure of adversity experienced in infancy on outcomes observed earlier in the human development process than in adulthood in SSA.

Intergenerational transmission of health from mother to child has been observed in most developing countries, using maternal height as a measure for accumulated health (Bhalotra and Rawlings, 2011; Monden and Smits, 2009; Özaltin et al., 2010). Although a part of this association has been attributed to SES, residual association remains indicating that maternal height is a proximate determinant

impacting child health directly. However, it appears that intergenerational health transmission occurs to a greater extent in disadvantaged environments (Bhalotra and Rawlings, 2013; Currie and Moretti, 2007). The second paper tests whether maternal height is associated with neonatal, postneonatal, and child mortality as well as with school attendance in SSA, and quantifies the extent to which the observed association is accounted for by various dimensions of living standards, demographic factors, and contextual and paternal characteristics. Whereas previous studies focused exclusively on child health outcomes, this study also explores the impact on school attendance. Last, the paper contributes to the literature through its assessment of whether public spending on health in SSA reduces intergenerational health transmission.

Children do not only inherit the health disadvantages from their parents; parental education has also been found to impact on children's health outcomes. Numerous studies have identified a positive association between parental education and child health, attributing it to various pathways (Caldwell, 1979; Vollmer et al., 2017a). However, social determinants of child health, such as parental education, are dynamic and highly context-dependent (Desai and Alva, 1998; Jeong et al., 2018). With recent advances in child health, education, and related factors, the context in LMICs has changed, which may have an impact on the observed association. The third paper explores the association between both maternal and paternal education with child health in LMICs and assesses whether the observed association has changed over time, as LMICs have developed. Also, it contributes to the literature through quantification of the statistical impacts of various dimensions of living standards and demographic and contextual factors, both for the observed association between parental education and child health and changes in the associations that have occurred over time.

Sociocultural factors, such as religion, have received much less attention than parental health and education. Studies have suggested that parental religious affiliation may be causally linked to child health via religiously prescribed behaviors and attitudes (Caldwell, 1986; Gyimah et al., 2006; Jarvis and Northcott, 1987). However, other studies have suggested that the differences in child health between religious groups can be explained by differences in living standards and access to resources (Gyimah, 2007). Muslim mothers' utilization of health care facilities has been found to be less than that of Christian mothers; a difference that is not fully explained by observed differences in living standards (Antai, 2009; Gyimah et al., 2006; Soura et al., 2013). Conversely, differences in SES fully explained the worse health outcomes observed for children born to Muslims compared to Christians in Ghana (Gyimah, 2007). The third paper revisits the topic of the Muslim disadvantage in child health and explores differences in child health outcomes between Muslims and Christians in 11 West and Central African countries. The main contribution of this paper lies in its assessment of the

relevance of geographic clustering of these religious groups—which only share a living environment to a limited extent—in accounting for observed differences in child health. The paper further explores the implications of community-level religious composition, and the statistical impact of various dimensions of living standards, health care use, and demographic characteristics.

## Data and methods

### Data

The empirical analyses presented in this dissertation are based on microdata obtained from the nationally representative DHS surveys conducted in numerous developing countries. Standardized questionnaires and measures are applied in the surveys, which are comparable across survey years and between countries, to obtain reliable data on population health and nutrition as well as other characteristics. The sampling is based on stratified multi-staged sampling. Stratification is commonly based on the type of residence (urban or rural) crossed by administrative or geographic regions. The primary sampling units (PSU) are sampled within each stratum, based on a probability proportional to population size, and using a sampling frame of geographically constructed areas, which are often the enumeration areas of the most recent census. Households are sampled within the second-stage sampling frame, and women aged 15–49 years within these households are interviewed by trained interviewers about their health, birth history, children’s health, partners, and household characteristics. In most of the surveys, all women in the 15–49 year age group are interviewed. However, in a few cases, only married women are interviewed, and in others, females aged 10–49 years old are interviewed. The response rate in the DHS surveys is very high in SSA, being approximately 98% and 97% for households and individual women, respectively, during phases II and III (Vaessen et al., 2005). Non-responses are not replaced, but numerous measures are included to ensure high response rates. Smaller population segments are oversampled to acquire an adequate number of observations for analysis. Sampling weights are provided to adjust for oversampling, non-responses, and for greater precision. Weights applied to both respondents and households are calculated as the inverse of the probability of being included in the survey (Aliaga and Ren, 2006).

The DHS provides various types of data files (recodes) arranged according to the units of analysis. The main type of recode used in this dissertation are birth recodes, in which each record is a single birth from the birth history of interviewed women, constituting the source of outcomes such as mortality and anthropometric

measures. The other outcome used in this dissertation, school attendance, was recorded in a household member recode, which contains basic information on each household member. In one analysis, a variable for community-level religious composition was calculated using the individual recode, entailing one record per respondent. The surveys are appended, and then the different recodes are merged using the identifiers provided in each survey as well a survey identification number attached to each data file.

Although efforts have been made to provide high quality and accurate data, there are some apparent deficiencies. Age heaping is a persistent problem, with respondents disproportionately reporting certain ages, such as ages ending in zero or five. On average, 5% of respondents misreported their ages, showing a digit preference (Lyons-Amos and Stones, 2017). Omissions of births from birth histories are another problem. It has been suggested that this problem is most common for births which occurred at younger ages among older cohorts. However, there have also been indications that omissions from birth histories may occur for more recent births, more commonly for deceased children and children of uneducated mothers (Schoumaker, 2011). Date-of-birth displacements have also been reported where birth dates are altered beyond a certain age threshold, for which more detailed information should be obtained. A detailed health questionnaire is administered for respondents with children below 5 years old, which may have motivated interviewers to displace birth dates that occur close to five years before a survey, to a date just after the threshold time for the detailed health questionnaire. Similarly, the ages of respondents may be displaced to below 15 years and above 49 years (Pllum, 2006).

The DHS surveys do, however, have numerous benefits. Primarily, they enable researchers to study a wide range of demographic and health-related topics in multiple developing countries where civil registration systems and health and education data are generally lacking. The major benefits of these surveys lie in their broad geographical scope and their use of a large number of standardized variables. Moreover, they are extensively used in the fields of demography, economics, epidemiology, and public health, thereby facilitating more efficient research and communication among scholars.

## **Methods**

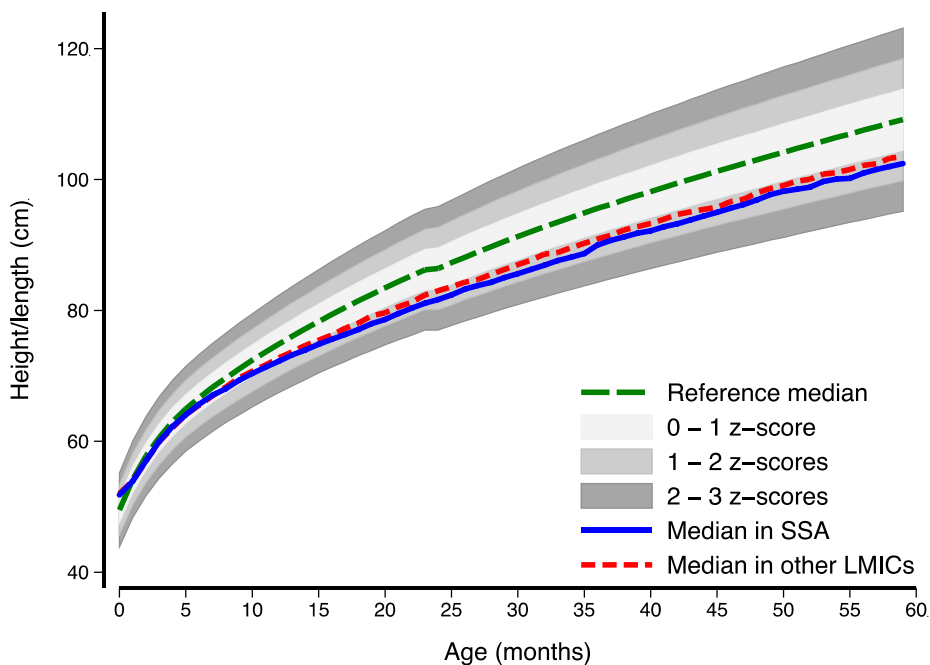
### *Outcomes*

Anthropometric measures are applied as outcomes for children in three of the papers. The WHO provides standards for the growth trajectory of healthy children (WHO, 2006a). The 2006 WHO growth standards are constructed using data from the WHO Multicentre Growth Reference Study which include breastfed infants

and appropriately fed children growing up in optimal conditions and of various ethnic backgrounds (WHO and UNICEF, 2009). Height-for-age z-scores reflect the standardized distribution of height, by age and sex, indicating standard deviations from the WHO growth standards.

$$\text{height-for-age z-score}_{as} = \frac{cm_{as} - r\widetilde{cm}_{as}}{\sigma_{rcm,as}}$$

The height-for-age z-score of an a-month old child, of sex s, is calculated by subtracting the median height of the corresponding age and sex in the reference population (rcm), from the child's height (cm) and divided by the corresponding standard deviation of the reference population ( $\sigma$ ). A z-score corresponds to a standard deviation from the reference median. Recumbent length is usually measured for children under 24 months old, while height is measured for older children.



**Figure 6. The 2006 WHO growth standard compared with those in sub-Saharan Africa (SSA) and other low- and middle-income countries (LMICs)**  
Medians are calculated using all available DHS data and are weighted using sampling weights adjusted to sum to one for each survey. The WHO growth standards released in 2006 show averaged growth for males and females. Source: DHS (2018); WHO (2006a).

Figure 6 shows the growth trajectory based on the WHO growth standards (2006) with the z-scores (or standard deviations) in relation to that trajectory. It shows that the height-for-age of children in SSA and other LMICs is slightly greater than the reference population in the first month, indicating that measurement errors or selective mortality may be a problem in relation to measures of neonates. Measurements for children in both SSA and other LMICs start to deviate from the growth trajectory as they advance in age, indicating cumulative exposure to infections and undernutrition. The deviation is greatest for children in SSA at around 24 months when they start catching up with the WHO growth standards, although only to a minimal extent.

Anthropometric measures are often dichotomized. Child stunting indicates chronic undernutrition, defined as two height-for-age z-scores below the reference median. Other common indicators are wasting, defined as two weight-for-height z-scores below the reference median, indicating acute malnutrition, and underweight, defined as two weight-for-age z-scores below a reference median, which is a composite indicator for chronic and acute undernutrition (WHO, 2010). Dichotomized measures are particularly useful in population-level comparisons and trends as they can be presented as prevalence measures. In analyses of individual data, continuous measures can be preferable, as exposure to undernutrition and diseases in early life shifts the entire distribution downward.

In two papers of this dissertation, school attendance is used as an outcome in relation to maternal height and adverse exposures in infancy. School attendance is a binary indicator of whether 7–16-year-olds attended school at the time of the survey. Children enter primary school when they are either 6 or 7 years old for the duration of 6 to 7 years (UNESCO, 2011). In three papers of this dissertation, under-five mortality is used as an outcome that indicates whether a child died between birth and the age of 59 months. In the paper on maternal height, all births from the compiled birth histories are included, whereas, in the respective papers on parental education and religion, only births occurring 0–59 months before a survey are considered. Information on health care use, such as whether or not a child was born in a health facility, is generally only recorded for births occurring less than 60 months prior to a survey. Because use of healthcare facilities is one of the mechanisms through which parental education and religion are thought to impact on child health, only births occurring less than 60 months before the surveys are considered for these papers.

As discussed above, the underlying causes of neonatal, post-neonatal, and child mortality are somewhat different. Therefore in the paper on maternal height, under-five mortality is separated into these three phases of mortality. Neonatal mortality is approximated as death within the first month, post-birth. Post-neonatal mortality refers to the death of a child who survived the neonatal period but died



between the ages of 1–12 months. Child mortality refers to the death of a child who survived the first 12 months but died between the ages of 12 and 59 months. Children below the age of one month at the time of the survey are excluded from the analysis of post-neonatal mortality, and children below the age of 12 months at the time of the survey are excluded from the analysis of child mortality because they had not entered the risk period. Descriptive statistics on mortality, especially child and under-five mortality are likely to be underestimated because not all children lived through the risk period.

### *Gelbach decomposition and Mundlak’s fixed effects*

Gelbach decomposition is used in three of the papers to estimate the statistical impacts of covariates on the relationships of interest (Gelbach, 2016). Estimates entailing the use of multiple regression models are common in social science research, beginning with a simple model and subsequently adding control variables, stepwise, to account for the statistical impacts of different covariates on the relationship of interest. The goal can be to comment on how much of the mean difference for a specific outcome between categories is attributable to category-level heterogeneity in the covariates. For example, the question of the extent to which observed differences in the height between children born to educated and non-educated mothers are due to differences in measures for fertility, SES, and use of health care facilities between the two groups can be considered<sup>5</sup>. The main problem entailed in the use of sequential addition of covariates to comment on the statistical impact of each of the added covariates on the relationship of interest is that the order in which variables are entered influences the results. To avoid this problem, Gelbach proposed a method of decomposition based on the formula for calculating omitted variable bias.

In practice, the decomposition is conducted by first running a restricted regression with outcome  $y$ , the exposure variable of interest  $e$ , and a vector  $\mathbf{x}$  containing any number of basic control variables.

$$y = \alpha^{\text{basic}} + e\beta^{\text{basic}} + \mathbf{x}'\boldsymbol{\rho}^{\text{basic}} + \varepsilon^{\text{basic}}$$

Here the outcome  $y$  denotes height, exposure  $e$  denotes maternal education, and  $\mathbf{x}$  denotes a vector of some control variables, e.g., the child’s age and sex.

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<sup>5</sup> The interpretation of the decomposition is the same regardless of whether a correlation coefficient for years of education is decomposed or mean difference in height between children born to educated mothers compared to non-educated mothers.

Subsequently, another regression is run that includes an additional set of covariates:

$$y = \alpha^{\text{full}} + e\beta^{\text{full}} + \mathbf{x}'\boldsymbol{\rho}^{\text{full}} + \mathbf{z}'\boldsymbol{\gamma} + \varepsilon^{\text{full}}$$

Here  $\mathbf{z}$  contains some number of variables, for example, household income, number of siblings, and the number of vaccines received. The objective is to estimate the independent statistical impacts of each of the additional covariates from  $\mathbf{z}$ , which appear in the unrestricted regression only, on the parameter of interest  $\beta^{\text{basic}}$ .

The difference between the two estimates is calculated as:

$$\boldsymbol{\delta} = \beta^{\text{basic}} - \beta^{\text{full}}$$

$\boldsymbol{\delta}$  is the total impact of all the covariates in  $\mathbf{z}$  on the association between maternal education and child height, adjusted for  $\mathbf{x}$ . In this example,  $\mathbf{z}$  entails three variables, namely income, vaccines, and siblings. Therefore,  $\mathbf{z}' = z_1, z_2, z_3$ . Three auxiliary regressions are run, the first for household income, which is expressed as follows:

$$z_1 = \alpha_1 + \alpha_{1e} e + \boldsymbol{\alpha}_{1\mathbf{x}}' \mathbf{x} + \omega_1$$

Here  $z_1$  denotes household income. The same process is followed for the other two covariates, siblings, and vaccines. In the above equation,  $\alpha_{1e}$  denotes the association between maternal education and household income, independent of  $\mathbf{x}$ . The total impact on  $\beta^{\text{basic}}$  attributable to all three covariates is calculated as:

$$\boldsymbol{\delta} = \beta^{\text{basic}} - \beta^{\text{full}} = \sum_{f=1}^3 \gamma_f \alpha_{fe}$$

The statistical impact of the income measure on the association between maternal education and height is obtained using the following calculation:

$$\delta_1 = \gamma_1 \alpha_{1e}$$

Therefore, the impact of the income covariate is determined first by the strength of the association between income and child's height, independent of vaccinations, number of siblings, age, and sex ( $\gamma_1$ ), and second by the strength of the association between maternal education and income, independent of age and sex ( $\alpha_{1e}$ ). The same applies to the other two variables in  $\mathbf{z}$ , namely vaccines and siblings.

The decomposition allows for any number of basic controls in  $\mathbf{x}$  and any number of covariates in  $\mathbf{z}$ . The impacts can easily be summed up for a set of covariates relating to similar mechanisms. For example, rather than using just the number of siblings to capture fertility, a set of variables, such as the number of siblings, maternal age at birth, and birth interval can be added. Consequently, the total statistical impact of the measures for fertility is the sum of the estimated impact of each of the covariates relating to fertility.

All of the analyses in this dissertation use fixed effects, which control for group-level heterogeneity, at the level of the survey, region-ethnicity, community (primary sampling units), mother, or father, respectively. Mundlak's fixed effects are used when conducting the Gelbach decomposition by adding a group level mean of all valid observations, for all independent variables (Antonakis et al., 2010; Mundlak, 1978). This procedure yields group-level parameters that can be used to decompose the statistical impact of between-group heterogeneity on the relationship of interest.

Two alternative methods are widely used to control for group-level heterogeneity, which are, however, not feasible when estimating the impacts of group-level heterogeneity using the Gelbach decomposition. The first method entails adding a dummy coded variable for the group. However, because the number of groups can number in the hundreds of thousands, this is not computationally efficient. A second conventional method of adjusting estimates for a large number of groups is to subtract a group-level mean of valid observations, from each independent variable. However, this method does not provide any group-level estimates, which are needed in the Gelbach decomposition to estimate the statistical impact of between-group heterogeneity on the relationship of interest. All three methods for controlling for group-level heterogeneity yield parametrically identical estimates for variables measured below the group level. Further, the impact of using Mundlak's fixed effects within the Gelbach decomposition is parametrically identical to that of decomposing a set of group-level dummy coded variables.

## Summary of papers

### **Paper I: Scarring and selection in sub-Saharan Africa: The effects of adverse environment in infancy on health and education**

High infant and child mortality, as well as the high prevalence of stunting, indicate the difficult conditions that infants and children are subjected to in SSA, where diseases and undernutrition are significant causes (Horton et al., 2008; Liu et al.,

2017, 2015; UNICEF, 2007). Other sources of adversity include, for example, indoor air pollution emanating from cooking fuel, which causes pneumonia (WHO, 2014). Human development is a process in which inadequate investments in critical areas, such as disease prevention and nutrition, during one life period, such as infancy, can have detrimental effects on outcomes during subsequent periods, and, ultimately, in adulthood (Bozzoli et al., 2009; Heckman and Corbin, 2016). There is extensive literature that links undernutrition and disease exposure in early life to outcomes in later life, such as cognitive abilities, earnings, education, and health (Almond, 2006; Barker, 1997; Bengtsson and Lindström, 2003; Case and Paxson, 2008; Finch and Crimmins, 2004). These studies indicate the occurrence of a scarring effect, whereby adverse exposures shift the entire distribution of health downward, resulting in a lower mean for health. Studies have also found evidence of a selection effect, whereby children with underlying health problems are more likely to die than healthier children when faced with adversity as a result of which the surviving population appears healthier (Deaton, 2007; Gørgens et al., 2012). It has been suggested that the selection effect may dominate in conditions of severe adversity, for example, in many countries in SSA.

Paper I tests the influence of an adverse environment during infancy on subsequent child health and school attendance in SSA. The contributions of this paper are threefold. First, a novel spatiotemporal indicator for adverse environment experienced in infancy is constructed using geocoded birth histories obtained from household surveys. Contrasting with previous studies that have relied on national-level measures of adversity, measured for calendar years, this indicator provides more variance in adversity as it is more geographically and period specific. Second, the effects of an adverse environment in infancy on observable outcomes during a part of the human development process that precedes adulthood are assessed. Previous studies have focused mostly on observable outcomes in adulthood, which may obscure some of the negative impacts of adverse exposures in infancy, which may be especially important in a context such as SSA, where selection effects may dominate scarring effects on health outcomes in adulthood. Third, the paper examined whether the observed impacts of an adverse environment in infancy are less severe in better-off households in SSA and whether there are differences in the effect by sex.

For the above analysis, data at the individual, household, and community levels extracted from DHS surveys conducted in 33 countries in SSA are used. The outcomes considered are height-for-age z-scores that are indicative of nutrition available for growth after accounting for disease, and school attendance. The incidence rate of postneonatal mortality (PNM) occurring within a 50 km radius of the place of birth during the period of infancy is considered an indicator of an adverse environment. The interactions of an adverse disease environment with household living standards are assessed to determine whether children in better-off

households are less impacted. OLS models with fixed effects at the levels of the survey, community, and mother are applied.

The results indicated that an adverse environment in infancy negatively affects the height-for-age of the surviving children. However, the magnitude of the effect, which is small, is only observed at the lower end of the PNM distribution. The association with school attendance is also found to be weak and negative at the lower end of the PNM distribution, but it is positive at higher levels. Households' socioeconomic status does not appear to modify the effect. Higher selective mortality at high levels of adversity may offer an explanation for the absence of negative effects at high levels of adversity.

## **Paper II: Maternal height and child development in sub-Saharan Africa: Underlying mechanisms and the role of public spending on health<sup>6</sup>**

Intergenerational transmission of poor health from parents to children is well established within the academic literature. Breaking these negative intergenerational cycles can substantially improve the health of populations in developing countries. In poorer countries, such as those in SSA, children are at a higher risk of inheriting their parents' poor health because poor health as well as low levels of household resources are aggravated by rampant diseases and vulnerability to food insecurity; lack of services, such as health care; and a poor health environment. Although SSA accounts for 11% of the world's population, its health expenditure accounts for only 1% of global health expenditure. Given that 50% of under-five mortalities occur in this region and that it bears 24% of the worldwide disease burden (WHO, 2006b), the need for adequate health care in SSA is substantially higher than in other regions. Human development, adult health, and related outcomes are compromised by infections and undernutrition in early life, which reduces physical growth and are, reflected in short average stature of women in SSA (Moradi, 2010; Silventoinen, 2003; Steckel, 1995b).

Studies conducted in a large number of LMICs have used maternal height and under-five mortality to assess intergenerational transmission of health from mother to child (Bhalotra and Rawlings, 2011; Monden and Smits, 2009; Özaltın et al., 2010). Suggested pathways include physiological factors and compromised human development from harmful exposures in early life, which influence adult health, and which subsequently determine income and education levels (Currie and Vogl,

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<sup>6</sup> Paper II was co-authored with Martin Dribe. Both authors contributed to the study concept and design, the interpretation of findings, and the drafting of the manuscript. The author of this dissertation acquired the data and conducted the statistical analysis.

2012). Hence, the mechanisms underlying the association of maternal height and child health can reflect a variety of factors, such as income, education, accumulated health, and related factors as well as physiological factors entailing impacts on the growth of the fetus during pregnancy and risk during birth.

Studies have examined interactions between maternal height and modifiable factors at the household, district, and national levels. At the household-level, outcomes of children born to educated mothers were found to have a weaker association with maternal height. However, maternal education reflects mother's past living standards, which is also a major determinant of adult height, so maternal height and education are therefore determined simultaneously, to an extent (Bhalotra and Rawlings, 2013; Monden and Smits, 2009). A few studies have therefore focused on variations in modifiable measures of living standards beyond the household with mixed results. Monden and Smits (2009) found no interaction effects between national-level GDP, district-level health care use and economic status, and maternal height, for under-five mortality. However, Bhalotra and Rawlings (2013) found an interaction between maternal height and changes in aggregate national-level factors at the time of birth, with improvements in GDP, female education, and vaccination rates reducing the strength of the transmission.

This paper is aimed at advancing understanding of the intergenerational transmission of health, using maternal height, in two ways. The first entailed an exploration of potential mechanisms. The association of maternal height with various outcomes that have different underlying determinants is first estimated, and the extent to which the associations are attributable to measures likely to overlap with maternal height (i.e., maternal education, fertility, household SES, and community and paternal characteristics) is quantified. The second contribution entailed an examination of whether increased public health expenditure has led to decreased intergenerational transmission of poor health in SSA. The paper also contributes to the literature in other ways. The first is the focus on SSA, which is the most impoverished region in the world with the worst child health outcomes, the lowest health expenditure, and a high proportion of disadvantaged households. The second contribution relates to the consideration of other outcomes apart from health and longer-term consequences of maternal height for human development through the inclusion of school attendance as an outcome.

Data at the individual, household, and community levels are extracted from multiple DHS surveys conducted in 35 countries in SSA between 1992 and 2016. These data are linked to data on annual government health expenditure for the period 1995–2015, obtained from the WHO Global Health Expenditure Database (WHO, 2017). The findings of the analysis are in line with those of previous studies, demonstrating a consistent relationship between maternal height and under-five mortality that is statistically significant in all but five countries. The

association with neonatal mortality appeared to be direct to a greater extent than the association with mortality at a later stage in childhood. Of the covariates, community-level factors appeared to have the most explanatory power, followed by household SES and fertility. Paternal and household characteristics explained most of the association with child mortality for children in polygamous households, but they do not account for any of the association with neonatal and post-neonatal mortality. However, after accounting for covariates, a robust residual association remained for all mortality outcomes. There is also an association between maternal height and school attendance, which, however, is weak and not statistically significant in most countries, and mostly explained covariates for community-level factors, maternal education, and SES. Government health expenditure substantially weakened the association between maternal height and under-five mortality, but this is not the case for education. These results indicate that physiology is the most important underlying mechanism behind the association between maternal height and under-five mortality, but interventions such as public health expenditure around the time of birth can substantially reduce its persistence, especially for infant mortality.

### **Paper III: Weakening association of parental education: analysis of child health outcomes in 43 low- and middle-income countries<sup>7</sup>**

The World Bank and the UN have recommended maternal education as a cost-effective way to improve child health in LMICs (Jamison et al., 1993; United Nations, 2014, 1994; Veneman, 2007). Studies have found that the association of child health with maternal education is stronger than for other measures of SES (Caldwell, 1979; Grepin and Bharadwaj, 2015; Harttgen et al., 2013; Headey, 2013; Lakshman et al., 2013; Makoka and Masibo, 2015; Murphy et al., 2009; Thomas et al., 1990). This association has been attributed directly to proximate determinants of child health, such as illness control and nutrition, whereas the effect of paternal education is mostly attributed to increased earnings (Mosley and Chen, 1984). The suggested pathways through which maternal education affects child health include SES (Cleland and Van Ginneken, 1988), skills (Handa, 1999; Thomas et al., 1991), assortative mating (Breierova and Duflo, 2004), reduced fertility (Grepin and Bharadwaj, 2015), use of health care facilities (Elo, 1992; Onsomu et al., 2015), female empowerment, and attitudinal changes (Caldwell, 1979).

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<sup>7</sup> Paper III was co-authored with Jan-Walter De Neve and S.V. Subramanian. All of the authors contributed to the study concept and design, the interpretation of findings, and the drafting of the manuscript. The author of this dissertation acquired the data and performed the statistical analysis. The paper has been published in the *International Journal of Epidemiology* (Karlsson et al., 2018).

Other researchers have shifted from an exclusive focus on maternal education, emphasizing the need to understand pathways and heterogeneity in the association (Subramanian and De Neve, 2017). The association between maternal education and child health demonstrates a very high degree of heterogeneity between countries and is rarely statistically significant for individual countries after accounting for community-level factors and household living standards (Desai and Alva, 1998; Jeong et al., 2018). Further, studies have found that the associations of each parent's education with child nutrition are of similar magnitudes (Vollmer et al., 2017a). Estimating a causal effect of parental education on child health is difficult because unobserved variables such as innate ability (Card, 2001) and other endowments (Behrman and Wolfe, 1987) determine both education and child health, leading to confounding bias. Education policy reforms have been exploited and used as “natural experiments” which provide causal estimates, but these studies have yielded conflicting results (Currie and Moretti, 2003; De Neve and Subramanian, 2017a; Grepin and Bharadwaj, 2015; Güneş, 2015; Lindeboom et al., 2009; McCrary and Royer, 2011).

As the literature suggests, the relationship between parental education and child health operates through multiple pathways, is likely to be confounded, and is highly context-dependent. Changing contexts in LMICs entail modernization and improvements related to child health and education as well as factors related to the suggested pathways and confounders. Therefore the relationship between parental education and child health is likely to have changed over time. A few studies have observed changes in the association between maternal education and child health. Caldwell observed attenuation over time in the association between maternal education and child survival in the 1970s (Caldwell, 1979). There was a modest decline in the differences in child undernutrition by maternal education between household surveys conducted in developing countries before and after 2000 (Vollmer et al., 2017b). The gap in under-five mortality rates between educated and uneducated mothers was lower for more recent birth cohorts in several countries in SSA (Bado and Sathiya Susuman, 2016).

A large sample of mutually comparable and nationally representative repeated cross-sectional studies from 43 LMICs are used to test changes in the associations of parental education with under-five mortality, stunting, wasting, and underweight status over time. The study explored the impact of measures of early-life conditions of mothers, assortative mating, fertility, households' living standards, use of healthcare facilities, urban-rural differences, and geographic clustering, in addition to differences between countries relating to changes over time. The results showed that the association of parental education has attenuated to a considerable extent over time. Underlying factors driving these changes appear to be related to the changing impact of fertility, households' living standards, and urban-rural differences on the association. Moreover, the



association of child health with nutrition is being increasingly driven by geographic clustering rather than by individual-level associations. However, an association remains between the education of both parents and all child health outcomes.

#### **Paper IV: Child health disparities by religious affiliation in West and Central Africa**

Religion is a major social force that plays a critical role in the lives of people in SSA. Over 90% of surveyed respondents stated that religion is very important in their lives (Lugo and Cooperman, 2010). Many countries are also religiously mixed with large numbers of both Christians and Muslims. Limited studies have been conducted on the sociocultural factors and child health, even though religion has an impact on norms, values, attitudes, and behaviors, while also reflecting SES. Some religions prescribe healthy behaviors relating to nutrition, hygiene, reproductive health, and substance use. Moreover, religion influences other known determinants of child health, such as education, productivity, and fertility (McQuillan, 2004). Differences in child health between religious groups have also been attributed to social and economic disparities (Gyimah, 2007; Jarvis and Northcott, 1987).

At the individual level, studies have found that Christian mothers demonstrate better health-related behaviors than Muslim mothers in West Africa and their children have been observed to have lower mortality rates (Gyimah, 2007; Gyimah et al., 2006; Soura et al., 2013). However, these studies have not fully accounted for geographic clustering of religious groups and community-level religious composition. Although Muslims and Christians coexist within national borders in West and Central Africa, these religious groups are highly clustered geographically and only share a living environment to a limited extent.

This paper studies the implications of geographic clustering of religious groups, as well as community-level religious composition, for child health. First, differences in outcomes between children born to Christians and Muslims are tested by comparing Christians and Muslims within religiously diverse communities. Secondly, children born to Muslims and Christians in communities that are religiously homogenous are compared. In addition, the implications of community-level religious composition are explored, for example, whether being a religious minority has any implications for child health. Last, the statistical impacts of living standards and demographic characteristics for the observed health differences are decomposed to identify the possible underlying factors linking religious affiliation and child health.

The results showed that in religiously mixed communities, there is no statistically significant difference in child health outcomes between Muslims and Christians, indicating that the observed discrepancies relate to geographic clustering of religious groups rather than to the direct effects of religious affiliation. All-Muslim communities have worse child health outcomes than all-Christian communities, which appears to be explained to a large extent by living standards, use of health care facilities, and fertility, although some residual differences remain.

## Discussion and conclusion

Human development is aimed at expanding capabilities that enable individuals to function and lead a good life. Fundamental capabilities are survival, bodily health, and basic education. Internal capabilities, or skills and capacities, accumulate throughout the life course, with early life and childhood being particularly important phases of accumulation. External capabilities provide individuals with the freedom and opportunities to develop and use capabilities. Examples include a disease-free environment with a secure supply of food and access to health care and education, as well as parents with sufficient resources. Whereas fundamental capabilities are almost guaranteed for children in developed countries, children in the developing world face challenges which jeopardize their survival, bodily health, and basic education. As a region, SSA has the highest rates of under-five mortality and out-of-school children as well as high levels of stunted physical growth. The main proximate determinants of child health are undernutrition and infectious diseases, as well as perinatal complications. Moreover, parental factors have been found to be important, and significant health disparities persist between groups.

This dissertation aims to explore the implications of context for the relationship between parental factors, and child health and school attendance in SSA as well as in other LMICs. Many household-level factors are geographically clustered, and parents with more resources are more likely to reside in favorable environments that independently determine child health and school attendance. For example, healthier and more educated parents are more likely to live in an environment with available education, health care facilities, and nutrition. Contextual environments are also correlated over the life course and across generations. Further, many of the proposed pathways behind parental determinants are related to contextual factors. For example, Mosley and Chen suggest that mother's education relates to her child's health by "influencing her choices and increasing her skills in health care practices related to contraception, nutrition, hygiene, preventive care, and disease treatment" (Mosley and Chen, 1984, p. 35). Therefore, the effectiveness of

parental education, or resources and skills more broadly, in determining child health evidently varies in accordance with the external environment with regard to, for example, the availability of health care, nutrition, contraceptives, health care, and clean water.

The first paper shows that the incidence rate of postneonatal mortality, which is a proxy for adverse environment in infancy measuring a large number of proximate determinants, affect physical growth negatively. However, the effect is small and is only observed at the lower end of the adversity distribution. For school attendance, there is also a small negative effect at the lower end of the distribution, but this becomes positive with higher levels of adversity. This finding indicates that adverse exposures in infancy can influence outcomes later in childhood, but also that selection effects may dominate in SSA, even when adversity is at relatively low levels. This finding supports the suggestion that selection dominates over scarring in contexts entailing high levels of adversity, such as in SSA (Deaton, 2007). The second paper shows that in most countries in SSA, maternal height appears to have a direct negative association with under-five mortality, independent of covariates, which corroborates findings from previous studies (Bhalotra and Rawlings, 2011; Monden and Smits, 2009; Özaltın et al., 2010). Further, because the association is strongest and most direct in the neonatal period, it is likely to be related to pregnancy and perinatal factors. The relatively limited impact of covariates indicates that maternal height is mostly a proximate determinant of child health. However, the association between maternal height and school attendance is mostly explained by other measures of living standards. Although the proximate determinants considered in these studies, namely maternal height and an adverse environment in infancy, appear to have an association with health outcomes in early childhood, they do not appear to negatively influence school attendance consistently or strongly. This may be because of the inadequacy of school attendance for capturing skill formation; a better measure would be achievements in school, such as grades.

The third paper shows that there is also a consistent association between parental education and child health in most LMICs, which is generally stronger for maternal education than for paternal education. This finding is in line with previous studies (Caldwell, 1986; Jeong et al., 2018). Mosley and Chen (1984), Caldwell (1986, 1979), and other researchers have suggested that maternal education is a socioeconomic determinant of child health that is of particular importance, as it is directly related to various proximate determinants. By contrast, paternal education is suggested to operate mostly via income. However, for all child health outcomes, the statistical impacts of covariates follow very similar patterns for maternal and paternal education, both for the main associations and for changes in these associations over time, which may indicate that maternal and paternal education may operate similarly in their relationship with child health.

Differences may, however, lie in the residual association. The fourth paper shows that, overall, in West and Central Africa, children born to Christian mothers have better health outcomes than children born to Muslim mothers, which corroborates previous findings (Antai, 2009; Gyimah et al., 2006). However, the difference in outcomes appears to be between all-Muslim and all-Christian communities and is mostly explained by observable measures of living standards, fertility, and use of healthcare facilities, although some residual differences remain.

The overarching research question of this dissertation is: “To what extents do contextual factors explain the observed disparities in child health by maternal health, parental education, and religious affiliation?” The results of this dissertation show that contextual factors matter for all parental factors, but to varying degrees. Contextual factors, measured as community-level factors explained about 12% of the relationship between maternal height and under-5 mortality, and about 21% for maternal height and school attendance. Community-level factors have greater explanatory power regarding under-five mortality rates than households’ living standards, whereas for school attendance community-level factors have less explanatory power than household living standards. Further, community-level factors explained a significant portion of the association of maternal education with under-five mortality (25%), stunting (16%) and underweight (18%) in the oldest set of DHS surveys, increasing to 42%, 27%, and 33%, respectively, in more recent DHS surveys. Similarly, community-level factors also explain a significant portion of the association of paternal education with under-five mortality (16%), stunting (13%), and underweight, (15%) in the oldest set of surveys, increasing to 40%, 25%, and 28%, respectively, in more recent DHS surveys. Community-level factors account for more of the associations between parental education and mortality than households’ living standards but less than fertility, whereas households’ living standards account for a greater portion of the relationship of parental education with stunting and underweight. The statistical impact of community-level factors on the associations has, however, increased over time for all outcomes (although not statistically significant for all outcomes), while the explanatory power of households’ living standards and fertility has decreased. Last, Muslims are only found to have worse child health outcomes in religiously homogenous communities in West and Central Africa. No differences are found between Muslims and Christians residing in religiously mixed communities, indicating that observed health differences are related to contextual factors.

The four sub-research questions focus on how parental factors interact with contextual factors at various levels. In relation to the first sub-question, children in better-off households, approximated by maternal education, are not found to be less affected by adverse environments in infancy. This indicates that better-off households do not mitigate harmful effects by investing more in children before,

during or after exposure to adverse environment in infancy. The findings relating to the second sub-question show that even though maternal height has a very consistent relationship with mortality in SSA, this association is reduced with an increase in public health spending at the national level. This finding indicates that public health spending benefits mothers with poor health and facilitates the care of children in disadvantaged households.

The findings relating to the third sub-question indicate that although parental education is consistently associated with under-five mortality and child health in LMICs, this association has decreased over time. Parental education does, however, still have an association with all child health outcomes in most countries. Further, over the investigated period, an urban penalty relating to child health appears to have emerged, which suppresses the association between parental education and child health, thereby contributing to the attenuation in the association over time. Conversely, geographic clustering appears to have increased over time, especially in the case of stunting. Consequently, the observed association is increasingly driven by the clustering of educated parents and healthy children in the same communities. Finally, with regard to the fourth sub-question, religious composition appears to have implications for children born to Muslims in West and Central Africa, where children in all-Muslim communities have worse health outcomes than children born to Muslims in religiously mixed communities. Most of this difference is explained by household living standards and the use of health care, but some residual differences remain.

In conclusion, the primary results of this dissertation reveal that context partly explains the relationships between parental factors and child health, but to varying degrees. A substantial part of the association between parental education and child health is explained by community-level factors, whereas community-level factors have less impact on the relationship between maternal health and mortality. However, both parental education and maternal health show a strong protective association with child health independent of community-level factors and a wide range of other measures of living standards, indicating that they are important indicators of external capabilities which give children the opportunity to survive, grow, and accumulate internal capabilities. However, the link between religious affiliation and child health appears to be mostly related to geographic clustering of religious groups, which reflect living standards and access to resources. Further, parental factors, especially socioeconomic and sociocultural ones, but also proximate determinants such as maternal height, vary in their relationships with child health depending on the context of the household. Improved contexts appear to weaken the link between parental education and maternal health, and child health. These findings underline the importance of considering the external context in which parental factors operate. SSA, as well as other LMICs, are going through

a rapid societal, economic, and epidemiological transition, which may change how parental factors influence child health.

The SDGs are aimed at improving survival, health, and education as well as reducing disparities by, for example, SES and ethnicity (UNICEF, 2018). Under-five mortalities in SSA and other LMICs increasingly occur in the neonatal period, indicating a shift from infectious diseases as the most critical factors influencing child survival, to preterm birth complications and perinatal factors (Liu et al., 2017, 2015). Maternal health needs to be ensured not only during pregnancy but also in her early life because the accumulated health of mothers appears to have a direct influence on survival beyond the neonatal period in SSA. Parental education has intrinsic value and also continues to be positively associated with child health in most LMICs. Disparities in child health between Muslims and Christians in West and Central Africa can be reduced through improved material living standards and access to, and use of health care facilities within Muslim communities. Improving the public health environment and preventing adverse exposures to infectious diseases and undernutrition is crucial for human development.

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