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Food security and human capital: The impact of community-managed granary bank activities on children's health and education in Burkina Faso

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Food security and human capital:

The impact of community-managed granary bank activities on children's health and education in Burkina Faso

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Abstract

Temporal food insecurity in the northern Burkinabé Sudano-Sahelian belt affects many poor, subsistence-based families. Some local and international organisations introduced granary banks and encouraged community-management as a conscious strategy to address this problem of food scarcity. A previous study in the same region has shown that granary banks have a positive impact on the nutritional state of the population. This impact evaluation study examines the additional effects on human capital by looking at the impact on health and schooling among children in the region. Based on a Randomized Control Trial, the study finds a reduction in diarrhea and stomach pain for boys younger than six. Among them, especially children from poorer families and children living in villages that are difficult to access reap these benefits. For school-age children, the granary banks reduce fever, stomach pain and respiratory disease, which is significantly strong for girls, children from richer families, and children in villages that are difficult to access and do not have a local market. Looking at school attendance, the program increases attendance rates for boys only, and especially children from badly accessible villages and villages without a market. Overall, the program brings the main benefits for children in the most vulnerable position based on village-level characteristics. It also smooths naturally existing gender differences in the prevalence of several diseases. The suggested channels are a direct effect through an improved nutritional state, which makes children less susceptible to infectious diseases; an indirect effect of a higher purchasing power due to the reduction in the price of sorgho, and a second indirect effect due to reduced time constraints, which positively affects the parent/child relationship and can have large spill-over effects on health and education in the long run. The impacts found after one year are a good indicator of a much larger impact if granary banks would be implemented over a longer timeframe, especially in regions which are highly food-insecure.

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Acknowledgment

The past nine months have marked a very intense period. With a non-economical background starting an advanced master in Development Economics has been a deliberate choice about 10 months ago. A choice I do not at all regret, given the tons of new knowledge I got to acquire at a rollercoaster speed.

The content of this personal study project was one of my motivations to enroll in the program. I wanted to add to my previously acquired anthropological fieldwork skills the knowledge and ability to conduct quantitave analysises in an economic framework. This impact evaluation study - although it's still a very basic work - exactly encompasses what I desired to learn/do this year: conduct an impact evaluation study with statistical analysises in a developing context of which the result might be interesting not only to myself and the ones that have to evaluate me, but likely also for further research/development programs.

Finishing off this project would have been absolutely impossible without the help of my supervisor Catherine Guirkinger, who gave me at necessary times thoughtful insights and to the point and very helpful feedback; and my tutor Jérémie Gross, who I could turn to over and over again for practical help in STATA, but also content-wise feedback and just any (sometimes obvious) question I was struggling with during the progress of this work. To both of you, I would like to say "Thank you very much!" cause I mean it when I say that this paper would not have been possible without your patience and feedback.

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Chapter 1. Introduction

1.1. Impact evaluation of a food security program on health and education in Burkina Faso

This paper outlines an impact evaluation study of a food security program based on the presence of granary banks in rural communities in northern Burkina Faso. As a previously conducted impact evaluation in the same region has already shown the positive effect of granary banks on the nutritional state of the population in these targeted villages (Gross & Mees, 2016), this study uses the same data to look at the additional effects on human capital, specifically focusing on health and schooling. The evaluation looks at the impact one year after the initial implementation of the granary banks, which marked a year with exceptionally low rainfall and large food insecurity. In that sense, this study serves as an indication of the much larger potential impact of granary banks on human capital in poor, food insecure communities, if the granary banks would be implemented on a much larger scale and over a longer period of time. The study also examines the linkages between the effects on nutrition, health and schooling, in order to suggest channels through which the impact takes place.

1.2. Problem definition: Food security in Burkina Faso

Burkina Faso is one of the many countries in Sub-Saharan Africa where a large share of the population still suffers from food insecurity and hunger. In the north of the country, rural communities from the Sudano-Sahelian belt live based on familial subsistence agriculture. Cereals dominate their diet and are harvested only during rainy season. The production of these cereals is usually sufficient to be stored in small familial granaries and to feed the family throughout the year, until the next harvest.

Due to the degradation of soils in the past decades, yields in northern Burkina Faso have decreased to such extent that families have become unable to meet their daily needs based on their own production. As most of the villages in the Sudano-Sahelian belt are isolated places, they are further disadvantaged due to limited access to credit and high transaction costs, which maintains their poorly developed local markets. Many villages do not have a local market or a permanent cereal trader. As such, the majority of families are obliged to cross a distance of approximately 7 kilometres by foot in order to purchase small amounts of foods at the nearest market (Gross & Mees, 2016). Hence, food insecurity and poverty among these people is high, especially near the end of the agricultural cycle.

In order to address this increasing food insecurity problem in Northern Burkina Faso, SOS-Faim and the National Federation of the Naam Groups (FNGN) (a Belgian-Luxembourg NGO and an important Burkinabé rural organisation respectively), launched a food security program in 2000 based on a revitalization of some 400 abandoned cereal banks from the 1980s and 1990s. The main objective was to encourage a community-managed market mechanism to provide sufficient access to cereals for the communities based on buying, stocking and selling cereals within the village. By selling the food

products at a low price to families in need, the program aimed to create a security safety net by increasing the competition at the local market, ameliorating the accessibility to food and increasing community capacity, women promotion and a diversification of the diet.

In the course of 2011-2012, which marked a cycle with strong cereal production shortfall as a consequence of exceptionally long periods of droughts, the Centre of Research & Development Economics (CRED) from Namur conducted an impact evaluation study based on a Randomized Control Trial in 40 villages. The application of this research design and the use of difference-in-difference as the main method of analysis allowed the researchers to look at the causal impact of the program. The four main indicators used to objectively measure the impact of the program were the nutritional state of children and adults based on BMI measures, the average distance crossed to purchase food products, the purchasing price and consumption behaviour.

The results were rather positive, and the best results were found for very isolated and very poor villages. For the nutritional state the study showed that the presence of the granary banks had prevented deterioration (due to bad harvests, as was the case in the control group) of the nutritional state measured by Body Mass Index. The effect was found on the entire population in the villages, not only on members of families who bought cereals from those granary banks. The program also caused an increase of 18% more purchases at the local market, and an average decrease of 20 kilometres per family per year that had to be crossed to buy food. The purchasing price of cereals also decreased. On average, a reduction of almost 8% in the price of one sac of sorghum - the main crop - was found amongst the treatment group beneficiaries. This price reduction is equivalent to enrolment rates at primary school for five children. Finally, no impact was found on consumption. People in the treatment group did not consume higher quantities and did not diversify their diet as a result of the food security intervention.

Notwithstanding no increase in consumption or diversification of the diet, the community-based food security program did have a positive effect on the nutritional state, and by increasing purchases at the local market families could save more time and money. This raises the question whether the food security program further contributes to the accumulation of human capital. Becker (1964) defined the concept of human capital as *"the knowledge, information, ideas, skills and health of individuals"* (Becker, 2002:1). It is assumed that individuals decide on their own education, training, medical care, and other additions to knowledge and health by weighing the benefits and costs (Becker, 1996). In this context, one might wonder whether the food security program based on community-managed granary banks in Burkina Faso has any additional effect on the health and education of children in these communities?

1.3. Objectives and relevance of the research

Ever-adapting theories since the 1970s have tried to prove the linkages between nutrition, health and education (see infra.) Numerous food security interventions have been implemented in developing countries in a context of alleviating poverty since the 90s. Increasingly well-conducted studies have found evidence for a causal relationship between intervention programs and improved well being and educational outcomes. The majority of the interventions however focus on nutrition supplements, either at infant age or in primary school contexts. So far, little is known about the health and educational outcomes of a food security program that intervenes on the local market through the creation of community-based granary banks in developing countries. Can granary banks in Burkina Faso have an impact on children's health and education? If yes, does this happen through an ameliorated nutritional state, as has been proven in the study conducted by the CRED? Or do other channels account for a possible impact of the food security program on health and education? Which channels could that be?

Based on the previous questions, the following research question will be examined: How does a food security program based on community-managed granary banks, affect children's health and education in poor, subsistence-based areas in northern Burkina Faso?

The following sub-questions will guide the research:

1) Which impact can be found after 1 year on children's health, aged zero to 18 years old?
2) Which impact can be found after 1 year on children's education, aged six to 18 years old?
3) What are the main channels through which the impact on education and health take place?
4) Which heterogeneous effects can be found across sex, age, wealth, accessibility and economic integration?

1.4. Structure of this paper

This report consists of six chapters. After this introduction, chapter two will delineate the academic debate in which this research is situated. The chapter includes the concept of food security, which is then further extended to a framework linking nutrition, health and education. Next, the pitfalls and potentials of granary banks and the contextual background of the research site will be outlined, followed by a summary of the results in the previously conducted study (Gross & Mees, 2016) on the nutritional state of the population. The chapter ends with expected results. Chapter three explains the research design and the method of analysis. Chapter four is a description of the results based on a quantitative analysis in the statistical program STATA and also starts an initial discussion of results. In chapter five, the results will be summarized and interrelated, looking at potential channels through which the food security program affects the health and educational status of children. Finally, chapter six will provide a conclusion and recommendations for future program interventions.

Chapter 2. Literature review/conceptual framework

2.1. Food security

Food security is a multi-faceted concept, which has been variously defined and interpreted over the past four decades. The concept originated at the 1974 World Food Summit when a time of global food crisis opened up discussions of international food supply problems. Its primary definition concerned the availability of adequate supplies at a global and national level (Shaw & Clay, 1998).

In the 80s, both he FAO and the World bank redefined the concept, including special attention to vulnerable people. In the 1990s, the concept evolved even further. The definition agreed upon during the World Food Summit of 1996 was the following: "*Food security, at the individual, household, national, regional and global level is achieved when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life*" (FAO, 1996). By adding "safe and nutritious", food safety and nutritional composition was emphasised, whereas "food preferences" led to a change in the concept from mere access to enough food to access to the food preferred. As such, cultural and social food preferences were taken into consideration as well as the high degree of context specificity around the world. This redefinition was mainly based on the ideas of human rights and human security, strongly inspired by the theories of Amarthyra Sen (UNDP, 1994).

The practical response after 1996 was to focus on narrower, simpler objectives at the individual level instead of the global level. Food security therefore has increasingly been interpreted as the means to reduce or eliminate poverty (FAO, 2003). What originated on the World Food Summit of 1996 was formally redefined as Goal 1 of the Millenium Development Goals formulated by the UN in 2000, which aimed to halve the number of hungry or undernourished people by 2015 (UN, 2000).

To do so, the concept of food security since 1996 has been extensively applied at the household level as a measure of welfare. There have been numerous attempts by international development policy-makers to make the concept useful in its design, implementation and evaluation of programs and policies. A household generally is considered food secure if it has the ability to acquire the food needed by its members to be food secure (Pinstrup-Andersen, 2009). Embedded in this implementation of the concept is the distinction between chronic food insecurity, which describes a long-term lack of access to sufficient food and is related to structural poverty; and transitory food insecurity, which implies periodic food insecurity due to periods of pressure on food supplies caused by disasters, economic collapse or conflicts (FAO, 1996).

But even when a household - based on several measures that fall outside the scope of this literature review - is considered food secure, it might not be able to assure enough food for all its

members. According to theories of intra-household allocation, there are two reasons explaining this. First of all, the ability to acquire enough food may not be converted into actual food acquisition, as households might prefer other goods and services such as school fees and housing. Secondly, the intra-household allocation of the food might not be based on the needs of each individual member. Moreover, the extent to which individual food security results in good nutrition depends on a set of non-food factors such as water quality, sanitary hygiene, infectious diseases and access to primary health care, especially for very young children (Pinstrup-Andersen, 2009).

Based on this, one could infer that food security does not assure nutritional security. However this view should be nuanced, as numerous projects and evaluation programs have been able to provide some evidence for linkages between food security programs based on nutrition interventions, people's nutritional state and well-being. Although results vary greatly depending on the research design and the specific health conditions in different settings, the linkages are strongest for interventions focusing on infants. It is reasoned that any improvements at such young age have long-lasting effects at later stages in life (UNICEF, 2009; WHO, 2012). Specifically, according to Martorell (1996) nutrition interventions may be effective only during pregnancy and the fist 2-3 years of life for the case of physical growth. For behavioural development, nutrition interventions may have a positive effect at later ages as well.

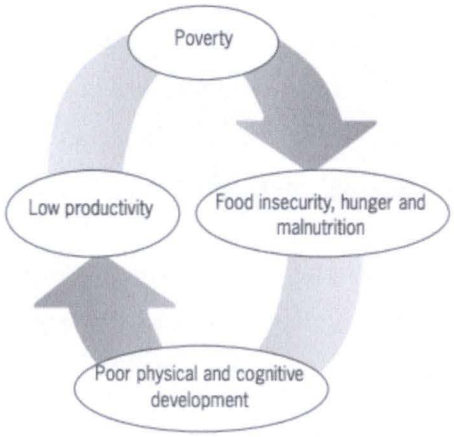
Inspired by Millennium Development Goal 2 - which defined that by 2015 boys and girls alike everywhere in the world should be able to complete a full course of primary schooling (UN, 2000) -, and the fact that cognitive abilities are often measured through school performance, (primary) education also became a priority in international development policies focusing on food security. Hence, researchers have increasingly studied the effects of food security programs on education, which is believed to be intrinsically related to health and nutrition.

In the following parts, an overview will be provided on what is temporarily known in the literature about the linkages between nutrition, health, and schooling for children. As the data in this paper will be divided in a sample of children younger than six years old, and a sample older than six years old, the same subdivision will be followed in the next section.

2.2. A framework linking nutrition, health and education

It is believed that food (in)security interacts with (mal)nutrition and mental and physical development in a framework which has the potential to alleviate (aggravate) poverty. The FAO in its practical guidelines suggests the following framework (2008):

Figure I: Framework linking food insecurity/malnutrition with physical well beign, cognitive abilities and poverty.



Malnutrition results from deficiencies, excesses or imbalances in the consumption of macro- and/or micronutrients. It is often an outcome of food insecurity, but it may also relate to non-food factors such as inadequate care practices for children, insufficient health services, and/or an unhealthy environment (FAO, 2008). For the remaining of the paper, the term malnutrition is used to refer to deficiencies and imbalances of micronutrients. Overnutrition will not be considered. The concept of 'low productivity' as seen in Figure I also falls outside the scope of this study.

Figure I clearly shows that all concepts related to nutrition, health, and education interact in a vicious circle. The bulk of studies addressing (parts) of this vicious circle usually start their analysis with the impact of malnutrition. A study from the World Bank done by Aldermann (2011) shows the negative effects of malnutrition on several of the Millenium Development Goals.

Table I. How malnutrition affects several of the MDGs

Millenium Development Goal	**(Mal)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.

(Adapted from Gillespie and Haddad, 2003; in Alderman, 2011)

It is clear from Table I that malnutrition has an effect on both health and education, and that females suffer more from the negative consequences of malnutrition compared to males. The question to be addressed for this paper however is whether improvements in the nutrition of children also ameliorate their health situation and schooling outcomes. The following sub-chapters will further explore this question by focusing on specific health and schooling aspects across younger and older children. Thereby it will also be tried to understand how the vicious circle between nutrition, health and education exactly works.

2.2.1. Linkages between nutrition and health for children younger than six

Especially the literature on early childhood nutrition is unanimous: whether or not children are well-nourished during their first years of life has profound effects on their health status, as well as their ability to learn, communicate, think analytically, socialize effectively and adapt to new environments and people in later stages of life (World Bank, 2016). According to Sagan & Druyan (1994) "*when there isn't enough food, the body has to make a decision about how to invest the limited foodstuffs available. Survival comes first. Growth comes second. In this nutritional triage, the body seems obliged to rank learning last. Better to be stupid and alive than smart and dead*". Good nutrition is in that sense the first line of defence against numerous childhood diseases and cognitive

impairments (Martorell, 1996). However, diseases among infants often serve as a contributing cause to malnutrition too. Two of the main (symptoms of) disease among children younger than six are diarrhea and stomach pain, which will be addressed separately.

1. Diarrhea

Diarrhea has been found to be both a cause and a consequence of malnutrition and severely affects a child's health, especially in the earliest stages of life. According to the WHO and UNICEF (2009) the impact of prolonged or acute diarrhea on nutrition and the effect of malnutrition on susceptibility to infectious diseases including diarrhea, can be linked in a vicious deadly cycle amongst children, especially in developing countries.

Children are at greater risk than adults of life-threatening diarrhea due to dehydration. Since water constitutes a greater proportion of children's bodyweight, young children use more water over the course of a day given their higher metabolic rates, and their kidneys are less able to conserve water compared to older children and adults. Moreover children with poor nutritional status and overall health as well ass those exposed to poor environmental conditions, are more susceptible to severe diarrhea and dehydration than healthy children. This is due to dietary deficiency diseases that may reduce the body's resistance to infections and adversely affect the immune system (UNICEF, 2009). Hence, whenever children suffer from persistent diarrhea, they are at great risk to worsen their nutritional status due to the decreased food intake and reduction in nutrient absorption, in combination with the child's increased nutritional requirements. This further aggravates their susceptibility to other diseases and worsens their overall well being. Therefore amongst the poor and especially in developing countries, diarrhea is a major killer among children (WHO, 2012).

Diarrhea is a symptom of infection caused by a host of bacterial, viral and parasitic organisms most of which can be spread by contaminated water or unsafe food. Food can be stored or prepared in unhygienic conditions, or unsafe water can contaminate food during irrigation. Fish and seafood from polluted water may also contribute to diarrheal diseases. Hence it is clear that diarrheal diseases are more common when there is a shortage of clean water for drinking, cooking and basic hygiene (UNICEF, 2009).

It can be prevented in two ways: either by directly reducing a child's exposure to the pathogens that cause diarrhea (for example through the provision of safe drinking water), or by reducing a child's susceptibility to severe diarrhea and dehydration (by improved nutrition and overall health).
One very strong natural method of prevention is the practice of breastfeeding. As breast milk contains the nutrients, antioxidants, hormones and antibodies needed by a child to survive and develop, infants

who are exclusively breastfed for the first six months of life and continue to be breastfed until two years of age and beyond develop fewer infections and have less severe illnesses than those who are not, even among children whose mothers are HIV-positive (WHO, 2012). As for nutritional supplements, it has been found that Vitamin A supplementation is a critical preventive measure, as it reduces the duration, severity and complications associated with diarrhea. Besides Vitamin A, also zinc intake among children is critical for normal growth and development and has been linked to a reduction in childhood diarrhea cases (UNICEF, 2009).

When diarrhea does occur, there are some widely accepted key measures to adequately threat it. The most important measure is to provide more fluids than usual, in the best case including oral rehydration salts solution to prevent hydration. Besides, feeding has to be continued, even though the child does not feel like eating. Thirdly, a health worker should be consulted if there are signs of dehydration in order to receive appropriate medicines (WHO & UNICEF, 2009).

Given this information, the negative vicious circle as addressed previously might also work in the opposite positive direction: if the nutritional state of children and adults is improved due to better acces to food, this might potentially reduce the prevalence of diarrhea; either by more effective prevention (better breastmilk quality or better quality of the food for children older than two years making them less vulnerable) or by efficient treatment practices (continuation of feeding due to easier access to food). However, this effect is probably not as strong as the opposite negative cycle, as studies having found causal impact are scarce.

2. Stomach pain

Similar to diarrheal diseases, the incidence of stomach pain amongst children in developing countries is closely related to malnutrition. According to the Merck-Manuals (2016), if reduced food intake continues for a month, the consequence is a decreased production of stomach acid and shrinking of the stomach, which causes severe stomach pain and - often - fatal diarrhea. Moreover, in regions where malnutrition takes place, a high prevalence of poor diet and infectious disease regularly unites into a vicious circle, further causing stomach pain (De Onis, Monteiro, Akré & Clugston, 1993; Rice, Sacco, Hyder & Black, 2000; FAO, 2004).

One common example of an infection causing severe stomach pain in developing countries is gastro-enteritis, which is a gastro-intestinal disease also referred to as infectious diarrhea. Similarly to diarrhea, the main causes are contaminated water and food and/or bad sanitary conditions. Malnutrition furthermore enhances the susceptibility to get infected. Such infections, especially if

accompanied by a fever, often lead to a loss of appetite and therefore to a further reduction of food intake. Some infectious diseases commonly cause vomiting, which leads to the same result. Undernutrition thus both serves as a cause and as a consequence of infectious diseases, often causing stomach pain, diarrhea, vomiting and fever (King, Glass, Bresee & Duggan, 2003).

Many more diseases might cause stomach pain, which in its turn can affect malnutrition. A complete overview falls outside the scope of this study. Exactly for this reason, general treatment protocols for stomach pain do not exist, as it often co-occurs with diarrhea, vomiting and fever as consequences of several types of diseases.

However general treatments for malnutrition and infectious diseases in developing countries have become more efficient in recent years, ranging from promoting breastfeeding and food supplementation schemes, to dietary diversification through home gardens and small livestock. To be effective, it is widely believed that such interventions require accompanying nutrition-education campaigns and health interventions (Müller & Krawinkel, 2005). However, due to little or no access to formal health and better sanitary conditions, many people especially in rural areas have never seen any of these treatments.

Based on this information, it can be presumed that amelioration in the nutritional state of children (and adults) positively affects the prevalence of stomach pain among infants. One can suppose that the improved nutritional state of mothers and children will result in higher-quality breastmilk (for infants until the age of two) and food (for children between two and six years old), which may reduce their susceptibility to get infected by diseases. However, it should be noted that this positive vicious circle is less convincingly justified in the literature than the negative spiral that aggravates nutrition and health. The results in this study will therefore be carefully examined, to not overestimate the direct channel of improved nutrition on health and education.

2.2.2. Nutrition, health and education for children older than six

According to the nutritional triage by Sagan & Druyan (1994), learning is ranked last when it comes to body functions that need to be fulfilled during persistent times of undernutrition. Various studies have shown that malnutrition and ill health at infant age might affect educational outcomes at later ages. The worst such impact is found across the poorest in the world. According to Jukes, Drake & Bundy (2007), this is called the double jeopardy. They refer to the concept, which originated in the context of at-risk children in the US, to the way in which the poorest in society suffer twice at the hands of disease and poor nutrition. First of all, they are more likely to suffer a condition of poor health and poor nutrition as the diseases that affect children and their education are most prevalent in

the poorest communities in poor countries. Second, conditions of poor health and nutrition have the biggest educational impact on the poor. Even when disease strikes rich and poor alike, it's the poor that will be most likely to experience disruption to their learning. This differential impact takes place because the poor have less capacity to cope with the additional burden of a new disease. As they are already struggling to pursue their education in the face of poverty, delayed development and poor general health, the marginal impact of a new infection or nutritional disease can lead to dropout and push them over the edge, as they don't have the resources to cope (Jukes, Drake & Bundy, 2007). It is therefore assumed that development policies and programs addressing the issues of poor health and nutrition will have the most profound impact in the poorest communities.

The first part of this section addresses the most prevalent diseases and their interaction with malnutrition for children older than six, similar to the previous section on infants and children younger than six. In the second part, the specific relation with education is added to the framework, as it is assumed that improved nutrition and health also has an impact on education. Effects on health and education in the long-term fall outside the scope of this paper as the data in this impact evaluation study only amounts to one year.

2.2.2.1 Diseases and malnutrition among school-age children

Whereas preschool diseases such as diarrhea-related illnesses become less important, other diseases such as parasitic worms and respiratory diseases become much more prevalent among school-age children worldwide. Between 25 and 35 per cent of school-age children are infected with one or more of the major parasitic worms such as roundworm, whipworm or hookworm (Partnership for Child Development, 1997). Although symptoms vary, heavily infected children might suffer from abdominal pain and fever in all three cases. Children with chronic worm infections may be stunted and underweight, which might lead to long-term retardation of mental physical development.

Parasitic infections can also contribute to further malnutrition as it causes a lack of appetite, malabsorption and anaemia through a loss of blood (Latham, 1997). Deworming treatments have proven to be an effective intervention to improve growth, reducing the extent of malnutrition and increasing appetite (Latham, 1997). The most influential study on deworming conducted by Miguel & Kremer (2004) shows that the group of children having received a deworming treatment had better reported health outcomes than the control group after one year. Through these improved health outcomes, Miguel & Kremer (2004) successfully showed how their deworming program even achieved higher attendance rates at primary school.

Besides parasitic worms and respiratory disease, also malaria is a high burden of disease for children at school as it is a major cause of absenteeism and cognitive impairment. HIV and aids leaves millions of school-age children without parents, leading to physical, social and psychological suffering which indirectly affects their school achievements (Jukes, Drake & Bundy, 2007).

The most common physical indicator of undernutrition among school-age children is a low height-for age – also called stunting –. Children who are stunted at primary school are likely to have been exposed to poor nutrition since their early childhood. The same accounts for low weight-for age – also called underweight -, which is another indicator common in school-age children of chronic and acute undernutrition. Especially in low-income countries, the prevalence of both stunting and underweight is high (with 48 to 56 percent for stunting and 34 to 62 percent for underweight) (Partnership for Child Development, 1997) and boys in general are more stunted than girls (Jukes, Drake & Bundy, 2007).

As for micronutrient deficiencies among school-age children, particularly iron, iodine and vitamin A deficiencies cause big problems. Except for negatively impacting growth and increasing the susceptibility for infections, a lack of these micronutrients also impairs mental developments and learning abilities. As a case in point, Sommer & West (1996, in Sridhar, 2008) found that vitamin A deficiency contributes to measles mortality and diarrheal illness and that it is moreover the leading cause of child blindness in developing countries. In 2001, Grantham, McGregor & Ani (in Sridhar, 2008) showed that iron deficiency is the leading cause of impaired cognitive development and lower school achievements worldwide.

2.2.2.2. Channels through which health and nutrition have an impact on education

Both diseases and malnutrition thus can affect educational outcomes for school-age children. Two very different pathways have to be considered when we want to examine how this impact on education is established: access to schooling, including enrolment rates, attendance rates and drop out on the one hand, and learning abilities including behavioural and cognitive development on the other.

1. Impact on school enrolment and attendance

The second goal of the Millenium Development Goals is universal primary education, based on primary school enrolment rates. By the end of 2015 primary school enrolment figures have shown an impressive rise, but the goal of achieving universal primary education has just been missed, with the net enrolment rate increasing from 83% in 2000 to 91% in 2015 (UN, 2015). However, the measure of school enrolment is not a correct picture of primary school education across the world, as

absenteeism and dropout numbers are enormous and primary school completion is far from being achieved. The situation is worst for girls, who are less likely than boys to enrol in schools and less likely to complete their schooling once they have enrolled.

Apart from direct costs of sending children to school, going to school can be an opportunity cost for poor families, as children are often required to work in the household and to contribute to the family's income. In this regard, the perception of the value of education and of school quality compared to health and nutrition are strong obstacles to educational access, especially in low-income countries (Jukes, Drake & Bundy, 2007).

Stunting can also lead to delayed enrolment in primary school, impared education achievements and cognitive functions (see next section). A study in the Philippines found that children who were severely stunted before the age of two were more likely to enrol late, to repeat a grade and to be absent from school (Mendez & Adair, 1999). This is often related to parental perceptions of their children's' school abilities and readiness. Smaller children are often perceived physically and mentally immature, or they are considered unable to walk safely over the long distances to school in rural areas (Jukes, Drake & Bundy, 2007). Moreover, parents might consider investing in healthy children as more cost-effective, which leads to healthy children being prioritized over their stunted siblings when it comes to decisions about school enrolment. This is in accordance to many findings that girls' enrolment is much more often delayed than boys' by stunting (Jukes, Drake & Bundy, 2007).

In a study for UNESCO, Sridhar (2008) found that in developing countries, there often is unequal participation of girls in schools due to the intertwining of biological and cultural forces. For example, menstruation exacerbates iron-deficiency anaemia while early marriage followed by pregnancy on its turn increases the nutritional demands. This all contributes to the fact that after the first years of schooling, girls tend to drop out of school more often than boys.

However, once children are enrolled, poor health and nutrition continue playing a role and are often expressed in high rates of absenteeism. Infectious diseases such as malaria and worms are both leading causes of school absenteeism. Malaria and deworming treatment interventions (Fernando, De Silva, Mendis & Wickremasinghe, 2006) have shown improved school attendance. Also improved nutrition due to school feeding programmes has shown some modest results on school attendance: school participation in Kenya rose substantially due to an intervention which offered children a cup of porridge for breakfast (Vermeersch & Kremer, 2004). These improvements resulted both from attracting new children and by improving the attendance of children who were already enrolled. However, it is very likely that attendance improved mainly due to the incentive to attend provided by the school breakfast, rather than as a result of improved health (Vermeersch & Kremer, 2004). In that

sense, it is important not to overrate school feeding programmes to other policies which might be more efficient in achieving increased educational access, such as health interventions and conditional cash transfers (Jukes, Drake & Bundy, 2007; Schultz, 2004).

Overall, school feeding, malaria prevention and deworming have all been shown effective in improving school attendance. Improving health and nutrition conditions appear to be effective ways to improve school participation.

2. Impact on educational achievements

The impact studies of health and nutrition on the behaviour and cognitive functions of children, which are essential for educational outcomes, are numerous. As no data on cognitive development has been collected in this study in Burkina Faso, a detailed description falls outside the scope of this literature review. An overview describes the most obvious and common results.

Jukes, Drake & Bundy (2007) make three big statements with regard to the impact of health and nutrition on educational achievements. First of all they argue against a critical period for cognitive benefits of good nutrition and they advice nutrition and health interventions throughout childhood. They also analysed that improved health and nutrition brings the greatest educational benefits to the poor and the more disadvantaged: Nutritional supplements lead to better education among the poor, and the cognitive development of low birth weight babies benefits most from breastfeeding. Furthermore they argue that health and education reinforce each other, as cognitive delays of undernourished children can be reversed only by a combination of early childhood education and nutritional supplements.

Hunger at school-age is a condition that does affect considerably the ability to learn at school. Missing breakfast has been found to impair performance to a greater extent for children of poor nutritional status (Simeon & Grantham-McGregor, 1989; Simeon, 1998). Moreover, short-term hunger has other effects that may affect school performance indirectly: it deteriorates general mood (Grantham-McGregor, Chang & Walker, 1998) and increases stress (Shariff, Bond & Johnson, 2000). However, results from a study in Jamaica (Grantham-McGregor, Chang & Walker, 1998) suggest that the effect of giving breakfast was extremely dependent on the school quality: children were more likely to concentrate when they had had breakfast in well-organised disciplined schools, whereas in poorly organised schools children who had eaten breakfast were more talkative and were less attentive in class. This again shows how health and education reinforce one another. It suggests that children benefit most from improvements in nutrition and the quality of schooling at the same time (Jukes, Drake & Bundy, 2007)

Also in the long-term studies have shown convincing results on the impact of improved nutrition on health and education. Hoddinott and others (2008) have provided nutritional supplements to children in a randomized control trial and followed both the treatment and the control group for a quarter century. In this study they did not just want to look at the long-term effects, but also wanted to control for economic and weather shocks. They found some evidence that the indirect inferences of the impact of nutrition on schooling and earnings based on economic and weather shocks are not misleading with regard to the potential program impacts. They found higher scores on cognitive tests for treated individuals between 25 and 42 years old, both for men and women, compared to the control group. Moreover, those men who had received the supplements before the age of three earned on average 44 % higher wages. For women, an increase in school attendance was identified.

Summarized, Sridhar (2008) states that improved nutrition and consequently improved health can have dramatically positive effects on education through two pathways. First of all, he argues that better child health due to better nutrition cognitively prepares children better for school, increasing cognitive ability and learning. Second, he states that a lesser chance of child mortality and a higher chance of survival into adulthood increase the incentives both for children and for parents to invest in education.

3. Real causality?

Until recently, the evidence that health and nutrition affect school enrolment and achievements has primarily taken the form of cross-sectional associations between children's health and their educational outcomes. Most of the studies cited so far have not used Randomized Control Trials, which means results should be interpreted very carefully. Only in the last one to two decades, innovative ways have been adopted to look at causal effects from observational data or to use randomized controlled trials to test the effect of child health on schooling outcomes. Perhaps the most influential study is the deworming program in Kenya by Vermeersch & Kremer (2004) as described in the previous section.

In 2008, Glewwe & Miguel drew some important conclusions regarding the interpretation of results in their meta-analysis *The impact of child health & nutrition on education in less developed countries*: First of all, they argue that many of the studies linking nutrition, health and education suffer from a scarcity of data, and base their important conclusions on a too limited database. Due to this, statistical analyses often face the problem of omitted variables, which causes biased outcomes. They also find several measurement errors in the studies under scrutiny.

Nevertheless measuring the impact of nutrition and health on education faces high obstacles, they argue it is not impossible. Based on several well-conducted studies, especially randomized control trial studies, they conclude that growing evidence can be found of a causal impact of nutrition and health on education. They also argue that based on many studies, no clear evidence of large gender differences in the impact of child health on education can be found. They advocate for further research that could confirm the causal impact in different settings and contexts. They stress the use of randomized control trials to allow for deducting causal relations, as randomized control trials do not face as many biases and measurement errors as other methodologies.

A very important study from Behrman (1996) already pointed out this important critique as mentioned by Glewwe & Miguel (2008). "*Too often in the past, results from studies showing only correlations have been interpreted as causal relationships. This has led to considerable resources spent on interventions that did not seem to work in the end*" (Behrman, 1996:2). He advocated being cautious with the interpretation of results, and not to overestimate nor overgeneralize the impact found in such studies.

2.2.2.3. How education impacts nutrition and health

As has been stated in the previous section, health and education reinforce each other, meaning they work together in many ways. Improving children's health at a time when they are learning maximises the possibility for this synergy. This argument sheds light on the fact that education in its turn has an enormous reverse impact on health and nutrition as well.

A long-standing literature reports positive associations between education and health in adults, of which the most important mediators are income, working conditions, health-related knowledge, cognitive ability, patience, attitudes towards risk, and cultural capital (specifically in interaction with health providers). However, all of these studies have been conducted in wealthy countries. Results for developing country are much more rare (Vogl, 2012).

Becker and others (2005) and Barro and Lee (2011; in Vogl, 2012) found that the health and education of parents – particuluarly mothers – affects outcomes in their children, especially in developing countries where levels of schooling and health are low. This inter-generational link between education and health is by far the most widely studied education-health association in poor countries.

Although natural experiments showing real causality are rather rare, a few studies in developed and developing countries show evidence for this link (Currie and Moretti, 2003; Duflo and Breierova,

2004; in Vogl, 2012). Sen and Sengupta (1983; in Sridhar, 2008) found that women's education could lead to an increase in household welfare, as they are better able to negotiate their position within the household. They found that children of such literate mothers had higher nutritional intakes than children of nonliterate mothers. However, Sridhar (2008) argues it is not just about providing education, but also when the education is most effective. Timing is important. It is argued that education is most important for school-age children.

Another channel through which education can have an intergenerational impact on health is through decreased fertility rates. When fertility rates fall, there are fewer children in the family hence children receive higher investments in the form of health, schooling and parental attention. Much cross-country evidence proves this positive association between increased schooling and reduced fertility. It is mainly due to intervening factors linked to education such as a delayed age at first marriage, modern methods of birth control, and higher likelihood of child survival (Feinstein et al, 2006).

At the social or national level, Feinstein et al (2006) found that education is a protective factor to the extent that it moderates the relationship between income inequality and health, mitigating the effects of inequality on the health of more educated people. He argues that education has a central role in the determination of income inequality and other aspects of inequality. However, it is not proven whether the effects of income inequality are felt only by the least well off in a society or whether the effects are more universal.

As for direct effects of education on health on adolescents and young adults, longitudinal follow-up of the recent spate of education-related randomized control trials in developing countries has begun to yield useful results on health behaviour too. Especially information about the return to schooling seems to be important. Studies (Jensen & Lleras-Muney, 2012; in Vogl, 2012) show that as a result, boys tend to stay in school longer, and tend to reduce heavy drinking and smoking at the age of 18. Training for girls about risky health behaviors and anticonceptiva yields good results on health behavior too (Bandiera et al, 2012; in Vogl, 2012). Overall, it seems that keeping boys 'off the streets' and equipping girls with health information may be key to any effect of education on health in young adulthood (Vogl, 2012). Due to the vicious circle described earlier, this improved health can further positively affect nutrition habitudes.

2.3. Food security granary banks: potential and pitfalls

As the previous section illustrates, the bulk of studies examining the causality between nutrition, health and education has been based on the inability to physically access food, leading to protein-energy malnutrition and micronutrient deficiencies. However, the definition of food security as defined at the World Food Summit in 1996 also includes economic access to sufficient, safe and nutritious food. One type of intervention that specifically addresses this issue is the introduction of community-managed granary banks to store cereals within the village. Especially in Africa, policy makers have experimented with cereal banks to ensure food and nutrition security in the fight against hunger (Bhattamishra, 2008).

Cereal banking can be defined as a community social safety net that is employed by communities in many arid and semiarid regions of the world, especially in food deficit countries or regions (Bosu et al 2012 in Raymond, 2014).

In 1990, Beer explained the procedure of cereal banking as a community-based risk management strategy, which involves buying of food during harvest when prices are low and storing for consumption during the lean period when food prices are high. The purpose then, is to smooth consumption in rural communities and households through the year. The intuition behind this is that rural subsistent agricultural households tend to sell the bulk of their farm production at low prices at harvest; but during the lean period they have to buy food (often the same products) at high prices. This inter-seasonal price variability tends to reduce the income of farmers at harvest when they are net sellers and erode their purchasing power during the lean period when they are net buyers (Beer, 1990).

Although the process of storing food as means of smoothing consumption dates back very long, the evolution and practice of cereal banks in Africa dates back to the 1960, which was until the 1990s closely linked with the drought that hit many of the regions in West-Africa (Beer, 1990; SOS FAIM, 2009; Moussa 2010; CCAFS 2003 in Raymond, 2014). However, recently its importance has been reemphasised as an intervention initiative to manage the increasing recurrent price and climate shocks that negatively impact food and nutrition security, especially for more vulnerable people.

Indeed, there is a growing body of literature that documents the impact of adverse shocks on children's health outcomes, both concurrent and in the long-term. Hoddinott and Kinsey (2001) use panel data from Zimbabwe to show that children aged 12-24 months, especially those from poorer households, experience a slowdown in growth due to a drought. They find that this cohort of children is not able to make up over time for this lost growth. Given that adult height is strongly correlated with height achieved by age 3 and is also correlated with labour earnings and productivity, the authors state

that the inability to smooth consumption increases the likelihood of chronic poverty. In addition, given the fact that taller women have - on average - healthier children, they posit that the impact of drought on female children can lead to the intergenerational persistence of poverty. Similarly, Hoddinott (2006) finds that recent droughts in Zimbabwe resulted in reduced growth for children of preschool-age. They find that this cohort is not able to catch up in terms of lost growth, as a result of which lifetime earnings are estimated to be roughly 7 % lower.

Cereal banks have most often been implemented by aid organisations and NGO's, and few impact evaluation researches have conducted their effectiveness. The few studies conducted solely focus on food and nutrition security as desirable outcomes. Recently these studies found generally positive results (Bhattamishra, 2008; Raymond, 2014; Gross & Mees, 2016). So far very few studies have included the impact on health and schooling. One extensive study conducted in India did study the impact of the grain banks on children's health but found no statistical evidence for grain banks to be effective in improving children's health status (Bhattamishra, 2008).

In this paper, I will examine whether grain banks have the potential to improve children's health outcomes in agricultural subsistence-based communities in the Sahel in northern Burkina Faso. By enabling households to smooth consumption over the agricultural cycle, it is hoped for that granary banks can not only improve children's health in the short term but also mitigate the long-term adverse impacts of seasonal malnutrition.

2.4. Contextual background of the research site

The rural population in the Northern region of Burkina Faso, belonging to the Sahel, practice subsistence-based rainfed agriculture. Families exploit small plots, and the production of cereals usually takes place over the course of the rainy season, which starts in May and ends in Octobre. The cereals, which are the principal component of families' diets, are stocked after the harvest in familial grarary banks to ensure sufficient supplies during the rest of the year. Nevertheless, bad soil quality, insufficient rain and other hazards related to the agricultural production regularly impede the families to produce sufficient cereal quantities to sustain their needs. When cereal supplies are depleted near the end of the year, families are obliged to buy cereals to mitigate their own production's shortages (Gross & Mees, 2016).

During dry season, families are usually involved in a multitude of other activities. In addition to gardening practiced in the lowlands or near dams, these activities also include small businesses, artisanal gold mining or farming. Revenues from these activities allow families to buy food to supplement their production and finance all other expenses (equipment, education, etc.). From April

on, these activities are gradually disappearing to the background. Families begin agricultural work before the arrival of the first rains and prepare to devote all their efforts during the rainy season. The annual agricultural cycle ends with the arrival of new harvests in October (Gross & Mees, 2016).

Not all villages have their own food market. In villages without a food market, people have to travel several kilometers to reach the nearest market. When traders are present in the village, they are usually few, ask high prices, and their commercial activity has a short duration and a limited scope. This exposes the population to problems of food access, which is reinforced in rainy season, when the reserves are dwindling and needs are becoming more pressing. The rains and poor accessable roads hamper the movement of the cereals. During this period, the cereals are also rare and more expensive on the market, which reduces the purchasing power of local people who are plagued by a lack of monetary resources (Gross & Mees, 2016).

These problems of availability and access to food largely explain the food risk to which these populations are exposed. During the period of scarcity in rainy season following a poor harvest, families are usually the most vulnerable. In this sense, the population suffers from temporal, primarily seasonal food insecurity. For example, in 2012, two out of three families in the North region were living below the national poverty threshold and nearly one in two was vulnerable in food (WFP, 2014; in Gross & Mees, 2016).

2.5. Previous impact evaluation study: the impact on the nutritional state of the population.

In the previously conducted impact evaluation study of granary banks on the nutritional state of the population in the same region, 40 villages out of 400 potentially eligible villages were randomly selected to be included in study. All of the villages were eligible, in the sense that they fulfilled the material and organisational conditions, had submitted an application for funds to install a granary bank, but had never benefited from the program before. Within the group of eligible villages, 20 villages where randomly selected to be in the treatment group. They received funds for the implementation and management of a granary bank in their village. The remaining 20 villages served as a control group, not receiving funds, nor a granary bank.

The villages and populations in the 40 villages in the study did not notably differ. As villages were randomly assigned to treatment and control groups, comparing the effect of the granary banks across treatment and control villages and across time allowed looking at the causal impact of the program (for more information on the methodology, see next chapter) (Gross & Mees, 2016).

The data used in this previously conducted study has been collected during the annual agricultural cycles 2010- 2011, 2011-2012 and 2012-2013. As none of the 40 villages had received any support from the program during the first cycle, that year served as the baseline. The second cycle, which begins with the arrival of the new harvest in November 2011 is the cycle in which some villages had a granary bank for the first time. The program's impact on the nutritional state of the population was measured on this second agricultural cycle (Gross & Mees, 2016).

It is important to note that, although variations exist from one village to another, the harvest generally appeared very good in 2010, very bad in 2011 and fine in 2012. Due to inadequate rainfall, the 2011-2012 cycle was marked by a major production shortfall. Over 80% of families have been forced to buy grain, whereas in a normal cycle, rather one in three depends on markets to supplement their grain deficit. Despite very large purchases in the year of the intervention that reach even more than a third of the cereals consumed, many families were still unable to meet their needs in the year 2011-2012 (Gross & Mees, 2016).

Each granary bank in the treatment villages bought an average of 18.2 tons of grain. Over 90% of these cereals were sold during the 2011-2012 agricultural cycle, most of them during the dry season and per 100kg bags. However, two in three of the granary banks had good grain for sale during the rainy season as well, and two in three have made retail sales. Nearly half of granary banks also sold other foodstuffs such as peanuts, sesame and other condiments.

Granary banks' market share reached 35% at the village level. One family in four went to the granary bank to procure grain. On average, these families were not very different from the others and justified their choice to buy at the granary banks based on the short distance. On average, each family has bought 304 kilos of cereals, which represents half of their purchases (Gross & Mees, 2016).

The results of the impact evaluation on the nutritional state were generally positive. The Corporal Mass Index (BMI) - the relationship between weight and height squared (kg / m2) - was calculated for each individual as it reflects the adequacy between nutritional intake of the food and energy costs of the body. Aggregated, this reflects the prevalence of malnutrition in a given population. The presence of a granary bank in the village has a positive impact on the nutritional situation as it allows the recipient populations to escape the deteriorating nutritional situation observed in the control villages during the 2011-2012 cycle.

One of the mechanisms by which the presence of a granary bank in the village creates this food safety improvement, is proximity. Proximity is the main criterion that motivates the choice of a particular seller by families, before continuous availability and prices. This reveals the preference of

families to purchase locally and suggests that the availability of local staple food is a major concern for these populations. The presence of a granary bank improves the availability of basic commodities in the village. The share of grain purchased in the village increases 5% in villages that received a granary bank while it fell more than 13% in the villages of the control group. Hence the program has a positive effect on the total distance to stock up on cereals, as it as reduced by over one third, which corresponds to approximately 20 km. The people thus benefit from saving time and effort, and face less risk (Gross & Mees, 2016).

A second mechanism by which the nutritional state might have improved is a reduction in the price. The poor harvest had resulted in a very high price level during the 2011-2012 agricultural cycle. The average price of a bag of grain increased from 14 000 FCFA in the previous year to almost 19 000 FCFA in 2011- 2012, an increase of over 35%. Prices also vary greatly from one season to another with a significantly higher price in the rainy season than in dry season. Prices also tend to be higher in the more isolated areas. The presence of a granary bank however has improved the access to economic goods. The average price paid to purchase a bag of grain was almost 8% lower in the beneficiary villages. In total, each family could save the money equivalent to five children's school fees in primary education (around 7500 FCFA) or the annual consumption of meat for two adults. As the observed decline in purchasing price takes place for both cereals bought in the village as cereals purchased from external vendors, this suggests an overall strengthening of consumer bargaining power (Gross & Mees, 2016).

A rather surprising result at first is that the increased nutritional state has not taken place by an improved consumption or diversification of the diet. As the food access conditions due to the granary banks improved, an increase in the purchases and the quantity of cereals consumed was expected. In addition, savings on cereal purchases could be spent on the purchase of other foods, which is promoted by the granary banks by offering other food products. The presence of a granary banks however does not significantly alter food consumption, nor does it increase food purchases, nor does it contribute to a more diverse diet. The impact on the daily ratio of cereals is zero or even slightly negative. Dietary diversification indicators did not react to the presence of a granary bank either (Gross & Mees, 2016).

The paradox between the improved nutritional state and no improvements at all in consumption patterns or diversification of the diet could be considered as follows: better nutrition mechanisms without changes in food consumption can be explained by the lower effort that needs to be devoted to collect grain, increased consumption of other nutrition-related goods such as health care or medication, or buying better quality cereals. However, they could be insufficient (the lower effort needed) or unconvincing in this context (health care or quality of cereals). Another plausible

explanation is that the program reduces the market risk (price and availability), which brings serenity to the people, reduces stress and increases their nutritional well-being (Gross & Mees, 2016).

As such the explanation could lie in a smoother pattern of consumption, as purchases can be done temporarily. While reducing the market risk, the presence of a granary bank allows families to delay purchases or, equivalently, reduce their grain storage. It is found that the families of the treatment group villages make fewer purchases before the depletion of their stocks. Stories told during the presentation of the initial results in the villages themselves, suggest that delaying purchases could prevent a less favorable distribution of food consumption. The program seems to limit the cost of these pressures (Gross & Mees, 2016).

One important note about the results in the impact evaluation study of the granary banks on the nutritional state is that the impact of the presence of a granary bank does not only affect the users of the granaray bank, but the whole village community. As other vendors are required to adapt their prices to the advantageous purchase conditions offered by the granary banks, this indirect effect affects non-granary bank users as well. Moreover, the most vulnerable populations benefited most from the presence of a granary bank in the village. Even more interestingly, it is mainly the families of the most isolated villages (no roads nearby, market or grain sellers) who have benefitted. The presence of a granary bank seemed to be even more relevant when access to food is worrisome (Gross & Mees, 2016).

2.6. Expected results

In line with the results in the previously described impact evaluation study done on the nutritional state of the population, a more pronounced effect on health and education of children is expected in the most isolated villages and the poorer families. Generally, it is expected to find an impact on the whole population in the treatment village, not only on the users of the granary banks. No clear expectations exist about the gender effect, given no results were found in the meta-analysis by Glewwe and Miguel (2008). However, as Table 1 has indicated worse consequences of malnutrition for girls, the impact of the granary banks in this study will be differentiated for between boys and girls to examine a potential gender effect. Based on the results found in the study on the nutritional state of the population, the three main expected mechanisms through which health and education might see an improvement could be (1) a lower susceptability for diseases due to the increased nutritional state, (2) an increase in the time available due to easier and closer access to food, and (3) a higher purchasing power of the population based on price reductions. Smoother consumption patterns might also have an influence on potentially better health and education outcomes due to the program. These channels will be carefully considered while analysing the results of the program on health and education among children in the villages under study.

Chapter 3. Methods

3.1. Randomized Control Trial

Following the suggestions by Berhman (1996) and Glewwe & Miguel (2008) and to deal with problems of self-selection and internal validity, this study is based on the implementation of a randomized control trial. This impact evaluation study of granary banks on the health and education makes use of the same data as collected for the study on the nutritional state of the population. As has been described in the previous section, out of 400 eligible villages 40 villages were assigned to the program. Half of these were randomly selected to receive a granary bank (treatment group) during the 2011-2012 agricultural cycle and half of them served as a counterfactual (control group) that did not receive a granary bank. By randomly assigning a control group, the simple difference between the two groups represents the impact of the program, as the control group is the representative of the situation that would have prevailed in the beneficiary group in the absence of the program.

Tabel II. Village characteristics at base year level (2010-2011)

	TREATMENT VILLAGES (T)	CONTROL VILLAGES (C)	DIFFERENCE (T-C)
Number of villages	20	20	0
Number of inhabitants	2350	2084	266
Accesibility			
Distance to the closest town (km)	16,65	13,5	3,15
distance to the furthest family center (km)	2,85	2,9	-0,05
Groomed trail in the village (%)	60	60	0
Closest road to the village (km)	7,88	10,62	-2,74
Occassionally inaccessible (%)	40	50	-10
Transport costs for bags of cereals (FTFA)	571,05	777,78	-206,73
Infrastructure			
Electricity (%)	15	15	0
Large diameter wells (number)	5,15	4,68	0,47
Barrage (%)	55	43	12
Primary school (%)	100	100	0
Primary schools (number)	1,5	1,85	-0,35
secondary school (%)	30	30	0
Health center (%)	60	40	20
Nurses (number)	3,4	7,75	-4,35
Mosk (number)	2,4	2,8	-0,4
NGO project (number)	1,92	2,27	-0,35
Activity			
Rice culture (%)	35	45	-10
Gardening (%)	45	35	10
Artisanal gold mining (%)	58	65	-7
Closest artisanal gold mining site (km)	12,16	9,53	2,63
Business			
Market in the village (%)	50	50	0
Distance to the closest market (km)	7	6,7	0,3
Shops (%)	5,85	4,55	1,3
Cereal vendor (%)	80	80	0
Permanent cereal merchant (%)	30	35	-5
Temporal cereal merchant (%)	60	60	0
Shopkeeper vendor of cereals (%)	40	35	5

* p<0.10, ** p<0.05, *** p<0.01

However, for randomized control trial experiments to be effective, it is necessary that both village and population characteristics do not significantly differ at their baseline, that be before the implementation of the program. Based on preliminary surveys in the agricultural cycle 2010-2011 (considered as the base year) Table II indicates the most important characteristics and the difference between treatment and control villages (T-C).

As is clear from Table II, treatment and control groups do not significantly differ in village level characteristics or in their population, making the comparison between treatment and control group villages to measure the impact of the program valid.

Throughout the analysis the data will further be carefully examined in all possible dimensions to account for differences that still might exist by chance. The evaluation method thus combines the random assignment of villages with the operation of data before and after the implementation.

3.2. Data collection

The database that is used is an original database designed for the primary purpose of assessing the impact of the granaray banks within the program. Collecting data has been done through questionnaires administered at the village, household and individual level. The administration of the questionnaires was carried out by a small number of specially trained investigators. Some of these investigators have even participated in all phases of the collection. Additionally, university researchers continuously insured a close supervision of the work of investigation and a systematic control of field surveys. The inquiry device has raised very precise and extremely reliable data on the situation of villages and population of the project area. Hence data was collected on topics broader than only the nutritional state of the population.

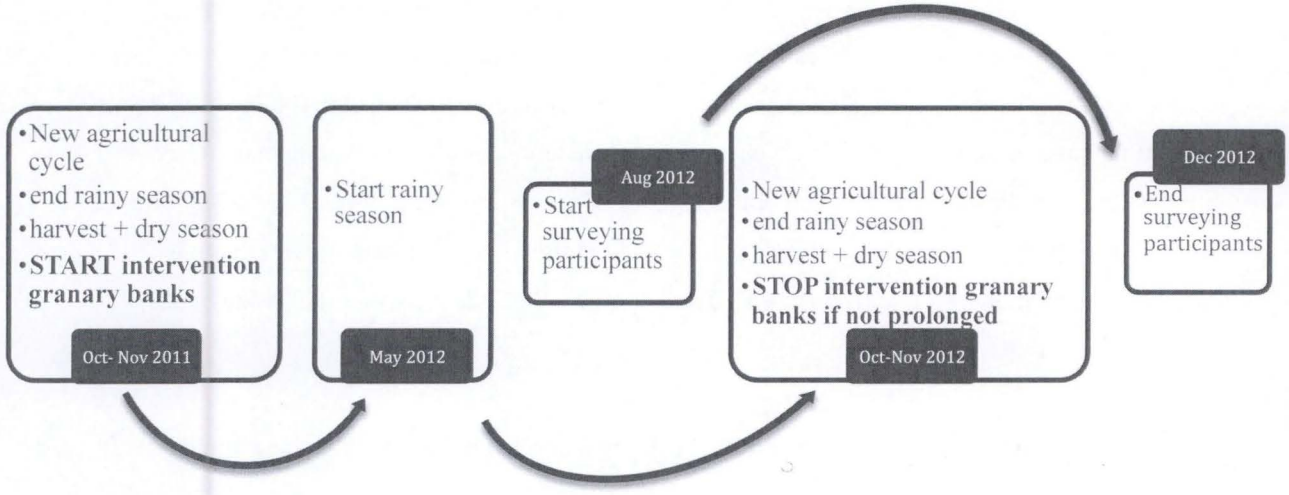
Ten households per village were interrogated, meaning in total in treatment and control villages information on 400 households has been collected for the impact evaluation assessment. The ten households represent on average a little less than 5% of the total population of each village. These households were randomly selected mostly from census lists obtained from local administrative authorities. For data on children, the responsible caregiver answered the survey. In most cases this was the mother, but sometimes this was an aunt, grandmother, etc.

The same households were followed over several agricultural cycles in order to compare panel data in which the baseline situation is compared with post-intervention data. Concretely the sample households were visited five times in the course of the agricultural cycles 2010-2011, 2011-2012 and 2012-2013. Three of the five phases of collection occurred at the end of each agricultural cycle and the other two occurred before the rainy season in the first and last period. All villages were visited in

every phase of the collection, of which only less than 2% of households could not always be surveyed. The attrition rate at the household level was very low so the total database resulted in a balanced panel, which covers a wide range of useful data across the three agricultural cycles concerned.

The specific data used to measure the impact of the program has been collected between August and December 2012, meaning half of the respondents were still in the last months of the rainy season, preparing for the harvests, whereas others had just started the next agricultural cycle at the time of the survey. The granary banks had been implemented for a minimum of 9 months at the time when the first participants were surveyed. Many of the questions in the survey refer to the health situation of the children in the last rainy season, meaning – more or less - the past three months. We can expect the health situation and food deprivation to be worse in this period, as it marks the end of the agricultural cycle. This means less food is available; and additionally to that children are more vulnerable for infections in rainy season. For an overview of the timeline of the agricultural cycle and the surveying period, see Figure II.

Figure II: Timeline of the agricultural cycle 2011-2012



3.3. Research design

Concretely, to analyse the impact of the food security program on children's health and schooling, different dependent variables related to the health situation and one variable related to schooling of children between the age of zero and six and between six and 18 are included. The analysis contains measures of the general impact of the granaray banks on the entire children's population, with and without control variables. Additionally, also the partial impact and heterogenous effects are looked at. Concretely, the study focuses on several dimensions, referring to individual, family-level or village-level characteristics. On the individual level, the analysis looks at gender and

age effects. At the level of the family, vulnerability in terms of expenditures is examined. At the village level, vulnerability is measured by means of physical isolation and economic isolation.

3.3.1. Dependent variables related to health and schooling

The impact of the program is measured separately among children zero to six years old and six to 18 years old, given hugh differences in health and education between these age categories. Within the sample six to 18 years old, results will also be examined across children six to 12 years old to be able to ascribe the impact to a more specified age category.

For children between the age of zero and six, the following six variables are analysed as dependent variables related to health: the moment of last diarrhea (one month, two months, or three months ago) (1), the duration of last diarrhea (in days) (2), whether the child showed symptoms of stomach ache (3), vomiting (4), fever (5) and coughing (6) during the last rainy season (all dichotomous). As the question refers to the prevalence in the last rainy season, it means it covers a timeframe of the last three months; not the full agricultural cycle. For the effect across age groups, four age groups were created: (1) younger than six months, (2) between six months and two years, (3) between two and four years, (4) between four and six years old.

For children older than six, the following six variables are analysed as dependent health variables: whether or not the child got sick during the last rainy season (dichotomous) (1), whether the child showed symptoms of diarrhea (2), fever (3), respiratory disease (4), stomach ache (5) or vomiting (6) during the last rainy season (all dichotomous). Again here, the questions related to health refer to the last three months only. Four age groups were created: (1) older than six years and younger than or nine years old, (2) older than nine years and younger than or 12 years old, (3) older than 12 years and younger than or 15 years old, (4) older than 15 years and younger than or 18 years old. The result is always first described for the whole database of children between six and 18. Whenever different results are found for the subsample of children between six and 12 years old, these will be discussed as well.

To look at the effect of the program on schooling among children, a sound analysis would require at least two dependent variables related to schooling. However, interpretation biases at the time of the surveying rendered the variable 'going to school this year' unuseful for this purpose. Therefore, ony one variable ('having ever attended school') will be included in the analysis. Whenever a child has attended school for at least one day, the answer on this question should be yes. The results found will be further complemented by relevant information from other non-biased available data, thereby partly presuming the impact on schooling.

3.3.2. Independent variable and heterogeneous effects

The independent variable in all cases is the dichotomous variable whether or not the child lives in a treatment or in a control village. For the general impact of the program, also covariates are included. These control variables include personal characteristics (age, sex), survey data (date of survey, month of survey, and variables related to health/schooling/work (for older than six years); health/breastfeeding (for infants).

To look at heterogeneity within the results, individual characteristics, family-characteristics and village characteristics are differentiated for. For individual characteristics, the impact is measured across sex, and across age (based on the age categories as mentioned above). Heterogeneity across family- and village characteristics has been interpreted as measures of vulnerability.

For vulnerability at the family-level, the impact of the program is differentiated across levels of wealth, based on a family's place within the distribution of general and food expenditures of the population. Families with high absolute expenditures/capita are supposed to be families with higher standards of living and vice versa. A distinction is made between general expenditures and food expenditures. Food expenditures refer to the capacity to generate the necessary resources to buy basic alimentaries. The poorest families, which are usually based on measures of income/capita are also the ones having the biggest difficulties to acquire basic food products on the market. As food expenditures typically are better reported than income/capita, the distribution of food expenditures is used instead of income/capita as a proxy of wealth and vulnerability.

At the village-level, vulnerability is measured across two different variables: physical accessibility and economic integration. Physical accessibility is measured whether or not villages have a road in the proximity. Economic integration is based on whether villages have a local market organised on-site. In the case where a village does not have a road or a market, families have higher difficulties and need to invest more time and money to acquire food products. This makes them more vulnerable, especially in times of food scarcity and during rainy season, when passages might be blocked due to floods.

3.4. Data analysis

Data has been analysed in Stata 13.0. Statistical analysis to measure the impact of the program on health and education in comparison to the control group included Ordinary Least Squares regressions (including control variables for the general impact). Additionally, interaction terms have been included to look at the differential impact across the various levels of heterogeneity. The interpretation of the results (general and heterogenous effects) in chapter four is based on both the data

from the linear regression models and the interaction tables. To further discuss and interpret results, Pearson correlations have been used to look at the relationship between various measures. The lowest statistical significance is set at $p<.1$, but higher statistical significant values are signalled in the data as well.

In the following chapter, the results of the statistical analyses will be outlined.

Chapter 4. Results of the analysis

4.1. Health

4.1.1. Children younger than six years

1. General effect on health

Granary banks do not have a significant general impact on the health variables included in this study (Appendix I). When control variables such as sex, survey date, age, and other health variables are included however, a positive significant effect is found for the moment of diarrhea (.098 with $p<.1$). The mean in the control for moment of diarrhea is 2.579, meaning that on average children have had their last moment of diarrhea two months and 17 days ago. The program seems to increase this last moment of diarrhea with almost three days for children in treatment villages, which signifies a relative impact of almost 4%.

2. Heterogenous effects

A delay in the moment of last diarrhea for boys

The impact of the program across sex shows an equal positive effect on the moment of last diarrhea only for boys (.201 with $p<.1$). For girls a much smaller positive non-significant effect is found. The difference in the impact of the program on boys and girls is almost significant (.185 with $p=.111$). Boys however have a natural disadvantage, as they had diarrhea more recently than girls (-.215 with $p<.01$) in the absence of the program. As boys in the control group on average had diarrhea two months and 14 days ago (2.472), the program prolongs this with 2.5 days. The relative impact of the program on boys is therefore 8,1%.

This could be (partially) explained based on breastfeeding practices, as only 36.15% of the boys under six were breastfed for longer than 3 months, compared to 38.90% of the girls. Moreover, 8.41% of the boys were given something else than breastmilk, whereas this number is only 6.21% for girls. Theories suggest that children should be breastfed continuously during the first six months of their lives, and ideally until the age of two to be prevented from infectious diseases, of which many cause diarrhea. The fact that mothers in Burkina Faso tend to breastfeed their girls longer and more often than boys might be part of the explanation why boys naturally have suffered from diarrhea more recently. This might refer either to a longer duration of episodes of diarrhea than girls, or they might suffer from diarrhea more frequently. The fact that the program almost makes up for this difference can be attributed to this general disadvantage. Given the easier access to food and a probable smoother consumption pattern due to the program, disadvantaged boys had most of the benefits, making them less vulnerable to suffer from diarrhea.

A second argument could be derived from the reduction in the price of sorgho due to the program. As the price was reduced by almost 8%, households in treatment villages had at higher purchasing power. As all of the treatment villages have minimum 2 and maximum 6 health practicioners in their village, the increased budget might have been used to buy medicines in favour of boys compared to girls.

No valid impact across age

Analysing the impact of the program on the same health variables across age, the only significant effect is found in the age group of children younger than 6 months on the variable *symptoms of vomiting* (.0789 with $p<0.1$). However, as none of the children in the control group ever had to vomit during the last agricultural cycle, and the impact of 7.8% points only accounts for 3 children in treatment villages, no valid conclusions can be made here.

Almost 50% reduction of stomach pain in badly accessible villages

The physical accessibility of the villages is measured by the presence or absence of a road in the proximity of the village. Although the interaction table doesn't show significant results, OLS regressions indicate that in control villages, 23.3% of the children between zero and six in villages without a road suffered from stomach pain in the past agricultural cycle. In the same badly accessible villages in the treatment group, the share of children with stomach pain almost halves (-.104 with $p<.05$). The program thus has a relative effect of almost 50% in reducing the prevalence of stomach ache in children from villages which are difficult to access. The average prevalence of stomach pain in the control group for villages with a road is 23.66%, however the impact of the program is negligible.

Stomach pain is also one of the symptoms of infectious diseases, and therefore often coincides with diarrhea. It is also a symptom of being underweight. Villages in the absence of a road concern 40% of all 40 villages included in the study. These villages on average are located further away from the district town and are more isolated from any type of social, economic and health services. In the absence of good infrastructure, sanitary conditions in such villages might be worse compared to villages with better accessibility to the services found in the district town. The building of a modern well for example might be easier in villages with good road accessibility. In that sense, children in villages without a road in the proximity might be more susceptible for infectious diseases compared to villages with better accessibility and better general infrastructure.

Although in this study an equal share of people use a traditional well in villages with and without a road (18.17% and 18.79% respectively), villages with a road generally have more boring

wells available than villages that are harder to access. Whereas in villages without a road 36% of the population only have 1 boring well at their disposal, with a maximum of 9 boring wells in one village, only 13% of the population have 1 boring well available in villages with a road. In these better accessible villages, one in four of the villages have 10 or more boring wells available. This confirms the hypothesis that people in villages with a road in the proximity live in better sanitary conditions. Hence, the presence of granary banks can have a more profound impact in more isolated villages, as the enhanced nutritional state of children between zero and six years might prevent them from catching infectious diseases stemming from bad sanitary conditions.

Another possible explanation is the idea that in very isolated villages without the presence of granary banks, mothers have to walk to the closest town to buy food products. During their absence, infants can not be breastfed, which might make them more vulnerable in the long run for different types of diseases. Granary banks prevent this to happen, as mothers do not have to leave home as frequently, which benefits the mother-child relationship and leaves more time for infants to be breastfed: a win-win situation with possibly very positive health benefits in the long run.

Episodes of diarrhea are delayed in the poorest half of the population

In terms of the distribution of general expenditures per capita, the program has a positive effect on the moment of last diarrhea for households below the median in the distribution (.188 with $p<.1$). The mean in the control group for people belonging to this share below the median in the distribution is 2.538, which indicates that on average children had diarrhea two months and 16 days ago. The program delays the moment of last diarrhea with 7.4%, meaning on average the program has postponed the last moment of diarrhea with almost 2.5 days. On the contrary, the impact of the program for households belonging to the upper half of the population in terms of general expenditures is negative and non-significant. The differential impact of the program is significant (.201 with $p<.05$) and in the benefit of the most vulnerable ones.

When the distribution of expenditures is specified to food expenditures only, a similar but stronger effect is found on the moment of last diarrhea. The program significantly delays the moment of last diarrhea for children from families belonging to the share below the median in terms of food expenditures per capita (.232 with $p<.05$). As the mean for the moment of last diarrhea in the control group of children belonging to this lower share of the food expenditure distribution is two and a half months ago, the relative impact of the program is slightly higher than 9%. It delays the moment of last diarrhea for children in treatment villages with almost three days. As the program has the opposite effect on children from families above the median in the distribution of food expenditures, there is a

highly significant differential impact of the program in the benefit of the most vulnerable (0.296 with $p<.01$).

The effect in both general and food distributions can be understood in terms of an increase in purchasing power. People with a low disposable income might benefit most from the increase in their purchasing power resulting from the reduced price for one bag of sorghum. The additional disposable income might be destined to purchase medicines, which would not have been possible in the absence of granary banks. Wealthier families on the other hand arguably are able to purchase medicines anyway, irrespective of the presence of a granary banks. The size of the effect is almost twice as big for households at the lower half of food expenditures as the measure of absolute food expenditures is a better predictor of the overall level of wealth than general expenditures.

An unexpected result is found on the prevalence of fever across households belonging to the lowest quarter in terms food expenditures. A significant differential increase is found in the prevalence of fever compared to households not belonging to this quartile (.145 with $p<.05$). In the control group of children belonging to the lowest quartile slightly more than half of the children (52.8%) have experienced fever. In the treatment group, the share has increased by 11.8% attributing a relative impact to the program of 22.3%. On the contrary, the program seems to reduce the prevalence of fever in households not being part of this first quartile by little, who naturally have a higher prevalence of fever (56,1%). However, the result is non-significant. Hence the program has an adverse effect for fever amongst children from the most vulnerable families, although they naturally have a slight advantage. The impact on the prevalence of fever for households belonging to the lowest two quartiles instead of the first quartile is negligible and non-significant.

4.1.2. Children between six and 18 years old

1. General effect on health

For children between six and 18 years old, the food security program does not have any basic significant effect. When including control variables (such as age, sex, whether or not they attended/went to school, whether they have income generated activities or whether they have other types of diseases), a significant reduction in the prevalence of stomach ache is found (-.0298 with $p<.01$). On average in the control group, only 7.3% of the children suffered from stomach pain in the past agricultural cycle, so the program contributes to a relative reduction of almost 40%, which is very high. The same result is a lot more striking in the subsample of children at primary school-age: amongst them almost 9.7% in the control group suffers from stomach pain, but the program decreases

the prevalence with a relative share of 50.2%. The program halves the prevalence of stomach pain. Similarly, an effect is found on the prevalence of fever among school-age children. On average in the control group 23.7% suffered from fever in the past agricultural cycle, but the program leads to a relative reduction of 26% (-.0679 with p<.1). A similar effect and relative size is found when covariates are included.

As described in the literature, fever is a very prevalent symptom of disease or disease itself among children at primary school-age and it is found to be very prevalent in Northern Burkina Faso. The result in this study confirms this: in the control villages for children aged six to 12, almost one in four had had episodes of fever in the last agricultural cycle. Compared to the other types of diseases included in this study, it is by far the most prevalent symptom of sickness across children in this study. As this prevalence is quite high, and as fever is highly contagious, a relatively small improvement in the nutritional state or increase in medical expenditures as a result of the program might profoundly reduce the prevalence of fever on the subsample in general. For stomach pain, the result is a bit more difficult to analyse, as the prevalence is low in control villages as well. Let's first of all look at the impact across sex.

2. *Heterogenous effect*

Reduction in fever, stomach ache and respiratory disease for girls only

Analysing the partial impact of the program on girls and boys yields interesting results: the program only benefits primary and secondary school-aged girls. Boys generally suffer less from diseases than girls. In the control group, the prevalence of boys on almost all health variables is lower relative to girls'. Boys must either have a natural immune system that is stronger around primary school-age compared to girls', or parents prefer to invest in medical expenditures and health practices for boys rather than for girls, as investment in boys yields higher returns. The latter has been well studied in theories of intra-household inequality (Sen, 1995; Iversen, 2003).

The impact of the program on girls might be rationalized based on this natural disadvantage they have. Concretely, the program seems to reduce the prevalence of respiratory disease for girls ranging from six to 18 years old. Whereas in the control group 9.4% of girls had respiratory disease symptoms in the last agricultural cycle, the program more than halves this share (51%) of girls in treatment villages (-.0488 with p<.1). The program for boys on the other hand increases the prevalence of respiratory disease, bringing about a significant difference between boys and girls due to the program (.0662 with p<.05). Girls in treatment villages thus suffer less from respiratory disease than boys. The program completely reverses the natural advantage of boys vice versa girls.

When only the subsample of primary school-aged children is considered, the size of the reduction in respiratory disease for girls practically remains the same, but the result is non-significant. However, the differential effect of the program between boys and girls remains significantly large, maintaining the reverse effect for boys and girls compared to the control group. But girls in this subsample benefit from two more health-effects: The program signifcanlty wipes out the natural advantage for boys compared to girls for the prevalence of fever and stomach pain. The relative impact of the program on the reduction of fever for girls amounts to slightly more than 36% (from 27.6% in the control group to 17.5% in the treatment), whereas for stomach ache the contribution of the program even rises to a reduction of almost 59% (from 12.4% in the control group to 5.09 % in the treatment). Although the program also seems to lower the prevalence of fever and stomach ache for boys in this sample, the result is small and non-significant.

The fact that the program only has a positive impact on the health measures for girls can most likely be ascribed to the fact that girls are disadvantaged in the absence of the program compared to boys. An increase in the nutritional state as a direct result of the program might therefore first and foremost benefit the most disadvantaged, reducing the gap between the initial health situation of boys and girls. Another hypothesis is that the sudden increase in families' purchasing power has been used for medical expenditures for girls, as they are sick more frequently. One can think of buying medicines from the healthcare practicioner in the village, or faster hospitalization in the nearest town in very advanced cases as transport costs might now be more easy to cover. Or perhaps the increased purchasing power might be directed to the improvement of sanitary conditions, which favours girls more.

It is no co-incidence that the same strong reduction is found for fever, respiratory disease and stomach pain. Fever can be a symptom of many different diseases, ranging from non-dangerous viral infections causing a few days of fever to life-threatening diseases caused by untreated innocent infections and poor sanitary conditions (WHO, 2001). Besides this, fever also occurs as one of the many symptoms of diarrheal disease and respiratory diseases (WHO, 2001). Respiratory diseases are the main cause of death among school-age children in developing countries. It is usually caused by tobacco smoke – including passive smoke exposures -, tuberculosis or indoor air pollution resulting from the smoke from fires used in heating and cooking. In fewer cases, also obstructive pulmonary disease, lung cancer, or respiratory cancer (Ferkol & Schraufnagel, 2014) cause respiratory disease.

A hypothetical additional explanation for the reduction in prevalence of this disease could be that the increased disposable income has been used to improve sanitary conditions and cooking facilities within the households. As girls are in or around the house more frequently than boys, such

improved conditions could explain the benefits of the program on girls only. However, too little information is available to justify this argument.

Regardless the exact cause for the reduction in the prevalence of respiratory disease, fever or stomach ache, they certainly mutually reinforced a further reduction. After all, the correlation between fever and stomach pain is 37.35 for the whole sample size of children between six and 18, and even 42.12 for for primary school-aged children. The correlation between fever and respiratory diseases accounts for 39.45 and 39,13 respectively, whereas the correlation between respiratory disease and stomach pain is 27.77 and 30.91 respectively. These very high correlations (especially for fever) confirm that the three symtoms often co-occur and are interrelated with each other.

The strongest reduction for fever among the youngest primary school-age children

Examining the impact of the food security program across different age groups, a relative reduction of almost 29 % in the prevalence of fever is found on children between six and nine years old, going from 29.68% of the children in the control group to 21.15% in the treatment group (-.0853 with $p<.05$). The benefit of the first age group comes at a cost for the age group between 12 to 15 years old. Although these children have the lowest natural prevalence of fever across all ages (18.35%), the program seems to increase the prevalence of fever in this group (non-significant), up to a difference with the first age group of 10.1 percentage points (.101 with $p<.05$). Despite non-significant results, on all other health variables the strongest reduction in prevalence is found on the first age group as well (except for diarrhea).

Vomiting also increases as an effect of the program from 3.6% in the control group to 6.3% in the treatment group for children ranging nine to 12 years old, leaving a significant different impact of the program (.0425 with $p<0,1$) with the first age group, where the prevalence of vomiting decreased (non-significant).

The highest reduction on all health variables (significant and non-significant) is found across the youngest children aged six to nine. These children are the most vulnerable as they systematically have a higher prevalence of all diseases in the control group compared to older peers. Given their less developed immune system and bodily functions compared to older peers, they are more vulnerable to catch diseases. Hence the program benefits the most vulnerable.

Significant reduction of stomach pain and fever in physically isolated villages

Physical accessibility does not have any differential effect on the health variables for children between six and 18 years old. Nevertheless it is unexpected that regardless of the program living in difficult accessible villages makes children suffer less from all types of diseases. The difference with the prevalence of diseases in villages with a road is even significant for diarrhea, fever and stomach ache (-.0208 with $p<.05$; -.0805 with $p<.1$; -.0408 with $p<.1$ respectively). The number of observations of children who suffer from diarrhea however is too low (25) to make any valid statements.

When only the subsample six to 12 years old is considered, a significant reduction is found for stomach pain in villages with a road (-.0547 with $p<.05$). As on average in the control group the prevalence of stomach pain is 11.80% for villages with a road, the program has a relative impact of slightly more than 46% for children living in these well-accessible villages. In badly accessible villages the prevalence of stomach pain is also reduced (-.037 with $p<.1$). As in the control group for these villages, only 6.46% have suffered from stomach pain, the relative impact of the program is even higher: 57.2%. Hence, the highest impact is found on the most vulnerable in terms of accessibility, even though children in these villages without a road already have a natural advantage compared to their peers in villages with a road.

Despite a very strong natural advantage for children in villages without a road in terms of suffering from fever (-.094 with $p<.1$) compared to villages with a road, the program also has the strongest impact on this group (-.0829 with $p<.1$). The prevalence of fever for children in badly accessible villages therefore has decreased from 20.4% by a relative share of just more than 40%. Fever is also reduced in well-accessible villages, but by less and without significant results. Hence, again the program benefits the most vulnerable in terms of accessibility, notwithstanding a natural advantage compared to peers in villages with a road nearby.

The reduction by the program of fever can be understood based on the high prevalence of fever in general: 22.58% across all children aged six to 12. Hence, if the program has an effect on the general health of children, it's evident the prevalence of fever reduces first. Stomach pain is correlated relatively high with fever (.417). A reduction in the prevalence of fever might thus reduce stomach pain simultaneously.

As for many illnesses primary health care is the best treatment, it could be hypothesized that due to the increased purchasing power and the fact that mothers are at home more frequently (as a result of closer access to food, which especially has an impact in villages without a road) parents now prioritize the health situation of their children. If a child is sick in an advanced stadium, the higher

purchasing power might be used for transport costs to the nearest hospital, which might have been infeasible without the program. Moreover, the simple ameliorated nutritional state due to the program can protect children physically against catching up diseases, which has a bigger impact in isolated villages than in accessible villages where other measures of treatment are more evident.

What remains striking and unexpected however is the natural advantage on all health variables in villages without a road.

Strongest reduction of stomach pain and fever in villages without local markets

Across the sample of children between six and 18 years old, no significant heterogenous impact is found across levels of economic integration. Whether a market is present or not in a village does not alter the health situation of children. However, in the subsample of children at primary school-age, a significant reduction on the prevalence of stomach ache is found for children living in villages with and without a local market (-.044 with p=.1 and -.0526 with p<.1). For children in villages with a market, in the control group 9.48% has suffered from stomach pain and the program leads to a reduction of almost 47%. For the villages without a market, 9.85% had been suffering from stomach pain in the control villages, whereas the program reduces this by slightly more than 53%. The biggest impact is therefore found on the most vulnerable ones, who were also disadvantaged (non-significant) from the beginning. It has to be acknowledged that the differential effect between both is small and non-significant.

Also fever has been reduced significantly in villages without a market, although this is not significantly clear from the interaction table. Although children in such villages start with an advantage compared to their peers in villages with a market (2,77% points lower prevalence of fever in the control group), the only significant impact is found on this group of children in villages without a market as well. The prevelance of fever in this control group is 24.81%. The program reduces this share significantly by almost 39% (-.096 with p<.05), thereby increasing the gap in the prevalence of fever between children living in villages with and without a market.

Similarly to the results on the health situation of children across physical accessibility at the village level, the most vulnerable benefit most from the program, even though in terms of fever they already start with a natural advantage compared to peers from villages that do have markets available.

Strongest reduction of stomach pain for children in 75% of families with highest general expenditures, who are naturally disadvantaged

To look across vulnerability at the family level, results across general expenditures and food expenditures are analysed. A distinction is made on both measures between belonging to the lowest quartile or belonging to the two lowest quartiles in the distribution. On the big sample including all children, one significant effect is increase in the prevalence of vomiting for children from families not belonging to the first lowest quartile in the distribution of general expenditures. However, as with previous results found on fever, the general prevalence and number of observations is too low to take this result into account. No results are found across the lowest 2 quartiles of the distribution.

Across the subsample of children aged six to 12, an additional impact is found: the program seems to reduce the prevalence of stomach pain for children from families belonging to the top three quartiles, excluding the first quartile. In the first quartile, the program also reduces stomach pain, but by less. As the mean in the control group of the top three quartiles is 11.1%, the program has a relative share in the reduction of almost 55%. However, children from families belonging to the lowest quartile in the distribution of general expenditures start with a hugh natural advantage as the mean in the control group for these children only amounts to 5.55%. The program does not have an effect that is strong enough to reverse this natural advantage for the most vulnerable group.

When the impact is considered across children below the median and over the median of the distribution, a more or less equal impact is found on the highest two quartiles, as stomach ache is reduced by 57% (from a prevalence of 11.16% in the control group for families higher than the median in the distribution to 4.78% in the treatment group). Across this distribution, the program leads to a reverse in the natural advantage of the lowest half: children from families in the top half of the distribution of general expenditures are generally better off after the intervention.

Significant reduction of stomach pain for children in 75% of families with highest food expenditures, who are naturally advantaged

When the expenditures are specified to food expenditures only no significant effect is found on the entire sample of children. But when only six to 12 year olds are taken into account, the program seems to significantly reduce the prevalence of stomach ache for children in families belonging to the top three quartiles (-.0386 with $p<.1$). The mean prevalence of stomach pain in the control group for these 75% least vulnerable families is 8.57%, meaning the program has a relative significant impact of 45%. Although the program seems to establish a much bigger reduction (62%) for stomach ache on

children from families that do belong to the lowest quarter and that are moreover disadvantaged naturally compared to their peers in the top three quartiles of the distribution (13.27% prevalence in the control group), this result is non-significant.

There seems to be a difference in the natural prevalence across the distribution of general expenditures and food expenditures. Children from families in the lowest quartile in terms of general expenditures naturally have a lower prevalence of stomach ache compared to children from families with higher general expenditures. On the other hand, children from families belonging to the lowest quartile in terms of food expenditures have a higher natural prevalence of stomach ache compared to children from families with higher food expenditures. As food expenditures are usually considered a better measure of a family's wealth, children from the poorest families start with a disadvantage: they suffer from stomach ache more frequently compared to richer families.

For these poorest families, in which children naturally have a higher prevalence of stomach ache, the program seems to reduce the prevalence by much, but the result is non-significant. The only significant reduction due to the program is found on children belonging to richer families.

In terms of general expenditures, the program also has the biggest significant impact in reducing the prevalence of stomach ache for children belonging to families in the top 75% of the distribution. However, here, these children start with a disadvantage. The program thus has the highest impact on children who are suffering most at the baseline.

4.2. Schooling

4.2.1. Children between six and 18 years old

1. General effect

No general effect is found on the measure of schooling, regardless which sample or subsample is used.

2. Heterogenous effect

Boys have attended school more than girls

Across sex, no big difference is found between the attendances in school in the control group. Boys have a small advantage in the sample of children aged six to 18 (non-significant), but in the subsample for children aged six to 12, the difference is negligible. This means boys have a slightly higher chance to continue secondary school than girls, whereas no gender discrimination takes place in primary school. As it is widely believed that the value of return for investment in boys is higher than investments in girls, parents probably allocate more resources to boys' further schooling careers than for girls'. The program however elicits a significant difference between the two sexes in both samples: It increases the attendance for boys only (.112 with $p<.05$ for children six to 18; .144 with $p<.05$ for children six to 12). In both samples, also the attendance of girls is increased, but by very little and the result is non-significant. As the mean in the control for boys in the entire sample amounts to 65.3%, the program has a relative impact of 17.15 % on boys. For the subsample until the age of 12, the mean in the control is 66.2%. The program thus has a relative impact of 21.7%.

As the impact on the measure 'having ever attended school' is large, it must be that at the time of the intervention more boys have been sent to school in treatment villages. A plausible hypothesis could be that the higher purchasing power as a result of the program (e.g. on average the equivalent of 5 school enrolment fees) made parents decide to enroll their boys at school. However, as enrolment at school for the year of the intervention took place in October and the program was implemented around that time or a few weeks later, and moreover good data on official enrolment rates at the time of the intervention are not available, this hypothesis cannot be analysed.

Another hypothesis is that due to the advantages of the program, more time has been available for children to go to school. As in the rural Sahel children are often employed in the household, work on the field or have an additional income-generating activity to contribute to the family's income, the program might decrease this necessity hence leaving more time for school. Data on children who have an income-generating activity does not support this hypothesis however. Both in control as in treatment villages for the sample of children six to 18 years old only around 2% of the girls earn an

income, whereas this is around 5% for boys. In the subsample for children until the age of 12, the share of the children working follows the same line as in the entire sample, but it is even smaller. The program does not have a significant effect on whether children earn an income or not.

As for working on the field, the program seems to increase the share of children who work on the field rather than decrease, as what would have been expected following the hypothesis. In the control group of the subsample six to 12 year olds 54% of the girls work on the field, whereas this is 66% of the boys. The program seems to increase the share by around 2% for boys and around 3% for girls, although the result is non-significant. For the bigger sample including children at secondary school too, 74% of boys work on the field, whereas this is 60% for girls. Despite non-significant results, the program here seems to increase the share of girls working on the field by more than 6%, whereas for boys the increase amounts to 1.2%. Again, this runs contra the previously stated hypothesis that the program might lead to abundant labor and consequently higher school attendance. It seems that boys in treatment villages tend to combine earning an income or working on the field with attending school much more than their peers in control villages.

Although the explanation is rather suggestive, the data clearly shows that the program leads to a significant positive discrimation towards boys in terms of school attendance. Regardless the underlying cause for the rise in the attendancy rates, parents seem to prefer to invest in boys' education, given their perceived better return to investment.

Strongest increase in attendance for age category nine to 12 years old

The program has the strongest impact in the age category nine to 12 years old. As on average in the control group 74.09% of children between nine and 12 have gone to school at least once in their life, the program seems to increase this share (.1128 with $p<.05$) relatively with 15.22%.
Looking at the differential effect for working on the field between boys and in this age category, a large discrepancy is found: despite a non-significant result, the program seems to increase the share of girls in the age group nine to 12 years old that work on the field by 13.12 percentage points (almost significant) (from 65.25% in the control villages to 78.37% in treatment villages), whereas for boys the share is only increased by 2.41% points (from 78.43 in the control villages to 80.84% in treatment villages). This result shows very well that the need for children working on the field in treatment villages is higher than in control villages and that parents prefer to assign their girls to field work whereas boys are more likely to be send to school. Hence, the program tends to provoke a positive discriminiation of boys compared to girls in terms of choices of investments in human capital.

Highest impact on school attendance in the least physically and economically integrated villages

The program has the strongest impact on school-going behaviour across families in the most vulnerable position: both in bad physically accessible villages and in villages without a local market the increase in school attendance is large and significant. Just slightly more than half of the children in villages without a road on average have ever attended school in their life. This share is much higher in villages with a road: 73.6%. The program signifantly increases the school attendance rate by 17.90% points for children in villages without a road, being a relative increase of 35%. This is for the entire sample of children ranging from six to 18 years old. For the subsample of primary school children, the impact is even bigger: there just slightly less than half of the children in the control group from villages without a road in the proximity have ever attended school, whereas this share is 77.2% for children in villages with a road. The program again only benefits the most vulnerable and disadvantaged: it increases significantly the share of children who have ever attended school in villages without a road by 22.7%, a relative increase by the program of almost 47%. In villages with a road, a non-significant decrease in attendance rates was found in both subsamples.

The same result is found for economic integration: whether a local market is present in the village or not. However, here the difference between villages with and without a market is not as explicit as between villages with and without a road. In villages with a local market, 69.5% of the children have ever attended school, whereas this is 59.7% in villages without a local market. Whereas the program tends to decrease attendance (non-significant) in villages with a local market, it increases significantly the attendance rate in villages without a market (.149 with $p<.05$), being a relative increase of nearly 25%. In treatment villages, school attendance rate is now higher in villages without a market than in villages with a market: the initial disadvantage (non-significant) has been reversed completely. The differential impact of the program across both groups of villages is only significant when the entire sample of children between six and 18 years old is considered.

Given that more primary schools and more teachers are available to children in villages which are economically integrated and physically better accessible, the increase in attendance rates in vulnerable villages only cannot be due to an ameliorated access to schooling facilities within the village.

No impact across the distribution of family's expenditures

No heterogeneous impact is found across vulnerability at the household level (which is measured by the position within the distribution of expenditures)

Chapter 5. Impact analysis discussion

In this chapter, the results as described in the previous section will be summarized. Afterwards all results will be interrelated in a broad discussion. The aim is to generalize to what extent and through which channels a food security program based on the introduction of granary banks has the potential to improve the health situation and education of children living in subsistence-based families. It is important to note that the data, which will be used to support the discussion on channels, is suggestive and based on correlations, rather than a presentation of clear-cut causality.

5.1. Summary of results

In the following tables, the main impact of the program on health and schooling outcomes across different datasets is summarized:

Table III: The main impacts found on health among children younger than six years old

Main impact on health across children younger than six years old			
Measure	**Impact**	**Relative size (approximately) (%)**	**Naturally disadvantaged/advantaged/no difference**
Basic impact			
General impact + control variables	delay in moment of last diarrhea	4	/
Partial impact			
Across boys	delay in moment of last diarrhea	8	Disadvantaged
Across vulnerability at the family level			
< median of general expenditures	delay in moment of last diarrhea	7	No difference
< median of food expenditures	delay in moment of last diarrhea	9	Disadvantaged
< 1quartile of food expenditures	increase of prevalence of fever	22	No difference
Across vulnerability at the village level			
No road	reduction of stomach ache	50	No difference

For children younger than six years old, with some minor exceptions the program positively affects two health variables: it delays the moment of last diarrhea and it reduces stomach pain. As diarrhea and stomach pain are common diseases (or symptoms of disease) among infants in developing countries (see literature review), this result is in line with the expectations. The effect on stomach pain is systematically much larger than the delay in diarrhea. The main beneficiaries of the delay in diarrhea are boys and at the family level children in families with low expenditures. The beneficiaries who experience a reduction in stomach ache live in badly accessible villages. Several of the beneficiaries across heterogeneous effects are significantly disadvantaged in the absence of the program. Moreover in all heterogeneous cases where 'no significant difference' was found in the absence of the program, the beneficiaries systematically showed close-to-significant disadvantages compared to their counterparts (the other value of the dummy variable).

In terms of vulnerability, the most vulnerable reap the highest benefits, except in one case. The program increases the prevalence of fever for the most vulnerable in terms of food expenditures, which can be considered as a proxy of the poorest segment of the population. Besides an increase in fever, also the prevalence of other diseases rises (or the reduction in the prevalence is smaller than

among children in richer families) among families in the lowest quartile of the distribution of food expenditures. However, children from these poorest families are advantaged naturally, as they systematically have a lower prevalence on all types of diseases than children from richer families in the absence of the granary banks. This is a contra-intuitive result. However, it could be reasoned that the sudden increase in available nutrition as a consequence of the granary banks has affected the low but smooth intake of food by poorer families, thereby disturbing infants' weaker immune system. If this were the case, one could expect the disturbed consumption pattern to be restored in the long(er) run, to a smooth but now higher food consumption equilibrium.

Table IV: The main impacts found on health among children between six and 12 years old

Main impact on health across children between six and 12 years old			
Measure	**Impact**	**Relative size (approximately) (%)**	**Naturally disadvantaged/advantaged/no difference**
Basic impact			
General impact + control variables	decrease of stomach ache	50	/
	decrease of fever	26	/
Partial impact			
Across girls	decrease of stomach ache	59	Disadvantaged
	decrease of fever	36	Disadvantaged
Across vulnerability at the family level			
> Q1 general expenditures	reduction of stomach ache	55	No difference
> median general expenditures	reduction of stomach ache	57	No difference
> Q1 food expenditures	reduction of stomach ache	45	No difference
< Q1 food expenditures	reduction of stomach ache	62 (amost significant!)	No difference
Across vulnerability at the village level			
With road	reduction of stomach ache	46	Disadvantaged
no road	reduction of stomach ache	57	Advantaged
	reduction of fever	40	Advantaged
with market	reduction of stomach ache	47	No difference
no market	reduction of stomach ache	53	No difference
	reduction of fever	39	No difference

Table V: Main impacts found on health among children between six and 18 years olds

Main impact on health across children between six and 18 years old			
Measure	**Impact**	**Relative size (approximately) (%)**	**Naturally disadvantaged/advantaged/no difference**
Basic impact			
General impact + control variables	reduction of stomach ache	40	/
Partial impact			
Across girls	decrease of respiratory disease	51	Disadvantaged
6 to 9 years old	decrease of fever	29	Disadvantaged
Across vulnerability at the village level			
No road	/	/	Always advantaged

For children older than six, effects are mainly found among children at primary school-age. The only significant effect found exclusively across the entire sample of children from six to 18 is a reduction in respiratory disease for girls. As the result is non-significant among girls younger than 12, all of the reduction in the prevalence of respiratory disease must take place among girls at secondary school-age. As has been discussed in chapter 4, too little data is available to make valid statements about the type of respiratory disease or the underlying causes.

Besides this impact on respiratory disease, the program further affects fever and stomach pain. According to the literature, fever becomes much more prevalent when children reach primary school-age, partially because it is contagious hence easily transmitted in a school context. In this study, around 26% of children between six and 12 years old had fever in the agricultural cycle preceding the survey. As this share is only 21% among children ranging six to 18 years old, it indicates that the major share of children suffering from fever is between six and 12 years old. Further the correlation between fever and stomach ache is very relevant: of the share of children with stomach pain, 80% also had fever. Reversed, almost one in four of children with fever also suffered from stomach pain. This share is much lower given that the prevalence of stomach ache in general is lower than 10%. Nevertheless this lower share does explain why the program has a relative larger impact on stomach ache than on fever, given that any reduction in both symptoms of diseases has a higher relative impact on stomach pain.

The main beneficiaries in the subsamples are girls, especially in the age category six to nine years old; at the family level children from families with larger expenditures; and at the village level children in villages that are badly accessible and poorly economically integrated. Only the beneficiaries' subgroup of girls had a disadvantage in the absence of the program compared to boys. This means the mean prevalence of fever, stomach ache and respiratory disease was systematically higher than the mean prevalance for boys in the control group. Again, with some minor exceptions (see infra), the beneficiaries' subgroup across heterogeneous results for whom results did not show any significant difference in the absence of the program, were in fact very close to significantly disadvantaged compared to their counterpart. Despite a slight non-significant result in many of the cases, this is in line with what one would ideally want the impact of the program to be.

Somewhat striking heterogeneous results are found across the measure 'physical accessibility'. There, regardless the sample used, the natural effect on all types of diseases always favours children in villages that are badly accessible. As these villages are the most isolated, one would expect the opposite result: higher prevalences of diseases. The program however has the highest impact on children from these isolated but naturally fortunate villages. Besides, it also reduces the prevalence of stomach pain among children who are disadvantaged in the absence of the program but live in villages that are well accessible, yet the impact is relatively smaller. Therefore, regarding vulnerability at the village level, children in the most vulnerable villages (no road, no market) in all cases are the main beneficiaries, even though sometimes they are advantaged in terms of health conditions in the absence of the program compared to their peers in less vulnerable villages.

At the family level however, again a different result is found: stomach ache is only significantly reduced among families with higher expenditures (both higher than the mean and higher than the first quartile), meaning they do not belong to the poorest half or quarter of the population. Here, children with lower vulnerability benefit more. However, despite 'no difference' in the table in

terms of baseline conditions, these children were close to significantly disadvantaged in the absence of the program compared to their poorer peers (in terms of expenditures).

Table VI: Main impacts found on schooling among children between six and 12 years old

Main impact on schooling across children between six and 12 years old			
Measure	**Impact**	**Relative size (approximately) (%)**	**Naturally disadvantaged/advantaged/no difference**
Partial impact			
Across boys	Increase in 'ever attended school'	22	No difference
Across vulnerability at the village level			
no road	Increase in 'ever attended school'	47	Disadvantaged

Table VII: Main impacts found on schooling among children between six and 18 years old

Main impact on schooling across children between six and 18 years old			
Measure	**Impact**	**Relative size (approximately) (%)**	**Naturally disadvantaged/advantaged/no difference**
Partial impact			
Across boys	Increase in 'ever attended school'	17	No difference
9 to 12 years old	Increase in 'ever attended school'	15	Advantaged (*)
Across vulnerability at the village level			
no road	Increase in 'ever attended school'	35	Disadvantaged
no market	Increase in 'ever attended school'	25	No difference

* One can not really compare children aged 9 to 12 to children aged 6 to 9, as the former group has had many more opportunities to 'having ever attended school' than the latter group, to which also children belong which are still too young to enroll in primary school.

Across schooling, the only independent variable available ('having ever attended school') shows that boys, and especially boys between nine and 12 years old are the main beneficiaries of the program. Regardless the sample, there is no pre-set difference between attendance for boys and girls. This indicates that parents do not discriminate across sexes to send them to school in the absence of the program, but that due to the program, they do positively discriminate for boys. The age category nine to 12 years old is naturally advantaged compared to the younger age-category. This result is could be expected as one can believe that various six-year olds have never attended school due to parents' believes about their capacities. However them too are included in this first age category, explaining the much lower share of attendance in this category.

However, across vulnerability, we see a clear pattern that children who are generally disadvantaged in the absence of the program in terms of school attendance are also the ones living in the most vulnerable villages and are the ones that benefit most from the program. The pre-set disadvantage is only significant across physical accessibility of villages, but the beneficiaries in villages without a market are very close to being disadvantaged significantly as well. This result exactly follows the line of our expectations based on the previous study on nutrition and other literature in which the most vulnerable are the main beneficiaries. No heterogeneous impact was found across family-level vulnerability measures.

5.2. Impact of granary banks on nutrition, health and education

5.2.1. A general rule

As a general rule, taking all results on health and schooling into account for children younger than six and children at primary school-age, systematically the highest heterogeneous impact has been found among children living in villages which are difficult to access (this is, villages without a road). Only in the subsample including children until the age of 18 this effect does not hold. As children from villages with bad physical accessibility are considered much more vulnerable to economic shocks (for example caused by bad weather conditions) this effect is in line with the expectations based on previous literature that the most vulnerable children are the main beneficiaries. Similar but less strong is the heterogeneous effect for children from villages which are economically less integrated (this is, villages without a local market).

Vulnerability at the family level based on the level of wealth by the position within the distribution of expenditures has a less convincing outcome. Children younger than six belonging to the poorer segment of the village population seem to be the main beneficiaries in terms of health outcomes. However, when children reach the age of primary school, the effect is reversed, with mainly children in wealthier households reaping the highest health benefits. In terms of schooling, no heterogeneous impact is found across the wealth distribution. Based on these very dissimilar results across the distribution of wealth, it is concluded that no consistent impact is found across the poorest people within the population in terms of expenditures.

Additional to the impact found on health and schooling within the most vulnerable villages, the program also seems to reduce the gap between preset heterogeneous differences. In other words, when a subgroup of the population starts in a disadvantageous position regarding their health or schooling condition compared to peers at the other end of the heterogeneous spectrum, the granary banks diminishe, erase or in rare cases even reverse that gap. Although this effect is only significant in about half of the heterogeneous cases, also in non-significant cases a similar trend is seen (with often close-to-significant 'natural' disadvantages). This effect is especially strong for health with regard to gender differences. Both for health across infants and older children there are gender differences (in the absence of the program) in the natural prevalence of several health variables. For children younger than six, the more deprived are boys, which has been explained by unfair breastfeeding practices. For children older than six, girls are more deprived, which can be reasoned by a weaker immune system or/in combination with parental gender discrimination. However, in all cases the program reduces the natural gap in prevalences, in most cases even tracing it back to close to zero. In that sense, also across

gender "the most vulnerable ones" are the main beneficiaries, although here vulnerability is interpreted differently.

This finding has quite a straightforward reasoning: we do not expect the program to improve the health situation of people who are relatively well off. If the prevalence of a certain disease across a certain subgroup of the population is low, we do not expect the program to have a large impact on this group. However, if for any reason the prevalence of whichever type of disease is higher across another group, it is plausible that any developmental program aiming to influence this health variable will first and foremost have its impact on this naturally deprived subgroup.

5.2.2 The nutrition-health channels

The introduction of granary banks has improved the nutritional state of infants and prevented deterioration in the nutritional state among adolescents and adults (Gross & Mees, 2016). In the previous chapters, it has been demonstrated that this effect on its turn directly or indirectly contributes to the health condition and school attendance of children across certain sub-groups in the population.

For infants until the age of six years old the impact of the granary banks has been established via three potential channels: one channel being a direct consequence of the improved nutritional state and the two others indirectly related to nutrition. The three channels are described according to their perceived importance for children until the age of six.

(1) The first channel and arguably also the most important channel for children younger than six is the indirect channel of an overall increase in purchasing power. The 8% reduction in the price level of a bag of sorgho increases the disposable income of the poorest families by approximately 7500 FCFA. Especially if mothers control the household resources, chances are high that the additional resources will be assigned to healthcare expenditures (Engle, 1991; Johnson & Rogers, 1993; in Michaelsen, 2000). All villages in this study have at least two health care practicioners, which makes physical access to appropriate medicines and healthcare feasible as well. Children from families belonging to the poorest half of the population are the main beneficiaries in this study, supporting the idea that an increase in purchasing power is the most important channel through which the prevalence of diarrhea is reduced. Concretely, a higher purchasing power may facilitate access to healthcare, as poor parents will likely use their larger disposable income for diarrheal treatment and prevention expenditures, which might have been considered too expensive previously. However, the health benefits do not reach families in the lowest quartile of the distribution. Following this argument, this suggests that these people's relatively higher purchasing

power compared to the past does not suffice to cover health care costs or that these families prefer to use the additional resources for other purposes. More data is needed to justify this argument.

(2) The second most important channel suggested is the direct effect of the improved nutritional state as was found in the previously conducted impact evaluation study (Gross & Mees, 2016). According to the World Health Assembly "during the first six months of life no food or liquid other than breast milk, not even water, is required to meet the normal infant's nutritional requirements, and that from the age of about six months infants should begin to receive a variety of locally available and safely prepared foods rich in energy additionally to breast milk, to meet their changing nutritional requirements" (in Michaelsen, 2000). Concretely they advice that breast-fed infants aged six to eight months should receive, in addition to breast-feeding, at least two or three meals per day, depending on the population's nutritional status, the likely energy density of these complementary foods, and whether children are malnourished or not (in Michaelsen, 2000). Moreover, sufficient energy density requirements combined with a balanced mix of micronutrients are the necessary determinants of infant's physical growth, immune system and cognitive development (Michaelsen, 2000).

Granary banks in the villages in this study have been able to maintain a sufficient provision of cereals in the diets of the villagers, so likely also complementary foods for infants. For very young infants, the prevented deterioration of the nutritional state found in the previous study (Gross & Mees, 2016) among adults means breastmilk must have contained sufficiently necessary nutrients. Hence the granary banks have been able to reduce infant's susceptibility to catch diseases through an improved nutritional intake. This is justified in our study as the main effects of the program on health are found in villages that are difficult to access. As these villages usually have bad infrastructure, sanitary conditions are worse than in accessible villages, which in turn creates an environment ideal to spread diseases. The improved nutritional state makes children less susceptible to catch and spread these diseases.

This direct channel through nutrition is stated as the second most important channel, as it was argued in chapter two that causal evidence for the assumed positive impact of improved nutrition on health is largely missing in the literature. Moreover, with better results found among poorer families, it is suggested that the increase in purchasing power is a more important channel than the direct effect of improved nutrition.

(3) A third channel that might explain the improved health among infants are the reduced time constraints for child care. Women in developing countries allocate a large share of their daily time to commitments including household production; time-intensive or labour-intense tasks such as carrying water, gathering fuel-wood, agricultural work, informal labour (Michaelsen, 2000), or in the case of the region in this study: walking long distances to purchase food in times of food scarcity in

their own villages. The time spend away from home to buy food elsewhere is especially long in villages without a market and without a road in the proximity.

Especially for infants, the proximity of a caregiver - preferably the mother - has important and long-lasting effects on their behavioural development. Moreover, new-borns should be breastfed exclusively in the first six months to receive all necessary nutrients, antioxidants, hormones and antibodies for a healthy physical and mental development. According to WHO and UNICEF (2009), children that continue to be breastfed until the age of two years old develop fewer infections and have less severe illnesses than those who are not. As the distance crossed to stock up cereals is reduced by around one third as a result of the granary banks, mothers will likely have more time for breastfeeding and childcare. As it has been shown that a caring mother-child relationship positively affects brain development in children (NICHD Early Childcare Research Network, 2005) and that breastfeeding guards children against all potential impairments in development, this increased time spent with their children due to the program can have long-lasting health and educational effects.

Children will have higher chances to enroll in time in the first grade of primary school if they are not underweight and if their cognitive capacities make them ready for primary school (Jukes, 2006). Moreover, healthier children are also less likely to drop out of school, further improving their educational outcomes in the long-run (Sridhar, 2008). As this study has been conducted over the course of one year, long-lasting effects are only suggestive. It would be interesting to look at the medium- and long-term effects of the program in a follow-up study.

5.2.3. The nutrition-health-school channels

When children reach primary school-age, they are introduced to a new environment with large potential for social skills, learning abilities but which is also the perfect playground to catch diseases: the school environment. The unexpected result in this study that children at school-age systematically have better pre-set health conditions in villages without a road in the proximity compared to their peers in well-accessible villages might have something to do with this school environment. In the entire sample of children aged six to 18 years old, almost 60% of them have ever attended school in villages without a road, whereas this share is 73% in villages with a road. In general, villages with a road also have more schools per village than villages without a road. As moreover the most common disease in developing countries among school-age children are parasitic worms (of which fever and stomach ache are common symptoms), which is highly contagious, it might be easier transmitted in villages where a large share of children attends school.

For children older than six, the indirect channel (a higher purchasing power) and the direct channel (improved nutritional state) keep playing a role in explaining the improvement in the health

conditions of children in treatment villages. Either the improved access to nutrition or a rise in health expenditures (or a combination of both) has reduced the initial gap between the health situation of boys and girls. However here, mainly girls in relatively richer families reap the benefits, which is contrary to the expectations and hard to clarify based on the available data.

Notwithstanding the enhanced health situation of girls, which is particularly explicit among primary school-age children, this does not have any direct results on school attendance in the short run. Whereas one would expect an increase in educational investments for girls given their improved health conditions, or at least an equal increase in attendance for boys and girls given no significant difference between both sexes in the absence of the program, the opposite is true: only boys' attendance has significantly risen.

The increase in attendance for boys has most likely been the result of the increase in purchasing power. As the equivalent of the additional 7500 FCFA is five school enrolment fees, it is plausible that at least part of this increased purchasing power has been deployed to send children to school. The decision to send boys to school might be a deliberate choice by parents: data shows that in the same age category nine to 12 years there seems to be a trade off between boys and girls for school attendance and child work on the field: Without the program, boys' share of child work on the field is a lot larger than girls' share, but school attendance is almost equal. The program reduces the gender gap between boys' and girls' share of child work on the field by only increasing the share of girls, whereas for boys only school attendance rises a lot. Parents likely value the expected return to investment in education for boys more than for girls, whereas the increased demand of labour on the field has been assigned almost entirely to girls. Perhaps the increase in the physical health of girls lies at the base of parent's beliefs that girls now have a comparative advantage in working on the field and that their returns to working on the field are higher than for them attending school.

It is very important to note that data on schooling is only based on one variable, and that additional measures of enrolment and dropout rates are missing. Therefore we should be careful with interpreting the results on schooling and child work, as they might not represent the whole picture. Given the equal school attendance rates of boys and girls at primary school in the absence of the program, one would rather have expected an unskewed increase in attendance rates for both sexes.

Moreover, improved health conditions of girls could even be expected to reduce frequently seen dropout rates among girls, which could possibly establish a larger transition of girls into secondary school. This is important, as very often girls in rural areas in developing countries drop out of school at this age due to biological, cultural and social beliefs, the main one being early marriage (Skoufias, 2005; Winthrop & McGivney, 2014). As these girls have a triple disadvantage – being

poor, living in a rural area, and being a girl, they are the most marginalized populations that have not yet gained sufficient access to schooling (Winthrop & McGivney, 2014).

Any improvements in girls' health situation as a result of the program could therefore have the potential to reduce the educational gender bias in the long run. To establish this, parents first have to believe in the returns to investment for girls' secondary education. This could be encouraged by awareness-raising campains. If the impact of the program would be sustained one could expect a rise in schooling for girls, given that better weather conditions in the following agricultural cycles will require less labour on the field, which might convince parents to allocate some or their additional resources to investments in education of their (healthier) girls. If this effect would be maintained over the course of a few years, an increase in the supply of pupils could increase the demand of schools and teachers in the villages. If in turn, qualitatively good education is provided by adequate teachers, this might ameliorate children's and adolescent's knowledge about health and nutrition, reinforcing healthy behaviour, risk-aversion and improved nutrition intra-& intergenerationally. According Feinstein et al (2006) education also serves as a protective factor as it can moderate the relationship between income inequality and health, mitigating the effects of inequality on the health of more educated people and in the end even smoothing income inequality. In the long run this makes people less vulnerable to shocks, increases their productivity and can eventually lift them out of poverty (see Figure I in chapter two). As was argued in the literature review that malnutrition and diseases can get caught in a vicious circle, improving children's health and allocating more resources to the education of children (especially girls) might be a solution to turn this negative vicious circle into a positive one.

Ofcourse, these hypothetical outcomes are very optimistic and much has to change in the believes of gender biases and returns to schooling before such transition can be put in place, especially in Sub-Saharan countries like Burkina Faso. It is clear that the modest impact of the granary banks on health and education after one year in northern Burkina Faso does not have the potential to set in motion such positive spiral. However, the very positive hypothetical exposition does suggest that nutrition, health and education can positively reinforce one another through the implementation of a market-based community-managed safety net such as granary banks; as long as the initial impact is large enough and maintained over the course of many years.

The results found thus show some interesting direct and indirect interlinkages between improved nutrition, enhanced health conditions, and higher attendance rates. The reciprocal impact of better education on health could not be analysed due to data scarcity, neither has the data been complementary enough to make sound conclusions about the direct impact of health on education. Rather, it has been assumed in this discussion that the indirect impact in terms of increased purchasing

power has predominantly influenced attendance rates. A direct impact on education based on improved health and nutrition can only be assumed in the longer run.

5.2.4. Impact in the long run?

To check for the real results on education in the medium to long run as well as the sustained effects on health, follow-up research is needed, preferably including more complementary data on schooling. A follow-up research has been conducted for the previous study on the nutritional state (Gross & Mees, 2016). Results after the agricultural cycle 2012-2013 were rather mixed. The prevention from a deterioration in adult's nutritional state was gone, as well as the significant price reduction in a bag of sorgho. Families again had to travel to purchase food, but not as far and not as long as they had to before the implementation of the granary banks. On the other hand, the improved nutritional state of children was still noticeable, suggesting that also the improved health conditions might be sustained. It would be interesting to study these results in the medium to long run.

However, the main reason for this rather low medium-term impact of the granary banks in 2011-2012 is the discontinuation of at least 50% of villages of the management of their granary bank in the agricultural cycle 2012-2013. A majority of the villages have been unable to pay the received money to the organisation, and have therefore not received funds for a second year of granary bank activities. This largely explains the rather low sustained impact two years after the program was first implemented. To really look at long-lasting effects it is suggested that granary banks' activity is maintained for at least a couple of years. To do so, it is important to study the underlying causes for villages not to reimburse the money to the organisation and to address these issues.

5.2.5. The special case of 2011-2012

On the other hand, the disruption of the activities of the granary banks in 2012-2013 in more than half of the villages can also be interpreted by the simple fact that the existence of granary banks in the next agricultural cycle was no priority anymore. After all, the year in which the granary banks were active and the impact evaluation is based on marked a very bad year in terms of weather conditions and failed harvests. As temporary food insecurity was substantial during this cycle, the existence of the granary banks was very useful and showed promising results on nutrition, health and education. However, if food insecurity is not an issue anymore, granary banks might be redundant given that subsistence-based families can stock up sufficient amounts of cereals to sustain their families until the next harvest. However, it can be argued that a permanent availability of granary banks in poor subsistence-based families can help to reduce risks related to weather shocks. Moreover

it can relieve the pressure on prices at the local market on other products, ensuring access at all times for all people to basic alimentary products for a healthy and balanced diet.

Given this argument, we should be careful not to overgeneralize the potential impact on nutrition, health and education of the population just by the mere presence of granary banks for one year. On the other hand, conducting an impact evaluation during a year with bad weather conditions created the opportunity to really study the potential impact of a community-managed granary bank market system on human capital in times of bad economic shocks. This study has proven that at least to a certain extent, granary banks form a security safety net, which reduces their vulnerability to shocks (especially for the most vulnerable ones), and at the same time has the potential to build up further human capital through mutual linkages between nutrition, health and education.

5.3. Limitations of the study

The most direct limitation of this study is a shortage of unbiased data on schooling variables. Only with additional data on enrolment rates and dropout rates, the full picture of the impact of the granary banks after one year on schooling can be analysed. As the data used in this study was originially collected with the purpose of conducting an impact evaluation study on nutrition, variables on schooling were no priority while surveying participants.

Another limitation is the limited scope to study health, nutrition and schooling. As the literature review makes clear, each of the three concepts has been the subject of extensive studies. Including all three concepts in one case study makes it impossible to include all aspects related to each of the concepts. Concretely, the intergenerational channel for education has been completely left out of this study: literature shows that parents' level of education and health – especially of the mother -, and also whether the mother has an income, is extremely important in determining the levels of health and education of children. It would be interesting to look at the differential effect of granaray banks by level of education/income/health of the mother in future research.

A third limitation is the fact that results have not been controlled for by weather shocks. Weather conditions during the agricultural cycle in which the intervention of the granary banks took place were very bad compared to the previous and the following cycle, but the evaluation did not take into account the regional variations. It is found that 55% of treatment villages suffered from very low rainfall (below the median of rainfall across all villages of the 2011-2012 agricultural cycle), whereas this was only 45% in the control group. It is clear that the impact of the program has been measured on villages that were suffering from bad weather conditions more than their counterparts in the control

villages. It would have been an added value to control for these imbalances in weather conditions between treatment and control villages.

The last limitation is the lack of data on underlying causes for the symptoms of stomach pain, diarrhea, fever and respiratory problems. As each of these symtoms can be caused by a large variety of diseases and are moreover strongly interlinked, it would be extremely interesting to know exactly which diseases the granary banks are more likely to have an impact on. This would also leave a possibility to assign the relative share of the direct and indirect channels through which the granary banks reduce these diseases, as well as linking this impact with the relative importance of sanitary and health conditions, healthcare practicioners, other environmental factors etc…

6. Conclusions

Food insecurity in developing countries is a widespread problem, which has received a lot of attention in development policies since the 1970s. Intervention programs trying to address food insecurity have predominantly taken the form of nutrition supplementaries for infants or are embedded in an educational context at school. Granary banks are another solution to provide sufficient access to food and have been been introduced in many African countries in the 1980s and 1990s. The effectiveness of different types of programs on the nutritional state of the population has been the subject of many studies. The main critique in the academic debate is the interpretation of correlations as causality. Experts therefore suggest that more studies should be conducted based on randomized control trial designs.

The study conducted in this paper has adopted a randomized control trial design to evaluate the impact of community-managed granary banks in the northern Sahel in Burkina Faso. A previously conducted study across the same population in the same region yielded positive outcomes for the granary banks on the nutritional state of children and showed that among adults a deterioration of the nutritional state was prevented. Given this impact, this study examined the additional effects of granary banks on the health and schooling of children in the villages.

The results show that granary banks in northern Burkina Faso after one year have a clear effect on health across children of all ages (although effects in secondary school start to diminish). There is an effect on schooling as well but it likely does not represent a full picture as only one dependent variable is considered.

Concretely, for children younger than six the presence of a granary bank in the village delays the last moment when children had diarrhea. Moreover it reduces the prevalence of stomach pain for children in badly accessible villages. For children between six and 12, the granary banks significantly lower the prevalence of fever and - again – stomach pain. The latter however is only significant for girls. When children reach secondary school-age, the impact on fever and stomach ache fades out, whereas the prevalence of respiratory disease – again among girls only – is reduced significantly.

In terms of schooling, the program leads to boys attending school significantly more than girls, especially boys between nine and 12 years old, despite no differential impact existed between the two sexes at the baseline. On the contrary, the share of girls employed in the field has increased significantly. The program created a trade-off between going to school and child work on the field differentially for boys and girls.

Hence in terms of gender bias related to health, the program equalizes gender differences by discriminatorily benefitting only the naturally more deprived in terms of prevalances of different types of disease. With respect to education, the program creates a large gender difference by discriminatorily only benefitting boys, despite no significant natural deprivation of one or the other sex. This effect runs contra the findings in meta-analyses that no gender differences are found for the impact of nutrition and health on education.

However a shortage of data on schooling and the short timeframe of the program (one year) before the evaluation took place prevented a sound analysis of the impact on schooling in the long run as well as an impact of education on health. It has been assumed that with a prolonged activity of a granary bank and especially in agricultural cycles with relatively better weather conditions, parents would reasonably invest more in girls' education as well, given their increased health. This could have profound returns in the long run on health and nutrition.

The main channels through which the impact is established are the direct effect of the granary banks on the improved nutritional state of children which makes them less vulnerable; the indirect effect of an increase in purchasing power which can be spend on health (especially for children younger than six) or schooling expenditures (for children older than six); and the indirect effect of parents spending more time in the household and with their children (especially important for infants). These channels have not been tested, but are rather suggestive based on correlations across available data.

In the majority of cases, the largest effects were found on children from the most isolated villages. No consistent differential effect was found across wealth; as for children younger than six mostly children from poorer families benefitted, whereas the highest health benefits for children older than six were reaped by those living in better-off families. It has been concluded in this paper that as a general rule the main beneficiaries of the program are the ones in the most vulnerable position related to village-level characteristics, and also the most vulnerable ones based on the level of initial deprivation across sexes.

Although this evaluation study is the result after only one year of activity of the granary banks, it is an indicator of a reasonably much more profound impact on human capital of granary banks in the long run in the Sudano-Sahel region of Northern Burkina Faso. On the other hand, one should bear in mind that communities might not want to invest time and means in the management of a locally-run granary bank if better harvests provide enough food security for families' self-subsistence. To prevent a total abandonment of the granary banks during those years and a consequent reduced capacity in years with bad harvests, it is suggested that subsidies or other incentives are given to the (local)

management to continue the activity of the granary bank at a lower pace (e.g. selling complementary foods that contribute to a varied, healthy diet) during years with good harvests. Therefore SOS-faim and FNGN, the organisers of the granary banks, should cooperate and coordinate with local municipalities and provinces in the future.

Although this case-study on granary banks cannot be interpreted as a blueprint for success everywhere in the world, it does provide evidence for a large potential of granary banks on human capital accumulation - even after one year - in poor, subsistence based regions, given bad weather conditions and temporary food shortage. By positively affecting income growth and children's nutritional state, which in turns encourages investments in health and education, a food security program based on granary banks can eventually lift people out of poverty, especially if combined with further investments in sanitary hygiene and safe drinking water.

7. Appendices

Appendix I: Impact on health for children younger than six years old.

IMPACT ON HEALTH FOR CHILDREN YOUNGER THAN 6 YEARS OLD							
		(1) MOM DIAHREA	(2) DUR DIAHREA	(3) STOMACH ACHE	(4) VOMIT	(4) FEVER	(5) COUGH
BASIC IMPACT							
BASIC IMPACT	Coef.	0.109	1.928	-0.0487	0.0141	0.0140	-0.0374
	P>|t|	[0.211]	[0.140]	[0.159]	[0.712]	[0.749]	[0.257]
	Obs.	999	208	1012	1012	1012	1012
Mean in control		2.579	5.786	0.235	0 .126	0.560	0 .212
INCLUDING COVARIATES	Coef.	0.0981*	0.919	0.0319	0.0605	0.00524	0.0291
	P>|t|	[0.078]	[0.508]	[0.785]	[0.371]	[0.937]	[0.701]
	Obs.	184	184	184	184	184	184
Mean in control		2.579	5.786	0.235	0.126	0.560	0 .212
HETEROGENOUS IMPACT							
Across sex							
IMPACT ON FEMALE (=0)	Coef.	0.0158	3.164	-0.0375	0.0336	0.0404	-0.0451
	P>|t|	[0.871]	[0.180]	[0.352]	[0.425]	[0.509]	[0.269]
Mean in control (female)		2.687	5.045	0.208	0.118	0.535	0.196
(DIFFERENTIAL) IMPACT ON MALE (=1)	Coef.	0.185	-2.126	-0.0208	-0.0396	-0.0524	0.0173
	P>|t|	[0.111]	[0.511]	[0.686]	[0.327]	[0.368]	[0.744]
Mean in control (male)		2.472	6.232	0.261	0.134	0.584	0.226
	Obs.	999	208	1012	1012	1012	1012
Across age							
IMPACT ON AGE CATEGORY 0 TO 6 MONTHS	Coef.	0.119	5.390	-0.0614	0.0789*	0.0062	0.0075
	P>|t|	[0.555]	[0.381]	[0.462]	[0.067]	[0.954]	[0.907]
Mean in control (0 to 6 months)		2.512	7.18	0 .166	0	0.309	0 .071
	Obs.	979	206	992	992	992	992
Across vulnerability							
IMPACT ON FAMILIES WITH ALL EXP/PERSON > MEDIAN (=0)	Coef.	-0.0125	3.019	-0.0130	0.0415	0.0378	-0.0341
	P>|t|	[0.886]	[0.149]	[0.822]	[0.436]	[0.612]	[0.441]
Mean in control (all exp/person > median)		2.631	4.913	0.269	0.126	0.569	0.243
(DIFFERENTIAL) IMPACT ON FAMILIES WITH ALL EXP/PERSON < MEDIAN (=1)	Coef.	0.201**	-1.807	-0.0501	-0.0309	-0.0338	0.0222
	P>|t|	[0.036]	[0.502]	[0.433]	[0.613]	[0.733]	[0.579]
Mean in control (all exp/person < median)		2.538	6.298	0.209	0.116	0.539	0.168
	Obs.	975	204	988	988	988	988
IMPACT ON FAMILIES WITH FOOD EXP/PERSON > Median (=0)	Coef.	-0.0629	2.849	0.00378	0.0814	0.0474	-0.0165
	P>|t|	[0.567]	[0.153]	[0.950]	[0.210]	[0.503]	[0.738]
Mean in control (food exp/person > median)		2.669	5.595	0.236	0.120	0.553	0.223
(DIFFERENTIAL) IMPACT ON FAMILIES WITH FOOD EXP/PERS < Median (=1)	Coef.	0.296***	-1.666	-0.0899	-0.103	-0.0563	-0.0149
	P>|t|	[0.008]	[0.435]	[0.202]	[0.180]	[0.583]	[0.796]
Mean in control (food exp/pers < median)		2.509	5.816	0.238	0.120	0.553	0.186
	Obs.	975	204	988	988	988	988
IMPACT ON FAMILIES WITH FOOD EXP/PERSON > Q1 (=0)	Coef.	0.0636	2.490	-0.0610	0.0217	-0.0269	-0.0440
	P>|t|	[0.533]	[0.138]	[0.144]	[0.620]	[0.590]	[0.297]
Mean in control (food exp/person > Q1)		2.587	5.752	0.25	0.123	0.561	0.209
(DIFFERENTIAL) IMPACT ON FAMILIES WITH FOOD EXP/PERS < Q1 (=1)	Coef.	0.136	-2.216	0.0515	0.00236	0.145*	0.0641
	P>|t|	[0.390]	[0.445]	[0.423]	[0.965]	[0.076]	[0.408]
Mean in control (food exp/person < Q1)		2.564	5.678	0.2	0.112	0.528	0 .184
	Obs.	975	204	988	988	988	988

(1) Coefficients for basic impact are obtained by OLS regressions with fixed village effects
(2) Covariates include variables at the personal level (age, sex , status, symptoms of sickness), survey data (date of survey, month of survey), breastfeeding practices (start breastfeeding, stop breastfeeding, something else than breastmilk)
(3) Heterogeneous effects are based on dummy variables (=1/=0) in interaction tables. Number of observations is equally derived from interaction tables. Only significant results are shown, including the respective mean in the control group.
(4) Relative standard errors (not shown) are grouped systematically at village level (cluster-robust-standard-errors)
(5)* p<0.10, ** p<0.05, *** p<0.01

Appendix II : Impact on health for children between six and 18 years old

IMPACT ON HEALTH FOR CHILDREN BETWEEN 6 and 18 YEARS OLD							
		1) DISEASE RS	2) DIAHREA	3) FEVER	4) RESPIRATORY	5) STOMACH ACHE	6) VOMIT
BASIC IMPACT							
BASIC IMPACT	Coef.	-0.0103	0.00310	-0.0434	-0.0159	-0.0241	0.00772
	P>|t|	[0.735]	[0.774]	[0.180]	[0.400]	[0.151]	[0.521]
	Obs.	1686	1708	1708	1708	1708	1708
Mean in control		0.176	0.021	0.230	0.070	0.073	0.037
INCLUDING COVARIATES	Coef.	0.0228	0.00911	-0.0339	-0.00489	-0.0298**	0.0170
	P>|t|	[0.354]	[0.452]	[0.124]	[0.810]	[0.022]	[0.262]
	Obs.	1138	1138	1138	1138	1138	1138
Mean in control		0.176	0.021	0.230	0.070	0.073	0.037
HETEROGENOUS IMPACT							
Across sex							
IMPACT ON FEMALE (=0)	Coef.	-0.0144	-0.00288	-0.0613	-0.0488*	-0.0350	0.0115
	P>|t|	[0.686]	[0.842]	[0.108]	[0.071]	[0.162]	[0.458]
Mean in control (female)		0.180	0.029	0.243	0.094	0.087	0.039
(DIFFERENTIAL) IMPACT ON MALE (=1)	Coef.	0.00822	0.0118	0.0359	0.0662***	0.0214	-0.00793
	P>|t|	[0.836]	[0.396]	[0.361]	[0.010]	[0.393]	[0.655]
Mean in control (male)		0.172	0.014	0.217	0.045	0.060	0.036
	Obs.	1686	1708	1708	1708	1708	1708
Across age							
IMPACT ON FIRST AGE GROUP (6 TO 9 YEARS OLD)	Coef.	-0.0344	0.00312	-0.0853**	-0.0208	-0.0394	-0.0153
	P>|t|	[0.421]	[0.867]	[0.030]	[0.553]	[0.210]	[0.436]
Mean in control (first age group)		0.209	0.036	0.296	0.091	0.118	0.059
(DIFFERENTIAL) IMPACT ON SECOND AGE GROUP (9 TO 12 YEARS OLD)	Coef.	0.0459	-0.000269	0.0481	0.0227	-0.0134	0.0425*
	P>|t|	[0.281]	[0.989]	[0.275]	[0.494]	[0.662]	[0.079]
Mean in control (second age group)		0.174	0.009	0.207	0.049	0.076	0.036
(DIFFERENTIAL) IMPACT ON THIRD AGE GROUP (12 TO 15 YEARS OLD)	Coef.	0.0632	-0.000123	0.101**	0.00842	0.0406	0.0409
	P>|t|	[0.167]	[0.995]	[0.018]	[0.813]	[0.107]	[0.205]
Mean in control (third age group)		0.149	0.024	0.183	0.053	0.053	0.024
	Obs.	1642	1664	1664	1664	1664	1664
Across vulnerability							
IMPACT ON FAMILIES WITH ALL EXP/PERSON > Q1 (=0)	Coef.	0.005	0.001	-0.0162	-0.0137	-0.0221	0.026*
	P>|t|	[0.872]	[0.855]	[0.697]	[0.526]	[0.229]	[0.065]
Mean in control (all exp/person > Q1)		0.177	0.020	0.227	0.072	0.077	0.027
(DIFFERENTIAL) IMPACT ON FAMILIES ALL EXP/PERSON <Q1 (=1)	Coef.	-0.0343	0.00122	-0.0836	-0.000424	-0.00947	-0.0412
	P>|t|	[0.575]	[0.968]	[0.256]	[0.990]	[0.850]	[0.137]
Mean in control (all exp/person < Q1)		0.155	0.028	0.229	0.057	0.066	0.038
	Obs.	1644	1666	1666	1666	1666	1666

(1) Coefficients for basic impact are obtained by OLS regressions with fixed village effects

(2) Covariates include variables at the personal level (age, sex , status, symptoms of sickness), survey data (date of survey, month of survey), schooling variables (having ever attended school), work variables (work on the field, income-generating activity) etc...

(3) Heterogeneous effects are based on dummy variables (=1/=0) in interaction tables. Number of observations is equally derived from interaction tables. Only significant results are shown, including the respective mean in the control group.

(4) Relative standard errors (not shown) are grouped systematically at village level (cluster-robust-standard-errors)

(5)* p<0.10, ** p<0.05, *** p<0.01

Appendix III : Impact on health for children between six and 12 years old

IMPACT ON HEALTH FOR CHILDREN BETWEEN 6 and 12 YEARS OLD							
		1) DISEASE RS	2) DIAHREA	3) FEVER	4) RESPIRATORY	5) STOMACH ACHE	6) VOMIT
BASIC IMPACT							
BASIC IMPACT	Coef.	-0.0194	0.000403	-0.0679*	-0.0118	-0.0486**	0.000444
	P>|t|	[0.611]	[0.972]	[0.084]	[0.617]	[0.016]	[0.976]
	Obs.	1031	1045	1045	1045	1045	1045
Mean in control		0 .1991	0 .0237	0 .2608	0 .0711	0.0968	0 .0533
INCLUDING COVARIATES	Coef.	0.0454	0.0173	-0.0590**	-0.00652	-0.0477***	0.0160
	P>|t|	[0.140]	[0.253]	[0.025]	[0.793]	[0.009]	[0.386]
	Obs.	727	727	727	727	727	727
Mean in control		0 .1991	0 .0237	0 .2608	0 .0711	0.0968	0 .0533
HETEROGENOUS IMPACT							
Across sex							
IMPACT ON FEMALE (=0)	Coef.	-0.0309	-0.00655	-0.101**	-0.0415	-0.0731**	0.00982
	P>|t|	[0.421]	[0.690]	[0.021]	[0.209]	[0.013]	[0.588]
Mean in control (female)		0.1975	0.032	0.276	0.096	0.124	0.052
(DIFFERENTIAL) IMPACT ON MALE (=1)	Coef.	0.0233	0.0136	0.0675	0.0590*	0.0482	-0.0191
	P>|t|	[0.641]	[0.426]	[0.188]	[0.061]	[0.121]	[0.466]
Mean in control (male)		0.2008	0.0156	0.2460	0.0468	0.0703	0.0546
	Obs.	1031	1045	1045	1045	1045	1045
Across vulnerability							
IMPACT IN VILLAGES WITH A ROAD (=0)	Coef.	-0.0152	-0.00758	-0.0547	-0.0159	-0.0547**	0.00755
	P>|t|	[0.782]	[0.650]	[0.259]	[0.625]	[0.041]	[0.725]
Mean in control (with road)		0.2317	0.036	0.2983	0.0918	0.1180	0.0557
(DIFFERENTIAL) IMPACT IN VILLAGES WITHOUT ROAD (=1)	Coef.	-0.00622	0.0205	-0.0282	0.0119	0.0170	-0.0169
	P>|t|	[0.924]	[0.288]	[0.665]	[0.778]	[0.610]	[0.545]
Mean in control (without road)		0 .1487	0.0049	0.2039	0.0398	0.0646	0.0497
	Obs.	1031	1045	1045	1045	1045	1045
IMPACT IN VILLAGES WITH A MARKET (=0)	Coef.	0.0217	0.00108	-0.0376	-0.0116	-0.0440*	0.00256
	P>|t|	[0.747]	[0.958]	[0.547]	[0.730]	[0.087]	[0.923]
Mean in control (with market)		0.1869	0.0301	0.2758	0.0818	0.0948	0.056
(DIFFERENTIAL) IMPACT IN VILLAGES WITHOUT MARKET (=1)	Coef.	-0.0779	-0.00166	-0.0587	-0.000990	-0.00856	-0.00418
	P>|t|	[0.317]	[0.943]	[0.434]	[0.983]	[0.824]	[0.892]
Mean in control (without market)		0.2097	0.0182	0.2481	0.062	0.0985	0.0510
	Obs.	1031	1045	1045	1045	1045	1045
IMPACT ON FAMILIES WITH ALL EXP/PERSON > Q1 (=0)	Coef.	-0.0158	-0.00926	-0.0520	-0.00873	-0.0608**	0.0246
	P>|t|	[0.737]	[0.390]	[0.294]	[0.749]	[0.017]	[0.179]
Mean in control (all exp/person > Q1)		0.2051	0.0277	0.2583	0.0722	0.111	0.0388
(DIFFERENTIAL) IMPACT ON FAMILIES ALL EXP/PERSON <Q1 (=1)	Coef.	0.0153	0.0309	-0.0554	-0.00476	0.0490	-0.0489
	P>|t|	[0.841]	[0.335]	[0.522]	[0.910]	[0.355]	[0.201]
Mean in control (all exp/person < Q1)		0.1587	0.0158	0.2698	0.0634	0.0555	0.0555
	Obs.	1010	1024	1024	1024	1024	1024
IMPACT ON FAMILIES WITH ALL EXP/PERSON > MEDIAN (=0)	Coef.	-0.0330	-0.0169	-0.0745	-0.0213	-0.0638**	0.0326
	P>|t|	[0.581]	[0.209]	[0.201]	[0.570]	[0.040]	[0.262]
Mean in control (all exp/person > median)		0.2262	0.0312	0.2946	0.1026	0.1116	0.0535
(DIFFERENTIAL) IMPACT WITH ALL EXP/PERSON < MEDIAN (=1)	Coef.	0.0407	0.0282	0.0180	0.0249	0.0284	-0.0335
	P>|t|	[0.485]	[0.115]	[0.781]	[0.511]	[0.514]	[0.340]
Mean in control (all exp/person < median)		0.164	0.019	0.2328	0.0419	0.0839	0.0345
	Obs.	1010	1024	1024	1024	1024	1024
IMPACT ON FAMILIES WITH FOOD EXP/PERSON > Q1 (=0)	Coef.	-0.0274	-0.00478	-0.0630	-0.00888	-0.0386*	0.00998
	P>|t|	[0.559]	[0.636]	[0.218]	[0.723]	[0.075]	[0.590]
Mean in control (food exp/person > Q1)		0.1978	0.0214	0.2546	0.0616	0.0857	0.0455
(DIFFERENTIAL) IMPACT WITH FOOD EXP/PERSON < Q1 (=1)	Coef.	0.0504	0.00871	-0.0235	-0.0154	-0.0436	0.00518
	P>|t|	[0.497]	[0.800]	[0.835]	[0.778]	[0.518]	[0.890]
Mean in control (food exp/person < Q1)		0.1769	0.0353	0.2831	0.0973	0.1327	0.0353
	Obs.	1010	1024	1024	1024	1024	1024

(1) Coefficients for basic impact are obtained by OLS regressions with fixed village effects

(2) Covariates include variables at the personal level (age, sex , status, symptoms of sickness), survey data (date of survey, month of survey), schooling variables (having ever attended school), work variables (work on the field, income-generating activity) etc...

(3) Heterogeneous effects are based on dummy variables (=1/=0) in interaction tables. Number of observations is equally derived from interaction tables. Only significant results are shown, including the respective mean in the control group.

(4) Relative standard errors (not shown) are grouped systematically at village level (cluster-robust-standard-errors)

Appendix IV: Impact on schooling for children between six and 18/ between six and 12 years old

IMPACT ON SCHOOLING FOR CHILDREN			
		1) EVER ATTENDED SCHOOL	
HETEROGENOUS IMPACT		**Between 6 and 18 years**	**Between 6 and 12 years**
Across sex			
IMPACT ON FEMALE (=0)	Coef.	0.0171	0.0248
	P>|t|	[0.778]	[0.690]
Mean in control (female)		0.634	0.662
(DIFFERENTIAL) IMPACT ON MALE (=1)	Coef.	0.0944**	0.119**
	P>|t|	[0.019]	[0.018]
Mean in control (male)		0.653	0.663
	Obs.	1702	1040
Across vulnerability			
IMPACT IN VILLAGES WITH A ROAD (=0)	Coef.	-0.0145	-0.0111
	P>|t|	[0.826]	[0.874]
Mean in control (with road)		0.736	0.772
(DIFFERENTIAL) IMPACT IN VILLAGES WITHOUT ROAD (=1)	Coef.	0.194**	0.239**
	P>|t|	[0.038]	[0.020]
Mean in control (without road)		0.501	0.497
	Obs.	1702	1040
IMPACT IN VILLAGES WITH A MARKET (=0)	Coef.	-0.0305	
	P>|t|	[0.699]	
Mean in control (with market)		0.695	
(DIFFERENTIAL) IMPACT IN VILLAGES WITHOUT MARKET (=1)	Coef.	0.180*	
	P>|t|	[0.084]	
Mean in control (without market)		0.597	
	Obs.	1702	

(1) Heterogeneous effects are based on dummy variables (=1/=0) in interaction tables. .
Number of observations is equally derived from interaction tables
Only significant results are shown, including the respective mean in the control group.
(2) Relative standard errors (not shown) are grouped systematically at village level (cluster-robust-standard-errors)
(3)* p<0.10, ** p<0.05, *** p<0.01

8. References

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