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CAUSAL RELATION BETWEEN BASIC EDUCATION, CHILD HEALTH AND NUTRITION FOR CHILDREN IN SUB-SAHARAN AFRICAN COUNTRIES: THE CASE OF TANZANIA

Doctoral Dissertation of

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« Ser Culto para Ser Libre »

(Be cultured to be free)

José Martí

Table of contents

Thesis Introduction

The main focus of this research thesis is the causal relationship between education and health for children who live in less developed countries. More precisely, I have decided to focus my attention on children of sub-Saharan Africa since those are the most vulnerable people. Moreover, in this part of the world the majority of the population still live in extreme poverty, and education, health and nutrition rates are much lower than those in the rest of the world. This situation is consequential to the lower quality and less accessible health and education services relative to industrialized countries.

Education and health care for young children have received high policy attention during the last decades. It has been recognized that equitable access to early childhood care and education of good quality, especially for the most vulnerable and disadvantaged children, is essential for sustainable economic and human development. Nevertheless, despite remarkable attainments in human capital, there is still room for improvement since less developed countries continue to face great challenges in improving education and health levels of their people.

The economics of education and the economics of health, beyond being mere investigations of economies, provide valuable means to understand the behaviour of the people involved in the development process. Several studies affirm that the main barrier to education and health in less developed countries is represented by parental choice, together with particular child's and social determinants. More precisely, low income, inadequate education, poor nutrition, high opportunity costs of child time are considered the major constraints on human capital investment, primarily in poor countries.

The economic science has affirmed in several fields the relevance of investments in people because it has been recognised that both individuals and society gain economic benefits from them. Enhancing the level of human capital should be a matter of public concern in less developed countries, since incentives to invest in public education or health vanish if a country is poorly endowed with human capital. Improvements in health status and primary education are not competing goals, but mutually reinforcing: enhanced pre-school nutrition will facilitate meeting the education objectives; further, acquisition of knowledge at school improving students' health and nutritional status. These

improvements imply positive relationships between both education and health with productivity, rising the opportunities of breaking the cycle of poverty.

The study of education and health status for children in less developed countries is a potentially fruitful area of research. For economists working on education and health, the study of developing countries offers both policy questions of fundamental importance and a rich set of experiences to examine. Nowadays, only few national statistics on the development of young children in those countries exist. To formulate policies focused on improving the status of children in poor countries, a clear understanding of the determinants of health, nutrition and education is needed.

The possibility of a strong connection between nutrition and schooling in less developed countries is of growing importance; the analysis presented in this work makes progress in sorting out such a casual relationship.

The research thesis consists of three essays focused on the relationship between education and heath for children in less developed countries.

The first chapter titled "The Role of Education and Health in Human Capital Development in Less Developed Countries" aims to offer the necessary tools to understand the issue and to implement a proper analysis on it. It provides an overview of what has been realised thus far, focusing on the pivotal aspects on which future research has to be directed.

Schooling and health systems of less developed countries are investigated to recognize which are the reasons of severe inequalities and inefficiencies that exist and afflict people who live in that part of the world. The effort is mainly focused on children of poor countries, with a particular focus on sub-Saharan Africa, since they represent the most vulnerable people. Furthermore, it is argued that intervention targeted on children during the first years of life is fundamental for fulfilling all other children's rights, represents the best guarantee of promoting sustainable development and would solve the efficiency and equity trade-off which subsist for investments later in life.

The following chapter represents a "Literature Review on the Causal Relations Between Education and Health for Children in Less Developed Countries". As the title suggests, it presents a detailed review of the literature on the evidence of the positive associations between education and health, trying to assess whether these relations mean

causality. Estimation methods used in these fields of study are identified. Then, distinction is made among the three possible options which may explain the observed positive association between education and health: education affects health; health affects education; a third unobserved factor affect both health and education in the same direction, without any causal relation between them. Final considerations are offered proposing suggestions for future research and policy interventions to improve the status of children in less developed countries.

The concluding and more important chapter is "Long-Term Impact of Health and Nutrition Status on Education Outcomes for Children in Rural Tanzania". It offers an empirical microeconomic analysis in order to corroborate the considerations made on the issues presented in the previous chapters, contributing to the existing literature with an innovative study.

This paper investigates the long-term effects of malnutrition presented by individuals during early childhood on subsequent education attainment of young adults living in a rural area of Tanzania. The data used are of an exclusive long term panel data set collected in the Kagera Health and Development Survey. Infants born in the early Nineties are traced and interviewed in 2004. To perform the main objective of the work, any attrition due to family or environmental characteristics is removed by differencing among siblings. In addition, a broad investigation on weather conditions during infancy is conduced, in order to attain the instruments to face the existing endogeneity proper of the health variable.

Consistently with the literature, the principal finding is that infant and child health status play a key role in schooling outcomes, suggesting that education and health are complementary inputs on the development process. By comparing the anthropometric measures of a Tanzanian preschooler with those of a child in a wealthy reference country, estimation results show that malnutrition and poor health experienced during early childhood have long term effects on her human capital growth. More precisely, improving her health status, she would have an additional 30% of probability of completing primary education. This result emerges if the two districts laying on the western board, where the refugees escaped from the genocides of Burundi and Rwanda in the early Nineties, are excluded from the analysis.

The result confirmed in this paper that better nourished children tend to perform better in school has potentially important policy implications. The long-run effects of early-life

conditions on schooling as adolescent should be factored into cost-benefit analyses of programs targeting this part of the population. Similar interventions are the promotion of exclusive breastfeeding, integrated child care and development programs and those providing nutritious supplements to pre-schoolers; all of these interventions have benefits and high rates of returns. Future research on this important topic will undoubtedly benefit from the collection of high quality longitudinal data that recognizes the relationship between nutrition and human capital accumulation.

Acknowledgements: I am grateful to Giorgio Brunello, Margherita Fort, Maarten Lindeboom, Anil Markandya and Lorenzo Rocco for comments on earlier drafts.

The Role of Education and Health in Human Capital Development in Less Developed Countries

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Abstract

This paper presents some basic patterns on health, nutrition and education outcomes of children in less developed countries. Its attempt is to offer the necessary tools to understand the topics and to implement a proper analysis on economics of education and health. Moreover, it provides an overview of what has been realised thus far, providing suggestions for future research.

Education and health care for young children have received high policy attention during the last decades. It has been recognized that equitable access to early childhood health care and education of good quality, especially for the most vulnerable and disadvantaged children, is essential for sustainable economic and human development. Nevertheless, despite remarkable attainments in human capital, there is still room for improvement since less developed countries continue to face great challenges in improving education and health level of their people.

The effort is mainly concentrated on children of poor countries, with a particular focus on sub-Saharan Africa, since they represent the most vulnerable people; additionally, in this part of the world the majority of the population still live in extreme poverty, with worse health and education outcomes.

Key words: Human Capital, Human Development, Primary Education, Child Health and Nutrition, Indicators of Education and Health, Incentives to Increase Quality and Quantity of Human Capital, Less Developed Countries, Sub-Saharan Africa, UN Millennium Development Goals.

Contents

List of Figures

List of Tables

List of Annexes

« *Health and education are not only beneficial in themselves, but they can be viewed as investments in human capital which lead to a higher future standard of living.*»

Schultz T.P. (1999)

1.1. Introduction

The concept idea of human capital in economics started a long time ago, but it has been developed mostly during the Sixties and the Seventies with crucial contributions by Theodore W. Schultz (1961), Gary Becker (1964/1993) and Jacob Mincer (1974). These authors introduced the importance of human capital for individual productivity and earnings, for the distribution of economic achievement and for the expansion of national income. In addition to the contribution of Schultz, Becker and Mincer in microeconomic terms, human capital theories have been investigated by Romer (1986), Lucas (1988) and Barro (2001) and others in macroeconomics, and more recently in the work of Cunha et al. (2006) on more refined economic models of human capital formation[1].

Becker's "Human Capital", published in 1964, rapidly became a standard reference for the subsequent studies on the topic; the author considered human capital as a means of production, into which additional investment yields additional output. The close similarity with the investment theory of the firm, where physical capital is demanded up to the point where its marginal productivity equates its user cost, has led many economists to think of education and health as investment in human capital.

In contrast with the mainstream, critical voices raised against this terminology, since on deeper scrutiny the analogy between investment in physical capital and investment in human capital proves somewhat imprecise. The definition of human capital refers merely to elements that have benefits via economic activity, without regarding the intrinsic personal benefit of being healthy or better educated as returns to human capital investment.

[1] For a detailed literature concerning human capital see, as instance, Kiker (1968).

Therefore, it considers the value of human capital investment for production instead of directly for consumption.

Human capital is important in specialized areas such as labour economics, public sector economics, welfare economics, growth theory and development economics (Blaug, 1970). As a matter of fact, "knowledge capital" and "health capital" have a fundamental importance by themselves, but they also complement each other; they take a long time to accumulate and lead to a higher future standard of living. While nutritional intake in early childhood forms the basis of a child's health capital, providing a foundation for subsequent child development, investments in schooling compose the base of the child's knowledge capital, which is directly rewarded in advanced labour markets and technologies. Thus, both education and health are essential to the broader concept of expanded human capabilities, which lies at the core of the development concept (Sen, 1999) [2].

A nation's human capital, represented by its stock of healthy, educated, competent, productive people, is a key determinant of its prospects for both economic growth and further human development, as well as for improved institutions and better governance.

This chapter sets the first stage for the rest of the research thesis by presenting some basic patterns on the health, nutrition and education outcomes of children in less developed countries. Its attempt is to offer the necessary tools for understanding the topic, the historical evolution and the actual situation of human capital development in those countries. Moreover, it provides an overview of what has been realised thus far, providing suggestions for future research.

The economics of education and the economics of health, beyond being mere investigations of economies, provide valuable means to understand the behaviour of the people involved in the development process. As discussed in the text, several studies affirm that the main barrier to education and health in less developed countries is represented by parental choice, together with particular child's and social determinants.

Schooling and health systems of less developed countries are investigated to recognize which are the reasons of severe inequalities and inefficiencies that exist and afflict them.

[2] Human capital approach focuses on the indirect capacity of education and health to increase utility by growing incomes, even though both of them also contribute directly to well-being. Beyond being essential components of human capital, education and health constitute two of the three indexes of the composite Human Development Index (HDI) elaborated by the United Nations in 1990 (see Appendix I).

The effort is mainly focused on children of those countries, with a particular focus on sub-Saharan Africa, since they represent the most vulnerable people; additionally, in this part of the world the majority of the population still live in extreme poverty, with worse health and education outcomes. This situation is consequential to the lower quality and less accessible health and education services relative to industrialized countries.

Even though human capital investment also includes health and nutrition, education consistently emerges as the human capital investment for empirical analysis (Schultz, 1981). For such a reason, the present chapter is directed to investigate both education and health capital, but a broader analysis is dedicated to the educational one.

1.2. The international approach concerning education

Human capital theories stress the central role of education as an investment in human capital. Concerning this topic, Psacharopoulos (1973) stated: "Thee is a field in economics known as the economics of human capital, or more narrowly, the economics of education." The core of this theory is that the education of each person represents an investment in her human capital; moreover, it allows her to contribute to the society in a productive way. As any kind of investment, that in human capital requires initial costs, in terms of both direct spending and the opportunity costs of students' time. Those costs are taken in view of expected benefits the investments will create, in terms of both higher productivity and future standard of living.

Human capital literature distinguishes among several types of education; in this paper, apart from informal, vocational and other forms, education stands for formal education.

The importance of education has been affirmed on various occasions by influential people worldwide, since the Universal Declaration of Human Rights was proclaimed by the United Nations General Assembly in 1948. The Declaration, Article 26, acknowledged that:

1. "Everyone has the right to education." It shall be free and compulsory, "at least in the elementary and fundamental stages. […] Higher education shall be equally accessible to all on the basis of merit."

2. “Education shall be directed to the full development of the human personality and to the strengthening of respect for human rights and fundamental freedoms. It shall promote understanding, tolerance and friendship among all nations, racial or religious groups, and shall further the activities of the United Nations for the maintenance of peace.”
3. “Parents have a prior right to choose the kind of education that shall be given to their children.”

The indicated propositions, together with those which follow in the Universal Declaration, affirm the central role of education for individual and society as a whole, since it empowers people and strengthens nations.

Education has also been recognised as essential for making progress toward sustainable economic, social, environmental and human development, since it improves individuals’ ability to address those issues (Agenda 21, chapter 36, 1992)[3].

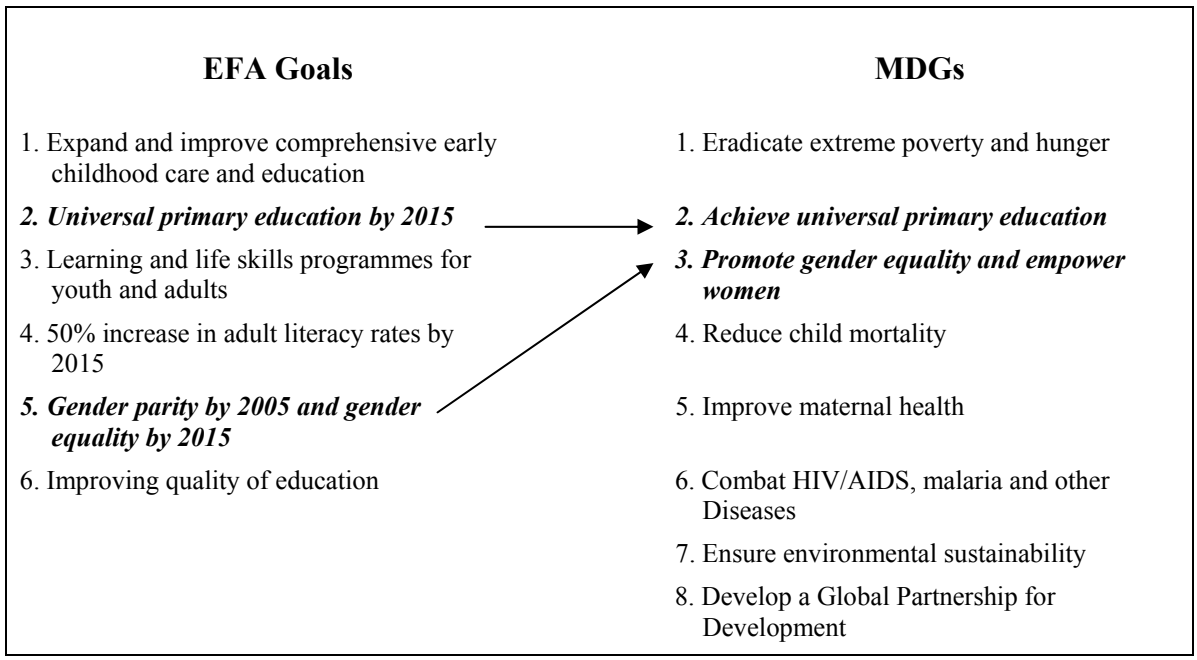
During last decades, the notion that every child in every country should have the chance to be educated has been recognized by both industrialized and less developed countries, together with international communities worldwide. As a result of this emerging awareness, some 150 less developed countries and their external partners participated at the World Conference on Education for All in Jomtien (Thailand) in 1990. At the conclusion of the Conference, the participants produced and signed the United Nations declaration on “Education for All” (EFA), an international commitment to bring the benefits of education to “every citizen in every society” by 2000. Following this trend, the governments and international organizations involved have made considerable efforts to increase quantity and improve quality of primary education within their national educational systems.

In response to slow progress obtained over the decade, the Jomtien commitment was reaffirmed and extended during the World Education Forum settled in Dakar (Senegal) in 2000. On this occasion, 189 Member Countries of the United Nations and their partners adopted the eight by now celebrated “Millennium Development Goals” (MDGs), with the

[3] On the topic of the contribution of education to sustainable development, UNESCO Director-General Koïchiro Matsuura has affirmed: “Education is one of the most powerful instruments we have for bringing about the changes required to achieve sustainable development”. In 2000, the Dakar Framework for Action, paragraph 6, reaffirms that “Education is a fundamental human right” adding that “It is the key to sustainable development, and to peace and stability within and among countries.”

aim of considerable improvement in the quality of life in less developed countries by 2015. Two of the EFA goals were included among the ambitious MDGs: first, for all children to complete primary school by 2015; second, to achieve gender equality at all levels of education by 2015 (see Table 1.1).

Table 1. 1: Connections between "Education for All" goals and "Millennium Development Goals".



Education, in particular primary education, is thus recognized as central to development; it constitutes not only a goal itself, but also a tool for attaining the other goals. Concerning its relation with the other goals, it can be stated that more equitable distribution of education is correlated with lower poverty and inequality and more rapid economic growth (MDG1). Greater education, especially for girls, has strong positive impacts on the health of infants and children, on immunization rates, on family nutrition and on children schooling attainment; moreover, it leads to a better family planning and lower rates of HIV/AIDS (MDG4, MDG5 and MDG6). Primary education also contributes to better natural resource management, including conservation of the tropical rain forest (MDG7). Finally, in conjunction with well designed macroeconomic policies, it is crucial for the construction of globally competitive economies and democratic societies (MDG8).

Achieving universal basic education is critical for attaining all the MDGs. Conversely, achieving other MDGs, such as those dealing with improved health and

access to clean drinking water, environmental sustainability and decreased poverty are crucial to achieve the EFA goals.

Whereas these goals define explicit targets supposed attainable by 2015, they do not explain how to attain them (see Annex I). Certainly, to attain the indicated goals, several countries have to implement new policies, and both countries and international donors have to allocate additional financial resources. More developed countries are assigned specific responsibilities by the MDGs, among which are: improved aid, abolition of the high debts of the poorest countries and elimination of trade and investment barriers.

Access to schooling has improved over the years since 1960, which corresponds to the earliest year with reliable data. Nevertheless, several less developed countries, most of which are in sub-Saharan Africa, are proceeding at a low current rate of progress; hence, they will not be able to attain the MDG of universal primary education completion in due time. Some 113 million children worldwide are still not enrolled, 94% of them live in less developed countries; 38 million of those children reside in sub-Saharan Africa and slightly more than half are girls (UNESCO, 2007) [4].

To better understand the present trend concerning education, the "EFA Development Index" (EDI) was introduced by UNESCO in the 2003/4 EFA Global Monitoring Report and is updated annually. The EDI is a composite measure of the situation characterizing a country in relation to the attainment of the EFA agenda. It is a simple average of four of the six EFA goals: Universal Primary Education, Adult Literacy, Gender Parity and Quality of Education [5]. EDI varies between 0 and 1, with 1 representing the EFA achievement[6].

Table 1.2 summarizes the results of EDI calculations for 2004 by region. Only 125 of 163 countries are included, because data for some less developed countries are missing; consequently, the general framework obtained is helpful, but does not completely capture the comprehensive EFA situation. Data show that some 47 countries worldwide present an

[4] The four major less developed regions in the world are East Asia, Latin America, South Asia and sub-Saharan Africa. Of these four, sub-Saharan Africa has had the worst economic performance since 1975.
[5] Each of the four goals is represented by a proxy indicator: UPE by total primary net enrolment ratio; Adult Literacy by literacy rate for persons aged 15 and over; Gender Parity and Equality by the gender-specific EFA index; Quality of Education by survival rate to grade 5. The index missed two goals because of lack of data on them.
[6] For an exhaustive explanation of the EDI's rationale and methodology, together with detailed values and rankings for 2004, see UNESCO (2006).

EDI score of 0.95 and above, and are categorized as having achieved, or being close to achieving, the EFA goals. Most of these countries are evidently located in North America and Europe, but there are some in Latin America and the Caribbean and Central Asia. Furthermore, 50 countries spread across all regions have an EDI value between 0.80 and 0.94. From 2003 to 2004, the index increased in 32 countries and fell in 17 through this category. Finally, 28 countries count an EDI score under 0.80. Two-thirds of these are in sub-Saharan Africa; some Arab States and Asian countries are also represented[7].

Table 1. 2: Present situation about EFA, by region.

	Far from EFA (EDI below 0.80)	Intermediate position (EDI between 0.80 and 0.94)	EFA achieved or close (EDI between 0.95 and 1.00)
Sub-Saharan Africa	19	8	1
Arab States	4	11	1
Central Asia	-	2	4
East Asia/ Pacific	2	6	3
South and West Asia	3	1	-
North America/ West. Europe	-	2	17
Latin America/ Caribbean	-	18	6
Central/ Eastern Europe	-	2	15
Total	**28**	**50**	**47**

Source: UNESCO (2007)

1.3. The relevance of investing in childhood

Ensuring every child the best start in life is crucial to fulfil all other children's rights. For this reason, investing in early years is also the best guarantee of promoting sustainable economic and social development.

[7] Many less developed countries will probably not achieve the MDG of universal primary completion and the current levels of external funding commitments are not sufficient to enable those countries to sustain the development of their primary education systems. If the goal of universal primary completion is to be achieved by 2015, an average of $10 billion per year are required (at 2005 prices). Approximately one half of this amount is required for sub-Saharan Africa with the addition of another 1.6 million teachers by 2015 (Unesco, 2006). Apart from UK and Canada, the other G8 countries would not be on track to meet their equitable share of financing for universal primary education in Africa. Italy has made statements in support for EFA, but its development assistance for primary education in Africa was just $3 million in 2004, of $141 planned for 2007, and no future plans to increase this level seem to have been announced (UNESCO, 2007).

The importance of early child development has been noted by researchers from various disciplines. Robert W. Fogel, who obtained the Nobel Prize in Economic Sciences in 1993, recognized that: "The quality of early child development has a significant effect on the quality of population and influences health outcomes in adult life." Although it is never too late to improve the quality of a child's life, medical research suggests that during the first three years of life the brain grows to roughly 80% of adult size (Martorell and Habicht, 1986). Hence, this period is crucial for her survival and for the development of both cognitive and physical skills.

Intervention targeted on children during the first years of life would solve the efficiency and equity trade-off which subsist for investments later in life. The most efficient strategy would target investments at children who have already attained plenty of skills, providing them with higher knowledge outputs; conversely, the most equitable strategy would be to invest in children who have achieved the fewest skills. Thus, an intervention during infancy or early childhood is both equal and efficient. It is equal offering all the children the same possibilities at the starting point, without any discrimination of family background, wealth, race or gender. It is efficient, because it has the higher returns increasing the productivity of education on the subsequent years of school. Consequently, there is no such trade-off, but even a complementarity between equity and efficiency for investments in early childhood.

Concerning the issue of the relation of efficiency and equity on education, Heckman and others economists have elaborated a particular perspective of early interventions during last years, affirming that the indicated trade-off is nonexistent (Cunha and Heckman, 2007; Heckman and Masterov, 2007). Their economic model of skill formation is based on the traditional theory of human capital and allows the measurement of education policies over the life cycle of a person in a combined structure (see, among others, Cunha et al., 2006; Wößmann and Schütz, 2006). Their main idea is that the formation of skills is a life cycle process that reveals both recursive productivity and complementarity. Recursive productivity means that the education acquired at first stage constitutes an input into the knowledge process of the subsequent stage. Complementarity means that the productivity with which investments at first stage of education are converted into valuable abilities is positively influenced by the level of abilities that a person has already achieved in the previous stages. These two elements together generate a

skill multiplier; through it an investment in schooling at first stage not merely directly increases the skills attained at that stage, but also indirectly raises the productivity with which educational investments at the next stage will be converted into even additional skills.

To conclude, there are early periods in a person's life cycle during which investments in education (as well as in health care) are particularly valuable and sometimes crucial. Consequently, investments have to be properly done in the first period, since there are high returns to early investments, but they must be followed up by later investments to be effective. Later investments are often less productive and remediation is often more costly than initial investment (Cunha and Heckman, 2009).

1.4. The benefits of education at individual and societal level. Evidence from less developed countries

The economics of education collects vast evidence on the substantial positive effects of knowledge on economic and social wellbeing at both individual and societal level. Furthermore, investment in education carries benefits not only on market, but also on non-market outcomes.

1.4.1. Market and non-market benefits of education to the individual

The most evident effects of schooling at market level for individuals are the increases on earnings for wage earners and on productivity for employers (Card, 1999; Harmon et al., 2003). The extent to which education raises earnings is commonly defined as the economic "return" to education. These kinds of returns remain a crucial concern for development policy and analyzing their pattern can facilitate the researchers to understand the potentiality of reducing poverty of different levels of education.

In less developed countries there is a limited but important evidence that the returns to education have been rising during last decades (Söderbom et al., 2006). The general belief is that labour market returns to education are highest for the primary level of education and lower for subsequent levels. Some have interpreted this to be in agreement with a notion of

diminishing returns to education, following the same rules as other kinds of investments. These studies show that, worldwide, for each additional year of schooling individual returns raise by almost 10% for both genders, at the mean of the distribution (Duflo, 2001; Psacharopoulos and Patrinos, 2004). In addition, Psacharopoulos (1994) shows that returns to an extra year of education are slightly higher for girls (12.4% on average) than for boys (11.1% on average). Nevertheless, returns vary at each level of education.

The general idea that returns to primary schooling are higher has been contested by several authors in recent years (see for instance, works by Knight et al, 1992; Bennell, 1996; Colclough et al., 2009). Lassibille and Tan J.P. (2005) estimate wage equations for employees in Rwanda, finding that returns to education raise with the level of education, contrary to the pattern usually reported in the literature. Additionally, the authors find that the returns to higher education are particularly high in this African country, even if there are differences across sectors of employment. Similarly, Kuepie et al. (2009) provide evidence of significant effects of education on individual earnings in the informal sectors of the West African cities analyzed, even at high levels of schooling. Moreover, they state that the public sector gives added value to education, followed by the formal private sector and then the informal sector. Finally, Ewoudou and Vencatachellum (2006) use the 2001 Cameroon household survey to estimate the rates of returns to education. The authors find strong convex and high rates of returns to education in each sector of employment and no returns to primary education. Concerning the informal sector, returns to education become positive from the first level of secondary education, while in the formal sector only from the second level of secondary education. They also find higher returns to vocational education in the informal sector than elsewhere.

The evaluations of the causal effects of education on earnings is hampered by many determinants, as for example, the “ability bias”. The amount of years of completed education may also reveal a person’s skill, and those who are more able would be expected to earn higher incomes, regardless of schooling. Hence, if innate ability and years of completed education are highly correlated then returns may be attributed to ability, rather than to education per se. Nevertheless, there is little empirical support for ability bias affecting the results.

Positive effects of cognitive test scores on individual labour-market performance is assessed by several micro data analyses (Currie and Thomas, 2001). Working conditions

are also different between educated and non-educated: the former have improved capacities and are more likely to participate in the labour market having better chances to be employed. Education also has positive influence on decisions on both expenditure and savings (Bernheim and Scholz, 1993; Solomon, 1975). Moreover, evidence suggests that education is particularly powerful for women for many different reasons, increasing their labour force participation rates and earnings.

To quantify the impact of education on its returns, some researchers, for instance, have analyzed the differences in earnings between siblings and have correlated these with differences in their educations[8]. Others analysis focused on those differences in years of completed education that can be accredited to institutional differences in places or time. For instance, different proximity to a school, or in boundaries on child labour, or in compulsory minimum school leaving ages may drive some children to complete more years of education. Psacharopoulos (1994), having confirmed findings on this topic as Duflo (2001) did, offers a complete set of estimates on the profitability of investments in education at a global level. The author assesses that basic education represents the former investment priority for less developed countries.

Schooling has non-market effects on the well-being of individuals (see Wolfe and Zuvekas, 1997; Haveman and Wolfe, 1984; Haveman and Wolfe, 2001; Wolfe and Haveman, 2000; McMahon, 2002[9]; McMahon, 2004; Behrman and Stacey, 1997). Until the early Sixties, the effects of education on non-market outcomes or behaviours were not

[8] Differences among siblings are due to differentiation in their inherited talents and motivations, experiences and stimuli they are exposed to. The scope to which environment varies between siblings depends on their age difference and on the changing conditions of the household and community associate with this laps of time (Grilliches, 1979). Presumed that siblings have the same access to family resources, the differences in earnings between them may be caused by difference in their schooling achievements. However, such a strategy does not explain why siblings differ in their educational outcomes. If these differences are due to personal diverse abilities between the siblings, which is unobserved, then this sort of strategy could end up to an upward bias.

[9] As an example of review, McMahon (2002) estimates the total effect of education on development, including economic growth and non-market aspects of the quality of life, through the basic model he presents. He investigates the indirect effects of education on a group of variables: health, population growth, democracy, human rights, political stability, poverty, inequality, the environment and crime. The total impacts of education policy changes on endogenous development are then estimated for several developing and industrialized nations using an interactive model, which results to be important to both of them. The knowledge diffusion of and the adaptation of new techniques have been identified as crucial to the growth process in the new endogenous growth models, and are of increasing strategic importance in current knowledge-based globalizing economies. The author concludes that "more theory and measurement" is required to attain "the ultimate outcomes of education" and thus enrich the intellectual debate on development.

investigated by economists. The impacts of variables except real income, real wealth and relative prices must run through tastes, and previous economists used not to take them in consideration[10].

There is evidence confirming that both life-satisfaction and happiness are connected to education, for instance through trust, and this relation is independent from income level (Putnam and Helliwell, 1999). The Noble prize Amartya Sen recognizes education as a fundamental tool to create and expand the essential and individual *capabilities* and freedom, perceived as the ultimate goal of economic life[11] (Sen, 1999). With "human capabilities" the author means power to reflect, make choices, seek a voice in society and enjoy a better life for individuals. Following this point of view, education enables people to choose more efficiently in a variety of situations (Wolfe and Haveman, 2000). For instance, studies of assortative mating suggest that marital choices improve with schooling[12] (Becker et al., 1977). Another example is that persons with a higher level of education are probably more disposed to move to areas where they expected to have more possibilities of wellbeing.

There is a vast empirical evidence concerning the effects of education on health (see for instance works by Grossman and Kaestner, 1997; Grossman, 2000; Grossman, 2005[13]). Education has extensive benefits on personal health and nutrition status, through several channels. It drives to better health behaviour, affects the decision to work in hazardous employments, and increases individual's life expectancy (Feldman et al., 1989). Some evidence has been established that education has not only positive effects on one's own

[10] Becker (1993) introduced the idea that consumers produce all their fundamental objects of choice, called *commodities*, in the non-market sector using inputs of market goods and services and their own time. Education is quite likely to influence the efficiency of these production processes. Consecutively, Becker stressed that the variables typically labelled as tastes can be approached by standard economic models of rational behaviour, with important implications for the role of schooling in many decisions.

[11] Sen uses a very broad definition of freedom, which includes freedom from hunger, disease, ignorance, all form of privatization, poverty, as well as political and economic freedom and civic right. Sen (1997), in his analysis of health and poverty in Bangladesh, explained that policies have to be focused on improving education rates, particularly for the poor, given its strong influence on poverty reduction and better health.

[12] For a more detailed analyses on this topic, see the works of Becker (1993), Ermisch and Francesconi (2002), Esping-Andersen (2004).

[13] Grossman (2005) investigates the educational effects on non-market outcomes from both theoretical and empirical viewpoints. The author studies the effects of education on health, fertility and child well-being reflected by their health and cognitive development. He considers models in which education has productive efficiency and allocative efficiency effects. He then modifies these frameworks to allow for the endogenous nature of schooling decisions, so that observed schooling effects can be traced in part to omitted "third variables", such as a point of reference towards the future. The empirical review provides vast evidence for the proposition that the education effects are causal, but is less decisive with regard to the classification of specific mechanisms.

health, but also on the health of one's spouse and children, household and community (Grossman, 1975).

Education has important intergenerational benefits. Schooling attainment of parents, mainly the mother, has significant effects on the well-being and the general health and nutrition status of their children, cognitive development included (Currie and Moretti, 2003). There is a vast empirical evidence on the fact that children of educated parents are more likely to acquire education (Plug, 2004). Moreover, education drives benefits mainly for women: it may reduce the fertility rates and increase the usage of reliable family planning methods, delay marriage and childbearing, reduce maternal mortality rates (Schultz, 1997; Schultz, 2002; Strauss and Thomas, 1995; Glewwe, 1999; Sahn and Stifel, 2002). Education can raise women's self-confidence and status in the household, enabling women to take a more active and effective role in intra-household decision making and in obtaining health care assistance (Smith and Haddad, 1999; Alderman et al., 2002). Women with some formal education are more likely to seek medical care, pay attention to prenatal care, ensure their children are immunized, be better informed about their children's nutritional requirements and adopt improved sanitation practices. It has been estimated that one year of female schooling reduces fertility by 10% and this effect is particularly marked for secondary education. Furthermore, mothers' education is a significant variable affecting children's education attainment and opportunities, because as it has been estimated, a mother with a few years of formal education is considerably more likely to send her children to school.

1.4.2. Market and non-market benefits of education to society

Beyond the individuals, education also bears benefits to the community and the society as a whole, both at market and at non-market level.

As the classical economist Adam Smith affirms: "The state derives no inconsiderable advantage from the education of the common people. If instructed they [...] are less liable to the delusions of enthusiasm and superstition, which among ignorant nations, frequently occasion the most dreadful disorders" (Smith, 1776)[14]. A more contemporary voice concerning the same point is the one of Milton Friedman. The author states his position on

[14] Smith (1776), "An Inquiry into the Nature and Causes of the Wealth of Nations", BookV, PartIII, Article2.

the responsibility of government in education: "A stable and democratic society is impossible without widespread acceptance of some common set of values and without a minimum degree of literacy and knowledge on the part of most citizens. Education contributes to both. In consequence, the gain from the education of a child accrues not only to the child or to his parents but to other members of the society; the education of my child contributes to other people's welfare by promoting a stable and democratic society." (Friedman, 1955)

At a societal market level, as emphasized by several macroeconomists (Lucas, 1988; Romer, 1991; Barro, 1991; Mankiw, Romer and Weil, 1992), education influences sustained economic growth, through both direct and indirect mechanisms. It raises the human capital inherent in the labour force increasing national labour productivity, which, in turn, should lead to higher income and improved economic performance. Concerning the linkage between schooling and growth, Pritchett (1996) argues that it is complicated to find such a correlation; other researches, among which those by Bils and Klenow (2000) and Krueger and Lindahl (2001), argue otherwise, affirming growth's dominant role on education.

In addition, schooling encourages innovation and diffusion of knowledge on new technologies and products, promoting growth primarily in less developed countries (Foster and Rosenzweig, 1996). The competitive use of knowledge often drives to comparative advantages among nations[15].

Finally, there are indirect effects of education on growth through democratisation, political stability, the influence on productivity of other workers owing to social interaction mechanisms, social cohesion and lower inequality (McMahon, 2004; Wößmann and Schütz, 2006; Psacharopoulos, 1977). For instance, more educated people are less likely to be eligible for welfare transfers payments and to fall back on these transfers even though they are entitled to them (Kiefer, 1985).

[15] Theoretically, poor countries should grow faster than wealthy countries since the former can adopt advanced technologies already tried and tested by the latter. However, the present situation is that the gap in education between poorer and richer countries is too large, then the transfer of these technologies that drive economic growth becomes complicated, with a consequent stagnation of economies of the poorest. To make possible to have positive returns to education, economic opportunities taking advantage of the skills embodied in education are needed. For instance, Rosenzweig (1995) assesses this proposition through an example of differences in the returns to primary education between regions of India during the Green Revolution. In agro-climatically suited areas to the use of the new better variety of seeds, educated farmers were apparently more skilful in adopting the new technology and returns to primary schooling increased. Differently, unsuited areas to the new seeds had no changes in primary schooling returns.

On the other side, education has non-market effects for the society (Wolfe and Zuvekas, 1997; Wolfe and Haveman, 2000; McMahon, 2002; McMahon, 2004). The external benefits of education are sizeable in the case of primary schooling, which is usually associated with the achievement of basic cognitive skills: being literate brings sets of behavioural changes that are beneficial to households and communities. In the same way, at higher levels of schooling, externalities from scientific research bring benefits which go beyond the direct benefits for the individual with that higher education (Colclough et al., 2009).

More in detail, education is essential for the support of pace and stability's values and the creation of democratic societies, with a growing demand for civic participation. While authoritarian dictatorial regimes gain from an illiterate and poor population, the development of civic institutions and human rights necessitates an educated population. Pace culture, spreading the values of human security, justice, equity and interculturality, is key determinant for the society as a whole.

Moreover, high-quality education is one of the most powerful tools known for transmitting culture and values, for reducing poverty and inequality and for enforcing social cohesion. Social cohesion is promoted by dropping alienation and social inequalities and by a growing consciousness of the responsibility that everyone has for the entire society (McMahon, 2002; McMahon, 2004). More educated people seem to have a higher level of social trust (Putnam and Helliwell, 1999). Micro-econometric analysis shows that higher level of education also has a negative effect on crime, by increasing the return to work and the opportunity costs of criminal activities (Lochner and Moretti, 2004). Disproportion on access to quality education can represent country's tradition of social inequality and ethnic or religious discriminations.

Additionally, the educational level of a person is connected to her own health, her children's or partner's health and the health level of the community in which she lives in many ways as, for instance, reducing the spread of infectious diseases by adopting and teaching safe behaviours (Grossman and Kaestner, 1997; Grossman, 2005).

Finally, education plays a crucial role in the promotion of the consciousness and the sensibility for the protection of the environment. An educated society can enhance natural resource management, national capacity for disaster prevention and adoption of new,

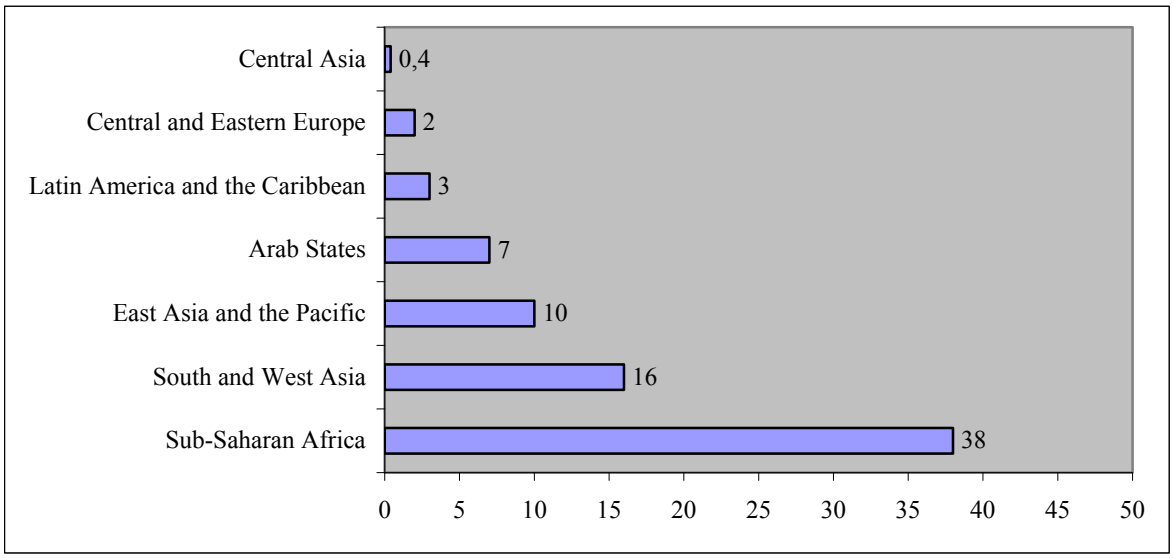
environmentally friendly technologies. Such relation is assessed, among the others, by McMahon (2002; 2004), who describes how education indirectly affects the environment, through the decreases of poverty and population growth rates, which are associated with a lower level of pollution.

To sum up, education is constructive for both the individual and the society as a whole. As a matter of fact, knowledge at individual level: improves health and nutrition; increases productivity and earnings; reduces inequality and poverty; enhances skills and expands individual freedoms and capabilities. Education at societal level: lays a foundation for sustained economic growth, national productivity and innovation; supports environmental issues; is essential for the promotion of value of social cohesion, pace and stability and for the construction of democratic societies.

1.5. Determinants of out-of-school children

As stated above, enrolment in primary education has increased during the last decades; nowadays, the amount of out-of-school children has fallen from 43 million to 38 million. Notwithstanding this, many countries will not be able to reach the second MDG of universal basic education by 2015. The worst situation is presented by sub-Saharan African countries, since they count almost half of the amount of out-of-school children worldwide. As Figure 1.1 shows, some 38 million of 1131 million African children of primary school age were out-of-school in 2004; 53% of them were girls (UNESCO, 2007). As it is discussed later in the text, sub-Saharan African countries not only count the lowest percentage of students enrolled, but also a lower spending per pupil, suggesting a low quality of schooling.

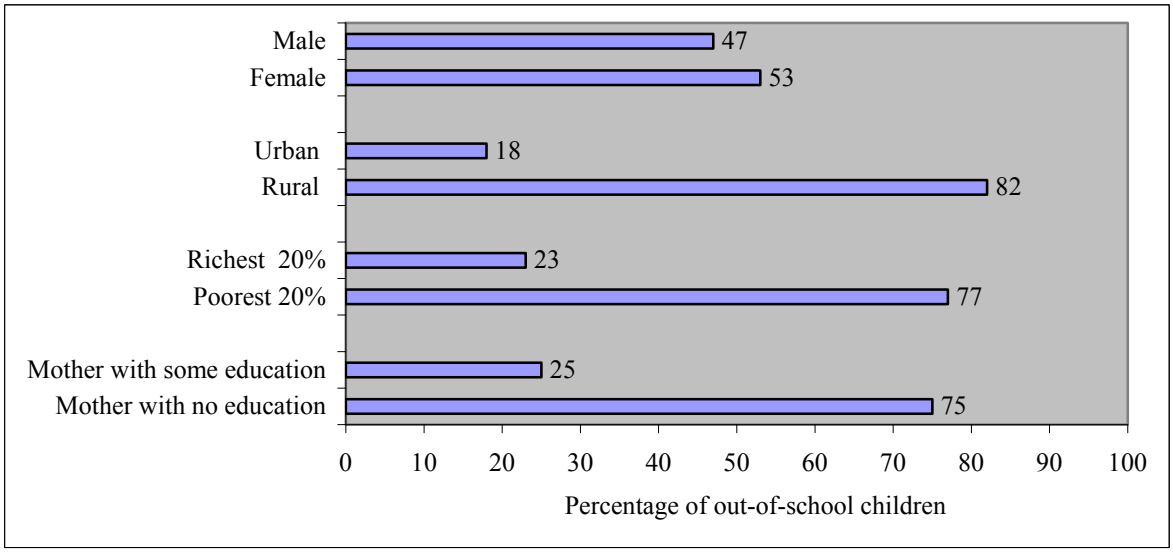
Figure 1. 1: Out-of-primary school children (in millions) by region, 2004.



Source: UNESCO (2007)

The children with much higher probability to drop out and to be out-of-school are females, who live in rural areas and come from the poorest households (see Figure 1.2). On average, a child with an uneducated mother is more likely to be out of school compared to a child whose mother has some education. Hence, access to education is particularly constrained for these people.

Figure 1. 2: Distribution of out-of-school children (%) of primary school age, in 2004.



Source: UNESCO (2007)

More in detail, there is a great variation concerning access and enrolment in school within and across countries. In less developed countries, the richest 20% of the population is almost three times as likely to be enrolled in school as the poorest 20% of the population does. Moreover, children from richer households in Latin America and Africa, on average, have 4 to 7 more years of education than the poorer. At country level, the average educational attainment in sub-Saharan African countries is 3.5 years while in wealthier countries it is almost 10 years (UNESCO, 2007).

Generally, access to education often suffers of gender disparities in several countries. Little more than half, about 53%, of the 113 million children of school-age not enrolled in school worldwide is female (Figure 1.2). Inequality in schooling access represents a main violation of woman's right and a barrier to social and economic development. As shown in Table 1.3, gender disparity in access to primary school is elevated in low-income countries, low in middle-income countries and roughly inexistent in high-income countries[16]. Globally, some differences subsist within regions. The gender gap at primary level is almost nonexistent in Latin America, OECD's countries, East Asia, Eastern Europe and Former Soviet Union. On the contrary, it is sizable in Africa and Middle East, being the widest in South Asia.

Table 1. 3: Gender inequality in gross primary enrolment rates, 2000.

Area	**Primary**	
	Boys	**Girls**
Country group		
Low-income	107	98
Middle-income	112	108
High-income	102	101
Region		
Sub-Saharan Africa	83	71
Middle East/North Africa	101	92
Latin America	129	125
South Asia	107	90
East Asia	112	111
East Europe/Former Soviet Union	100	99
OECD	102	102

Source: World Bank (2003)

[16] This gender gap is amplified at the secondary level in low and middle-income countries, while girls have a slightly higher rate at the secondary level in high-income countries.

1.6. Reasons explaining child's non-attendance and delay in school enrolment in less developed countries

Concerning the educational topic for less developed countries, one important question is raised: What determines child enrolment and attendance at school? This paragraph tends to reply to this issue, showing that reasons are complex and wide-ranging.

The postponed enrolment at primary school can be investigated through a simple dynamic model, rather than with the standard static time allocation framework (Rosenzweig and Evenson, 1977). From the perspective of the demand side, a primary distinction rise between "attendance" and "enrolment". The necessary but not sufficient condition for a child to attend school is that she is enrolled. Often, enrolment and attendance rates differ in less developed countries, since several children enrolled at the beginning of the year, actually, do not attend school. Hence, it is important to make a distinction between who is not-enrolled (thus not-registered) and who is enrolled although does not attend (is absent).

Child's human capital enhancement is influenced by several individual, family, and community variables; some of these variables can be observed by social scientists and policy analysts, while others remain unobserved.

The main reason for delayed enrolment or even being never enrolled is supposed to be economic. Enrolment of each family member can be considered as both an investment and a consumption good[17]. Concerning the investment side, when making educational choices, current income opportunities are renounced in exchange for better income prospects in the future. Thus, human capital investment in less developed countries (high education in particular) is frequently viewed as significantly inhibited by household financial resources[18]. Parents in poor households are very sensitive to both price and quality of primary education. High school costs and low level quality considerably reduce poor children's attendance in schools. (The same effect occurs for the demand of health care).

Costs of education are both direct - such as school fees, uniforms and text books - and indirect - such as the opportunity costs of time. Even when primary education is free and

[17] Schultz (1963) expanded this proposition, indicating the two components of consumption: present, as the pleasure of knowing, and future, as the improvement of the ability to consume all other goods.

[18] From intergenerational viewpoint, family liquidity constraints can start a poverty trap mechanism. Poor families cannot invest in the education of their children because of resources' shortage and incapacity to enter financial markets; as a consequence, their children remain uneducated and deprived, unable to invest in their grandchildren. A review of this approach is offered by Loury (1981), Piketty (2000), Banerjee and Newman (1993)

compulsory and child's physical conditions are fine, poor households either cannot afford to send their children to school (since they may have no possibility to borrow against the future earnings of their children, have no savings, pay high fee or educational tools) or need the income provided by the working children. When a young child is needed to work on family farms or at home, the opportunity cost of her labour is high for the family. If she spends her time at school, the family either needs to engage a paid worker to substitute her or will bear a loss of valuable output necessary for the subsistence of the household's components[19].

Family's structure is also determining in child's delay in enrolment. For instance, possible causes of it can be due to the presence of two or more closely spaced siblings in a borrowing constrained household. In order to smooth household consumption, parents may decide to spread out the schooling enrolment of their children by holding a younger child back, especially if there are substantial school fees, which discourage part-time school attendance. Other related causes can be the household head gender and the general structure of the household.

The first expected benefit to educate children for family is the expectation of future higher monetary returns. Another expected benefit can be the higher level of knowledge or improved agricultural techniques that can be used directly in the field to raise and ameliorate the products.

Private returns to the quantity of years of education attained by a person is the object of many empirical work in human capital[20]. The strong and positive link between years of schooling and earnings of students once they enter the labour market is by now one of the best established facts in labour economics[21]. As discussed in paragraph 1.4.1, the common

[19] Stochastic shocks may lead to a delay in school enrolment together with a reduction of final grade achieved. Economic shocks can be, for instance, changes in price shocks, in labour demand or in expenditure patterns within the family; those shocks can lead to a requirement of child labour in the farm or can diminish household's ability to sustain school costs. Another possible shock is the illness of the child or of some other family member, especially one for whom the child's labour is readily substitutable, working for the sick person or having to care for her. However, illnesses are usually temporary and so would be unlikely to cause many full year delays (Glewwe and Jacoby, 1993). On the contrary, recent mortality of adult or another family member with a high probability influence permanently the decision to delay child's enrolment, since it could lead to a reallocation of household's resources and an increased demand on child's time.

[20] Estimation of returns assumes that markets works efficiently and that earnings are a good measure of productivity at the margin. Exception for a few attempts to quantify their scale and impact (Haveman and Wolfe, 1984; McMahon, 2002), estimates also take no account of the external benefits of education.

[21] Mincer (1970; 1974) tried to explained how investments can be transformed into observed differences across individuals in his famous standard "Mincer formula". Private rates of return to education can be estimated by calculating the difference in average post-tax earnings between those who have a given level of

idea is that education is characterized by diminishing returns, as other kinds of investments. Much of the empirical evidence from the Sixties to the Nineties suggested that in most countries the connection between education and earnings was concave (Duflo, 2001; Psacharopoulos, 1994; Psacharopoulos and Patrinos, 2004). A study conduced by Psacharopoulos (1994) documented social and private rates of return to investment in education by countries and levels (Table 1.4). Among the three main levels of education, primary education presents the highest rates at both private and social level worldwide; the private returns are much higher owing to the public subsidies to education. Comparing less and more developed countries, the former are characterized by higher rates of return from investments in schooling. The reason of such discrepancy is that the income gap between more and less educated people in poor countries is larger on average than for people in wealthy countries. The private rate of return in sub-Saharan Africa and Asia is especially high, at about 40%. Despite the importance of this value, the majority of households do not make these investments because of financial constraint they have to face, which means parents are not able to borrow even the small amount of money that a working child can convey to the family.

Table 1. 4: Social and private rates of return to investment in education by level of education, country type and region.

Country Type and Region	Private Rate of Return (%)			Social Rate of Return (%)		
	Primary	Secondary	Higher	Primary	Secondary	Higher
Less developed						
Sub-Saharan Africa	41	27	28	24	18	11
Asia	39	19	20	20	13	12
Latin America	26	17	20	18	13	12
More developed	22	12	12	14	10	9
World	29	18	20	18	13	11

Source: Adaptation from Psacharopoulos (1994).

More recent evidence suggests that the pattern is changing and that the rate of return to primary education may now be lower than that to advanced levels of education. Several

education and those at the next lower level. The rate of interest equating the discounted value of this net earnings stream with the cumulated discounted private costs of attending the level of education concerned is the private rate of return. In a similar way, social rates of return can be estimated using gross rather than post-tax earnings. Nevertheless, most studies do not take account of the costs of education and measure instead the wage increases to education (Colclough et al., 2009).

studies employing 1990s and early 2000s cross-section data show that the return to primary education in wage employment is considerably lower than that to post-primary education (see, for instance, Schultz, 2004; Kingdon et. al., 2008). Tables 1.5 shows the results obtained for different countries in a recent cross-section study by Kingdon et. al. (2008). Overall, the return to an additional year of education increases with the level of education. A recent work by Colclough et al. (2009) discusses reasons and implications related to the changed pattern of returns to schooling.

Table 1. 5: Estimates of returns to different levels of education for male waged workers, using latest data.

	Primary	**Middle or Lower secondary**	**Secondary or Higher secondary**	**Higher**
Ghana (1998)	8.9	8.5	8.8	16.9
Kenya (2000)	11.6	---	16.4	25.5
Tanzania (2001)	10.2	---	12.0	27.3
South Africa (2003)	12.0	21.6	24.4	34.1
India (2004)	0.0	7.2	12.6	15.6
Pakistan (2001)	6.0	6.1	13.2	15.3
Indonesia (2000)	5.0	8.4	13.7	17.2
China (2004)	0.0	7.8	7.5	10.1
Philippines (1999)	8.4	7.8	8.4	21.6
Thailand (2002)	3.5	13.4	10.6	23.1
Cambodia (2004)	5.3	5.6	7.7	11.1
Average	**7.4**	**9.6**	**12.3**	**19.8**

Source: Kingdon et al. (2008).

Concerning the consumption side, behavioural parental preferences are determinant. Households may attribute an intrinsic value to schooling, choosing different levels of education for their children; on the contrary, they may not value education because they themselves are uneducated. Therefore, parents can allow their children to attend school because may desire to offer them some education, even or not also attracted by higher future wage. Anyhow, some evidences recently produced affirm that family's budget constraint is stronger that parental value of education of their children. For instance, Mukherjee and Sinha (2009) focus their study on the role of parental attitude towards education in combination with the returns to education in deciding between child labour and child schooling. The authors find that several children drop out of school before completion and join the workforce as the returns from full schooling are not high enough. This happens even when parents intrinsically value education and also because of the wage premium, which is a strictly positive function of the time spent in school.

Regarding investments in children's human capital, beyond parental preferences, child's enrolment is also determined by her own characteristics. Some of those child's characteristics are unobservable by parents during the first years of life, such as motivation, the inner talent and healthiness; other are known, such as gender, the relation to household head and to the other components.

Child's health may indirectly influence household's decisions about investments in education of all the children. Parents can expect that education for a child in good health rises her lifetime productivity or, conversely, that better health status for a child decreases the costs of attaining a certain level of education. Otherwise, parents may choose to compensate an unhealthy child by investing more in her education. Conversely, if the child is considered not ready to attend school, their parents may prefer to employ her on non-wage-earning domestic activities or on the farm; otherwise, she may be employed in a remunerated work, so as to grow and to collect enough savings to finance consumption for the future, at the time when she will attend school.

Child's gender is another influential element. Female children have lower enrolment rates than males, mainly in the poorer countries, where females are often required to help at home. In addition, if the household's resources are scarce, a male child may be more likely to be sent to school, as this is seen as a better investment.

From the community perspective, other factors may influence child's enrolment, such as: population size and density, social culture and values, access to quality infrastructures. For instance, in poor rural areas of less developed countries children may have to walk long distances to go to school. Besides, females may be constrained to attending school because it is seen interfering with their marriage plans and prospects. Furthermore, environmental aspects may determine child's delay; for instance, child labour is often required during a particular season, such as for agricultural activities, with consequent delay in enrolment and reduction of attendance in school.

On the supply side, there are other possible explanations for delays in enrolment of primary education. The level and quality of education is represented, among others, by the availability of educational infrastructure, the quantity of school places accessible, the adequacy of access. Low levels of these elements are often frequent in school system offered by governments of less developed countries, being determined mostly by political

processes. As a matter of fact, schools in those countries commonly suffer from inefficiency, inadequate access, absence of teachers, of text books and sometimes even of classrooms. Public provision from the supply side has the advantage of lowering access barriers, but in the meantime reduces the incentives for richer families to invest more in the education of their children. (For a deep investigation on this topic, see Checchi, 2006). A deeper analysis concerning the topic of provision of education is dealt in paragraph 1.9.

1.7. Trends in the quantity of education

A generalized rise in educational attendance throughout the world has been affirmed in the subsequent years of the Second World War. Actually, school enrolment rates at all levels and adults' years of schooling rose quickly especially in almost all less developed countries since 1960, the earliest year for which reliable data exist. However, the trend slowed down during the Eighties. By the beginning of the Nineties OECD countries, Latin America, North Africa and East Asia had succeeded in having all the population enrolled in primary education; differently, sub-Saharan Africa and South Asia have performed worst over time than other regions at all levels of education. A positive effect of the generalised increase in access to education is that it has reduced distances not only between countries, but also within countries. As assessed by Checchi (2006), countries with an higher level of educational achievement show lower differences in it within the population. Though these significant improvements, the situation in many less developed countries remains complex.

The most used and widely available indicator of education quantity is the "gross enrolment rate" (GER). This rate is defined as the amount of children enrolled in a given level of education, regardless of age, as a percentage of the population in the age cohort associated with that level.

Table 1.6 shows the GER of students of primary school age - usually enrolled within six and eleven years - both for region and for country group[22]. As shown, the GER have increased dramatically in all countries during the decades, and in the new millennium,

[22] This categorization of countries is elaborated by the World Bank by per capita income in 1960. *Low-income countries* have a per capita income below $200 per year, *middle-income countries* have an income between $200 and $450, and *high-income countries* have an income greater than $450.

except in sub-Saharan Africa, they had reached or exceeded 100% in all regions. In sub-Saharan Africa, the GER increased to reach 80% in 1980, it declined slightly towards the end of the century to raise again with renewed vigour during the first years of the new millennium [23] (often following the abolition of school fees). Corresponding data are reported in Figure 1.3; the graph presents the trends in GER in primary school by region within a period of thirty years. As data reveal, the GER exceed 100% in some cases. This figure does not imply that all school-age children are enrolled and attend school, but that some factors lead to an upward bias. Both grade repetition of students (as well as the inclusion of children who are over or under age) and over-reporting in official data by principals and teachers can determine reported GER to reach or exceed 100% even when many children never enrol in school (Glewwe, Miguel, 2008).

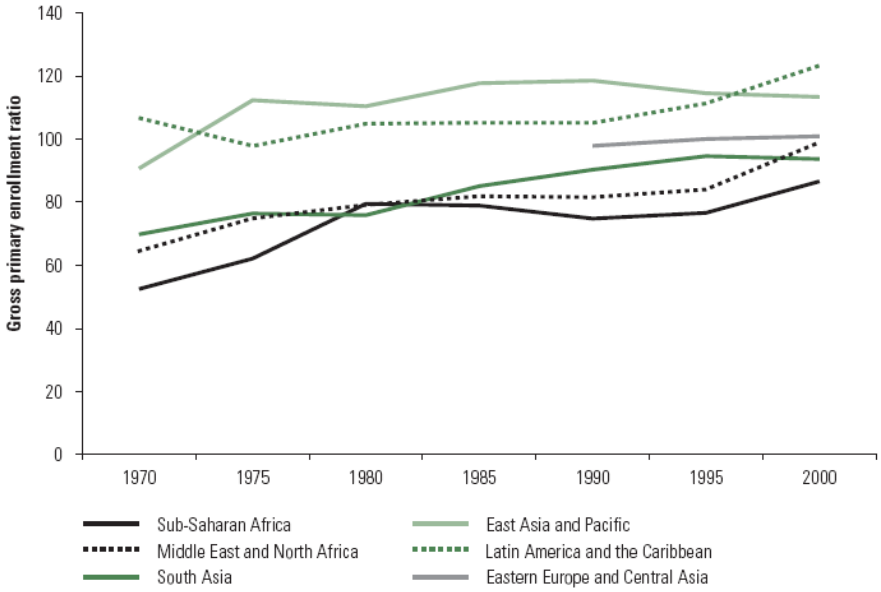
Table 1. 6: Primary school gross enrolment rates.

	Area	***1960***	***1970***	***1980***	***1990***	***2000***	***2004***
	World	80	87	97	102	104	106
Country group	Low-income	65	77	94	102	102	107
	Middle-income	83	103	101	103	110	107
	High-income	109	100	101	102	102	101
Region	Sub-Saharan Africa	40	51	80	74	77	91
	North Africa & Middle East	59	79	89	96	97	102
	Latin America & the Caribbean	91	107	105	106	127	118
	South Asia	41	71	77	90	98	110
	East Asia	87	90	111	120	111	113
	East Europe & Former Soviet Union	103	104	100	98	100	102
	OECD[1]	109	100	102	103	102	101

Source: Adaptation of Barro and Lee (1997); UNESCO (2002); World Bank (2003), UNDESA (2007).
Note: Countries with populations of less than 1 million are excluded.
1. OECD is the acronym for Organization for Economic Cooperation and Development.

[23] Among less developed countries regions, Latin America, the Caribbean and the Pacific have the highest pre-primary GER; far behind come East Asia, South and West Asia, the Arab States and the last one is, as expected, sub-Saharan Africa.

Figure 1. 3: Trends in gross primary enrolment ratios by region, 1970–2000.



Source: UNESCO Statistical Yearbook (1999), World Bank (2004)

Another indicator of the education quantity is the "net enrolment rates" (NER), defined as the number of children enrolled in a particular level of education who are of the age associated with that level of schooling, divided by all children of the age associated with that level of schooling. Of course, this is a more precise and reliable measure than the previous one. Indeed, the NER can never exceed 100% because the upward bias in GER caused by repetition or delayed enrolment is removed, and over-reporting is not addressed[24]. Hence, NER are obviously lower than GER for both low- and middle-income countries, mainly for sub-Saharan Africa. These discrepancies reflect higher repetition of grades and delay of enrolment in many less developed countries.

The divergences between GER and NER, and the total number of children enrolled in primary school within 1999 and 2004 are shown in Table 1.7. Enrolment in primary school raised by 6%, from 645 million to 682 million worldwide, between 1999 and 2004; the highest increases are in sub-Saharan Africa and South and West Asia. In the same period, the GER increased in almost all less developed countries, except for Latin America. As expected, the ratio increased in both South and West Asia and sub-Saharan Africa. Less developed countries as a whole have an increased average NER in the period considered; it

[24] Other measures of quantity of education have being developed, using age-specific enrolment rates and accounting for late entrants, but the quality of data available is often insufficient.

rose considerably, over again, both in South and West Asia and sub-Saharan Africa. The remarkable increase of NER in some sub-Saharan Africa countries during the early 2000 often follows the abolition of primary school fees.

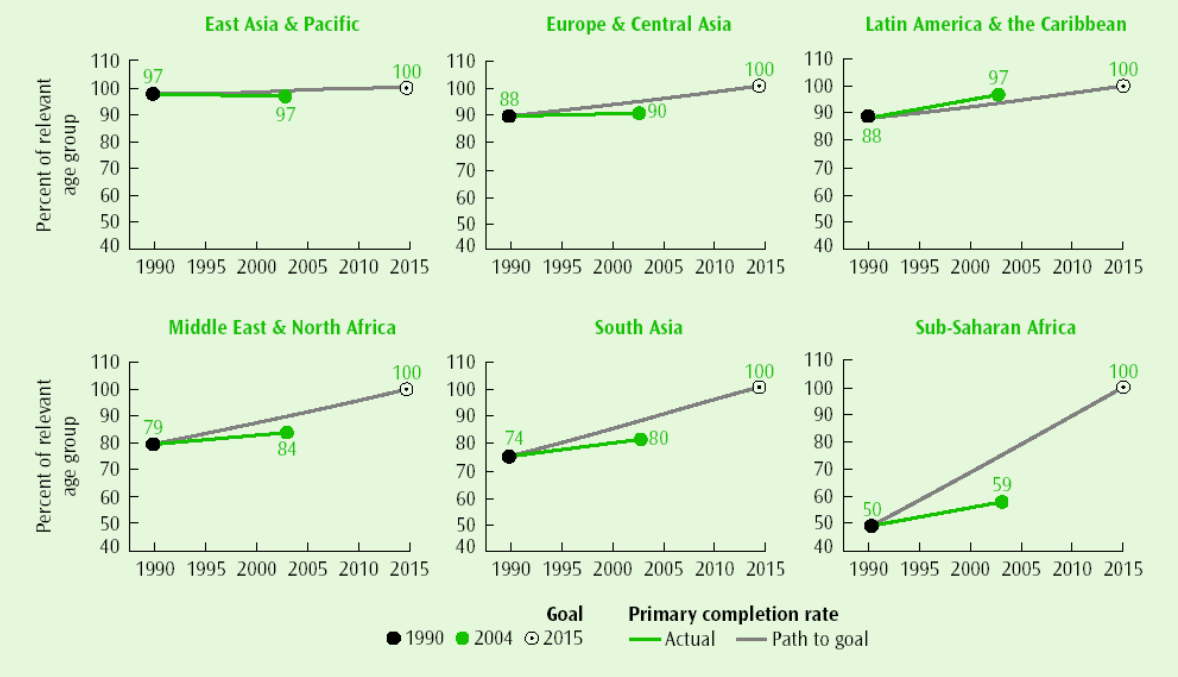
Table 1. 7: Enrolment in primary education for school years ending in 1999 and 2004, by region.

		Total enrolment (000)		*Gross enrolment ratios (%)*		*Net enrolment ratio (%)*	
	Area	***1999***	***2004***	***1999***	***2004***	***1999***	***2004***
	World	644,985	682,225	100.1	106.2	82.8	85.7
Country group	Low-income	558,733	600,879	99.8	106.8	81.2	84.6
	Middle-income	15,834	13,926	100.0	107.3	85.0	90.7
	High-income	70,418	67,419	102.2	101.4	96.7	95.6
Region	Sub-Saharan Africa	79,772	101,424	79.0	90.9	55.0	64.9
	Arab States	34,725	36,700	88.6	93.3	77.1	81.5
	Central Asia	6,853	6,376	98.7	101.6	88.6	91.6
	East Asia and the Pacific	217,575	206,217	111.9	113.2	96.0	93.9
	East Asia	214,277	202,712	112.2	113.5	96.2	94.0
	Pacific	3,298	3,505	93.9	97.9	87.4	89.6
	South and West Asia	157,510	187,884	93.9	109.9	77.3	85.9
	Latin America & the Caribbean	70,206	69,259	120.7	117.9	93.4	94.9
	Latin America	67,705	66,637	121.0	117.6	94.0	95.3
	Caribbean	2,500	2,622	115.0	126.3	77.1	83.5
	North America and Western Europe	52,857	51,734	102.9	101.7	96.7	95.2
	Central and Eastern Europe	25,489	22,630	99.6	101.5	89.2	90.7

Source: Adaptation from Annex, Statistical Table 5, UNDESA (2007)
Note: Countries with populations of less than 1 million are excluded.

A last consideration is that though a child is enrolled it does not mean that she will complete the school path. The literature (see, among the others, Grossman, 1972; Fuchs, 1965) suggests that final grade achieved is negative correlated with delaying entrance. Both are the observed outcomes of the latent propensity for schooling. Actually, for many countries, first of them in sub-Saharan Africa, a high discrepancy exists between completion rates and enrolment in primary school (Figure 1.4). This statement is important to assess whether the universal primary education goal will probably be achieved or not by 2015. In particular, in sub-Saharan African countries, even though the primary school completion rate actually rose from 50% in 2000 to 59% in 2004, the rate is still much too low and it will probably remain almost the same in 2015.

Figure 1. 4: Primary Completion Rate, by region (% of relevant age group).



Source: UNESCO (2006), UNESCO Institute for Statistics and World Bank joint database.
Note: Data are weighted by population.

1.8. The quality of education

The investigation presented in the previous paragraphs mainly focused on the quantity of education; however, the analysis on educational quality is of fundamental importance indeed. Increases in the quantity of education in less developed countries could be jeopardized by weaknesses in the quality of education. For this reason, the success occurred since the Sixties in expanding the quantity of schooling has shifted attention to education quality.

The economic effects of differences in educational quality are less known than those of educational quantity, primarily because of difficulties concerning the availability of measurement, restricted to a small amount of countries. The importance of quality of education, as its contribution to higher earnings for individuals and to growth rates of national income, is supported in several empirical studies (Behrman and Birdsall, 1983; Hanushek et al., 1992; Card and Krueger, 1992; Behrman and Rosenzweig, 1994; Behrman, Ross and Sabot, 2002; Hanushek and Wößmann, 2006; Aturupane, Glewwe, Wisniewski, 2006).

The quality of education in many less developed countries is lower than in the developed world. More precisely, children learn much less in school than the curriculum states they should learn; moreover, grade repetition and leaving school at an early age are common. Additionally, primary school teachers lack adequate qualifications, have weak incentives and little supervision, and their absenteeism is high. Then, in many rural areas services are often inadequate, pupil-teacher ratios are in excess of 40:1, schools often lack the most basic equipment and school supplies, such as books, blackboards, desks and sometimes even classrooms (Lockheed and Verspoor, 1991; Harbison and Hanushek, 1992; Hanushek, 1995; Glewwe, 1999). This situation has been almost predictable, mainly because the rapid increase of primary and secondary education in poor countries during the last decades has strained under financial and human resources branches.

Furthermore, differences exist in education finance of poor countries if compared to industrialized countries; as a matter of fact, per-pupil expenditures are often quite low, even after adjusting for price differences. Thus, distortions in educational budgets often lead to inefficient allocation and spending of funds. In the year 2000, the poorest countries of the world - for which data are available - spent about $82 billion on primary education. Firstly South Asia and secondly sub-Saharan Africa are the less developed regions with the lowest spending per primary school pupil. Of the indicated amount of money, sub-Saharan African countries totally spent $6.1 billion for 89 million students in primary school, which means $68 per pupil per year on average. This average amount, which represent a low sum by itself, is also overstated by a small number of countries (Botswana, Cape Verde, Mauritius, South Africa, and Zimbabwe) that have already achieved the primary education completion goal and spend, on average, $376 per student annually. Additionally, Seychelles, for which some data are missing but is well known that it is characterized by the highest enrolment ratio through Africa (UNICEF, 2006), the government spends $650 per student each year. All these countries kept out, Table 1.8 counts per student spending rates equal $35 for countries that are on track to accomplish primary education for all students, $27 for countries that are off track, and $31 for countries that are seriously off track. It can be concluded that sub-Saharan African countries present a considerable number of 39 million students who are not completing primary education; furthermore, only a very low spending per pupil is attributed to enrolled children, reflecting low quality of schooling (Glewwe, 2005).

Table 1. 8: Current Expenditures on Primary Schooling in sub-Saharan Africa in 2001.

Sub-Saharan African Region	Percent of Population		Spending per Student (US $)	Total Spending (millions US $)	Percent of population with spending data
	Within Region	All Developing Countries (except Europe & Central Asia)			
Already Attained	9	1	376	3720	94
On Track to Attain	6	1	35	388	100
Off Track	35	5	27	820	100
Seriously Off Track	48	7	31	1160	84
No Enrolment Data	2	0	650	7	1
Total	100	14	68	6100	98

Source: Data from World Bank (2002), Bruns at al. (2003)

Quality of education is measured by standardized tests of academic achievement and ability, repetition and drop-out rates. Since comparable measures of quality across countries is difficult to assess, it is important to recognize that omitting it leads to a source of measurement error. However, because minimal quality is partially reflected in attainment and enrolment rates, the omitted variable bias to the estimates are expected to be smaller[25]. As indicated by Glewwe and Kremer (2005), students in the majority of less developed countries learn less than their counterparts in wealthy countries, and these gaps are notable. These wide gaps could certainly reflect differences in family characteristics, but they also reflect low school quality proper of poor countries. Barro and Lee (1997) explore the determinants of educational quality in a panel data set that includes input and output measures for a wide number of countries. The authors find that family inputs – such as family characteristics income and education of parents - and school resources - as smaller class sizes and higher teacher salaries - are strongly linked to school outcomes, measured by internationally comparable test scores, repetition rates, and drop-out rates. The results also show that further school resources enhance educational outcomes.

When quality of education is enhanced for poor children, thus enrolment and attainment rates are often observed to increase; among the others, this is the case, for

[25] Comparisons of education quality across countries require internationally comparable data on academic performance. Important sources of such data are the Third International Mathematics and Science Study (TIMSS) and Progress in International Reading Literacy Study (PIRLS) projects, managed by the International Association for the Evaluation of Educational Achievement (IAEEA), and PISA (Programme for International Student Assessment) project, administered by the OECD. All the three projects collect data mainly from wealth countries, while they include not many less developed countries. For example, see the study of the situation in Bangladesh by Greaney, Khandker and Alam (1999); the analysis on Ghana's data by Glewwe (1999); the work on Indian data by Lockheed and Verspoor (1991).

Brazil in the study by Behrman and Birdsall (1983) and for Indonesia as noted by McMahon, Suwaryani and Boediono (2002). Given these considerations, with the aim of expanding primary education, governments have to make efforts not only in what concerns the quantity but also the quality of education.

1.9. Provision of education and the role of incentives in improving school attendance in less developed countries

In less developed countries educational provision - which implies schools finance and education system - is generally different to that in wealthy countries and faces many challenges. As shown in the previous paragraphs, the former countries are characterized by low quality, quantity and finance of education. Additionally, external shocks, such as HIV/AIDS and armed conflicts, continue to afflict education systems. For example, Zambia loses about 1,000 teachers to HIV/AIDS annually. About one third of African countries are involved in some form of civil conflict (World Bank, 2003).

Enhancing the level of human capital should be a matter of public concern in less developed countries. Schuppert and Wirz (2008) find that incentives to invest in public education vanish if a country is poorly endowed with human capital.

Hanushek (1995) reviews research on the impact of school spending in less developed countries. Based on 100 studies in that part of the world, the author reports little evidence that the teacher-pupil ratio or teacher salaries are positively and significantly related to student performance. Nevertheless, fully 35 of 63 studies find positive significant effect of teachers' education on scholar performance, and 22 out of 34 studies report positive and significant association between school facilities and student performance. The overall pattern suggests that school spending might matter more in a developing country context than in an industrialized one. Fuller and Clark (1994) report similar evidence bringing diminishing returns as an obvious explanation for that.

Halsey and Vegas (2009) state that expanding and improving primary education in less developed countries requires, at least, teachers who are present in the classroom and motivated to teach; however, this essential input is often missing. Surprise school visits reveal that teachers are absent at high rates in countries such as India, Indonesia, Uganda, Ecuador, and Zambia, reducing the quality of schooling especially for children in rural, remote, and poor areas. More broadly, poor teacher management and low levels of teacher

accountability afflict educational systems of many poor countries. Das et al (2007) focus on primary schools in Zambia. Controlling for many other observable inputs into student learning, the authors conclude that teachers absenteeism has a surprisingly large effect on learning for the typical student. Similar results are obtained by Duflo et al. (2007) in randomized evaluations made in rural Rajasthan, India. Other studies, as those conducted by Kremer et al. (2005) in India and Suryadarma et al. (2006) in Indonesia find akin outcomes, even though they are less reliable since they are not able to correlate an individual student's achievement with the absence of his or her own teacher.

Extensive discrepancies also exist between schools and education system within countries in less developed countries. In this situation, designing a single curriculum appropriate for all students is complex for any country. Notwithstanding this difficulty, many of those school systems are highly centralized and inappropriate for the typical child, due to a selected orientation of many curricula; therefore, a significant proportion of students on national examinations present poor performance, high dropout and repetition rates[26].

In response to the high cost and low quality of some centralized school systems in less developed countries, alternative and locally controlled systems - defined non-formal education - have been established in some of those countries. Policies toward private schools vary widely, from absolute prohibition (Cuba, Sri Lanka) to substantial subsidization (Chile). Consequently, while in some countries (Algeria, Mongolia, Tanzania) less than 1% of primary school students are enrolled in private schools, in other countries (Chile, Pakistan, Zimbabwe) nearly one half or more are enrolled in private primary schools. An example of existing differences in educational quality between public and private schools may be given once more by the rate of absenteeism of teachers. Kremer et al. (2005) find that private school teachers in India have absence rates one third lower than their public school counterparts in the same villages – despite the fact that private school salaries are only one fifth to one quarter that of public school salaries. In Pakistan, Das et al. (2006) find an even larger attendance gap.

As investigated above, in many less developed countries the number of children who do not attend school is predominant. Glewwe and Zhao (2005) show that, in many less

[26] For example, in Tanzania between 1997 and 2001, only 22% of the students who attempted were able to pass the primary education final examination, and only 28% of those who attempted passed the certificate of secondary education exam (Tanzania Media Monitoring, 2002).

developed countries, even though infrastructures and teachers are available, parents still do not enrol their children in those schools. Experts argue that the main barriers to entry in those countries are represented by households financial constraints. Parents in poor households are highly sensitive to both price and quality of primary education. A child is most probably an income earner necessary to sustain her family. However, in view of the modest potential contribution of primary school age child to household's income, it is supposed that improvements in school quality or small incentives could considerably enlarge the enrolment ratios. These incentives in providing attendance of primary education can be allocated both directly or indirectly. A direct incentive could be in monetary form, with the aim of reducing financial constraints either by decreasing the cost of school or compensating students or their parents for school attendance. An indirect non-monetary incentive could be addressing health problems, in the form of provision of meals at school, medicines or vaccines. Families respond to direct reductions in the cost of education either through subsidies to attend private schools (Angrist et al. 2002, 2006), reduced user-fees (Barrera et al., 2007) or scholarships (Kremer et al., 2007). Families also respond to direct inducements to attend such as school meals and direct cash incentives (see Vermeersch and Kremer, 2005; Schultz, 2004; Glewwe and Olinto, 2004; Schady and Araujo, 2006; Attanasio et al., 2006 among others).

The demand for education for females has an higher elasticity than for males; therefore, policies and programs that do not specifically target females as well may result in larger increases in school participation for them. Recent studies in support of this hypothesis are offered by Chin (2002) regarding placement of additional teachers in schools; Drèze and Kingdon (2001) on the provision of mid-day meals; both Schultz (2004) and Morley and Coady (2003) in their evaluations of PROGRESA.

The impact on learning of providing more educational inputs presents mixed evidence. Glewwe and Kremer (2005) confirm that education systems in less developed countries are weak: education finance systems lead to budget distortions, incentives for teachers are small or nonexistent, and curricula are often inappropriate. Governments have to assess costs and benefits of applying such incentives, to better choose among the various alternatives, such as hiring more teachers or building new classrooms.

1.9.1. Programs targeted to reduce cost of education

Economists have long debated concerning the usefulness of school fees. Some of them support the value of fees arguing that they are required to finance inputs and increase parental participation in school governance; moreover, they suggest that fees represent only a slight barrier to school enrolment and that the price elasticity of demand for education is small (see among the others, Jimenez and Lockheed, 1995). On the contrary, some researchers argue that fees are one of the main barriers to school entry and, consequently, dropping school fees would significantly increase enrolment of students. In support of this second view, important estimates have been collected for some less developed countries. The abolition of primary school fees in Uganda in 1997, in the United Republic of Tanzania in 2001 and in Kenya in 2002 drove to a doubled enrolment ratio of students in those countries[27] (UNICEF, 1999; Coalition for Health and Education Rights, 2002).

Among the several randomized evaluations assessing the effects of a reduction of costs on the school enrolment, the one conduced by Kremer et al. (2002) drives interesting and general results. The authors estimate a program in which a non-governmental organization provided uniforms and textbooks and built classrooms for some schools randomly selected among those with a poor performance in rural Kenya. The results are reduced dropout rates and higher completion rates; moreover, many students from close schools were sent by their parents into treated schools, raising extraordinarily the class size. A direct conclusion is that those persons preferred to trade off much larger class sizes for the benefit of free uniforms, textbooks and improved classrooms. Similarly, Michaelowa (2002) states that rather than promoting programs in sub-Saharan Africa that target to rise teachers salaries, reduce class size and increase academic qualification prerequisites, other simple measures, such as improved equipment with textbooks, are both more effective and cheaper.

Other programs give an incentive in the form of payment to students, both directly through cash grants or indirectly through school meals, to encourage their attendance. Perhaps the best known randomized evaluation is the PROGRESA program in Mexico (now "Oportunidades"), a large-scale poverty mitigation program designed to enhance

[27] Countries in sub-Saharan African region that have abolished school fees since 2000 are: Lesotho (2000), the United Republic of Tanzania (2001), Zambia (2001), Kenya (2002), Madagascar (2003), Mozambique (2004) and Benin (2005).

human capital. The program was planned to amplify school enrolment rates and academic achievements by paying cash grants to mothers conditional on their children's school attendance and involvement in preventative health measures, such as health care visits, nutrition supplementation and health education programs[28]. Schultz (2004) assesses the program has been successful in reducing the delay in school enrolment and the level of grade repetition rates, in reducing drop out rates, in increasing the enrolment rate, on average, for all students, particularly among girls.

The well documented success of the program leads to its expansion to urban communities; afterwards, similar programs have been implemented in several nearby Latin American countries (for instance, the PRAF program in Honduras) and in other parts of the world. In India, Bangladesh, Brazil, Jamaica and Swaziland such programs have been implemented aiming to increase both enrolment and attendance rates of primary students (World Food Program, 2002). Several other studies, such as the one by Barrera-Osorio et al. (2008) in Colombia, confirm that multiple variants of the conditional cash transfer are effective.

Some voices state that families may diminish resource allocation to children who receive school meals. Others support school meals claiming that such programs may represent an effective incentive for students to attend school, since they must attend school in order to receive the rations, and that improves students' academic performance by enhancing their nutrition. In support to the latter view, some researches are provided, as, for instance, those of Long (1991) and Powell (2006). Drèze and Kingdon (2001) in their deep analysis assess that the mid-day meals provided at school affect years in primary school for girl, but not for boys. Jacoby (2002), from the results of his study conduced in Philippines, presents evidence that parents do not diminish food provided at home in response to school feeding programs. Vermeersch and Kremer (2005), from their study on the impact of free breakfast on attendance of students in Kenya, show that school participation remarkably increased (it was 30% greater) in the treated schools than compared to the others. Additionally, they find that school meals program do not strengthen children's nutritional status and that the academic test score obtained more probably owe to additional time in school.

[28] The program did not start everywhere at the same time, therefore the researchers finally assesses the divergence in outcomes between treated groups and similar groups randomly chosen who were not treated. Then, at the starting point in year 1998, 506 communities participated, half of them were randomly selected.

1.9.2. Programs focused on health improvement at school

A potential non-monetary incentive to increase enrolment and, consequently, attendance of primary school students can be that schools offer means of providing health care to those children. Empirical studies show that in situations of shortage of primary health-care facilities, schools may provide the tools to improve health care to a large proportion of the school-age population. For instance, both studies by Glewwe and Jacoby (1995) and by Alderman et al. (2001) state that improved heath, measured by height-for-age, increases school enrolment. Glewwe, Jacoby and King (2001) affirm that well nourished children have better achievements in school since they start school earlier and learn more per year of educating. Bobonis, Miguel and Sharma (2006) confirm that health programs can increase preschool attendance. Kremer and Miguel (2004) show that deworming drugs improved school attendance, although is not the same for test scores, among Kenyan primary school students. Other researches make a further step, trying to shed light on the best mechanisms to implement such health programs in schools of less developed countries (Kremer and Miguel, 2003; Glewwe and Kremer, 2005). Outcomes of those analysis suggest that reliance on external financing of medicine is not sustainable, whereas health education, water and sanitation improvements, financing the provision of medicine through local cost sharing all lead to feasible results. This statement is confirmed by Azarnert (2008) who, consistently with empirical evidence from sub-Saharan Africa, shows that foreign aid can work against its stated goal of accumulating human capital and promoting growth. The analysis suggests that humanitarian aid fosters population growth, although may lock a recipient economy in a low-equilibrium trap since it adversely affects the recipients' incentive to invest in human capital.

An important element of any health programme for school-age children is represented by health education and communication. Children need relevant knowledge to understand their daily health problems, and they need practical abilities in how to recognize and protect themselves against diseases. Such knowledge and skills are crucial to allow children to prevent illness, making such investments more sustainable. Thus, the aim of health education targeted at children should be to create awareness and responsibility concerning diseases for children and their families. However, reality shows that the

majority of health education activities for school-age children fall short of such ideals (Behrman et al., 2004).

1.9.3. Programs aimed to build new schools or to improve the quality of the existent

Another topic of discussion is related to the trade-off between investments to improve the quality of existing educational facilities, making schools more attractive to students, and investments to construct supplementary schools, in order to increase the access to students by increasing capacity and reducing distance. Evidence on the extent to which school participation responds to school quality is miscellaneous.

Retrospective studies are proposed by Glewwe and Jacoby (1994) in Ghana, Bommier and Lambert (2000) in Tanzania, Drèze and Kingdon (2001) in India. The findings of this class of studies suggest that improved school quality is reasonably effective on quantity of schooling; moreover, it is a more cost-effective means of increasing the quantity of schooling than building additional schools. Even so, however, those results raise concerns in interpreting outcomes of retrospective studies, mostly owing to omitted variable biases.

Outcomes from natural experiments and randomized evaluations probably suggest more reliable evidence on the impacts of school quality. Natural experiments are offered, for instance, by Case and Deaton (1999) in South Africa and by Duflo (2001) in Indonesia. Randomized evaluations are developed, among the others, by Banerjee et al. (2000) in Indian and by Glewwe, Kremer and Moulin (2002) in Kenya. These estimates indicate mixed and likely biased estimates concerning the effects of increased school resources on schooling outcomes.

Studies by Michaelowa (2002) and Wechtler et al. (2007) state there is only very limited evidence for the effectiveness of expensive measures such as rising teachers salaries, reducing class size, and increasing academic qualification prerequisites in less developed countries. Other measures, as for instance more textbooks, are both more effective and cheaper.

Some recent studies (Banerjee et al., 2007; He et al., 2007; Muralidharan and Sundararaman, 2006) state that, in the short-term at least, interventions proven to develop the quality of education generate few changes in participation levels, seeming not to be a major incentive. Hence, promoting high quality schools is very hard, suggesting that

inefficiency can only be dealt with by the introduction of substantial performance incentives in schools and by more directed evaluation of educational experiments. Incentives, decentralized decision making and evaluation seem to be crucial to the improvement of the school system.

Concerning the topic, Hanushek (2008) states that viewing such a undesirable trade-off between providing broad access or high quality in education is a very bad approach to think about human capital development. Students respond to quality in education reducing existing inefficiencies, and may even sufficiently recover investments in quality in a short time (Pritchett, 2004). To resume, evidence suggests that there are several ways to amplify the quantity and quality of education attained by children. Even though the studies conducted on that topic provide mixed indications on the level to which school involvement responds to school quality, they also suggest that it is reasonably responsive to incentives.

1.10. The international approach concerning health and nutrition

The rights to adequate food and health status are fundamental human rights and preconditions of the right to live. As integral components of our economic, social and cultural human rights, they acknowledge the fact that every human being has a legally valid right to good health and sufficient food. Health, as defined by the Constitution of the World Health Organisation (WHO), is not merely the absence of disease or infirmity, but also a state of complete physical, mental and social well-being.

The 1948 Universal Declaration of Human Rights held in Paris recognized adequate health, including adequate food, among a basic human right. Art.25 of the Declaration states:

1. “Everyone has the right to a standard of living adequate for the health and well-being of himself and of his family, including food, clothing, housing and medical care and necessary social services, and the right to security in the event of unemployment, sickness, disability, widowhood, old age or other lack of livelihood in circumstances beyond his control.”

2. "Motherhood and childhood are entitled to special care and assistance. All children, whether born in or out of wedlock, shall enjoy the same social protection."

The right to health and nutrition was reiterated in 1989 during the Convention on the Rights of the Child, adopted by almost all United Nations Member Countries, as composing part of their constitutions.

The implementation of the right to food, as reinforced in the 1976 International Pact on Economic, Social and Cultural Rights (IPESCR), was included in the Plan of Action drawn up at the 1996 World Food Summit. The Plan states that in a food-secure population "all people, at all times, have both physical and economic [regular] access to sufficient, safe [, culturally suitable] and nutritious food to meet their dietary needs and food preferences for a productive and healthy life." (World Food Summit, 1996). Hence, people must have access to adequate foodstuffs, ensuring self-reliant food security, in order to nurture themselves with dignity rather than being nurtured; food aid is only acceptable as a temporary solution during acute emergency situations.

During the World Summit for Children on child and maternal health held in 1990, a group of world leaders identified a set of goals on the topics of health, nutrition, education, water supply and sanitation. Particular attention was given to reducing infant and child mortality by at least one third and behalf maternal mortality. These commitments for the involved countries started to draw a path for human development through the end of the decade.

In the year 2000, 189 Member States of the United Nations and their partners adopted a set of eight Millennium Development Goals. Those countries reaffirming their shared duty to "all the world's people, especially the most vulnerable and, in particular, the children of the world, to whom the future belongs." The first of these goals is to eradicate the extreme poverty and hunger, and in most cases this cannot occur without improvements in nutrition. The two targets of this goal are more modest, indicating to halve the proportion of people living under the absolute poverty line of one dollar a day and the proportion of people who suffer from starvation. To attain this goal, the realization of all the others goals is needed. The links among poverty, hunger and malnutrition, which is the focus of MDG 1, are evident. In addition, nutrition has a central role in the other MDGs. It is central to efforts to improve maternal and child health (MDG 4 and MDG 5)

and to fight against HIV/AIDS and other diseases (MDG 6). Better nutrition among schoolchildren also contributes to achieving universal primary education (MDG 2) by reducing absences and enabling students to better concentrate and develop their potentialities (see Table 1.9).

Table 1. 9: Nutrition and the MDGs.

Goal Nutrition	Effect
Goal 1: Eradicate extreme poverty and hunger.	Malnutrition erodes human capital through irreversible and intergenerational effects on cognitive and physical development.
Goal 2: Achieve universal primary education.	Malnutrition affects the chances that a child will go to school, stay in school, and perform well.
Goal 3: Promote gender equality and empower women.	Anti-female biases in access to food, health, and care resources may result in malnutrition, possibly reducing women's access to assets. Addressing malnutrition empowers women more than men.
Goal 4: Reduce child mortality.	Malnutrition is directly or indirectly associated with most child deaths, and it is the main contributor to the burden of disease in the developing world.
Goal 5: Improve maternal health.	Maternal health is compromised by malnutrition, which is associated with most major risk factors for maternal mortality. Maternal stunting and iron and iodine deficiencies particularly pose serious problems.
Goal 6: Combat HIV/AIDS, malaria, and other diseases.	Malnutrition may increase risk of HIV transmission, compromise antiretroviral therapy, and hasten the onset of full-blown AIDS and premature death. It increases the chances of tuberculosis infection, resulting in disease, and it also reduces malarial survival rates.

Source: Based on Gillespie and Haddad (2003)

In 2002, it was the time for a Special Session on Children by the United Nations General Assembly. During this circumstance, world leaders assessed progress gained since the World Summit and set additional goals specifically concerned with ensuring the rights of every child. At the conclusion of the Assembly, almost 180 countries adopted the document "A World Fit for Children".

At present, it is dramatically clear that whether the global trends continue on the same path in the future, these targets will have scarce probability to be achieved within the time set. Given appropriate estimates, 380 million people will still live on less than one dollar a day in 2015. The reduction in under-five mortality, instead of being reduced by two-thirds, will accomplish nearly one-quarter, which means 4.4 million preventable children's deaths (UNDP, 2007).

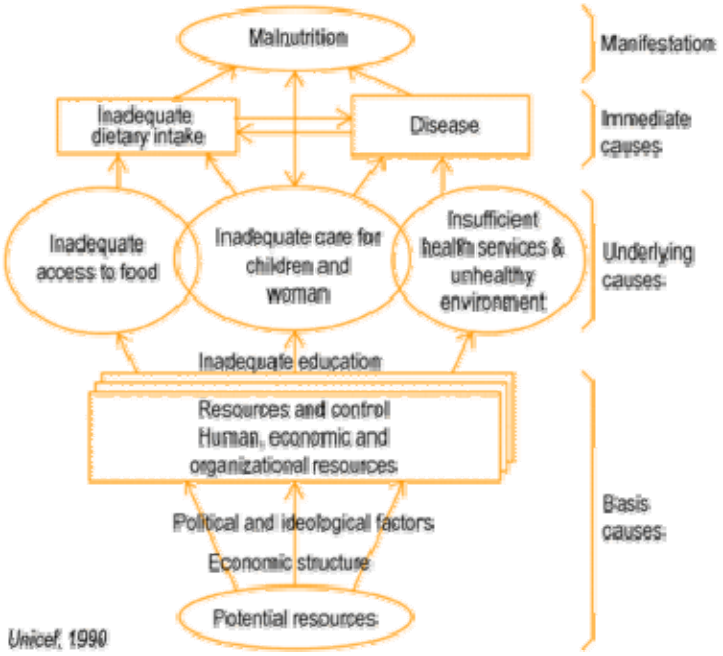
1.11. Causes and consequences of child malnutrition

Malnutrition represents one of the most important health and welfare problems among infants and young children in many less developed countries, being particularly serious in sub-Saharan Africa.

The determinants of children's nutritional status are complex, multidimensional and interrelated. These causes range from biological and social-economic factors; they have been differentiated on three levels, following the conceptual framework developed by UNICEF in1990 and later extended by Engle, Menon and Haddad in 1997. Those levels of causes are: primary (or basic causes), fundamental (or underlying causes), direct (or immediate causes). From this point of view, the immediate determinants of children's nutritional status are dietary intake and health status. Macronutrient (calories and protein) and micronutrient (vitamins, iodine, iron) deficiencies, whether from inadequate food intake or from illness, as diarrhoeal disease, respiratory infections and measles, directly cause malnutrition. Immediate determinants are, in turn, influenced by those defined underlying. Inadequate food intake is a consequence of insufficient food available at the household level and/or adequate care for mothers and children, as improper feeding practices. Unsafe healthy environment (which includes the availability of safe water, sanitation, health care and environmental safety) and inadequate care for children and women puts young children at increased risk of illness, which in turn adversely affects their nutritional status. Inadequate food intake, poor environmental sanitation and inadequate care for children and women reflect primary political, social and economic conditions at the community and national level, which are the basic determinants of children's nutritional status (Smith and Haddad, 1999).

The conceptual framework for malnutrition's causes in the society described above is represented in Figure 1.5.

Figure 1. 5: Conceptual framework for the causes of malnutrition in the society.



Source: UNICEF (1990)

At present, malnutrition is a trouble in both poor and prosperous countries, with the poorest people most affected. In the past, undernutrition - indicating the child consumes too little food to maintain a normal level of activity - with regard to macro and micro nutrients, has been and continues to be the dominant nutritional problem in less developed countries; however, other forms of malnutrition, in particular those that lead to obesity, are a rising public health concern. Obesity, although often considered a symbol of wealth and abundance, appears more and more frequently in less developed countries, representing a sign of poor and inadequate nutrition.

1.12. Indicators of child health and nutrition status for less developed countries

During the past decades data on child health and nutrition for less developed countries used to be scarce. Nowadays, national statistics on the development of young children, which allow the comparison of malnutrition indicators among these countries, are growing. The most common useful indicators relevant to different periods of life are described in this section.

One period of greatest vulnerability for malnutrition is pregnancy, when the child is still in the uterus (see among the other, Martorell, 1997; UNICEF, 1998). Scarce maternal health and nutrition before or during pregnancy have been shown to be noteworthy determinants of intrauterine growth retardation, measured as the prevalence of newborns below the 10th percentile for weight given gestational age (ACC/SCN, 2000). Gestational age is rarely known, therefore it is often proxied by Low Birth Weight (LBW) equal of even below 2500 grams. About 16% of newborns worldwide, especially in south Asia, have a LBW (ACC/SCN, 2000, ACC/SCN, 2003).

The infant mortality rate, which is indicated as under-one year mortality rate, is a commonly used measure of infant health and is a sensitive indicator of the socio-economic conditions of a country. The under-five mortality rate is another informative indicator of infant and child survival.

The following vulnerable period is the first two or three years of life. Several studies point out that the immediate causes of growth faltering are inadequate diets and diseases and that these are interactive. Young children are more susceptible to infections, because their immature immune systems fail to protect them adequately, and have also high nutritional needs, partly because they are growing rapidly. In less developed countries, the diets usually offered to most young children as complement to breast milk are of low quality, with poor energy and nutrient concentrations. In addition, younger children have not already acquired the ability to make their needs known and are more vulnerable to the effects of poor care practices. Consequently, multiple nutrient deficiencies are frequent. Moreover, foods and liquids are often contaminated with faeces or other pollutants, becoming vehicle of infections. As a result of infections and inadequate diets, most young children in less developed countries succumb to malnutrition.

Assessment of nutritional status is founded on the basis that in a well-nourished population, one observes a statistically predictable distribution of children of a given age with respect to height and weight. Pre-school and school-age children's nutritional status is frequently assessed by means of anthropometric measures. These measures commonly indicated: height-for-age, weight-for-age, and weight-for-height. Each indicator captures different aspects of malnutrition. For comparison purposes, children's height measurement is standardized according to the International Referenced Population defined by the U.S. National Centre for Health Statistics (NCHS) with the Centres for Disease Control (CDC)

and the World Health Organization (WHO) (WHO, 1995)[29]. Thus, all three indicators are expressed as a z-scores[30], which compare a child's measurements and sex with those of a similar child in a reference, healthy population defined by the US NCHS, who has a z-score with mean zero and standard deviation (SD) of one.

A low height-for-age z-score defines stunting, which means the child is too short for the age. Stunting indicates slow physical growth since the birth, usually due to repeated episodes of poor nutrition and/or episodes of diarrhoea and other illnesses. It is likely to persist even after these conditions are eliminated. It is a cumulative indicator of past episodes of malnutrition; thus, it is also defined as indicator of chronic malnutrition.

A low weight-for-height z-score defines wasting, which means the child is too thin for the height. Wasting indicates recent malnutrition and/or recent episodes of diarrhoea and other illnesses; hence, it is also defined as indicator of acute or transitory malnutrition.

A low weight-for-age z-score defines underweight, reflects both stunting and wasting. This condition can result from either chronic or acute malnutrition, or a combination of both.

The various degrees of severity of malnutrition are often classified using the following z-scores. In general, a mild stunted child has a height-for-age z-score that is between -2 and -1 SD below the mean of the reference population indicated by the NCHS/CDC/WHO; a moderate stunted child has a height-for-age z-score that is between -3 and -2 SD; a severe stunted child has a height-for-age z-score<-3 SD. Not stunted children has height-for-age z-score>-1 SD. Similar classifications are for the various degrees of severity of wasting and underweight. Table 1.10 summarizes the various degrees of severity of malnutrition, classified using the z-scores.

[29] The use of this reference population is based on the finding that well-nourished young children of all population groups follow very similar growth patterns. Although variations in height and weight exist, these approximate a normal distribution when the population under study is large.

[30] Z-scores are a means of answering the question: "How many standard deviations away from the mean is this observation?" If our observation X is from a population with mean μ and standard deviation σ, then $Z_x = \frac{X - \mu_x}{\sigma_x}$. A positive (negative) z-score indicates that the observation is greater (less) than the mean.

Table 1. 10: Malnutrition Indicators expressed as z-scores.

Malnutrition Indicator	-2.0 < Z ≤ -1.0	-3.0 < Z ≤ -2.0	Z ≤ -3.0
Height-for-Age	Mild Stunting	Moderate Stunting	Severe Stunting
Weight-for-Height	Mild Wasting	Moderate Wasting	Severe Wasting
Weight-for-Age	Mild Underweight	Moderate Underweight	Severe Underweight

Numerous elements contribute to deprived anthropometric status for young children, as LBW and reduced breastfeeding (see for instance Hoddinott and Kinsey, 2001; Li, 2003). Research has shown that *severe* malnutrition in early childhood is causally linked to irreparable deficits in cognition while *moderate* malnutrition is associated with cognitive and mental development (Brown and Pollitt, 1996; Grantham-McGregor et al., 1999). The WHO recommends stunting as a reliable measure of overall social deprivation (WHO, 1986), whereas the MDG nutritional indicator is defined as underweight.

Finally, children and adults' nutritional and health status is often measured in term of Body Mass Index (BMI), which reflects short-term and long-term nutrition and health. It is calculated by dividing weight in kilograms by the square of height in meters.

$$BMI = \frac{Weight(Kg)}{Height^2(m)}$$

A person is considered to be chronically energy underprovided if her BMI is below 18.5, overweight if it is greater than 25 and obese if it is greater than 30.

1.13. Causes of child mortality and potential interventions

As discussed in par 1.11, child morbidity and mortality in less developed countries can be determinate by several different reasons. A detailed assessment of the "burden of disease" - in terms of "disability adjusted life years" - for children in the poor countries was conduced by the World Bank in 2001; the situation remains almost unchanged at the present time (see Lopez et al., 2006; Glewwe and Miguel, 2008). These data offer a

comparison of different kinds of diseases for under-five years-old children and school-age children in those countries, underlying substantial differences between regions. Table 1.11 summarizes the in-depth investigation conducted by the authors on this topic. The work compares data on diseases for children who separately belong the two indicated age cohorts. What emerges is that illnesses of pre-school age children have permanent effects on their cognitive and health development; moreover, they may have much stronger effects than illnesses on school-age children.

Concerning the cohort composed by the youngest children, slightly more than 15% of total "healthy years of life" are lost. About one half of the overall burden of disease is due to communicable diseases, the most prominent of which are (in descending order of importance): respiratory infections, diarrhoea, malaria and measles (the last of which is easily preventable by vaccination). The burden of disease for those children is composed of one half by prenatal problems; one fifth by non-communicable diseases, such as mental retardation and congenital malformations; nearly 4% by nutrition problems and injuries.

Wide discrepancy across geographic regions is shown in the table. In middle income countries, the percentage of healthy years of life lost is about 10% and only about one third of the burden of disease for East Asia and the Middle East and one fourth for Latin America is due to communicable diseases. Highest values are reported for low income countries. The percentage of health years lost is 17% for South Asia and 29% for sub-Saharan Africa; the burden of disease due to communicable diseases is about 49% and 73% respectively. More deeply, it can be assessed that in middle income countries pertussis, measles and tetanus, which are diseases for which children can be easily vaccinated against, slightly contribute to the burden of disease; conversely, those justify almost 8% of the burden of disease in South Asia and 12% in sub-Saharan Africa.

Regarding the second cohort composed by school age children, data show that, considering all less developed countries collectively, 0.8% of healthy years of life are lost. Of the burden of disease, just 37% owed to communicable diseases, mainly respiratory infections and measles; 30% is given to non-communicable diseases; 29% is due to injuries. As the former group of children, only almost 4% owed to nutritional problems.

Once more, likewise for the youngest cohort of children, the burden of disease varies largely across geographic regions. Measles and respiratory infection rates are broadly

different between countries. Communicable diseases in South Asia and sub-Saharan Africa contribute for 38% and 56% respectively to the overall burden of disease.

Both HIV/AIDS and malaria play a remarkable role in sub-Saharan Africa, where are primarily located poor countries. HIV/AIDS counts 6% for under-five years-old children and rises to 11.3% for school-age children. On the other hand, malaria registers 20% for children who are under-five years-old and decreases consistently to 2.3% for school-age children. Concerning these data related to the two age cohorts, it is evident that in sub-Saharan Africa, although malaria is the principal cause of disease for under-five years-old children, AIDS plays a key role for school-age children. Therefore, the suggestion is to focus governments' intervention on the first years of life: principally on malaria for the younger children, primarily providing mosquito-net to the infant; on HIV/AIDS for the elder, assuring them the necessary knowledge of the virus transmission, permitting them to behave appropriately to avoid its contraction.

Table 1. 11: Burden of Disease for pre-school and school-age children in less developed countries.

Age cohort of 0-4 years children

	East Asia and Pacific	Latin America and Caribbean	Middle East and North Africa	South Asia	Sub-Saharan Africa	All Less Developed Countries
Communicable diseases, of which:	30.8%	23.6%	35.1%	48.7%	72.6%	52.4%
AIDS	0.3%	0.8%	0.1%	0.3%	6.0%	2.5%
Diarrhoea	10.8%	8.0%	11.1%	14.5%	12.8%	12.6%
Pertussis	0.9%	1.5%	1.5%	2.7%	3.8%	2.7%
Measles	2.1%	0.0%	1.4%	3.1%	6.6%	4.0%
Tetanus	0.7%	0.1%	0.5%	1.8%	1.6%	1.3%
Malaria	1.4%	0.3%	2.7%	1.3%	20.2%	8.5%
Respiratory Infections	10.5%	7.5%	7.5%	18.7%	14.7%	14.8%
Prenatal	28.8%	26.7%	19.8%	26.3%	12.4%	21.1%
Nutrition problems	4.5%	3.7%	5.8%	4.3%	4.1%	4.4%
Non-communicable illnesses:	30.3%	41.8%	33.4%	17.3%	8.4%	18.6%
Injuries	5.5%	4.1%	5.9%	3.3%	2.5%	3.6%
Percent of Healthy Years Lost	**8.4%**	**8.6%**	**11.3%**	**16.8%**	**28.6%**	**15.1%**

Age cohort of 5-14 years children

	East Asia and Pacific	Latin America and Caribbean	Middle East and North Africa	South Asia	Sub-Saharan Africa	All Less Developed Countries
Communicable diseases, of which:	23.0%	16.6%	15.0%	38.2%	56.4%	36.9%
Tuberculosis	1.4%	0.7%	0.5%	1.7%	1.9%	1.5%
AIDS	0.1%	1.4%	0.0%	0.4%	11.3%	3.7%
Diarrhoea	2.1%	3.7%	1.7%	1.2%	1.2%	1.6%
Measles	4.7%	0.0%	2.9%	6.5%	10.4%	6.5%
Tetanus	0.8%	0.0%	0.2%	2.0%	1.4%	1.3%
Malaria	0.5%	0.3%	0.8%	0.9%	2.3%	1.2%
Intestinal helminths	3.3%	1.7%	1.7%	1.5%	4.4%	2.7%
Respiratory Infections	5.6%	4.2%	4.1%	6.0%	9.1%	6.6%
Nutrition problems	4.9%	2.1%	7.1%	4.4%	2.8%	4.1%
Non-communicable illnesses:	38.4%	58.4%	40.9%	29.1%	15.5%	30.3%
Injuries	33.6%	22.6%	36.7%	28.1%	25.0%	28.5%
Percent of Healthy Years Lost	**0.5%**	**0.5%**	**0.6%**	**0.9%**	**1.4%**	**0.8%**

Source: World Bank (2006, Table B.63C), Glewwe and Miguel (2008)

As debated here above, the majority of childhood diseases – such as acute respiratory infection, diarrhoea, malaria and measles - that often cause death in less developed countries are preventable or treatable. Numerous epidemiological studies support interventions as preventive measures, which can reduce the risk of people contracting specific diseases, and treatments, which can diminish the probability of dying

from diseases. Most of these interventions need to be implemented not only by individuals, but also by families and communities. The problem is that poor rural families often live in areas with shortage of medicines, health care facilities and means of transport to these structures.

Breastfeeding protects babies from diarrhoea and acute respiratory infections, stimulates their immune systems and response to vaccinations, contains hundreds of health-enhancing antibodies and enzymes. If every infant were exclusively breastfed from birth, an estimated 1.5 million lives would be saved – and enhanced – every year. Certainly, some other interventions are necessary to protect the 515,000 women dying each year because of pregnancy and childbirth complications.

Diarrhoea is caused by ingesting certain bacteria, viruses or parasites that are usually spread by flies or through contaminated water, food, utensils and hands. Therefore, hygiene practices such as hand washing and safe disposal of faeces go a long way in preventing diarrhoeal diseases. Good nutrition and vital micronutrients[31] are also critical for preventing diarrhoea. Finally, most diarrhoea-related deaths in children are due to dehydration from the body in the liquid stool, many of which can be prevented with the use of oral re-hydration therapy.

Adequate nutrition and micronutrient supplementation successfully prevent acute respiratory infections (ARI), the most common of which can be treated with affordable antibiotics.

Routine immunization against common vaccine-preventable viral infections, including measles, tetanus, hepatitis B, meningitis, yellow fever, diphtheria, tuberculosis and pertussis, is critical to ensuring that children survive and thrive. The consequences of these virus are often complicated because they act in conjunction of additional diseases. The cost of these vaccines is relatively low, approximately US$1.

Early diagnosis and treatment of malaria saves lives and prevents the development of complications. As stated here above, malaria can be highly controlled basically by using insecticide-treated bednets. Epidemiological studies have assessed that under-five mortality rates for children residing in malarial areas could be reduced by roughly 28% with its usage. Additionally, malaria can be prevented with the Intermittent Preventive

[31] "Investments in micronutrients have higher returns than those from investments in trade liberalization, in malaria, or in water and sanitation. […] No other technology offers as large an opportunity to improve lives at such low cost and in such a short time." Copenhagen Consensus (2004)

Treatment (IPT), by providing two or more doses of an anti-malarial drug to pregnant women.

As shown in Table 1.11, HIV/AIDS is most common among young people living in less developed countries, mainly in sub-Saharan Africa. More than 20 million Africans have already died of AIDS and there are currently an estimated 12 million AIDS orphans on that continent (UNAIDS, 2004). AIDS is primarily transmitted through sexual practise, then by infected blood and prenatal transmission, occurred from infected mother to foetus. AIDS has no cure and no vaccine, but it is preventable. The best measures to prevent the spread of the virus is ensuring young men and women the access to the information, education and services required to adopting a correct health and reproductive behaviour necessary to shrink their vulnerability to the infection.

1.14. Recent situation concerning health and nutrition status for children in less developed countries

This section provides some estimates on health and nutrition status for children living in less developed countries, with the purpose of clearly depicting the extreme present situation related to that topic.

Out of 100 children born alive in 2000, 31 will most likely suffer from malnutrition in their first five years of life, 26 will not be immunized against the basic childhood diseases, 19 will lack access to safe drinking water, 40 to adequate sanitation and 17 will never attend school. About 842 million people do not have adequate access to food (FAO, 2003). As a consequence, some 25,000 persons die from conditions related to hunger and malnutrition every day (UN World Food Programme, 2002). Moreover, a child in a less developed country has approximately 25% possibility of living in extreme poverty. As a result, nearly 11 million children each year (about 30,000 children a day) die before reaching five years old, mostly (6 millions) from preventable causes. Of these children, 4 million die in their first month of life and tens of millions more are not fulfilling their developmental potential, suffering physical and/or mental disabilities or learning impairment. Actually, even when children do survive, they too often do not grow (Lancet, 2007; UNESCO, 2006).

Table 1.12 presents data on both underweight and mortality rate for under five years of age children living in less developed countries. The prevalence of underweight as a whole was 46.5% in 1970; however, it had decreased to reach 27% during last decade and it continues to drop, though slowly. Data diverge across regions: low level of Latin America balances the highest of South Asia; no figure can be drawn for sub-Saharan Africa since data are missing for many of its countries. As shown in the table, there is a small improvement counted by the under five mortality rate decreasing from 10.3% in 1990 to 8.7% in 2003. Once more, there is huge variation by regions: considering 2003 data, while the rate was narrow in Latin America counting 3.3%, it was higher in both South Asia and sub-Saharan Africa, counting 9.2% and 17.1% respectively.

Table 1. 12: Malnutrition and mortality rate for children in less developed countries, by region.

Region	Underweight (%) (children < 5 years)	Under-Five Mortality Rate (per 1,000)	
	1995-2003	1990	2003
East Asia and Pacific	15	59	41
Latin America	9	53	33
Middle East/N. Africa	15	77	53
South Asia	48	130	92
Sub-Saharan Africa	-	187	171
All less developed countries	27	103	87

Source: World Bank (2005), Glewwe, Miguel (2008)

Even though sufficient food is being produced worldwide to feed everyone, for many people the prize of foodstuff is too much high compared to their own salaries or income (UNDP, 2003). Malnutrition is more prevalent among poor than among non-poor children and in rural than in urban areas. This evidence might be expected since it is well known that in rural areas poverty is generally higher, the provision of health services less adequate, clean drinking water more scarce, and hygiene and education levels lower than in urban areas. Thus, while households can protect their children against modest economic shocks, it is not the same in case of dramatic economic shocks.

Table 1.12 shows the prevalence of disadvantaged, stunted or poor, children under-five years in less developed countries[32]. Of the overall sum, 22% are living in absolute poverty,

[32] Among the anthropometric measures of malnutrition, stunting appears more closely related to household income levels than wasting is, since the latter is variable and unrelated to family expenditures at low income levels. Several studies state that family expenditures have consistent impact on preschool-age children's long-term nutritional indicator status, represented by stunting, but not on her short-term nutritional indicator status,

28% are stunted and 39% are both stunted and living in poverty. The worst health and nutrition situation characterizes Asia and sub-Saharan Africa. What emerges from the table is that, even though sub-Saharan Africa and South Asia both present similar rates of stunted children, in South Asia - as in most less developed countries - prevalence has been declining since 1990, whereas in sub-Saharan Africa it has increased, also counting a higher proportion of poorer families.

Table 1. 13: Prevalence of poor and malnourished children under 5 years old, by region in 2004.

Region	Population younger than five years	Percentage living in absolute poverty	Percentage stunted	Percentage both stunted and poor
Sub-Saharan Africa	117.0	46%	37%	61%
Middle East and North Africa	44.1	4%	21%	22%
South Asia	169.3	27%	39%	52%
East Asia and Pacific	145.7	11%	17%	23%
Latin America and the Caribbean	56.5	10%	14%	19%
Central and Eastern Europe	26.4	4%	16%	18%
Less developed countries	**559.1**	**22%**	**28%**	**39%**

Source: Lancet (2007), UNICEF (2006), WHO (2006)

1.15. Final considerations

This chapter sets the first stage for the research thesis. It offers the necessary tools to the implementation of a proper analysis on economics of education and health, focusing on the pivotal aspects on which future research has to be directed.

Education and health care for young children have received high policy attention during the last decades. It has been recognized that equitable access to early childhood health care and education of good quality, especially for the most vulnerable and disadvantaged children, is essential for a sustainable economic and human development. Nevertheless, despite remarkable attainments in human capital, there is still room for improvement since less developed countries continue to face great challenges in improving education and health levels of its people.

represented by wasting. For a deep investigation on this topic, see Xiao (1998/2006), and the comparison between "Living Standards Measurement Survey" made for several sub-Saharan African countries.

The economics of education and the economics of health, beyond being mere investigations of economies, provide valuable means to understand the behaviour of the people involved in the development process. As discussed in the text, several studies affirm that the main barrier to education and health in less developed countries is represented by parental choice, together with particular child's and social determinants. More precisely, low income, inadequate education, poor nutrition, high opportunity costs of child time are considered the major constraints on human capital investment, primarily in poor countries. The paper attempts to recognize which are the reasons of severe inequalities and inefficiencies that exist and afflict those people; additionally, it aims to determine which of these limitations is most important in order to define a path for the development of policies.

The effort is mainly concentrated on children of less developed countries, with a particular focus on sub-Saharan Africa, since they represent the most vulnerable people; additionally, in this part of the world the majority of the population still live in extreme poverty, with worse health and education outcomes. This situation is consequential to the lower quality and less accessible health and education services relative to industrialized countries. Furthermore, it is argued that intervention targeted on children during the first years of life is fundamental for fulfilling all other children's rights, represents the best guarantee of promoting sustainable development and would solve the efficiency and equity trade-off which subsist for investments later in life.

Enhancing the level of human capital should be a matter of public concern in less developed countries, since incentives to invest in public education or health vanish if a country is poorly endowed with human capital. Improvements in health status and primary education are not competing goals, but mutually reinforcing: enhanced pre-school nutrition will facilitate meeting the education objectives; further, acquisition of knowledge at school improving students' health and nutritional status. These improvements imply positive relationships between both education and health with productivity, rising the opportunities of breaking the cycle of poverty.

To conclude, from the discussion presented in this section, some considerations are offered concerning the role of education and health policy in promoting sustainable economic and social development. Governments have to realistically recognize that basic education and health care provision for all children worldwide needs time and much more

efforts. Moreover, decentralisation and local control can be recommended in some cases since they contribute to the efficiency and equity of spending. Finally, a group of uncoordinated spending on educational and health programmes risks to have little effect on human development and reduction of poverty. On the contrary, the coherence of public interventions on education and health sectors in a long-term perspective leads to a higher result than the sum of the effects of each service.

1.16. References

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1.17. Annex I: Gross domestic product and Human Development Index

The gross domestic product (GDP) is one of the measures of national income and output for a given country's economy. It represents the total monetary value of all final goods and services produced in a particular economy within the borders of a nation in a given year. The measurement of overall GDP is subject to uncertainties and to difficult measurement problems in some areas[33].

GDP per capita has been considered and widely used by economists as indicator of macroeconomic development representing the average level of well-being of a population in a country. However, its limitations have been soon realized. Since GDP is based almost exclusively on economic growth, it does not take into account many elements, such as, among others: disparity in incomes between the rich and poor, the capital (primarily natural capital) lost during such growing processes, activities that are not provided through the market, the quality of goods, externalities or economic bads such as damage to the environment, sustainability of growth. Kuznets (1934) in his very first report to the US Congress in 1934 stated: "The welfare of a nation [can] scarcely be inferred from a measure of national income"**.** Given that quality of life of people tends to improve as GDP per capita increases, all other things being equal, GDP can be considered as a proxy for standard of living, rather than being a direct measure of it.

A couple of decades ago the inadequacy of GDP per capita was recognized as a direct measure of the standard of living, hence a new index was required in order to count different factors - apart form the GDP - which could not being held in a consistent manner by a single person[34]. For the same purpose, Pakistani economist Mahbub ul Haq, Sir Richard Jolly, with an help from Gustav Ranis of Yale University and Lord Meghnad Desai of the London School of Economics finally developed the Human Development

[33] By construction, GDP at factor cost is equal to gross income earned in the process of producing output. To measure the contribution that economic activities provide to the well-being of the residents of a country, income transfers received by residents from abroad should be added to GDP (and transfers made by residents to people in other countries should be subtracted) to attain a measure of Gross National Income (GNI). A second adjustment, to reflect the consumption of capital, is required to get a better measure of the economic resources that are available to individuals in a country for current and future consumption, resulting in a measure of Net National Income (NNI).

[34] Other alternatives to GDP can be: Genuine Progress Indicator; Wealth Estimates - developed by the World Bank Private Product Remaining as discussed by Murray Newton Rothbard and other Austrian economists; European Quality of Life Survey; Gross National Happiness - on which the Centre for Bhutanese Studies in Bhutan is currently working; Happy Planet Index - introduced by the New Economics Foundation.

Index (HDI) in 1990. The ideas and studies of Indian Nobel prize Amartya Sen were determinant in the development of the index[35]. The HDI is an index of macroeconomic development used to measure and rank countries by level of "human development", a concept that, according to the United Nation Development Program (UNDP), refers to the process of widening the options of persons, giving them better opportunities for education, health care, income, employment, etc. HDI is a simple average of three indexes reflecting a country's achievements in:

- education and knowledge, as measured by adult literacy[36] rate (with two-thirds weighting) and the combined primary, secondary and tertiary gross enrolment ratio (with one-third weighting);
- health and longevity, as measured by life expectancy at birth[37];
- income, as measured by real GDP per capita in purchasing power parity terms in US dollars.

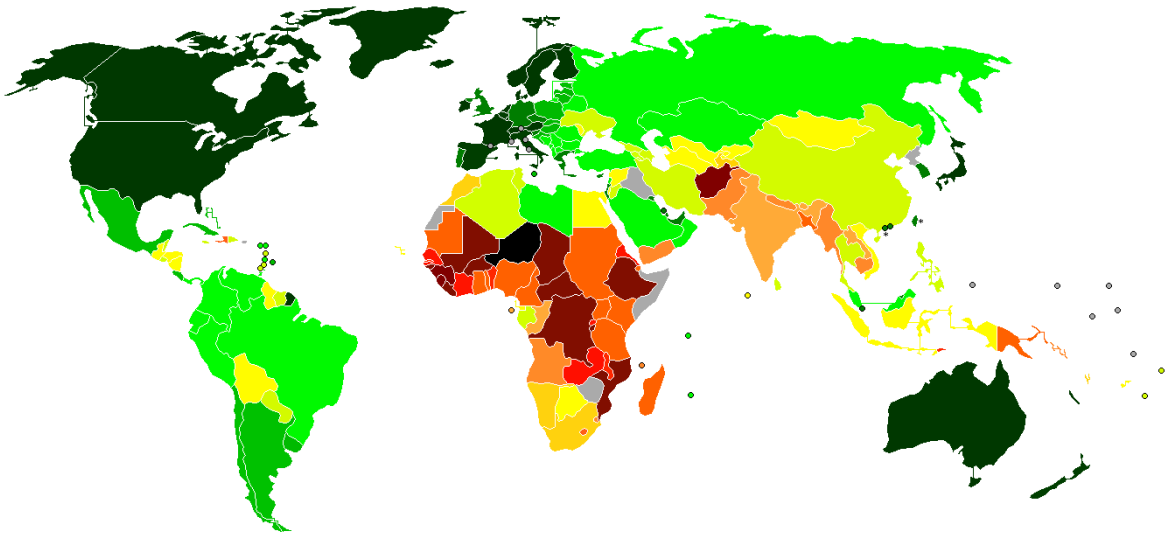
Together with the GDP per capita, the HDI has been used by the United Nations since 1993[38]. HDI discloses that a country can do much better than might be expected at a low level of income. By combining social and economic data, the HDI allows nations to take a broader measure of their development performance, both relatively and absolutely, and thus to focus their economic and social policies more directly in areas in need of improvement. Nevertheless, the index has been criticized under various aspects during the time, as, for instance: its redundancy as measure of development; its failure to include any ecological considerations; to not paying much attention to development from a global perspective.

The HDI's scale is in thousandth, decreasing from 1 to 0, and attempts to rank all countries into four groups of human development: very high (index between 0,900 and 1), high (index between 0,800 and 0,899), medium (0,500 and 0,799), low (index between 0.0 and 0,499). The list of countries by HDI covers 182 countries, of which 178 UN members (out of 194 states) with the addition of Hong Kong and Palestine. Of those countries, 38

[35] For an extended elucidation about the HDI, see UNDP (1990) and http://hdr.undp.org/en/humandev
[36] Literacy is the fraction reported or estimated to have basic abilities to read and write.
[37] Life expectancy is the average number of years newborn children would live if subjected to the mortality risk prevailing for their cohort at the time of their birth.
[38] Since the main focus of the research is on children, it can be interesting to indicate the work of van der Gaag and Dunkelberg, (2005). who tried to develop a "Child Welfare Index", a Human Development Index focused on children.

are at very high, 45 at high, 75 at medium, 24 at low human development. At the highest levels, in descending order, are: Norway (at first place), Australia, Iceland, (Italy is 18°); at the bottom, in ascending order, are: Niger (at last place), Afghanistan, Sierra Leone (UNDP, 2009).

Figure 1. 6: World map indicating Human Development Index (2009)



Very High
0.950 and over
0.900–0.949

High
0.850–0.899
0.800–0.849

Medium
0.750–0.799
0.700–0.749
0.650–0.699
0.600–0.649
0.550–0.599
0.500–0.549

Low
0.450–0.499
0.400–0.449
0.350–0.399
under 0.350
not available

Sources: UNDP (2009)

1.18. Annex II: Goals and targets from the Millennium Declaration Indicators

Table 1. 14: Goals and targets from the Millennium Declaration Indicators

Goal 1	**Eradicate extreme poverty and hunger**		
Target 1	Halve, between 1990 and 2015, the proportion of people whose income is less than $1 a day	1	Proportion of population below $1 (PPP) a day
		1	Poverty headcount ratio (percentage of population below the national poverty line)
		2	Poverty gap ratio [incidence × depth of poverty]
		3	Share of poorest quintile in national consumption
Target 2	Halve, between 1990 and 2015, the proportion of people who suffer from hunger	4	Prevalence of underweight children under five years of age
		5	Proportion of population below minimum level of dietary energy consumption
Goal 2	**Achieve universal primary education**		
Target 3	Ensure that, by 2015, children everywhere, boys and girls alike, will be able to complete a full course of primary schooling	6	Net enrolment ratio in primary education
		7	Proportion of pupils starting grade 1 who reach grade 5
		8	Literacy rate of 15- to 24-year-olds
Goal 3	**Promote gender equality and empower women**		
Target 3	Ensure that, by 2015, children everywhere, boys and girls alike, will be able to complete a full course of primary schooling	6	Net enrolment ratio in primary education
		7	Proportion of pupils starting grade 1 who reach grade 5
		8	Literacy rate of 15- to 24-year-olds
Target 4	Eliminate gender disparity in primary and secondary education, preferably by 2005, and in all levels of education no later than 2015	9	Ratios of girls to boys in primary, secondary, and tertiary education
		10	Ratio of literate women to men ages 15–24
		11	Share of women in wage employment in the non-agricultural sector
		12	Proportion of seats held by women in national parliaments
Goal 4	**Reduce child mortality**		
Target 5	Reduce by two-thirds, between 1990 and 2015, the under-five mortality rate	13	Under-five mortality rate
		14	Infant mortality rate
		15	Proportion of one-year-old children immunized against measles
Goal 5	**Improve maternal health**		
Target 6	Reduce by three-quarters, between 1990 and 2015, the maternal mortality ratio	16	Maternal mortality ratio
		17	Proportion of births attended by skilled health personnel
Goal 6	**Combat HIV/AIDS, malaria, and other diseases**		
Target 7	Have halted by 2015 and begun to reverse the spread of HIV/AIDS	18	HIV prevalence among pregnant women ages 15–24
		19	Condom use rate of the contraceptive prevalence rate
		19 a	Condom use at last high-risk sex
		19 b	Percentage of 15- to 24-year-olds with comprehensive correct knowledge of HIV/AIDS
		19 c	Contraceptive prevalence rate

		20	Ratio of school attendance of orphans to school attendance of non-orphans ages 10–14
Target 8	Have halted by 2015 and begun to reverse the incidence of malaria and other major diseases	21	Prevalence and death rates associated with malaria
		22	Proportion of population in malaria-risk areas using effective malaria prevention and treatment measures
		23	Prevalence and death rates associated with tuberculosis
		24	Proportion of tuberculosis cases detected and cured under directly observed treatment, short course (DOTS)
Goal 7	**Ensure environmental sustainability**		
Target 9	Integrate the principles of sustainable development into country policies and programs and reverse the loss of environmental resources	25	Proportion of land area covered by forest
		26	Ratio of area protected to maintain biological diversity to surface area
		27	Energy use (kilograms of oil equivalent) per $1 GDP (PPP)
		28	Carbon dioxide emissions per capita and consumption of ozone-depleting chlorofluorocarbons (ODP tons)
		29	Proportion of population using solid fuels
Target 10	Halve, by 2015, the proportion of people without sustainable access to safe drinking water and basic sanitation	30	Proportion of population with sustainable access to an improved water source, urban and rural
		31	Proportion of population with access to improved sanitation, urban and rural
Target 11	By 2020, to have achieved a significant improvement in the lives of at least 100 million slum dwellers	32	Proportion of households with access to secure tenure
Goal 8	**Goal Develop a global partnership for development**		
Target 12	Develop further an open, rule-based, predictable, non-discriminatory trading and financial system Includes a commitment to good governance, development and poverty reduction—both nationally and internationally		Some of the indicators listed below are monitored separately for the least developed countries (LDCs), Africa, landlocked countries and small island developing states. **Official development assistance (ODA)** 33. Net ODA, total and to the least developed countries, as a percentage of OECD/DAC donors' gross national income. 34. Proportion of total bilateral, sector-allocable ODA of OECD/ DAC donors to basic social services (basic education, primary healthcare, nutrition, safe water and sanitation) 35. Proportion of bilateral official development assistance of OECD/DAC donors that is untied 36. ODA received in landlocked countries as a proportion of their gross national incomes 37. ODA received in small island developing states as proportion of their gross national incomes **Market access** 38. Proportion of total developed country imports (by value and excluding arms) from developing countries and from the least developed countries, admitted free of duty 39. Average tariffs imposed by developed countries on agricultural products and textiles and clothing from developing countries 40. Agricultural support estimate for OECD countries as a percentage of their gross domestic
Target 13	Address the special needs of the least developed countries Includes tariff and quota free access for the least developed countries' exports; enhanced programme of debt relief for heavily indebted poor countries (HIPC) and cancellation of official bilateral debt; and more generous ODA for countries committed to poverty reduction		
Target 14	Address the special needs of landlocked countries and small island developing states (through the Programme of Action for the Sustainable Development of Small Island Developing States and the outcome of the 22nd special session of the General		

	Assembly)		product 41. Proportion of ODA provided to help build trade capacity **Debt sustainability** 42. Total number of countries that have reached their HIPC decision points and number that have reached their HIPC completion points (cumulative) 43. Debt relief committed under HIPC Debt Initiative 44. Debt service as a percentage of exports of goods and services
Target 15	Deal comprehensively with the debt problems of developing countries through national and international measures in order to make debt sustainable in the long term		
Target 16	In cooperation with developing countries, develop and implement strategies for decent and productive work for youth	45	Unemployment rate of 15- to 24-year-olds, male and female and total
Target 17	In cooperation with pharmaceutical companies, provide access to affordable essential drugs in developing countries	46	Proportion of population with access to affordable essential drugs on a sustainable basis
Target 18	In cooperation with the private sector, make available the benefits of new technologies, especially information and communications	47	Telephone lines and cellular subscribers per 100 people 48a Personal computers in use per 100 people 48b Internet users per 100 people

Sources: UNDP: http://www.undp.org/mdg/basics.shtml

Literature Review on the Causal Relations Between Education and Health for Children in Less Developed Countries

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Abstract

This paper represents a review of the literature on the evidence of the positive associations between education and health, identified as the two main components of human capital formation, trying to assess whether these associations mean causality. Therefore, it identifies the estimation methods which are used in these fields of study and it distinguishes among the three possible options which may explain the observed positive association between education and health: education affects health; health affects education; a third unobserved factor affect both health and education in the same direction, without any causal relation between them. I conclude with several suggestions for future research and policy interventions to improve the status of children in less developed countries.

Key words: Primary Education, Child Health and Nutrition, Human Capital, Human Development, Less Developed Countries, Estimation Methods (Cross-Sectional Data, Panel Data, Randomized Trials).

Contents

List of Tables

"If you are planning for a year,
sow rice.
If you are planning for a decade,
plant trees.
If you are planning for a lifetime,
educate people."

(Chinese proverb)

2.1. Introduction

Past and recent research and evidence underline the huge importance of education and health as the main dual components of human capital (defined as people's abilities, knowledge and skills), both in developed and in less developed countries[39].

The relationships between "knowledge capital" and "health capital" have been recognised and dealt in different periods of time and with diverse approaches. On one hand, past researches have recognized that an educated population is fundamental for sustainable economic growth and development and for a higher quality of life (see Lucas, 1988; Barro, 1991; Mankiw, Romer, Weil, 1992; UNDP, 2003; World Bank, 2001). Following this direction of causality, education specifically raises productivity, reduces fertility, and improves child health. These effects are manifest for industrialized world but are more evident for less developed countries. For this reason, governments in less developed countries should implement policies that raise educational attainment, given its priority, since growth and development are objectives of almost all less developed countries (Becker, 1995; Hanushek, 1995; UNDP, 1990; World Bank, 2001).

On the other hand, recent evidence suggests that poor childhood health and under-nutrition also have serious negative effects on educational achievement and cognitive development later in life. Following this proposition, policies and programs targeted toward improving child health and nutrition status will result in positive educational outcomes and skills development. This connection could lead to higher economic and human development and, consequently, to an improvement of the quality of life for people.

[39] The human capital theories have been developed mostly during the '60s and '70s with crucial contributions by Theodore W. Schultz (1961), Gary Becker (1964/1993) and Jacob Mincer (1974). For a deeper review on this topic, see the previous chapter.

Again, this relation is much more evident in less developed countries, where eight out of ten of the world's children live, most of them suffering from poor health and nutrition.

Additionally, there are important spillover benefits in investing in human capital. For example, an educated person affords benefits to those around her, for example reading for them, communicating her knowledge or managing innovations that benefits the community. A person in good health is less contagious and can be employed in many ways to benefit the community.

Both relations suggest that investing in education and health care is critical for the future. On the other hand, investigation on the links between them states that a clear articulation of health and nutrition issues is largely absent from the policy agenda in many countries, while it should be a priority. Given these considerations, governments and policy makers have start to direct more attention and efforts to protect, expand and improve human and children rights of universal primary education and good health status.

Having confirmed the positive association between educational attainment and child health, many researchers have attempted to estimate the causal relations. The causality question is important both for a clear understanding of the determinants of health and education, necessary for establishing the exact relation between them, and from a policy point of view, to formulate new possible policy interventions to improve the status of children in less developed countries. Only if the positive association between education and health is a true causal relation will a shift in expenditures from one field to the other be effective in improving both the level of education and the health status of the population.

Having recognized the importance of the positive association between the two issues, as we will see, many obstacles remain to obtaining credible estimates on causality between them. Data are often scarce and many possible sources of bias exist when attempting to estimate relationships between child health and education. Although significant progress has been made, much more research is needed.

The sections of this chapter are organized as follows. At first it presents the three possible causal relations between education and health. Then it offers a deep research of the literature review of empirical evidence on both of the directions of the relation, aware of estimation problems and potential solutions. Finally, it makes suggestions for future research directions.

2.2. The possible causal relations between education and health

The analysis on the relationships between education and health suggests that we can distinguish three possible approaches which may explain the observed positive association between them.

1. One possibility is that the direction of causality runs from better (poor) health status to more (less) education outcomes.
2. Another possibility is that there is a causal relation that runs from increases (decreases) in education attainment to increases (decreases) in health status.
3. A last possibility is that no causal relationship is implied by the correlation, but that there is a "third factor" not possible to observe, such as mental and physical ability or parental characteristics, which affect both health and education in the same direction.

As Grossman (Grossman, 1975) noted, the three explanations are not mutually exclusive but from a theoretical and a public policy approach it is crucial to distinguish among them and to achieve quantitative estimates of their relative extent.

It is realistic to assume that better health led to more education achievement. People who are healthier would be more efficient learners of new skills and competencies and invest more in education. Healthier students miss fewer days of school due to illness and therefore learn more for that reason. Furthermore, this causal path may have long lasting effects if past health is an input into current health status.

Likewise, it is reasonable to assume that a higher education would leads to a healthier life style and better health. Similarly, an increase in parents' schooling is expected to increase the well-being of their children as measured by their health and cognitive development.

Finally, omitted "third variables" may cause schooling and adult health or child well-being to vary in the same direction. If relevant third variables, which can be either genetic endowments or social background, were omitted from the demand curve of education (or health) the estimated effect of schooling on health (or reverse) would, under certain conditions, be biased. The third-variable hypothesis, which we will deal within the next discussion about the two possible directions of relation, has received a good deal of attention in the literature. It had been explored in detail by Mincer (Mincer, 1974) and in

hundreds of studies since his seminal work (see, among the other, Card, 1999; Card, 2001 for reviews of these studies).

2.3. The causal effects of child health and nutrition on education

Better infant and child health and nutrition are welfare-enhancing in themselves. Child health is an important policy issue in low-income countries because of the wide-ranging impact that early childhood health is thought to have on the subsequent development potential of the individual. Poor health may reduce learning for a variety of reasons, including fewer years enrolled, lower daily attendance and less efficient learning per day spent in school. On the other hand, improved child health and nutrition are widely thought to improve various dimensions of child school performance and therefore subsequent productivity (Behrman, 2000; Case and Paxson, 2010).

The study on the effects of health and nutrition on schooling is hampered by the fact that these three variables are not randomly determined but rather are based, at least in part, on the choices made by individuals and their families. These choices are made in response to possibly important predetermined characteristics that researchers and policymakers cannot observe, such as innate ability, motivation, genetic robustness, and the environment. Families make choices, too, that typically are not observed, such as the amount of time that parents spend educating children at home.

A clear explanation of the variables influence child's achievement in school is essential for a correct analysis of the causal effects of health and nutrition on education. To the aim of illustrating the probable affecting conditions, cognitive achievement can be considered as an important indicator of schooling success. Cognitive achievement is influenced by several individual, family, and community variables, some of which can be observed by social scientists and policy analysts, others cannot, hence the are “unobserved”. Table 7 illustrates how these variables might be sorted.

Table 2. 1: Classification of Variables Influencing Cognitive Achievement.

Variables	*Observed by researchers*	*Unobserved by researchers*
Individual	Health indicators Age Gender School attainment	Innate ability Motivation Genetic endowment Capacity to concentrate
Family	Income Parental occupation Parental education	Parental preferences for education and health Household intellectual atmosphere Parental time devoted to cognitive development of child Amount and quality of food given to child
Community	Population size and density Pupil-teacher ratio Public health programs	General intellectual atmosphere Social culture and values Effectiveness of school management Nature of job market

Source: Adaptation of Behrman (1996)

The methods that can be applied to estimate the relationships depend on the data available, which can be differentiated in three main types: cross-sectional data, panel data and data from randomized trials. In the following paragraphs we will explain all these estimation methods presenting evidences offered by earlier and recent studies.

2.3.1. Estimates based on randomized evaluations

The first studies that have attempted to estimate the effects of health and nutritional programs and policies on cognitive and education outcomes for less developed countries have been made on nutrition and epidemiologic fields. These studies were based on the randomized trials, an ideal experiment designed to compare treatment and control population. Specifically, a population under study is randomly divided into two groups: one of the groups, called the "treatment group", participates in the program (for example, receives a health care treatment) and the other group, the "control group", does not (receives an identical-appearing placebo). In some cases the population can be separated into more than two groups, one control group and several treatment groups, each with a different treatment. The assignments are double-blind so that neither the children nor the administrators know which children are in which group. If the division of the population into these groups is really random, than the only difference between these two groups is that one participated in the program while the other did not.

Some of the most primitive randomized studies by nutritionists and other public health researchers focused on the impacts of specific nutrients that were deficient in children's

diets in less developed countries; other studies have focused on parasitic infections, especially intestinal parasites and on general food supplementation to supply calories and protein. These studies had brought mixed results and only some of them had reached strong conclusions[40] (Glewwe and Miguel, 2007).

In this section we indicate only the INCAP study, which probably is the most well known among the studies on this field and has contributed much to current understanding of growth failure in less developed countries (Martorell et al., 1995, Schroder et al., 1995; Pollitt et al., 1993). The Institute of Nutrition of Central America and Panama (INCAP) was initiated in rural Guatemala in 1969. The study was designed to assess the effect of improved nutrition on child growth and development through the comparison of a food supplementation experiment with treatment in two villages, randomly selected, and placebo provided in two apparently similar villages. An important conclusion of the INCAP Guatemalan study is that growth during infancy, rather than birth weight (which has received more emphasis for developed economies, e.g. Hack, 1998), was negatively related to adolescent performance on cognitive and achievement tests. Despite these findings, it is difficult to attribute unequivocally cognitive, behavioural, or physical effects to severe malnutrition. But, as emphasized by Granthan-McGregor (1995) in her survey of the effects of severe malnutrition on mental development, varying disadvantages in the homes and families of malnourished children make it very difficult to match treatment and control children adequately.

Over the next years, from follow-up studies sizeable effects on later cognitive outcomes from providing the food supplementation to young children and mothers emerge[41].

The studies on the indicated topic, and thus the INCAP study as well, can be criticized under some aspects. Many of these studies have relatively small sample sizes or a high sample attrition rate; in some studies the control group also received an intervention; other studies include education interventions combined with health interventions; finally, in some studies treatment groups are not randomly selected but they are voluntary.

[40] For a very recent summary of work done by nutritionists see the set of papers recently published in *The Lancet* (Grantham-McGregor et al., 2007; Walker et al., 2007; and Engle et al., 2007)

[41] Follow-up studies of the INCAP Guatemalan longitudinal study were carried out by various authors. See Martorell, 1995; Martorell et al., 1995; Pollitt et al., 1993; Ramakrishnan et al., 1999 ; Rivera et al., 1995. Moreover, Maluccio, Hoddinott, Behrman, Martorell, Quisumbing and Stein (2006) used that dataset to make a further step beyond the previous literature on the effect of early childhood nutrition on education in less developed countries.

While randomized studies have long been used in medicine and biology, until recently they have been rare in education research. Some very recent randomized studies on the impact of health interventions on education outcomes have been carried out by economists. All of these papers evaluate school-based health interventions, which have been considered among the most cost-effective approaches for delivering health and nutrition services to children in less developed countries (Bundy and Guyatt, 1996; Glewwe and Miguel, 2007).

Kremer and Miguel (2004) used randomized methods to evaluate a program of twice-yearly school-based mass treatment with inexpensive deworming drugs in Kenya (where the prevalence of intestinal worms among children is very high). The study is based on a large sample of 75 primary schools, with a total enrolment of almost 30,000 children. The sampled schools were drawn from areas where there is a high prevalence of 92 percent of intestinal parasites among children. The authors found that deworming increased schooling by 0.14 years on average per pupil treated and that absenteeism in treatment schools was 25% (7 percentage points) lower than in comparison schools. Given the low cost of deworming medicine, and the large effect on education, this can be considered a cost effective measure. As shown by other authors, in treatment effects between female and male students there is no statistically significant difference. Another important finding is that both school participation and child health improved not only for treated students but also for untreated students both at treatment schools (22% of pupils in treatment schools chose not to receive the deworming medicine) and at nearby untreated primary schools. This last impact can be considered as an "epidemiological externality" due to reduced disease transmission brought about by the intervention. The authors underline the importance of an accurate consideration of these externalities in order to avoid substantial underestimations of the benefits of the intervention and the cost effectiveness of deworming treatment. A last consideration is that despite the small increase in years of schooling and the reduction in absence, no significant impacts were found on student performance on academic tests.

Vermeersch and Kremer (2005) conducted a randomized evaluation on how a preschool feeding program implemented in 50 Kenyan preschools effects participation of their students. The authors found that preschool participation rate was 30 percent higher in the 25 Kenyan preschools where a free breakfast was introduced than in the 25 comparison schools. Moreover, in schools where the teacher was relatively well trained prior to the

program, the meals program led to higher test scores (0.4 of a standard deviation) on cognitive tests. On the other hand, there were no significant effects on tests of general cognitive skills, implying the school meals program did not improve children's nutritional status and that the academic test score increases were likely due to more time spent in school. Vermeersch and Kremer noted, from their study, that households' school choices may be sensitive to preschool feeding programs given the large inflows of pupils into the feeding schools led by the program. An ultimate relevant consideration is that this feeding program is more expensive than deworming treatment or micronutrient supplement, and that this fact will increase the cost-benefit ratio to a great extent.

A last study we present is the one by Bobonis, Miguel and Sharma (2006). The authors conducted a randomized evaluation of a health program applied in India, which provided deworming medicine and iron supplementation to pre-school children of the age between two and six years in 200 preschools in poor urban areas of Delhi. Only 30 percent of the sampled of Indian preschoolers were found to have worm infections, while 69 percent of children had moderate to severe anemia according to international standards. In this case, the authors found a treatment effect similar to the estimated school participation effect in the Kremer and Miguel (2004) study presented above. Actually, after five months of treatment, Bobonis et al. (2006) found large weight gains and a 5.8 percent reduction in absenteeism among four to six year olds, although not for younger children. Finally, the authors tried to achieve estimates after two years, but attempts to obtain unbiased longer term impact estimates were complicated by high sample attrition and apparently non-random enrolment of new children into the preschools.

As the previous studies, also these recent randomized evaluation studies have remarkable limitations (Glewwe and Miguel, 2007). Kremer and Miguel (2004) find increased school participation, represented by both attendance and reduced dropping out, that is not reflected in students' test scores. From the cost-benefit analyses they presented at the conclusion of the work, results that the intervention is cost-effective, but it is not clear how to interpret these, given that the intervention does not increase learning of basic skills.

The Vermeersch and Kremer (2005) study is deficient in anthropometric data on sample children, limiting comparability with earlier studies in the literature. Furthermore, the study does not permit to differentiate between school attendance gains consequential

from improved child nutrition by itself versus a desire to receive food through the daily feeding program, which makes the estimates difficult to interpret.

The India study by Bobonis et al. (2006) does not permit to discern between the separate impacts of treatment of iron supplements and deworming medicine because all children received a combined treatment of the two. Moreover, the study encountered severe sample selection and attrition problems in the second year, which prevented a clear estimation of the long-term impact of the health intervention in India. Finally, it collected no data on any type of child learning, and, as a consequence, is limited to examining school enrolment, school attendance and anthropometric outcomes.

While randomized trials method may appear to be the solution to many econometric problems, there are some limitations of using randomized trials: they can be expensive to implement; they are limited to health interventions that do not violate regulations on human subjects research; some experiments are unethical or impossible, withholding food or vaccine; maintaining appropriate experimental procedures is not easy and random assignment to treatment and control groups is often violated in practice, as individuals or households in the control group attempt to switch from being in the control group to being in the treatment group; they may suffer from selection bias.

Randomized trials can be performed with only one round of data collection, by collecting cross-sectional data after the health policy or program has been implemented for the treatment group. A different approach, which may be more statistically efficient, is to collect panel data that measure children's education outcomes for the treatment and the control groups both before and after the intervention has been implemented in the treatment group. This permits researchers to look at variation in the outcome variable over time, which in some cases will provide an estimate of the impact of the program that has a lower standard error (also "better" if larger effects are important).

2.3.2. Retrospective estimates using cross-section or panel data

A second approach is to make retrospective estimates using cross-sectional data, which are data collected on a large number of children, individuals or households at a single point in time, and panel data (or "longitudinal data"), which are data collected from the same children, individual or households at several points in time.

Cross-sectional data usually come from a household survey or a survey of schools. Such data are the easiest data to collect, and therefore the most common type of data available. Earlier socioeconomic studies, over the last thirty years, have tended to present positive associations between child nutritional and health status and school achievements using mostly cross-sectional non-experimental data. Most of these studies did not present persuasive evidence regarding causality because they did not incorporate in the analysis that child nutrition and health reflected behavioural decisions in the presence of unobserved factors such as genetic endowments[42].

The standard econometric tool for overcoming bias due to omitted variables and for removing bias due to measurement error in the explanatory variables is "Instrumental Variables" estimation. The basic idea is that all unobserved variables (and errors in measurement) can be considered to be included in the error term (residual) of the regression model, and any bias is due to correlation of the observed variables with that error term. Instrumental variables are variables which are correlated with the observed variables that have bias problems; but are themselves uncorrelated with the error term and thus uncorrelated with all unobserved variables and any measurement errors; and not already explanatory variables in the equation of interest. If one can find such instrumental variables one can then obtain unbiased estimates by first regressing the observed variables that are correlated with the error term on the instruments and then using the predicted values of the observed variables as regressors (instead of their actual values) in the equation of interest. While instrumental variables estimation works in theory, it is very hard to find some plausible instrumental variables for use in cross-sectional estimation of the impact of child health on education.

Two fairly recent studies use cross-sectional data on 1,757 Ghana children aged six to fifteen years from the 1988-9 Ghanaian Living Standard Measurement Study (LSMS) collected by the World Bank. Moreover, they attempt to deal with some aspects of the behaviours determining child health and nutrition.

Behrman and Lavy (1998) estimate cognitive achievement production functions in which child health/nutrition is one of the inputs. The estimated impacts of child health on cognitive achievement vary considerably depending on what assumptions are made about underlying behaviours. If it is assumed that child health reflects behavioural decisions of

[42] Some of such studies are reviewed in Behrman and Deolalikar 1988; Pollitt 1990; Behrman 1996; Strauss and Thomas 1995 and Strauss and Thomas 1998.

households in the presence of unobserved individual, family and community predetermined variables (e.g., genetic endowments, general learning environments) but there are no unobserved inputs to child cognitive development that reflect choices of households (such as parental time allocations), current prices are appropriate instruments for these production function estimates. In this case the estimated child health impact is three to seven times as large as in OLS estimates. If assumption is dropped, however, and within-sibling data[43] are used to control for unobserved family/community factors, the estimates indicate that the standard "naive" procedure biases the true causal impact of child health on child schooling success substantially upwards.

Glewwe and Jacoby (1995) carefully investigate the impact of child nutrition on age of school enrolment and years of completed schooling (academic skills are excluded). They demonstrate that malnutrition may lead to delays in initial enrolment resulting in a delay in entering the labour market (unless the child leaves school early, in which case it results in less human capital formation). Such a delay will lead to a loss in post-school labour earnings. Their estimates, based on cross-sectional data, indicate that delays in enrolment are responsive to early child health as represented by height-for-age, which they interpret to support the importance of early child nourishment in schooling enrolment. This effect is reduced by almost two fifths, however, if there is control for unobserved family and community variables by using within-sibling estimators, which suggests that indicators of child health in part proxy for such unobserved factors in standard estimates. In contrast to the support that they find for the importance of preschool nourishment, they find little, if any, support for alternative explanations of delayed school enrolment due to capital market constraints or due to local school supply constraints. Probably because of the small sample size, they find no evidence that child health increases school attainment.

These two studies suggest that estimates of the impact of child health on child schooling success is highly sensitive to underlying behavioural assumptions and the nature of unobserved variables. However, although both studies are carefully carried out, their reliance on a single cross-sectional survey is limiting. In particular, the authors cannot utilize direct

[43] The use of a within-sibling approach reduces heterogeneity in the family background as the siblings come from the same family. Therefore, within-sibling data long have been used in the social sciences to control for unobserved family background and community characteristics to eliminate any family background effects and produce more accurate estimates (see early works by Chamberlain and Griliches 1975, Behrman and Taubman 1976, Olneck 1977). However the within-sibling approach is limited in several ways. For example, it will only remove across family differences but not within family differences.

measurement of pre-school child health. Similarly, they do not have instruments that unambiguously identify factors that might have affected pre-school outcomes yet do not determine schooling attainments themselves. These instruments are questionable for identification if current prices affect not only the observed variables (including child health) but also other unobserved behaviours such as parental time use that affect various indicators of child school enrolment and performance.

Some more recent studies have advanced the state of the literature on the impact of nutrition on aspects of schooling success in less developed countries by using longitudinal non-experimental data. The potential benefits of panel data are that they are collected over all the time periods and that some unobserved variables that do not change over time can be differenced out of the regression and thus need not be measured. However, this method has its limitations.

Glewwe, Jacoby and King (2001) develop an explicit dynamic framework to explore the impact of child nutrition on child schooling decisions and academic achievement, including the age of initial school enrolment, grade repetition and cognitive achievement. They use the Cebu Longitudinal Health and Nutrition Survey (CLHNS) from more than 2,000 households for 1983-4, 1991-2 and 1994-5 from the metropolitan Cebu area in the Philippines. They control for unobserved family and community heterogeneity by using within-sibling estimates. They suggest that the coefficient estimates of child height-for-age may be biased towards zero by measurement error in OLS regressions so for their preferred estimates they instrument the difference in heights between siblings using the older siblings' height-for-age (at birth, 12 months and 24 months) for identification. They find that malnourished children enter school later and perform more poorly on cognitive achievement tests. Their preferred estimates imply that a one standard deviation increase in child health increases achievement test scores by about one third of a standard deviation of that score or about the equivalent of spending eight more months in school, which implies a benefit-cost ratio of three or more (based on their estimates, other estimates and some assumptions that can not be tested with their data about the relation of adult productivities to child human capital investments). Their preferred estimates, however, must be qualified because they are conditional on the assumptions that growth in child height-for-age after age two is not correlated with child height-for-age up to age two (which is used as an instrumental variable to control for measurement error) despite the literature on serial

correlation in child growth (e.g., Martorell 1995, 1999) and that child heights-for-age at age two are not correlated with the disturbance term in the relations for school accomplishments as they would be if there is a genetic correlation between physical stature and innate ability or if pre- and post-natal health shocks influence both the physical and mental development of children. To conclude, the study finds strong impacts of children's health status in the first two years of life on several schooling outcomes. Specifically, better health reduces delayed enrolment and grade repetition and greater learning per year of schooling.

Glewwe and King (2001) use the same data to investigate whether malnutrition in the first six months has the greatest adverse effects on child cognitive development, as argued by some observers. They find that, instead, the second year of life is most critical once there is control for the behavioural determination of child nutritional status at the start of each period of children's lives, but that simpler OLS estimates give misleading results in this regard (again with some qualifications about the instruments used, particularly parental schooling given intergenerational correlations in genetic endowments).

Alderman, Behrman, Lavy and Menon (2001) also develop an explicit dynamic multi-period model of investments in pre-school children and the subsequent schooling enrolment decisions, with persistent endowment effects across periods. They use longitudinal data collected for about 800 households in poor areas of rural Pakistan from 1986 to 1991 by IFPRI and the Pakistan Ministry of Food and Agriculture. Their preferred estimates use price shocks as instrumental variables when children were of pre-school age to control for behaviour determining the child health stock measure. The authors find that child health, as measured by height-for-age when five years old, has a strong positive effect on the probability of being enrolled in school at age of seven, especially for girls. Specifically, their estimates indicate that child health is three times as important for determining school enrolment than suggested by "naive estimates" that assume that child health is predetermined rather than determined by household choices in the presence of unobserved factors such as preferences and health endowments.

Handa and Peterman (2006) in their study use longitudinal data from South Africa to estimate the relationship between early childhood nutritional status, in 1993, and schooling outcomes five years later, in 1998. In doing this, the authors try to assess the stability of the results in Alderman, Behrman, Lavy and Menon (2001) by replicating their estimation

strategy. Past nutritional status is treated as endogenous and instrumented using prior period price shocks as is consistent with dynamic household human capital decision rules. Preferred estimates from the full sample aged 0-5 in the base year show no impact of past nutritional status on current schooling. However significant estimates are found for children who were malnourished in the base year, as well as among children aged 0-30 months in the base year. These results suggest that the relationship between health and cognitive achievement is complex, and the effects may be highly sensitive to time between measurements and the timing of malnutrition itself.

A last panel study is the one conduced by Alderman H., Hoddinott J., Kinsey B. (2006), who examine the impact of child health and nutrition on subsequent human capital formation (health and education attainments as young adults) in a sample of 665 Zimbabwean young adults surveyed in early 2000 (which was a follow-up to two earlier surveys of children carried out in 1983/4 and 1987). The authors also estimate impacts on delayed enrolment. The founded tracking rate is exceptionally high. The study uses a maternal fixed effects (or sibling comparison) instrumental variables method. In particular Zimbabwe in the late 1970s experienced the final years of a brutal civil war, and the country was later affected by back-to-back droughts in 1982-83 and 1983-84. Representations of these transitory shocks (civil war and drought), are used to identify differences in preschool nutritional status, measured as height-for-age, on later outcomes across siblings. Using this approach, Alderman et al. (2006) find that improvements in height-for-age in preschoolers are associated with significantly increased height as a young adult and number of years of schooling completed as well as being causally associated with starting school at a younger age. The effects are substantial: the increase from median pre-school child height in this sample to median child height in a developed country, by adolescence, would lead to an additional 3.4 centimetres in height, an additional 0.85 grades of completed schooling and an earlier starting school-age of six months. These fixed effects instrumental variables estimates are substantially larger than simple fixed effects estimates. Moreover, estimated health effects for females and males are not significantly different from each other in the Zimbabwe study.

These studies, thus, strongly confirm the findings of earlier cross-sectional in highlighting the important effect of early childhood health on later schooling outcomes. Moreover they reinforce the fact that preschool child human capital as behaviourally

determined in the presence of unobserved endowments may make a considerable difference in understanding the impact of preschool child human capital on schooling outcomes.

In summary, panel data provide additional possibilities for overcoming the estimation problems that plague studies based on cross-sectional data. Nevertheless some estimation problems often remain. This approach assumes that the troublesome variables that are unobserved do not change over time, and that they do not interact with variables that do change over time. Another serious problem is that measurement error in observed explanatory variables could lead to greater bias in estimates based on differenced equations than in estimates based on the original equation. Finally, there is the obvious disadvantage that panel data are more expensive to collect because they involve collecting data at two or more points in time.

Both cross-sectional data and panel data are collected from real world settings in which no attempt is made by the researchers to alter the behaviour of the people from whom the data are collected. Yet the problems of bias raised above are very probable, if not almost certain, when using data collected in this manner.

As Glewwe (2005) notes, it is likely that worries about estimation bias due to behavioural responses to health programs and policies may be exaggerated. Even so, it would be irresponsible to ignore the potentially serious estimation programs that arise in estimates based on non-experimental cross-sectional and panel data.

To recapitulate what above argued, much of the existing previous literature does not succeed to recognize and satisfactorily control for the fact that child health and education are both the consequence of human resource investment decisions by households; therefore they do not establish a causal relationship between infant health and schooling. More recent studies try to change the approach to obtain more credible estimates.

Moreover, existing evidence on the relationship between child health and schooling is quite sensitive to the underlying behavioural assumptions used to estimate the relationship. As we have seen, estimates based on cross-sectional data account for unobserved heterogeneity with respect to household and community variables (Behrman and Lavy, 1998; Glewwe and Jacoby, 1995); these kinds of estimates lead to parameter estimates which are significantly *lower* than 'naïve' estimates that do not account for these variables. This observation suggests that the impact of child nutritional status on schooling is much *smaller* than otherwise believed. But cross-sectional studies must use current prices to identify child

health, and these are likely to be correlated with unobserved variables influencing both child health and schooling, thus rendering questionable the results based on these specifications.

The other studies, based on longitudinal data, estimate this relationship in a manner that is consistent with a dynamic model of human resource investment. In particular, such data can be used to construct prior period price shocks to use as identifying instruments for early childhood health; these shocks are uncorrelated with subsequent period price shocks which influence schooling decisions in that (later) period, and thus permit consistent identification of the causal impact of child health on schooling (Alderman, Behrman, Lavy and Menon, 2001). The relationship between child health and subsequent schooling obtained by longitudinal data is actually much *larger* than those implied by naïve estimates, which do not account for behavioural choices. In addition, Alderman, Behrman, Lavy and Menon (2001) show that alternative specifications which use current price levels as instruments, as is commonly used in the literature, lead to small and insignificant parameter estimates of the relationship between child nutritional status and schooling in their Pakistan data.

2.3.3. Conclusions from the literature review

This chapter has reviewed the studies which much have contributed to current understanding on impact of child health and nutrition status on education outcomes in less developed countries and the estimation issues that complicate attempts to measure that relation.

Research on the causal effect of child nutritional status and health problems on schooling faces many econometric challenges. As Behrman (1996) and Glewwe (2005) note, despite the extensive literature which show strong positive associations between health problems and school performance, researches on this issue are difficult and ambiguous, in part because of scarcity of high-quality data with which to address the issue, particularly for less developed countries, in part because there are many possible source of bias (omitted bias, measurement error bias and sample selection bias) when trying to estimate relationship between child health status and education achievement.

Yet much remains to be learned because associations do not necessarily indicate causality, although they are so interpreted. Actually, estimates using retrospective data usually are likely to be biased in one direction or the other because of unobserved factors,

such as parental preferences for health and education which may determine both nutrition and education outcomes, generating a correlation between these two outcomes that is not necessarily causal. Otherwise, child health (and nutrition) and schooling performance both reflect behavioural choices of parents decisions regarding investments in children's human capital. Almost all the literature on the impact of this relationship ignores this behavioural implication. Randomized trials offer a clearer method for identifying causal relationships, but they are relatively rare and encounter several difficulties in practice.

Although significant progress has been made, much more research is needed. Our opinion is that what is needed for better comprehend the relationships between child health and education outcomes are, of course, better data and better econometric identification. More panel data collection efforts are now being undertaken in less developed countries than ever before, which will set the stage for understand the underlying processes behind these links in order to design new possible policy interventions.

More randomized studies should be conducted and their findings should be compared with standard cross-sectional or panel data estimates based on the control group data, to create a large source of information of the likely bias of non-experimental methods.

The last recommendation concerns the coherence of public interventions in a long-term perspective. As noted above, the result of a co-ordinated set of education and health services is higher than the sum of the effects of each service. Without a coherent strategy in a long-term perspective, the benefits of these increasing returns of social spending are lost. Indeed, children's health and education and their school performance depend partly on the health and education of their parents. Therefore, education and health spending as a means to improve the quality of life should be a priority.

2.4. The causal impact of education on health

In both developed and less developed countries, a strong correlation exists between schooling and good health. In the previous chapter we have presented some past and recent studies that assess the impact of child health and nutrition status on education outcomes in less developed countries. Unluckily, fairly few studies actually test the opposite causal relation, which means that a less extensive review exists on whether the direct effect of

education on health is a causal relation for less developed countries. Almost all studies show that education strongly contributes to a better health.

The literature in this area has been remarkably reviewed by Grossman and Kaestner (1997) and by Grossman (2000). The causality in the effect of education on health arises because higher educated people are more efficient in maintaining and fostering their health, or, as Grossman and Kaestner (1997) express it, higher educated people produce health more efficiently[44]. Moreover, the authors conclude that years of formal schooling completed is the most important correlate of good health, more important than occupation or income, the two other components of socioeconomic status. This finding emerges whether health levels are measured by mortality rates, morbidity rates, self-evaluation of health status, or physiological indicators of health, and whether the units of observation are individuals or groups (see among the others: Lleras-Muney, 2005; Case, 2002; Groot and van den Brink, 2006 and 2007).

2.4.1. Identifying causal effects of education on health

As we have seen for the reverse effect, to determine the health effects of education and to attempt to rectify the estimation problems several statistical techniques exist. Even though the medical model ideal of a social experiment is the most robust technique in the majority of settings, a natural experiment is more feasible for most situations. After all, it is difficult or even impossible to manipulate education. A valid example of a natural experiment is a situation in which some key feature of the education system, as the minimum school leaving age, undergoes an exogenous change that is not due to the actions of the individuals whose education and health is to be studied. Therefore, if this change causes random impacts on the education received by individuals then, under certain assumptions, the impact of these changes in education cannot be the result of selection bias or reverse causality.

The methods of natural experiments and instrumental variables are strongly linked and both have been applied by economists in particular, attempting to use these changes to

[44] The authors distinguish between two forms of efficiency in the production of health: productive efficiency and allocative efficiency. Productive efficiency refers to the situation whereby higher educated people are able to obtain higher health benefits from the same amount of inputs. Allocative efficiency refers to the fact that higher educated people are more informed about the health effects of certain inputs.

identify genuine causal impacts, in the sense of causality. Estimation by instrumental variables requires the identification of a quasi-experimental change that causes variation in education but not in health except through education. The change is quasi-experimental in the sense that it is also unrelated to any underlying factors that may explain both education and health. Under such circumstances, the changes in health brought about by the quasi-experimental change provide a guide as to the impact of education on health.

As expected, various problems emerge in using such estimation. The estimation results will be biased towards the scale of effects for those in the study that were most affected by the quasi-experimental change. Moreover, tests of the validity of the assumptions are often inconclusive; hence divergences about the validity of the resulting estimates often appear. Finally, the estimate of the marginal effect of education in a given study offers an indication of the possible impact of education under the assumption that the change in education for the marginal person does not change the impact for other current participants in education. In economic terms, this is the partial equilibrium assumption. It is important because if changes to the allocation and distribution of education cause changes to the marginal benefit of education then estimates evaluated when there is one particular level of participation in education will not be a valid guide to the impact of education in the circumstances of extended participation (OECD, 2006).

Notwithstanding these limits and omissions, and subject to the validity of their assumptions, estimates resulting from quasi-experimental or instrumental variables methods go beyond other studies in their attempt to identify the one-way causal impact of education. Therefore, these estimates are considered the most rigorous and informative available in terms of the guidance they provide as to the likely impact of changes in the quantity and distribution of education.

Somewhat less rigorous than such methods but still useful are methods that rely on the changes observed over time in panel (or longitudinal) data. These methods attempt to recreate a before-after dichotomy in which a like-with-like comparison can be drawn under certain assumptions. Such methods can considerably remove estimation bias and add noticeably to the evidence base.

While this dynamic nature is recognized within the literature, typically attempts to model the effects of years of schooling on health outcomes are based on cross-sectional single equation models, mainly due to the lack of multi-period data. The scarcity of information in

cross-sectional data regarding individuals' situations before education took place makes it impossible to understand whether associations are due to selection bias, reverse causality or educational causation.

In this review we highlight the evidence from instrumental variables studies that appear to offer the most reliable estimates of precise effect sizes, although evidence from studies using longitudinal data with rich control sets are included. The best basis for policy decisions is replication; therefore, the results of any single study may be strongly influenced by the context and time of that study and by the quality of measures and methods used.

2.4.2. Mechanisms through which education may affects health

There are many ways in which education may affect health. Education may improve health simply because it results in greater resources, including access to health care. This is perhaps the most obvious economic explanation (Autor, Katz and Kearney 2005). However, this theory is not the whole of the explanation and many indirect effects can be traced.

More highly educated individuals may have "better" jobs that, in addition to paying higher incomes and providing health insurance, offer safer work environments.

Alternatively education could affect health through risk aversion. People who have more schooling could learn to understand the risks better and become more risk averse (Barsky et al., 1997).

Though income, health insurance and other factors may not affect health per se, they may change an individual's incentives to invest in health: if education provides individuals with a better future along several dimensions (because it gives access to more income, it makes one happier, and generally the present discounted value of future lifetime utility), people may be more likely to invest in protecting that future. Similarly, in some theoretical models it has found that as incomes rise, willingness to pay for health improvements increases as well. This theory would also explain why the less educated are more likely to engage in riskier activities, and is also consistent with smaller gradients for women and for blacks.

Moreover, education might matter for health not just because of the specific knowledge one obtains in school, but rather because education can also provide individuals with better access to information and improved critical thinking skills and decision-making abilities. Education increases people's understanding of sanitation and hygiene, improves their ability to read labels of all sorts, encourages their use of health care systems and, in countless other ways, acts to protect and promote their health (Caldwell 1986).

Link and Phelan (1995), propose that gradients in health arise or increase when there is knowledge and technology available to prevent or treat. That happen because in this situation there is a universal demand for better health, and those with more education are likely to use new knowledge and new techniques more rapidly and more effectively. However, health disparities between better and less well educated people often increase when a new health technology is introduced. If better educated people understand the importance of a health innovation more quickly, or are able to change their behaviours more rapidly to take advantage of health advances, we would expect to see differences in health status between better and less well educated people widen, at least in the medium run, until those with less education are able to catch up with the new technologies.

Education may alter other important individual characteristics and preferences that affect health investments and ultimately health. Becker and Mulligan (1997) suggest that higher schooling, probably through future income, encourages individuals to invest in lowering their discount rate. Going to school is in itself an exercise in delaying gratification, so it may contribute to lower discount rates that way. Fuchs (1982) affirms that individuals with lower discount rates are more likely to invest more heavily in both education and health and adds that this is a weak relationship.

Finally, there are many other possible mechanisms that determine education effect on health, which makes it difficult to quantify the impact of education in this domain.

2.4.3. The impact of women's education on their fertility

Numerous studies report that more educated parents have fewer children both in developed and less developed countries (see, among the others, Becker, 1991; Schultz, 1993). Schultz (1993) terms this relationship "one of the most important discoveries in research on non-market returns to women's education (p.74)." In respect to this relation, a majority of the

studies indicate larger effects for mother's schooling than for father's schooling. This finding is consistent with a division of labour within the household in which the mother is the family member most involved with child care.

There are many reasons why we would expect increased education to have a causal effect on fertility decline. Once children are in school, not only do they have less time for work, but also their status as students tends to lower the household's expectations about their work. And, given that the education of children has a public good component, society also invests in children's educations, raising expectations generally that children's families will protect that investment.

Lucas (2003) emphasizes the increased return to investment in education as leading couples to choose to limit the number of children they raise, in order to offer each child more education. The author argues that the phenomenon of children leaving the family farm, where all necessary skills are acquirable through on-the-job training, for work that requires additional skills learned at school, where there is a substantial return to this investment, may result in fertility declines.

Caldwell (1982) focuses on the increased costs of raising a child and diminished expectations of the lifetime return to parents from that child — both consequences of schooling — as setting off a fertility transition.

The higher income of the male means the couple can afford to have more children. However, the higher levels of consumer spending and lifestyle changes for parents and each child result in a choice to limit the number of children born. The overall trend worldwide is that higher income families have fewer children but have higher expenditures per child.

Woman's education reduces her desired family size and improves her ability to achieve it (Becker et al., 1977); moreover, it increases the age of both marriage and first pregnancy. Education increases the opportunity cost of women's time, as the skills learned at school find a return in the marketplace. Better educated women may have higher aspirations for their children and to give more importance to the quality of their children's school.

Women's education may also have an indirect effect on fertility through the role it plays in reducing infant mortality. Better educated women are more likely to know about hygiene and nutrition, and are more likely to act on this knowledge. Education is apt to give women more voice in household decisions, allowing women to stand up to men in

general. If women are the protectors of the needs of small children, then children are apt to benefit indirectly in this way from mothers' schooling.

Unfortunately, estimating the causal impact of education on fertility is a difficult task, since both are endogenous variables. It may not be women's education per se that causes fertility to decline, but that educated women are more likely to marry educated men Greenwood et al. (1997), and these men may have strong preferences for lower fertility. Young women who have had children may find it difficult to return to school — both because of the demands placed on them at home, but also because many schools discriminate against young mothers returning to school. All of these would lead us to find a connection between women's education and fertility, but not one that was causal. Even keeping these third factors in mind, some researchers argue that the evidence supports a causal impact of education on fertility.

There are some studies that exemplify this problem for less developed countries. Duncan Thomas (1999), using a dataset of South Africa, finds a strong and statistically significant negative correlation between years of schooling and children ever born among South African women, even after controlling for several other variables. When test scores on mathematics and reading comprehension are added, the latter is statistically significant and the coefficient on years of schooling declines by one third, though it is still significant. This suggests that at least part of the correlation between schooling and fertility works through cognitive skills. Since the test scores measure skills at about the third or fourth grade level, tests covering a broader range of skills would probably have reduced the impact of years of schooling even further. Thomas makes no claim to have found a causal relationship. He speculates that reading skills improve women's ability to gain access to and assimilate information, and presents evidence consistent with this hypothesis, but cannot go further with the data at his disposal.

Another study on fertility is produced by Raylynn Oliver (1999), who analyzes a Ghanaian dataset. She also finds a strong and statistically negative impact of years of schooling on fertility (in terms of children ever born), though she is more willing than Thomas to interpret this as a causal relationship. When test scores for reading and mathematics are entered, her findings are very similar to those of Thomas— only reading scores have significant negative effects, and when tests scores are added the years of schooling coefficient declines by about one third but remains statistically significant.

Another interesting finding is that "ability," measured by the Raven's test[45], has no significant impact on fertility. While Oliver too quickly ascribes causal impacts to her findings, the similarity with Thomas' results is striking. The absence of an effect of the Raven's test is also noteworthy, since it suggests that innate ability has no effect on fertility apart from its indirect impact through increased cognitive skills.

A last example of evidence comes from India. Drèze and Murthi (2000) find that women's education is the most important correlate of fertility decline, both across districts and within districts over time. Because they are following districts from decade to decade, these researchers can estimate the impact of education on fertility solely using differences in these variables over time within each district. Doing so allows them to rule out some of the third factor explanations for the relationship between education and fertility by eliminating differences between districts that remain fixed over time. Drèze and Murthi find large effects of women's education: a ten-percentage point increase in female literacy is associated with an expected decline in the total number of children born to women during their lifetimes of 0.2 children. To understand the magnitude of this estimate, it is interesting to compare it with the impact of religion on fertility: a ten percentage point increase in the percent of the population in the district that is Muslim is associated with an increase in total fertility of 0.2 children.

2.4.4. Intergenerational transfer of human capital: parent's education on child's health. The crucial role played by mothers.

There is a considerable body of evidence that parents' education impacts on child anthropometric measures (see research by Edwards and Grossman, 1981, 1982, and 1983; Shakotko et al., 1981). These evidences suggest that home environment in general and mother's schooling in particular play an extremely important role in the determination of child and adolescent health. On the contrary, many other studies show that, differently from the case of fertility, there is no significant differences between mother's and father's schooling on infant mortality (Breierova and Duflo, 2004; Duflo, 2002). Recent papers by

[45] Raven's Progressive Matrices are multiple choice tests of abstract reasoning, originally developed by Dr John C.Raven in 1938. In each test item, a candidate is asked to identify the missing segment required to complete a larger pattern.

Case et al. (2002) and by Currie and Stabile (2003) confirm the importance of parents' schooling on child health outcomes at a variety of different ages.

This paragraph report an update and complete review of the literature on child's health status effects of parental schooling, with particular focus on the role of the mother.

Several studies, both earlier and recent, find a strong and significant impact of maternal years of schooling on child health (see Behrman and Wolfe, 1997; Sahn and Stifel, 2002, ecc). There are several possible mechanisms that could explain this relationship. Perhaps education directly increases mothers' knowledge of health and health-care procedures. Alternatively, schooling may reduces women's adherence to traditional cultural practices, making them more receptive to modern health-care treatments (Caldwell, 1979). Education can also raise women's self-confidence and status within the household, enabling women to take a more active and effective role in intra-household decision making and in obtaining health care assistance (Smith and Haddad, 1999; Alderman, Hentschel, and Sabates, 2003). Finally, increased maternal schooling may improve children's health outcomes by increasing household income.

Distinguishing between these different pathways is difficult because there are really few data sets with detailed information on all these potential effects of schooling for less developed countries.

One of the earlier studies on this topic has been produced by Caldwell (1979). The author, in an influential paper based on Nigerian data, hypothesized that maternal education has a direct and independent effect on child survival. Even after incorporating other socioeconomic controls such as father's education and area of residence, Caldwell found that children of educated mothers fared better than those of uneducated mothers. Caldwell's seminal article has been followed by numerous studies, many of which demonstrate the generally positive relationship between maternal schooling and child health outcomes.

Other more recent studies have been produced. Thomas, Strauss and Henriques (1991) estimate the effects of education on child height in Brazil in 1986, Wolfe and Behrman (1983) in Nicaragua, Glewwe (1999) in Morocco in 1991, Glewwe and Desai (1999), in Ghana and Alderman, Hentschel and Sabates (2003) in Peru in 1997. In general, these papers highlight the importance of mother's education as opposed to father's education in the provision of child nutrition. Furthermore, Wolfe and Zuvekas (1997) find that in poorer countries higher levels of educational attainment by girls is strongly associated with lower

infant mortality and lower birth rates. The papers indicated also find that regional differences in educational effects may be large. For example in Brazil, a child's height (controlling for age and sex) increases by about 0.50 percentage points on average with each additional year of mother's education. In the urban sector, the effect of mother's education is almost half as large, 0.28 percentage points.

In the following part of the paragraph we attempt to broader present some of these studies. Thomas et al. (1991) conduce an analysis based on approximately 1,300 children age five or less in the 1986 Brazilian Demographic and Health Survey (DHS). The authors find that practically all of the positive effect of mother's schooling on child height is due to information as measured by whether the woman reads newspapers, watches television, and listens to the radio. These three variables are treated as endogenous. The instruments are the existence of a local newspaper in the mother's municipio of residence, dichotomous indicators of the number of television channels in the municipio of residence, and mother's age.

Glewwe (1999) employs a sample of approximately 1,500 children ages 5 or younger in Morocco in 1990-91 obtained as part of the World Bank's Living Standards Measurement Study (LSMS). This sample contains a direct measure of the mother's general health knowledge obtained as the number of correct responses to five questions. Child health was measured by height-for-age. Unlike Thomas et al. (1991), Glewwe is able to control directly for the child's health endowment by employing mother's and father's height as regressors. Glewwe's analysis of these data led to two conclusions. First, health knowledge appears to be the most important skill that mothers need to care for their children. Second, Moroccan mothers do not directly acquire health knowledge in school. Instead, they acquire it indirectly by using the literacy and numeracy skills acquired in school. These findings suggest that Moroccan schools should seriously consider adding basic health education to the primary and secondary school curricula, since such change could significantly improve child health.

While the findings of the Morocco study are potentially very important, they should be treated with caution. The study found evidence that health knowledge should be treated as an endogenous variable and, as always, one could equivocate with the instrumental variables used. Moreover, the health knowledge test contained only five questions, and thus gives little guidance on the content of a new health curriculum in primary and

secondary schools. Finally, the evidence is based on only one country. Similar studies using data from other countries are needed to check the robustness of the finding that mothers' health knowledge is the key pathway by which maternal education raises child health.

Another study of mother's cognitive skills and child health is by Glewwe and Desai (1999), who also used data from Ghana. They examined two dependant variables for a random sample of 1,107 Ghanaian children age zero to five years: height-for-age and weight-for-height. Ability (measured by the Raven's test) never has a statistically significant impact. In the height-for-age regressions, none of the mother's education variables (years of schooling, mathematics score and reading score) was statistically significant, an unexpected result. In the weight-for-height regressions mothers' mathematics scores are generally significant, although not very precisely estimated. Neither years of schooling nor the reading score are ever significant.

The study by Glewwe and Desai has several weaknesses relative to the Morocco study. First, there are no data on health knowledge, which the Morocco study suggests is critical. Second, the Ghana study did not use instrumental variables for the test score variables, which (if credible instruments can be found) could have reduced problems of measurement error. Third, the insignificant impact of education on height-for-age is puzzling, since that measure of child health generally has a higher signal-to-noise ratio than does weight-for-height. On a more positive note, the insignificance of the Raven's test suggests that innate ability alone will not improve child health.

A more recent study is presented by Chou *et al.* (2003), who exploit a natural experiment to estimate the causal impact of parental education on children's birthweight (child health) in Taiwan. In 1968, the Taiwan government extended compulsory education from six to nine years. To accommodate the expected increase in enrolment in junior high schools, the government opened 140 new junior high schools in 1968, a 70% increase. Their natural experiment exploits variations across cohorts in exposure to compulsory education reform and across regions in newly established school density. The authors estimate the impact of mother's education on child health by using cohort and newly established school density interactions as instruments for parents' education. Results suggest that mother's schooling has larger effects on child health outcomes than father's schooling. When estimating the partial effects of mother's and father's education, results

show that the mother's schooling remains significant. In this case, an additional year of mother's schooling lowers the probabilities of very low birthweight and prematurity by 0.7 percentage points and 1.28 percentage points, respectively. The authors find that parental schooling improves birthweight and related outcomes, but has no significant impacts on infant mortality.

Different results are obtained by Breierova and Duflo (2004), who have investigated the causal element of effects of education on mortality using instrumental variables. They use the Indonesian government's implementation of a primary school construction project in the years 1973-79 in their instrumental variables estimation. Specifically, they use the interaction between an individual's cohort and the number of schools built in his/her region of birth to evaluate the impact of the programme. Their results show that average number of years of education in the household has the effect of reducing child mortality by approximately 10 percentage points from a mean level of 22.5%. Additionally, mother's and father's schooling have about the same negative effects on infant mortality, without any significant difference. The same result was obtained by Duflo (2002) using the same data. Although their findings are relatively robust to endogeneity bias, the authors recognise that their results could be driven in part by bias due to assortative matching.

2.4.5. Conclusions from the literature analysis

The literature on the impact of cognitive skills on health outcomes for less developed countries is recent and small, leaving many gaps. The associations between health and education are not always clear-cut and causalities are often hard to interpret. Some recent evidence from natural and quasi-natural experiments suggests that at least part of the correlation between education and health is indeed causal.

Based on the evidence reviewed here, we conclude that there is quite robust evidence to support the hypothesis of effects of parental education on fertility and child health. This is particularly robust for the case of mortality and anthropometric measurements. The most intriguing finding is that mother's health knowledge, as opposed to other knowledge or skills, seems to be the key contribution of education to child health.

In spite of this concern, it is important to highlight Grossman conclusion. In documenting evidence of the causal impact of parent's schooling on children's health, he

underlines that education is not the only factor that plays a role in the intergenerational transmission of advantage. Grossman suggests that the challenge for future research is to separate the causal links associated with genetic and behavioural factors that affect child health (Grossman, 2005).

It is clear that further studies for less developed countries are needed to offer a greater quantity of data available and to assess the robustness of these findings.

A final consideration is on the crucial role of the relation between education and health for public policy. What this survey has shown is that there are large spill-over effects between education and health. This implies that education and health policies do not have an effect within their own sphere, but that there are large costs and benefits associated with these policies. This entails that these policies should not be looked upon in isolation, as they actually do, but that rather a more integrated policy approach to education and health is essential.

2.5. References

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Long-Term Impact of Health and Nutrition Status on Education Outcomes for Children in Rural Tanzania

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Abstract

This paper investigates the long-term effects of malnutrition presented by individuals during early childhood on subsequent education attainment of young adults living in a rural area of Tanzania. The data used are of an exclusive long term panel data set collected in the Kagera Health and Development Survey. Infants born in the early Nineties are traced and interviewed in 2004. To perform the main objective of the work, any attrition due to family or environmental characteristics is removed by differencing among siblings. In addition, a broad investigation on weather conditions during infancy is conduced, in order to attain the instruments to face the existing endogeneity proper of the health variable.

By comparing the anthropometric measures of a Tanzanian preschooler with those of a child in a wealthy reference country, estimation results show that malnutrition and poor health experienced during early childhood have long term effects on her human capital growth. More precisely, improving her health status, she would have an additional 30% of probability of completing primary education. This result emerges if the two districts laying on the western board, where the refugees escaped from the genocides of Burundi and Rwanda in the early Nineties, are excluded from the analysis.

The possibility of a strong connection between nutrition and schooling in less developed countries is of growing importance; the analysis presented in this work makes progress in sorting out such a casual relationship.

Key words: Primary Education, Child Health and Nutrition, Weather Shocks, Family Fixed Effects, Instrumental Variables, Tanzania, Sub-Saharan Africa.

Contents

List of Figures

List of Tables

List of Appendixes

« *To build a country,*
build a schoolhouse. »

Amartya Sen,
New York Times (2000)

1. Introduction

Persons and households principally located in rural areas of less developed countries are often exposed and vulnerable to exogenous shock, as, for example, weather-related shocks. These kind of episodes drastically affect households income and, thus, wellbeing for its components[46]; they can produce variations in consumption and, therefore, of utility of both households and individuals.

In developing country contexts, a body of literature, some of it outside of the field of economics, has explored the relationship between preschool nutritional status and the education of school-age children and adolescents. It is reasonable to assume that enhanced health leads to further education achievement. People who are healthier would be more efficient learners of new skills and competencies and invest more in schooling. Healthier students miss fewer days of school due to illness and therefore learn more for that reason. Furthermore, if past health is an input into current health status, this causal path may have permanent effects. On the other hand, a malnourished person is not as productive as she could otherwise be. Chronic infant and childhood malnutrition have been shown to inhibit growth, retard mental development, reduce motivation and energy level, causing a reduction of educational attainments and delay in school entry (Pollitt, 1984). In addition, malnourished adults cannot work as productively as well-nourished, with effects for their incomes and, consecutively, the national income.

Good nutrition is both a desired outcome for guaranteeing optimal human health, as well as a crucial determinant of development, for the individual and for society in general. Consequently, understanding the nature of the causal relationship between health and education, which both reveal household choices about investments in the human capital of

[46] A growing literature analyses both households kinds of respond to these shocks and the effectiveness of these responds in reducing fluctuations in consumption (Hoddinott and Kinsey, 2001)

their offspring, is important for determining the exact relation between them[47]. External shocks may cause permanent damage to children's future welfare and cognitive abilities (World Bank, 1993a); hence, further empirical investigation is required to more precisely assess the magnitude of the effect of such shocks on early child growth.

From a policy point of view, understanding the relationship between health and education is essential to formulate new possible policy interventions, which aim at the improvement of children's status in developing countries. Investigations on this topic state that a clear articulation of health and nutrition issues is largely absent from the education policy agenda in many developing countries. The possibility of a strong connection between nutrition and schooling in less developed countries is of growing importance; the analysis presented in this work makes progress in sorting out such a casual relationship.

This paper extends the literature on the determinants of human capital formation; it goes beyond previous works[48] on the impact of child health and nutrition on education attainment in developing countries by proposing a specific research. It performs microanalysis examining the long-term effects of health status presented by individuals during early childhood on subsequent education attainment of young adults. The data used are of an exclusive long term panel data set collected for a rural area of Tanzania, called Kagera Health and Development Survey, which covers a period from 1991 to 2004. The respondents this paper considers are infants born in the early Nineties who are traced and interviewed in 2004. Differently from much of the literature on shocks, this paper assess the impact at individual level, rather than a household one.

To perform the main objective of the work, the attrition due to family or environmental characteristics is removed by differencing among siblings. In addition, a broad investigation on weather conditions during infancy is conduced, in order to attain the instruments to face the existing endogeneity proper of the health variable. Rainfall data existing from 1980 to 2004 are used to construct an *ad hoc* indicator, linking historical rainfall for year and location of birth for each person with outcomes of the same individuals as young adult. Specifically, exposure to transitory weather shocks experienced

[47] Associations do not necessarily indicate causality; in fact, estimates are usually likely to be biased in one direction or the other because of unobserved factors, such as parental preferences for health and education. These unobserved factors may determine both nutrition and education outcomes, generating a correlation between these two outcomes that is not necessarily causal.

[48] See, among the others, works of Glewwe and Jacoby (1995), Behrman (1996), Alderman et al. (2001), Glewwe, Jacoby and King (2001), Maluccio et al. (2006), Alderman, Hoddinott and Kinsey (2006), Fletcher and Lehrer (2009). For an extended review on this topic, see Chapter II.

by Kageran children during their birth year is assessed to identify differences in height-for-age of siblings as pre-schooler, and, then, connected to schooling outcomes during early adulthood.

By comparing the anthropometric measures of a Tanzanian preschooler with those of a child in a wealthy reference country, estimation results show that malnutrition and poor health experienced during early childhood have long term effects on her human capital growth. More precisely, improving her health status, she would have an additional 30% of probability of completing primary education. This result emerges if the two districts of Karagwe and Ngara laying on the western board, where the refugees escaped from the genocides of Burundi and Rwanda in the early Nineties, are excluded from the analysis.

Section 2 of this paper presents the theoretical framework and the identification strategy. Section 3 contains the description of the dataset employed and the its framework. Section 4 describes the empirical model and the estimation strategy. Section 5 discusses the main findings. Section 6 presents the conclusions and policy implications.

2. Theoretical framework and identification strategy

This section proposes a conceptual framework, which helps to understand the mechanisms through which child health and nutrition status of preschoolers affect schooling outcomes in adolescence. To this aim, the determinants of children's educational attainment are included in a simple model, emphasizing the role played by child health in this process.

The optimal quantity of investments in knowledge capital and the number of years of formal school completed should be positive functions of the efficiency with which individuals transform all the inputs into the knowledge stock. Efficiency in producing human capital through education is given by factors such as health, physical and mental abilities. Moreover, investments health is expected to have positive effects on education given that the returns from investment in education last for many periods and that health status is positively correlated with life expectancy. Finally, the opportunity to finance human capital investments should determine the quantity of schooling achieved by the child.

Health and education are partly determined by genetic endowment, but they are not completely exogenous in a life cycle model, because family background and socio-

economic environment also play crucial roles. Hence, investments in child's human capital are subject to the constraints imposed by family resources and options in the community available to the individual. It is assumed that, in response to signals of their children's health and ability endowments, altruistic parents opt for inputs that maximize the family indirect utility function, subject to a budget constraint made by the production functions for academic achievement and for child health. Some of these inputs enter both schooling and health production functions, creating stocks of human capital for each child in the household. As discussed further below, parents provide their children who have various abilities and health outcomes with different inputs, whether the marginal returns to investments in education of one child is equated, in equilibrium, to the marginal returns to investments in health in their siblings(Fletcher, Lehrer, 2009).

Given the specific focus of this paper, the approach to it is illustrated as follows. Lets consider a two time periods model[49]. The first period (t=1) covers the time during which the individual is a newborn and still a preschooler. In the second period (t=2) the individual is a primary school student or a young adult. Within both phases, parents make fundamental decisions on child's human capital investments, even if those in the first period are among the more important for her developing path. The choice of distinguishing among those precise periods is consequent to the assumptions by medical research, which assess that the first three years of life are the critical for cognitive and physical development for an individual; what happen during this period of life has long-term effects. The manifestation of health and nutritional shocks occurs long time before parental investments on human capital are completed.

Following the well known economic model of human capital investment (Rosenzweig and Wolpin, 1988), the central interest of the analysis is represented by a linear production function for achievements in education by the child i in the second time period. This function can be denoted by the vector S_{i2} as follows:

$$S_{2i} = \beta_0 + \beta_1 X_i + \beta_2 H_{2i} + \beta_3 FB_{2i} + \beta_4 CO_{2i} + \beta_5 CA_{1i} \qquad (1)$$

Assuming that:

[49] This argument follows previous elaborations made by Glewwe, Jacoby and King (2001), Alderman, Behrman, Lavy and Menon (2001), Alderman, Hoddinott and Kinsey (2006), Glewwe and Miguel (2008).

N_{1i} is endogenous

$$N_{2i} = \theta_0 + \theta_1 N_{1i} + \theta_2 DE_{2i} + \theta_3 FB_{2i} + \theta_4 CO_{2i} + \theta_5 CA_{1i} \quad (2)$$

$$H_{1i} = \lambda_0 + \lambda_1 N_{1i} + \lambda_2 M_{1i} + \lambda_3 DE_{1i} + \lambda_4 FB_{1i} + \lambda_5 CO_{1i} + \lambda_6 \eta_i \quad (3)$$

$$H_{2i} = \gamma_0 + \gamma_1 H_{1i} + \gamma_2 N_{2i} + \gamma_3 M_{2i} + \gamma_4 DE_{2i} + \gamma_5 FB_{2i} + \gamma_6 CO_{2i} + \gamma_7 CA_{1i} \quad (4)$$

$$CA_{1i} = \tau_0 + \tau_1 \alpha_i + \tau_2 H_{1i} + \tau_3 FB_{1i} + \tau_4 CO_{1i} \quad (5)$$

Equation (1) can be revised as follows:

$$S_{2i} = \omega_0 + \omega_1 N_{1i} + \omega_2 X_i + \omega_3 DE_{1i} + \omega_4 DE_{2i} + \omega_5 FB_{1i} + \omega_6 FB_{2i} + \omega_7 CO_{1i} + \\ + \omega_8 CO_{2i} + \omega_9 M_{1i} + \omega_{10} M_{2i} + \omega_{11} \alpha_i + \omega_{12} \eta_i \quad (6)$$

In the equations presented above are included inputs at individual, household and community level influencing academic performance. i is the identification for the child; t=1 and t=2 are the first and the second time periods respectively.

X_i is a vector of individual characteristics representing the time-invariant demographic variables, such as gender and age.

α_i and η_i indicate time invariant individual specific characteristic, unknown by parents during the first years of child's life. α_i represents child's innate ability, motivation and genetic endowment; η_i is the inherent physical condition of the child.

N_{ti} and H_{ti} indicate respectively the child's nutrition and health status at time period t, which reflect the history of health inputs and parental decisions on investing in child's health. Health variable has direct and positive impacts on education outcome through several paths. It may influence the child's physical energy level, which determines the time necessary for learning and the school attendance. Moreover, it affects mental status of the child, having a direct impact on performance at school. Finally, it may affect parents', teachers' or peers' action towards the child, influencing in part her educational environment.

CA_{1i} represents child's cognitive abilities developed during the life cycle and is influenced by the nutritional history. CA_{1i} is indicated at time period 1 since the sensitive periods for cognitive skills is assumed to come before age ten (Borghans, Duckworth, Heckman et al., 2008).

FB_{ti} represent the family background characteristics, as the level of education of both parents, the family size and composition, the general family environment in which the child grows up. Moreover, it includes parents' investment in educational inputs, such as books, education toys, time spent by parents with the child. Intergenerational transfer of education plays a vital role in households' living standards, maternal education in particular. Parental involvement is essential in a child's educational growth: for instance, they can teach patterns to children, interpersonal communication skills, expose them to different cultures, educate them about a healthy lifestyle[50].
M_{ti} represents the health inputs, as medical treatments and medicines, in time period t.

CO_{ti} indicates the community level characteristics, such as social culture and values, public infrastructures, public health programs. It also includes the supply of education, which means the level and the quality of school, as: educational infrastructures, teachers' competences, the quantity of school places available, the pupil-teacher ratio, the adequacy of access.
DE_{ti} represents the local health environment in which the child lives, as the possibility to contract an infectious disease, air and water quality, in time period t.

The best source of data to properly measure the causal effect of childhood nutritional and health status on academic achievement is an experimental dataset, or at least a panel. Research on the causal effect of child nutritional and health status on schooling faces many econometric challenges. As Behrman (1996) and Glewwe (2005) note, despite the extensive literature which show positive associations between health problems and school performance, researches on this issue are difficult and ambiguous, in part because of a lack of high-quality data with which to address the issue, in part because there are many

[50] There is a quite extensive socioeconomic literature that shows that there are associations between parental family background and early childhood outcomes in less developed countries, much of which is reviewed in Behrman and Deolalikar (1988), Strauss and Thomas (1995, 1998). While early childhood outcomes are usually represented by physical health measures, parental family background are generally represented by schooling, occupation, income. A much smaller set of studies explore such relations while attempting to control for familiar aspects of unobserved endowments by using data on siblings. Behrman (1988), for example, uses sibling data on child anthropometrics and nutrient intakes for siblings from rural semi-arid tropical India to estimate to what extent households allocate nutrients among children consistent with parental preferences. The estimates suggest that parental preferences among children are not neutral, but favour to differing degrees across seasons the children who are better off.

possible source of bias: omitted variable bias from a variable that is correlated with the exogenous variable but is unobserved, so cannot be included in the regression; measurement error bias; sample selection bias; simultaneous causality bias. In the following sections of the paper, some techniques used to face such estimation problems are discussed.

If complete data on all the right hand variables in equation (1) were available, the production function equation could be estimated by using relatively simple methods (such as naïve Ordinary Least Squares), which would produce unbiased estimates of the direct impacts of each variables on academic skills. Unfortunately, in some cases, as the present one, is not possible to have all the required data, thus some factors like ability remain unobserved, causing grave estimation problems.

The stochastic specification shows the problem of spurious correlation between health status and educational achievement. Since child's health at the first time period is probably correlated with individual or household characteristics included in the error term, the naïve estimate regression of equation (1) would probably be biased. In performing such analysis an endogeneity problem exists, because the health status during the infancy can be not orthogonal to the error term. Thus, estimates obtained by using OLS would be either upward or downward biased. This opportunity can be driven by several reasons. At first, there is a possible correlation of individual effects. For instance, a child with a poor genetic endowment would probably die between the two periods, leaving a selected sample of individuals with an average better genetic development potential. Otherwise, a child with high genetic grow potential would be taller than her peers in both time periods. Another possibility is the correlation of household effects. As soon as a child's talent or motivation for learning is recognized by parents, it may influence their allocations of health and nutritional inputs. For example, parents who have a short child in the first period may decide to drive more resources on that child, or, on the contrary, support educational inputs, presuming that she would perform better in intellectual work during the following period. Those genetic characteristics or parental investments are also unobserved to the data analyst.

A possible path to solve the problem related to endogeneity of the childhood nutritional status could be using N_{i0}, the nutritional status of the child in her prenatal and first two years of life (which represents the determinant period of child's cognitive development),

instead of $N_{i1,}$ given that the former is uncorrelated with the error term. Unfortunately, data on health during this period are often not available for all children. However, as explained further below, different strategies are used to correct for the measurement error bias.

Another option to face the problem of correlation between nutritional status and the error component is assuming to have a sample of sibling, with available information on schooling and health. Differencing has the advantage of purging any unobserved inputs that are constant across siblings (assuming constant impacts between family members), as household and environment characteristics[51].

Within-siblings device is not enough for the purpose of the paper. As a matter of fact, such a model maintains the possibility of correlation between the nutrition status and the error term. This correlation can be removed with the addition of instrumental variables (IV) to this estimation. An appropriate instrument has to satisfy two main conditions: those of relevance and exogeneity. The first means that an instrument must explain a substantial proportion of variation in the endogenous variable. The second implies that the instrument must only have an effect on the outcome of interest through the endogenous variable and cannot be correlated with the residual. Hence, in order to be a good instrument, incidence of transitory shocks should satisfy both of these conditions. Concerning the aim of this analysis, it is very difficult to find such a variable since most factors influencing decision of investing in health will also influence the decision of investing in education.

The model assumes that the child's health and nutritional status in a given period are partly due to a health shock or a combination of shocks (which work as a "natural" experiment) that takes place after parents have made decisions for the same time period. This kind of shock would be (i) of adequate magnitude and persistence to affect a child's health variable used, (ii) adequately variable across siblings in the same household, (iii) adequately transitory not to affect the sibling's health variable used, (iv) and not correlated with education performance.

To resume, since the naïve estimates assume that nutrition is exogenous (pre-determinate) and lead to biased estimates of the parameters, the preferred estimation

[51] Within-sibling data long have been used in the social sciences, since early works by Chamberlain and Griliches, 1975; Behrman and Taubman, 1976; Olneck, 1977. However the within-sibling approach is limited in several ways, since, for instance, it will only remove across family differences but not within family differences.

strategy here adopted is a fixed effects with instrumental variables approach. In presenting the empirical model, the choice of this strategy will be confirmed by additional reasons.

3. Description of data

3.3.1. Tanzania: country profile

Since the present work uses baseline data from a region of Tanzania, painting the framework of the global situation can facilitate the comprehension of the topic investigated. The United Republic of Tanzania is the largest country in East Africa and shares common characteristics with other sub-Saharan African countries, being representative of it (see Table Appendix I). The country is one of the poorest and least developed in the world[52], with an annual per capita income estimated at US$350 in 2005 and a rank of the 159th out of 177 countries in the Human Development Index classification (UNDP, 2007).

The economy is predominantly agrarian, with agriculture providing over 80% of all employment. There are regional differences in households income[53] and availability of education and sanitary services. Poverty remains overwhelming in rural areas where about 87% of the poor population live. Akin to many sub-Saharan Africa countries, people are more educated and in better health in urban than in rural areas[54].

In Tanzania, prior to independence access to basic education and health services used to be limited and unequally distributed by race, region and gender. In the mid-Forties fewer than 10% of the school-age population were enrolled in primary school and less than 1% in secondary school. Moreover, at the same time no females had ever progressed beyond the

[52] According to the Household Budget Survey of 2000/01 (NBS, 2002) the proportion of the population below the national food poverty line is 18.7% and the proportion below the national basic needs poverty line is 35.7%. Comparing these results with those of the Household Budget Survey of 1991/92 (NBS, 1992) there has been a small decline in the proportion of the population below the national poverty lines. Details of the poverty status can be found in recent analyses and reports, in particular: the Poverty and Human Development Reports (2002, 2003), the Household Budget Survey 2000/01 (NBS, 2002), the 2002 Population and Housing Census main report, and the National Accounts (2002 and 2003).

[53] The expenditure share of the bottom 10% of the households was only 2.8%, in contrast to 30.1% for the top decile of the expenditure distribution.

[54] Dar es Salaam and the Northern region are the richest zones with higher educational rates and levels of schooling, compared to the Central, the Southern and the Western zone, comprehensive of Zanzibar.

primary level. The health system relied heavily on traditional healers, a few clinics, and missionary health centres[55].

Since independence of British colonial rule in 1961, during the socialist policies of Julius Nyerere, first prime minister, the Tanzanian government focused heavily on achieving social equity through the development of a strong health and education sector. In the mid 1970s and early 1980s, the country faced a severe economic crisis and budgets were cut. In 1986 the Tanzanian government began a series of structural adjustment programs.

The education policy in Tanzania started in the Sixties has emphasised a unified, centralised system with equality for all pupils, resulting in increases in enrolment and improvements in gender equity (Roy-Campbell, 1992). The investments in the social sector at first led to a wide increase in the level of education; however, in the 1980s and 1990s these trends reversed and primary enrolment rates fell or remained stagnant. During the last decade, the government of Tanzania has made efforts toward improving the educational sector; it has used its saving to increase education spending and eliminate school fees at the end of 2001. Subsequently to this reform, an estimated additional 1.6 million children enrolled in primary school rapidly, reaching a total of almost 2.7 million more children enrolled in 2005 compared to 2001[56].

Nowadays, similar to many sub-Saharan Africa countries, there is substantial evidence of late enrolment in school in Tanzania. Although the legal age of school enrolment is seven being compulsory for seven years, the average age at school enrolment is between eight and nine years and enrolment rates have been well below 100%. Moreover, a gender difference concerning patterns of schooling exists. Although girls receive less schooling on

[55] Despite the high burden of disease and room for improvement, recently there have been some notable social and economic improvements in Tanzania. The education and health sectors are doing relatively well, as is the country's economic performance. One result has been a decline in child mortality. From 1999 to 2005, infant mortality fell from 99 deaths per 1,000 live births to 68 per 1,000, while under-five mortality fell from 147 per 1,000 to 112 per 1,000. Children's nutritional status also has improved. Between 1999 and 2005, the incidence of stunting decreased from 44 percent to 38 percent, wasting from 5 percent to 3 percent, and underweight from 29 percent to 22 percent (see Appendix IV and TDHS, 2006).

[56] Gross Enrolment Rate reached 106.3% in 2004, compared to only 77.6% in 1990. The Net Enrolment Rate was 58.8% in 1990, 66% in 2001, 90.5% in 2005. However, the pace of transition to secondary schools is low, despite the growth of private secondary schools. There are also large gender disparities in enrolment at secondary and tertiary levels. The vulnerability of girls to cultural belief and customs, early pregnancies and sexual abuse remain challenges to enrolment and completion of schooling. Illiteracy remains high. About 28.6% of Tanzanians cannot read and write in any language. There is more illiteracy among women (36%) than men (20.4%). Consequently to the abolition of school fees, many more children have access to school, with an increase in the quantity of education, but the burden for the teachers increased and that the teachers' status declined, with a decrease in quality.

average than boys and a greater proportion of them never attend school, they start their schooling at an earlier age (Bommier and Lambert, 2000)[57].

3.3.2. Kagera Health and Development Survey (KHDS)

This study uses baseline data from a longitudinal Living Standards Measurement Survey (LSMS)[58] originally conducted in the entire rural Kagera region located into the North West of Tanzania. The study was carried out by the World Bank, Muhimbili University College of Health Sciences and University of Dar es Salaam. The Kagera Health and Development Survey (KHDS) is a longitudinal socio-economic detailed survey, into the long-run wealth dynamics of households and individuals. The data hold a rich set of community characteristics on health care, education and prices as well as individual and household specific information.

The Kagera region is representative of many parts of sub-Saharan Africa, therefore its study is noticeable because it may reveal many important aspects similar to other sub-Saharan African countries. The region, which takes its name from the Kagera River, lies just south of the equator, on the western shore of Lake Victoria, bordering Uganda to the north and Rwanda and Burundi to the west. The region lies at about 1,340 above sea level, consists of 28,953 square kilometres of land surface and 11,885 square kilometres of water surface. The population - 1.9 million in 1991-1994, about 2 million in 2004 (United Republic of Tanzania, Population and Housing Census, 2002) - is of diverse ethnic make-up and overwhelmingly rural. Thus, agriculture is the guide sector, accounting for 45% of GDP and about 60% of export earnings during last years[59] (PRPS, 2006). Almost one third

[57] Filmer (2000) finds a small gap in favour of girls for six- to eleven-year-olds and a slight advantage for boys in the gender gap among twelve- to fourteen year-olds. Bommier and Lambert (2000) using Human Resource Development Survey carried out in Tanzania in 1992-93 state that in Tanzania, actual school enrolment takes place two or three years later on average than the legal enrolment age. The authors suggest that the gender difference concerning patterns of schooling could be due to different return from pre-school training in the family's economic activities or it could be related to the wish to have girls ready to be married as early as possible. Moreover, Mason and Khandker (1997) confirm that before entering school, Tanzanian children actively participate to family activities, so that there is a high opportunity cost to primary schooling, which is found increasing with age.

[58] The KHDS was the first fully longitudinal LSMS survey. Moreover, it is one of the few surveys that has data over such a long period and that can address questions concerning long-term effects of orphan hood, disability, lack of education, mortality, morbidity, etc.

[59] Agriculture is the source of food and raw materials for industries. It also provides livelihoods to 82% of the population, primarily engaged in producing bananas and coffee in the northern districts and rain-fed annual

of the entire population is below the nationally defined poverty line, but there are wide disparities in welfare indicators within the region. Annual household expenditure was US$217 per capita in 1991, ranging from US$118 to US$357 within the six districts of Kagera region.

The survey is a four-round panel from 1991 to 1994 followed up in 2004[60]. The KHDS used a random sample that was stratified geographically and according to several measures of adult mortality risk (see Appendix II)[61]. The first KHDS consisted of 915 households effectively interviewed up to four times, from September 1991 to January 1994 (at 6-7 month intervals). Households are drawn from 51 villages (or "clusters") of 16 households each in the 6 administrative districts of Kagera: Biharamulo, Bukoba Rural, Bukoba Urban, Karagwe, Muleba and Ngara[62].

During the first passage, a total of 840 households were interviewed. This group included the 816 "original" households selected from the enumeration (or their replacements) and 24 "extra" households. By the end of the fourth passage, 81 households (9.6% of the 840 interviewed in the first passage) had dropped out and this attrition rate compares favourably to other panel datasets (Alderman et al., 2001). The main cause for such little rate of shrinkage in size was that the household moved, principally due to an adult death in the household (see Appendix II).

In 2004, a fifth round of data collection was completed. The objective of the KHDS 2004 survey was to re-interview all individuals who were household members in any round of the KHDS 1991-1994 and who were alive at the last interview. The KHDS 2004 intended to provide data to revise economic mobility and variations in living standards of the sample of individuals interviewed in the decade before (Beegle et al., 2006).

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crops (maize, sorghum, cotton) in the southern districts. More recently fishing in Lake Victoria has provided alternative sources of income.

[60] More precisely, KHDS 1991-1994 was undertaken by the World Bank and Muhimbili University College of Health Sciences, whereas KHDS '04 was funded by DANIDA and World Bank and implemented by E.D.I. (Economic Development Initiatives) in Kagera. For a detailed description and data set of the first four waves see World Bank (2004) and Living Standards Measurement Study website. For further information see Ainsworth et al. (1992) and World Bank (1993b). Concerning the follow-up survey see Beegle, de Weerdt, Dercon (2006).

[61] The original sample of households was selected from a random sample of communities from the 1988 Tanzanian census, stratified on agro-climatic zone and adult mortality rate. The KHDS formerly intended to examine and assess the economic impact of young-adult mortality and morbidity (primarily due to HIV/AIDS, which finds the epicentre in this zone) on surviving household members (Ainsworth, Semali, 2001).

[62] Recently, two more districts have been added within the same geographical region: part of Bukoba Rural became Mishenyi and part of Biharamulo became Chato.

Considerable effort was made to track surviving respondents to their current location, be it in the same or a nearby community, within the region, or even outside the region (see Appendix II). Excluding households in which all previous members are deceased, the field team managed to re-contact 93% of the baseline households in 2004. This is an excellent rate of re-contact compared to panel surveys in low-income countries and high-income countries.

3.3.3 Rainfall pattern and data

Development in Tanzania has been vulnerable and adversely affected by inter annual variations in weather and climate and their related disasters, such as drought and floods (caused by excess or deficit of rainfall respectively). Drought is characterized in terms of its spatial extension, intensity and duration and a precise universal definition for it is not easy to find[63].

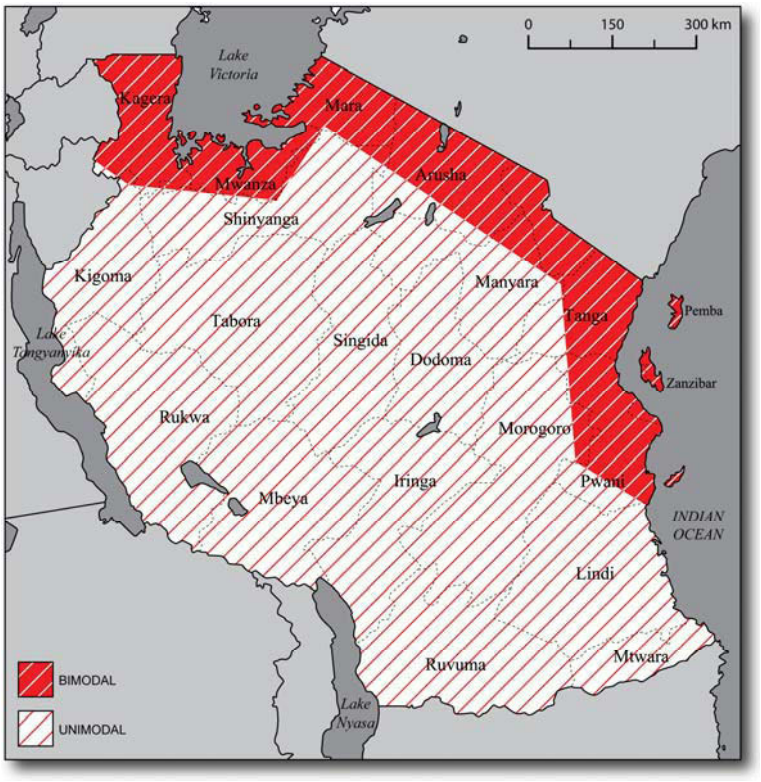
In recent years parts of Tanzania have experienced recurring droughts. The most devastating were those of 1983-1984 and 1993-1994. According to Tanzania historical data, droughts occur every four years, affecting over 3.63 million people[64]. Differently from the general pattern, data of KHDS elaborated for the paper show that the period of severe droughts occurred between 1988 and 1990.

Kagera region presents a bimodal seasonal calendar in a 12 month with 900-2,000 mm per annum, temperatures range between 20°C and 28°C, and the timing and duration of each season vary according to setting within the region. It presents long rains (the masika season) from March to May and short rains (the vuli season) from October to December; dry seasons (the kiangazi season) between the two rainy seasons (Figure 3.1 and Figure 3.2).

[63] Agriculturalists consider drought as a shortage of humidity within the root zone for plant growth and development. Hydrologists conceive drought as a severe reduction in stream, lake and reservoir levels. Meteorologists consider droughts as basically a prolonged period of precipitation shortage that cause severe hydrological imbalance. Economists regard droughts as a serious water shortage that negatively affects the economy.

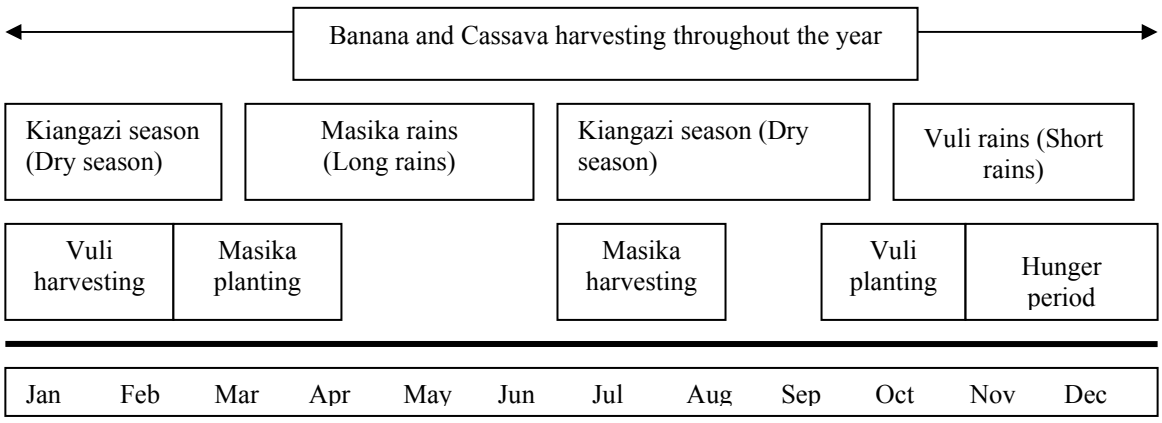
[64] The most frequent hit areas from droughts are central areas of Dodoma, Singida and some parts of Pwani, Shinyanga, Mwanza and Mara. These regions receive 200mm to 600mm of annual rainfall. Experience of 1980-2000 has shown that floods occurred 15 times and killing 54 people and affecting 800 thousand people. Flood prone regions are Tanga, Mbeya, Pwani, Morogoro, Arusha, Rukwa, Iringa, Kigoma and Lindi.

Figure 3. 1: Unimodal and bimodal seasonal calendar in Tanzania.



Source: Author's elaboration based on FEWS NET.

Figure 3. 2: Seasonal calendar and critical events.



Source: Author's elaboration

To perform the declared aim, this paper uses monthly rainfall data collected by Tanzania Meteorological Agency and reported on the EDI (Economic Development Initiatives) website. Historical rainfall data are available for 25 years, from 1980 to 2004; total millimetres of rain per month and total days of rain per month for 21 weather stations in Kagera region are collected[65].

Average annual rainfall in Tanzania varies considerably between areas. Kagera region is not the driest throughout Tanzania, given its location, but its weather is still of considerable impact on people's wellbeing. For agricultural production, however, it is not the average annual rainfall which matters the most, but its seasonal pattern[66]. The increased vulnerability of households to weather shocks and their sharp dependence on the timing and quantity of rainfall is emphasized by the 2008 WDR (World Bank, 2008)[67].

The season during which a child is born is one crucial factor for her nutrition and health status. As already stated in the paper, the impact of season of birth becomes less significant after the third year of child's life. The rainfall occurring the season before the child is born is extremely important, given that it more probably affects production and therefore the availability of food for child's nutrition. The season and period during which a child is delivered is also crucial. If a child is born during both long or short rainy season, higher agricultural production requires higher (also feminine) labour force employed in the fields. The consequences are twofold: less care by mothers who are usually the care giver[68], with negative effects on child's health; higher family wealth, which positively affects both child's and the other existent family members' health.

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[65] The Kagera rainfall data can be used in combination with the KHDS survey data, matching each KHDS cluster with a rainfall station the nearest and second nearest station. The dataset also offers monthly rainfall measurements over the five districts (Bukoba urban and rural combined) from January 1989 to December 1993, but given the short period and the missing data, they result useless for the estimations.

[66] Corresponding to the bimodal seasonal pattern, the agricultural season starts in October. The distribution of rainfall during the short rainy season is critical, as it determines when fields preparations can start and the success of early crops. The second critical period in relation to rainfall is the length of the dry spell between the short and long rains.

[67] At author's knowledge, the only analysis based on a part of rainfall data (ten years historical trend) assembled by EDI website is by Litchfield and McGregor (2008), which connect rainfall in 2004 and welfare in Kagera, showing that the weather shocks have larger effect for the poorer households than for the wealthier.

[68] Artadi (2006) shows that in sub-Saharan Africa there is a trade-off between infant health and family income and that households living in areas where such trade-off is present, tend to choose the worse birth months for infant survival. The author recognises that Tanzania has a strong seasonal pattern of malaria, and higher precipitation around the time of birth is associated with higher infant mortality. Moreover, she reveals that the rural population in the country does not face such trade-off, and that concentrates births when survival is higher.

Moreover, higher early-life rainfall is supposed to increase spread of diseases such as malaria, which in turn negatively affects infant health status[69]. As revealed by data elaboration, malaria is the first cause of death in Kagera and prevalent in Tanzania. The risk to contract malaria (principally as P. falciparum) is present throughout the calendar year in Tanzania, under 1800m of altitude[70].

4. Empirical model and estimation strategy

3.4.1 Empirical model

The objective of the paper is to estimate a production function equation which helps to analyse the long-term consequences of infant and early childhood health status on education outcomes. This equation has to be as close as possible to that presented in the theoretical model, taking into account the available dataset and the estimation problems presented above. The structural form for educational outcomes is the following:

$$S_{2i} = \kappa_0 + \kappa_1 N_{1i} + \kappa_2 X_i + \kappa_3 DE_i + \kappa_4 FB_i + \kappa_5 CO_i + \kappa_6 M_i + \varepsilon_{2i} \quad (7)$$

Inputs included in the empirical model are the same as indicated in the theoretical one. In line with the data availability, a few considerations concerning some variables are done.
The academic input on which the analysis is focused would be the child's nutritional history during the early years of life. However, as a realistic issue, quantifying cumulative nutrition inputs appears exceptionally difficult. Assuming that N_{1i} is unobservable, H_{1i} can be employed as a proxy for it in the empirical model.

Concerning both the family background (FB_i) and the social characteristics (CO_i), some variables are unobserved, therefore they are included in the error term (ε_{2i}).

[69] According to the World Malaria Report 2005 (WHO and UNICEF, 2005), Tanzania is classified as a malaria endemic country, subject to frequent and recurrent epidemics, mainly generated by anomalies of rainfall and/or temperature. 93% of the population is living in areas at risk of stable malaria. Getting precise information about incidence and trends of malaria in Tanzania is not easy, mainly because malaria is not considered a notifiable disease in the country and because people, especially in rural areas, tend to cure diseases at home without seeking care to formal health providers. Concerning Kagera, information about the incidence of malaria is not easily available, but the region is classified as being at high risk of malaria and easily subject to serious outbreaks.

[70] Given this consideration, a dummy variable is elaborated regarding possibility of contracting malaria, in relation to the altitude of the nearest station.

Furthermore, the Kageran society is almost "static", as it is overwhelming rural and traditional; hence it is unfeasible that considerable changes occur between the two time periods. Additionally, the model considers siblings with a small age difference between them. Taken all these considerations, both variables are supposed to be stable in the model[71].

ε_{2i} is the individual specific error term that affects the educational outcome of interest and is composed by three elements: the time invariant individual specific characteristics that are unknown by parents during the first years of child's life (as child's innate ability, motivation and genetic endowment, which means the unobservable variables α_i); the time invariant household environment characteristics (as parental preferences on human capital investments of their children, the time spent and care given to cognitive development of their children, the household intellectual atmosphere) common to all children in the family and that influence education; a white noise error term.

To resume, the production function in equation (7) describes the role of child health in determining academic outcomes. Thus, it illustrates how, *ceteris paribus*, variations in child health status could affect schooling performances. Each right hand variable (which can be both exogenous and endogenous) has positive and direct impact on S_{2i}, building up a structural relationship. Conversely, equation (8) represents the reduced form equation, presenting a function that depends only on exogenous factors.

$$S_{2i} = \varphi_0 + \varphi_1 R_{1i} + \varphi_2 X_i + \varphi_3 DE_i + \varphi_4 FB_i + \varphi_5 CO_i + \varphi_6 M_i + \xi_{2i} \quad (8)$$

R_{1i} represents the environmental conditions experienced in early life. Higher rainfall during the time of birth should be interpreted as a positive shock to Kageran population, leading to higher products from agriculture.

The estimating strategy is based on households fixed effects - instrumental variable estimator. Differencing among siblings purges any inputs, both observed and unobserved,

[71] Even if schools can eventually vary during the time (as it actually does with the abolition fee in 2001), in this analysis, the child is still a preschooler during the first time period, hence no information about school at that time is collected. Consequently, data on quality of school considered are those of the second period, when the child is an adolescent and have had the possibility to attend school.

that are constant among them, as household and environment characteristics. Rainfall can be used to overcome the endogeneity and simultaneity problems of health measure. As argued above, the weather shock has to be the one that affect H_{i1}, varies across siblings in the same household and be sufficiently temporary not to affect S_{i2}. Weather shock is conceivably related to difference in sibling's height-for-age, but, plausibly, it has no persistent effects on schooling outcome observed[72]. While there might not be any existing evidence that rainfall considered in this study have any effect on the achievement production process, it remains possible. In other words, the instrumental variable R_{1i} is correlated with the random regressor H_{1i}, but is uncorrelated with the disturbance ε_{i2}, which means: $cov(H_{1i},R_{1i})\neq 0$ and $cov(R_{1i},\varepsilon_{2i})=0$, thus: $cov(\upsilon_{1i},\varepsilon_{2i})\neq 0$. Following the indicated strategy, H_{i1} is first estimated using the selected instrumental variable R_{1i}, and then S_{i2} is estimated using $\hat{H}_{i1}$ from the first stage.

To resume, in the first stage equation, variations between siblings heterogeneity in health outcomes are explained using rainfall at location and time of birth as instrumental variables, while controlling for other individual and family and community characteristics that affect both health and education outcomes. The first stage is shown by the following equation:

$$H_{1i} = \pi_0 + \pi_1 R_{1i} + \pi_2 M_i + \pi_3 DE_i + \pi_4 FB_i + \pi_5 CO_i + \upsilon_{1i} \qquad (9)$$

υ_{i1} is the individual specific error term that affects health status of interest and is composed by three elements: the individual specific characteristics unknown by parents during the first years of child's life (as child's genetic endowment, indicated with η_i); the household environment characteristics (as parental preferences for their children's health, the care given to their children, the amount and quality of food given to child, their ability and sensibility, their involvement in child's educational growth) common to all children in the family and that influence health status; a white noise error term.

To ensure the validity of the indicated strategy, it has to be considered that environmental or social factors as, in this case, a weather shock occurred during the first

[72] Certainly the shock not only influence health status of children, but more probably it affects the economy as a whole. The approach used takes in consideration the differential impact of the selected shock on siblings; hence, the time it took the local economy to recuperate is not a feature in the analysis.

years of life, can eventually be correlated not only with nutrition and health, but might also affect cognitive ability throughout different channels. For this reason, a correct analysis of the composition of the error term is crucial to understand whether the rainfall instrument is acceptable.

A severe drought - or other kinds of shock - might alter the amount or the quality of child care provided by parents since they must spend more time in coping with the drought and in achieving enough food for the family, with probable negative consequences on education (Neumark, 1999; Ashenfelter and Kruger, 1992). Otherwise, unusual rainfall might alter the disease environment, with direct effects on the absorption of nutrition particularly in the vulnerable early years of rapid growth. Fluctuations in precipitation may influence other environmental conditions correlated with economic activity and public health, such as the availability of potable water and agricultural pest control. Indeed, some of these channels may imply a negative impact of rainfall that would somewhat offset positive effects via improved agricultural output. Other kinds of shock could in turn create new sources of stimuli, with positive effects on schooling.

Differences among siblings are due to differentiation in their inherited talents and motivations, experiences and stimuli they are exposed to. The scope to which environment varies between siblings depends on their age difference and on the changing conditions of the household and community associate with this laps of time (Griliches, 1979). Given these considerations, the correlation between weather shock and cognitive ability would justify the inclusion of household fixed effects, which would eliminate the ability differences between siblings that can be hardly observed by the researcher[73]. The choice of such expedient is strengthen by the fact that children included in the main sample have a small age difference and it can be assumed that all siblings would be affected on the same measure by the shock. Robustness checks are offered on children with a reduced age difference.

The first stage presents a linear representation of the child's health production function. Estimating the first stage by OLS and construct the predicted values for H_{1i} drives to:

[73] Ashenfelter and Kruger (1992) surprisingly find no evidence on positive effect of unobserved ability to the final grade achieved; alternatively, they find some weak evidence on negative correlation of unobserved ability to schooling level.

$$\hat{H}_{1i} = \hat{\pi}_0 + \hat{\pi}_1 R_{1i} + \hat{\pi}_2 M_i + \hat{\pi}_3 DE_i + \hat{\pi}_4 FB_i + \hat{\pi}_5 CO_i \quad (10)$$

Estimating again by OLS, the second stage estimate is obtained:

$$S_{2i} = \kappa_0 + \kappa_1 \hat{H}_{1i} + \kappa_2 X_i + \kappa_3 DE_i + \kappa_4 FB_i + \kappa_5 CO_i + \kappa_6 M_i + \varepsilon^*_{2i} \quad (11)$$

ε_{2i} , $\upsilon_{1i,}$ ε^*_{2i} and ξ_{2i} all contain unobserved individual, household and community variables that influence the educational performance. All of them include both time invariant as well as time-varying portions of the disturbance term.

The academic input on which the analysis is focused would be the child's nutritional history during the early years of life. However, as a realistic issue, quantifying cumulative nutrition inputs is exceptionally difficult. A straightforward option for the nutritional history up to that age can be to use the child's anthropometric measure of height-for-age[74]. For comparison purposes, children's height measurement is standardized according to the International Referenced Population[75] defined by the U.S. National Centre for Health Statistics (NCHS) with the Centres for Disease Control (CDC) and the World Health Organization (WHO) (WHO, 1995). High-for-age indicator is thus expressed as a "z-scores"[76], which compare a child's measurements and sex with those of a similar child in a

[74] The synthetic long-term anthropometric measures of pre-school and school-age children's nutritional status are height and weight: height-for-age as measure of stunting or chronic malnutrition; weight-for-height as measure of wasting or acute/transitory malnutrition; weight-for-height reflects both stunting and wasting, resulting from either chronic or acute malnutrition, or a combination of both. Each indicator captures different aspects of malnutrition. The WHO recommends stunting as a reliable measure of overall social deprivation (WHO, 1986). The Jamison (1986) and Moock and Leslie (1986) studies found height-for-age indicator to be the most strongly associated with school progress compared to the other anthropometric measures of malnutrition.

[75] The use of this reference population is based on the finding that well-nourished young children of all population groups follow very similar growth patterns. Although variations in height and weight exist, these approximate a normal distribution when the population under study is large.

[76] Z-scores are a means of answering the question: "How many standard deviations away from the mean is this observation?" If our observation X is from a population with mean μ and standard deviation σ, then $Z_x = \frac{X - \mu_x}{\sigma_x}$. A positive (negative) z-score indicates that the observation is greater (less) than the mean.

The various degrees of severity of malnutrition are often classified using the following z-scores. In general, a mild stunted child has a height-for-age z-score that is between -2 and -1 SD below the mean of the reference population indicated by the NCHS/CDC/WHO; a moderate stunted child has a height-for-age z-score that is between -3 and -2 SD; a severe stunted child has a height-for-age z-score<-3 SD. Not stunted children has height-for-age z-score>-1 SD. Similar classifications are for the various degrees of severity of wasting and underweight. For a more detailed description of anthropometric measures, see Chapter I.

reference, healthy population defined by the US NCHS, who has a z-score with mean zero and standard deviation of one.

A low height-for-age z-score defines "stunting", which means the child is too short for her age. Stunting indicates slow physical growth since birth, usually due to repeated episodes of poor nutrition and/or episodes of diarrhoea and other illnesses. Hence, it is a cumulative indicator of past episodes of malnutrition and, since it is likely to persist even after these conditions are eliminated, it is also defined as indicator of chronic malnutrition.

A possible criticism of this measure can be that height-for-age also captures the consequences of illness and other environmental and genetic influences, reflecting more than just a child's cumulative nutritional history. For this reason, controls with the Body Mass Index (BMI) have been done at first analysis to corroborate the results obtained[77].

The respondent variable corresponding to educational achievement indicates if the adolescent has completed or not the entire cycle of primary education. This choice is determined by some reasons. At first, given the data structure and the periods of time available, this one results the foremost information to analyze. For instance, primary school is mandatory (and free since the end of 2001); therefore, all children are supposed to attend and complete primary education. Nevertheless, as it is shown in the following paragraphs, of the children in the selected sample, almost 20% enter school at the due time, while two third is enrolled between 8 and 10 years old. Moreover, a child can have repeated many times a school year, but only if she has completed the final grade of primary school denotes she has adequately achieved the basic information required to pass the final exam. Thus, the selected dependent variable not only is a good indicator of individual characteristics, as for example health status, but it also reveals essential socio-economic elements, as parental preferences or cultural traditions.

A suitable schooling outcome can be also total years of schooling completed. The literature (see among the other works, those of Grossman, 1972; Fuchs, 1965) suggests that among socio-economic variables, years of formal schooling completed is probably the most important correlate of good health. This study is focused on a sample of children, the

[77] BMI reflects short-term and long-term nutrition and health status of children and adults. It is calculated by dividing weight in kilograms by the square of height in meters. A person is considered to be chronically energy underprovided if her BMI is below 18.5, overweight if it is greater than 25 and obese if they have a BMI greater than 30.

majority of whom are still attending school. Therefore, years of education attained do not necessarily indicate the total years to be achieved by the respondent if the child is still going to school and expected to complete additional years of education. Data concerning actual year of completed schooling are deeply analyzed and summarized, in order to avoid to throw away essential information. For the sake of clarity, the main regressions are analyzed maintaining as respondent variables both final grade achieved and the completion of primary school respectively; the results (shown in Appendix V) corroborate the choice of the second variable[78].

Besides, another important measure to be included in the analysis is the delay in primary school enrolment. Many children enter school after the minimum age at which they are allowed to enrol and this fact reveals parental assessment of whether their child is ready to go to school. This phenomenon has been noted in many low income countries, despite the human capital theory predicts that schooling will begin at the earliest possible age (see Glewwe and Jacoby 1995).

A supposed negative correlation between delaying entrance and grade achieved exists. As a matter of fact, both final grade achieved and delay in enrolment are the observed outcome of the latent propensity for schooling. Often, information on enrolment and attainment differs because a child enrolled at the beginning of the year does not attend school later on.

As shown by the evidence presented in the following paragraphs, higher rainfall should be interpreted as a positive shock to Kageran population, leading to higher products from agriculture. From the analysis of the historical data on rainfall for a period of 25 years, computing the mean and standard deviation for such long period of rainfall, the paper identifies whether rainfall at location and time of birth was substantially above or below normal levels, and therefore measures the effect of weather shocks on child's human capital attainments. Specifically, exposure to transitory weather shocks experienced by children during their birth year can be assessed to identify differences in height-for-age of

[78] The weird result obtained in regressing the final grade achieved on height-for-age is that the health status seems to negatively affect education. The same sign of relation appears between rainfall and education. See Appendix V.

siblings as pre-schooler, and, then, connected to schooling outcomes during early adulthood[79].

3.4.2 Description of main variables

The objective of the paper is to estimate the production function equation (1), which helps to analyse the long-term consequences of infant and early childhood health status on education outcomes. Given the estimation problems presented above, data requirement is elevated.

In the selected model, in the first period the individual is a newborn or a preschooler, and is interviewed for the first time during 1991-1994; in 2004, the second period, she is an adolescent between 10 and 19 years old[80].

A serious problem in dealing with dataset collected for less developed countries is that people frequently do not have precise information concerning themselves. The suitable sample for the analysis is constituted by children with available information on health status, which means anthropometric measures, on the first time period; educational outcomes, which means final grade achieved (and delay in enrolment), in the second time period; the identified shock used to instrument health as described above; birth date and location of children to accurately associate and measure the effect of the shock to each child. The sample has to preserve the same children traced both in the first and in the second period, without attrition bias between the two. A complete list of all variables included in the estimation is presented in Table 3.1.

[79] Nevertheless it is possible that parents may undertake compensatory actions in the aftermath of these events, such actions are not sufficient to prevent these "temporary" events having long lasting impacts (Alderman et al., 2006). Anyhow, with the dataset exploited in this paper is not possible to directly test for the presence of such compensatory actions.

[80] Actually, the entire period during which KHDS 1991-1994 was completed is of 27 months, not 48 months as one could expect. More precisely, passage I went from 9/30/91 to 5/10/92, passage II from 4/23/92 to 11/30/92, passage III from 11/14/92 to 5/25/93, passage IV from 6/6/93 to 1/5/94.

Table 3. 1: Description of the variable used and descriptive statistics, KHDS (1991-2004).

Variables	Definitions of Variables	Obs	Mean	Std. Dev.	Min	Max
	Individual variables					
Gender (female)	1= Child is female; 0=Child is male	622	.463	.499	0	1
Age as adolescence (in year) in 2004	Child's age as adolescence (in months) in 2004	622	1.473	2.381	10	20
Height-for-age z-score	Height-for-age for pre-schoolers (1991-1994) z-score statistics	622	-1.648	1.503	-6	4.08
Vaccine	1= Child has a Vaccination Card; 0=no	537	1.091	.288	1	2
	Household variables					
Small family	1= Child lives in a family with 2 children maximum, 0=elsewhere	622	.453	.498	0	1
Education of household head	1=Household head has completed primary education, 0=no	622	.436	.496	0	1
Father's height	Father's height (cm)	497	1.678	8.675	100	183
Mother's height	Mother's height (cm)	577	1.572	6.087	139	178
Community	***variables***					
Karagwe	1= Households located in Karagwe District, 0=no	622	.172	.378	0	1
Bukoba Rural	1= Households located in Bukoba Rural District, 0=no	622	.281	.450	0	1
Bukoba Urban	1= Households located in Bukoba Urban District, 0=no	622	.193	.395	0	1
Muleba	1= Households located in Muleba District, 0=no	622	.169	.375	0	1
Biharamulo	1= Households located in Biharamulo District, 0=no	622	.080	.272	0	1
Urban	1= Child lives in rural area, 0=no	622	.254	.436	0	1
Rainfall variation z-scores	Rainfall at location and time of birth z-score statistics	622	.036	.232	-.336	1.026
Household location (possibility of malaria)	1=Household located under 1800m of altitude (where malaria is more likely), 0=elsewhere	622	.254	.436	0	1

Source: Author's elaboration from KHDS dataset

Specifically, the analysis focuses on children born between March 1985 and January 1994, and traced in 2004. Data show that of 1,548 preschoolers in 1991-1994, some 1,214 are traced in 2004, of whom almost half is female and half male. Of these children still in the sample in 2004, some observations have to be dropped because of missing data in fundamental variables: 84 children lack information about birth month; 118 lack

information on education[81] (principally the final grade achieved); 157 lack information on anthropometric measures (height) and 7 children whose anthropometric measure has a plausible measurement error[82]. Counting for these missing values (Table 3.2), the applicable sample consists of 238 households with more than one child of preschool age, for an amount of 622 not only-children (334 male and 288 female). All children are households member and have ever attended school, by 2004.

Table 3. 2: Distribution of not-only-children in each household, by order of birth.

Birth order	Freq.	Percent
1	238	38.26
2	238	38.26
3	97	15.59
4	33	5.31
5	10	1.61
6	3	0.48
7	2	0.32
8	1	0.16
Total	**622**	**100.00**

Source: Author's elaboration from KHDS dataset

The following tables report some summary statistics concerning the sample employed in the analysis. Table 3.3 and Table 3.4 show that the mean height-for-age z-score is -1.65; almost 70% are moderately stunted, performing an height-for-age z-score under one standard deviation below the mean of the international reference population; nearly 40% are severely stunted, with an height-for-age z-score under -2 standard deviation[83]. These considerations are corroborated by both the histogram in Figure 3.3, which represents the distribution of children by height-for-age z-scores, and the bar graph in Figure 3.4, indicating height-for-age z-scores for pre-schoolers by age expressed in months. The distribution does not appear normal, is negatively asymmetric and has an high concentration at the level of –2 standard deviations.

Taking into consideration results shown in Table 3.3 on height-for-age, there is considerable chronic malnutrition among Kageran children, reflecting the general situation in Tanzania (see Appendix IV). Gender and residency are two important discriminating

[81] The first seven grade of primary education are counted with points from 1 to 7; the first year of secondary school is indicated with grade 8, with and ascending order for the following grades. If the child have some education indicated as "Adulted", "Koranic" or "None", all of them have been assigned education level equal to 0.
[82] In detail, seven children whose height-for-age z-score is less that -6 or more than +6 are left.
[83] These results are consistent with those collected by Alderman et al. (2005) and by TDHS datasets.

factors for possible malnutrition. Male and rural children are slightly more likely to be stunted than female and urban children.

Table 3. 3: Heath status of children in KHDS 1991-1994, represented by "stunting" measure.

Variable	Gender		Residence		Total
	Female	Male	Urban	Rural	
Height-for-age z-score<-1 SD	64.93%	74.85%	66.46	71.55	70.26%
Height-for-age z-score<-2 SD	31.94%	47.31%	32.91	42.67	40.19%

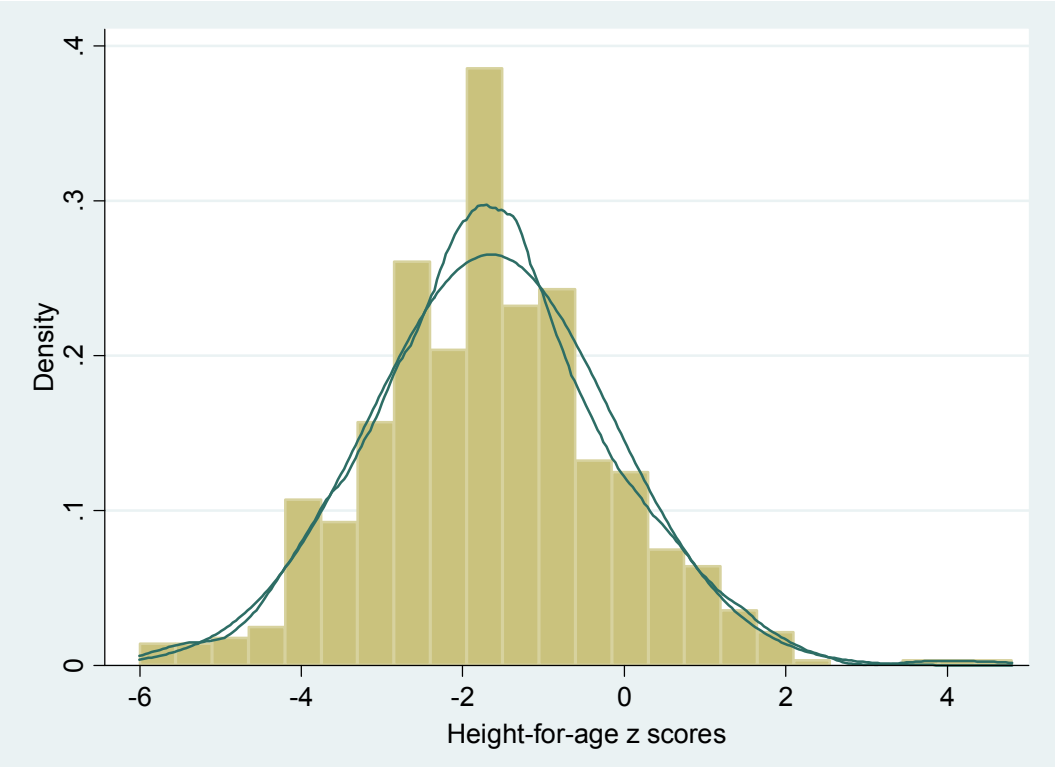
Source: Author's elaboration from KHDS dataset

Table 3. 4: Descriptive statistics on children in KHDS 1991-1994.

Variable	Obs	Mean	Std. Dev.
Height-for-age z-score	622	-1.65	1.50
Stunted	622	0.70	0.46
Age (in months)	622	32.58	24.87
Gender (female)	622	0.46	0.50

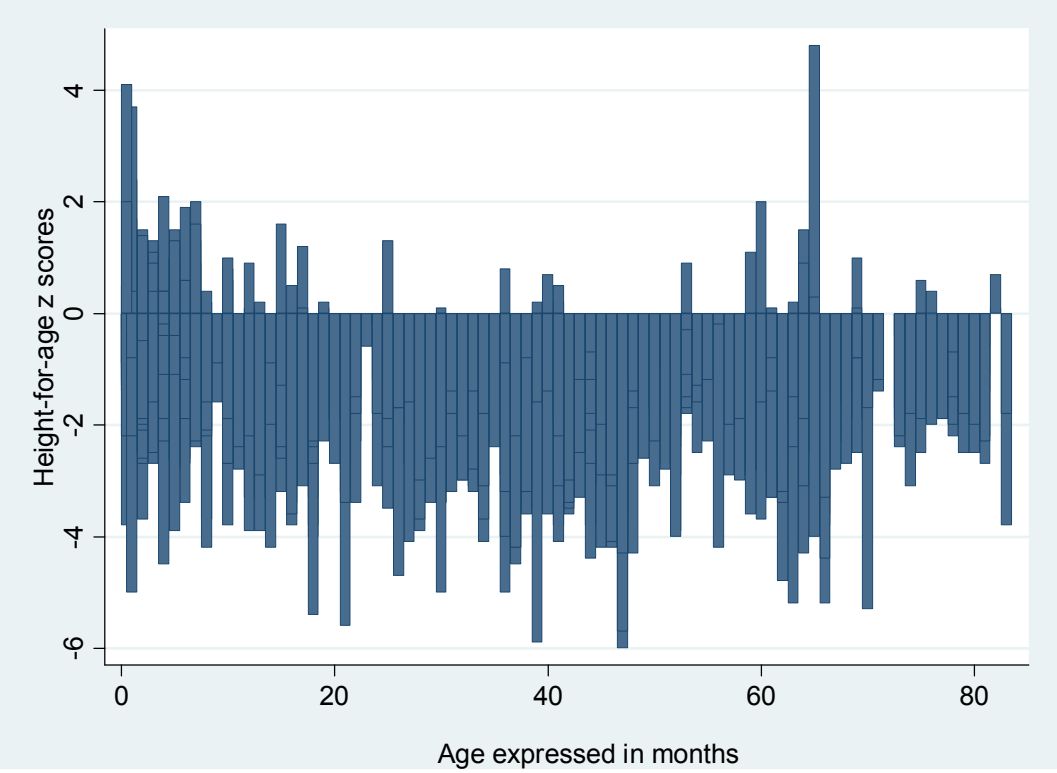
Source: Author's elaboration from KHDS dataset

Figure 3. 3: Height-for-age z-scores in Kagera, for pre-schoolers (1991-1994).



Source: Author's elaboration from KHDS dataset

Figure 3. 4: Height-for-age z-scores for pre-schoolers in Kagera, by age expressed in months (1991-1994).



Source: Author's elaboration from KHDS dataset

Let's consider some characteristics proper of children at the second time period: height as adolescent, final grade achieved, age at school entry. Enrolment is delayed when a child does not enter school at the due time. Even though primary school is mandatory from the age of seven in Tanzania, Table 3.5 shows that, on average, they start school at nine years old. More precisely, of the children in the selected sample, almost 22% enter school at the due time, while 65% is enrolled between 8 and 10 years old (see Figure 3.5). Some of them are still enrolled in primary education, and therefore they have not terminated the primary school cycle. As stated above, the decision to enter school is highly determined by parents preferences and child's characteristics, as ability or height. Moreover, the later a child is enrolled the later she can complete the primary school. These results realistically reflect the general situation of Tanzania, as presented above in the paper.

Table 3. 5: Descriptive statistics on children in KHDS 2004, by residency and gender.

Variable	Obs	Mean	Std. Dev.
Total			
Height as adolescent	544	148.05	12.47
Final grade achieved	622	4.40	2.25
Age at school entry	621	8.90	1.67
Residency			
Rural			
Height as adolescent	411	147	12.28
Final grade achieved	464	4.18	2.24
Age at school entry	463	9.02	1.72
Urban			
Height as adolescent	133	151.29	12.55
Final grade achieved	158	5.03	2.15
Age at school entry	158	8.52	1.45
Gender			
Male			
Height as adolescent	295	147.68	13.1
Final grade achieved	334	4.22	2.24
Age at school entry	333	8.96	1.58
Female			
Height as adolescent	249	148.49	11.69
Final grade achieved	288	4.59	2.24
Age at school entry	288	8.79	1.75

Source: Author's elaboration from KHDS dataset

Figure 3. 5: Age at school entry in Kagera (2004).

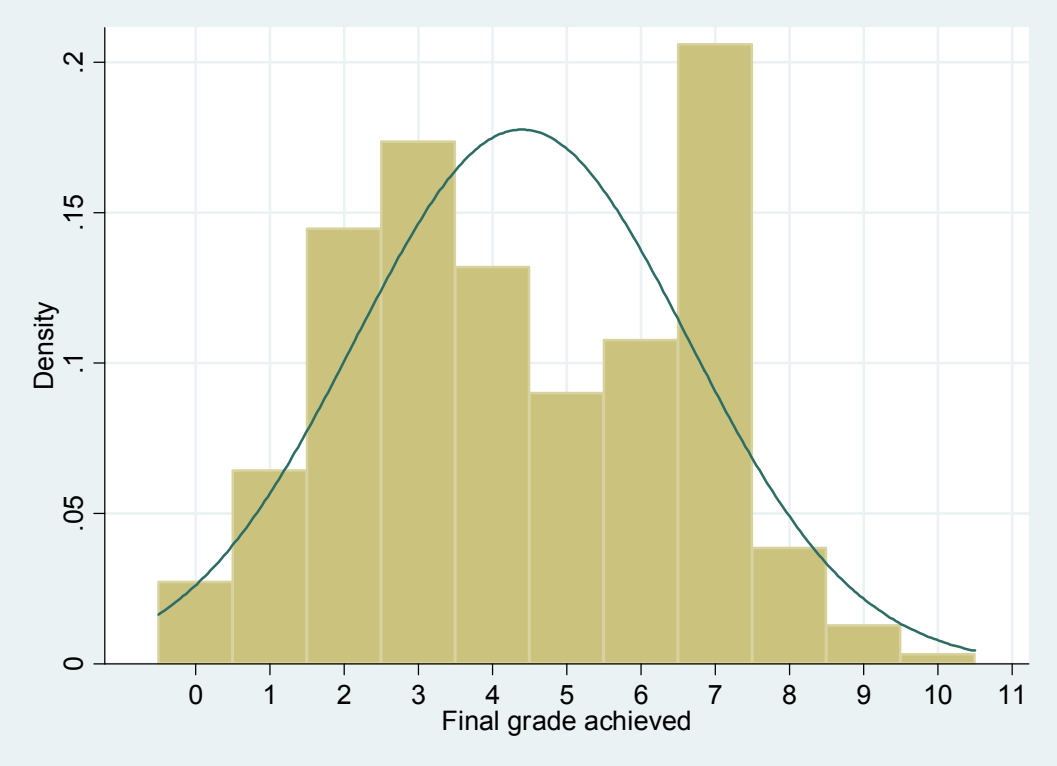
Source: Author's elaboration from KHDS dataset

Data concerning actual year of completed schooling are deeply analyzed and summarized, in order to avoid to throw away essential information. An important observation is that, as shown in Figure 3.6, the curve is binomial. Though the children are almost equally distributed by age in the sample, besides the peak at the final year of primary school (grade 7), a second peak exists in the third year of primary school in Kagera. This fact can be determined by parental choices. Plausibly, rural households need child's help in the fields or have limitation in financial resources that lead the child to drop out school after having achieved the rudimental knowledge of reading, writing and counting. Otherwise, it can be a consequence of some informal customs of the community. Another explanation can be that an institutional law in Tanzania, for example, provide for a blockage examination, which a child needs to succeed to proceed the schooling path[84]. Moreover, the abolition of fees for primary education in Tanzania could have an impact on this trend, and on the investments decision concerning all children both already and still not enrolled. Unlikely, the dataset does

[84] The first researches on this topic did not reveal the existence of such kind of law, but there is still the possibility of an informal social custom that drives to the same result. A similar trend has been revealed by studies in other countries, as the one of Maluccio et al. (2006) for Guatemalan, but no mention about this fact appears.

not cover such a long period to examine long term consequences of the law on educational choice, and, therefore, on the second peak at grade 3. This point needs to be analyzed more in detail collecting new information on this population, because it probably hides some interesting information that could enrich the results of the research in general.

Figure 3. 6: Final grade achieved in Kagera (2004).



Source: Author's elaboration from KHDS dataset

Table 3.5 continues reporting the same variables as in its first part, making distinction by residency and by gender. At a glance, children resident in rural areas are much more numerous then those in urban areas. Moreover, on average, those in the first group are shorter, achieve less grade of schooling and start school later than those in the second one. More precisely, rural children are 4.29 cm shorter, achieve 0.85 years of education less and delay half a year in school entry.

Data show that males are slightly more numerous than females and very few little difference exist among them; this result reflects the socialist culture of Tanzania, impressed in both the health and educational system. Specifically, following the evidence showed in the

literature, females are 0.81cm taller, they have completed 0.37 years of schooling more, enter school 0.17 years before.

3.4.3. Selection biases

As previously stated, the sample employed for this study can be subject to some sources of attrition biases. The primary difficulty in managing dataset collected for less developed countries is that people often do not have accurate information concerning central aspects of their life. The dataset exploited in this paper does not make an exception. Consequently, a potential attrition bias may be determined by the missing data in fundamental variables for some children, such as birth date, the final grade achieved, starting school age and anthropometric data in one or both time periods. Given the scarcity of relevant information for some children, a number of observations have to be dropped inevitably, with the consequent constraint of the sample.

Additionally, controlling for siblings of a similar age considerably narrows the sample, generating a possible selection bias.

Finally, the sample selection can be biased because of the deaths occurred through the panel composition. More precisely, 131 children of preschool age (56% female), died between the two time periods. For the 90% of this group the principal cause of death was illness: the first cause was malaria by 23%; the second cause was associated to AIDS/HIV by 20%. Moreover, almost 90% was malnourished. Given these considerations, excluding from the sample those children, who died essentially as they were particularly unhealthy, leads to upward biased estimates, unavoidably based only on survivors.

Table 3.6 indicates the same voices as Table 3.3. It confirms that children who dead between the two periods compared to survivors (who build the original sample employed in the analysis) generally present worst levels of health. This consideration is driven by the assessment of height-for-age z-score under -2 standard deviations.

Table 3. 6: Heath status of children who dead between KHDS 1991-1994 and KHDS 2004, represented by "stunting" measure.

Variable	Gender		Residence		Total
	Female	Male	Urban	Rural	
Height-for-age z-score<-1 SD	72.41%	76.71%	65.52	77.45	74.81%
Height-for-age z-score<-2 SD	62.07%,	57.53%	48.28	62.75	59.54%

Source: Author's elaboration from KHDS dataset

5. Empirical results

3.5.1. Testing the validity of the instruments and estimates

The respondent variable corresponding to educational achievement indicates if the adolescent has completed or not the entire cycle of primary education. The explanatory variables for the individual i are: height-for-age, which represents the measure of stunting expressed in z-scores at the time of the first interview, occurred within 1991-1994; the age as adolescent in the second time period, and gender, which is time invariant. The estimating strategy is based on households fixed effects - instrumental variable estimator using a linear probability model. Differencing among siblings purges any inputs, both observed and unobserved, that are constant among them, as household and environment characteristics.

Table 3.7 shows the results of estimating the impact of height-for-age as pre-schooler on educational outcomes as adolescent. The estimates reported are four: the "naïve" Ordinary Least Squares estimate (OLS) with controls for time invariant child's characteristics, like age as adolescent and gender; the family fixed effects estimate (FE); the instrumental variable estimate (IV) with district fixed effects; the household fixed effects - instrumental variables estimate (FE-IV), by means of the weather shock variable described above as instrument

All the independent variables have positive impact on the dependent variable. Females have slightly more chance to complete primary education, but it is not statistically significant. Age is statistically significant at the 1% level on education and its positive impact remains almost the same for all the estimation approaches. Certainly, the older the child is, the higher the probability of having completed the primary school is.

Better pre-school health status is associated with greater educational attainments in all the estimation approaches. The effects of both un-instrumented and the instrumented approaches are roughly comparable in magnitude by couples. The un-instrumented estimates have almost halved marginal effects (but also lower robust standard errors) compared to the those instrumented, remaining still imprecise. Height-for-age variable appears statistically significant at the 1% level when using the un-instrumented estimates, while it is no more significant for those instrumented; this fact can be a result of the partial endogeneity of health for education.

The R^2, as statistical measure of how well a regression line approximates real data points, is high for all the estimation strategies.

Table 3. 7: Estimates of the education achievement equation for siblings.

Estimation Approach	OLS	Family Fixed Effects (3)	Instrumental Variables	Family Fixed Effects - Instrumental Variables (3)
Gender (female)	0.0377	0.0261	0.0243	0.0141
	(0.026)	(0.032)	(0.037)	(0.038)
Age in adolescence (in months)	0.115***	0.110***	0.120***	0.117***
	(0.0064)	(0.0080)	(0.010)	(0.013)
Height-for-age z-score	0.0471***	0.0379***	0.0838	0.0795
	(0.0082)	(0.011)	(0.066)	(0.061)
Constant	-1.380***	-1.310***	-1.383***	
	(0.080)	(0.11)	(0.084)	
Observations	622	622	622	622
Number of hh		238		238
R-squared	0.38	0.41	0.36	0.39

Notes:

1. Robust standard errors in parentheses. * Significant at 10%; ** Significant at 5%; *** Significant at 1%
2. Standard errors for all the estimates are robust to clustered (village) sample design.
3. "Family Fixed Effects" and "Family Fixed Effects - Instrumental Variables" are estimated using a linear probability model

Table 3.8 reports the results of the first stage within siblings regression used to instrument the endogenous variable of child's height-for-age. Rainfall has a positive and statistically significant impact at the 1% level on initial height-for-age. As the summary statistics reveal (Table 3.1), rainfall value at location and time of birth expressed in z-score is globally included in the interval [-.336, 1.026]. In sub-Saharan African countries rainfalls

are very often the main source of safe water for drinking, personal hygiene and farming (hence nutrition for both the child and the care giver). Therefore, the more rainwater is available (within safe bounds), the higher the probability is of the child being healthier.

Both gender and age as adolescent are statistically significant at the 1% level on initial height-for-age. While being a female has a positive impact on the early health status, the effect of age is negative, since the older the child is, the smaller the gap is with the reference healthy child.

Staiger and Stock (1997) employ as rule of thumb that the F-test statistic for joint significance of the instruments in the first-stage should exceed 10. The F-test statistic is particularly high and equal to 17.67 and 21.61 for Instrumental Variables and Family Fixed Effects - Instrumental Variables respectively. It can be concluded that the instrument is valid and not weak.

Table 3. 8: First-stage within siblings regression used to instrument endogenous variable of child's height-for-age.

Estimation Approach	Instrumental Variables	Family Fixed Effects - Instrumental Variables (3)
Gender (female)	0.358***	0.278**
	(0.12)	(0.13)
Age in adolescence (in months)	-0.107***	-0.135***
	(0.027)	(0.031)
Rainfall in z-score	0.748***	1.187***
	(0.24)	(0.26)
Constant	-0.272	
	(0.41)	
Observations	622	622
Number of households		238
R-squared	0.07	0.13
F-test statistic	17.67	21.61

Notes:

1. Robust standard errors in parentheses. * Significant at 10%; ** Significant at 5%; *** Significant at 1%
2. Standard errors for all the estimates are robust to clustered (village) sample design.
3. "Family Fixed Effects - Instrumental Variables" are estimated using a linear probability model

Concerning the reduced form estimates, reported in Table 3.9, both gender and age as adolescent have positive effects on education. Being a female has a small positive impact on the option of completing primary education (gender has a minor effect on education compared to that on health as showed above), and it is statistically significant only using

the "naïve" estimate. Age is statistically significant at the 1% level on education and its positive impact remains almost the same for the two estimation approaches.

Rainfall has a small positive, but not statistically significant impact on education. as already stated, the chosen instrument is not weak, although not much correlated with education.

Table 3. 9: Reduced form of education achievements.

Estimation Approach	OLS	Family Fixed Effects (3)
Gender (female)	0.0543**	0.0362
	(0.027)	(0.032)
Age in adolescence (in months)	0.111***	0.106***
	(0.0064)	(0.0075)
Rainfall in z-score	0.0628	0.0944
	(0.048)	(0.071)
Constant	-1.406***	-1.328***
	(0.083)	(0.11)
Observations	622	622
Number of households		238
R-squared	0.36	0.39

Notes:

1. Robust standard errors in parentheses. * Significant at 10%; ** Significant at 5%; *** Significant at 1%
2. Standard errors for all the estimates are robust to clustered (village) sample design.
3. "Family Fixed Effects" are estimated using a linear probability model

Lets add some controls to the estimates of the impact of height-for-age as pre-schooler on educational outcomes as adolescent, which results are shown in Table 3.10.

The independent variables as gender and age have more mitigated impacts on the dependent variable, compared to those presented in Table 3.7. Gender in family fixed effects estimates here results negatively correlate with education, but the magnitude of the impact remains very small and not statistically significant.

Age is statistically significant at the 1% level on education and its positive impact remains almost the same for all the estimation approaches, even slightly lower than in the regressions without controls.

Concerning pre-school health status, estimates are almost similar to those presented in Table 3.7. The un-instrumented estimates have almost the same marginal effects and robust standard errors, while the instrumented estimates have reduced marginal effects compared to those of the previous estimations. Height-for-age variable appears statistically significant at the 1% level when using the un-instrumented estimates, while it is no more significant for those instrumented, corroborating the previous results.

Household characteristics have relatively small, and in some cases very small, impact on educational achievements. At community level, all districts have negative statistically significant impact on education of almost the same magnitude. Living in urban or healthy areas, on the contrary, significantly increases the opportunity to be educated and to conclude the primary school.

Several other variables were also included in earlier models, but were dropped due to significantly high correlation with other variables, or too few observations in some categories.

Table 3. 10: Estimates of the achievement equation for siblings, controls included.

Estimation Approach	OLS	Family Fixed Effects (3)	Instrumental Variables	Family Fixed Effects - Instrumental Variables (3)
Gender (female)	0.0245	-0.0161	0.0264	-0.0224
	(0.036)	(0.044)	(0.047)	(0.056)
Age in adolescence (in months)	0.111***	0.107***	0.109***	0.113***
	(0.010)	(0.012)	(0.024)	(0.031)
Height-for-age z-score	0.0345**	0.0382**	0.0276	0.0639
	(0.015)	(0.017)	(0.11)	(0.12)
Vaccine	-0.0716	0.0247	-0.0740	0.0269
	(0.056)	(0.078)	(0.070)	(0.078)
Small family	0.0176		0.0171	
	(0.037)		(0.038)	
Education of household head	0.0930**		0.0947*	
	(0.045)		(0.050)	
Father's height	-0.00309		-0.00289	
	(0.0028)		(0.0041)	
Mother's height	0.00398		0.00422	
	(0.0029)		(0.0048)	
Karagwe	-0.219**		-0.222**	
	(0.098)		(0.098)	
Bukobar	-0.148**		-0.149**	
	(0.065)		(0.065)	
Bukobau	-0.354**		-0.361**	
	(0.14)		(0.17)	
Muleba	-0.204**		-0.204**	
	(0.090)		(0.087)	
Biharam	-0.220**		-0.223***	
	(0.084)		(0.083)	
Urban	0.220**		0.226*	
	(0.091)		(0.13)	
Household location (possibility of malaria)	0.200***		0.206**	
	(0.055)		(0.095)	
Constant	-1.445**	-1.275***	-1.510	
	(0.59)	(0.18)	(1.18)	
Observations	385	385	385	385
Number of hh		153		153
R-squared	0.34	0.31	0.34	0.31

Notes:

1. Robust standard errors in parentheses. * Significant at 10%; ** Significant at 5%; *** Significant at 1%

2. Standard errors for all the estimates are robust to clustered (village) sample design.

3. "Family Fixed Effects" and "Family Fixed Effects - Instrumental Variables" are estimated using a linear probability model

3.5.2. Estimates for a particular sub-sample of districts

If each district is removed in turn, maintaining the variability by districts, the outstanding outcome is that height-for-age is significant in some cases (Table 3.11). More precisely, removing districts 1 or 5 height-for-age is statistically significant at 10% level, while eliminating both districts the variable become more significant, with an increased magnitude.

Table 3. 11: Robustness checks. Sub-Samples of children removing one district in turn

	All districts but 1	All districts but 2	All districts but 3	All districts but 4	All districts but 5	All districts but 6	All districts but 1 & 5
Gender (female)	-0.0243	0.00398	0.0245	0.0314	0.0196	0.0274	-0.0212
	(0.046)	(0.044)	(0.047)	(0.039)	(0.039)	(0.041)	(0.047)
Age in adolescence (in months)	0.124***	0.123***	0.114***	0.116***	0.123***	0.100***	0.129***
	(0.013)	(0.017)	(0.018)	(0.013)	(0.012)	(0.014)	(0.012)
Height-for-age z-score	0.111*	0.118	0.0701	0.0373	0.0988*	0.0232	0.125**
	(0.062)	(0.081)	(0.10)	(0.065)	(0.051)	(0.063)	(0.051)
Observations	515	447	517	572	557	502	450
Number of hh	199	168	198	223	212	190	173
R-squared	0.37	0.33	0.38	0.43	0.37	0.38	0.36

Notes:

1. Robust standard errors in parentheses. * Significant at 10%; ** Significant at 5%; *** Significant at 1%

2. Standard errors for all the estimates are robust to clustered (village) sample design.

3. "Family Fixed Effects - Instrumental Variables" are estimated using a linear probability model

4. District n.1 is Karagwe; district n.2 is Bukoba Rural; district n.3 is Muleba; district n.4 is Biharamulu; district n.5 is Ngara; district n.6 is Bukoba Urban.

Further investigation on these two districts has been carried out in order to find plausible reasons for such a different result. Comparing the two problematic districts with the other four, emerges that, while the former have all almost the same values of education outcomes, gender and age, they present differences concerning health status and weather conditions. More precisely, except for Biharamulu, children residing in Karagwe (district n.1) and Ngara (district n.5) have the worst health performance on average.

What seems noticeable are the dissimilarities of rainfalls. Karagwe and Ngara districts have negative average values of rainfall in z-score, meaning that the two areas are dryer in

comparison with the other districts. The map of Kagera (see Figures in Appendix III) show that both Karagwe and Ngara are the only two districts located far from Lake Victoria. Except for small lakes spread through the region, the two districts are characterized by more continental, and thus stable, weather, since they are less subject to the influence of the lake. Rainfall in these two districts has a negative and not statistically significant value at the first stage regressions. This fact explains the reason why it is not significant when considering all districts.

Table 3. 12: Descriptive statistics of the main variables of interest, by district, KHDS (1991-2004).

District	Variable	Obs	Mean	Std. Dev.	Min	Max
1. Karagwe	Primary education diploma	107	.2804	.4513	0	1
	Gender (female)	107	.4860	.5022	0	1
	Age in adolescence (in months)	107	14.8430	2.3944	10	20
	Height-for-age z-score	107	-1.8206	1.4191	-5.9	1.6
	Rainfall in z-score	107	-.03464	.2211	-.3361	.5135
2. Bukoba Rural	Primary education diploma	175	.24	.4283	0	1
	Gender (female)	175	.4629	.5001	0	1
	Age in adolescence (in months)	175	14.76	2.3730	10.6	19.2
	Height-for-age z-score	175	-1.5309	1.5345	-4.8	2. 4
	Rainfall in z-score	175	.0053	.1517	-.2249	.2673
3. Muleba	Primary education diploma	105	.2952	.4583	0	1
	Gender (female)	105	.4476	.4996	0	1
	Age in adolescence (in months)	105	14.6762	2.5270	10	19.5
	Height-for-age z-score	105	-1.3086	1.5060	-6	4.8
	Rainfall in z-score	105	.1247	.3471	-.2273	.8510
4. Biharamulu	Primary education diploma	50	.1	.3031	0	1
	Gender (female)	50	.38	.4903	0	1
	Age in adolescence (in months)	50	14.432	2.3716	10.6	19.1
	Height-for-age z-score	50	-2	1.3520	-5.2	1
	Rainfall in z-score	50	.1638	.3478	-.0724	1.0263
5. Ngara	Primary education diploma	65	.2	.4031	0	1
	Gender (female)	65	.4615	.5024	0	1
	Age in adolescence (in months)	65	14.5923	2.3620	10. 7	18. 9
	Height-for-age z-score	65	-2.3939	1.4093	-5.7	1.7
	Rainfall in z-score	65	-.0106	.1301	-.2623	.1383
6. Bukoba Urban	Primary education diploma	120	.3417	.4763	0	1
	Gender (female)	120	.4917	.5020	0	1
	Age in adolescence (in months)	120	14.81	2.2910	10	19.1
	Height-for-age z-score	120	-1.4133	1.4802	-5	4.1
	Rainfall in z-score	120	.0380	.1391	-.2173	.2673

Besides those considerations, the strongest explanation for the noticed difference among districts is the following. Since the early Nineties, extremist militia groups carried out the extermination of élite Tutsis and moderate Hutus in the genocides of Burundi (1993) and Rwanda (1994). Almost one million people were killed and thousands were compulsorily displaced from their homes. Over the course of a few months, Karagwe and Ngara districts of Kagera were the primary asylum for some 600,000 refugees from Burundi and Rwanda to escape ethnic violence in their home countries. Consequently, in Karagwe and Ngara districts the road infrastructure was damaged through over use, school and health facilities were overloaded, trees were cut extensively to make way to refugee settlements, some diseases spread[85]. The damages wrought by the refugees in the two districts of Kagera after half a year were estimated to require at least $65 million to be repaired (Smith, 1995). Despite these serious problems, the number of refugees continued to grow till double the locals in number over the time[86].

Let's investigate the same regressions as for the original sample, excluding districts 1 and 5. Table 3.13 shows the results of estimating the impact of height-for-age as pre-

[85] Baez (2008) investigates the causal effects of hosting Burundi and Rwanda's refugees on the outcomes of Kageran children. The author finds evidence of adverse impacts on children's anthropometrics, the incidence of infectious diseases and the mortality for children under five almost 1.5 years after the shock. He also finds that childhood exposure to this massive arrival of refugees reduced height in early adulthood by 1.8 cm (1.2%), schooling by 0.2 years (7.1%) and literacy by 7 percentage points (8.6%).

[86] After decades of ethnic rivalries, on October, 1993, the Hutu president of Burundi - democratically elected few months before - was assassinated; subsequently, the country entered a period of civil conflict. The Hutu community reacted to the killing by slaughtering thousands of Tutsi civilians. Then, the Burundian militia (still controlled by Tutsis) provoked a violent mass-slaughter of Hutu civilians. Some 150,000 persons died in the genocide; more than 800,000 Burundians were forced to abandon their homes towards Rwanda, Tanzania, and Democratic Republic of Congo (ex-Zaire). The cruel ethnic rivalry outstretched soon to Rwanda. On April 6, 1994, the airplane carrying both the presidents of Rwanda and Burundi was deadly attacked. Subsequently, extremist army groups set off the extermination of ethnic Tutsis and moderate Hutus. In three months, nearly one million people perished (more than one tenth of Rwanda's population) and at least two million people escaped towards bordering countries.
Tanzania has a quite long history as receptionist for displaced people and is the host to the biggest refugee populations in Africa. Kagera region was particularly affected by the enormous influx of refugees from the conflicts in Burundi and Rwanda in the Nineties. It was assessed that Kigoma and Kagera regions received some 250,000 Burundians refugees in late 1993, and over 250,000 Rwandans flooded into Kagera overnight on April 1994. According to UNHCR (1997) the last represents the largest and fastest refugee movement ever occurred. Kagera alone hosted between 500,000 and 600,000 refugees from both the genocides, approximately 40% of its local citizens in 1993, which counted 1,580,000 inhabitants UNHCR (2005). Refugees from Rwanda and Burundi shared a similar ethnic lineage with the populations in western Tanzania; hence, refugees were often hosted in the towns by relatives and other groups of people ethnically tied to them. Refugee settlements were principally concentrated in a subset of districts of Kagera: Karagwe and Ngara. Burundians and Rwandans refugees together outnumbered local populations of the two main recipient districts, with populations of roughly 320,000 and 250,000 inhabitants in Karagwe and Ngara districts respectively in the period preceding the genocides (Baez, 2008).

schooler on educational outcomes as adolescent for the selected districts. The independent variables have positive impact on the dependent variable. The couple of un-instrumented and instrumented estimates have almost the same marginal effects and robust standard errors among them. The main difference with results obtained in Table 3.7 is that, here, height-for-age variable appears statistically significant not only when using the un-instrumented, but also with the instrumented estimates.

Table 3. 13: Estimates of the education achievement equation for siblings, districts 1 and 5 removed.

Estimation Approach	OLS	Family Fixed Effects (3)	Instrumental Variables	Family Fixed Effects - Instrumental Variables (3)
Gender (female)	0.0171	0.0146	-0.0194	-0.0212
	(0.031)	(0.037)	(0.044)	(0.047)
Age in adolescence (in months)	0.117***	0.116***	0.129***	0.129***
	(0.0072)	(0.0091)	(0.013)	(0.012)
Height-for-age z-score	0.0451***	0.0455***	0.130*	0.125**
	(0.011)	(0.012)	(0.069)	(0.051)
Constant	-1.403***	-1.376***	-1.436***	
	(0.091)	(0.13)	(0.11)	
Observations	450	450	450	450
Number of hh		173		173
R-squared	0.38	0.43	0.30	0.36

Notes:

1. Robust standard errors in parentheses. * Significant at 10%; ** Significant at 5%; *** Significant at 1%
2. Standard errors for all the estimates are robust to clustered (village) sample design.
3. "Family Fixed Effects" and "Family Fixed Effects - Instrumental Variables" are estimated using a linear probability model

The first stage estimates report almost the same values as those of the original sample, being slightly greater in magnitude (Table 3.14). Equivalent considerations are worth concerning the reduced form estimates, reported in Table 3.15. Rainfall has doubled its effects on education, becoming now statistically significant at the 1% level.

Table 3. 14: First-stage within siblings regression used to instrument endogenous variable of child's height-for-age, districts 1 and 5 removed.

Gender (female)	0.423***	0.452***
	(0.14)	(0.16)
Age in adolescence (in months)	-0.121***	-0.126***
	(0.030)	(0.034)
Rainfall in z-score	0.812***	1.572***
	(0.27)	(0.29)
Constant	0.0384	
	(0.46)	
Observations	450	450
Number of hh		173
R-squared	0.09	0.18

Notes:

1. Robust standard errors in parentheses. * Significant at 10%; ** Significant at 5%; *** Significant at 1%

Table 3. 15: Reduced form of education achievements, districts 1 and 5 removed.

Estimation Approach	OLS	Family Fixed Effects (3)
Gender (female)	0.0357	0.0353
	(0.031)	(0.037)
Age in adolescence (in months)	0.114***	0.113***
	(0.0073)	(0.0087)
Rainfall in z-score	0.106**	0.197***
	(0.049)	(0.075)
Constant	-1.431***	-1.432***
	(0.097)	(0.13)
Observations	450	450
Number of hh		173
R-squared	0.36	0.42

Notes:

1. Robust standard errors in parentheses. * Significant at 10%; ** Significant at 5%; *** Significant at 1%
2. Standard errors for all the estimates are robust to clustered (village) sample design.
3. "Family Fixed Effects" are estimated using a linear probability model

Controls are added to the estimates of the impact of height-for-age as pre-schooler on educational outcomes as adolescent in the four selected districts; results are shown in Table 3.16. Being female has now a still small but negative impact on the dependent variable, being statistically significant with the family fixed effects – instrumental variable estimation approach. Age is statistically significant at the 1% level on education and its

positive impact remains almost the same as that in the original sample, being slightly higher when applying the instrumented approaches.

Pertaining to the pre-school health status, it appears statistically significant when using the family fixed effects and all the estimates, except for OLS, present higher or even much higher values than those of the original sample. The value obtained applying the family fixed effects – instrumental variable approach is high and statistically significant for this sub-sample, resulting an outstanding result.

At community level, differently than the complete sample, all districts have positive statistically significant impact on education of almost the same magnitude among them. Living in urban areas increases the opportunity to be educated and to conclude the primary school, and the magnitude is doubled compared to the original sample.

Table 3. 16: Estimates of the achievement equation for siblings, controls included, districts 1 and 5 removed.

Estimation Approach	OLS	Family Fixed Effects (3)	Instrumental Variables	Family Fixed Effects - Instrumental Variables (3)
Gender (female)	-0.0360	-0.0778	-0.0698	-0.152*
	(0.044)	(0.054)	(0.059)	(0.079)
Age in adolescence (in months)	0.109***	0.113***	0.127***	0.143***
	(0.013)	(0.016)	(0.027)	(0.030)
Height-for-age z-score	0.0271	0.0597***	0.111	0.189*
	(0.020)	(0.021)	(0.10)	(0.10)
Vaccine	-0.0434	0.0310	-0.0148	0.0932
	(0.082)	(0.10)	(0.095)	(0.12)
Small family	0.0318		0.0275	
	(0.046)		(0.052)	
Education of household head	0.0681		0.0378	
	(0.052)		(0.064)	
Father's height	-0.00782**		-0.0110**	
	(0.0034)		(0.0055)	
Mother's height	0.00210		-0.000446	
	(0.0040)		(0.0051)	
Bukobar	0.458***		0.387*	
	(0.16)		(0.23)	
Muleba	0.408***		0.336	
	(0.15)		(0.23)	
Biharam	0.384**		0.342	
	(0.16)		(0.22)	
Urban	0.496***		0.420*	
	(0.14)		(0.21)	
Household location (possibility of malaria)	0.192***		0.116	
	(0.071)		(0.11)	
Constant	-0.946	-1.318***	0.00676	
	(0.80)	(0.23)	(1.42)	
Observations	254	254	254	254
Number of hh		102		102
R-squared	0.34	0.33	0.28	0.18

Notes:

1. Robust standard errors in parentheses. * Significant at 10%; ** Significant at 5%; *** Significant at 1%

2. Standard errors for all the estimates are robust to clustered (village) sample design.

3. "Family Fixed Effects" and "Family Fixed Effects - Instrumental Variables" are estimated using a linear probability model

Examining the results obtained for the sub-sample with the selected four districts, the level of the impact of health status on educational outcome is meaningful. The height-for-age z-score for pre-schooler is -1.5 as indicated in Table 3.17 (or eventually -1.65 for the complete sample). If the population had the nutritional status of well-nourished children of the reference population, the mean z-score would be 0. Applying the family fixed effects – instrumental variable parameter estimates reported in Table 3.17, this would result in an additional 30% of probability of completing primary education.

Table 3. 17: Descriptive statistics on children in KHDS 1991-1994, districts 1 and 5 removed.

Variable	Obs	Mean	Std. Dev.
Height-for-age z-score	450	-1.50	1.50
Stunted	450	0.66	0.47
Age (in months)	450	32.63	25.07
Gender (female)	450	0.46	0.50

Source: Author's elaboration from KHDS dataset

3.5.3. Robustness checks

This section presents robustness checks to corroborate the results presented above and to find possible explanations regarding the missed causal link between pre-school anthropometric status and subsequent education achievements.

The scope to which environment varies between siblings depends on their age difference and on the changing conditions of the household and community associate with this laps of time (Griliches, 1979). The correlation between weather shock and cognitive ability has been used to justify the inclusion of household fixed effects, in order to eliminate the ability differences between siblings. To strengthen the choice of such expedient, assuming that all siblings would be affected on the same measure by the shock, the sample can be restricted to children who have a difference of age minor to three years. Even if the sample is remarkably reduced in size, Table 3.18 (a) shows almost the same results compared to those of the original sample (Table 3.7). The same is worth pertaining to height-for-age variable, which is statistically significant at the 1% level when using the "naïve" estimates, while it is no more significant for the family fixed effects – instrumental variable. Equivalent result of height-for-age on education can be obtained applying a threshold of age difference of two years within children of the same household (Table 3.18

(b)). The sub-sample become very small, thus the values cannot be considered precise representation of the original sample.

Table 3. 18: Robustness checks. Sub-Sample of children in household with difference of age <=3 years (a) and <=2 years (b).

Estimation Approach	OLS (a)	Family Fixed Effects - Instrumental Variables (3) (a)	OLS (b)	Family Fixed Effects - Instrumental Variables (3) (b)
Gender (female)	0.0237	0.0240	-0.00631	-0.0197
	(0.030)	(0.042)	(0.039)	(0.055)
Age in adolescence (in months)	0.121***	0.112***	0.123***	0.0978***
	(0.0089)	(0.027)	(0.013)	(0.033)
Height-for-age z-score	0.0436***	0.0678	0.0443***	-0.00266
	(0.010)	(0.059)	(0.014)	(0.10)
Constant	-1.451***		-1.457***	
	(0.11)		(0.17)	
Observations	386	386	228	228
Number of hh		183		109
R-squared	0.36	0.16	0.36	0.11

Notes:

1. Robust standard errors in parentheses. * Significant at 10%; ** Significant at 5%; *** Significant at 1%
2. Standard errors for all the estimates are robust to clustered (village) sample design.
3. "Family Fixed Effects - Instrumental Variables" are estimated using a linear probability model

Similarly, few considerations can be driven regarding regressions on siblings with restricted age difference for the sub-sample with the selected four districts. Although the sample is reduced in size, Table 3.19 (a) shows the same important outcome pertaining to the height-for-age variable, meaning that it is statistically significant at the 5% level even for the family fixed effects – instrumental variable. Applying a threshold of age difference of two years within children of the same household (Table 3.19 (b)), the new sub-sample becomes very tiny. Not much can be said, except for the positive sign of height-for-age in the family fixed effects – instrumental variable, in comparison with Table 3.18 (b).

Table 3. 19: Robustness checks. Sub-sample of children in household with difference of age <=3 years (a) and <=2 years (b), districts 1 and 5 removed.

Estimation Approach	OLS (a)	Family Fixed Effects - Instrumental Variables (3) (a)	OLS (b)	Family Fixed Effects - Instrumental Variables (3) (b)
Gender (female)	0.00988	-0.0359	-0.0324	-0.0985*
	(0.035)	(0.052)	(0.045)	(0.057)
Age in adolescence (in months)	0.125***	0.140***	0.118***	0.104***
	(0.010)	(0.030)	(0.017)	(0.037)
Height-for-age z-score	0.0352***	0.111**	0.0409**	0.0597
	(0.013)	(0.049)	(0.019)	(0.059)
Constant	-1.519***		-1.398***	
	(0.13)		(0.22)	
Observations	279	279	172	172
Number of hh		131		82
R-squared	0.38	0.12	0.34	0.16

Notes:

1. Robust standard errors in parentheses. * Significant at 10%; ** Significant at 5%; *** Significant at 1%
2. Standard errors for all the estimates are robust to clustered (village) sample design.
3. "Family Fixed Effects - Instrumental Variables" are estimated using a linear probability model

6. Final considerations

In recent years the crucial role of human capital in economic growth and poverty alleviation has been almost unanimously stated. The correlation between mental and physical preschooler health and education outcomes has been widely recognized, with the acknowledgment that improving health and nutrition are important development objectives in their own right. However, the exact mechanisms by which these outcomes are related is only progressively being revealed and remains a considerable challenge.

Extending the literature on the determinants of human capital formation mainly focused on cross-sectional analysis, this paper makes use of a high quality dataset from the KHDS, focusing on the nature of the causal relationship between health and education.

The central results reported in this paper are based on household fixed effects estimates; consequently, any attrition consequential of family or environmental characteristics is removed by differencing among sibling. Actually, the estimates suggest that family fixed

effects estimators by themselves cannot fully account for the potential endogeneity of nutritional status. In order to drive an innovative kind of study, this paper takes into account the endogeneity bias by instrumenting it using weather shocks at the community level. External shocks may cause permanent damage to children's future welfare and cognitive abilities, therefore further empirical investigation which helps to quantify the magnitude of the effect of such shocks on early child growth is required. Differently from much of the literature on shocks, this paper assesses the impact at individual level, rather than at household level.

Consistently with the literature, the principal finding is that infant and child health status play a key role in schooling outcomes, suggesting that education and health are complementary inputs on the development process. This result comes after having isolated the two districts on the western board, which had to cope with the difficult situation consequent to the settlement of refugees escaping from the genocides of Burundi and Rwanda in the early Nineties. Applying the family fixed effects – instrumental variable approach, a child in good health status during infancy has an additional 30% of probability of completing primary education.

Almost all the literature on the impact of health on education ignores the fact that individuals and households make choices in response to important predetermined characteristics unobservable for researchers and policymakers. The result confirmed in this paper that better nourished children tend to perform better in school has potentially important policy implications. The long-run effects of early-life conditions on schooling as adolescent should be factored into cost-benefit analyses of programs targeting this part of the population. Similar interventions are the promotion of exclusive breastfeeding, integrated child care and development programs and those providing nutritious supplements to pre-schoolers; all of these interventions have benefits and high rate of returns (Behrman et al., 2004). Future research on this important topic will undoubtedly benefit from the collection of high quality longitudinal data that recognizes the relationship between nutrition and human capital accumulation.

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8. Appendix I: Economic and welfare indicators of Tanzania

Table 3. 20: Economic and welfare indicators of Tanzania, sub-Saharan Africa and less developed countries as a whole.

Indicators of wellbeing		*Year*	*United Republic of Tanzania*	*Sub-Saharan Africa*	*Developing countries*
Total GDP (billion of US$)		**1990**	4.81	.	.
		2004	.	641.45	.
		2007	12.78	853.39	.
Under-5 mortality rank		**1990**	.	.	.
		2004	31	151	.
		2007	29	146	.
Infant mortality rate (under-1)		**1990**	102	112	72
		2004	78	102	59
		2007	73	89	51
Under-5 mortality rate		**1990**	161	188	105
		2004	126	171	87
		2007	116	148	74
Total population (th.)		**1990**	25,494	.	.
		2004	37,627	697,561	5,166,574
		2007	40,454	767,218	5,432,837
Annual no. of births (th.)		**1990**	1,408	28,715	120,128
		2004	1,403	28,263	119,663
		2007	1,600	30,323	122,266
Annual no. of under-5 deaths (th.)		**2004**	177	4,833	10,411
		2007	186	4,480	9,109
GNI per capita (US$)		**2004**	330	611	1,524
		2007	400	965	2,405
Life expectancy at birth (years)		**1990**	51	.	.
		2004	46	46	65
		2007	52	50	67
Total adult literacy rate		**2000-2004**	69	60	77
		2000-2007	72	62	79
Net primary school enrolment/ attendance ratio (%)		**1990-1995**	50	.	.
		1996-2004	82	60	80
		2000-2007	73	64	83
% share of household income	**Lowest 40%**	**1993-2003**	18	12	15
	Highest 20%		46	57	50
	Lowest 40%	**1995-2005**	19	13	15
	Highest 20%		43	54	50

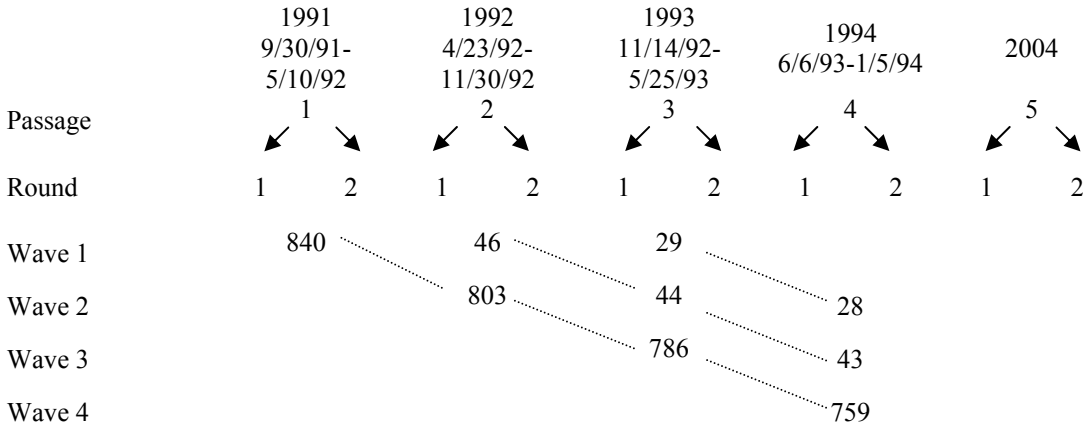
Source: UNICEF (2006), UNICEF (2009), World Development Indicators (2008).

9. Appendix II: Survey design

Several considerations on the survey design, employing information collected by World Bank (2004) and Beegle et al. (2006), can be useful to have a more precise idea concerning data used in this article.

The original purpose of the KHDS 1991-1994 has been to collect data functional to well understand the consequences of adult mortality on the wellbeing of the survivors. The KHDS 2004 intends to track all households, included those which moved, currently including at least one person who has been previously interviewed in any round of the KHDS 1991-1994 and is still alive in 2004. Information about the household members who were alive during the last interview in KHDS 1991-1994 but deceased by KHDS 2004 have been collected in the mortality questionnaire[87]. Table 3.21 describes households' questionnaire construction.

Table 3. 21: KHDS households' questionnaire structure.



Source: Author's elaboration.
Notes: The attrition rate is computed as follow: 840-759=81 which represent the 9.64%.
From a total of 1,009 households originally selected for the sample, 816 were actually interviewed in the first passage, including replacements; 24 "extra" were added by field teams during the first passage, 46 in the second passage and 29 in the third passage. To resume, 840 households were interviewed in the first passage, and 915 households were ever interviewed during the survey, from one to four times.
The KHDS 1991-1994 survey was conduced in four **passages**, which correspond to distinct time intervals, at which a fifth one was successively added. Each passage lasted 6-7 months each, from September 1991 to January 1994. Passage I went from 9/30/91 to 5/10/92, passage II from 4/23/92 to 11/30/92, passage III from 11/14/92 to 5/25/93, passage IV from 6/6/93 to 1/5/94. During each passage, each household was visited two times, or **rounds**. The number of times that a given household has been interviewed corresponds to the **wave** of the household questionnaire. The household interviewed for the first time received a *wave 1* questionnaire,

[87] In the mortality questionnaire are gathered data on the circumstances of death, living arrangements and information on health seeking behaviour briefly before the death. The respondents for this questionnaire are generally members of the same household as the deceased or other relatives within the same panel.

and so for the other waves. When a household dropped out on the middle of the survey, it was replaced with a new household, which was interviewed for the first time with a *wave 1* household questionnaire, irrespective of the passage. Therefore, all households received a wave 1 questionnaire during the first passage, but there was no household interviewed for the first time in the fourth passage. Thus, in the case of the household questionnaire, the wave number of the questionnaire does not necessarily correspond to the passage in which the household was interviewed.

In this survey, a person or a group of persons living in the same dwelling and sharing meals together for at least three months in the last year were defined as household (World Bank, 2004). Of the 915 households completing the former sample, 3 were composed by single-person who died before the end of the KHDS 1991-1994 rounds, leaving 912 households to be interviewed. Table 3.22 reports the rates of households interviewed in KHDS 1991-1994 and those re-interviewed in KHDS 2004. Kept out the full amount of 17 households (comprehensive of 27 individuals) in which all previous members are deceased, the re-contact rate is 93% of the baseline households[88].

Table 3. 22: Households composition in KHDS 1991-1994 and KHDS 2004.

KHDS '91-'94		KHDS '04 Re-interview Rates			
Number of interviews during '91-'94	**Households interviewed**	**Re-interviewed**	**Deceased**	**Untraced**	**Re-interview rate among survivors**
1	39	22 (56%)	2 (5%)	15 (39%)	60%
2	45	38 (84%)	1 (2%)	6 (13%)	86%
3	69	59 (86%)	1 (1%)	9 (13%)	87%
4	759	713 (94%)	13 (2%)	33 (4%)	96%
Overall	**912**	**832 (91%)**	**17 (2%)**	**63 (7%)**	**93%**

Source: Based on Beegle et al. (2006)
Notes: Concerning KHDS 2004, "re-interviewed" indicates households with at least one member of the baseline household re-interviewed at that time; "deceased" indicates households with all previous household members reported to be dead; "untraced" indicates households with no previous member re-interviewed.

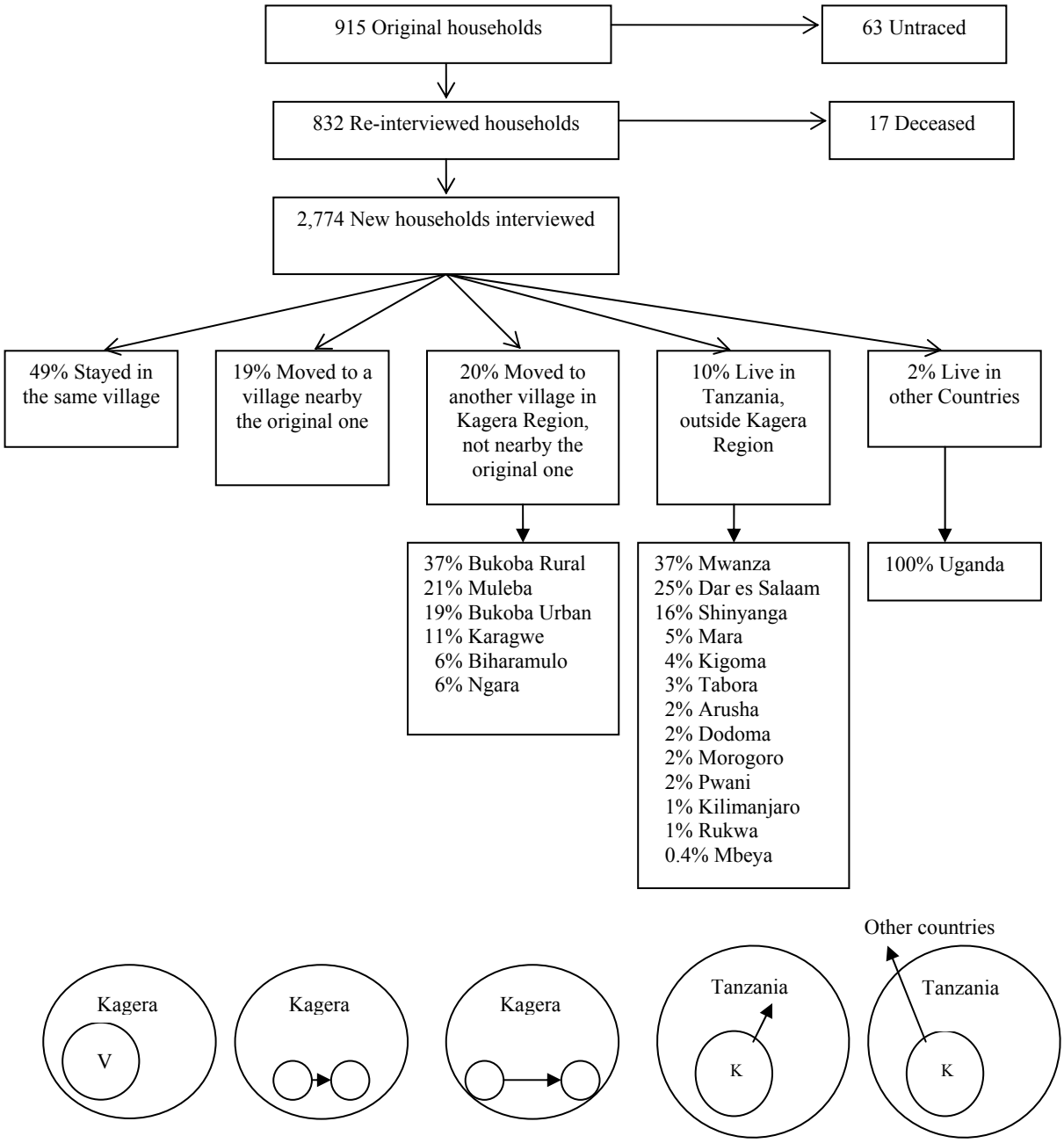
A former rearrangement of baseline households is illustrated in Figure 3.7. Of the original 915 households, 832 households were traced. Noticeably, many of the former household members, especially the younger, had moved out forming their own households. Actually, who was a child in 1991-1994 most probably live by her own after ten years. Others were orphan, moved out of their original household, got divorced, or went to live with extended family. Consequently, the new sample consists of an increased number of 2,774 households.

[88] The re-contact rate is calculated as follow: $\left(\frac{832}{832+63}\right)100 \approx 93\%$

While almost half of the split-off families remained in the original village, many households were traced in other villages in Kagera, in other regions of Tanzania, and even in other countries (most in Uganda). Of those households tracked, almost 40% had moved within the region, 10% to another region in Tanzania and 2% had moved to another country.

Among people who moved to another village in Kagera Region, most of them moved to Bukoba Rural, Muleba and Bukoba Urban. Within other regions of Tanzania, most households were found living in Mwanza, followed by Dar-es-Salaam and Shinyanga. Those who had moved to other countries were mostly found living in Uganda, Rwanda and Kenya, but some were reported to be living as far away as Norway, Germany, Sweden and the United Kingdom. KHDS 2004 limits the tracking to international migrants for Uganda only, even if the setting of those in other countries was identified.

Figure 3. 7: New households re-interviewed in KHDS 2004.



Source: Based on Beegle et al. (2006)
Notes: Concerning KHDS 2004, "re-interviewed" indicates households with at least one member of the baseline household re-interviewed at that time; "deceased" indicates households with all previous household members reported to be dead; "untraced" indicates households with no previous member re-interviewed.

From an individual respondent perspective, concerning the sample of 6,204 respondents, Table 3.23 illustrates the status of the respondents by age group. As can be noticed, the re-interview rates are diminishing by age, although the reasons differ by age cohort. Excluding people who died, 82% were located and re-interviewed with success.

Table 3. 23: Individuals by age in KHDS 1991-1994 and KHDS 2004.

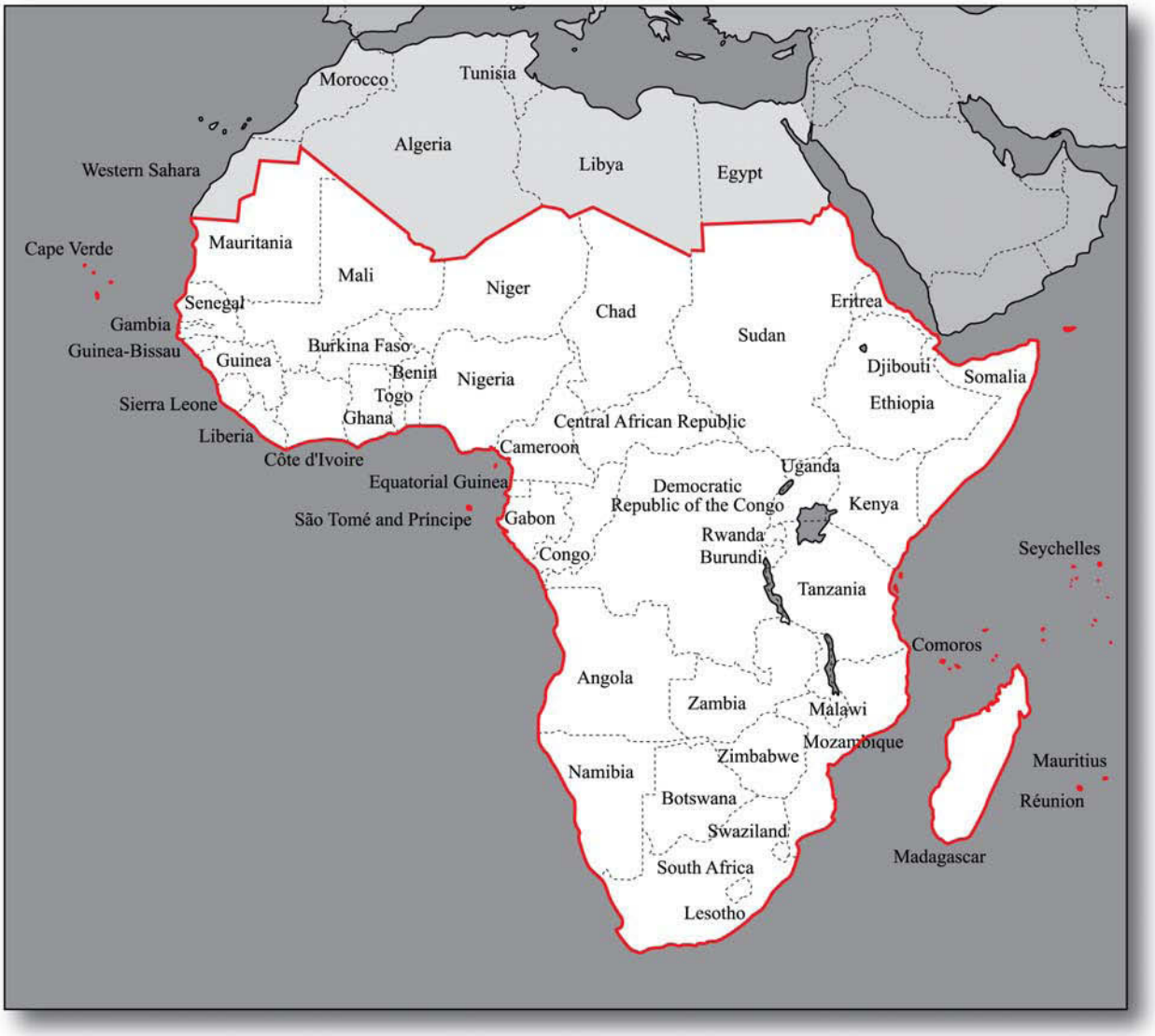
Age at KHDS 1991-1994	KHDS '04 Re-interview	Deceased	Untraced	Re-interview rate among survivors
<10 years	1,606 (79%) 1,604 (77.1%)	122 (6%)	317 (15%)	83%
10-19 years	1,408 (73%)	97 (5%)	413 (22%)	77%
20-39 years	828 (66%)	234 (19%)	189 (15%)	81%
40-59 years	436 (74%)	119 (20%)	34 (6%)	93%
60+ years	163 (41%)	228 (57%)	10 (2%)	94%
Overall	**4,441(72%)**	**800 (13%)**	**963 (16%)**	**82%**

Source: Beegle et al. (2006)

Notes: The sample is composed by individuals interviewed in KHDS 1991-1994 and surviving at last interview. Concerning KHDS 2004, "re-interviewed" indicates households with at least one member of the baseline household re-interviewed at that time; "deceased" indicates households with all previous household members reported to be dead; "untraced" indicates households with no previous member re-interviewed.

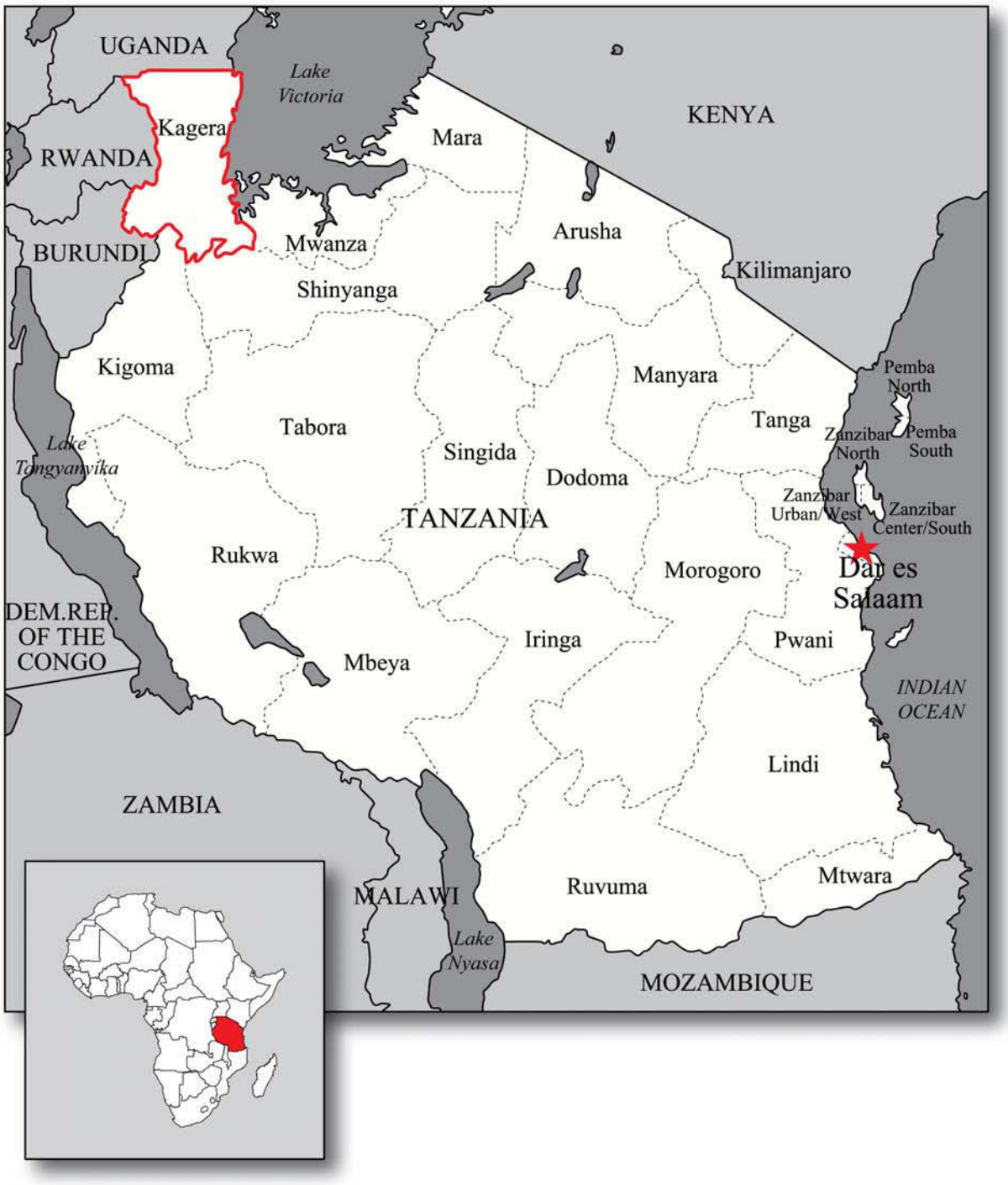
10. Appendix III: Maps

Figure 3. 8: African Continent, sub-Saharan Africa highlighted.



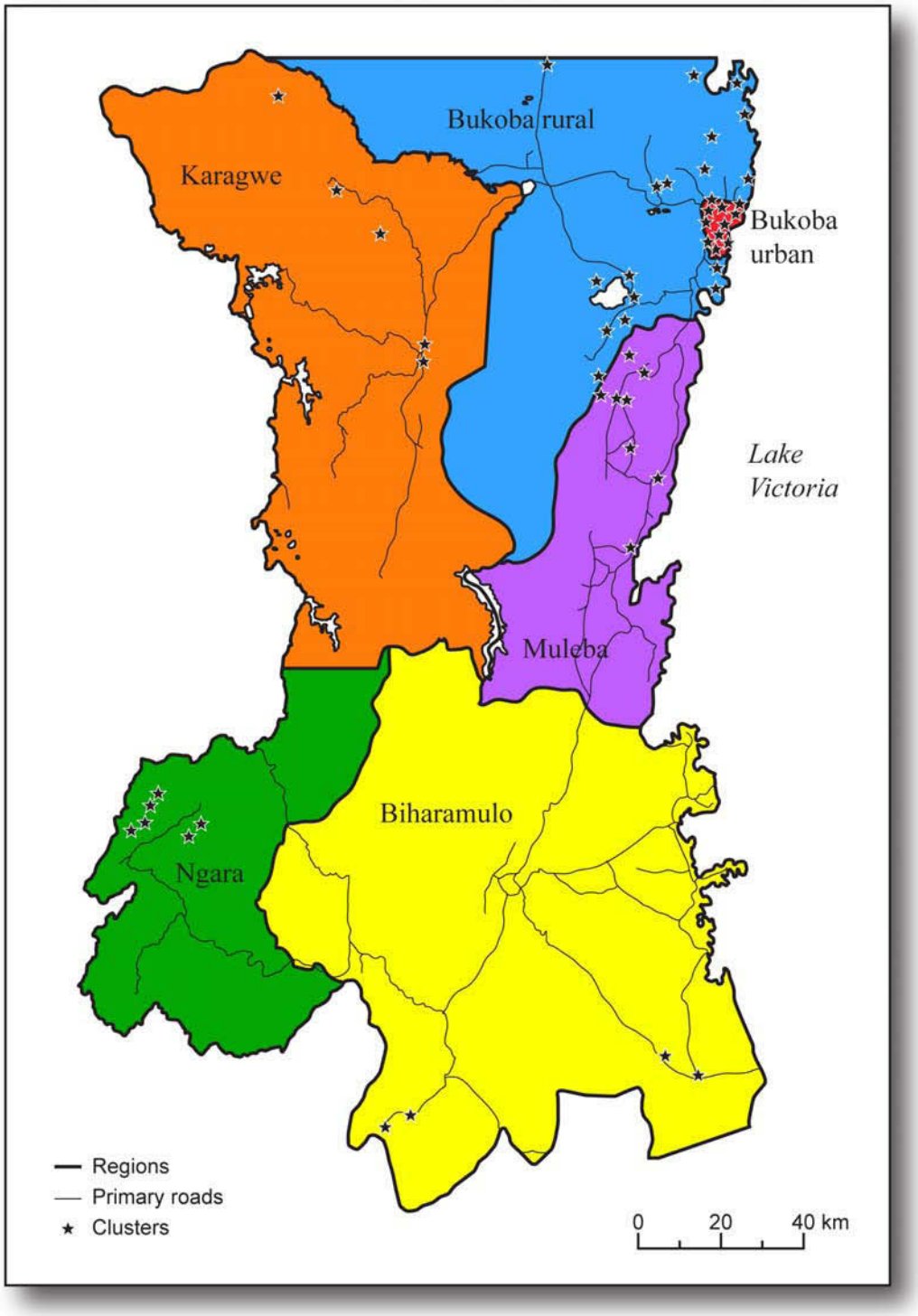
Source: Author's elaboration

Figure 3. 9: United Republic of Tanzania.



Source: Author's elaboration

Figure 3. 10: Kagera Region, Tanzania. KHDS clusters' location.



Source: Author's elaboration, based on World Bank (2004)
Notes: The KHDS was conducted in 51 clusters of households throughout Kagera region. The clusters were distributed across districts as follows: Bukoba Urban (11); Bukoba Rural (17); Muleba (8); Biharamulo (4); Ngara (6); Karagwe (5).

11. Appendix IV: Health status for children living in Tanzania

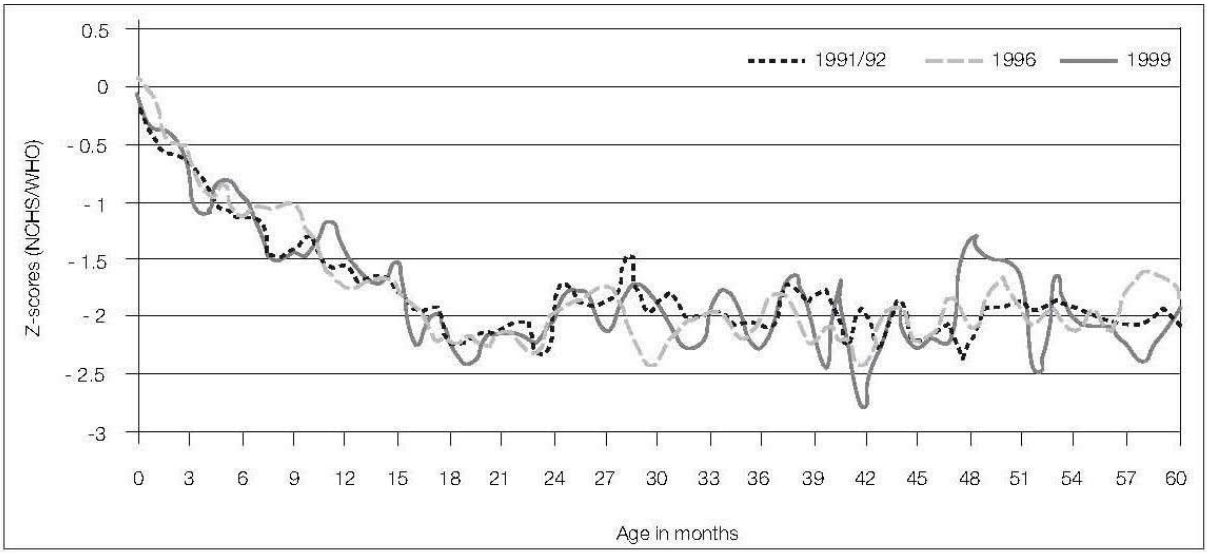
Deficiency of nutrition security is reflected in malnutrition affecting many Tanzanian children. A study of REPOA (2009) on nutrition status among children in Tanzania in the 1990s shows a pattern similar to that in the present study of Kagera (see Table 3.3, Figure 3.3 and Figure 3.4)

Table 3. 24: Health status for children under-five years old living in Tanzania, represented by measure of stunting.

Variable	1991-92	1996	1999	2004-5
Height-for-age z-score<-2 SD	43%	43%	44%	38%

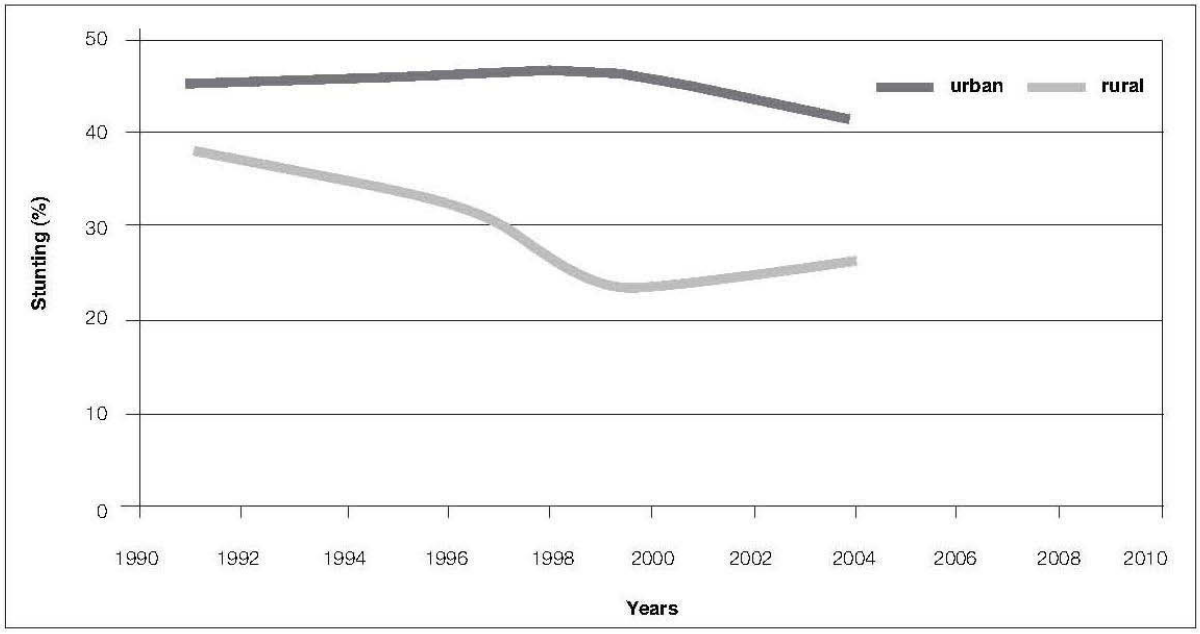
Source: REPOA (2009), calculated using TDHS 1991/92, TDHS 1996 and TRCHS 1999, TDHS 2004/2005.

Figure 3. 11: Health status for children under-five years old living in Tanzania, represented by measure of stunting, by age in months, 1991-1999.



Source: REPOA (2009) and Lindeboom and Kilama (2005), calculations based on data from TDHS 1991/92, 1996 and 1999.

Figure 3. 12: Prevalence of stunted children in urban and rural Tanzania, 1991-2004.



Source: REPOA (2009) and Lindeboom and Kilama (2005), using data from TDHS 1991/92-2004/05

12. Appendix V: Regressions with final grade achieved as respondent variable

Table 3. 25: Estimates of final grade achieved for siblings.

Estimation Approach	OLS	Family Fixed Effects (3)	Instrumental Variables	Family Fixed Effects - Instrumental Variables (3)
Gender (female)	0.330**	0.234*	0.690***	0.338**
	(0.14)	(0.12)	(0.23)	(0.15)
Age in adolescence (in months)	0.673***	0.616***	0.545***	0.554***
	(0.026)	(0.027)	(0.064)	(0.047)
Height-for-age z-score	0.164***	0.0584	-0.822**	-0.301
	(0.041)	(0.042)	(0.42)	(0.23)
Constant	-5.398***	-4.690***	-5.307***	
	(0.35)	(0.39)	(0.47)	
Observations	622	622	622	622
Number of hh		238		238
R-squared	0.49	0.63	0.09	0.57

Notes:

1. Robust standard errors in parentheses. * Significant at 10%; ** Significant at 5%; *** Significant at 1%
2. Standard errors for all the estimates are robust to clustered (village) sample design.
3. "Family Fixed Effects" and "Family Fixed Effects - Instrumental Variables" are estimated using a linear probability model

Table 3. 26: Reduced form of final grade achieved.

Estimation Approach	OLS	Family Fixed Effects (3)
Gender (female)	0.395***	0.254**
	(0.14)	(0.12)
Age in adolescence (in months)	0.633***	0.594***
	(0.026)	(0.026)
Rainfall in z-score	-0.615**	-0.357
	(0.24)	(0.26)
Constant	-5.083***	-4.464***
	(0.36)	(0.39)
Observations	622	622
Number of hh		238
R-squared	0.49	0.63

Notes:

1. Robust standard errors in parentheses. * Significant at 10%; ** Significant at 5%; *** Significant at 1%
2. Standard errors for all estimates are robust to clustered (village) sample design.
3. "Family Fixed Effects" are estimated using a linear probability model

Table 3. 27: Estimates of final grade achieved for siblings, controls included.

Estimation Approach	OLS	Family Fixed Effects (3)	Instrumental Variables	Family Fixed Effects - Instrumental Variables (3)
Gender (female)	0.259	0.0598	0.499	0.132
	(0.18)	(0.15)	(0.30)	(0.19)
Age in adolescence (in months)	0.694***	0.665***	0.512***	0.596***
	(0.039)	(0.033)	(0.13)	(0.11)
Height-for-age z-score	0.143**	0.172***	-0.772	-0.122
	(0.063)	(0.061)	(0.66)	(0.43)
Vaccine	-0.550*		-0.876*	
	(0.31)		(0.50)	
Small family	-0.128		-0.192	
	(0.22)		(0.26)	
Education of household head	0.491**		0.723**	
	(0.25)		(0.33)	
Father's height	-0.00718		0.0182	
	(0.016)		(0.028)	
Mother's height	0.0228		0.0546*	
	(0.018)		(0.030)	
Karagwe	-0.851		-1.347	
	(0.82)		(1.06)	
Bukobar	-0.320		-0.425	
	(0.74)		(0.95)	
Bukobau	-1.148		-1.994	
	(0.97)		(1.27)	
Muleba	-0.808		-0.878	
	(0.84)		(1.02)	
Biharam	-1.049		-1.501	
	(0.85)		(1.04)	
Urban	1.217**		2.006**	
	(0.52)		(0.77)	
Household location (possibility of malaria)	0.520		1.288	
	(0.72)		(1.05)	
Constant	-7.676**	-5.073***	-16.28**	
	(3.72)	(0.48)	(7.60)	
Observations	385	385	385	385
Number of households		153		153
R-squared	0.51	0.62	0.21	0.58

Notes:

1. Robust standard errors in parentheses. * Significant at 10%; ** Significant at 5%; *** Significant at 1%
2. Standard errors for all estimates are robust to clustered (village) sample design.
3. "Family Fixed Effects" and "Family Fixed Effects - Instrumental Variables" are estimated using a linear probability model

Table 3. 28: Robustness checks on final grade achieved equation. Sub-Samples of children removing one district in turn.

	All districts but 1	All districts but 2	All districts but 3	All districts but 4	All districts but 5	All districts but 6	All districts but 1 & 5
Gender (female)	0.399**	0.206	0.330**	0.339**	0.298**	0.433**	-0.0212
	(0.17)	(0.18)	(0.16)	(0.15)	(0.14)	(0.18)	(0.047)
Age in adolescence (in months)	0.568***	0.569***	0.556***	0.556***	0.575***	0.496***	0.129***
	(0.048)	(0.069)	(0.059)	(0.050)	(0.040)	(0.054)	(0.012)
Height-for-age z-score	-0.269	-0.283	-0.185	-0.373	-0.201	-0.492*	0.125**
	(0.25)	(0.34)	(0.32)	(0.26)	(0.18)	(0.26)	(0.051)
Observations	515	447	517	572	557	502	450
Number of hh	199	168	198	223	212	190	173
R-squared	0.60	0.56	0.58	0.57	0.60	0.46	0.36

Notes:

1. Robust standard errors in parentheses. * Significant at 10%; ** Significant at 5%; *** Significant at 1%

2. Standard errors for all estimates are robust to clustered (village) sample design.

3. "Family Fixed Effects - Instrumental Variables" are estimated using a linear probability model

4. District n.1 is Karagwe; district n.2 is Bukoba Rural; district n.3 is Muleba; district n.4 is Biharamulu; district n.5 is Ngara; district n.6 is Bukoba Urban.

13. Appendix VI: Glossary of statistical terms

Anthropometry	Originally a branch of Anthropology that deals with making comparative measurements of the human body.
Assortative matching	The trend that individuals form personal or professional relationships with people similar to themselves in terms of key features such as family background or education.
Attrition bias	Systematic differences between the comparison groups in the loss of participants from the study. It has been called exclusion bias.
Bias	The difference between the parameter and the expected value of the estimator of the parameter.
Consistent estimator	An estimator is consistent if the probability that it is in error by more than a given amount tends to zero as the sample becomes large.
Cross-sectional data	Parallel data collected on a large number of units (such as children, individuals or households) at a single point in time.
Disability adjusted life years (DALY)	The sum of years of potential life lost due to premature mortality and the years of productive life lost due to disability.
Endogeneity	An explanatory variable that is said to be endogenous and determined within a wider system of equations being estimated. This induces the problem of endogeneity bias when estimating the effect of the explanatory variable on the outcome of interest.
Fixed effects	A method of estimating parameters from a panel data set using change over time to add to robustness. In many circumstances the method will remove bias from any unobserved factors that do not change over time.
Generalised least squares (GLS)	A generalisation of the ordinary least squares procedure to deal with situations in which the error terms have properties that do not fit the assumptions of ordinary least squares regression.
Instrumental variables (IV)	Either refers to an estimation technique or to the exogenous variables used in the estimation technique. When estimation is biased due to reverse causality or some other form of endogeneity, this technique can, under certain conditions, remove the bias. The method is akin to a natural experiment. The replacement regressors are called instruments but must meet strict conditions. Such variables are often hard to find and are often controversial.
Likelihood function	In maximum likelihood estimation, the likelihood function is the joint probability function of the sample, given the probability distributions that are assumed for the errors.
Logistic distribution	A logistic distribution has the cumulative density function $F(x) = 1/(1+e-x)$
Logistic regression	A model in which the dependent variable, that can be only one or zero, is a function of a set of independent variables and the error term is distributed according to a logistic distribution.
Matching methods	Compares the outcomes of individuals with similar background and personal characteristics, some of whom received the treatment (in this case education) and some of whom did not. The method is nonparametric, so nonlinear assumptions are made and all background factors can interact. The method assumes that unobservable factors are not responsible for the difference in likelihood of receiving the treatment. The method is non-parametric.
Maximum simulated likelihood (MSL)	The maximum likelihood estimation is simulated on a number of repetitions, from which it is possible to obtain an average probability and with it to build the simulated likelihood function.
Meta analysis	The process or technique of synthesising research results by using various statistical methods to retrieve, select, and combine results from previously separate but related studies.
Multi-level estimation	Include fixed and random effects and incorporate both individuals and groups of individuals within the same model so that estimation results can be affected by the clustered nature of the data.
Multinomial Logit (MNL)	The multinomial logit model is the generalisation of the logit model when there are more than two alternatives for the outcome variable.
Multivariate or multiple regression	Analysis that allows for assessment of the relationship between one dependent variable and several independent variables.

Natural experiment	An isolated change occurs in one aspect of the environment so that the effects of that change can be studied as if it were an experiment; that is, by assuming that every other exogenous input was held constant.
Ordered Logit models	A model where the dependent variable is categorical and its values follow some ordering. The outcome variable is a function of a set of independent variables and the error term is distributed according to a logistic distribution.
Ordered Probit models	A model where the dependent variable is categorical and its values follow some ordering. The outcome variable is a function of a set of independent variables and the error term is distributed according to a normal distribution.
Ordinary least squares (OLS)	The classical linear regression procedure.
Natural experiments	Experiments which use natural variation in a school characteristic that is unlikely to be correlated with all other factors that determine learning.
Panel or longitudinal or cross-sectional time series data	Data collected on a (usually large) number of cross-sectional units, such as children, individuals or households, from a (usually small) number of time periods.
Poisson regression	Aims at modelling a counting outcome variable, counting the number of times that a certain event occurs during a certain time period.
Probit model	A model where the dependent variable, that can be only one or zero, is a function of a set of independent variables and the error term is distributed according to a normal distribution.
Propensity score matching	An estimate of the probability that an observed entity like a person would undergo the treatment. This probability is itself a predictor of outcomes sometimes.
Quintile regression	Rather than modelling the whole distribution of the outcome variable, this statistical technique estimates the effect of the explanatory variables in different quintiles of the distribution of the outcome variable.
Random effects	The Generalised Least Squares procedure in the context of panel data.
Randomised trial	Scientific procedure of collecting data from an experiment in which one group, or more, is randomly selected to receive a treatment while the non-selected groups serve as a control group. This method is considered the most reliable form of scientific study because it provides the best known design for eliminating a variety of biases.
Retrospective studies	Studies based on data collected from schools as they currently exist.
Reverse causality	The notion that the outcome variable (health) may exert a causal effect on the covariate (education).
Selection bias	Bias in estimation that results from the fact that individuals are not randomly allocated to the state or treatment under investigation.
Structural equation modelling	A statistical method to estimate the associations between the all variables in a structural model. It deals with the way in which explanatory variables relate to each other and how these relate to the outcome of interest. The method relies on its theoretical basis to form the structure of the statistical estimation.
Time-variant/ invariant heterogeneity	Synonym for unobserved effects. These sources of bias can be time variant and time invariant.
Tobit models	An econometric model in which the dependent variable is censored or truncated, for example, when the dependent variable is expenditures on durables which cannot take values below zero. This means that this variable is truncated at zero.
Two stage least squares (2SLS)	Two stage least squares is an instrumental variables estimation technique. Extends the IV idea to a situation where one has more instruments than independent variables in the model
Unbiased sample	A sample drawn and recorded by a method which is free from bias. This implies not only freedom from bias in the method of selection, *e.g.* random sampling, but freedom from any bias of procedure, *e.g.* wrong definition, non-response, design of questions, interviewer bias, etc. An unbiased sample in these respects should be distinguished from unbiased estimating processes which may be employed upon the data.
Weighted least squares (WLS)	The use of weight in the ordinary least squares estimation