Nutrition and Child Development in Low- and Middle-Income Countries –

Evaluation of Three Micronutrient Interventions

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1. General Introduction

This dissertation consists of three essays on the link between nutrition and child development (chapters 2-4). In the general introduction (chapter 1) I discuss the significance of the dissertation topic, define important scientific terms, and highlight the similarities and differences between the essays. In section 1.6 of this introduction I draw a general conclusion from the findings of the three essays.

1.1 Linking Nutrition, Poverty and Development (Economics)

With the scientific contributions of Amartya Sen (1999), economists have gone on to define poverty as a multidimensional concept that is not only comprised of insufficient income or consumption (i.e. living on less than 1.9 USD a day) but also to include deprivation in non-monetary dimensions that are considered essential for well-being (Bourguignon & Chakravarty 2003). According to Sen's influential capability approach, a person is considered poor if he or she is deprived in *basic capability*, i.e. valuable options or freedom in real choice. Only if basic capabilities are ensured, can human beings develop other, higher capabilities. For instance, only a healthy, well nourished and educated person will be able to pursue the career, she or he has reason to value (Alexander 2008). A limited capability set, means a limited number of options from which an individual can choose, i.e. that only a limited number of *functionings* (i.e. *doings* and *beings*) can be realized. A functioning is the realization of a particular option from the capability set. For example, one might have the capability to eat a healthy meal because it is available and accessible; however, one might not choose the option to eat it and be well nourished (one functioning) but instead to fast and choose to remain hungry (another functioning) (Sen 1999). According to Drèze & Sen (2013) the expansion of capabilities is *"...what development is ultimately about"* (p. 182) and hence only implicitly the realization of certain functionings. Different researchers have come up with different lists of basic capabilities (e.g. Nussbaum 2011) that, among other things, include the possibility of achieving adequate health, sufficient nutrition and sufficient education.

Nowadays expanding the capabilities of human beings has been established as a means to economic development as well as an end of itself. This is reflected in poverty measures that no longer rely only on income or consumption, but are composed of multiple

dimensions such as the human development index (UNDP 2015) or the multidimensional poverty index (Alkire & Foster 2007). Out of the 17 sustainable development goals, only one directly relates to income (Goal 1: By 2030, eradicate extreme poverty measured as living on less than 1.25 USD a day), whereas the other goals focus on health, nutrition, education and environmental conservation among others (United Nations 2017).

There are different reasons why one might want to ensure basic capabilities. Possibly the most quoted are social justice and humanity. This relates to an understanding of the collective responsibility for protecting disadvantaged groups such as the disabled, weak, elderly and poor. Assuming that being in a state of poverty is based on misfortune and unequal opportunities, a wealthy person with altruistic preferences might feel negatively affected by seeing a person in poverty.[1] Therefore, the utility of the wealthy person increases with the provision of goods and services that reduce poverty, e.g. providing nutritious food, clothing or shelter (Zweifel et al. 2009). Furthermore, poverty alleviation contributes to political stability and peace (Collier & Dollar 2004). Moreover, some areas of social life, for instance many parts of health care, exhibit externalities. Infectious diseases have negative externalities because they are transmitted from one individual to another and the cost of the person to whom the infection was transmitted is not taken into account when making one's own investment decisions. Similarly, undernutrition weakens the immune system and thus inhibits the resistance against infectious diseases. Being undernourished can therefore exhibit a negative externality. Externalities result in an inefficient allocation of resources and require regulation and governmental intervention (Zweifel et al. 2009). Lastly there is a financial argument why basic capabilities should be ensured. Basic capabilities enable human beings to make use of their potentials, to be productive and to generate income. On a macro-level this might translate to economic growth (Dasgupta & Ray, 1986 and Strauss & Thomas 1998).

In this dissertation, I evaluate three different concrete interventions that aim at expanding the perhaps most basic of all capabilities: *nutrition*.

[1] This perception can be illustrated by using the concept of the 'veil of ignorance', developed by Rawls (1971). According to Rawls, agreeing on the degree of social security benefits should be done in the following way: A society anonymously agrees upon social security benefits without anybody knowing if she will eventually belong to the low or high income group. An agreement would likely include some basic level of social support for all.

1.2 Undernutrition and its Implications for Child Development

Nutrition is defined as

> *"... the process through which living organisms use food to maintain life, growth and normal functioning"* (Kent 2005, p. 7).

Malnutrition emerges either because of an inadequate food intake or because of problems in processing the nutrients from the diet (Kent 2005). There are three forms of malnutrition: First, overweight and obesity, i.e. when a person consumes too many calories. Second, there are two forms of undernutrition: protein-energy or macronutrient undernutrition, i.e. when a person consumes too few calories, and micronutrient deficiencies, i.e. when a person lacks important vitamins and minerals such as zinc, iron, or iodine (WHO 2017b). This dissertation focuses on the latter aspect: micronutrient deficiencies. One of the differentiating factor between micronutrient deficiencies and protein-energy malnutrition, where people directly notice a feeling of hunger, see small food portions or look very short and skinny, is that a lack of micronutrients is often not directly visible, unnoticed or involves symptoms that are not attributed to malnutrition. This is why micronutrient deficiencies are commonly called the *hidden hunger* (Kennedy et al. 2003).[2] A second key factor of micronutrient deficiency lies in the circumstance that a person needs very few of them, but when they are deficient, the consequences are severe (UNICEF 2017).

Low-income populations are especially prone to micronutrient deficiencies because they often depend on a single staple food. As such, their diet lacks variety and especially products that are rich in micronutrients, such as animal-sourced products, fruits and vegetable or micronutrient-fortified products (Kennedy et al. 2003).

There are 19 micronutrients known to be essential for proper physical and mental development, for the functioning of a bodies metabolic processes and an intact immune system (Kennedy et al. 2007). It is estimated that more than two billion people, one in three individuals and double the number of individuals that suffer from protein-energy malnutrition, are deficient in at least one micronutrient (FAO et al. 2014, Graham et al. 2007). This dissertation focuses on two micronutrient deficiencies: iodine (essay 1) and iron (essays 2 and 3). Along with zinc and vitamin A, iodine and iron deficiencies are the most prevalent nutritional disorders in the world (Kennedy et al. 2003). Approximately 1.8 billion people suffer from iodine deficiency (von Grebmer et al. 2014, de Benoist et al.

[2] There are few exceptions where micronutrient deficiency becomes directly visible, e.g. blindness from Vitamin A deficiency and goiter from iodine deficiency (von Grebmer et al. 2014).

2008). With 1.6 billion worldwide, the number of people suffering from iron deficiency is similarly high (von Grebmer et al. 2014).

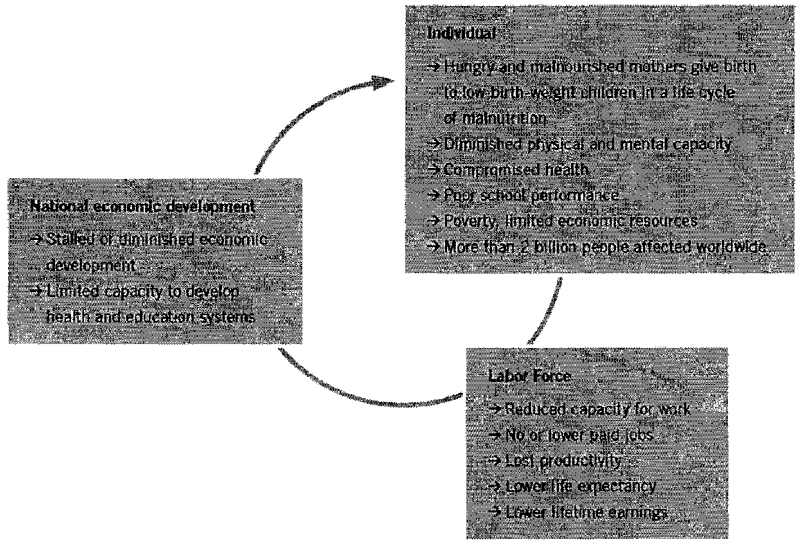
Micronutrient deficiencies can lead to dramatic impairments in *child development*. Child development is defined as the physical, motoric, cognitive, social-emotional and linguistic changes that occur from gestation until adolescence (Bartolotta & Shulman 2010). Child development is influenced both by genetic-controlled processes, i.e. maturation (also referred to as *nature*) as well as by the impact of the environment (also referred to as *nurture*). Nutrition is counted as an environmental factor (Berk 2012). While iron and iodine deficiencies both adversely influence cognitive development, iodine is also know to affect physical growth.[3] Indirectly, they might also affect other aspects of child development, e.g. motor and language skills, because these other aspects of child development strongly depend on a child's cognitive development (Lozoff 2007). Iodine is required for the synthesis of different hormones, that among other things, are necessary for skeletal growth and neurological development (Dunn 1992, Samuels, Wierman, Wang, & Ridgway 1989). Iron deficiency affects cognitive development through immediate neurobiological processes, i.e. the inhibition of the central nervous system to develop properly (e.g. the brain and the spinal cord) (Beard 2003), and secondly through functional isolation. Functional isolation emerges from the symptoms of iron deficiency. Children deficient in iron engage less with their environment, have lower interpersonal interactions, show lower attention and are relatively unresponsive to stimuli in comparison to their non-iron deficient counterparts. Hence, they have difficulties in accumulating new skills (Lozoff et al. 1998). Cognitive development directly influences the education outcomes of a child. For example, if a student is unable to focus their attention and to ignore distraction, they are likely to have trouble concentrating and hence have difficulties in acquiring new skills and knowledge. The same is likely to be true for the symptoms of anemia such as frequent illness or tiredness. Both iron and iodine deficiency therefore hinder human capital formation (Halterman et al. 2001, Bobonis et al. 2006). Sufficient micronutrient intake is therefore essential for a person to reach their physical and cognitive potential, i.e. to expand the set of capabilities.

When impairments in child development, due to malnutrition, lead to lower educational attainment this might result in lower adult productivity and income poverty, which in turn might lead to undernutrition of the individual as well as their offspring. Therefore, the *micronutrient poverty trap* enforces the intergenerational transmission of

[3] The evidence of iron on child growth is inconclusive (Ramakrishnan et al. 2004).

poverty. Through reduced productivity and high health care costs, micronutrient deficiency constrains economic development at the national level as well (Dasgupta and Ray, 1986 and Strauss & Thomas 1998). Stein and Qaim (2007) estimate that the short-term economic costs of micronutrient deficiencies in India amount to between 0.8% and 2.5% of the gross domestic product. Figure 1.1 illustrates the vicious and continuous cycle of hidden hunger and impaired economic development.

Figure 1.1: Cycle of hidden hunger, poverty and stalled development



Source: von Grebmer et al. (2014)

While the biological basis for the positive effects of increased micronutrient intake is clear and well established, the crucial question is in what way and by which means an adequate micronutrient intake of the population in need can be ensured most effectively.

1.3 Interventions to Fight Micronutrient Deficiencies

There are different approaches to cure and prevent micronutrient deficiencies. They can be broadly divided into nutritional supplements and food-based approaches. Supplements refers to the administration of capsules, tablets or injections that contain high concentrations of minerals or vitamins (FAO & WHO 2002). Food-based approaches are comprised of dietary

diversification and fortification (including bio-fortification). Dietary diversification refers to a change in production and consumption patterns towards a broader range of micronutrient-rich foods (Allen et al. 2006). Bio-fortification is the selective breeding or genetic manipulation of crops with the aim of increasing their nutrition value (Global Panel 2015). Food fortification is the direct addition of micronutrients to processed foods such as salt, rice or wheat (FAO & WHO 2002). Food-based approaches do not end with an increase in the availability of iron-rich or iron-enriched products, but can only be successful if accessibility (i.e. monetary feasibility) is ensured, and a change in feeding practices, i.e. utilization, follows (Allen et al. 2006).

Nutrition interventions – just like interventions in other fields – can be further categorized into supply- and demand-side interventions. While supply-side interventions generally increase availability and often also the accessibility of certain products or technologies, demand-side interventions aim to increase the knowledge and awareness about the benefits of a certain product or technology that might lead to an increase in demand and therefore a behavioral change in feeding practices (World Bank 2006).

The Copenhagen Consensus Expert Panel continuously ranked nutrition interventions, including vitamin C and zinc supplementation and iron and iodine fortification, among the best interventions for economic development in terms of their cost-benefit ratio (Copenhagen Consensus 2008, Copenhagen Consensus 2012). From the neoclassical point of view, a rational agent,[4] would be expected to adopt and implement these technologies due to their high benefits and low costs.

In this dissertation, I evaluate three different food-based approaches that aim to increase children's consumption of iodine and iron:

(1) Essay 1: The usage of iodized salt at the household-level

(2) Essay 2: The usage of iron-fortified iodized salt in a school-feeding program

[4] Early neoclassical models define rationality in terms of utility maximization. Individuals maximize their utility given their preferences and the constraints they are facing. It is generally assumed that individual utility maximization is exclusively based on self-interest. A rational agent performs an action, e.g. makes an investment or buys a certain good, if the marginal utility of the action is higher than the marginal costs. An individual behaving according to this pattern is called *homo oeconomicus* (Mankiw & Taylor 2011).

(3) Essay 3: Informing parents about the anemia status of their child and the provision of short and simple nutritional advice

Table 1.1 outlines the similarities and differences between the three interventions at a glance.

The possibility to attain a higher consumption level of iron and iodine in children will enlarge their nutritional capability. First, I test whether the enlargement of the nutritional capability indeed results in a state of better nutrition or *functionings* in terms of Sen's capability approach (e.g. anemia, dietary diversity score, child growth). Secondly, since being in a state of good nutrition expands other capabilities, I further look at how these interventions affect the educational and cognitive aspects of child development in essays 2 and 3 (higher capabilities).

Table 1.1: Overview and comparison of the three essays

	Title	Research question	Outcomes	Intervention					Data/ Sample	Age group	Method	Quality of evidence	Result
				Nature	Poten-tial Actors	Supply or demand side	Adoption private or public decision	Category					
1st Paper	Association between household unavailability of iodized salt and child growth – Evidence from 89 demographic and health surveys	Is there a general association between household unavailability of iodized salt and child growth across countries?	Stunting, wasting, underweight, low-birth weight	Iodized salt used in households	Public, private, NGOs	Supply	Possibly private, public if mandatory fortification policy	Fortified product	89 Demographic and Health Surveys from 48 low- and middle-income countries	Newborns and children until the age of five	Logistic regression with control variables and a primary sampling unit, fixed effects	Association	- Universal positive association with low birth weight - Child growth indicators are only statistically significant associated for the sample of India
2nd Paper	School feeding, iron-fortified salt and child cognitive ability – Evidence from a randomized controlled trial in rural India	Does the usage of iron-fortified iodized salt in the Indian school-feeding program reduce anemia and improve cognitive and educational outcomes?	Hemoglobin, anemia, cognitive ability and education outcomes	Iron-fortified iodized salt used in school-feeding	Rather public, maybe NGOs	Supply	Public	Fortified product	Self collected dataset of about 2000 school-aged children and their households from two blocks in rural Bihar, India	Primary school children	Randomized-controlled trial	Intent-to-treat effect	- Decrease in any form of anemia and mild anemia - No effect on cognition - Weak evidence for a small increase in math and reading skills for high rates of school attendance
3rd Paper	Nutrition information, anemia testing and feeding practices – A regression discontinuity analysis using data from rural India	Does informing the parent about the anemia status of their child and giving them short and simple nutrition advices improve feeding practices, reduce anemia and improve cognitive and educational outcomes?	Feeding practices, hemoglobin, cognitive ability and education outcomes	Information about anemia status and better feeding practices	Public, private or NGO	Demand	Private	Dietary diversification	Self collected dataset of about 2000 school-aged children and their households from two blocks in rural Bihar, India	Primary school children	Regression discontinuity design	Marginal treatment effect	- No robust impact on any of the tested outcomes

1.4 The Role of Evaluation

This chapter explains why it is important to identify the true causal impact of these interventions, the challenges in identification of the causal impact and how the identification problem can be solved.

1.4.1 Why Evaluate?

This chapter explains why it is important to identify the true causal impact of these interventions, the challenges in identification of the causal impact and how the identification problem can be solved. A great deal of money has been and is continuously being spent by local governments, private institutions and in the form of development aid on interventions that aim at reducing poverty in its multiple dimensions, including nutrition. In a world of scarce resources, different interventions must be traded off.[5] Rigorous impact evaluation enables one to *causally* attribute a change in an outcome to a specific intervention. Evaluation answers the question if an intervention is effective at all; and secondly, by which magnitude it has changed the outcome of interest. Costs and benefits or effects of different interventions can be compared to provide policy makers with empirical evidence to decide on one or the other intervention. Evaluation also enables policy makers to be held accountable and provide transparency in resource allocation (Khandker et al. 2010).

1.4.2 The Evaluation Problem

To answer the question if and in how far these three interventions causally affected child health, cognitive and educational outcomes, one must answer the counterfactual question: How would these children have done without being exposed to these interventions? How would the growth of one of these children have been different had they not consumed iodized salt at home, or their anemia rate had they not have received iron-fortified salt through their school meal? How would these parents have fed their child had they not been informed that their child suffers from anemia and should be fed differently? However, we are never able to observe the same individual with and without being exposed to the treatment at one point in

[5] A famous debate on aid effectiveness was held by Jeffrey Sachs and William Easterly. While Sachs argued that with sufficient money poverty could be eradicated via a big push (Sachs 2005), Easterly argued that the 2.3 trillion dollars that have been spent on development aid have not been successful in ending poverty, doubting that the next 2.3 trillion dollars could do so (Easterly 2006). The motivation of impact evaluation can be positioned between these two poles, as impact evaluations assess each potential aid project individually.

time. This fact constitutes the evaluation problem (Angrist and Pischke 2008, Duflo, Glennerster, and Kremer 2007).

One intuitive first approach to create the counterfactual outcomes would be to simply compare how children performed before and after the intervention. In this approach, outcomes before the intervention would then constitute the counterfactual. However, this approach would lead to biased results in most cases because factors other than the treatment itself might have caused a change in the outcome. Hence, in this approach, the treatment effect cannot be disentangled from the effect of other factors. Indeed, it is never possible to estimate the true treatment effect for a given individual. It is however possible to estimate the *average* treatment effect for a *group* of people compared to another *group* of people that did not receive a treatment. The crucial point in evaluation is to create two groups that would have had the same outcome in the absence of the treatment. Unfortunately, when looking at real world policies, it turns out that the treated and not-treated groups created are mostly very different from one another. Real world policies or programs are generally targeted to special groups or attract people with particular characteristics. For instance, households that buy fortified salt possibly have higher literacy and education levels, which enables them to understand the benefits of the fortified product compared to individuals that do not buy fortified products. We never know if the difference in outcomes of interest, e.g. the health and nutrition status, is indeed due to the fortified product, or due to the fact that the outcomes of interest for those individuals that buy the fortified product are anyways better because their better education is also an underlying cause of their more healthy diet. The systematic difference between those who received the treatment or self-selected into it is called the *selection bias*. Using the potential outcomes framework, developed by Rubin (1974), the evaluation problem is formalized as follows.

Let Y_i^T be the average observed outcome of an individual i that was exposed to an intervention T and Y_i^C the average observed outcome of an individual i that was not exposed to an intervention. As described above, we can never observe Y_i^T and Y_i^C at the same time, i.e. we can never estimate the individual treatment effect Y_i^T - Y_i^C. We can however observe these two outcomes as averages within a population.

$$D = E[Y_i^T|T] - E[Y_i^C|C]$$

Subtracting and adding the expected outcome for an individual that was exposed to the intervention had they not been exposed (unobservable), we can rearrange the equation as:

$$D = E[Y_i^T|T] - E[Y_i^C|T] + E[Y_i^C|T] - E[Y_i^C|C]$$

Where

$E[Y_i^T|T] - E[Y_i^C|T] =$ the causal effect of the treatment, i.e. what we are interested in

and

$E[Y_i^C|T] - E[Y_i^C|C] =$ the selection bias.

The oftentimes called *gold standard* to overcome selection bias is *randomization*. If households were randomly allocated into one group that uses the fortified product and another one that does not (the control group), and the number of observations was large enough it would ensure that, on average, all observable and unobservable characteristics between the treatment and control groups are the same, such that the selection bias is:[6]

$$E[Y_i^C|T] - E[Y_i^C|C] = 0$$

and the true causal effect is identified.

Mostly for financial, ethical or practical reasons, randomly allocating individuals to treatment and control groups is not always feasible. That is why economists oftentimes rely on quasi-experimental methods. In quasi-experimental methods, researchers try to identify the causal relationship between two variables without controlling the assignment of an entity to the control or treatment groups themselves, but use groups that have already been created *naturally*. Quasi-experimental methods consist of identifying situations in which the selection bias is either not present, or where methods can be applied such that one can correct for it (Duflo et al. 2007). Quasi-experimental approaches differ in the way the control group (i.e. the counterfactual) is created. Whether the created control group is internally valid depends on the plausibility of a set of *identifying assumptions* (Angrist and Pischke 2008; Duflo, Glennerster and Kremer 2007).

[6] The balance in means of the characteristics of the treatment and control group is only true, on average, meaning if a random sample of entities would be drawn many times. It is still likely that due to random chance, and especially if the sample size is small, some means show up to be different between the control and treatment groups (Altman 1985; Imai et al. 2008).

1.4.3 Solving for Selection Bias in the Three Essays

The three essays of this dissertation use the following control groups and are based on the following identifying assumptions:

(1) Essay 1: Controlling for observable characteristics in a parametric regression framework. This method assumes that even though the treatment and control groups are not randomly allocated, controlling for a set of factors X that influence the treatment status and the outcome of interest at the same time eliminates the selection bias, or put differently, conditional on factors X there would have not been a difference in outcomes in the absence of the treatment.

$$E[Y_i^C \mid X, T] - E[Y_i^C \mid X, C] = 0$$

This however implies that any factor simultaneously influencing the treatment status and outcomes has to be incorporated to overcome the selection bias and any omitted variable will produce biased results (in this context, selection bias is also known as *omitted variable bias*). Furthermore, as we apply a linear regression model, we make the assumption of a linear relationship between the treatment variable, covariates and outcomes. The assumptions of this evaluation method are relatively strong. Since we cannot rule out the possibility of the presence of some degree of selection bias, we prefer using the terms *association* and *correlation* instead of effect in this analysis.

(2) Essay 2: Using randomization (in a randomized controlled trial – RCT), where the randomization of schools into treatment and control groups prevents the presence of a selection bias and hence the true causal effect is identified with the minimal assumption that the randomization process was successful (and a few more minimal conditions that are discussed in chapter 3.6). Hence by construction

$$E[Y_i^C \mid T] - E[Y_i^C \mid C] = 0$$

(3) Essay 3: Randomization at a threshold X' that is the result of the data generating process, where assignment to the treatment is a discontinuous function of a variable X (Regression discontinuity design – RDD).

$$E[Y_i^C \mid T, X < X' + h, X > X' - h] - E[Y_i^C \mid C, X < X' + h, X > X' - h] = 0$$

The assumption implies that given that all observable and unobservable characteristics evolved smoothly with the variable X, conditional on X, the selection bias is 0 around a narrow bandwidth of h from the threshold X'. Individuals just above (below) the threshold are used as the control group for individuals just below (above) the threshold.

1.5 Summaries of the Three Essays

1.5.1 Essay 1

In essay 1, we investigated if there exists a general association between a household's unavailability of iodized salt and child growth across countries. That means we basically test if the expansion of the nutritional capability of a household through the availability of iodized salt indeed results in child growth, which is an indicator for nutrition and health status (i.e. the realization of certain functionings). We used 89 nationally representative, repeated cross-sectional and mutually comparable demographic and health surveys (DHS), conducted between 1994 and 2012 across 46 low- and middle-income countries. We analyzed the data for the outcome variables stunting (low height-for-age), underweight (low weight-for-age), wasting (low weight-for-height) and low birth weight in children between 0 and 59 months at the time of the interview, using logistic regression models. The unavailability of iodized salt at the households was tested using a rapid chemical test. Our samples consisted of 390,328 children for the stunting analysis, 397,080 for the underweight analysis, 384,163 for the wasting analysis and 187,744 for the low birth weight analysis. Models were adjusted for individual, maternal and household covariates and fixed effects on the level of the primary sampling unit (PSU). In the fully adjusted models (including all covariates and PSU fixed effects), the unavailability of iodized salt was associated with a 3 % higher odds of being stunted, a 5 % higher odds of being underweight, and a 9 % higher odds of low birth weight. When excluding India from the sample, the association was only statistically significant for low birth weight. Though we do not establish causality in our analysis, the findings might indicate that the causal effect of iodized salt on child growth, if it exists, is most profound in utero, and is not universally effective across all countries with respect to longer run child growth outcomes such as stunting and underweight. The findings are very much in line with the previous literature that found mixed results of increased iodine consumption on stunting, wasting and underweight, but mostly positive associations with low birth weight. These findings support the general notion in the health and nutrition literature that emphasizes that pregnancy is a crucial period for child development.

1.5.2 Essay 2

In essay 2, we analyzed if the Indian school-feeding program is an effective channel to deliver iron and reduce the high-risk of iron deficiency that is common among children in rural India. We test the effectiveness of such an intervention by running a randomized controlled trial in which 54 randomly selected government-funded schools, from two blocks in Bihar, India, used iron-fortified iodized salt to prepare the school lunch for a period of one year. Fifty-three randomly selected schools functioned as control schools and continued using conventional iodized salt. In addition to anemia, we investigated the effect on cognitive and educational outcomes. Framed in the capability framework, we expand the capability set through the provision of iron-fortified iodized salt to government-funded schools and test if this results in the realization of a state of better health and nutrition (of which anemia constitutes the indicator). Since a state of good health and nutrition (being non-anemic) is the foundation for a good education and cognitive skills (i.e. health and nutrition enlarge the educational and cognitive capability set), we also look at these additional outcomes.

The treatment reduced the prevalence of any form of anemia by 20% and of mild anemia by 30%. There is no statistically significant interaction effect between treatment and school attendance, i.e. the treatment effect does not change significantly with increasing compliance. However, despite the short treatment period, there is weak evidence that at a school attendance rate of 80% or 90%, the treatment had a positive effect on reading and math scores. In addition, there is some evidence that children from historically disadvantaged groups – scheduled castes and tribes – benefitted slightly more from the treatment in the form of reduced anemia; whereas children from a non-disadvantaged background, saw a larger benefit in terms of their educational outcomes. These results provide encouraging evidence of the positive effects from using school-feeding programs as a channel to provide school-aged children with iron-fortified salt.

1.5.3 Essay 3

In essay 3, we studied if revealing the anemia status of a child and informing the child's parents about the need to feed the child more iron-rich food items is effective in changing their feeding practices, the child's hemoglobin level and subsequently cognitive and education outcomes. This research is motivated by the circumstance that many low-cost technologies to improve health and nutrition currently exist, but the adoption of these technologies remains

low or lower than expected (Dupas 2011, Banerjee & Duflo 2012). This has led researchers to the hypothesis that the supply of or access to health and nutrition technologies, i.e. availability and monetary feasibility, might not be the only constraints poor households in low-income countries are facing. There is a growing strand of literature that investigates how far the lack of information constitutes an additional constraint, which limits the demand for and the proper use of these technologies (Dupas 2011b, Karlan et al. 2014). The theory being that individuals would make better health and nutritional investments if the information constraint was loosened by providing them with the required information.

Using a dataset from rural India we exploit the discontinuity in the provision of information that resulted from the ethical need to inform parents about the anemia status of their child in a randomized trail, if their child's hemoglobin level was below a clinical threshold. This circumstance allows us to apply a regression discontinuity design, which has the potential to identify the causal effect of the intervention. We do not find any robust treatment effect on any of the tested outcomes. Information alone, even when combined with revealing the anemia status of a child, does not seem to be effective in changing nutritional behavior. This might indicate that other forces constrain people in making rational nutrition investments. We speculate that the unavailability and inaccessibility of iron-rich food items, as well as other social and psychological factors, might be the underlying causes for why we did not find robust effects. A drawback of this study is that the given dataset only provides the statistical power to detect relatively large effect sizes.

1.6 General Conclusion

What are the general implications that can be drawn from these three papers? What can these three evaluations teach us about the life of poor people and the effectiveness of nutrition interventions to improve their wellbeing? In how far are these three interventions in fact able to expand the capability set of poor people? Starting with essays 2 and 3: Assuming that too little power is not the underlying reason for the non-detection of an effect in essay 2, why is the school-feeding intervention effective and why did the nutrition information intervention not show any statistically significant effects? One important condition that differentiates these two interventions is how much freedom of choice people have in response to these interventions. The usage of iron-fortified salt in the school feeding program was mandatory for the treatment schools. Parents and children were not given any choice to take-up the

treatment or not. By going to school and eating the lunch, children received the iron-fortified salt without any further decision or choice to make and is comparable to a mandatory food policy.[7] In contrast, in the nutrition information intervention in essay 3, it was fully up to the parents to decide how to act on the information they received. Does this mean that if poor people are given freedom to choose they make bad, i.e. irrational, decisions? These results are from only two evaluations from one particular area in rural India; therefore, the generalizability of these findings should not be overstretched. Still, the results of this thesis are very much in line with the latest literature on the conditions that influence the human decision making process and the particular influence that a life in poverty has on it (The World Bank 2015, Karlan et al. 2014, Dupas 2011 for overviews). This thesis adds pieces of evidence to the potential presence of these conditions.

One of these conditions is missing or imperfect markets. Even standard economic theory recognizes that individuals might be prevented from making rational choices when markets are missing, imperfect or when individuals are not well informed. Essay 3 presents an intervention that aimed at loosening the information constraint. However, missing markets might still constrain individuals from changing nutritional behavior, even if they intend to do so. The financial means (credit market) and the goods and services (commodity market) required for this behavioral change might not be available or accessible. If the diversity of available food items is low, or certain food items are too expensive, people are not capable of changing their diet. Imperfect and missing markets are particularly prevalent in rural areas in low-income countries (e.g. Ray 1999, Mankiw and Taylor 2011).

More recently, insights from sociology and psychology have entered economics and researchers have started to depart from the neoclassical perception of a human being as a self-controlled, fully rational decision making *homo oeconomicus*, who, as long as she or he is well informed and markets are perfect, makes decisions that maximize their well-being. Behavioral economists have promoted the hypothesis that social norms, beliefs and certain cognitive tendencies often prevent human beings from rational decision making even when markets are perfect and they are fully informed (e.g. Sunstein and Thaler 2009, Tomer et al. 2013). The *World Development Report 2015: Mind, Society and Behavior* has emphasized the idea that the insides of sociology and psychology should be used in development as its theme (The World Bank 2015). In recent years, increasingly more empirical research has combined

[7] Only by not sending their child to school, but since they did not know about the intervention, this is not of any concern in this context.

sociology, psychology and development economics to understand why individuals do not always make choices that improve their wellbeing. What are the central insights from this interdisciplinary research?

Beliefs, social norms, habits and culture play a crucial role when individuals make decisions about food intake (Fox 2003, Ma 2015, Wood and Neal 2009). In case new information contrasts with deep-seated beliefs and habits, individuals will hardly comply with new information. For instance in Maharashtra, a west Indian state, fever is treated with rice, whereas in West Bengal, an east Indian state, renouncing rice when having fever is a deeply-rooted belief (Childs et al. 1997, Banerjee & Duflo 2012).

Furthermore, individuals have the mental tendency to strongly discount the future. They give stronger weight to rewards and discomforts that are in the present. This so called *present bias* results in the procrastination of tasks that include discomfort or costs on the one hand, and the disability to resist temptations that cause short-term rewards on the other hand (Laibson 1997, O'Donoghue and Rabin 1999, Banerjee and Mullainathan 2010, Dupas 2011, Karlan et al. 2006). Present bias prevents human beings from putting their intentions into actions. With respect to the nutrition intervention evaluated in essay 3, present bias might prevent parents from spending more money on a diverse diet today, even though they have the intention to do so, because the temptation to invest the additional money into tobacco, sweets, festivals or religious rituals, is stronger. This psychological phenomenon applies to the poor as well to the rich.[8]

Moreover, human beings underlie a *limited degree of attention*. Given the wealth of information a human being is exposed to, they can hardly take into account all dimensions and options in the decision-making process. While this circumstance is true for every human being, according to Mullainathan & Sharif (2013), it is particularly true for the poor. Due to the fact that having very few of the basic requirements for living, e.g. money, food, health and shelter, poor people allocate all of their attention and energy to those things that are scarce in their life to make the most of them. As a consequence, almost no or only very limited mental space is left for other important decisions or certain skills such as self-control or long-term planning. If you have little money and you are unsure if you will be able to buy sufficient calories, all your attention will be dedicated to getting more calories and you will not have the

[8] The same holds for people in high-income countries. People struggle to eat healthy diets and to be physically active regularly, even though they know that they are putting themselves on a much higher risk for diabetes and strokes; however, the present bias seems to prevent them from putting their intention of physical exercise and more healthy diets into practice.

mental capacity to maximize dietary diversity (Mullainathan & Sharif 2013).[9] The high potential for irrational decision making of the poor is not only based on scarcity alone, but also on the circumstance that poor people need to make many more decisions in their daily life than rich people. Public and private institutions oftentimes do not provide them with the services that make life easier. For example, they often do not have safe and clean piped water at their home, but must make the decision to add chlorine to purify their water each and every time they collect water from the well. They are generally not covered by social security and must decide whether to spend what little money they have either directly or save it for shocks or pension. An additional hypothesis explaining why it often seems that poor people make irrational decisions is that it is not because they are not clever or uninformed, but because the number of decisions to be taken every day would exceed the mental capacity of any human being (Banerjee & Duflo 2012).

It was not within the scope of this thesis to analyze the true underlying causes of human decision making in the unique setting of each essay. However, when combining the results of the nutrition information from essay 3 and the school-feeding program intervention from essay 2, with the existing literature on human decision making, it gives a good indication that in addition to a lack of information and missing markets, social and psychological forces play a role in decision-making. I do not want to neglect the importance of market access and information as these are two necessary conditions. However, they are possibly not sufficient conditions, particularly when it comes to nutrition and health behavior. If this is true, the obvious next question that needs to be asked is what this implies for policy making? How should policies be designed to help people to make rational health and nutrition investments?

Indeed, the insights from psychology and sociology question the conviction of many societies, governments and schools of thought that emphasize the self-responsibility of citizens, the sovereignty of the consumer and the trust that informing people is sufficient to give them a basis to make choices that enhance their well-being. The findings from this thesis combined with the psychological and sociological knowledge on human behavior questions the statement of the Indian government that lifted the ban on the production of non-iodized salt in 2000 with the reasoning "*matters of public health should be left to informed choice and*

[9] The list of phenomena from sociology and psychology that influence the understanding of economic decision making is much longer and for instance also includes loss-aversion and over-optimism (Karlan et al. 2014). I limit the outline to social norms, present bias and limited attention since I consider these to be the most relevant, especially in the context of dietary decisions.

not enforced" (FAO 2006, p. 136). It might also object the emphasis on capabilities in the capability approach, i.e. the idea that development is only about expanding the set of choices, while leaving the decision of which of the different options is chosen, i.e. which functioning is realized, to the individual. Instead, it gives much more responsibility to governments and society as a whole, including different players in international development, to take over some of the decisions that people in low-income contexts have to make, such that certain functionings can be realized with certainty.

To overcome social and psychological barriers in rational decision-making, different tools, such as *commitment opportunities*, *reminders*, *nudging* (i.e. small incentives) and *enforced mandatory policies*, have been developed and empirically tested. Dupas and Robinson (2013) test different commitment opportunities to increase savings for preventive health care and find that simply earmarking funds by providing individuals with a safe box and a key already helps them improve their self-control and overcome present bias. Another well-established rather than newly developed commitment opportunity consists of rotating savings and credit organizations (ROSCAs)[10], where people voluntarily have come up with a organized form of savings commitment (Gugerty 2007).

Regarding the limited degree of attention, reminders have been tested. In a randomized experiment, Karlan et al. (2013) sent messages to bank clients reminding them of their self-set savings goal and found large increases in savings.

Nudging has been tested for instance in the context of immunization. Setting up immunization camps in one Indian district, Banerjee et al. (2010) find that giving parents one kilogram of lentils for each completed immunization and a set of metal meal plates when having completed all five required immunizations, nearly doubles the full immunization rate. Similarly, Thornton (2005) finds that giving individuals financial incentives to learn their HIV status after having been tested at their household, doubles the take-up of HIV test results. The effectiveness of conditional-cash transfers (Schultz 2004) is possibly also, at least to some extent, based on the nudging component.

If properly implemented and enforced, mandatory policies might also be the most effective, as they not only ensure that the take-up of certain health or nutrition products is

[10] In ROSCAs, a fixed group of people meets regularly. They commit themselves to contribute a certain amount of money at every meeting into a joint pot. The pot is given to another person from the group at every meeting. Commitment is, however, not the only reason for the existence of ROSCAs; others are insurance and intra-household conflict over savings (Gugerty 2007).

increased (as in the case of nudging, incentives and reminders), but that these products are universally adopted, as no choice is left to the individual. Mandatory policies can target the population of a whole country or specific groups within a country. The further advantage of mandatory policies is that they provide more integrated solutions, which is particularly important when markets are imperfect. Mandatory policies not only ensure that people put their intentions into actions, but also ensures sufficient supply and financial accessibility (Dupas 2011b). Mandatory policies are widely spread in low as well as in high-income countries. For example, in Germany, health and unemployment insurance are mandatory and are generally directly deducted from a person's salary. In the United States, children are only enrolled in school when their parents can prove their full immunization status (Ciolli 2008). Essay 2, and to some extent essay 3, of this dissertation add pieces of evidence to the effectiveness of mandatory policies. The intervention evaluated in essay 2 made the usage of iron-fortified iodized salt mandatory in a selected number of government-funded schools and found large reductions in anemia rates due to this intervention. This finding thus supports the effectiveness of mandatory government food policies. The usage of iodized salt at the household level, as it has been studied in essay 1 of this dissertation, can only be partly attributed to mandatory policies. In the cross-country analysis, we cannot disentangle the reason why households possess iodized salt. It might have been an individual choice at the point of purchase or a national mandatory salt fortification policy.[11] In essay number 1, we find a small universal positive association of iodized salt with low birth weight across countries and with stunting and underweight when we look only at India. This is very encouraging evidence with respect to the potential of a mandatory iodized salt policy, or of nudges or reminders combined with the availability of the technology.

Intervening into the lives of people via the outlined tools and particularly through mandatory policies might sound paternalistic at first and initially I was hesitant to make this concluding statement. However, over and above the market failure argument that legitimates governmental intervention based on standard economic theory, it becomes clear that psychological and social tendencies, such as social norms, present bias and limited attention prevents people from putting their intentions into actions. The presented tools would therefore help people to make the choices they indeed strive for. While this argument for limiting free choice applies to all human beings to some extent, there is another argument that is particular

[11] In all countries in the sample, at least a small portion of the population does not possess iodized salt, such that the presence of universal mandatory salt fortification is implausible. However, the reason for the unavailability of iodized salt can also be that iodine dissipates if not properly stored.

to low-income settings and that is borrowed from Banerjee & Duflo's (2012) book *Poor Economics*. Banerjee & Duflo (2012) state that taking over decisions from poor people is indeed not paternalistic or at least not more paternalistic than the behavior of governments and society in high-income countries, with the small difference that citizens in high-income countries do not realize it anymore. As already stated, in high-income countries safe drinking water enters households via piped water. The decision between chlorinating it or not does not emerge in the first place. Social security contributions are directly deducted from a person's salary and there is no decision making process required to choose between spending that money on tempting goods or saving for shocks. Incentives, nudging and enforced mandatory policies surround people from high-income countries all the time and those means free their minds for the rest of their daily decisions. The crucial question to ask is *which* decisions should be taken over by government (or other institutions) and *which* should be left to the individual. This question brings us back to the first section of this introduction. As outlined in section 1.1, most societies see a social responsibility for ensuring that basic capabilities are realized. Being properly nourished forms one of the most basic capabilities, if not the most central. With respect to the capability approach, the reasoning outlined in this section would therefore imply that the requirement to ensure that poor people can reach a stage of good nutrition and health is not the expansion of the capability set, i.e. giving people more options, but rather taking away some of their freedom of choice to directly ensure that certain basic *functionings* of being in a stage of good nutrition and health are reached.

Summarizing the potential implications from these three essays into one sentence: Taking over some of the (nutritional) decisions poor people have to make every day – e.g. taking away some freedoms through mandatory policies, such as mandating the use of fortified products in school-feeding programs – will eventually enable them to widen their sets of several higher capabilities.