The London School of Economics and Political Science

Life-chances of children in Indonesia:

The links between parental resources and children's outcomes in the areas of nutrition, cognition and health

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Declaration

I certify that the thesis I have presented for examination for the MPhil/PhD degree of the London School of Economics and Political Science is solely my own work other than where I have clearly indicated that it is the work of others.

I warrant that this authorisation does not, to the best of my belief, infringe the rights of any third party.

I declare that my thesis consists of 77,766 words.

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The journey is the reward. ~Chinese Proverb

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Abstract

The majority of children in the developing world are suffering from hardship and poverty, and are not able to reach their full potential. This thesis focuses on the relationship between parental resources and children’s outcomes in the areas of nutrition, cognition and physical health in Indonesia. The life-stages early childhood to young adulthood are crucial for human capital formation. Nutrition, cognition and physical health are key human capitals that are important both as a means to achieve wellbeing and as an end in their own right. They have been identified as some of the main routes for changes in well-being over the life-course and as significant pathways for breaking intergenerational poverty cycles.

Disadvantages in these domains are especially salient in developing countries. Yet, evidence is still limited due to lack of appropriate data. Here, data from the Indonesian Family Life Survey (IFLS) is used, a rich panel data set consisting of four waves of data spanning a period of 14 years. I study a cohort of children who are less than three years old in the first wave of the IFLS and for whom relevant outcomes can be observed.

While the availability of longitudinal data from IFLS is very important, the setup and design of the data presented an enormous challenge: unlike with longitudinal datasets from developed countries, such as the British Household Panel Survey (BHPS) or the cohort studies, the IFLS data is presented more or less in raw form. In order to facilitate a critical and careful approach to working with this kind of complicated raw data, I completed two self-organized research stays with the IFLS team in which I witnessed the data collection and interviewed IFLS team members. This helped me to understand the questionnaire and measures better and to identify the strongest parts of the IFLS: the self-collected measures for children – namely the physical health measures height and lung capacity (collected by specially trained nurses) as well as a cognitive measure – the Raven’s coloured progressive matrices. These are unique features for a general household survey in a developing country context and constitute important child outcomes.

As a starting point from which to ask more specific research questions concerning the three types of children's outcomes, I synthesized research from relevant domains such as neuroscience, social science, childhood studies and economics.

Chapter 1, 2 and 3 constitute the setup of the research by detailing the motivation and background for the research, the conceptual frameworks, literature reviews, data and methodology as well as the research questions. Chapter 4, 5 and 6 are the empirical chapters investigating the aforementioned child outcomes in detail.

Chapter 4 entitled: “Children’s nutritional status in early life and dynamics into adolescence” investigates firstly, to what extent parental resources are associated with children experiencing stunting in early childhood and in adolescence. Results for parental resources for stunting in early childhood reveal protective factors which include mother’s height and direct measures of living standards. For stunting in adolescence the importance of parental resources as protective factors increases (mother’s height is stronger related and father’s height is now significant as is household consumption as a measure of financial resources). The association with direct living standards decreases. Secondly, I investigate if there are stunting dynamics – that is, movement in and out of stunting between early childhood and adolescence. For dynamics of stunting I use transition matrices to show that entries and exits from stunting occur over children’s entire life-course (not just in early childhood). *Movements into stunted growth* decrease the older children get but are still around 6% between middle childhood (7-10 years old) and adolescence (14-17 years old). *Movements out of stunted growth* occur over the whole life-course of children with the highest exit rates of around 19% between ages 7-10 years and 14-17 years. My results support Adair’s study for the Philippines (1999) and Schott and Crookston’s recent research for Peru (2013).

In Chapter 5, I investigate children’s cognitive outcomes – i.e. Raven’s coloured progressive matrices and math scores. Firstly, I examine to what extent children’s growth status in early childhood and change in growth is associated with cognitive test results in adolescence. Secondly, to what extent parental resources are associated with children’s cognitive test results. One key result indicates a significant positive association between initial/early height-for-age (HAZ) and cognitive test scores. This could support the hypothesis on early sensitive periods for cognitive development and the important role of pre– and post natal influences up to the early childhood measure. However, I also find evidence that changes in growth into middle childhood (i.e. the residual HAZ between early and later childhood) is significant positive associated with children’s cognitive test scores. This supports the hypothesis of the plasticity of the brain beyond early years.

Chapter 6 is about children’s physical health measure of lung capacity. I investigate to what extent children’s growth status in early life and growth dynamics into adolescence are associated with children's lung capacity. Further, I examine to what extent parental resources are associated with children's lung capacity. A key result is that in terms of parental resources there is a strong positive association between father's and mother's lung capacity and their children in adolescence. Also maternal years of schooling is significantly associated. I do not find a significant positive association between initial/early height-for-age (HAZ) and lung capacity. This would work against the hypothesis on early sensitive periods and rather point to the importance of changes in growth after early childhood for children's lung capacity development. The change in growth into middle childhood (residual HAZ) is significant positively associated with children's lung capacity. These result differ from what I find for cognitive outcomes where early growth status and changes in growth are both relevant.

Chapter 7 discusses recommendations for future research; for example, how new data collection efforts in Indonesia could contribute to closing evidence gaps on children's life chances identified in this thesis by collecting birth cohort data or extending the IFLS. I also address implications for policy covering recommendations for more holistic childhood interventions, the kind of support provided and targeting of vulnerable children.

Evidence on children's life chances from Indonesia is very limited. I set out to make a contribution in providing evidence on child outcomes that are uniquely featured in the Indonesian Family Life Survey (IFLS). My key concern is to study the *intergenerational determinants* of child outcomes – that is, asking to what extent parental resources are linked to the level of children's nutrition, cognition, and health but also the *intra-generational link* – that is to what extent nutritional status is linked to later growth dynamics and other child outcomes such as cognitive and health outcomes. To the best of my knowledge, there are very few previous studies for Indonesia that investigate these important child outcomes, especially with the focus on the intergenerational and life-course determinants.

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CHAPTER 1: Introduction

"We are guilty of many errors and many faults, but our worst crime is abandoning the children, neglecting the foundation of life. Many of the things we need can wait. The child cannot.
Right now is the time his bones are being formed, his blood is being made and his senses are being developed. To him we cannot answer 'Tomorrow'. His name is 'Today'."

Gabriela Mistral[1]

This chapter gives an overview of the thesis entitled: *"Life-chances of children in Indonesia: The links between parental socio-economic resources, childhood malnutrition, cognitive skills and health outcomes."* Section 1.1 will outline the motivation for the research, detailing why we should be interested in children's life-chances and their links to parental socio-economic resources. Section 1.2 gives an overview of the research questions that we address in the thesis. Section 1.3 provides some insights into why we chose Indonesia and why the research questions are important in the Indonesian context. Section 1.4 outlines how the rest of the thesis is structured.

1.1 Studying the life-chances of children

Why are we or should we be interested in children's life chances, their growth, nutritional status, cognitive skills and health outcomes? The majority of children in the developing world are suffering from hardship and poverty, and are not able to reach their full developmental potential. According to the Childhood Poverty Research and Policy Centre, about 600 million children are growing up in absolute poverty[2]. The most extreme cases of child poverty are linked to undernutrition: it accounts for over one half of the 10 million childhood deaths that occur annually for children under five years of age (Caulfield et al. 2006; UNICEF 2008; Grantham-McGregor et al. 2007). Further, in 2007 in the Lancet Grantham-McGregor estimated, that worldwide over 200 million children under 5 years fail to reach their cognitive development potential as a result of

[1] Chilean poet, educator, diplomat, and feminist, 1889-1957.
[2] Absolute income poverty defined according to international reference of below US$1 (1993 PPP) per day

poverty and related problems (Grantham-McGregor et al. 2007, 60). It is further estimated that over 150 million (24 percent) of all children worldwide are affected by stunting (de Onis 2008). Despite setting the goal of reducing malnutrition by 50 percent by the year 2000 at the World Summit for children[3] in 1990 and the Millennium Development Goals[4], many countries lag behind achieving this target.

This thesis studies to what extent parental socio-economic resources are associated with children's nutritional status. Moreover, it asks how parental resources and children's nutritional status is associated with other crucial aspects of child-wellbeing: their cognitive skills and their health achievements.

Nutrition, cognition and health are key human capitals that are important both as a means to achieve wellbeing and as an end in its own right (Sen 1999). They have been identified as some of the main routes for changes in well-being over the life-course and seen as significant pathways for breaking intergenerational poverty cycles and reversing disadvantaged starts in life due to material poverty (Blanden, Gregg, and Macmillan 2006; Blanden and Gibbons 2006; Handa, Simler, and Harrower 2004; Harper, Marcus, and Moore 2003; Litchfield 2001; Moore 2004; Smith and Moore 2006). Amartya Sen also points out that these key human capitals are intrinsically valuable; that is, as ends in and of themselves. In his capability approach, he conceptualizes poverty in a multi-dimensional way: as deprivation of basic capabilities, and nutrition, cognition and health as direct measures of well-being (Sen 1979; Sen 1985; Sen 1987). Furthermore, health (especially basic health) and adequate food have been recognized as fundamental rights with manifestation dating back to the Universal Declaration of Human Rights (1948), and the UN Convention on the Rights of the Child (UN General Assembly 1989)[5].

With malnutrition being a persistent problem, its long-term consequences have been studied increasingly. For example, Alderman and colleagues investigate the long term consequences of malnutrition on grades attained and age started school for Pakistan and Zimbabwe (Alderman et al. 2001). They find that preschool malnutrition in rural Zimbabwe impacted on human capital formation. Malnutrition caused stunting, delayed schooling and reduced work experience opportunities which led to a loss of lifetime earnings of about 14 percent (Alderman, Hoddinott, and Kinsey 2006). Other studies have shown that malnourishment not only is a problem in its own right but can also

[3] World Summit for children in 1990: A promise to children. More details at: http://www.unicef.org/wsc.
[4] Target 1C: Halve the proportion of people who suffer from hunger.
[5] E.g. the right to the enjoyment of the highest attainable standard of physical and mental health (UDHR A25, ICESCR Article 12) and the right to adequate food.

hinder the development of other skills such as children's cognitive development (Grantham-McGregor, Fernald, and Sethuraman 1999a; Kar, Rao, and Chandramouli 2008; S. P. Walker et al. 2007; S. P. Walker et al. 2011). There are still debates as to whether this is reversible or not (Levitsky and Strupp 1995a). How this can translate into intergenerational transmission is shown by the example of how girls who grow up with inadequate nutrition face greater health risks during pregnancy, thus completing the cycle of maternal and child malnourishment and intergenerational transmission (ACC/SCN/IFPRI 2000; Harper, Marcus, and Moore 2003). Other routes are through poor cognitive skills with children being more likely to perform poorly at school, achieving lower educational levels, having more difficulties in the labour market and in turn lower earning (S. P. Walker et al. 2007; S. P. Walker et al. 2011).

While children's development is influenced by multiple factors that are often interrelated, parental resources seem to have the strongest association on children's development outcomes (G. Duncan and Brooks-Gunn 1997; G. J. Duncan et al. 1998; Gershoff et al. 2007; Grantham-McGregor et al. 2007). In their recent book Ermisch et al. describe in detail how different parental socio-economic resources are associated with children's outcomes over their life course (Ermisch, Jäntti, and Smeeding 2012). Parental resources, often monetary, are needed for quality child care and early childhood education, providing educational inputs such as books or computers, living in neighbourhoods with access to good public schools and health care facilities. But also other investment that are low in monetary costs but require time such as reading to the child, teaching them informally and developing their socio-emotional skills such as interactions with others, empathy, impulse control, motivation and ability to concentrate (Ermisch, Jäntti, and Smeeding 2012, 3–4).

There is also a lack of information from developing countries and a need to combine an intergenerational and life-course (longitudinal) perspective. There are few national statistics on the development of young children in developing countries (Grantham-McGregor et al. 2007, 60). Some information is available about the situation of children from cross-sectional surveys such as Demographic and Health Surveys[6] and Multiple Indicator Cluster Surveys (MICS)[7]. However cross-sectional surveys have limitations. As Victora and Barros put it metaphorically: "[cross-sectional data] provide still photographs of the health and nutrition of young children at a given point. They do not

[6] http://www.measuredhs.com/aboutsurveys/dhs/start.cfm

[7] MICS: international survey by UNICEF on situation of children and women http://www.childinfo.org. MICS1: 1995, MICS2: 2000, MICS3: 2006, MICS4: 2011/2012. Indonesia took part in MICS1 & MICS 2 and a subnational survey exists for MICS4.

tell us about dynamic processes such as growth, (…) or intellectual development (…). Nor do these surveys allow linking early exposures to later health, developmental, or behavioral outcomes, an area of growing importance in life-course epidemiology (…) (Victora and Barros 2012, 3). As the authors continue to show there is little evidence available on the association between parental resources and child outcomes in developing countries. Most of what we know on the association is from high-income countries often from specifically designed birth cohort studies. So there is a need for developing country research to move "from still photographs to full-length movies" as evidence from high-income birth cohorts are often used to justify global health policies. That the context is very different is shown by the important example of over and undernutrition. While for high-income countries consequences of child obesity are very relevant this is only true to a limited extent for low and middle income countries where poor nutritional status and stunting are still highly prevalent (Victora and Barros 2012). That the topic of hunger and nutrition has not lost its urgency is shown by new and ongoing campaigns such as the Enough Food For Everyone IF campaign 2013 with its motto: "The world produces enough food for everyone, but not everyone has enough food"[8] or the Scaling-Up-Nutrition Campaign[9]. Also recent financial crises and natural disasters (such as drought and flood) have added to the difficulty to provide adequate food for everyone around the world (FAO 2013).

To conclude this section we can see that children around the world are still far away from fulfilling their full potential diminishing their chances in lives in various dimensions. And evidence from low- and middle-income countries is limited due to lack of appropriate data. In the next section, we will look briefly at the research questions this thesis addresses in the field of children's life-chances.

[8] Enough Food For Everyone IF campaign: http://enoughfoodif.org
[9] Scaling-Up-Nutrition Campaign www.scalingupnutrition.org

1.2 Research questions of the thesis

This thesis focuses on the relationship between parental socio-economic resources and children's outcomes in the areas of nutrition, cognition and health over children's life-courses. The life-stages (early childhood to young adulthood) are important because they are crucial for human capital formation (especially cognition and health) which in turn influences well-being in adulthood and potentially in the next generations (Harper, Marcus et al. 2003).

Adopting a longitudinal approach with a focus on intergenerational relationships provides a useful framework to investigate inequalities in children's life chances. The majority of existing studies in developing countries examine the intergenerational relationship between parents' characteristics and children's outcomes at one point in time, often focusing on young children and rarely following children into adolescence years. Here, we bring together a life-course approach with the intergenerational perspective. This allows us to understand whether parents' resources and children's outcomes only matter in early childhood or if they are relevant for later recovering from early childhood experiences. These findings are relevant for the design of effective and appropriate policies that span well over children's life course from early childhood into adolescence.

Disadvantages in these domains are especially salient in developing countries. Here, we use data from the Indonesian Family Life Survey (IFLS), a rich panel data set consisting of four waves of data which span a period of 14 years. To follow children's dynamics of outcomes from early childhood to adolescence, we study a cohort of children who were less than three years old in the first wave of the IFLS and for whom we can observe relevant outcomes in different waves. The range of parental socio-economical resources we look at include (i) individual-level ones such as maternal and paternal education, height and lung capacity; (ii) family-level: financial resources (i.e. consumption), quality of the living environment and family structure.

The next section gives an overview of how the three empirical chapters (four, five and six) are linked together. This is not a conceptual framework, but rather an overview to show the focus of each chapter and the link between them. It is followed by a short description of each of the research questions.

This thesis answers three research questions. ***Firstly***, we are interested in what factors are associated with children’s nutritional status in early and later childhood and the dynamics of nutritional status (e.g. catch-up in growth) between early childhood and adolescence. This is the focus of chapter 4.

We focus on investigating the dynamics of children's nutritional status over time. There is mixed evidence on whether recovery from shocks to the nutritional status of children (e.g. stunting) in early childhood is possible. Further, only a few studies explore what factors are associated with nutritional status dynamics that span children’s life-course into adolescence. This is partly due to data requirements – one needs longitudinal data that spans a substantial period of time to observe this phenomenon. This focus is linked to a debate about child development in the literature. One side argues that it is only the early years in children's development that are formative and if disadvantages occur in this critical window they can be irreversible. Some support to this claim comes from insights of intervention studies that covered nutritional and stimulation inputs. They show that improvements are only possible for very young children or in the short term (Pollitt, Watkins, and Husaini 1997). The other side cites evidence that suggests that the brain is a very resilient organ, able to adapt to disadvantaged circumstances and even recover to some extent from the damage it has experienced long into adolescence years (Levitsky and Strupp 1995b)

To our knowledge, there are no studies that explore the dynamics of nutritional status over a timespan from early childhood to adolescence for Indonesia. Using the IFLS data, we are able to follow these children into adolescence – a life-stage that has not been researched very much in developing countries, due to the time-span of data needed. There are a few studies from other countries that look at the dynamics of nutritional status (stunting) but the timespans and life stages considered are normally shorter. So we are interested in exploring whether parental resources are associated with different dynamics (e.g. catch-up growth). This should help to understand if the improvements or worsening of children’s nutritional status is occurring and what factors are associated. It is also the groundwork for the next two research questions that look at the consequences of parental resources and child nutrition on cognitive development and schooling outcomes.

Secondly, we are interested to investigate how important malnutrition is to other child outcomes later on in life. We focus on examining the relationship between children’s nutritional status and cognitive outcomes (the results of the Ravens matrix test). This is done in chapter 5.

The relationship between malnutrition and cognitive outcomes is important, as malnutrition can reduce children's learning capacities. Research has shown that malnutrition has an effect on the development of the brain in particular the working memory functions which are necessary for learning (Levitsky and Strupp 1995a; Levitsky and Strupp 1995b). Together with other disadvantages such as inadequate financial resources the risk of lower school achievements or even drop-out of school may increase. The consequences are a depletion of children's human capital which is likely to lower their earning capacities in later life and laying the foundation for a cycle of disadvantages possibly passed on to the next generation as well.

Thirdly, we investigate the relationship between parental resources, children's earlier malnutrition and the dynamics of malnutrition between earlier childhood and adolescence with the physical health measure of children's lung capacity. This is done in chapter 6.

We are interested to see whether children's malnutrition in early life is negatively associated with children's lung capacity in later life. Furthermore, we ask whether there are differences of children's lung capacity by children's nutritional dynamics and parental resources. Conceptually the relationship between malnutrition and children's lung capacity goes via the route of organ development that can be hindered by malnutrition. Further, malnourished children are more prone to illnesses such as respiratory illnesses which can affect children's lung capacity – this can be especially critical in tropical countries such as Indonesia where the humid climate enforces infections of the respiratory system. Respiratory illnesses are still a major cause for child death in developing countries. We make use of a unique feature of the IFLS - the availability of a measure of children's lung capacity collected by a trained nurse. Household surveys and even demographic health surveys very rarely collect these kind of physical measures of lung capacity in developing countries. We use this unique feature of the Indonesian Family Life Survey to examine an aspect of children's physical wellbeing that has potential long lasting effects on their overall physical health as adults, which in turn is related to what kind of jobs they are able to perform, thus influencing labour market outcomes.

To conclude this section we have given a first overview of the research questions that are addressed in the thesis and provided some rationale why those are important in relation to children's life chances. We have further illustrated how the three empirical chapters are connected with each other with chapter 4 examining parental resources and children's nutritional status early in life and the dynamics into adolescence and chapter 5 and 6 examining the consequences for two crucial areas of children's wellbeing, namely cognitive skills (Raven's coloured matrices) and physical health (lung capacity). A more detailed account of the research question is provided in chapter 2 section 3 and each of the empirical chapters. The next section will give a brief overview of the Indonesian context in which the research is situated and provides some justification as to why Indonesia was chosen as a case study.

1.3 *The Indonesian context*

Indonesia provides a fitting case study for the research question that this thesis addresses. Indonesia has an important socio-demographic status as the fourth most populous country in the world as well as the country with the largest Muslim population.[10] It represents a wide range of spatial differences with diverse settings and poverty experiences (Booth 1993).[11] Despite a positive trend in many areas, it squarely belongs to the countries identified as lagging behind in reducing malnutrition by 50 percent by the year 2000 (World Summit for Children) and the Millennium Development Goals. At the same time, the Indonesian Family Life Survey (IFLS) dataset provides us with unusually rich longitudinal data, when compared to other developing countries. This section outlines the country context to better understand life chances of children in Indonesia for the period around 1990s until around 2007 which corresponds to the time that the data we use (the IFLS) was collected.

Brief context on children's health in Indonesia

Examining some of the national trends from cross-sectional data in Indonesia shows that health indicators steadily improved over the last decades. For example, infant mortality decreased from 118 (per 1000 live–births) in 1970 to 49 in 2004 (ADB 2004). Similarly, life expectancy at birth increased from 48 in 1970 to 65 years in 2004. Underweight children (under 5 years) decreased from 37.5 percent in 1989 to 24.6 percent in 2000; interestingly there were greater reductions in numbers in rural areas (Statistic Indonesia 2007). Health inequality also shows great regional differences. For example, there were 17.9 percent underweight children in Bali compared to 38.6 percent in East Nusa Tenggara (UNDP 2004a; UNDP 2004b). While the trend in stunting has decreased it is still highly prevalent for Indonesia's middle income country status. "Stunted children is a serious issue now because, in Indonesia, out of every three children, one of them is stunted. This is quite scary," Ali Khomsan, professor of nutrition from the Bogor Agriculture University (IPB) (Afrida 2013).

While the above were national averages, there exist great inequalities in health care use and expenditure as well as health outcomes. Some examples of outcomes by socio-economic resources follow. There also exists a substantial health divide along social-

[10] In 2007 the estimated population of Indonesia was: 234,693,997. From the Census 2000 - Muslim: 86.1per cent, Protestant: 5.7per cent, Roman catholic 3per cent, Hindu 1.8per cent (CIA World Factbook, 2008).
[11] Number of population in Indonesia in 2006 according to the Statistical Yearbook of Indonesia: 222 million.

stratification dimensions such as household consumption. For example: infant mortality rates were 78 (per 1,000 live births) for the 20 percent consumption poorest compared to 23 for 20 percent consumption richest. The gap was further visible in the under 5 mortality rate: 109 (per 1000 live births) for the poorest compared to 29 for the richest. And lastly, maternal health risks with birth attended by skilled health personnel was only 21 percent for the poorest as compared to 89 percent of the richest. So it is not surprising that maternal death is still high by neighbouring South-East Asian country standards (373 maternal deaths per 100,000 live births in 2002) (HDR 2004).

Indonesia has special health system in relation to children. The so called Posyandu, a basic community based health activates for maternal and child health. It is a monthly meeting conducted by trained volunteers that is intended to provide family planning, ante- and postnatal care, immunisation, simple interventions for diarrhoea and nutritional problems (dehydration solutions). These community based childcare activities were established under the presidency of Soeharto and expanded between 1984-1998 due to substantial funding and massive national campaigns to promote the Posyandu including the now well-known song “Aku Anak Sehat” (I am a Healthy Child). However, due to lack of funding and the limitation to build the system around volunteers has resulted in a decline in the provision and use of Posyandu activities. Recent efforts try to revive the system by integrating it with the early childhood education center (Paud) to get more children for regular health checks (Posyandu TAT) (Afrida 2013).

Brief context on children’s cognitive skills and educational achievements

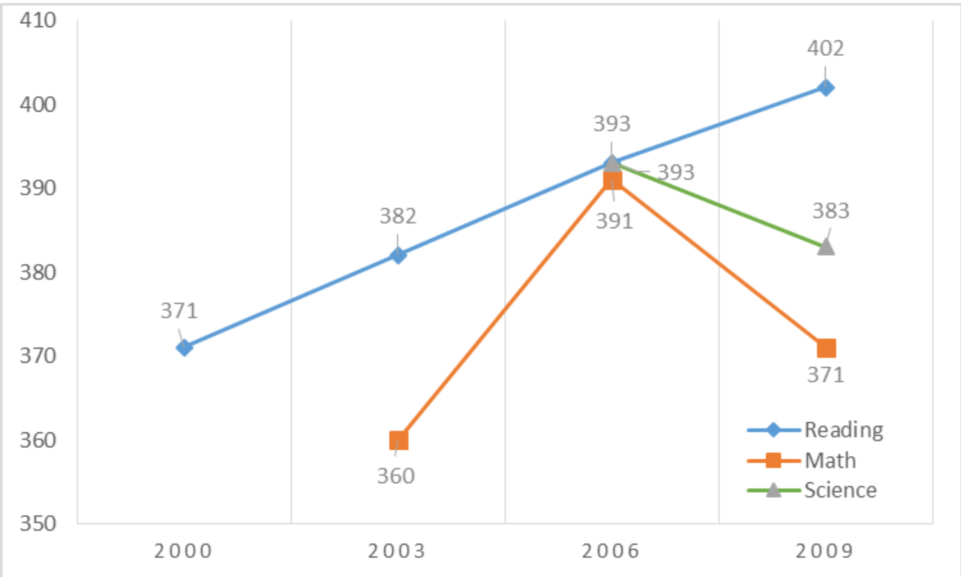
There is no national data available in Indonesia for direct measures of children’s cognitive skills, so we review some trends in schooling as well as results from the Program for International Student Assessment (PISA).

National profile and trends of education in Indonesia over the last decades show improvements. Between 1973 and 1979, Suharto set aside oil revenues to launch a massive school construction programme with more than 61,000 primary schools built (Levine & Jellema, 2007). Duflo (2004) shows that the rapid expansion of primary schools has led to an increase in years of schooling and a decrease in the gender gap (Levine & Jellema, 2007). This was paralleled by a reduction of fertility and a shift towards small nuclear families with declining influence of the extended family and the increased labour market participation of women (Central Bureau of Statistics, 2003).

However, while near universal primary school attendance was achieved in the late 1980s, the government has not yet accomplished the same for secondary schooling. A nine-year compulsory basic education programme was launched in 1994 and 2008 was declared as the year where the universal nine-year education target should be met (UNDP, 2004). However, net enrolment rates (NER)[12] for junior secondary school level show only 65 percent enrolment in 2004 compared to 54 percent in 1994. The completed junior secondary schooling for the working aged population was only 46 percent. The school attendance for senior secondary school is even lower. Therefore, universal access to secondary schooling is still far from achieved in Indonesia (Suryadarma, Suryahadi, & Sumarto, 2006).

In order to be able to evaluate the quality of schooling provided and how Indonesia compares to other countries in school outcomes, we use the results from the Program for International Student Assessment (PISA). The study was conducted in 2000, 2003, 2006 and 2009 and Indonesia took part in all of them (OECD 2010; Fleischman et al. 2010). In Figure 1 we have assembled the available data points for reading literacy, math and science scores for Indonesia. As the blue line in Figure indicates, there is a steady upward trend for reading literacy between 2000 and 2009.

Figure 1: Average scores of 15-year-old students in literacy, math and science score



[Source: Compiled by the author based on (Fleischman et al. 2010)[13]]

[12] Net enrolment rates refer to school level appropriate aged children in contrast to the gross enrolment rate which refers to any age.
[13] Data source used to create figure 3: Fleischman et al, 2010: Table R5, p.19 & Table M2, p.51

As first insight, the OECD identified a particularly strong and positive association between reading performance and regularly reading fiction, and a negative association between reading performance and regularly reading comic books. The increase in reading fiction was particularly pronounced in Indonesia with only 37% of students in 2000 reporting to read fiction regularly, compared to nearly 60% of students in 2009 – a 23-percentage-point increase. Indonesia together with Peru was the only country where students reported regularly reading magazines (OECD 2010, 94–95).

Figure 2 only shows the averages for students, not revealing the gender difference in reading scores. This data was only available for 2009 with 15 year old female students scoring on average 37 points higher for the on PISA reading literacy test compared to male students (female: 420, male: 383). This difference is the equivalent of one year of schooling (Fleischman et al. 2010, 14).

Here, it is important to put Indonesia's reading literacy results into international context. While there was a positive upward trend between 2000-2009, Indonesia only ranked 57 (65 countries in total). This compared to rank 49th (out of 57 countries) in the 2006 result, still very close to the bottom of performance.

The picture for math scores looks a bit different.[14] In 2003, 15 year old students only scored 360 but increased substantially within three years with 391 in 2006, but then declining 20 percentage-points in the course of three years to 371 in 2009 (OECD 2010, 150). There is no additional information to judge what the course of the increase and decrease in math scores could explain. In terms of international rank in 2009 this means that Indonesia only reached 61st place out of 65 countries for math proficiency.

For the science scores the trend is even gloomier although we only have two data points[15]. The science proficiency of Indonesian students declined by 10 percentage-points from 393 in 2006 to 383 in 2009 – mirroring the declining trend for the math scores. For 2009 the international rank for Indonesian students in science scores is 60th out of 65 countries.

Comparing resuls of the 2009 PISA to other countries in the region of Southeast Asian shows that they fared better than Indonesia. For example, Singapore scored 526 points and was in fifth place for reading, 562 points and second rank for math, and 542 points and fourth rank for science. Probably more comparable, Thailand scored 421 points and

[14] Note for PISA Math scores: "The PISA mathematics framework was revised in 2003. Because of changes in the framework, it is not possible to compare mathematics learning outcomes from PISA 2000 with those from PISA 2003, 2006, and 2009." (Fleischman et al, 2010: 51).

[15] Note for PISA Science scores: "The PISA science framework was revised in 2006. Because of changes in the framework, it is not possible to compare science learning outcomes from PISA 2000 and 2003 with those from PISA 2006 and 2009." (Fleischman et al, 2010: 65).

was in 50th place for reading, 419 points and 50th place for math, and 425 points and 49th place for science (Asrianti 2010).

Why Indonesia as case study?

Indonesia represents an interesting case study for examining the association between parental socio-economic resources, children's nutritional status and their cognitive and schooling outcomes for several reasons.

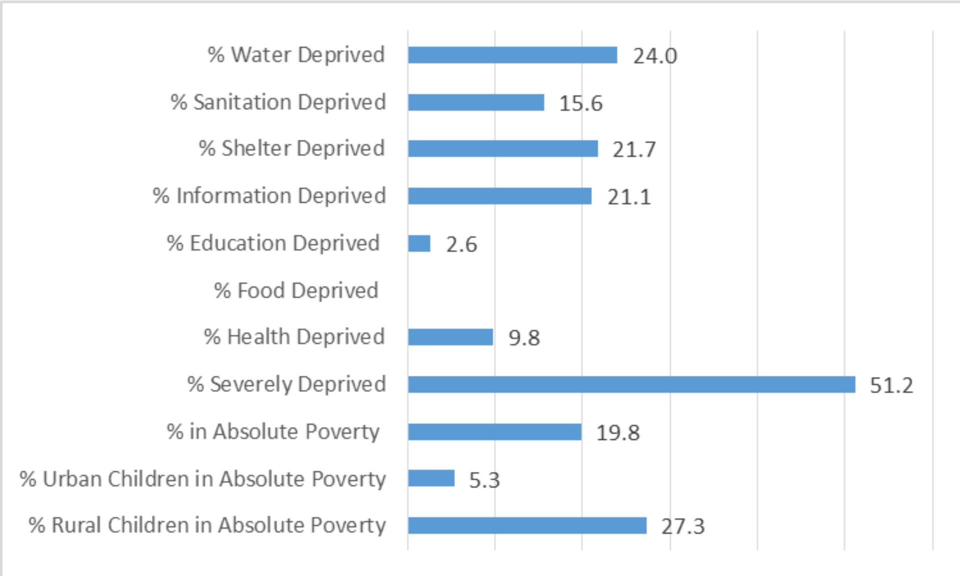
First, for its trend in poverty: Between the 1960s and mid-1990s, Indonesia underwent rapid economic and social development which resulted in a large reduction of the population living below the national poverty line from 40.1 percent in 1976 to 11.3 percent in 1996, and also enabled the government to invest in public spending (Lanjouw et al. 2001). However, the economic and political crisis in 1997/98 pushed millions of Indonesians back into poverty. Indonesia was hit hardest by the East Asian crisis (1997-1998) which cumulated with the end of Suharto's military dictatorship (McCulloch et al. 2007). Poverty is therefore again on the top of Indonesia's development agenda.

The Asian financial crisis in 1997-1998 hit Indonesia particular hard after 30 years of rapid growth in the region. Real GDP fell by 13 percent in 1998, domestic investments declined by 35.5 percent. The sudden and dramatic price changes were mostly due to exchange rate depreciation. Starting in January 1998 until March 1999 Indonesian witnessed a massive increase in food prices with the nominal food prices increasing three-fold. This was one of the major impacts during the crisis that were felt by the majority of the Indonesians as a typical Indonesian household spends approximately half of its budget on food. The food share for rural regions is even higher with nearly 60 percent; among the poor this food share is even higher (Strauss et al. 2004).

When looking at broader indicators, the Human Development Index (HDI), a composite indicator consisting of three dimensions (life expectancy, educational attainment and command over the resources needed for a decent living), UNDP observes: "Although most developing countries have done well, a large number of countries have done particularly well—in what can be called the "rise of the South". Some of the largest countries have made rapid advances, notably Brazil, China, India, Indonesia, South Africa and Turkey" (UNDP 2013, 13–24). In other words Indonesia made greater progress on HDI between 1990 and 2012 than would have been predicted from its previous performance on the HDI.

In a similar direction goes the multidimensional child poverty report by (Gordon et al. 2003). We used data from this report to assemble the graph in Figure 2 on different dimensions of severe deprivation and absolute poverty of Children living in Indonesia.

Figure 2: Severe Deprivation and Absolute Poverty of Children in Indonesia



[Source: Figures from Appendix IV (Gordon et al. 2003, 122)[16]]

Second, Indonesia still has a very high incidence of malnutrition compared to its neighbouring countries and in relation to its status as a lower-middle-income economy[17]. While health trends overall have improved over the last decades, some of the health problems in Indonesia have still a worrying extent. The stunting[18] prevalence for children under 5 years for the years 1996-2004 was 42 percent for children under the age of five years. Overall, Indonesia still lags behind other countries in the region (e.g. Malaysia, Thailand) that have better health outcomes (Lanjouw, Pradhan et al. 2001).

The potential link between malnutrition and cognitive skills points to how much children will actually be able to benefit from education, even if it is accessible. Indonesia has made substantial progress with providing education and increasing investment in educational programmes. With the high prevalence of malnutrition however, it seems especially relevant to study its effects on the ability of children to profit from education. This highlights the possible impairment of malnourished children's learning ability and

[16] Child population in 2000: 78,233,000

[17] According to the World Bank classification: http://data.worldbank.org/about/country-classifications/country-and-lending-groups#Lower_middle_income

[18] Definition of stunting: height-for-age z-scores (HAZ) =< -2SD compared to the international reference group of the WHO. For more details see chapter 3 (Methods).

thus school performance. With an evolving economy that needs a more skilled workforce it is important to identify where human capital may be compromised and children are not reaching their development potential.

Thirdly, a longitudinal dataset is available – the Indonesian Family Life Survey (IFLS). For analysing life chances of children over time, panel data are needed. There is a lack of such data for most developing countries, which has led to a dearth in the quantitative analysis existent in developed countries (Baulch and Hoddinott, 2000). However, Indonesia is one of the few countries that have publicly accessible prospective panel data: the Indonesian Family Life Survey (IFLS) started in 1993 and thus far completed four survey waves, with the most recent one in 2007. That this data set is available in a developing country is remarkable in itself but particularly when considering Indonesia's wide geographical spread (see appendix 1 for a map of IFLS data collection sides in Indonesia).

The Indonesian Family Life Survey (IFLS) is one of the few panel data sets that has a long enough span of 14 years to overcome the lack of comprehensive studies on the issues of childhood disadvantages and educational progression, especially in developing countries. Further, with the data that is directly collected on children's outcomes such as the measures taken by a trained nurse on children's anthropometrics and lung capacity as well as the collected cognitive tests of the Raven's coloured progressive matrices make the IFLS a unique dataset to investigate children's life chances.

To conclude in this section we have shown in what country context our research is situated giving some background information on children's health and education in Indonesia and also outlining the different reasons that make Indonesia a valid candidate for research on children's life chances. The next and final section of this chapter will give an overview of the structure of the rest of the thesis.

1.4 Overview of the thesis

This section provides an overview of the different chapters of the thesis. In the next chapter (Chapter 2), we review conceptual framework for examining children's life-chances. While there is great interest in understanding what determines children's life-chances and a recent increase in research in this area, there is no established conceptual framework. Thus, we explore some relevant frameworks. The second part of chapter 2 reviews some existing empirical evidence on children's life chances in Indonesia using the IFLS.

Chapter 3 is focused on the research design of the thesis. It starts with discussing the data source used – the Indonesian Family Life Survey (IFLS), a longitudinal dataset that started in 1993 and spans 14 years until 2007 with four waves of data. We present the advantages and disadvantages of the IFLS. We are able to use some insights that were gained during a field visit during the data collection in 2007 (IFLS4) and some qualitative interviews done with interviewers from the IFLS4 in a second institutional visit to the University of Yogyakarta in 2008. The discussion of the data also includes an assessment of its quality in terms of coverage, attrition and representativeness. The second part of chapter 3 explains the outcome variables, the creation of the analytical dataset and the methods of data analysis that we employed.

Chapter 4 is the first of three empirical chapters, and addresses the question to what extent parental socio-economic resources influence children's health outcomes (their height-for-age) in early childhood and health dynamics between early childhood and adolescence. More specifically, we investigate to what extent the growth of children in early childhood is stratified by parental socio-economic resources and if dynamics such as reversal of stunting between early childhood and young adulthood differ by parental background. We study a cohort of 1,037 children who were less than three years old in the first wave of the IFLS in 1993 and for whom we can observe health outcomes in all four waves. For growth in early childhood we find that the effects of maternal human resources are consistently higher and more significant than father resources, but fathers' resources still have a separate effect over and above that of mothers. Often parental socio-economic resources are only often mapped as the characteristics of either the mother or the father. Some datasets, especially birth cohort studies do not interview fathers and only have reported responses from their spouses. Further results suggest that direct measures of living standards – e.g. cleanliness of the living environment, indoor water facilities etc. are more strongly associated with children’s growth than indirect measures of financial resources such as consumption.

And lastly, the structure of the family (e.g. birth order, size of family) also turns out to be an important aspect that has significant association with children’s growth. This has not often been looked at in previous research. For dynamics of stunting, such as the reversal of stunting between early childhood and adolescence, maternal height is again significantly associated with children having higher probability of experiencing reversal of stunting. Similarly to growth in childhood, father’s height is also significant but the effect size is smaller. Parental education is not significant for the probability of reversal but financial resources are. While the effect size and significance level were low in the growth model for early childhood, for recovery from stunting it is significant.

Chapter 5 of the thesis, the second empirical chapter, looks at the link of parental socio-economic resources, children's malnutrition and cognitive outcomes. We first outline possible explanations of how malnutrition and cognitive outcomes are linked via pathways such as brain development and caregiving practices and living environment. Our empirical results show that early height-for-age (HAZ) has an independent effect (even after controlling for later height) on cognitive processes which could support the hypothesis on early sensitive periods for cognitive process development and the important role of prenatal influences up to the early childhood outcomes. However we also find evidence that what happened to children after first five years of life (i.e. the changes in height during middle and later childhood) is also significant supporting insights from neuroscience that brain development is more complex than previously thought and plasticity of the brain an important factor. The association between early HAZ and cognitive outcomes survives but is attenuated by later HAZ in a substantial way. We suspect that the observed observation would even be stronger, if instead of Raven’s test results (a measure of general cognition) more specific tests for working memory would be available (the area that is most effected by malnutrition). As for parental resources, schooling and financial resources do not stay significant in the full model, only housing conditions. The results also reveal some insights into other factors that are associated with cognition and provides some evidence for Indonesia where not many studies on determinants of cognition exist. For example we find that pre-school experience, presence of grandparents, quality of living environment and being Muslim are associated with test results. We also find a rural area disadvantage that seems fully accounted for once we include electricity and indoor water facilities.

Chapter 6 asked to what extent children's nutritional outcomes in early childhood and their dynamic (i.e. change over time) as well as parental resources influence children's lung capacity in adolescence. To the best of our knowledge, there are no studies that investigate the links between children's nutritional status, parental resources, and children's lung capacity in Indonesia. We used a unique feature from the Indonesian Family Life Survey (IFLS) – the peak flow meter results for children's and parents lung capacity. Providing some evidence with the unique feature of the IFLS is therefore a gap that we wanted to contribute to filling in this chapter.
Conceptually there could be direct and indirect links between parental and child lung capacity. Directly, through organ growth and size, which is partly genetically influenced. Indirectly, as parents are exposed to the same hazards as their children. We find that father's and mother's own lung capacity are both significantly positively associated with children's lung capacity. What is striking is that the coefficient for maternal lung capacity is greater than that for fathers. A possible explanation could be that mothers as the main caregivers spend more time in the same environment as their children, so we would expect a closer relationship between maternal lung capacity and that of their child. We also examined whether children who were stunted in early childhood in 1993 when aged 0-3 years old have worse lung capacity than children who were not stunted in infancy. Children that have been stunted in early childhood have a significantly reduced lung capacity by 10 L/min compared to children that were not stunted in early childhood. This association could support the conceptual link with malnourished children being more likely to experience illnesses such as respiratory illnesses which can affect children's lung capacity. Malnutrition has also been reported to lead to poor organ growth of lungs themselves but also the wasting of important muscles necessary for respiratory functioning (Kaur Rajneet 2012).

Chapter 7 is the concluding chapter of the thesis and first summarises the main points of the thesis and then discusses the implications for policy and future research. More specifically the research question and findings are reviewed followed by a discussion on the limitation of the research. Further, policy implications for Indonesia are discussed by addressing questions on what we found on factors that determine life changes of children.

We proceed to chapter two to discuss the conceptual framework and literature.

CHAPTER 2: Conceptual Framework and Literature

In the first part of this chapter we start by exploring conceptual frameworks for examining children's life-chances. This serves as a starting point for the more specific frameworks that are developed in each of the three empirical chapters specifically for children's nutrition, cognition and health. It should help to situate the specific child outcomes and frameworks in the broader conceptual discussions on intergenerational transmission of child poverty.

The second part of the chapter reviews the existing empirical findings on what we know about parental resources and children's life chances. We try to use as much evidence from Indonesia as possible, however, due to limited evidence we supplemented the review with selected studies from other developing countries, as well as the UK, and the US. The appendix provides in-depth information on the reviewed empirical studies.

2.1 Frameworks to study parental resources and children's life chances

There is a growing interest in understanding how children's life chances are influenced by their family background. To define what we understand by children's life chances we briefly outline the three broad areas of child development, namely physical, behavioural and cognitive development. This is not a complete summary of all the child development skills but is rather for better orientation of the multidimensional nature of children's life chances.

- *Physical development*: children's nutrition, growth, their physical health as well as motor skills. Fine motor skills (for example children's ability to use small muscles, i.e. their hands and fingers to pick up small objects, etc.) and gross motor skills (e.g. children's ability to use large muscles, for example to sit or pull up, etc.)
- *Behavioural development*: emotional and social skills (for example children's ability to interact with others, including helping themselves and exercising self-control)
- *Cognitive development*: verbal (for example children's ability to both understand and use language) and non-verbal (e.g. child's ability to learn and solve problems)

It has been hypothesised that there is an interrelationship between the different child development skills. For example, improved motor maturation can broaden children's natural developmental involvement with their immediate environment thereby increasing stimulation and affecting subsequent cognitive developments (Husaini et al. 1991; Grantham-McGregor et al. 2007; Carneiro, Meghir, and Parey 2007).

There are a number of frameworks from different disciplines, such as child developmental psychology, cognitive and neuroscience, demography, epidemiology, nutritional science, economics (e.g. human capital investment theories), anthropology, education studies and sociology (e.g. structural, socialisation and role models). All of them provide important information on determinants of children's life chances.

In the next section we specify elements of a conceptual framework that would be helpful for our research purpose. Secondly, we review existing frameworks from different disciplines and evaluate them against the elements we identified.

Elements of a framework to study parental resources and children's life chances

Before we review different existing frameworks, we discuss elements that would be helpful for our research purpose. (points 1-4 below) and what purpose it should serve (point 5). This will help us to evaluate which existing frameworks or elements are useful for our research but also how we might need to adapt existing frameworks. Further, it is also relevant to assess if the proposed frameworks are applicable to a low and middle income country context as the majority were developed with high income countries contexts in mind.

We identify five main considerations for a conceptual framework namely: 1) specific on child development outcomes; 2) parental resources and pathways are specified; 3) a life-course perspective is adopted; 4) broader environmental factors are considered and 5) it serves as a guidance for model and variable specification. We will explain each one briefly.

1) *Child developmental outcomes* – a framework should specify child outcomes, ideally at different developmental stages – i.e. early, middle, late childhood and young adolescence. For our research we would further be interested in frameworks that try to specify what determines children's nutrition status, cognition and physical health outcomes and how they might be linked with parental resources and with each other.
2) *Parental resources & pathways* – a suitable framework should specify the pathways of how parental resources are likely to influence children's outcomes, ideally for fathers, mothers or other caregivers separately due to their different roles in caregiving, and help to identify if there are direct or indirect links between parental resources and children's outcomes.
3) *Life-course perspective:* we are interested in the perspective over time – i.e. how parental resources and children's outcomes are connected over children's life-course, ideally indicating pathways of how previous experiences influence later ones. The timing aspect also points to concepts discussed most prominently in epidemiology such as accumulation of risks over time and if critical or sensitive periods exists (Ben-Shlomo and Kuh 2002; Kuh et al. 2003). Another important aspect in this regard is the timespan that child outcomes are observed for. For our research we are interested in early to middle childhood and young adulthood. Often studies focus on either very short-term timeframes or association between parents and adult children outcomes. We are particularly interested in the

pathways in middle childhood and young adulthood and adopt a medium term perspective.

4) *Broader environment:* children and parents are embedded in a broader environment, such as the local community and national context with important relationships, policy and institutional context that go beyond parental resources and are likely to affect children's development. While we will try to account for these factors in our analysis as best as possible, in the framework we do not explicitly map them out to keep the schematic representation clear and focused. The relationship between parental resources and child development outcomes is complex, so a simplified schematic representation cannot map all aspects.
5) *Guidance for model and variable specification:* Besides understanding the links and pathways between parental resources and children's development, a conceptual framework should also help us to guide how we specify relevant models and variables for data analysis. Haveman and Wolfe conclude in their review of the literature on what determines children's attainment that there is no commonly used framework that guides researchers which model or variables to choose for analysis (Haveman and Wolfe 1995, p. 1872). We will review the framework that they propose and as well as other relevant frameworks in the next section in this regard as well.

Four broader models of transmission of poverty from parents to their children

In 1995, Mary Corcoran reviewed the literature on intergenerational transmission of poverty and discussed four models of why poverty persists between parents and their children's (Corcoran 1995). She proposed four models are: 1) lack of material resources model; 2) correlated disadvantage model, 3) welfare-dependency model and (4) structural model. They differ in what is assumed to be the causal explanation of the intergenerational poverty transmission. We briefly summarise the main arguments of these models.

The first model emphasises the lack of material resources. It states that affluent parents can invest the necessary material resources for their children's development: e.g. afford better quality food, health care, schooling, educational materials and extra-curricula activities as well as better housing conditions. These investments make a difference in children's human capital formation in childhood and adolescent and their achievement in young adulthood, thereby improving their chances of success in the labour market and in turn for their material resources in adulthood. This model was first developed by Becker and Tomes and further developed by Solon and Zimmerman (Becker and Tomes 1979; Becker and Tomes 1986; Solon 1992; Solon 2004).

The second model, the "correlated disadvantage model" argues that it is not material resources that lead to the intergenerational persistence of poverty but rather other parental characteristics which are often associated with low material resources. Susan Mayer's "good parent theory" from the book "What Money Can't Buy" (Mayer, 1997) is an example for this position. Examples for these "correlated disadvantages" are low education achievement, little time and energy to support and supervise children often from being a lone parent, lack of good role models for employment and other areas of life. This approach argues that once models control for these parental characteristics the effect of parental income becomes non-significant. Pathways through which parental characteristics are linked to child outcomes are captured in this model not only via human capital investment but also via children's attitudes, aspirations and behaviours (Uzuki 2010).

The third model, the welfare-dependency model, also argues against the idea that it is a lack of material resources that causes intergenerational persistence of poverty. It is rather the attitudes and behaviours that are shaped by receiving welfare state benefits acquiring negative work attitudes and motivations (Mead, 1986, 1992; Murray, 1994). There is not sufficient evidence of dependency on government benefits across generations. Further, while all of the four models have been developed mostly in a developed country context (the US), they still provide useful insights with the exception of this welfare dependency model. In a developing country context like Indonesia with no or very limited welfare state existence this model can be ruled out from the start.

The fourth model, the structural model, emphasises structural and environmental factors beyond the household or family. Examples for these kinds of environmental conditions are social class structure, the composition of the neighbourhood, labour market conditions, discrimination and demographic changes. For example, it is argued that the composition of a neighbourhood is important. If poor parents have no other choice but to live in a poor neighbourhood, their children experience additional disadvantages by also being deprived of good schools, role models and employment opportunities that may enhance their aspiration (Glennerster, Lupton, Noden, & Power, 1999).

We can now use our criteria that we have developed earlier to evaluate the usefulness of the models.

1) *Child developmental outcomes:* The main outcome that is tried to be explained is the income status of adult children. Some earlier child development outcomes, such as children's human capital or their attitudes and behaviours, are considered as intermediate pathways. However, the theories are rather broad to specify children's outcomes, especially differentiating between children's developmental life stages. The outcomes that are important to this thesis, nutrition and cognition are not explicitly mentioned by any of these theories while schooling outcomes are mentioned in some of them.
2) *Parental resources & pathways:* The parental resources that get most attention is material resources and their influence on human capital formation of the child. Parental education and attitudes or role models are also considered by some of the theories. However, the specific pathways how these parental resources are related to children's specific outcomes is rarely spelt out in detail.
3) *Life-course perspective:* Most of the presented theories adopt an intergenerational perspective, i.e. they are mainly concerned with adult children's outcomes as they focus on income mobility and do not explicitly adopt a life-course perspective.
4) *Broader environment:*

The fourth model, the structural model, emphasises structural and environmental factors beyond the household or family. The other frameworks are not very explicit about the role of the broader environment on children's developmental outcomes.

5) Guidance for model and variable specification:

The presented models are only to a limited extend helpful to specify analytical models and variables. The categories are very broad, for example it is not specified which child human capitals are used and at which points in children's life or in which sequence human capital build on each other.

To conclude for this section, we introduced four main models that are often discussed in intergenerational transmission of poverty and emerged in the literature in developed country contexts. We could nevertheless identify some relevant elements for a possible frameworks for a developing country context. First, the material resources model seems plausible as it is material resources that often buys access and quality of goods that are more widely publically available in developed countries like schooling, health care and infrastructure. Second, the correlated disadvantage model is also likely to be important in developing countries as education, stress levels of parents and time and parental care practices are all likely to be correlated with material resources and important for children's developmental outcomes. And third, the structural approach emphasised the broader environmental factors that are important.

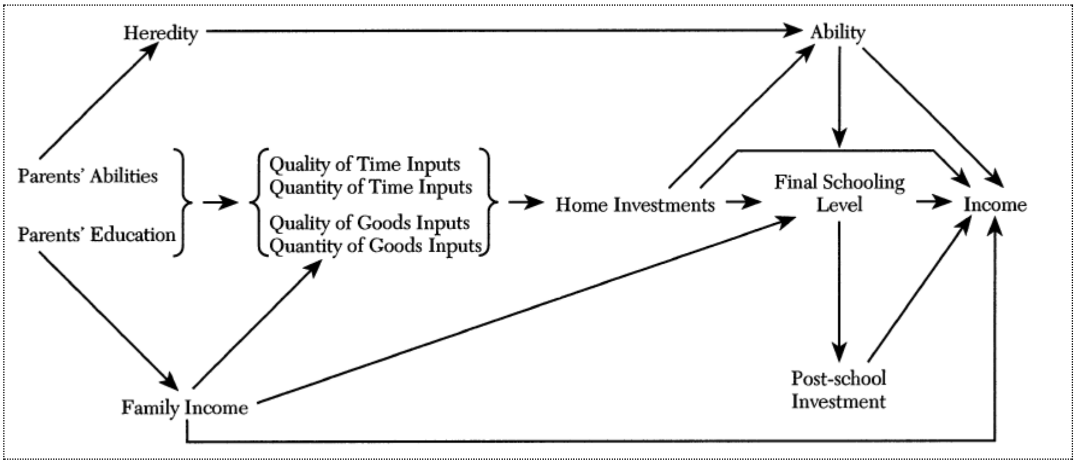
However, we have also shown that the four models are very broad in scope and are limited in adopting a life-course approach and map out specific child developmental outcomes and are limited in their usefulness to guide model and variable specification. The next sections therefore explore more detailed frameworks that build on some of the insights we gathered.

Frameworks that focus on parents' resources and child outcomes in adulthood

Haveman & Wolfe (1995) adapted a framework from Leibowitz (1974) that is much more explicit on how parental resources (ability and education) influence children's outcomes (ability, schooling and income) by the mechanism of transmission such as family income, heredity route, quality and quantity of time and goods that parents invest in their children. Figure 3 shows the framework. It mirrors some elements from the "lack of material resource" framework we reviewed earlier in that it emphasises parental's investment behaviour but goes beyond this and also captures other parental resources such as education and ability.

While this framework is much more specific for our research purposes there are a couple of elements that are not clear enough and too general but could be adapted.

Figure 3: The Determinants of Children's Attainments (Haveman & Wolfe Framework)



[Source: (Haveman and Wolfe 1995, 1833)

1) *Child developmental outcomes:* the main outcomes that are mapped in this framework are for adult children, such as the final schooling level, post-school investment and income. This framework spans a long-term timeframe for children's outcomes motivated by the intergenerational transmission of parental resources (their education and income) on the same outcomes for children. So the intergenerational perspective dominates in this framework. The intra-generational perspective (i.e. children's life-course) is only indirectly represented in this framework by giving very little specific child outcomes mapped in early, middle or later childhood. They might in fact be lumped together in the element "Home Investment". Children's nutritional status and cognition are not explicitly

mentioned and only final schooling outcomes and income are mapped out in this framework.

2) *Parental resources & pathways:* This framework employs several parental resources, namely parental ability, parental education, family income. As well as pathways these parental resources influence children's outcomes, namely heredity route, time and goods investment route.

   The starting points for Haveman & Wolfe's (1995) adapted framework from Leibowitz (1974) are two parental resources, namely parental ability and parental education (left side of the figure). According to the graphic representation parental education is linked to the investment behaviour, i.e. the quantity and quality of time and goods inputs for their children. This is turn is linked to the home investments, final schooling level, ability and income. Parental education is also indirectly linked to these outcomes via the second pathway – the family income route. Better educated parents will be able to generate more family income which enables them to provide more and better inputs for their children such as tuition fees for more and better schooling resulting in higher levels of final schooling.

   The second parental resource that the authors emphasise is parental ability. Parental ability influences children's ability directly via the heredity route. It also has an indirect route through the parental investment behaviour.

   Overall the adapted framework that Haveman & Wolfe's (1995) present is much more detailed on different parental resources and the pathways through which they influence childrens outcomes.

3) *Life-course perspective:* As discussed under point 1 the intra-generational perspective (i.e. children's life-course) is only indirectly represented in this framework. There are no explicit child outcomes mapped in early, middle or later childhood, just in adolescence or young adulthood with final schooling level, income, etc. It is not clear if child outcomes in other life stages are lumped together in the element "Home Investment".

4) *Broader environment:* Elements on the broader environment such as community characteristics or the national context are not included in the framework.

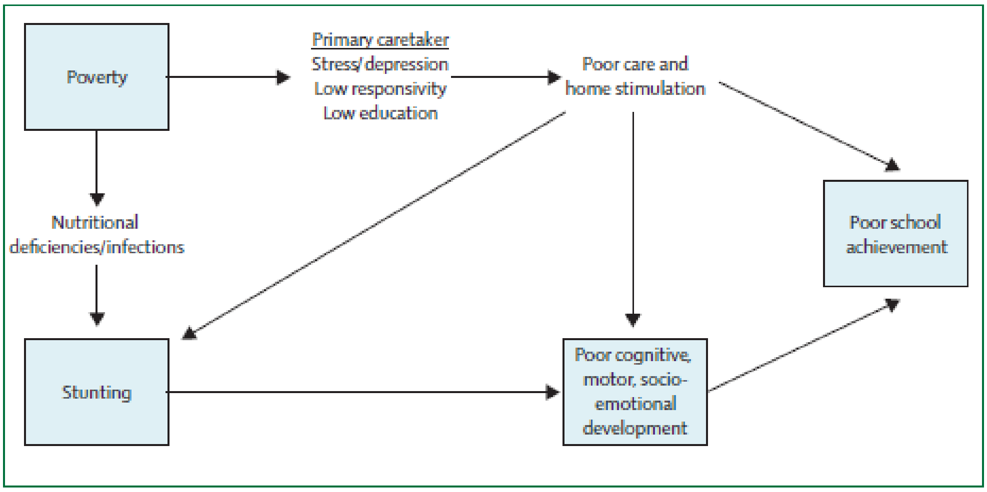
5) *Guidance for model and variable specification:* This framework gives better guidance as to which parental resources should be used as variables and the outcomes for adult children. It also hypothesises some of the pathways that these parental resources influences these adult child outcomes which could be used to guide how analytical models would be set up.

Overall the adapted framework of Haveman & Wolfe’s (1995) is much more detailed on different parental resources and the pathways through which they influence childrens outcomes and is a good starting point for model and variable specification. However, as the framework focuses on adult children outcomes, we need to adapt the framework we are using to accommodate child outcomes in early, middle and late childhood and how they might be linked together. More specifically we would need to adapt the framework to include children’s nutritional status, cognition and intermediate schooling outcomes. To achieve this, we review a framework by Grantham-McGregor in the next section that uses these elements.

Framework that maps poverty, child nutrition, cognitive and school achievement

Figure 4 shows a framework developed by Grantham-McGregor that links poverty to children's outcomes. This is a relevant framework for this thesis as it links the child outcome variables that we are interested in – namely nutrition (stunting), cognitive development and poor physical health development.

Figure 4: Hypothesised relations between poverty, stunting and child development outcomes



[Source: (Grantham-McGregor et al. 2007, 62)]

In this section we briefly outline how the framework fares against the 5 criteria that we have selected.

1) *Child developmental outcomes:* The framework includes several child outcomes, such as children's stunting (bottom left of the figure), children's cognitive, motor and socio-emotional development outcomes and children's school achievement. Including these different child outcomes is a more holistic and specific way then what we have seen in the reviewed frameworks so far.
2) *Parental resources & pathways:* Parental resources are specified to a certain extent mostly focusing on the primary caretaker except for poverty (which seems to be defined on the family level, but this is not very clear. Further parental resources are specified under the primary caretakers characteristics such as i) stress/ depression, ii) low responsivity and iii) low education and iv) primary caretaker's home stimulation and care activities. What is missing from the framework in regards to parental resources are parents or primary caretaker's physical health, as well as information on characteristics like educational level of

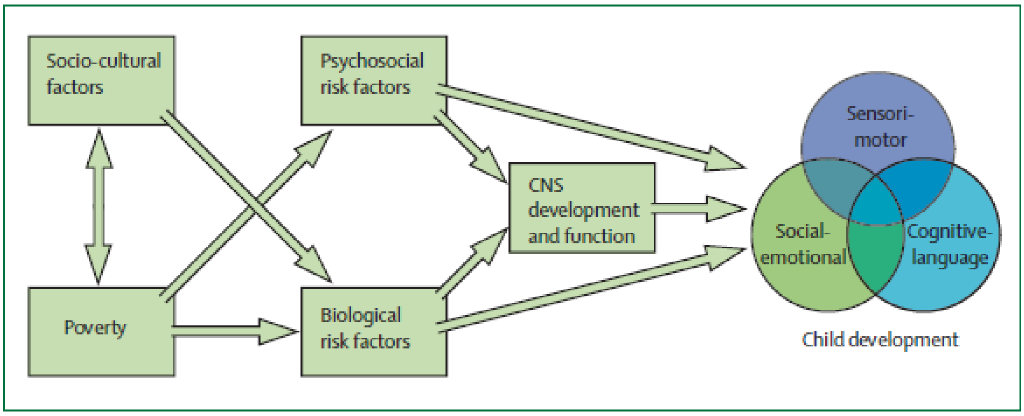
parent that is not the primary caretaker. The advantage of this framework is that the pathways showing how parental resources and children's outcomes are related are hypothesised in a schematic way, assuming that the root cause is poverty that leads to primary caretaker’s poor mental health outcomes (stress/depression), their low responsiveness in the interaction with the child and low education. Contrary to the Haveman framework, here low education of the primary caretaker is depicted as the result of poverty not the other way around. The pathway of these three low primary caretaker's characteristics on children's developmental outcomes works through the primary caretaker’s poor care and home stimulation.

3) *Life-course perspective:* The framework seems to implicitly adopt a life-course perspective for children's outcomes in that it shows a sequencing of children's outcomes from stunting to poor cognitive, motor and socio-emotional development to the final outcome of poor school achievement. Children's outcomes span a medium time frame not until adult's children's outcomes (long-term) but also not just focusing on a short-term perspective. It is not clear at which times child outcomes are measured and if dynamics of children's outcomes are taken into account – i.e. changes in their outcomes. For example stunting is only mentioned in early childhood.
4) *Broader environment:* The framework is very focused on children's outcomes and the immediate poverty and primary caretaker characteristics leaving out any community factors etc.
5) *Guidance for model and variable specification:* The framework that Grantham-McGregor proposes is more explicit on the variables for children's outcomes and parental (caretakers) characteristics that should be included in a regression model. Also the hypothesised relations help to specify the models to run. There are still some open questions as to when the child outcomes are measured (for example poverty and stunting). But the framework represents a good start for developing our own specific model.

Framework that adds central nervous system as pathway

The framework by Walker and colleagues in Figure 5 adds another component – the central nervous system's (CNS) as intermediate path to explain children's development in the areas of sensor-motor, social-emotional and cognitive-language development.

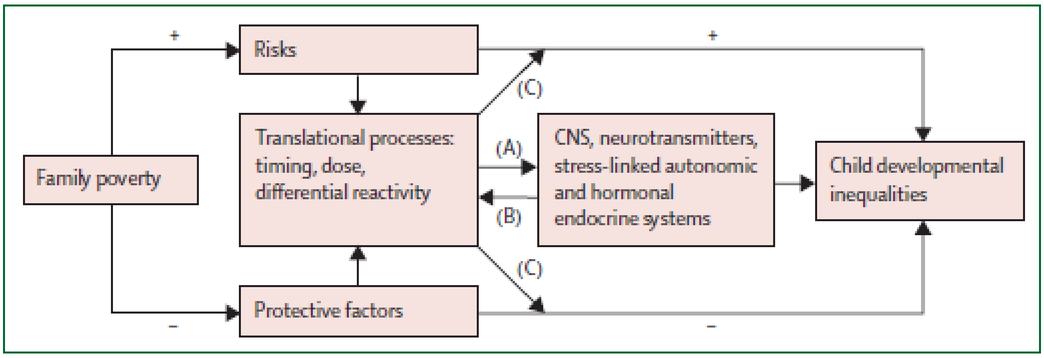
Figure 5: Pathways from poverty to poor child development via cenral nervos system



[Source: (S. P. Walker et al. 2007, 146)]

While the framework is much more specific on children development outcomes and the intermediate pathways, it is not very explicit on parental resources. They could nevertheless be assumed to fit in some of the boxes such as poverty and risk factors. The main focus for Walker and colleagues is the addition of the brain structure and functions to add to the child development outcome frameworks as important mechanism. They develop the framework even further in 2011 to specify what specific reactions are happening in the brain (S. P. Walker et al. 2011, 1327), namely how neurotransmitters and stress-linked hormonal systems influence inequalities in child development outcomes (Figure 6).

Figure 6: Pathways linking poverty to child developmental inequities



[Source: (S. P. Walker et al. 2011, 1327)]

Conclusion for the section of the conceptual framework

We started by reviewing some of the most influential models in the debate on intergenerational transmission of poverty before zooming in on more specific conceptual frameworks that focused on the mechanisms between parental resources and children's outcomes especially the ones that we will look in our empirical chapters. The importance of brain structure and functions as intermediate channels was also reviewed – an aspect that is especially important for us in Chapter 5 when we develop our specific conceptual framework for linking children's nutritional status and cognitive Raven's coloured progressive matrices.

The majority of existing frameworks use a predominately intergenerational perspective in the sense that they try to use same variables for parents and children (e.g. income, final educational level). The life-course perspective on how these adult child outcomes are formed is rarely included. However, combining the perspective of intergenerational transmission of poverty (changes between children's and parent's generation) with the children's life course perspective – how their later outcomes are influenced by earlier ones – seems important. Adopting a longitudinal approach with a focus on intergenerational relationships provides a useful framework to investigate inequalities in children's life chances. The majority of existing studies in developing countries examine the intergenerational relationship between parents' characteristics and children's outcomes at one point in time, often focusing on young children and rarely following children into adolescence years. Here, we bring together a life-course approach with the intergenerational perspective. This allows us to understand whether parent's resources and children's outcomes only matter in early childhood or if they are relevant for recovering from early childhood experiences. These findings are relevant for the design of effective and appropriate policies that span well over children's life course from early childhood into adolescence.

The life-stages (early childhood to young adulthood) are important because they are crucial for human capital formation (especially education and health) which in turn influences well-being in adulthood and potentially in the next generations (Harper, Marcus et al. 2003).

These insights will be important when we develop the specific frameworks for child outcomes in the respective chapters. For children's nutritional status in Chapter 4, children's cognitive outcomes in chapter 5 and children's physical health outcome in Chapter 6.

2.2 *Literature on children's life chances in Indonesia*

This section briefly reviews some of the key empirical studies for Indonesia focusing on the relationship between parental socio-economic resources and children's outcomes in the areas of health, cognition and education over children's life-course. As we are interested in the intergenerational links over the life-course prospective longitudinal data is needed. This section therefore mostly reviews papers that used the Indonesian Family Life Survey (IFLS). More details on these studies can be found in the literature grid in the appendix 2.1 (p. 189).

Lisa Cameron and Jenny Williams for example examine the associations of different measures of household financial resources (e.g. household income, consumption and wealth) on two subjective measures of children's general health; one is derived from a question that parents answered and one a trained nurse answered after having examined children's height, weight, etc. (Cameron and Williams 2009).

They show that low household resources adversely affect health outcomes. For example, doubling household income is associated with an average increase in the probability of reporting to be 'very healthy' by 10.4% (p. 313). They do not find that this income effect differs by age of the child. The authors argue that this suggests the income effect on health is not accumulated over time. However, it is important to notice that the authors only use one wave of the IFLS and do not include previous information on household resources, which could have changed over time (Cameron and Williams 2009).

Another dimension of socio-economic resources, namely maternal education, is an important determinant of general health status of children under age of 3 years. These results are robust to the inclusion of previous health measures (e.g. birth weight at birth) and household resources are still significant determinant of health status after controlling for them. Including parental health shows large and significant effect of parental health on child health. For example, a mother who reports being "very healthy" has 19 percentage points higher chances of reporting good health as well. However, the coefficient of household resources are largely unaffected by this inclusion (Cameron and Williams 2009).

Other studies support the positive relationship between maternal education and children's outcomes (Beegle, Frankenberg, and Thomas 2001; Nobles and Frankenberg 2009; Suryadarma, Pakpahan, and Suryahadi 2009; Alisjahbana 1999; Chang 2006; Chernichovsky and Meesook 1985; Deolalikar 1993; Park 2007; Pradhan 1998; Quisumbing and Maluccio 2003; Suryadarma 25; Xu 2008). Only Thomas at el. find an abnormality: higher educated mothers are more likely to report a cough for their child (p.12-13). However, the authors assume this to be reporting error due to higher awareness of respiratory problems for higher educated mothers rather than the children being unhealthier (Thomas, Contreras et al. 2002).

A less frequently used dimension of socio-economic resources is analysed by Jenna Nobles and colleagues. The authors use mothers' access to social capital to study the association with children's height for age. Social capital is operationalised as participation in key community programs (e.g. cooperatives, voluntary labour initiatives and the village women's association). Additionally, they also use household expenditures, maternal education and maternal kin support. This employs a fuller representation of the different dimensions of socio-economic resources than most other reviewed studies. Based on a sample of 5,144 children the authors find that children from families with low levels of human and financial capital fare better in respect of health status when their mothers are more active participants in community organizations (Nobles and Frankenberg 2009). However, this positive influence is limited to women from disadvantaged backgrounds only.

In a study on pre-natal and delivery care Kathleen Beegle, Elizabeth Frankenberg and Duncan Thomas make use of a unique feature of the IFLS data set. From the second wave onwards the IFLS collects information on relative resources for married couples such as i) wife's relative assets shares, ii) whether they are better educated than their husbands, iii) whether they are from a family of higher social status and iv) if their parents are better educated than their parents-in-law (Beegle, Frankenberg et al. 2001).
With an analytical sample of 1,679 married women aged 15-49, who recently had a child, the authors find indeed that women with higher asset shares have better pre-natal and delivery care outcomes. Further, women that are better educated than their husbands use more services especially early in the pregnancy (i.e. 9% more in first trimester) compared to women who have less education than their husband. In this analysis the overall level of education is controlled for.

Quisumbing et al. use a special designed survey of 268 households in West Sumatra that investigate outcomes such as i) the household expenditure shares for education and ii) children's completed years of schooling compared to same aged children (Quisumbing and Maluccio 2003). As independent variable, the authors also use relative pre-marital assets: more specifically the size and type (e.g. paddy, forest) of land. What is interesting about the findings is, that for the analytical sample of 178 children from 88 household (p.318), women's asset at marriage have a positive effect on son's schooling but not on daughters. One could reach a rushed conclusion on gender favouritism by stopping the investigation here. But as the authors show, daughters seem to be compensated by inheriting more land. This study has its limitations as it is just a small region of Indonesia and not national representative. The analytical sample size is quite small as well. And all measures are retrospective and recall error is a problem, as this is a one-off study not a longitudinal.

Zeyu Xu extends the range of educational outcome variable and investigates measures such as: i) mathematics scores, ii) cognitive assessment scores, iii) whether the child repeated a grade and iv) children's educational expenditure as share of total household expenditure (Xu 2008). Controlling for expenditure, the relative parental resource variable used, is again the value of assets brought to the household at the time of marriage (in constant Indonesian rupiah – p.32). The findings of this study also support the claim that it matters which parent controls resources. Maternal relative resources (proxied by assets brought to marriage) have a significant positive effect on children's educational expenditure shares, mathematic and cognitive performance. Contrary to the studies by Quisumbing, Thomas and colleagues, Xu finds that there is no evidence for gender favouritism by either mother or father. Quite interestingly, the author is also able to show the dynamic evolution of parental preferences which tend to convergence the longer the marriage lasts.

In the domain of child outcomes in the domain of education, the majority of studies examine a quantitative aspect of education (i.e. how much time is spent in school) – namely, the current enrolment status of children at different schooling levels. For the post-schooling life-stage, the focus tends to be on the outcome variable of final educational attainment as well as the individual economic returns to schooling (proxied, for example, by hourly wage). One of the gaps in the educational domain is rare studies that examine cognitive outcomes. While the IFLS as a general household survey is very limited in children's outcomes it has a unique feature that is underutilised – it collects information on children's performance on a non-verbal cognitive test – the Ravens' coloured progressive matrices. This is the motivation to address these issues in chapter 5.

Futher, from reviewing empirical studies from Indonesia most studies use the anthropological measure of height for age (see for example studies by Cameron et al., Nobles et al. and Park et al. (Park 2007; Cameron and Williams 2009; Nobles and Frankenberg 2009) but often only at one point in time not looking at the dynamics of children's growth and its determinants. This is the motivation for us to explore this in more detail in chapter 4.

Only few studies use a variety of health measures (e.g. nurse assessed measures such as weight and haemoglobin level and subjective measures of general health by Cameron & Williams, 2009). We therefore extend our own empirical analysis in chapter 6 with the child health outcome of children's lung capacity.

Conclusion for this section:

- Parental socio-economic resources are adversely affecting children’s outcomes in terms of education and health
- Maternal education is a strong predictor varying by childrens age. One study showed adverse effect of maternal education but the authors concluded that higher educated mothers report worse health outcomes. Effect strongest for younger children, seems to fade over life course.
- Relative resources owned by husbands and wives can make a difference to children’s outcomes additionally to the overall level of resources. In general, women with more socio-economic resources positively influence their children’s outcomes
- The review of studies in Indonesia in the area of children’s health outcomes shows that the main focus is on outcomes in pre-school and especially anthropological measures but that no dyanamic analysis over children’s life course is done which we identify as a gap that we address in our own empirical analysis in chapter 4.
- In the area of educational outcomes the main focus is on quantity of schooling (e.g. enrolment status) and post-school outcomes such as final level of education and return to education (e.g. wages). There is a scarcity of studies that use behavioural or cognitive outcomes. We therefore investigate available cognitive outcomes of the IFLS in chapter 5.
- A further gap can be indentified – the lack to adopted a life-course perspective by investigating how health and cognitive outcomes are unfolding over children’s life-course and how they influence each other.

CHAPTER 3: Data & Methodology

This chapter focuses on the dataset we are using for our analysis. The structure of the chapter is as follows. Section 3.1 describes the dataset we are using in this research – the Indonesian Family Life Survey (IFLS). Section 3.2 shares some insights we were able to gain during the piloting of the IFLS4 during a fieldwork stay in Indonesia, witnessing the intensive four-week training of the interviewers. We also draw on a unique opportunity to interview three of the interviewers of IFLS4 in another fieldwork after the end of data collection. While these interviews themselves are not representative of all the interviewers, it still provided an opportunity to gain a better understanding of the data collection of this secondary data set. In section 3.3 we explain why we have chosen the IFLS and discuss its advantages, drawbacks and limitations. Section 3.4 assesses the data quality especially in terms of attrition. Section 3.5 gives an overview of how the variable of height-for-age (HAZ) was created and how stunting was defined. Section 3.6 gives a short overview of the data sample and analysis used.

Other methodological issues such as creation of outcome variables for children and parental socio-economic resources, control variables, overview of the data analysis methods used, with a description of the analytical sample and the models of analysis is provided in each empirical chapter for context specific details.

3.1 Data source: The Indonesian Family Life Survey (IFLS)

This section gives an overview of the data source we are using in this research. We start by describing some of the main features of the IFLS.

Main features of the IFLS

The Indonesian Family Life Survey (IFLS) is a longitudinal survey, which started in 1993 and has to date four survey waves. For an overview of some of the features of the IFLS see textbox 1 below.

Information about the Indonesian Family Life Survey (IFLS)

- ***What was the original purpose for collecting the IFLS?***

The IFLS was designed as a multi-purpose household survey covering a wide range of topics such as demographic, education, migration, employment, social economic and health status of individuals (of all age groups), households and communities (Frankenberg et al., 1995, pp. 1-4).

- ***Who funds the IFLS?***

National Institute on Aging (NIA), the National Institute for Child Health and Human Development (NICHD), World Bank, Indonesia Office and others.

- ***Who conducts the IFLS?***

RAND Corporation, University of Indonesia (IFLS1&2), Gadjah Mada University (IFLS3&4), Field survey organisation: since 1997 Survey Meter (www.rand.org/labor/FLS/IFLS/teamfund.html).

- ***When was data collected? [And what is the sample size?]***

Wave 1:	IFLS1	Aug'93 – Jan'94; [7,200 households; ~22,000 individual interviews]
Wave 2:	IFLS2	Jun'97 – Jan'98; [7,500 households; ~33,000 individual interviews]
Wave 3:	IFLS3	Jun'00 – Nov'00; [10,400 households, ~39,000 individual interviews]
Wave 4:	IFLS4	Nov'07– Apr'08; [15,200 households, ~55,000 individual interviews]

- ***What was the attrition rate? Household re-contact rate***

Wave 2 in 1997: 94.3%; Wave 3 in 2000: 94.7% (Strauss, Beegle, Dwiyanto et al., 2004, p. 14), Attrition is low as the IFLS tracks movers and split-off households (Behrman, 2006, p. 12; Thomas et al., 2001, p. 14). For example, a total of 2648 split-off households were found in IFLS3 (Strauss, Beegle, Sikoki et al., 2004, p. 14). Attrition checks done for the IFLS find no significant differences between people who stay in the survey and people who are lost (Strauss, Beegle, Dwiyanto et al., 2004; Thomas & Frankenberg, 2006).

- ***Is the IFLS representative?***

Compared to the 1990 census and the 1993 SUSENAS Household survey IFLS represents 83% of Indonesia's population. Urban areas and smaller provinces were purposefully over-sampled in order to compare i) urban versus rural and ii) Javanese versus non–Javanese characteristics (Frankenberg et al., 1995). Overall the IFLS is able to capture the wide variety of Indonesian living standards.

- ***What was sampling design for 1st wave in 1993?***

The multi–stage sampling strategy aimed at representing Indonesia's cultural and socio-economic diversity while managing travel & communication costs. It contained three stages:

1) The sample was stratified by provinces (13 out of 27 provinces selected).
2) The sampling frame of the Indonesian Central Bureau of Statistics for the 1993 SUSENA (a national representative household survey of 60,000 households) was used.
3) The households within the SUSENA enumeration areas (EAs) were randomly sampled – 20 household in each urban EA and 30 in each rural EA.

- ***Accessing the data:***

After registering at the IFLS website, the data and documentation for waves 1, 2, 3 and 4 of the IFLS are publicly available.

- ***Type of information IFLS collects***

The IFLS covers information on three levels: the community, the household and the individual. While it is important to control for community and household characteristics when investigating the association between relative power of women and investment in child's education, it is crucial to have information on individual characteristics. The IFLS collects data on labour force participation, earnings, non-labour income, assets, education, marriage, history of pregnancies and contraceptive use (Strauss, Beegle, Sikoki et al., 2004). In addition, the IFLS also collects information on community and facility characteristics such as availability and quality of schools and interviews community leader and the head of the community women's group.

3.2 *Some insights from data collection fieldwork*

During a 6 weeks stay in Indonesia in 2007 I had the chance to meet with the principal investigators of the IFLS and to observe both the training of the interviewers and actual interviews conducted during the pilot phase of the IFLS4 near Solo, Java. This presented a unique opportunity for a secondary data user to get an insight into how interviewers are trained and how the data is collected.

The IFLS data collection organisation, called Surveymeter, trains their interviews during an intensive four week training course (six days a week) with lectures, seminar and practice session from 8am-8pm. Ca. 180 interviewers are trained in this wave. A second wave of training happened a few weeks later. The following pictures give an impression of the scope of the training sessions.

Pic. 1: IFLS4 Interviewing training in 2007 in Solo, Java. Here lecture style explanation of the content of different questionnaires.

Pic. 2: Practice session on filling in different parts of the questionnaires: e.g. formats, codes and skipping patterns.

The training consisted of the following elements. First, the content and scope of the different questionnaires were explained in a lecture style format (Picture 1) with explanation for why these questions are asked and a discussion of their wording, etc. In a next step, practical sessions were conducted that trained the interviewers in how exactly to fill in the questionnaires (Picture 2). This included testing the interviewers understanding by giving them problems sets to solve themselves.

Other training sessions include that interviewers interview themselves to practice the questionnaires while observing each other or being observed by the trainers and getting feedback. In the last days of the three weeks training, real interviewees were invited into the training session and interviewed (Picture 3). This lasted the whole day and extensive feedback is given to interviewers about their performances during these interviews.

Pic. 3: Practice session with real life respondents during final days of three week training course.

Pic. 4: Pilot testing during one week base camp in a village outside of Soho. Challenge of one-to-one interview requirement.

Finally, there is a one week pilot testing in a base camp with interviewing IFLS members in their homes. This also helped me to understand the dataset and the questionnaire much better and appreciate of the intensity of the training, which was impressive for a developing country context and evidence for the attempt of the principal investigator and the survey organisation to provide good quality data, which increased the confidence in the dataset.

However, some of the well known challenges in quantitative interviewing, especially in developing country context became also apparent – especially during the piloting in the base-camps. While trained under best interviewing conditions, interviewers now faced real world challenges in their interviewing.

To give one example of a real life interview situation, consider the situation in Picture 4. The part of the questionnaire was intended for the spouse of the household head and concerned amongst other things her subjective well-being. Notice the TV running in the back, two of her grandchildren being directly present and three more children playing loudly. Moreover, her daughter-in-law is also present. When being asked if she thinks that compared to five years ago her living standard has (a) improved, (b) has stayed the same or (c) got worse, she replied it stayed the same. The daughter-in-law protested and reminded her of the new fridge they got and the now running motorcycle and concluded that her life got better. The actual respondent then changed her initial answer to the question and agreed that it indeed improved. As this question tries to capture the subjective wellbeing, this is problematic. Similarly, when she was asked about her income and whether there were any transfers from other family members, she listed some but seem to have forgotten other of which her daughter-in-law reminded her – namely the remittances send by her eldest son from abroad, which she then added as well.

Regarding the influence on the data quality, the results seem to be mixed and could both mean influencing respondents but also improving recall bias and thus data completeness.

Pic. 5: Pilot testing during one week base camp in a village outside of Soho. Challenge of informal translators (=son of respondent)

Pic. 6: Preparation and feedback discussions every morning and evening to exchange on learning experience during the day.

Another challenging interview situation is captured in Picture 5. The women that was intended to be interviewed only speaks very little Bahasa Indonesia and the interviewer did not speak Javanese as he originally came from another region of Indonesia with different local languages. So the woman asked her 8-year-old son to translate for her. While he agreed and complied in the beginning, a while into the interview he got bored and wanted to go back to play football rather than answering dull questions. So instead of continuing to translate the question to his mother and translate her answer back to the interviewer, he shortened the procedure and started to answer for her. The interviewer did not intervene and proceeded. But when the 8-year-old started answering the contraceptive use questions for his mother, the interviewer looks nervously to his supervisor who had observed in the background. After the interview, he was told that this was not an acceptable way of conducting the interview, and that he should have ensured better translation or switched with an interviewer that speaks Javanese, her native language.[19] This example was also raised during the feedback discussions (Picture 6). At the end of the four weeks, a decision was made as to whether the interviewer would be recruited.

[19] Just to add, as these are the centrally held training sessions in Solo, Java to reduce costs, it is not surprising that interviewers from different parts of Indonesia would not speak the local language. However, in the actual data collection after this pilot testing, interviewer teams consist of local students and it is much less likely that no common language is shared between interviewers and respondents.

Over the six months of data collection, interviewers gain a lot of insights and may have valuable information about the process. But they are not often asked about their experience of the data collection. So as part of gaining a better understanding of the secondary dataset I am using, I asked for permission to interview three interviewers in the summer 2008 that was also informed by the earlier observing the training and piloting of IFLS4 in autumn 2007 described in section 2.

During an institutional visit to the University of Gadja Mada in Indonesia who is involved in collecting the IFLS I was granted access to three interviewers. I collected some brief context information about them such as their ages (24, 25, 40), educational level (S1 – equal to a BSc), when they joined IFLS (all in 2007 for 4^{th} wave). One of them even became a supervisor for other interviewers during the data collections with potential more experience on issues affecting a wider range of his supervised interviewers. They mostly interviewed in West Java, Central Java

I interviewed them in the office of SurveyMeter (the fieldwork organisation) who selected interviewers for me to interview.

Pic. 7: Interviewing the interviewer

To help interviewers to remember and be precise, I decided to ask them to imagine that they are back in the field collecting data for IFLS and to pretend that my research assistant is one of the respondents. I than asked them to do a simulation of an interview with a research assistant.

This was very helpful as I was able to observe how interviewers did the prompting, explaining of terms, etc. during the interview, and it helped them to immediately remember the part of the questionnaire I wanted them to focus on. After just one minute I could see that they were back into the interviewing routine and they said that they remembered it very clearly again. After the simulation was over, I asked them about the training for this section was done, whether some questions are too embarrassing/personal, whether they think people give a true answer, and discussed some items on the questionnaire in depth.

We hope this gave a good account of the observations that increased my understanding of what is involved in data collection. We will now turn to more general discussions of the IFLS data set.

3.3 Strengths and limitations of the IFLS

Overall, the IFLS's advantages are that it is a nationally representative, longitudinal dataset which has low attrition – especially considering the fact that it operates in a developing country context where tracking respondents is very challenging. It contains a wide range of information with some information on children's outcome and quite detailed information on socio-economic resources of parents – much more detailed than in most birth cohort studies. It is therefore a good source for secondary data analysis in a data-constraint context – especially in regards to longitudinal datasets. And most importantly it is actually accessible to use compared to the other datasets.

However, there are also some limitations. First, the IFLS is not specifically designed for child development issues and thus cannot compete with what specifically birth cohort data in other countries can provide. The Indonesian Family Life Survey is a general household survey with multiple cohorts encompassing all ages from 0 to 99 years. It is further a multi–purpose study that has a very range of topics it covers from agriculture, contraceptive use, consumption, crime (since IFLS4), farm and non-farm businesses, migration etc. Thus the IFLS does not contain a battery of child specific outcomes let alone specific for their developmental stage. This is important to keep in mind when comparing it to birth cohort studies that solely study one age cohort and follow them over time. However, for a general household survey the information that are available for children is remarkable – e.g. the Ravens coloured progressive matrices is rarely available in general household survey.

Nevertheless, we have to acknowledge that there is a lack of detailed information on factors such as childcare practices, maternal mental health, learning environment of the child or aspirations of parents – all likely channels through which parental socio-economic resources influence children's outcomes.

As unrivalled effort to collect longitudinal household data in developing countries, IFLS is an invaluable resource with unique features to study children's life chances. However, the very nature of the data collection in a developing country setting, and the particular design of IFLS entail a number of limitations in the data that are important to take into account. We discuss the most important ones in the following, and also mention how we dealt with them.

Gaps between the different survey waves

We do not know what happens to children between the survey rounds and before 1993. However, follow up studies in developing countries into later childhood and adolescence all suffer from this problem and there is no alternative to this. This leaves us to be cautious about the claims of how persistent stunting is or how circumstances changed in between survey rounds. In response to this limitation, we chose stunting as it is a long-term measure with less fluctuations than weight or occurrence of illnesses – this could help to be more confident that gaps are not as relevant.

No information on the onset (i.e. timing) of stunting

The IFLS does not have the information on the timing when children first experienced stunting. For correct information on this, one would need to follow children (especially in the first two years of live) with a higher frequency. For example, the CEBU study from the Philippines collected bimonthly data on children's anthropometrics. However, the IFLS is not a one-year birth cohort but a multi-cohort study that was not designed for the specific purpose of assessing children's nutrition and health status. Furthermore, it is much larger in scope trying to be nationally representative – the CEBU study for example only covers the metropolitan area of the CEBU island in the Philippines. While it is understandable that it was not in the scope of the IFLS to provide this data, research from the Philippines has shown that the onset of stunting has a significant effect on cognitive scores in later childhood (Mendez and Adair 1999). We only know whether children were stunted or not at the time of the survey. In response to this problem, we chose the sample so that children are likely to have experienced stunting (e.g. after 24 months – as previous research has shown that children's stunting peaked at two years). As explained above, we do not know when onset of stunting happened. However, as the research from the Philippines has shown, the onset of stunting is related to the severity of stunting. As they show, children that experienced stunting earlier were also more likely to be more severely stunted by the age of 2. So including the severity of stunting does to some extent capture the effect of when the onset of stunting happened.

All things considered, IFLS is a nationally representative, longitudinal dataset and has very low attrition and is thus a good quality dataset. It also contains some information on children's outcome and quite detailed information on socio-economic resources – much more detailed than in most birth cohort studies. One recommendation for data collection in Indonesia would therefore be to have a longitudinal birth cohort dataset that can focus more closely on child specific development outcomes and detailed information on processes of child care etc. Another valuable extension would be to expand the child specific outcomes that are collected in the IFLS to introduce some more detailed and age specific child outcome measures.

3.4 Data quality assessment

The IFLS was compared to the 1990 census and the 1993 SUSENAS Household survey and showed that 83% of Indonesia's population in 1993 was represented by the IFLS1 (Frankenberg & Karoly, 1995). Urban areas and smaller provinces were purposefully over-sampled in order to (be able to) compare i) urban versus rural and ii) Javanese versus non–Javanese characteristics. To adjust for the household and within household sampling strategy used for the IFLS, sampling weights are provided (Thomas & Frankenberg, 2006).

Over time, attrition becomes the most important problem for panel studies, especially in developing countries where communication and infra-structure is a real challenge to track people over time (Harold Alderman, Behrman, Kohler, Maluccio, & Cotts Watkins, 2000). 7,224 households were contacted in 1993. In 2000, 6,752 (93.5%) of the original households could be re-contacted. In 101 of the missing households, all its family members had passed away.[20] As households are not stable over time and change composition, good quality panel studies should follow split-off households as well (Greg Duncan & Hill, 1985). The Indonesian Family Life Survey was able to follow up 1215 split-offs found between 1993 and 2000. In 2000, 2648 additional households were found which will be followed up in the new wave currently conducted (John Strauss et al., 2004).

The representativeness can suffer if households and individuals who stay in the panel are different (non-random) from those who attrit. To check this, socio-economic and demographic characteristics in 1993 should be compared to those households that were re–contacted in 2000 and those that could not. If missing respondents are evenly distributed along these dimensions (i.e. it their difference in means is close or equal to zero) one can be more confident about the quality of the sample. Attrition checks done for the IFLS find no significant differences between people who stay in the survey and people who are lost. They conclude that attrition bias is not likely to be of great importance for the analyses with these data (John Strauss et al., 2004; Thomas & Frankenberg, 2006).[21] However, it is important to note that the first wave of the IFLS targeted 7,730 households for interviews but 5% could never be found and 2% refused to

[20] No attrition rates on the individual level could be found, so only household rates are reported which could hide exact information on attrition.
[21] For further research such attrition tests should be conducted independently. Another method would be to run a logistic regression for the probability of attrition as dependant variable and socio-economic and demographic characteristics as explanatory variables.

take part. About these 7% no information are available whether they differ from the ones who took part and biases cannot be excluded.

Overall however, the attrition in the IFLS over a period of 14 years is low – especially for developing countries (Harold Alderman et al., 2000; Duncan Thomas, Elisabeth Frankenberg, & James Smith, 2001).

3.5 Z-scores for height-for-age (HAZ) and stunting variable

This section details how the variable of height-for-age (HAZ) was created detailing which variables are necessary to run the WHO programmes. Further it is explained how stunting was defined.

Stunted growth and HAZ were chosen as indicators for child health as the medical and public literature indicates that it is an objective indicator of general health status. It is also a good measure for long-term health and nutritional deprivation as it accumulates episodes of inadequate nutrient intake and disease over time, which results in stunted growth or lower HAZ (WHO, 1995a,b; Mosley et al. 1984).

Standardized z-scores for height-for-age for under 5 year olds

Standardized z-scores for height-for-age were calculated using two programmes developed by the WHO, the so called ANTHRO programme and the ANTHRO PLUS programme. The different reference groups that are employed by these two programmes are briefly explained and an explanation why it should be possible to use these two reference groups together in one analysis.

Table 1: Programme to calculate z-scores for different age groups of selected cohort

Wave	**IFLS1 (1993)**	**IFLS2 (1997)**	**IFLS3 (2000)**	**IFLS4 (2007)**
Age in moths	0-59	ca.48-107	ca.84-143	ca.168-227
Programme to calculate z-scores for Height-for-Age (HAZ)	WHO Anthro programme *(igrowup_standard.ado)*	For 48-60 months: WHO Anthro programme *(igrowup_standard.ado)* For 61-107 months: WHO AnthroPlus *(who2007.ado)*	For 84-143 months: WHO AnthroPlus *(who2007.ado)*	For 168-227 months: WHO AnthroPlus *(who2007.ado)*

Table 1 shows which programme had to be used to calculate the z-scores for height-for-age in the different waves of the IFLS. So for the cohort of 0-59 months old children in 1993 the WHO ANTHRO programme was used. As these children are between 48-107 months in 1997, the height-for-age for the 48-60 months year old was calculated with the ANTHRO programme but for the older children 61-107 the ANTHRO PLUS programme was used.

Standardized z-scores of height for children below 5 years of age (0-59 months) were calculated using the ‘ANTHRO’ computer programme which employs new WHO Child

Growth Standards based on community-level information in 6 countries, namely Brazil, Ghana, India, Norway, Oman, and the United States. For more information and to download STATA ado-files, see: www.who.int/childgrowth/en/. The old programme used the US 1977 NCHS/WHO growth reference data collected by the National Centre for Health Statistics (NCHS) and recommended by the WHO (World Health Organisation) since 1987 (Sullivan and Gorstein 1999). The US-based reference population was criticised for its limits to apply to other countries – especially developing countries. As a consequence, the WHO developed the new standards, which were published in 2006 (WHO 2006; WHO 2007).

After downloading the WHO Child Growth software and documentation from www.who.int/childgrowth/software/en/. The version used is WHO ANTHRO (version 3.1, June 2010) and macros for STATA. The software consists of three modules: the anthropometric calculator; the individual assessment and the nutritional survey. The user manual can be accessed at: www.who.int/childgrowth/software/anthro_pc_manual.pdf (WHO 2010).

The macro (=STATA package) is called igrowup.ado and calculates up to 9 indicators of the attained growth standards if data is available namely: 1) length/height-for-age, 2) weight-for-age, 3) weight-for-length, 4) weight-for-height, 5) body mass index-for-age, 6) head circumference-for-age, 7) arm circumference-for-age, 8) triceps skinfold-for-age and 9) subscapular skinfold-for-age. STATA/SE (=Special Edition) is needed for full calculation of all indicators. The user notes for the programme can be accessed here: www.who.int/childgrowth/software/readme_stata.pdf.

Standardized z-scores of height for children above 5 years

The new international reference data is only collected for 0-5 year olds. For older children and adolescent between 5 to 19 years the old reference data has to be used.
So the reference category against which the Indonesian data is compared is different for children under 5 and children over 5 years of age. As we are interested to look at the growth trajectories over time and wanting to use standardised measures to know how much children lack behind their growth potential it could be possible that the different reference categories could introduce an artefact in the data that is due to different reference categories and not a change in growth trajectories.

One approach could have been to collect similar international data for the older children and adolescents. But the WHO concluded that this approach would not be feasible as it would not be possible to control the dynamics of the environmental factors for older children and adolescent as had been the case for under 5 year olds (de Onis, Onyango et al. 2007). The WHO concluded that the best approach was to reconstruct the 1977 NCHS/WHO growth reference using the original sample and supplementing the data with data from the WHO Growth Standards. For further details on statistical techniques please see (de Onis, Onyango et al. 2007). This resulted in developing an appropriate single growth reference for children and adolescents aged 0-19. These are not only used in research but also in screening and monitoring children by health practitioners. So the reference data of the international Child Growth Standard for 0-5 and the US based reconstructed NCHS Standards for 5-19 can be used together. But there are still different programmes to implement these calculations. For the children above 5 years of age one has to use the so called WHO 'ANTHRO PLUS' programme with the STATA macro who2007.ado. The height-for-age z-scores can be calculated for 61-228 months old.[22]

Height-for-age beyond 228 months is not commonly assessed. What surveys (e.g. DHS, MICS) usually report is low adult height, i.e. % < 145 cm in women of reproductive age.

The ANTHRO programme

After preparing the IFLS data according to the ANTHRO programme user notes, I was able to run the programme called igrowup_standard.ado which creates a dataset with the calculated nine indicators of the attained growth standards.

In a first step the IFLS data is standardized and in a second step it then is compared to the WHO reference population to evaluate the attained growth standard of Indonesian children. So for example if a child has a z-score of -2.5 it is 2.5 standard deviations below the mean height-for-age of the reference data.

The programme also provides flags for extreme (i.e. biologically implausible) z-scores for each indicator. For example the values that have z-scores for the length/height-for-age smaller than -6 or larger than 6 are flagged. In 1993 for example there are 87 implausible values for the standardised height-for-age which is ca. 3% of the sample. I assigned the special STATA code for missing values of .o (i.e. out of range) to the

[22] More details: www.who.int/growthref/who2007_height_for_age/en/index.html

biological implausible values. The procedure for the ANTHRO PLUS programme is very similar.

Stunting definition and indicator variable

We follow the WHO and their stunting definition. Stunting is defined as height-for-age Z-scores (HAZ) smaller than -2 standard deviations (SD) from the mean. Sometimes further categorised along the WHO guidelines of mild -2SD to -1SD, moderate -2SD to -3SD, severe (<-3SD).

So from the calculated z-scores we created the binary stunting indicator variable. With 1 being a child with height-for-age below minus two standard deviations from the median height-for-age of the WHO reference population. Thus, this is a dichotomous and cross-sectional indicator.

While the WHO has set this cut-off point and it is widely used, there is no clear evidence that there are distinct health related risks that increase when the cut-off is crossed. While a shortfall in height is associated with negative health benefits, it is not clear where exactly this cut-off point should be. We therefore use the continuous variable of HAZ in most of our analysis. Only for the transition matrices we needed to limit it to dichotomous stunting variables.

3.6 Data sample and overview of analysis

Analytical sample (Cohorts of children 3-36 months in 1993)

As outline in the above section, IFLS is a longitudinal household survey with multiple cohorts. In order to mirror birth cohort datasets but also to have a big enough sample size we chose a 3 year age cohort – i.e. children in 1993 that are between 3-36 months and follow them through the different waves. HAZ is thus created for the survey years 1993, 1997, 2000, 2007. Pooling same aged children from different waves is not feasible as the gaps between the waves are uneven and height would not be available for the same ages.

We have a cohort of 1,037 children between ages 3-36 in 1993 which forms the analytical sample for the model on stunting in early childhood.

Table 2: Ages of cohort and child outcomes in different IFLS rounds

Round 1 (1993)		**Round 2 (1997)**		**Round 3 (2000)**		**Round 4 (2007)**
3-36 months	Survey gap: ~ 4 years	**~ 4-7 years**	Survey gap: ~ 3 years	**~ 7-10 years**	Survey gap: ~ 7 years	**~ 14-17 years**
• Height & Weight		• Height & Weight		• Height & Weight • 7-24: Cognitive Test • ≥9: Lung capacity		• Height & Weight • 7-24: Cognitive Test • ≥9: Lung capacity

[Source: compiled by author based on IFLS documentation such as user guides, codebooks and questionnaires.] Notes: n=1,037

Table 2 above shows which child outcome measures are available in which IFLS data wave and for which age group. A lot of the measures in the IFLS are only available for school aged children or older. For example, the cognitive test was only introduced in round 3 in 2000 for children between 7-24 years. Only height and weight is available for all four waves of the IFLS.

Overview of analysis

We use a variety of descriptive statistics. For example in chapter 4 in order to investigate movements in and out of stunted growth we use so called mobility transition tables. As an example the 2x2 contingency tables capture the partial bivariate relationship between the children's health status in 1993 and their health status in 1997, treating the first as the independent and the second as the dependant variable which follows from the time of occurrence. Also the immobility measure used by Baulch and Mausset is used where I = 1 would be complete mobility (Baulch and Masset 2003). For more details see Chapter 4.

Depending on the nature of the outcome variable, different regression models will be used. For example, for the model for being stunted in early childhood from Chapter 4, we use logistic regressions. For estimating the regression between HAZ in early childhood on cognitive test scores in Chapter 5 we use OLS regressions. All models will take the hierarchical structure of the data (clustered at the level of family, community and region) into account by clustering at the household level. For data cleaning, merging and variable construction as well as statistical analysis, the computer software STATA 11 will be used.

Residual of later height

We are interested to assess the influence of HAZ in early childhood and the changes in height later in childhood on cognitive outcomes (Chapter 5) and lung capacity (Chapter 6).

There is an on-going debate of how a variable that is in the causal pathway in the analysis is best adjusted for (Keijzer-Veen et al, 2005; Lucas et. al, 1999). In our example – just adding height in later childhood to a multivariate regression model of earlier height on cognitive scores or lung capacity would make the interpretation of the coefficients difficult. The reason is that the effect of later height is codetermined by the effect of earlier height on cognitive scores or lung capacity, because later height is in part determined by earlier height, which influences the coefficients in a combined model (Keijzer-Veen et al, 2005).

To address this problem, we follow the approach suggested by Keijzer-Veen et al, 2005. To be able to explore the association with cognitive test scores and lung capacity separately, we use a multivariate regression model containing height-for-age in earlier childhood and residual height in later childhood. So we use the method of residual height instead of using the actual height in later childhood. The coefficients of such a multivariate regression model show the association with the outcome directly.

The residual height in later childhood is calculated by subtracting the expected (predicted) height from the actual height. The expected height is estimated by a regression model using earlier height. For further details of the algebraic explanation of this model, see Keijzer-Veen et al, 2005.

General approach to selecting independent variables for the regression analyses

Depending on the analytical framework we developed for each outcome variables and the review of similar empirical studies we include relevant variables that are available in the IFLS in a full model. We then use stepwise elimination of those variables that are not significant until a final model of relevant and significant independent variables is derieved. The output of the final models are shown in the empirical chapters. Conceptual important variables such as the HAZ and residual HAZ are always shown in the output tables as they are a core interest of analysis.

Treatment of death as an outcome in the analysis, for children and for their parents

Children from our initial sample that die over the course of the 14 years of the IFLS from 1993 till 2000 are not included in the final sample as parts or all of their outcome or independent variables would be missing. However we constructed a dummy variable for children that died between 1993 and 2007 and conducted a sensitivity analysis including the dummy variable into our outcome regression models. We did not receive significant coefficients for these dummy variables. This is a cautious indication that our sample does not seem to be biased by attrition due to children's death.

As for parents death we used a similar approach and did not receive any significant results for the maternal or paternal death dummy variable.

CHAPTER 4: Children's nutritional status in early life and dynamics into adolescence

4.1 Introduction and Motivation for the Research

Why are we or should we be interested in children's growth and nutritional status? Sadly, even today, undernutrition is a main underlying cause for childhood deaths with accounting for nearly one half of the 10 million childhood deaths that occur annually for children under five years of age (Caulfield et al. 2006; UNICEF 2008). Such early ends to children's lives are preventable and it should be highest priority to ensure that children are able to grow up and live to their fullest potential.

Malnutrition is the consequence of a combination of inadequate intake of protein, carbohydrates, micronutrients and frequent infections. There is a distinction between two major types of malnutrition: 1) protein-energy malnutrition – which relates to a deficiency in any or all nutrients, and 2) micronutrient malnutrition – deficiency of specific micronutrients – most often iron, vitamin A and iodine.[23]

Protein-energy malnutrition can lead to children's faltering in their growth – so called *stunting* – where children's growth falls below two standard deviations compared to an international adequately nourished reference group. It is estimated that there are over 150 million (24%) of all children worldwide that are affected by stunting (de Onis 2008). And despite setting the goal of reducing malnutrition by 50% until the year 2000 at the World Summit for children[24] in 1990 and the Millennium Development Goals[25], Indonesia still lacks behind achieving this target.

More generally, health is of concern to international and national policy makers. Internationally, the WHO strongly argues for the need to reduce health inequality within countries in addressing differences between its socio-economic groups (e.g. WHO, 1985, 1986; Whitehead, 2000). Nationally, the Government of Indonesia – manifested even in the preamble of the 1945 Constitution – claims that the principles of the health system in Indonesia should be in accordance with human rights, justice and equity (MoH RI, 2003a

[23] [Source: http://conflict.lshtm.ac.uk/page_115.htm#Malnutrition_Types].
[24] World Summit for children: A promise to children. More details at: http://www.unicef.org/wsc.
[25] Target 1C: Halve the proportion of people who suffer from hunger.

cited in (Massie 2008). According to Amartya Sen and human rights activists, health is intrinsically valuable as an end in itself. Sen's capability approach conceptualizes poverty in a multi-dimensional way as deprivation of basic capabilities and health as a direct measure of well-being (Sen 1979; Sen 1985; Sen 1987). Further, health (especially basic health) and adequate food have been recognized as fundamental rights with manifestation dating back to the Universal Declaration of Human Rights (1948), and the UN Convention on the Rights of the Child (1989)[26].

Apart from its intrinsic value, health is of concern as it is also instrumentally important. Health has been identified as one of the main routes for changes in well-being over the life-course through a number of direct effects but also indirect effects, including achievements in education and returns in the labour market. Studies from developing countries for example show how earlier shocks unfold over time. Alderman and colleagues' study of Pakistan (Alderman et al. 2001) and of Zimbabwe investigates the long term consequences of malnutrition on grades attained and age started school. They find that preschool malnutrition in rural Zimbabwe impacted on human capital formation. Malnutrition caused stunting, delayed schooling and reduced work experience opportunities which led to a loss of lifetime earnings of about 14 percent (Alderman, Hoddinott, and Kinsey 2006).

Malnourishment can also hinder a child's cognitive development; if this occurs "before age two, the impairment may be irreversible regardless of a later improvement in their nutrition and circumstances" (ACC/SCN/IFPRI 2000). Further, girls who grow up with inadequate nutrition face greater health risks during pregnancy, thus completing the cycle of maternal and child malnourishment and mortality and intergenerational transmission. Stunted girls "are more likely to be underdeveloped for childbirth, and face higher risks of […] low birth weight and stunting among their own children" (ACC/SCN/IFPRI 2000; Harper, Marcus, and Moore 2003).

Apart from the relationship with the worst-case scenario of child mortality, malnutrition can have other consequences that influence children's wellbeing. As research has shown stunting is associated with adverse cognitive development, delays in motor development, lower IQ; fewer years of schooling, delayed entry into school, less likely to be enrolled in school, lower school achievement; decreased productivity and reduced adult stature (Crookston, Penny, and Alder 2010).

[26] E.g. the right to the enjoyment of the highest attainable standard of physical and mental health (UDHR A25, ICESCR Article12) and the right to adequate food.

Main research questions

There is mixed evidence if recovery from stunting in early childhood is possible and only a few studies explore what factors are associated with stunting dynamics that span children's life-course into adolescence (Schott et al. 2013; Adair 1999; Mendez and Adair 1999). This is partly due to data requirements – one needs longitudinal data that spans a substantial period of time to observe this phenomenon.

Our main research questions are: What factors are associated with children experiencing stunting in early childhood and reversal of stunting (catch-up growth) between early childhood and adolescence? More specifically, do parental resources stratify the likelihood of children experiencing stunting in early childhood and reversal of catch-up growth? Do children with disadvantaged parents (less educated, less height, less consumption) have less favourable health outcomes (as proxies by nutritional status: stunting in early childhood)? And are children from more advantaged family background are more likely to experience catch-up growth then more disadvantaged groups?

Structure of the Chapter

The chapter is structured as follows: Section 4.2 briefly discusses the conceptual framework we are using for determinants of children's nutritional status. Section 4.3 gives an overview of the few existing studies that investigate children's dynamics of stunting. Section 4.4 details the research questions we are addressing in this chapter. Section 4.5 describes the methods we are using, the construction of the anthropometric outcome variable and analysis. Section 4.6 present the results, descriptive and from the regression analysis of stunting in early childhood and dynamics of stunting – in particular catch-up growth. Section 4.7 discusses and summarises the main findings and concludes.

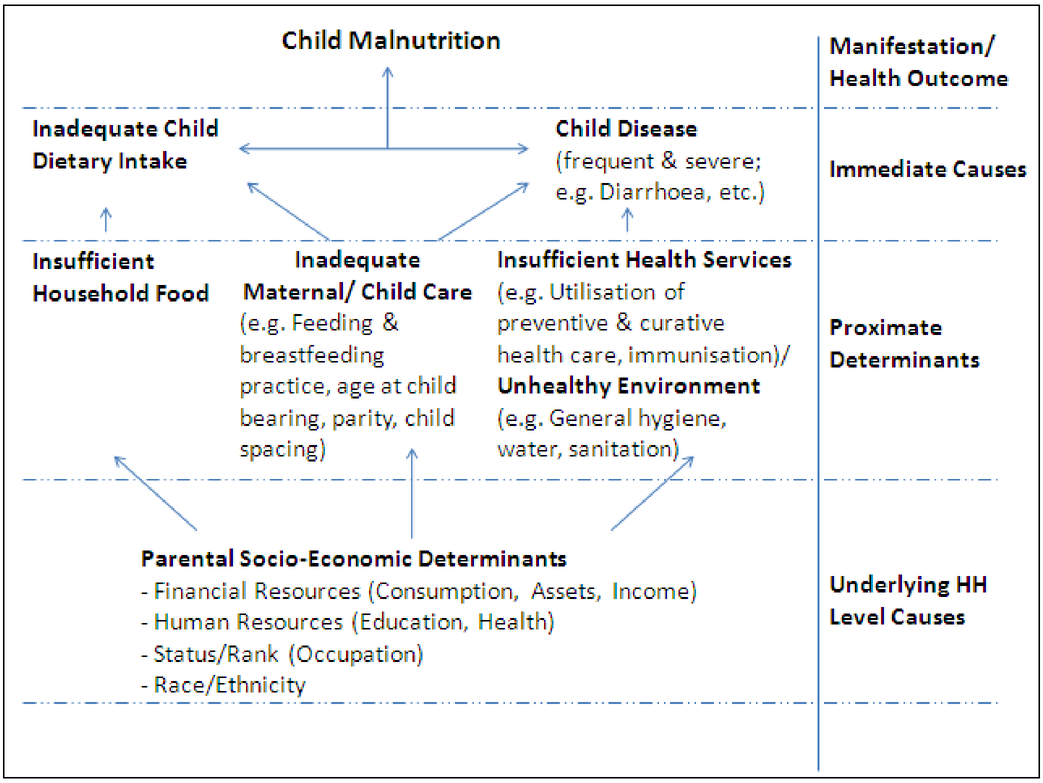
4.2 *Conceptual framework for children's nutritional status*

This section gives an overview of the conceptual framework we are using for the analysis. We will in particular look at what is known about the determinants of children's nutritional status measured by their height-for-age z-scores (HAZ) and growth dynamics such as growth recovery. Furthermore, we are interested in how to conceptualise the relations between parental resources and children's growth outcomes and dynamics.

Conceptual framework for children's nutritional status

The analysis of this study is based on an adapted framework (see Figure 7) from ideas that are widely used in the literature to study child health outcomes. Namely, the framework adapts ideas from the UNICEF model of malnutrition (UNICEF 1998), Mosley and Chen's proximate determinants framework (Mosley and Chen 1984), and Schultz's biological endowment and preference model (Schultz 1984).

Figure 7: Adapted framework for children's nutritional status



The main idea of this modified proximate determinants framework is that all social and economic determinants of child mortality/malnutrition operate through a set of biological or proximate determinants to affect a child's probability of survival/malnutrition. On this account, child malnutrition is immediately caused by inadequate dietary intake (either in quantity or quality) and/or frequent and severe child diseases (such as episodes of diarrhoea and infections). This model combines social, economic, medical and biological explanations of child malnutrition. The immediate causes of malnutrition are related to proximate determinants, which are grouped into insufficient household food, inadequate maternal and or childcare and insufficient health services and unhealthy living environments.

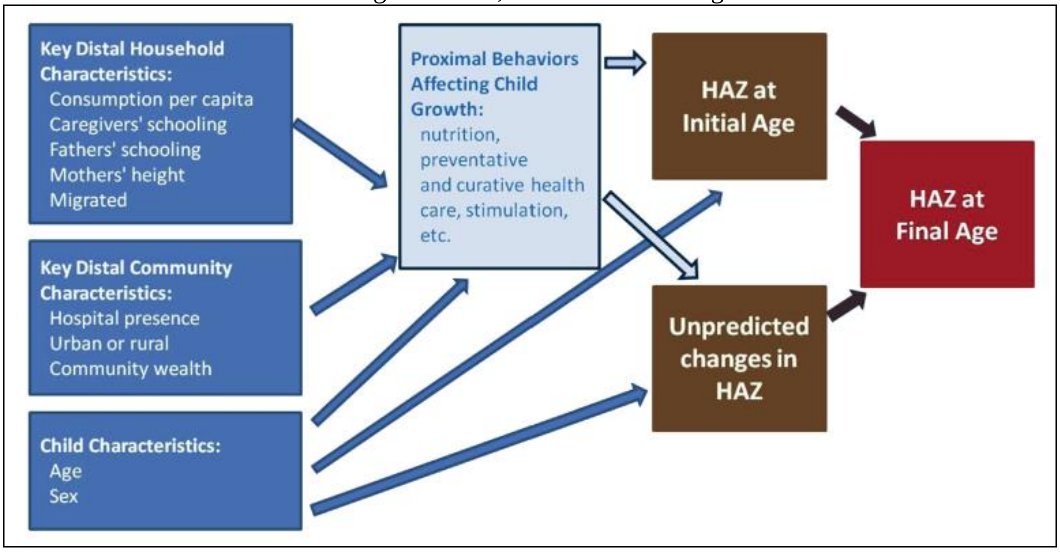
Link to parental socio-economic resources

Parental resources are the underlying household-level causes working through these channels on children's nutritional status. For example, it is assumed that a child of parents with adequate financial resources is provided with better quality and quantity of household food, and parents are able to afford sufficient preventative and curative care as well as healthy environments. Maternal schooling is conceptualised to mainly work through the route of adequate childcare. As mothers are main childcarers, their schooling influence is thus assumed to be of greater magnitude than paternal education. Further, more educated mothers might have better health and nutrition related knowledge and better able to provide better quality food or better health habits (even if we hold the financial resources constant).

Conceptual framework for children's growth dynamics

As the previous introduced framework (Figure 7) only conceptualised the growth status of children at one point in time, we consider a schematic overview (Figure 8) by Schott and colleagues to introduce the dynamic nature of children's growth at different points in time (Schott et al. 2013).

Figure 8: Key distal household and community characteristics and HAZ at initial age, unpredicted changes in HAZ, and HAZ at final age



Source: (Schott et al. 2013, 3)

Figure 8 is to some extent similar to the proximate determinants framework. It lists key distal characteristics at the household and community level on the left side of Figure 8. Together with child characteristics, they work through proximate factors that affect children's growth at initial age. The authors mention nutrition, preventative and curative health care, and stimulation as intermediate or proximate determinants. The framework distinguishes between height at initial age and height at final age, which allows us to characterise children's growth as a dynamic process (instead of a static outcome).

4.3 Literature review on growth dynamics and parental resources

This section gives an overview of the empirical literature that has looked at children's nutritional status – especially dynamics. There is limited evidence from Indonesia, and we will use relevant literature from other countries to fill in the gaps.

Complementary to this section is the grid in Appendix 4.1, where we developed a mapping of the key literature mentioned here for more information about the data, variables, sampling, estimation methods and results they contain. This enables us to contrast and compare the previous contributions according to their different aims, methods, and results in more depth than would be possible in this section.

We focus on investigating the dynamics of children's nutritional status over time. There is mixed evidence on whether recovery from shocks to the nutritional status of children (e.g. stunting) in early childhood is possible. Further, only a few studies explore what factors are associated with nutritional status dynamics that span children's life-course into adolescence. This is partly due to data requirements – one needs longitudinal data that spans a substantial period of time to observe this phenomenon. This focus is linked to a debate about child development in the literature. One side argues that it is only the early years in children's development that are formative and if disadvantages occur in this critical window, they can be irreversible. Some support to this claim comes from insights of intervention studies that covered nutritional and stimulation inputs. They show that improvements are only possible for very young children or in the short term (Pollitt, Watkins, and Husaini 1997). The other side cites evidence that suggests that the brain is a very resilient organ, able to adapt to disadvantaged circumstances and even recover to some extent from the damage it has experienced long into adolescence years (Levitsky and Strupp 1995b)

There are only very few studies which investigate health in a dynamic life-cycle approach for developing countries with panel data. Baulch and Masset (2003) use a panel study from Vietnam with two waves of data (1992/3 & 1997/98) and find substantial movements in and out of stunted growth for both children and adults. For their child sample of 1,660 children between 1-5 years of age in 1992/3, 14.1% are mildly or severely stunted in both waves compared to 35% that are never stunted in both waves. They find that nearly 18% of individuals in their sample move out of stunted growth (i.e. they can catch up and are not stunted four years later). This is particularly relevant as the controversy regarding the possibility of catch-ups is still not settled and such evidence is rare (Baulch and Masset, 2003). However, they do not differentiate dynamics of stunting along socio-economic resources of parents and investigate whether catch-ups are more likely for more advantaged groups of children compared to disadvantaged groups.

Another study that uses the same panel dataset comes to slightly different results, probably because the categories for the different health statuses have been chosen differently (the transient health deprived were differentiated by Baulch and Masset whereas they were collapsed here). Substantial movements in and out of health deprivation are also observed by these authors (Günther and Klasen, 2007).

Crookston et al. use a cohort of 1,674 Peruvian children to identify factors that are associated with catch-up growth between infancy and childhood. The analytical sample consists of 374 children. They use two waves of data with a cohort of children aged between 6-18 months in the first wave and 4.5-6 years in the second wave. Catch-up growth is defined as being stunted in the first wave (infancy) but not stunted in the second (childhood). The authors identify the following factors to be associated with catch-up growth: children who had grandparents at home, experienced less severe stunting in infancy (1^{st} wave), and had taller mothers (Crookston, Penny et al. 2010). Crookston et al. are not using any information on fathers' individual level characteristics, probably due to not being available in the dataset that they are using. Furthermore, there is no direct measure of consumption/income, but only a wealth composite indicator mixing together consumer durables, services and housing quality making it difficult to assign the components that may influence children's health status.

4.4 Research questions

This sections details the research question for this chapter. First we are interested to examine the nutritional status of a cohort of children and see to what extent it is related to parental socio-economic resources. We further examine the patterns of children's nutritional changes over time e.g. complete, partial or no recovery from earlier malnutrition and to what extent parental resources are associated with these changes.

Nutritional status of children in early childhood and adolescence

To what extent are parental resources (individual-level: education, height; family-level: consumption, quality of living environment and family structure) associated with children's nutritional status (height-for-age and stunting) in early childhood?
We also examine several sub-questions as well:

- Which parental resources show the strongest association?
- Are there differences in the association by gender of the child?
- Are there differences in the association by the age of the child?

Patterns of children's nutritional changes over time

To what extent are children's nutritional statuses in one period associated with the child nutritional status in the subsequent period?
To what extent are children's growth retardation (stunting) early in life permanent or is partial or full recovery possible and to what role do parental socio-economic resources play? Are there differences by the gender of the child?
To what extent is final height in young adolescence & adulthood associated with previous height in earlier life-stages and parental socio-economic resources?

To our knowledge, there are no studies that explore the dynamics of nutritional status over a timespan from early childhood to adolescence for Indonesia. Using the IFLS data, we are able to follow these children into adolescence – a life-stage that has not been researched very much in developing countries, due to the time-span of data needed. There are a few studies from other countries that look at the dynamics of nutritional status (stunting) but the timespans and life stages considered are normally shorter. So we are interested in exploring whether parental resources are associated with different dynamics (e.g. catch-up growth). This should help us to understand whether the improvements or worsening of children's nutritional status is occurring and what factors are associated. It is also the groundwork for the next two chapters that look at the consequences of parental resources and child nutrition on cognitive development and schooling outcomes.

4.5 Method

Outcome variable: Child's height-for-age z-scores (HAZ)

Health can be conceptualised and measured over various dimensions. Therefore it is clear that no single indicator or narrow group of indicators can capture the multi-dimensional concept of health in its various dimensions (Ware, Davies-Avery et al. 1980). However, due to data limitations but more importantly due to the advantages of the widely used health indicator of height, we chose this proxy for our research.

Stunted growth[27] was chosen as an indicator for child health as the medical and public literature indicates that it is an objective indicator of general health status. It is also a good measure for long-term health and nutritional deprivation as it accumulates episodes of inadequate nutrient intake and disease over time, which results in stunted growth (WHO, 1995a,b; Mosley et al. 1984).

Using stunting (based on height-for-age) is also more preferable to measures such as underweight (based on weight-for-age) as the latter is sensitive to short-term changes in nutritional status whereas stunting is an indicator for long-term nutritional changes which can date back years ago. This is important as we observe the sample of children only every three to four years and between the 3rd and 4th wave there is even a seven years gap. So we do not know what happens to children in-between waves of the survey. Using stunting gives us more confidence to capture the health and nutritional shocks that a child might have experienced between waves.

Other indicators of health, especially self-reported morbidities, are more subjective and prone to over-reporting by socio-economic resources. For example, Thomas at el. find that higher educated mothers are more likely to report a cough for their child (p.12-13). However, the authors assume this to be reporting error due to higher awareness of respiratory problems for higher educated mothers rather than the children being unhealthier (Thomas, Contreras et al. 2002).

Standardised height is also more suitable for the research of health dynamics over time than indicators such as mortality or life-expectancy due to selection bias and censoring of data (Pradhan, Sahn et al. 2003).

[27] Definition of stunting: Stunting is defined as height-for-age Z-scores (HAZ) smaller than -2SD from the mean. Sometimes further categorised along the WHO guidelines of mild -2 to -1SD, moderate -2 to -3, severe (<-3SD).

Children's anthropometric measure as dependent variable

This sections outlines briefly how children's height information was collected in the IFLS and how the measures were than standardised against a reference group to judge if growth was stunted or not employing the WHO growth references and programmes written for STATA. For more details, please see Chapter 3.

How are anthropometric measures collected in the IFLS? And what is the overall quality? As the documentation of the IFLS details, a physical health assessment is conducted by two specially trained nurses, who record physical measurements of health for household members **(**Usernotes IFLS3 (2000) p. 34). While the later waves of the IFLS have quite detailed health information, the earlier waves do not. Or health measures are not available for all age groups. As we need the same health measure over time for the cohort of children that we chose, height-for-age was chosen as it is the measure that was taken in all the waves across all age groups.

How is the data quality of the anthropometric measures? The measurement of height was done in the same way in all four waves and thus is consistent over time. However the data for 1997 was not published until 2010 (13 years after it was collected) without giving any plausible explanation.[28] With regards to measurement error, for the method of height measurement the WHO recommends that children younger than 2 years (or 24 months or 731 days) should be measured lying down (lengths-for-age) and height-for-age for children older than 2 and adults is measured by standing up (See photos next page for visualisation of the different height-measurement method for young children and adults). This would be a problem for the cohort we are looking at in the first wave in 1993, for the children that are younger than 2 years. To get an idea of how many children were measured correctly, we use the information from the anthropometric file that details the method of height measurement. The majority of cases were correctly measured but some children younger than 2 years still indicated as measured standing up. We construct an indicator variable for including in our sensitivity checks and analysis. Analysis not shown but indicator variable did not flag up as significant.

[28] Several inquiries with the principal investigators and the support team at RAND were unsuccessful to obtain the data. While the data is finally published, there are no help files for these files, which makes the data cleaning an even more time consuming task than for the other waves. But we decided to include the data for all four waves because the gaps between the data collections would be quite substantial otherwise.

Overall the measurement of height in the IFLS seems according to standards of other surveys like the Demographic Health Survey and therefore is used for the analysis in this chapter.

Figure 9: Taking the height measurement of an adult standing

Nurse preparing the measurement of height for respondent [Source: http://www-scf.usc.edu/~smani/ifls/]

IFLS trainer taking adult height measure [Source: Authors photo taken during the piloting phase of IFLS4, on 17.11.2007, in Solo, Indonesia]

Figure 10: Taking the height measurement of a child lying down

[Source: http://www-scf.usc.edu/~smani/ifls/]

Stunting indicator variable

From the calculated z-scores we created the stunting measure. A child will be defined as stunted if their height-for-age is below minus two standard deviations from the median height-for-age of the WHO reference population. Sometimes further categorised along the WHO guidelines of mild -2 to -1SD, moderate -2 to -3, severe (<-3SD). Thus, this is a dichotomous and cross-sectional indicator. While the WHO has set this cut-off point and it is widely used, there is no clear evidence that there are distinct health related risks that increase when the cut-off is crossed. While a shortfall in height is associated with negative health benefits, it is not clear where exactly this cut-off point should be. We therefore should examine when we change the cut-off point and sensitivity analysis.

Longitudinal dynamics of stunting for two wave comparison

The above measure is a cross sectional outcome measure, e.g. it focuses on height outcome in one wave only. As we are interested in changes over time, we also investigate longitudinal measures of height development – e.g. the dynamics of stunting.

We follow the categorisation of stunting dynamics used by similar studies for Peru (Crookston, Penny et al. 2010) and Philippines (Adair 1999) on catch-up growth with. Table 3 defines the four different dynamics and their prevalence in the cohort of children we have chosen.

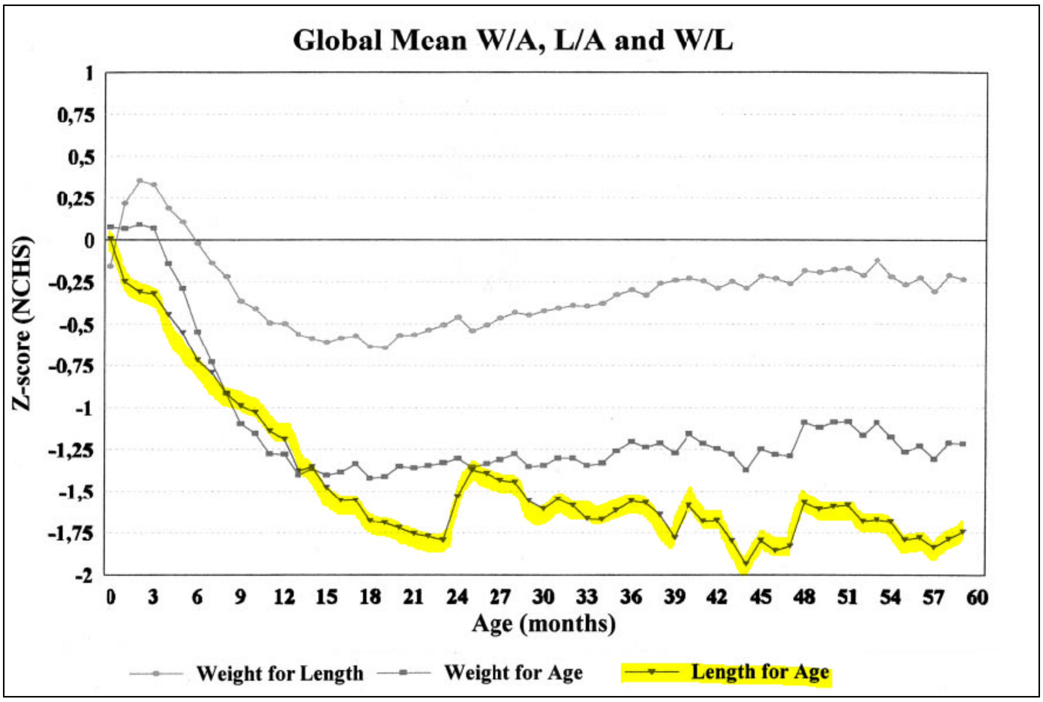
Table 3: Dynamics of childrens growth (between 0-3 years in 1993 and 14-17 years in 2007)

Dynamics of Stunting	**n**	**in %**
Never: Not stunted in early childhood nor adolescence	497	47.93
Catch-up: Stunted in early childhood not adolescence	231	22.28
Deteriorate: Not stunted in early childhood but in adolescence	124	11.96
Chronic: Stunted in early childhood and in adolescence	185	17.84
Total	1,037	100.00

Growth profiles

Based on results from 39 national representative datasets[29] from developing countries for children under the age of 5 years, Shrimpton et al. have shown that at birth the mean for lengths/height for age is close to the international reference group – see
Figure 11. Growth faltering however, starts immediately after birth and lasts well into the third year of age building up anthropometric deficits over time (Shrimpton, Victora et al. 2001). While Shrimpton et al. make an important contribution in understanding the growth faltering for children until the age of 60months (i.e. 5years of age) they do not investigate what happens to growth faltering after the age of 5. As the authors only use cross-sectional data, the timeline is constructed by different age cohorts of children and not following children over time as they get older.

Figure 11: Mean anthropometric z-scores for 39 countries, relative to NCHS reference



[Source: (Shrimpton, Victora et al. 2001)]

[29] World Health Organisation (WHO) Global Database on Child Growth and Malnutrition collates data from 39 cross-sectional anthropometric surveys worldwide. For more information see: http://www.who.int/nutgrowthdb/database/en/

Analytical sample (Cohorts of children 3-36 months in 1993) and analytical strategy

As we are interested to follow children over time from early childhood into adolescence, we decided to choose a cohort of young children in the first wave of the IFLS in 1993, namely children under the age of 3 years or more precisely less or equal to 36 months and older than 3 month.

To be eligible for being selected into the analytical sample, children must:

- have valid age-in-months information from the household roster in 1993,
- be between 3-36 months in 1993,
- be measured (length/height) in 1993,
- have valid (biological plausible values) for height.

Any loss in information can be assigned to one of these four criteria. The information needed for selecting children into the sample are discussed in more detail in the appendix.

We have a cohort of 1,037 children between ages 3-36 in 1993 which forms the analytical sample for the model on stunting in early childhood.

Table 4: Ages of cohort (n=1,037) in different IFLS rounds

Round 1 (1993)		**Round 2 (1997)**		**Round 3 (2000)**		**Round 4 (2007)**
~ 0-3 years (3-36 months)	Survey gap: ~ 4 years	~ 4-7 years	Survey gap: ~ 3 years	~ 7-10 years	Survey gap: ~ 7 years	~ 14-17 years

Table 4 above gives the details about the cohorts we have chosen from the IFLS. The table shows all four rounds of the IFLS dataset, as well as the ages of the cohorts in the different rounds, the gaps that are between the data collection rounds.

As the IFLS is a multi-cohort panel dataset it contains individuals of all ages. This is different to a birth cohort dataset where individuals are often chosen that were born within a calendar year. There are several reasons to choose the 3-year-age-cohorts one being the sample size would be too small if we would restrict the cohort to 1-year-age-cohorts. Further, the age cohort was chosen, as there is an ongoing debate as to whether early life-course events affect later outcomes, something we want to study especially for children's nutritional dynamics. Having information on the early years in infancy is important for this purpose.

Overall, having a three year cohort enables us to gain a round picture of children's life course over their entire childhood and not just short-term fractions of it. This is important, as it is still not clear whether some childhood disadvantages will affect later life stage outcomes only in the medium- or also in the long-term.

The longitudinal nature of the panel data was exploited and children's health transitions were investigated by using mobility transition tables. The 2x2 contingency tables capture the partial bivariate relationship between the children's health status in 1993 and their health status in 2000, treating the first as the independent and the second as the dependant variable which follows from the time of occurrence. Also the immobility measure used by Baulch and Mausset is used where I = 1 would be complete mobility (Baulch and Masset 2003).

To compare the persistence of the stunting prevalence, we adapt the immobility measure suggested by Scott and Litchfield (1994):

$$I = \frac{\text{trace}(M)}{N}$$

where M refers to the square transition matrix, trace (M) is the sum of the cell frequencies along the leading diagonal, and N is the number of individuals in the panel. The immobility measure varies between zero when there is complete mobility and one when there is complete immobility.

4.6 Results

Descriptive analysis

In order to get a better idea of how trends in child health status as measured by height-for-age z-scores (HAZ) have developed over time in Indonesia, we start by examining HAZ for different birth cohorts. Table 5 shows the trend in mean height-for-age z-scores (HAZ) and the percentage of children classified as stunted[30] for under the age of 5 years (0-59 month). We used repeated cross-sectional data[31] for the four waves of the IFLS in 1993, 1997, 2000 and 2007. Over this 14-year period, there is a significant improvement in mean height-for-age z-scores for children born between 1988 and 2007. The statistics indicate that mean height-for-age z-scores worsen until 1997 and then improve during 1997-2000 and 2000-2007. The percentage of children classified as stunted also increases between 1993 and 1997 and then declines between 1997 and 2007.

Table 5: Summary statistics on Height-for-age z-score (HAZ) for children between the age of 3 and 59 months in 1993, 1997, 2000, 2007 (repeated cross-sectional data)

Years	Birth Year	Observations	HAZ<-2 in %	Mean HAZ	Mean Difference (years)
1993	~ 1988-1993	2475	43.80	-1.67	-0.116 (1997-1993)
1997	~ 1992-1997	2392	46.70	-1.79	0.192 (2000-1997)
2000	~ 1995-2000	3534	40.58	-1.60	0.174 (2007-2000)
2007	~ 2002-2007	4365	35.67	-1.42	0.250 (2007-1993)

- Source: compiled by author based on IFLS 1993, 1997, 2000, 2007

The reason for the worsening between 1993 and 1997 is not clear but it could be related to the rural crisis in 1997. There were a series of major forest fires and a major drought and national rice production fell by 4% compared to 1996 (Strauss et al. 2004, 4, 143; Sastry 2002). However, as outlined earlier, height-for-age is more of a long-term measure and it is unlikely that it was immediate responsive to the events in 1997. And the more short-term responsive measures of shocks to child health (weight-for-height and weight-for-age) do not show this negative trend (see Appendix 4.2: Weight-for-age z-

[30] HAZ<-2: Height-for-age z-scores (HAZ) are below 2 standard deviations of the international reference data.
[31] Cross-section data includes data for children between the ages 3 and 59 months in 1993, 1997, and 2000 waves of the IFLS.

scores (WAZ)). Other research (Mani 2008; Strauss et al. 2004) does not have an explanation for this trend either, so this is an area for further research.

These results and trends are in line with results from other research (Mani 2008, 16; Strauss et al. 2004, 139) and statistics from the Demographic Health Survey and SUSENAS (household survey).[32] To summarise, trends in child health status as measured by height-for-age z-scores have improved by the year 2007. However, it is important to note that despite the improvements in stunting levels over the years, levels are still high in Indonesia.

Table 6 shows the trends for height-for-age z-scores (HAZ) for children and adolescents aged 5-19 years in 1993, 1997, 2000 and 2007. As the age range is very broad the birth years overlap quite substantially in the IFLS survey years, making a direct comparison of the trends difficult. So we just focus on the 1993 and 2007 waves, as they are distinct birth cohorts and only slightly overlapping. Between these two groups it is apparent that a substantial improvement in health measured by height-for-age has occurred in Indonesia with stunting levels falling from over 45% for the children born between 1974 and 1988 to around 33% for children born between 1988 and 2002. This is a substantial improvement but a prevalence of stunting over 33% is nevertheless high for region and worldwide standards, only exceeded by some countries in South Asia.

Table 6: Summary statistics on Height-for-age z-score (HAZ) for children between the age of 5 and 19 years in 1993, 1997, 2000, 2007 (repeated cross-sectional data)

Year	Birth Year	n	HAZ<-2 in %	Mean HAZ	Mean Difference
1993	~ 1974-1988	6,303	45.60	-1.85	0.033 (1997-1993)
1997	~ 1978-1992	9,521	42.21	-1.82	0.059 (2000-1997)
2000	~ 1981-1995	10,583	40.22	-1.76	0.217 (2007-2000)
2007	~ 1988-2002	10,853	33.15	-1.54	0.308 (2007-1993)

[Source: compiled by author based on IFLS 1993, 1997, 2000, 2007]

[32] Note however, that the research only uses the old WHO reference data and not includes the 2007 data so it is not exactly comparable.

Next we are interested to see if the trends we have observed for the repeated cross-sectional data is comparable to panel respondents. Panel respondents are children in 1993 who can be followed through the 1997, 2000 and 2007 waves of the IFLS.

Table 7: Summary statistics Height-for-age z-score (HAZ) for cohort (panel data) who are 3-36 months in 1993 and followed through 1997, 2000 and 2007

Years	Age	N	HAZ<-2 in %	Mean HAZ	Mean Difference
1993	~ 0 -3 years	1,037	40.12	-1.48	-0.329 (1997-1993)
1997	~ 4 -7 years	1,037	43.30	-1.81	0.054 (2000-1997)
2000	~ 7-10 years	1,037	42.82	-1.76	0.158 (2007-2000)
2007	~ 14-17 years	1,037	29.80	-1.60	-0.118 (2007-1993)

[Source: compiled by author based on IFLS - 1993, 1997, 2000, 2007]

Notes: The chosen cohort was born between ~1990 and 1993.

Table 7 (for the young cohort) and Table 8 (for the older cohort) show a similar trend of worsening of the child health status as measured by height-for-age z-scores between 1993 and 1997 and then a substantial improvement until 2007 for the younger cohort. Unfortunately, the WHO reference data is only available until the age of 19 years, so we could not calculate the height-for-age z-scores for the older cohort for 2007 as the ages are between 19 and 22 years. Some age ranges between the two cohorts are not exactly comparable but are similar enough to make some first observations that the younger cohort's health status is better than the older cohort. This is quite likely the result of the interrelated cohort and period effect. For example, in 1997, the younger cohort around 4 to 7 years old and has a mean HAZ of -1.81 and over 43% of children in that cohort are malnourished as measured by stunting. If we compare this to the older cohort in 1993, where children were slightly older (between 5 to 8 years) they have a mean HAZ of -1.83 and stunting prevalence of over 45%. This could be due to the children being slightly older and having accumulated more health shocks up to the date of the survey. However, if we examine other similar ages between the two cohorts this is not the case. If we take the younger cohort in 2007 (aged 14-17 year) and compare them to the older cohort in 2000 (aged 12-15 years) the improvements for the younger cohort have been much more substantial with a drop to around 30% prevalence of stunting in 2007 compared to over 40% in 2000 for the older cohort.

Table 8: Summary statistics on Height-for-age z-score (HAZ) for older cohort (panel data) who are aged 5-8 years in 1993 and followed through 1997. 2000, 2007

Years	Age	n	HAZ<-2 in %	Mean HAZ	Mean Difference
1993	~ 5 -8 years	1517	45.22	-1.83	-0.043 (1997-1993)
1997	~ 9-12 years	1517	46.08	-1.87	0.094 (2000-1997)
2000	~ 12-15 years	1517	40.54	-1.78	0.051 (2000-1993)
2007	~ 19-22 years	1517	/	/	/

[Source: compiled by author based on IFLS - 1993, 1997, 2000, 2007]. Notes:

- The chosen cohort was born between ~1985 and 1988.
- The WHO reference data is only for children up to 19 years, so for 2007 there are no HAZ

Transition matrices

Next, we want to make use of another feature of panel data. We cannot only follow the same children over time observing their real health trends over their life-course (and not just cross-sections information on different children), we can also further investigate to what extent the current health status of children correlated previous health. For this purpose we employ so-called transition matrices, as descriptive tool, to compute the covariance and correlation between past and current binary measures of children's health as measured by being stunted or not.

Table 9: Transition Matrix for stunting (HAZ<-2) between 0-3 years and 4-7 years

All

		Stunted 1997 (Age 4-7)		
		No	**Yes**	**Total**
Stunted 1993 (Age 0-3)	**No**	441 (71 %)	180 (29 %)	621
	Yes	147 (35.4 %)	269 (64.7 %)	416
	Total	588	449	1037
	Corr(H_{97}, H_{93})			0.3529
	Immobility Index			0.68

Boys

		Stunted 1997 (Age 4-7)		
		No	**Yes**	**Total**
Stunted 1993 (Age 0-3)	**No**	231 (72.4 %)	88 (27.6 %)	319
	Yes	77 (32.5 %)	160 (67.5 %)	237
	Total	308	248	556
	Corr(H_{97}, H_{93})			0.3972
	Immobility Index			0.70

Girls

		Stunted 1997 (Age 4-7)		
		No	**Yes**	**Total**
Stunted 1993 (Age 0-3)	**No**	210 (69.5 %)	92 (30.5 %)	302
	Yes	70 (39.1 %)	109 (60.9 %)	179
	Total	280	201	481
	Corr(H_{97}, H_{93})			0.2982
	Immobility Index			0.66

Table 10: Transition Matrix for stunting (HAZ<-2) between 4-7 years and 7-10 years

All

Stunted 1997 (Age 4-7) / **Stunted 2000** (Age 7-10)

	No	**Yes**	**Total**
No	489 (83.2 %)	99 (16.8 %)	588
Yes	104 (23.2 %)	345 (76.8 %)	449
Total	593	444	1037
Corr(H_{00}, H_{97})		0.6008	
Immobility Index		0.80	

Boys

Stunted 1997 (Age 4-7) / **Stunted 2000** (Age 7-10)

	No	**Yes**	**Total**
No	257 (83.4 %)	51 (16.6 %)	308
Yes	55 (22.2 %)	193 (77.8 %)	248
Total	312	244	556
Corr(H_{00}, H_{97})		0.6137	
Immobility Index		0.81	

Girls

Stunted 1997 / **Stunted 2000** (Age 7-10)

	No	**Yes**	**Total**
No	232 (82.9 %)	48 (17.1 %)	280
Yes	49 (24.4 %)	152 (75.6 %)	201
Total	281	200	481
Corr(H_{00}, H_{97})		0.5852	
Immobility Index		0.80	

Transition Matrix for stunting (HAZ<-2) between 7-10 years and 14-17 years

All

Stunted 2007 (Age 14-17)

Stunted 2000 (Age 7-10)		No	Yes	Total
	No	533 (89.9 %)	60 (10.1 %)	593
	Yes	195 (43.9 %)	249 (56.1 %)	444
	Total	728	309	1037
	Corr(H_{07}, H_{00})			0.4973
	Immobility Index			0.75

Boys

Stunted 2007 (Age 14-17)

Stunted 2000 (Age 7-10)		No	Yes	Total
	No	288 (92.3 %)	24 (7.7 %)	312
	Yes	99 (40.6 %)	145 (59.4 %)	244
	Total	387	169	556
	Corr(H_{07}, H_{00})			0.5581
	Immobility Index			0.78

Girls

Stunted 2007 (Age 14-17)

Stunted 2000 (Age 7-10)		No	Yes	Total
	No	245 (87.2 %)	36 (12.8 %)	281
	Yes	96 (48 %)	104 (52 %)	200
	Total	341	140	481
	Corr(H_{07}, H_{00})			0.4252
	Immobility Index			0.73

Table 9, shows the transition tables for the stunting prevalence in the younger cohort of children, first for all children together and then for girls and boys separately. The transition matrices show that the leading axis (i.e. the diagonal that is most frequent in the data) is the one that shows that the previous health condition (i.e. stunting) is associated with the current one. For example, of the 416 stunted children in 1993 aged 0-3 years old, around 65% will also be stunted in 1997 but around 35% are able to move upwards i.e. they experience catch up in growth. The gender specific tables show that this correlation is highest for boys with close to 68% staying stunted in 1997 compared to girls with 61%. It also increases with the age of the children, e.g. boys aged 7-10 in 2000 who were not stunted, 92.3% will also be not stunted in 2007, aged 14-17. We also report the correlation coefficient between the previous and current health (i.e. the two stunting variables). The highest coefficient is for boys aged 7-10 years old in 2000 & their transition matrix to age 14-17 in 2000.

Children's nutritional status in early childhood (3-36 months)

As a first step we are interested to examine the nutritional status of children in early childhood when the cohort we chose is aged between 3 and 36 months. As we are interested in children's changes in nutritional status over time, it is important to understand the starting position in early childhood before moving on to the dynamic nutritional analysis.

As detailed in the descriptive results section above, of the 1,037 children that are in our analytical sample, 416 children (40.1% of the sample) are stunted in early childhood aged 3-36months. Table 11 displays the results from the logistic regression of stunting in early childhood.

Table 11: Logistic regression model for being stunted in early childhood (1=yes, 0=no) among Indonesian children aged 3months-3 years in 1993

Independent variables	Marginal effects	Standard Error
Child's Age, in months	0.0381***	0.00987
Child's Age^2, in months	-0.000587*	0.000236
Weight-for-age Z-scores	-0.264***	0.0210
Mother's height, in centimeters	-0.0122**	0.00391
Number of children in the household	0.0321*	0.0138
Household has electricity (d)	-0.0956*	0.0454
Household has indoor toilet (d)	-0.110**	0.0374
Household in rural area located (d)	0.109**	0.0409
Household owns their house (d)	- 0.0988*	0.0419
N	940	
R^2	0.352	

- Marginal effects are evaluated at average values of the explanatory variables; 95% confidence intervals in brackets (d) for discrete change of dummy variable from 0 to 1; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
- Robust estimates corrected for household level clustering
- Data reported in the table come from round 1 (when the child was between 0-3 years of age)
- Variables that had no significant effect on children's stunting in 1993 and are not reported in table above: Interaction Female*Child's Age, Gender of the child, mothers age at birth of the child, grandparents present in household, father's height in centimeter, mother's weight, father's weight, mother's years of schooling, fathers years of schooling, Log per capita monthly expenditure, household size, child is oldest child, drinking source in the house, walls are not from concrete material, ethnicity (Javanese), religion (Muslim), household owns a phone, if family ever visited health centre (puskesmas)

Child's individual characteristics: age, gender and weight-for-age-z-scores (WAZ)

We first added the individual child demographics of age in months in 1993. For each month of children's age the probability of being stunted in 1993 increases by 3.8%. This result is in line with what we would expect as we chose a cohort of 3-36 months old children in 1993 and we know that stunting occurs with children being more prone to infections and poor weaning practices and poor dietary quality (Adair, 1999: 1140). This could also reflect the growth patterns that we expect with children under 5 years of age. For example, based on results from 39 national representative datasets[33] from developing countries for children under the age of 5 years, Shrimpton et al. have shown that at birth the mean for lengths/height for age is close to the international reference group. Growth faltering however, starts immediately after birth and lasts well into the third year of age building up anthropometric deficits over time (Shrimpton, Victora et al. 2001). In 1993 when our cohort is between 3-36 month, we expect older children to be more likely to be stunted, as breastfeeding shield the children from malnutrition and children are especially prone to malnutrition when they start to be introduced to food and the risk of diarrhoea increases by age as polluted drinking water instead of breast milk is more likely to be consumed.

In many developing countries there is a male bias, with male children having better health due to better nutrition and health care they receive. With Indonesia being a predominantly Muslim country, one could assume that this male bias is even more pronounced. However, we do not find any gender bias which is in line with other research in Indonesia (Suryadarma, Pakpahan, and Suryahadi 2009; Lanjouw et al. 2001; Strauss et al. 2004).

Ideally, we would like to control for birth weight of children to get a proxy for pre-natal and in-utero factors that are important for children's nutritional status early on and their dynamics of recovering from growth restrictions. Unfortunately, there are high missing values for birth weight in Indonesia due to the majority of birth still occurring at home without a trained mid-wife or doctor. So accurate measurements are very difficult to obtain retrospectively. As a proxy we include children's weight-for-age z-scores (WAZ) in early childhood. This measure will most likely capture both, the pre-natal factors as well as the short term nutritional influences. As the results in Table 11 show, for each

[33] World Health Organisation (WHO) Global Database on Child Growth and Malnutrition collates data from 39 cross-sectional anthropometric surveys worldwide. For more information see: http://www.who.int/nutgrowthdb/database/en/

standard deviation in weight-for-age z-scores (WAZ), children are 26.4% less likely to be stunted in early childhood.

Parental socio-economic resources

Next we look at parental human capital variables – namely their schooling and their height (as a proxy for health). We use both mother's and father's information to be able to see if they have an independent association and how their effects sizes differs – e.g. suggesting which parent variable is more closely associated with children's health.

For mother's height we see that for each centimetre in mothers height children are 1.2% less likely to be stunted in early childhood. This effect is significant ($p<0.01$). For father's height – for each centimetre in father's height, children are 0.7% less likely to be stunted but this is not significant (not shown in the table).
The results suggest that mothers height is closer associated with children's health outcome. When going back to our analytical framework in section 4.2 than this result could be due to mothers role as primary care giver and her height as proxy for her health status during critical periods such as pregnancy and breastfeeding. Some genetic component is likely to be captured as well.
We also controlled for parental weight but this measure was not significant for neither mothers nor fathers (not included in table).

Other parental socio-economic resources

We included parental schooling in our model. For each completed year of mothers schooling, children are 1.4% less likely to be stunted. However, this is not significant. The marginal effects for father's years of schooling are smaller than maternal years of schooling and also not significant in the full model. Once we control for household assets and the quality of the living environment parental education becomes insignificant.

We also control for financial resources (log per capita monthly expenditure) of parents, however the association is not significant in the full model. Other measures of financial resources such as owning the house that the family lives in, improves the child's chances of not being stunted in early childhood by nearly 10%. Similarly, when a child aged 3-36months lives in a household that has electricity it is nearly 10% less likely to be stunted compared to a child that lives in a household without electricity. An indoor toilet improves the chances of not being stunted in early childhood by 11%. From our conceptual framework it is likely that the sanitation and housing qualities have a direct effect as it could decreases children's infection risks. These factors could additionally act as proxy for children's living standards.

Family structure

We also investigated family structure and how it is associated with children's stunting probabilities. For the number of children in the household – for each additional child in a household the probability of being stunted increases significantly by 3.2%. We also controlled for size of the household, to see if it was the number of family members per se, which it does not seem to be, as it is not significant. So it could be due to the higher dependency ratio – e.g. more children to care for compared to adults.
Another aspect could be the birth order of the children in the household. This could go in different directions. What we find is that children that are the oldest child in the household have a 0.6 % higher probability of being stunted compared to children that are not the oldest in the household – controlling for the age of the child. So same aged children, with the same number of siblings who are the oldest are still more prone to stunting. This could be due to the oldest child having to take on care or other work responsibilities and receiving less care him/herself. However, this association is not significant.

Rural location

As there are likely to be other characteristics at the community level that we have not included into the model, we include the location of the household in the model. Living in a rural area compared to an urban area increases the likelihood of being stunted significantly by 10.9%.

Summary of results of stunting in early childhood

- Child’s age and weight-for-age-z-scores significantly associated
- Association of maternal human resources as proxied by her height in centimetre closer and more significant for children’s outcomes than father height
- Direct measures of living standards – e.g. cleanliness of the living environment, indoor water facilities etc. have the strongest association, stronger than indirect measures of financial resources such as consumption. This could be due to financial resources being measured with more error (e.g. reporting error due to problems recalling the correct consumption) or that it is more the assets a household has and the living environment is better captured by direct measures than the indirect measure of consumption.

Children's nutritional status in adolescence (14-17 years)

Of the 1,037 children in our sample, 309 are stunted in 2007 when they are between 14-17 years of age. This is nearly 30% of our sample. Table 12 shows the results from the logistic regression of the significant variables on children's nutritional status in adolescence. We want to see if earlier stunting in early childhood already explains the majority of the variation in children's stunting in adolescence or if other factors still play a role.

Table 12: Logistic regression model for being stunted in adolescence (1=yes, 0=no) among Indonesian children aged 14-17 years in 2007

Independent variables	Marginal effects	Standard Error
Child stunted in 1993 (d)	0.113^{**}	0.0372
Weight-for-age Z-scores (2000)	-0.111^{***}	0.0187
Mother's age at child's birth	-0.00848^{**}	0.00322
Mother's height, in centimeters	-0.0207^{***}	0.00380
Father's height, in centimeters	-0.0131^{***}	0.00324
Log per capita monthly expenditure	-0.0608^{*}	0.0304
Number of children in the household	0.0311^{*}	0.0148
Household has indoor water supply in 2007 (d)	-0.0694^{*}	0.0367
N	724	
R^2	0.2135	

- Marginal effects are evaluated at average values of the explanatory variables; 95% confidence intervals in brackets (d) for discrete change of dummy variable from 0 to 1; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
- Robust estimates corrected for household level clustering
- Variables that had no significant effect on children's stunting in 2007 and are not reported in table above: Age of the Child, Interaction Gender*Child's Age, Gender of the child, if child attended preschool, hemoglobin level in 2000 of the child/mother/father, grandparents present in household, mother's weight, father's weight, mother's years of schooling, fathers years of schooling, household size, child is oldest child, walls are not from concrete material, if households uses electricity in 2007, if household has an indoor toilet in 2007, if household is located in rural area, if household owns the house they live in 2007, ethnicity (Javanese), religion (Muslim), household owns a TV, if family ever visited health centre

Child individual characteristics: age, gender, stunted in early childhood, WAZ in 2000

Different to stunting in early childhood, age is not significantly associated with stunting in adolescence. Similar to stunting in early childhood, there is also no gender bias for stunting rates in adolescence.

We also include stunting in early childhood, as it captures the accumulated health status up until early childhood of children and is most likely to influence how children's health status develops into adolescence. For children that were stunted in early childhood in 1993, the likelihood of being stunted in adolescence in 2007 is 11.3% higher than for children not stunted in 1993. While this shows that previous health status matters it also points out that there are other factors that are important for children to be stunted in adolescence.

We include lagged weight-for-age-z-scores (from 2000) into the model to capture the short term health and nutritional developments. For each standard deviation in children's lagged health, the stunting prevalence in adolescence is 11% lower.

Due to the unique feature of the IFLS from the second wave onwards in 1997, we are able to include more measures of children's nutritional status to our model. We are able to control for the lagged haemoglobin level of the child. Haemoglobin level can give some indication on infection and micronutrient deficiencies such as iron deficiencies, etc. We include lagged haemoglobin levels (from 2000) into the model. However, we do not find significant results.

We also include a dummy variable to indicate if a child attends preschool or not. For children that attend preschool they are 3.8% less likely to be stunted. However, this association is not significant.

Parental socio-economic resources and stunting prevalence in adolescence

Different from stunting in early childhood, mother's age at the child's birth does have a significant positive association with stunting in adolescence. Older mothers are less likely to have stunted children in adolescence. For each year in mother's age, the likelihood significantly decrease by 0.9%.

In terms of maternal height, for each in mother's height the likelihood of being stunted in adolescence decreases by 2.1%. Compared with stunting in early childhood, this association is stronger and more significant in adolescence. A possible reason could be that the coefficient represents both, the direct influence during pregnancy and early childhood of maternal health proxied by her height, as well as the genetic component. This could be supported by father's height also being significantly associated in adolescence while being insignificant in early childhood. For each cm in father's height, the likelihood of being stunted in adolescence decreases by 1.3%.

Different to financial resources (measured by log per capita monthly consumption) in early childhood, parental financial resources in adolescence seem to have a protective factor for children's stunting prevalence.

In terms of direct measures of children's living environment in adolescence – living in a household that has indoor water supply in 2007 decreases the likelihood of being stunted in adolescence by nearly 7%.

Family structure variables show similarly to the results for early childhood, that the number of children is significantly associated with stunting prevalence rates in adolescence. For each child the likelihood of being stunted in adolescence increases by 3%.

So overall, while there are similarities of the factors associated with stunting in early childhood and later childhood, namely the weight-for-age-z-scores, mothers height and number of children, there are also differences, namely that parental resources seem more closely associated with stunting in later years (e.g. father height and financial resources). This could indicate that stunting in early childhood due to higher prevalence rates is more universal and that those stunted in adolescence are more stratified by parental resources.

Children's nutritional dynamics between early childhood & adolescence

In a next step we want to make use of the longitudinal feature of the IFLS and see what the dynamics are of children's nutritional status between early childhood and adolescence. Table 13 gives an overview of the 4 different dynamics that we have defined.

1) Never stunted: Those children that are neither stunted in early childhood nor in adolescence
2) Catch-up growth: Those children that are stunted in early childhood but not in adolescence
3) Deteriorate in nutrition: Those children that are not stunted in early childhood but are stunted in adolescence
4) Chronically stunted: Those that are stunted in early childhood and in adolescence

As Table 13 shows, of the 1,037 children from our cohort, 497 (48%) fall into the category of never stunted children; 231 (22%) experience catch-up growth between early childhood and adolescence; 124 (12%) experience a deterioration in their nutritional status and 185 (~18%) are chronically stunted.

Table 13: Dynamics of Stunting

							Mean Height in 2007		
Dynamics of Stunting	**N**	**in %**	**Mean age in 2007**	**Mean HAZ in 1993**	**Mean HAZ in 2007**	**Δ HAZ (2007-1993)**	**all**	**girls**	**boys**
Never: Not stunted in early childhood nor adolescence	497	47.93	15.33	-0.41	-1.02	-0.6	159.6	154.3	164.4
Catch-up: Stunted in early childhood not adolescence	231	22.28	15.49	-3.02	-1.37	1.7	157.5	152.8	161.2
Deteriorate: Not stunted in early childhood but in adolescence	124	11.96	15.01	-0.36	-2.73	-2.4	146.0	143.9	148.2
Chronic: Stunted in early childhood and in adolescence	185	17.84	15.55	-3.20	-2.71	0.5	148.1	145.1	150.3
Total	1037	100.00							

Table 13 also displays the mean height-for-age z-scores in early childhood and adolescence for the different dynamic profiles of stunting. As we would expect the chronically stunted have the lowest mean z-scores in early childhood and second lowest in adolescence. Children that experience catch-up growth have a mean HAZ in early childhood of -3.02 and seem to substantially improve their HAZ in adolescence and nearly achieve similar HAZ in 2007 as the never stunted children.

We further look at the children's height in centimetres in adolescence. As height varies by gender we differentiate the graphic by gender of the child. We see that overall, male children are taller than females, as we would have expected. Children that were neither stunted in early childhood nor in adulthood have the highest mean height in centimetres in 2007, with a substantial gap to children that are chronically stunted. For males the difference amounts to over 14 cm and for females to 9.2cm. Children that experience catch-up growth are able to close the gap to the never stunted children quite dramatically compared to the other two stunting categories with a difference for males of 3.2cm and females with 1.5cm difference.

Catch-up growth between early childhood and adolescence

Catch-up growth in this paper is defined as a reversal of stunting between early childhood and adolescence. We choose to investigate the first and last wave spanning 14years to capture the long term changes for children's reversal of stunting well into adolescence.

Analytical sample

Of the 1,037 children that are in our analytical sample, 416 children (40.1% of the sample) are stunted. These 416 children are the analytical sample for the logistic regression of catch-up growth. As we define catch-up growth as children that were stunted in 1993 but are not stunted in 2007, we have to limit the sample to those that were stunted in 1993. Of the 416 children stunted in 1993, there are 231 (55.5%) that experience catch-up growth.

Data analysis

We used logistic regressions and calculated the odds ratios and mfx (marginal effects). Covariates were retained or dropped based on P-values and conceptual considerations. All models were tested for interaction and compliance with logistic model assumptions – significance levels of $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$ were used. Robust estimates corrected for household level clustering to account for the scenario in which one family had more than one child in our analytical sample.

Table 14: Logistic regression for catch-up growth (1=yes, 0=no) among Indonesian children that were stunted in early childhood and recovered by adolescence

Independent variables	Marginal effects	Standard Error
Weight-for-age Z-scores (2000)	0.191***	0.0409
Mother's height, in centimeters	0.0373***	0.00721
Father's height, in centimeters	0.0129**	0.00619
Household has indoor water supply in 2007 (d)	0.132**	0.0689
Household has an indoor toilet in 2007 (d)	0.131*	0.0741
Household owns a TV in 2007 (d)	0.127*	0.0761
Household is Muslim (d)	0.224**	0.101
N	315	
R^2	0.2104	

- Marginal effects are evaluated at average values of the explanatory variables; 95% confidence intervals in brackets (d) for discrete change of dummy variable from 0 to 1; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
- Robust estimates corrected for household level clustering
- Data reported in the table come from round 1 (when the child was between 0-5 years of age) except for parental information which is a mean of information collected in different waves and books within one wave of the IFLS.
- Variables that had no significant effect on children's stunting in 1993 and are not reported in table above: Interaction Female*Child's Age, Mothers age at birth of the child, if parents are dead or live somewhere else, if grandparents are present, schooling of grandparents, if Province is on the main island of Java, if floor is made from dirt, wood or bamboo; if toilet is located within the household; if family ever visited health centre (puskesmas), Age of the child

Child's individual characteristics: age, gender, WAZ

For each months of age of children the probability of experiencing catch-up growth increases by 0.9%. Hence, the older the child, the more likely it is to experience catch-up growth. This effect however is not significant (output not shown).

As for the other models, we find no gender bias for children's catch-up growth.

The lagged weight-for-age z-scores (from 2000) show a strong, positive and significant association with the likelihood of experiencing catch-up growth. For each standard deviation in WAZ, the likelihood of experiencing catch-up growth between early childhood and adolescence is 19%.

Parental socio-economic resources and children's catch-up growth

For children with taller mothers, the probability of recovery from stunting increases. For each centimetre in mother's height children are 3.7% significantly ($p<0.01$) more likely to experience catch-up growth. For each centimetre in the father's height, children are 1.3% significantly ($p<0.01$) more likely to experience catch-up growth. Similar to the relationship between stunting and parental height, mothers' height as a proxy for her health is more closely associated with children's improvement in health – e.g. the reversal of stunting probably due to role as primary carer and her special role during pregnancy and early childhood. However, the role of father's height is also important and points to the genetic component.

Interestingly parental schooling is not significantly associated with catch-up growth. For each year of mother's schooling children are 0.8% more likely to experience catch-up growth. This however is not significant ($p=0.324$). Similarly fathers schooling is also not significant ($p=0.248$) and for each year father have completed schooling, children are 0.9% less likely to experience catch-up growth (output not shown). Once we include other measures of direct living conditions or assets into the full model, parental education becomes insignificant.

So living in a household that has indoor water supply in 2007 increases the likelihood of experiencing catch-up growth by 13.2% and having an indoor toilet by 13.1%. Owning a TV in 2007 (proxy for assets) increases the likelihood of experiencing catch-up growth by nearly 13%.

The only other variable we could find significantly associated with children's catch-up growth is being Muslim, compared to other religions such as Christianity, Hinduism and Buddhism. Being Muslim compared to the other religions increases the likelihood of experiencing catch-up growth by 22.4%. It is not quite clear how to interpret this result.

Contrary to the other models, family structure is not significantly associated with catch-up growth, nor is living in a rural area.

Children's deteriorating nutritional status between early childhood and adolescence

Deteriorating nutritional status in this paper is defined as late onset of stunting between early childhood and adolescence – i.e. not being stunted in early childhood but being stunted in adolescence. We chose to investigate the first and last wave spanning 14years to capture the long term changes for children's nutritional status dynamics well into adolescence.

Analytical sample and data analysis

Of the 1,037 children that are in our analytical sample, 621 children (~60% of the sample) are not stunted in early childhood. These 621 children are the analytical sample for the logistic regression of deterioration of nutritional status. As we define deterioration in nutritional status as children that were not stunted in 1993 and are stunted in 2007, we have to limit the sample to those that were not stunted in 1993. Of the 621 children stunted in 1993, there are 124 (~20%) that experience deterioration in nutritional status.

We used logistic regressions and calculated the odds ratios and mfx (marginal effects). Covariates were retained or dropped based on P-values and conceptual considerations. Robust estimates corrected for household level clustering to account for the scenario when one family had more than one child in our analytical sample. 15 displays the results for the significant variables in the full model.

Table 15: Logistic regression model for deteriorating nutritional status (1=yes, 0=no) among Indonesian children that were not stunted in early childhood but are in adolescence

Independent variables	Marginal effects	Standard Error
Weight-for-age Z-scores (2000)	-0.0685***	0.0164
Mother's age at child's birth	-0.00669**	0.00302
Grandparent present in 1993 (d)	0.0830*	0.0469
Mother's height, in centimeters	-0.0110**	0.00366
Father's height, in centimeters	-0.0112***	0.00310
Mother's years of schooling	-0.00924*	0.00492
Household has indoor water supply in 2007 (d)	-0.0623*	0.0369
N	450	
R^2	0.1695	

Marginal effects; Standard errors in parentheses
(d) for discrete change of dummy variable from 0 to 1; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Child's individual characteristics: age, gender, WAZ

Similar to the model of catch-up growth, the age of the child is not significant and we do not find a gender bias for children's likelihood to experience deterioration of nutritional status (output not shown). The lagged weight-for-age z-scores (from 2000) show a strong and significant association with the likelihood of experiencing deterioration of nutritional status. For each standard deviation in WAZ, the likelihood of experiencing deterioration of nutritional status between early childhood and adolescence decreases by nearly 7%.

Parental socio-economic resources and children's catch-up growth

For children with taller mothers the probability of the nutritional status to get worse decreases. For each centimetre in mother's height children are 1.1% significantly (p<0.01) less likely to experience deterioration in their nutritional status. For each centimetre in fathers height, children are 1.1% significantly (p<0.01) less likely. Different to the relationship between catch-up growth and parental height, mothers' height as a proxy for her health seems similarly closely associated with children's health as fathers' height.

Also differently from the recovery model and the other models, maternal education is significantly associated with children's likelihood of experiencing deterioration in their nutritional status. For each year of mother's schooling children are 0.9% less likely to experience deterioration in their nutritional status. Fathers schooling is not significant (output not shown).

Living in a household that has indoor water supply in 2007 decreases the likelihood of experiencing a worsening of nutritional status by 6.2%.

Similar to the model of catch-up growth, family structure (measured as number of children in the household), is not significantly associated with deterioration, nor is living in a rural area. However, if grandparents are present in 1993 has a negative influence. If grandparents are present in early childhood, then children are more likely to experience deterioration of their nutritional status, by 8.3%. The relationship could go both ways, with grandparents having a protective influence on children. However, in this model it seems that the additional resources needed to care for dependent adults could be missing for young children.

4.7 Conclusions

Childhood disadvantages in health and nutrition can have long lasting effects over the life-course and even be transmitted over generations. This chapter has asked to what extent children’s health and nutritional outcomes as measured by children’s height-for-age z-scores (HAZ) are dynamic (i.e. change over time) and to what extent parental resources influence children's health and nutritional outcomes in early childhood and the dynamics between early childhood and adolescence.

Disadvantages in health are especially salient in developing countries. Here, we used data from the Indonesian Family Life Survey (IFLS), a rich panel data set consisting of four waves of data which spans over a period of 14 years. To follow children’s health and nutritional dynamics from early childhood to adolescence, we studied a cohort of 1,037 children who were between 3 and 36 months old in the first wave of the IFLS in 1993 and for whom we can observe health outcomes in all four waves.

We studied to what extent a range of parental resources (individual-level: education, height; family-level: consumption, quality of living environment and family structure) influences children's health outcomes in early childhood and the dynamics between early childhood and adolescence. Height-for-age and stunted growth was chosen as an indicator for child health as the literature indicates that it is an objective indicator of general health status and as prevalence rates for stunted growth in Indonesia are still high (around 42% in under 5 year olds). We investigated to what extent the stunting prevalence rates in early childhood are stratified by parental resources and if stunting dynamics such as reversal of stunting between early childhood and young adulthood differ by parental background.

Adopting a longitudinal approach to children’s nutritional status with a focus on intergenerational relationships provides a useful framework to investigate health inequalities. The majority of existing studies in developing countries examine the intergenerational relationship between parents' characteristics and children's outcomes at one point in time often focusing on young children and rarely following children into adolescence years. Here, we brought together a life-course approach with the intergenerational perspective. This allows us to understand whether parent’s resources only matter in early childhood or whether they are relevant for recovering from early childhood experiences. This, in turn, is relevant for the design of effective and appropriate health policies that span well over children's life course from early childhood into adolescence.

We have obtained the following results. For stunting in early childhood, we find that the effects of maternal human resources are consistently higher and more significant for children's outcomes than the resources of fathers. Further, direct measures of living standards – e.g. cleanliness of the living environment, indoor water facilities and electricity – have the strongest association, especially when compared to indirect measures of financial resources such as consumption. This shows the importance of the physical environment children are growing up in.

For dynamics of stunting, such as the reversal of stunting between early childhood and adolescence, maternal height is again significantly associated with children having higher probability of experiencing reversal of stunting. Similarly to stunting in childhood, father's height is also significant, but the effect size is smaller. Parental education is not significant for the probability of reversal but so are financial resources. While the effect size and significance level was low in the stunting model for early childhood, for recovery from stunting it is significant.

CHAPTER 5: Children's cognitive outcomes

5.1 Introduction and motivation for the research

In the previous chapter we have examined the factors that are associated with children's nutritional status in early childhood and the dynamics into adolescence. We have seen that there are changes in children's nutritional status into adolescence and that it is not only the early years that matter but also later development. This chapter goes a step further and investigates the link to other child outcomes and examines the relationship with cognitive outcomes – children's performance on the Raven's Coloured Progressive Matrices.

The relationship between nutritional status and cognitive outcomes is important, as malnutrition can reduce children's learning capacities. Together with other disadvantages such as inadequate financial resources the risk of lower school achievements or even drop-out of school increases (Glewwe and Miguel 2008; Glewwe, Jacoby, and King 2001; Harper 2004). The consequences are a depletion of children's human capital which is likely to lower their earning capacities in later life and laying the foundation for a cycle of disadvantages possibly passed on to the next generation as well (Duflo 2001; Duflo 2004; Grantham-McGregor et al. 2007; Walker et al. 2007; Yaqub 2002).

Alderman et al. (2006) employ data from a longitudinal study from Zimbabwe to show the relationship between malnutrition and schooling. The results suggest that malnutrition has a negative effect on the schooling starting age and the grades a child attains. To quantify this negative effect, the authors compare a median pre-school child in their sample to the hypothesised median child in terms of height-for-age (indicator for malnutrition) and conclude that they started school on average six months later and completed 0.85 schooling grades less than their more advantaged counterparts (Alderman, Hoddinott, and Kinsey 2006).

The results from Alderman et al. (2006) are supported by studies from other countries. For Malawi Gandhi, Ashorn et al. (2011) use longitudinal data to show that conditional height gain during 18-60 months was positively associated with mathematical results at age 12 and total number of grades and negatively with number of times repeating grades (Gandhi et al. 2011). Another study from a birth cohort from the Philippines found that children that were stunted in the first two years of their life tended to start school later than non-stunted children, delay initial enrolment, have higher absenteeism' higher grade repetition, and achieved lower grades. Children stunted at an age of two years were three times more likely to have dropped out of school, 1.8 times more likely to have repeated a grade and 1.2 times more likely to have been absent in the month before the interview date (Mendez and Adair 1999).

Malnutrition is a violation of children's rights and wellbeing in and of itself – no child should suffer from hunger and go without adequate food. Further, malnutrition has consequences for children's growth and development, as nutritional foods form the basis of many physical, cognitive and behavioural developments. Having to go hungry makes it difficult to concentrate and fulfil the various tasks children need to be able to perform – especially in school. Research has shown that malnutrition has an effect on the development of the brain in particular the working memory functions which are necessary for learning (Levitsky and Strupp 1995b).

Another motivation to look at this specific problem is the Indonesian context. Indonesia still has a very high incidence of malnutrition compared to its neighbouring countries and in relation to its status as a lower-middle-income economy. However, Indonesia has made substantial progress with providing education and increasing investment in educational programmes. With the high prevalence of malnutrition however, it seems especially relevant to study its effects on the ability of children to profit from education. This highlights the possible impairment of malnourished children's learning ability and thus school performance. With an evolving economy that needs more and more skilled workforce it is important to identify where human capital may be compromised and where children are not reaching their development potential.

The chapter proceeds as follows. Section 5.2 examines conceptual explanations of how parental resources and children's malnutrition and cognitive outcomes are linked via pathways such as brain development and caregiving practices and environment. It also conceptualises the link between the underlying parental socio-economic resources and cognitive outcomes, for example how maternal schooling changes mothers' childcare behaviour and provides more stimulation that is likely to improve children's cognitive outcomes. Section 5.3 reviews existing evidence on both malnutrition and cognition and also identifies the existing gap in the literature that will be addressed in this chapter. Section 5.4 outlines the research questions and hypotheses. Section 5.5 discusses the methods, including the data, sample selection, variable constructions and the analytical strategy. Section 5.6 presents and discusses the research findings. Section 5.7 concludes with some reference to the limitation of this research and formulates recommendations for further research.

5.2 Conceptual framework for children's cognition

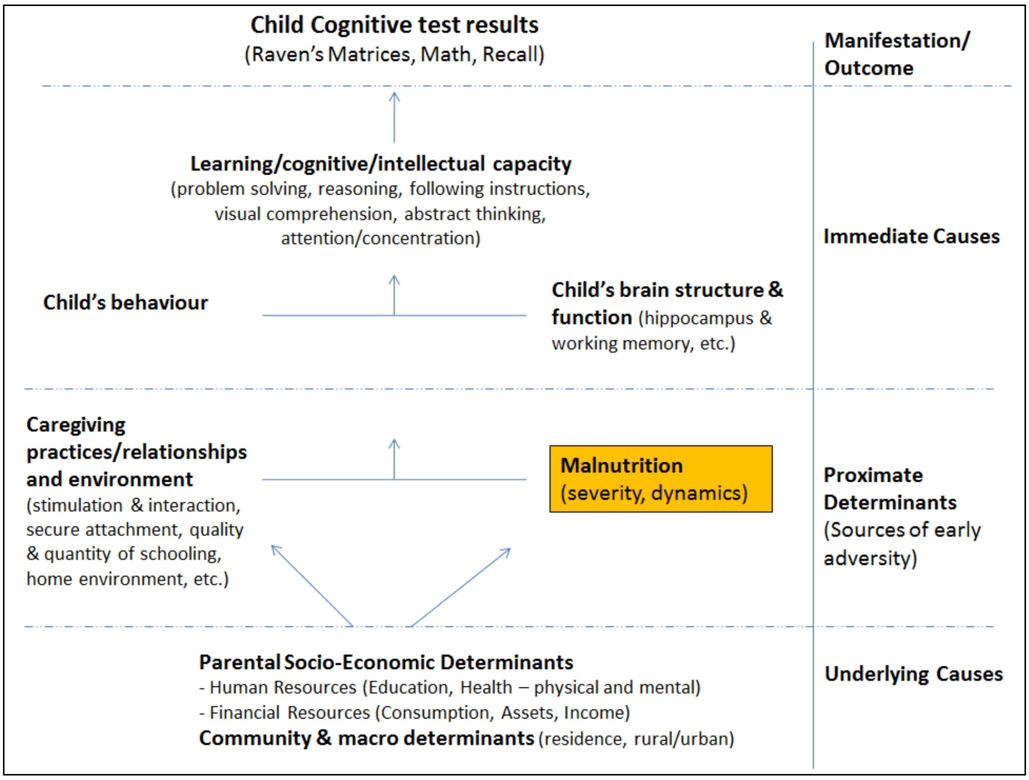
This section gives an overview of how we conceptualise the relationship between malnutrition and cognition.

Cognitive abilities can broadly be divided into verbal and non-verbal skills. The former centers around language development, while the latter is more concerned with aspects such as information processing, intelligence, reasoning, problem solving and memory. There are only a few studies that explicitly describe the conceptual link between malnutrition and cognitive outcomes. This section therefore outlines it in more detail. The conceptual framework draws on insights from both natural and social sciences to better understand the building blocks for cognition. Neuroscience, epidemiology and nutrition science provide evidence on how brain functions and brain structures are formed. Behavioural and social sciences such as developmental and cognitive psychology, anthropology and demography add to this knowledge by providing evidence on the effects of care giving and learning practices.

What predicts cognition? A general framework for the determinants of cognition

Figure 12 shows our general framework for the different factors that influence cognition. We distinguish between the three levels of immediate, proximate and underlying causes to systematise the different predictors of cognition. This originates in the so called proximate determinant framework which is often used in demography for fertility and child survival outcomes but has recently been used in other areas as well (Bongaarts 1978; Mosley and Chen 1984; Boerma and Weir 2005). The different levels are helpful to understand the connection between the various elements of the framework and to realise that cognition is a result of the interplay of many factors. While we do not have data on all the building blocks from the framework, we nevertheless think it important to map them out to in detail to better interpret and discuss results. It will also be useful for discussing the limitations of our research and for formulating recommendations for future research and what kind of data should be collected in Indonesia to shed more light on this important issue.

Figure 12: Overall conceptual framework for cognitive outcomes



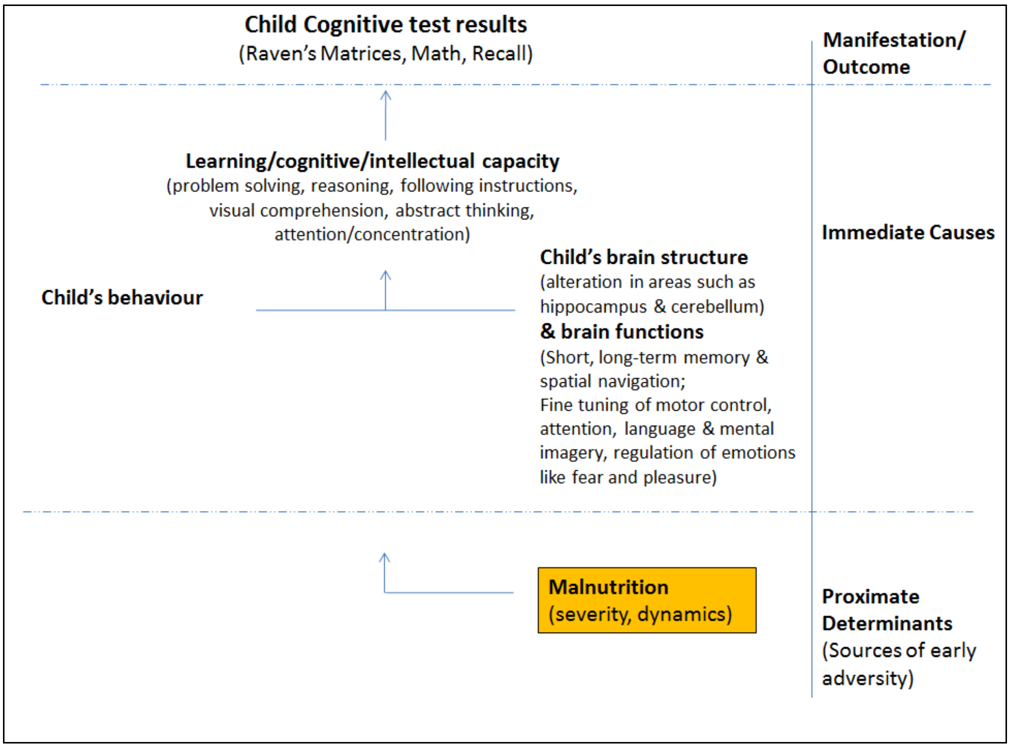
[Source: compiled by author]

The first level of Figure 12, the *immediate causes* of cognitive test results, includes learning capacity/cognitive/intellectual skills and abilities, child behaviour and child brain structure and function. So it is both child's behaviour and child's brain structure and functions that are hypothesised to influence each other and the learning capacity. With this we add more detail of the mechanisms through which malnutrition and other factors are linked with children's cognition. The second level of *proximate determinants* relates to caregiving practices, environment and malnutrition. The third level of *underlying causes* concerns parental socio-economic resources and community and macro factors that are likely to influence nutrition and cognition. This is not a complete framework, but rather a representation of some of the main factors that have been indentified (Ivanovic et al. 2004). It also helps to remind us that individual behaviour and circumstances are embedded in their immediate family environment as well as community and macro-economic and political context. Within the perimeters of the available data, we will be able to control for some of these. The next sections will outline the elements of the framework in more detail – especially the link via the brain development.

Which brain areas and functions are affected by malnutrition?

As detailed in the partial framework in Figure 13, malnutrition is conceptualised to affect cognition through the channels of child's brain structures and functions and children's behaviour. Malnutrition is associated with affecting both the structure and the function of the brain areas. There is evidence that suggests that malnutrition can lead to damage of the brain tissue, growth retardation, disorderly differentiation and a reduction in synapses and synaptic neurotransmitters (Kar, Rao, and Chandramouli 2008).

Figure 13: Partial framework for the link between malnutrition and cognition



[Source: compiled by author]

While some alterations in the growth of brain structures eventually recover, there seem to be permanent alterations in other brain structures that persist, such as the hippocampus and cerebellum (Levitsky and Strupp 1995b; Levitsky and Strupp 1995a). In Figure 13 these two brain areas and their associated functions are briefly summarised. They are most likely to be affected by malnutrition. The hippocampus[34] has several functions such as the consolidation of short and long-term memory and spatial navigation. The cerebellum[35] has motor, cognitive and emotional functions. Motor functions relate to the coordination, precision and timing of movement. Cognitive functions include attention, language and mental imagery. Emotional functions include the regulation of fear and

[34] The hippocampus is named after its shape similar to a seahorse.
[35] The cerebellum is Latin for little brain.

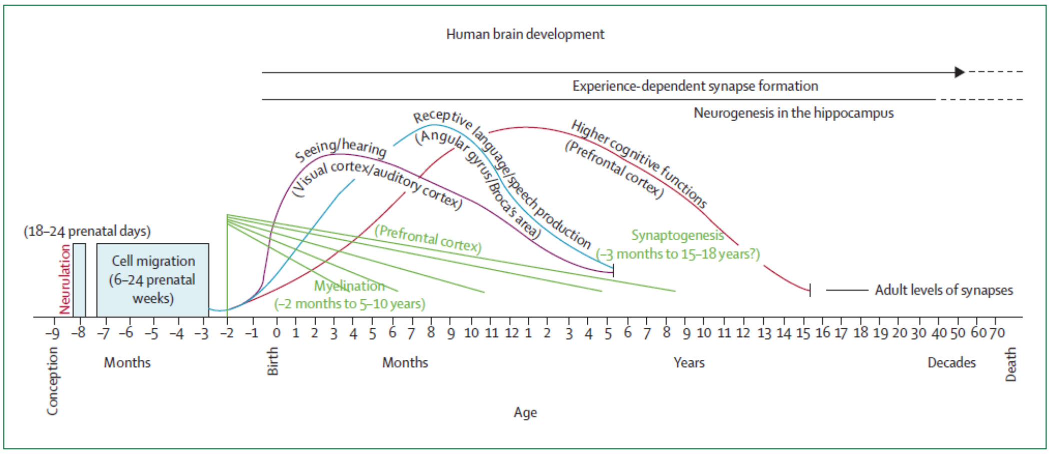
pleasure. A review of studies finds that reasoning and perceptual-spatial functions are consistently affected by malnutrition, as are motor skills (Grantham-McGregor 1995). Of relevance for our research interest is that the cerebral cortex (brain region most closely linked to cognitive and intellectual functioning) is reduced in its volume and width by malnutrition. The number of neurons itself is not affected (a resilient mechanisms of cell packing can be observed) but the width is affected. In addition, various support structures (pyramidal and cortical glial cells, dendritic spines) are reduced and the complexity of its branching is diminished. These are likely to affect the ability to process information and thus also affect cognition. More details on brain structure and functions that are affected by malnutrition are well surveyed and documented (Levitsky and Strupp 1995a; Levitsky and Strupp 1995b).

Timing: When are children most vulnerable and is damage reversible?

One of the main problems in discussing malnutrition and cognition is that of determining when malnutrition is harmful and whether its effects are reversible. For a long time it was assumed that prenatal malnutrition is the most critical period in altering the structure of the brain permanently due to the organisation of specific neurons during ontogenesis[36] that take place – the so called *fetal origin hypothesis* (Lucas, Fewtrell, and Cole 1999). A contrary position argued that postnatal malnutrition was more important as it is the time when the brain is growing most rapidly and structures that develop after birth such as the cerebrum, hippocampus and cerebellum are most vulnerable to malnutrition – the so called *post-natal hypothesis*. Recent evidence shows that the window for vulnerability due to malnutrition is wider and spans pre- and postnatal periods (Levitsky and Strupp 1995a; Levitsky and Strupp 1995b; Lucas, Fewtrell, and Cole 1999; Selevan, Kimmel, and Mendola 2000; Grantham-McGregor et al. 2007). Relatively new are insights from neuroscience into the development of the brain that reach well into middle childhood and adolescence. Although the numbers of brain cells (neurons) are determined at birth, the connections between them (called axons) continue to develop well into adolescence (Paus et al. 2001). So there is some reason to believe that what happens to children's nutritional status after early childhood will matter for children's nutritional outcomes.

[36] Ontogenesis refers to the origin and the development of the human organism

Figure 14: Stages of human brain development



[Source: (Grantham-McGregor et al. 2007, 61)]

Figure 14 shows graphically when the different regions of the human brain develop and that the development processes build on each other. It shows that, for example, the prefrontal cortex and the associated higher cognitive functions develop well into adolescence (Grantham-McGregor et al. 2007, 60–61). This helps to understand why the windows for vulnerability to malnutrition on children's cognitive development could be larger than previously assumed.

A larger window for vulnerability is supported by insights from magnetic resonance imaging (MRI)[37]. A study that investigated the developing human brain from birth into adulthood (Paus, Collins et al. 2001) shows that fastest growth occurs during the first three years of life and by the age of five years the brain weighs about 90% of the adult brain. Nevertheless an important finding was that the *white matter* of the brain continues to mature during childhood and adolescence.[38] For a long time, solely grey matter was associated with processing and cognition. However, the importance of white matter has gained in recognition. White matter seems to provide the essential connectivity, uniting different regions into networks that perform various mental operations. This has been discovered when this connectivity is disrupted by disease or other damage to white matter (Paus, Collins et al. 2001).

Further research links white matter with cognitive tasks such as the Raven's coloured matric test. A recent study by Berthiaume et al. studied the effect of brain damage on the

[37] As there is a connection between the smooth flow of information and the anatomic maturation in major brain fibre tracts, methods such as MRI can be used to gain an understanding of functional interactions in the developing human brain.
[38] The white matter increases in its volume and becoming more myelinated. Myelination is an electrical insulation process essential for the proper functioning of the brain cells. White matter is composed of myelin-coated axons and grey matters are composed of neurons.

cognitive task of Raven coloured matrices tests by using computational simulation. They found that white matter damage produced most error in learning and performing the cognitive task. One of their explanations was that white matter damaged networks had to deal with changing information, whereas grey matter damaged networks were constantly inactive and in turn, allowed for better adaptation (Berthiaume, Shultz et al. 2010).

Malnutrition and behavioural capacities

In the previous section, we have discussed the consequences of malnutrition for cognition via brain development. As our framework for cognitive outcomes points out, there is another route: via behavioural effects. In order for children to learn and perform well at cognitive tests and school they should be attentive, curious, and explorative, able to focus on tasks and cope properly with social situations. Malnourished children meet these demands poorly. The behavioural anomalies found in hungry and malnourished children include being more apathetic, less active and exploring the environment less, both in quantity and complexity, more irritability, maladaptation in social situations, a low attention-span and phobic reactions instead of normal curiosity toward new objects (Amcoff 1981; Grantham-McGregor 1995; Dercon and Sanchez 2011).

The interrelationships between cognitive and behavioural development was also suggested from animal studies. The hypothesis is that observed altered cognitive performance after a period of undernutrition may actually result from increased emotionality rather than from impaired cognitive function (Pollitt, Watkins, and Husaini 1997).

However, the precise mechanism of how malnutrition causes behavioural deficit is not clear yet, although there are some brain regions that affect behaviour that are effected by malnutrition, as reviewed in the previous section. Further, the fact that malnourished children also grow up with other disadvantages makes it difficult to disentangle the direct effect of malnutrition on behaviour. Malnutrition is generally accompanied by deprivation of environmental stimulation, a condition that could cause poor psychological development in and of itself.

In this context, insights from child psychology on attachment theory could be important. Attachment is the emotional bond to another person. Attachment theory focuses on the bond between children and the primary caregiver. A main theme is that a secure bond especially during the first years of life to an available and responsive caregiver establishes a sense of security in children that forms the basis to explore the world which in turn influences the learning experience (Lieberman and Zeanah 1999; Cassidy and Shaver 2008; Berlin and Cassidy 1999). Secure attachment and stimulating caregiving is important for children to learn to solve problems on their own and also to learn to concentrate for longer periods. These are all important components for cognitive skill development. In a setting of deprivation and poverty it is much more challenging for parents and other care givers to provide this secure and important attachment which children need for their development.

From intervention studies it seems indicative that a good balance between adequate nutrition and a socially and psychologically stimulating environment seems necessary for children to develop their cognitive and behavioural capabilities (Grantham-McGregor, Fernald, and Sethuraman 1999; Grantham-McGregor 1995).

Parental socio-economic resources, caregiving and environmental factors

As we have outlined in our general framework, cognitive outcomes are a result of a multitude of factors. Cognitive deficits are likely to be a result of a complex combination of factors with malnutrition being only one of them. Malnourished children usually come from families who suffer from many disadvantages. These include poor physical and economic resources, such as overcrowded homes with poor sanitation and water supply and low income. Often larger families have more children close in age that competing for resources and caring by their parents. Further, if parental health and nutritional status are poor and educational levels low, the multitude of disadvantages for the children is even higher. Low-skilled occupations, little media contact and few social contacts is often another dimension of family disadvantages. Stimulation in the home is poor, with few toys or books and little participation by the parents in play activities and parents are less likely to be able to afford child care outside of the home (Amcoff 1981; Grantham-McGregor 1995). This section describes some of these. We will keep this brief as more is known on these mechanisms but it should serve to contextualise the analysis and for helping to interpret the results.

(1) Route of parental socioeconomic resources via malnutrition

As discussed in Chapter 4, parental financial and human resources are linked to malnutrition. For example, parents with more financial resources are more likely to be able to afford adequate nutrition as well as preventive and curative health care and safe and healthy environments and thus reduce the adverse sources of malnutrition which in turn positively influences children's brain development and their cognitive outcomes. Parents with more human resources – e.g. better educated parents – are also more likely to have better knowledge about the quality of food, health care and child care practices to implement due to for example their familiarity with acquiring information. Parental health and education – especially of mothers – is directly linked to children's nutrition and cognitive development due to the importance during pregnancy but also afterwards as main carer.

(2) Route of parental socioeconomic resources via caregiving practices

Maternal schooling is a highly consistent socio-economic predictor for children's wellbeing. As the data is limited, we have to rely on this proxy. For instance, the data contains no information on the amount of time a mother or other caretaker spends with the child and what kind of interactions (e.g. reading, etc.) between children and their carers take place. To justify to some extent how maternal schooling could be a good proxy for maternal caring practices, we review a study in more detail that comes from a mixed method study from Mexico. Researchers collected survey data on women's schooling and other socio-economic variables and various maternal childcare practices. A subsample was also observed in depth on how they interacted with the child (LeVine et al. 1991). Five maternal behaviours relating to responsiveness to the child (infants) were examined in the observational studies – if the mother reacted to infants' vocalisation and infants' motor activities either through looking at the child or speaking with the child and how much time mothers were holding their children without actively interacting with them. The results of the study showed that schooled mothers have more active interaction with the child than unschooled mothers who were more passive – i.e. just holding the child.

By presenting two models of learning, the authors put forward possible explanations for how formal schooling changes women's childcare practices. The first model is the so called *"apprenticeship model of learning"* and is especially prevalent in agrarian communities. Children learn through gradually participating more in the new tasks rather than learning about them through verbal instructions. Also, children participate in these tasks primarily for the purpose of production and not primarily for learning. The second, contrasting, model is the so called *"classroom model of learning*" which provides a model of verbal interaction between an adult and a child which mothers imitate with their children for pedagogical purposes (LeVine et al. 1991). Findings from a qualitative study from Indonesia also point out how parental education and parents perception of the age children are able to learn is related. Less educated parents share the belief that the inability of a child to speak is a sign that they are not ready to learn something and passive caregiving instead of stimulation is more likely to result in such a situation (Maika 2011).

Another important caregiving area is the one of breastfeeding and its potential influence on cognitive skills. Using an instrumental variable approach with data from the Millennium Cohort study, Del Bono at al. show how breastfeeding has significant effects on cognitive outcomes at ages 5 and 7 as measured by the British Ability Scale. They explain this relationship with findings on several breast milk components – most prominently long-chain polyunsaturated fatty acids – that are known to accumulate in the brain and retina through ingestion of breast milk. Furthermore, the amount, quality, and timing of sensory stimulation to the developing infant is improved by the skin-to-skin contact involved in breastfeeding as well as causing the release of substances - prolactin and oxytocin - in the mother, which are thought to contribute to mothering behaviour (Del Bono and Rabe 2011).

(3) Route of parental socioeconomic resources via children's living environment

Parental financial resources are important in terms of providing children with stimulating and safe environments – e.g. books and other educational toys as well as housing and learning facilities and safe environment and neighbourhoods to play and interact with others (Carneiro, Meghir, and Parey 2007). Unfortunately the data that we have on children's living conditions is limited. For example, we do not have much information on the home environment – e.g. if any educational toys or books are available. We have a range of parental socio-economic resource variables that are likely to influence parents' ability to provide such environments.

Key points from this section on the link between malnutrition and children's cognition

- Children's cognition is a result of interplay between immediate and proximate factors, which we summarised in a general framework (Figure 12).
- Malnutrition and children's cognitive test results are linked through the channels of *children's brain structure and functions*.
- Malnutrition can lead to damage of brain tissue, growth retardation, and reduction in synapses and neurotransmitters.
- Brain areas and functions most affected by malnutrition are the *hippocampus* and *cerebellum,* with associated cognitive functions of short and long-term memory, attention, language and mental imagery as well as the *cerebral cortex* – the brain region most closely linked to cognitive and intellectual functioning.
- The window for vulnerability due to malnutrition spans pre- and postnatal periods with, for example, the *cerebral cortex* and the *white matter* (essential for uniting different regions of the brain) continuing to mature during childhood and adolescence.
- We briefly reviewed how behavioural and parental resources via malnutrition, caregiving practices and living environment could be linked to children's cognition.

5.3 Literature review on malnutrition and cognitive outcomes

This section gives an overview of empirical literature that has looked at children's malnutrition and its relationship with cognitive outcomes. We only have a few examples from Indonesia but will use relevant literature from other countries to fill the gaps.

Complementary to this section is the grid in Appendix 5.1, where we developed a mapping of the key literature mentioned here for a schematic overview of data, variables, sampling, estimation methods and results of the articles mentioned here. This enables us to contrast and compare the previous contributions according to their different aims, methods, and results in more depth than would otherwise be possible in this section.

The literature review is structured as follows: first we briefly review evidence on the link between malnutrition and behavioural outcomes. Then we focus on more specific cognitive non-verbal skills such as perceptual reasoning, problem solving and the working memory, as the test we use, the Ravens matrices, attempts to tests these areas. And we discuss the different aspects of malnutrition – i.e. the timing, duration and dynamics of malnutrition and review the few studies that investigate the link between these aspects and children's non-verbal cognitive skills.

Children's nutritional status and their behavioural outcomes

There is some evidence that children stunted at an early age behave differently to those that are not stunted. Children are reported to be less sociable, more apathetic, and less willing to explore their environment in the early ages. All factors interrelate with cognitive skills through their likelihood of decreasing children's interaction and stimulation and thereby affecting subsequent cognitive development.

There are only very few datasets from developing countries that have information on children's behavioural outcomes. In a recent study using pooled data from the *Young Lives*[39] project in India, Vietnam, Peru and Ethiopia, Dercon and Sanchez find a relationship between early under nutrition and later psychosocial status (Dercon and Sanchez 2011). They look at three psycho-social competencies that might be linked to

[39] An international study of childhood poverty, involving 12,000 children in 4 countries over 15 years. The countries are India, Vietnam, Peru and Ethiopia. For more information: http://www.younglives.org.uk/

adult earnings namely: 1) self-esteem, 2) self-efficiency and 3) educational aspiration.[40] The authors investigate how children psycho-social competencies at the age of 11-12 years are related to children's nutritional status (HAZ) at the age of 7-8 years. They find that increasing height-for-age by one standard deviation (SD) increases school aspirations by 7.8%, self-efficiency by 5.8% and self-esteem by 3.4% (Dercon and Sanchez 2011, table A3, p.19).

Furthermore, the interrelationships between cognitive and behavioural development were suggested from animal studies. Here, the hypothesis is that observed altered cognitive performance after a period of undernutrition may actually result from increased emotionality rather than from impaired cognitive function. The short-term supplementary feeding intervention in Indonesia attempted to test this hypothesis by observing physical movements, facial expressions, and sounds made by children while taking a particularly difficult test. These behaviours were not different between groups, suggesting that emotions did not seem to play a role in the differences observed in working memory. However, the authors themselves admit that the validity of the method used to assess emotional response was not established and the results are not conclusive (Pollitt et al, 1997).

Children's nutritional status and their cognitive outcomes

Insights from neuroscience indicate that cognitive development takes place from early childhood through adolescence well into adulthood and that early malnutrition can have long-term cognitive implications (Glewwe, Jacoby, and King 2001; Kar, Rao, and Chandramouli 2008) (Glewwe, Jacoby et al. 2001) (Kar, Rao et al. 2008). We review various studies that look at a range of cognitive skills.

One of the widely used tests to assess children's overall cognitive development is the so called 'Wechsler Intelligence Scale for Children (WISC)'. It is an intelligence test for children aged 6-16 that can be completed without reading or writing. It generates an IQ score which represents a child's general cognitive ability. It tests four cognitive ability areas: 1) Verbal Comprehension index, 2) Perceptual Reasoning Index, 3) Processing Speed Index and 4) Working Memory Index[41]. The Perceptual Reasoning Index includes

[40] The self-esteem and self-efficiency index is derived averaging the answers to various statements using 4-point Likert scale that range from strong agreement to strong disagreement (p.8). Educational aspiration is the child's reported highest grade of education that they hope to achieve.
[41] For more information on children: http://en.wikipedia.org/wiki/Wechsler_Intelligence_Scale_for_Children and adults: http://en.wikipedia.org/wiki/Wechsler_Adult_Intelligence_Scale

a sub-test of matrix reasoning, very similar to the Raven's matrices we use in our analysis. Unfortunately the majority of studies just use the total scores of the WISC and do not report the results for the sub-tests. It would have been interesting to see the matrix reasoning scores for comparison to our results from the Raven's matrices.

A birth cohort of 239 children from Peru uses the Wechsler test (WISC) and finds that children who were stunted in their second year of life scored 10 points lower on the overall WISC test at the age of 9 years than adequately nourished children. What makes this study unique is the strong empirical base for children's nutritional status. The research team collected children's stool samples weekly and measured children's height every 30 days in the first two years. In turn, the authors have information on the age at first stunting, stunting persistence and diarrhoea and parasites episodes and how they relate to children's cognitive WISC scores (Berkman et al. 2002).

Results from longitudinal data from Bangladesh support the findings from Peru. The authors of the study link a survey to a 4 year longitudinal health and surveillance study for an urban slum in Dhaka. Similar to Berman et al (2002) they find that stunting at baseline (at the age of 2-5 years) is significantly associated with cognitive test scores at the age of 6-9 years (Tarleton et al. 2006, Table 5, p. 479). The baseline Height-for-age (HAZ) as continuous outcome is even stronger associated than binary stunting outcome. The duration of stunting during the four years is significantly associated with verbal score – i.e. children's language development. In their sample, 29% of children were stunted and 64% of those remained stunted over the entire four years. In multiple regression analysis, maternal education completely accounted for father's education and other socio-economic variables (Tarleton et al. 2006, 477).

Results from a randomised intervention from Jamaica provide further insights (Walker et al. 2000). Here, the Wechsler test is also used to test children between 11 and 12 years of age (eight years after the intervention).[42] The intervention consisted of nutritional supplementation and psycho-social stimulation for a little over a year between 9-24 months of age. The nutritional supplementation consisted of 1kg of weekly milk-based formula and the psychosocial stimulation of weekly home visits where trained nurses instructed mothers on how to play with home-made toys (Walker et al. 2000). Results indicate that nutritional supplementation had short-term benefits to cognition in early

[42] The cognitive function tests used in this intervention were very comprehensive, consisting of: 1) visual reasoning (Ravens Matrices), 2) PPVT (language comprehension), 3) verbal analogies, 4) vocabulary test, 5) modified Stanford Binet, 6) auditory working memory tests (digital span forward/backward), 7) visual-spatial memory (Corsi blocks), 8) search test and 9) modified Stroop test (p.37).

childhood but long-term benefits at age 11 and 12 were not significant. This is in contrast to the long term benefits from nutritional intervention that started during pregnancy and continued for at least first three years of life in Guatemala and Colombia (Walker et al. 2000, 39). The authors also find that growth restricted children had significantly poorer performance than non-growth restricted children on 9 out of 10 cognitive tests. Home-based stimulation for growth-restricted children had a small but significant long-term benefit to WISC, reasoning ability (Ravens matrices) and vocabulary test. While the weekly milk formula was probably not continued after the intervention, psycho-social stimulation was carried on for much longer than the original intervention by changing mother-child interaction such as improving teaching techniques and quality of verbal interaction.

Findings from studies that use different cognitive tests also find a relationship between nutriton and cognitive outcomes. For instance, a cross-sectional study from Bangalore in India uses the so called NIMHANS tests – a set of neuropsychological tests for children sensitive to the effects of brain dysfunction and age related improvement. It consists of sub-tests on motor speed, attention, visual-spatial ability, executive functions, comprehension, learning and memory. Findings indicate that malnourished children aged 5-10 years compared to adequately nourished children, perform poorer on most of the cognitive tests (Kar, Rao, and Chandramouli 2008). The authors found that there were some age related improvements with older children scoring better on the tests than younger children but that they were still lacking in comparison to the adequately nourished children. The cognitive measures used in the study are very comprehensive and worth reviewing here. However, the study has serious limitation in being cross-sectional, thus measuring the nutritional status and children’s cognitive outcomes at the same time. Further, the sample size is very small, with only 40 children studied. So the findings need to be treated with some caution.

Investigating the relationship between malnutrition and verbal cognitive skills, a longitudinal study from Peru employed the Peabody Picture Vocabulary test and found that one standard deviation increase in concurrent Height-for-Age (HAZ) was associated with an increase in child’s score on the verbal test by 2.35 points (Crookston, Dearden et al. 2011). They also use a quantitative subtest where children are tested for their perception of amounts. This score only increases by 0.16 points.

To summarise, we have seen that for various test of cognitive skills malnourish children perform poorer than better adequately nourished children. The size of the coefficient vary probably due to different study designs, ages of children tested and the test used to measure cognitive abilities. Moreover, different cognitive abilities could be affected differently by malnutrition. On the basis of the available evidence, this cannot be inferred, as the results for the detailed sub-scores would be needed in addition to the overall cognitive tests scores.

In the next section, we therefore zoom into more specific areas of cognitive functions and review studies that use separate tests for non-verbal abilities around visual reasoning and working memory perceptual, as these are the areas the test we employ in the analysis, the Raven's matrices, have been shown to reflect.

Children's nutritional status and their visual reasoning and working memory

This section reviews studies that investigate the link between malnutrition and specific areas of children's cognitive abilities – namely non-verbal abilities around visual reasoning and working memory. As we know from the conceptual framework (Figure 13), malnutrition is hypothesised to affect these cognitive skills via its alterations in the brain structures such as the hippocampus and cerebellum.

A study from India that examines children aged between 5 and 12 years from a tribe in West Bengal (India), uses the Ravens matrices (Chowdhury and Ghosh 2011, 189). The authors find that children gradually score lower with the increased grade of stunting, wasting and underweight. They also find that the scores are stratified by parental socio-economic resources. But there are some weaknesses with this study. First, it is a cross-sectional survey where both outcome and independent variable are assessed at the same time. So we do not know anything about the nutritional history of the children. The authors also use the old WHO reference data to calculate the anthropometrics. Those have been cautioned to use for developing country contexts. And lastly, the analysis is mostly descriptive and only very few confounding variables have been controlled for. So the results must not be interpreted as showing a causal relationship.

One recent but small scale, cross-sectional study from Indonesia looks at children's nutritional status and working memory performance (De Neubourg and De Neubourg 2011). 79 children aged between 9 and 13 years are assessed in terms of their stunting status and their performance on different tests for working memory, namely the 1) digital span tasks, 2) coding tasks (both sub-tasks of the WISC and the 3) Bourdon-Vos task (p.7, 17-18) and the Raven's matrices. Findings indicate that stunted children score significantly lower on the digital span forward test (immediate repeating of a series of digits). They also perform worse in the coding task, the digital span backward and the Raven's test, but the difference is not significant. However, this could partly be due to the small sample size which increases the standard errors. One limitation is that the data is only cross-sectional, so that concurrent stunting is related to working memory performance and no information is available about the history of stunting. To be fair, the main focus of the study was not on malnutrition but to examine Post Traumatic Stress disorder (PTSD), which also explains the choice of the region in which the study was carried out, Banda Aceh. Banda Aceh was the closest major city to the earthquake's epicentre in December 2004 and was worst hit by the tsunami shortly afterwards. The reviewed paper is a by-product to this main focus and investigates the malnutrition link (De Neubourg and De Neubourg 2011). The limited control variables are nevertheless a problem – so the analysis is mainly descriptive. But the study nevertheless supports some first indication of a relationship between malnutrition and working memory.

The next study uses longitudinal data from Indonesia, Philippines, Jamaica, and Brazil (Grantham-McGregor et al. 2007). The data for Indonesia is from the IFLS, but the paper does not specify which data waves were used. As the paper is published in 2007, we assume that IFLS1 (1993) and IFLS3 (2000) were used. Poverty (wealth quintiles) and stunting status in early childhood were used and related to cognitive tests and schooling outcomes in later childhood and adolescence. So for Indonesia, 368 children aged 9 years and their Ravens matrices and arithmetic test results are used for the analysis (Grantham-McGregor et al. 2007, 61, 63). Stunting in early childhood is related to later measures of cognition and grade attainment in all studies (unadjusted, descriptive differences used only; p. 63-64). Children that were stunted (moderately/severely) scored on average 9.7 points on the Raven's score matrix compared to children that were not stunted and scored on average 11.2 points higher (p.63, table 2). Similar findings are found for Philippines, Jamaica and Brazil and thus further support evidence for a link between children's malnutrition and cognitive outcomes. The comparative perspective however limits the control variables the authors are able to use. So the results are not adjusted for parent's schooling or health. And the results are mainly descriptive. Furthermore, the dynamics of children's nutritional status are not studied; only the earlier nutrition status is examined.

In a study from Bangladesh, Tarleton et al assess 191 children, aged 6-9 years for their cognitive test of the Raven's coloured progressive matrices (Tarleton et al. 2006). The nutritional status (Height for age – HAZ and weight for age – WAZ) is obtained for children when they were between 2 and 5 years old by linking data collection to 4-year longitudinal health surveillance survey. They find that baseline stunting[43] is significantly associated with Ravens Matrices. They further find significant interactions between children's age and baseline malnutrition for Raven's. In other words, older children who are stunted at baseline do not differ significantly in their test scores from younger stunted children, while those without baseline stunting have significant differences based on age (Tarleton et al. 2006, 477). So the natural age improvement of cognitive test scores is not present for stunted children and supports the hypotheses that malnutrition impairs cognitive development. They also find that Raven's scores are significantly associated with child's age, mothers' and fathers' education and being in the lowest income group. Episodes or duration of diarrhoea are also significantly associated with Raven's scores before but not after controlling for parental socio-economic resources. The duration of intestinal parasites stays significant. The authors add another interesting aspect by looking at the duration of malnutrition and its link to cognitive outcomes. They define duration as the percentage of study time that a child was stunted. Duration of stunting during the 4 years of the health surveillance study is not significantly associated with Raven's but with verbal score (Tarleton et al. 2006, 479). So duration seems to be more important for language development.

Evidence from an intervention study from Vietnam does not support the link between nutritional improvement and beneficial cognitive abilities. The authors linked previous nutritional data from children aged 0-36 months that received nutritional intervention to their Raven's scores at around 6-9 years of age (Watanabe et al. 2005). They could not find a significant relationship of the nutritional intervention on cognitive outcomes in this medium-term follow-up.

The supplementation feeding intervention in Indonesia in the 1980 that we introduced earlier used another test for working memory, the so called Sternberg test (Pollitt, Watkins, and Husaini 1997). 231 children were assessed for long-term benefit of the intervention at ages 9 to 12 years in the computerized (i.e. touchscreen) cognitive abilities. The findings show that for the total sample no difference between treatment and control group was found. Only the sub-group of younger children that received supplementation before 18 months of age (n=73) performed better on working memory test (Sternberg) – e.g. greater scanning speed of working memory (Pollitt, Watkins, and Husaini 1997, 1361). This could support the view that there is a sensitive window for the timing of nutritional intervention to improve children's working memory early on.

[43] Baseline HAZ as continuous outcome is even stronger association. However, these are only results from simple regression.

Another more recent study of the few studies for Indonesia that investigates the relationship between children's nutritional status and cognitive outcomes actually uses the IFLS (Cheung 2006). One major contribution of the study lies in its methodology. The author uses specific models for count data (e.g. answering 0-17 questions correctly can be treated as count data). The author chooses a one-year age cohort of children 0-1 in 1993 (first wave of the IFLS) and who were around 7 years of ages in 2000 (third wave of the IFLS) when the cognitive assessment was conducted. With the specific regression models the author finds that zero inflation (i.e. getting no question right) is significantly predicted by lower maternal education and not attending school (Cheung 2006, table II, p. 3018). Correct answers are predicted by: weight-for-age at 7 years of age but not by earlier weight or maternal education or attending school. The interaction between early and later WAZ is also not significant. The author argues that these results do not support the hypothesis of a critical window of cognitive development in infancy as in none of the models studied was weight in infancy significantly related to the proportion of correct answers. The author argues that this rather suggests that it is the lack of catch-up growth after poor growth in infancy that is hazardous and that childhood weight gain is influential regardless of weight in infancy. It would have been interesting if the author would have used other measures of nutritional status such as height-for-age as well which is a much more often used measure and more likely to map children's long term nutritional deprivations.

Summary of the empirical evidence of children's nutritional status and cognition

- Several studies that used a wide range of cognitive tests – verbal and non-verbal – found a link between children's nutritional status and different cognitive abilities.
- The size of the coefficients vary probably due to different study designs, ages of children tested and the specific test used to measure cognitive abilities. Moreover, different cognitive abilities are likely to be affected differently by malnutrition depending on the area and functioning of the brain.
- Ravens matrices test, a cognitive non-verbal test for perceptual reasoning, problem solving and the working memory, has mixed results for links to children's nutrition. Studies from India, Bangladesh and Indonesia (using the IFLS) find an association with children's nutritional status. Studies from intervention studies in Vietnam and a cross-section study from Indonesia do not find one.
- Ravens scores are also stratified by parental socio-economic resources, although only few studies include these controls.

- With regards to the timing, duration and dynamics of malnutrition there are only few studies that investigate the link between these aspects of children's nutritional status and children's non-verbal cognitive skills.
- Some studies find a significant association between duration of stunting with verbal score but not with non-verbal results of matric reasoning.
- Results from long-term effects of nutritional interventions in early childhood on later cognitive outcomes are mixed, all studies show short term benefits to cognition in early childhood. However, long-term (e.g. eight years after the interventions in middle childhood and adolescent) were not significant for Jamaica. However, those long-term effects could be observed for nutritional intervention that started during pregnancy and continued for at least first three years of life in Guatemala and Colombia.
- Evidence for Indonesia is limited and the majority of studies were not large-scale longitudinal studies that looked at children's nutritional status changes from early childhood to adolescence.

5.4 Research Questions

This section outlines the main research question with their related sub-research questions that we address in this chapter.

Main Research Question:

To what extent is children's nutritional status associated with cognitive test results?

Sub-research questions

RQ 1: What matters more for children's cognitive test results – children's nutritional status in earlier or later childhood? (This question is related to the debate between the early critical window/irreversible hypothesis on the one hand and the later accumulation hypothesis on the other hand).

RQ 2: What are other parental/ family characteristics that are associated with children's cognitive scores?

- To what extent are i) parental financial resources/consumption, ii) parental health (their height-for-age) or iii) parental education (their years of schooling) associated with children's cognitive scores?
- To what extent is the relationship between nutrition and cognitive test results mediated/reduced by other parental/family characteristics?

RQ 3: Do the dynamics of stunting between early and later childhood matter for cognitive test results?

- Do children who are chronically malnourished (stunted) have the worst cognitive test results?
- Do children that recover from stunting are also able to catch up on their cognitive test results and have similar cognitive test results to those children that were never stunted?

5.5 Methods

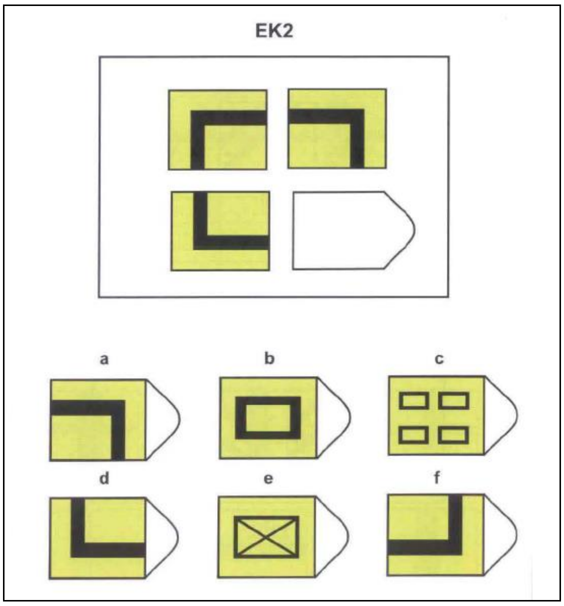
This section explains the outcome of the cognitive test of Ravens coloured progressive matrices in more detail and assesses its strengths and limitations. It further discusses how the outcome variable was constructed as well as the analytical sample chosen.

Child cognitive outcome: Raven's coloured progressive matrices

Raven's coloured progressive matrices were developed by John Ravens in 1936 and have been further developed since then. They constitute a non-verbal test and are commonly used in psychology and accepted as the single best measure of Spearman's general intelligence factor g – more specifically a person's capacity for systematic method of reasoning (Kaplan and Saccuzzo 1997). The test was developed to cover the widest possible range of mental abilities and to be useful to all age groups regardless of their cultural, educational or physical conditions. The World Health Organisation recommends Raven's test for its worldwide applicability, the ease of use and the high reliability for children and it has been widely used in different country contexts (Ivanovic et al. 2004; Prabhakaran et al. 1997; Tarleton et al. 2006; Chowdhury and Ghosh 2011; Grantham-McGregor et al. 2007; S. Walker et al. 2000). For more background information on the Raven's Standard Progressive Matrices (SPM) test, see Raven (1958/1993/2000).

There is a standard version and an advanced version of the test. The IFLS team uses the standard version, which consists of twelve visual problems which measure cognition through a non-verbal assessment. This is a unique feature for a general household survey and an underutilized module. Indeed, that the IFLS collects the data on an accepted objective measure of cognition is one of the great benefits of the survey. Children aged between 7 and 14 years were given 12 Raven's Coloured Matrices questions and five math problems to assess their cognitive function. A similar, but shorter, test was given to individuals between the ages of 15 and 24 years. Instead of 12 matrices this test only comprised nine of the matrices but with six mathematics questions. Figure 15 shows a sample question of such a Raven Coloured matrix for younger children.

Figure 15: Sample Question from IFLS's Raven's Matrices Test



[Source: IFLS 4 Questionnaire]

The test in conducted by first giving children one practice question to ensure they understand what they have to do. Each visual problem has one missing element and the child is asked to identify which one of six possible patterns displayed underneath to choose to complete the pattern. The test is not timed, so the child continues until it makes the choice. As the test continues, the visual problems become progressively more difficult – hence the test name of progressive matrices.

To sum up, we justify the use of Raven's coloured progressive matrices as follows. First, they cover a wide range of non-verbal cognitive skills. Second, there is evidence from neuroscience that links it to the working memory, which other studies have shown to be affected by malnutrition. One study for example is able to show brain activation of where working memory is located by measuring with magnetic resonance imaging when children performed the Ravens test (Prabhakaran, Smith et al. 1997). And thirdly, the outcome is widely used in other relevant research – see section 5.3 for a review of some empirical studies that used the Raven's matrices.

However, it is important to emphasise that the Raven progressive matrices constitute a single test. While it is a general and reliable test, it still tests rather specific non-verbal visual reasoning skills. It might be possible that it does not pick up on children's impairments due to malnutrition. Hence, it would be preferable to have additional cognitive tests as well. But as the IFLS is not a survey specifically designed to monitor and assess child development, but rather a comprehensive household survey, this constitutes the available evidence. It is well worth using the data that is available in one of the few large-scale longitudinal datasets for Indonesia and we have some additional results from mathematics problems in IFLS.

The second part of the cognitive assessment consists of a mathematics set consisting of five questions assessing basic algebra such as subtracting, multiplying, fraction, etc. The math set for 15-24 year-olds contains three basic algebra questions and three mathematics problems describing a situation in a short text. All of the questions have four multiple choice answers. The underlying concept behind both the pattern recognition and the math test is that of logical deduction which motivates to add these two sets of questions together into one variable. We nevertheless also conducted a sensitivity analysis were we run separate analysis for each of the two assessments and do not find any significant differences.

Outcome variable construction and sample selection

With the 12 matrices and 5 mathematics problems, there are 17 items in total for the cognition test. We argue that the underlying concept for these tasks is logical deduction and reasoning and construct a variable that sums the correct answers over the 17 items and expresses it in percentage of the correct answers to these 17 questions. Previous research that uses the IFLS that followed the same approach (Cheung 2006; Walker et al. 2000).

The specific outcome that we created for our analysis is percentage of correct answers of the cognition test. As described earlier, the test consists of 17 items – 12 pattern recognition questions and 5 mathematics questions. We created the sum of the correct answers and converted this into percentages by first dividing the number of correct answers by 17 and then multiplying by 100. Percentage of correct answers = sum of correct answers/17*100. [44]

The sample for analysis was chosen in the following way. As outlined in Chapter 3, the IFLS is a longitudinal household survey with multiple cohorts. In order to mirror birth cohort datasets but also to have a big enough sample size we chose a 3-year age cohort – i.e. children in 1993 that are between 0-3 years of age and follow them through the different waves.

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[44] The IFLS source files (BEK_EK1 and BEK_EK2) were updated on May 10, 2011 to correct for an error in the EK#X variables and are used for analysis here.

As main independent variables we use nutritional status of children in early childhood, dynamics between early childhood and adolescence and parental financial and human resources, namely consumption, parental education and height.

Concerning control variables: since the Coloured Progressive matrices (CPM) test is based on pattern recognition, there is a natural positive correlation with age among the children respondents from age seven to fourteen. Instead of standardising the test results by age we decided to control for age in the model specification by controlling for age and displaying all descriptive results by separate age groups.

Formal schooling is one factor for children's cognition so we include attending school at the time of taking the Ravens Matrix test into the models. Part of the effect of stunting on cognitive scores sometimes is attributed to the lower level of schooling received by children stunted in early in life (Mendez and Adair 1999).

Multivariate regression model with unexplained residuals of later height

We are interested to assess the influence of nutrition in early childhood (proxy: height-for-age) on cognitive test scores as well as the influence of changes in height during later in childhood.

There is an on-going debate of how a variable that is in the causal pathway in the analysis is best adjusted for (Keijzer-Veen et al, 2005; Lucas et. al, 1999). In our example – just adding height in later childhood to a multivariate regression model of earlier height on cognitive scores would make the interpretation of the coefficients difficult. The reason is that the effect of later height is codetermined by the effect of earlier height on cognitive scores, because later height is in part determined by earlier height, which influences the coefficients in a combined model (Keijzer-Veen et al, 2005). To address this problem, we follow the approach suggested by Keijzer-Veen et al, 2005. To be able to explore the association with cognitive test scores separately, we use a multivariate regression model containing height-for-age in earlier childhood and residual height in later childhood. So we use the method of residual height instead of using the actual height in later childhood. The coefficients of such a multivariate regression model show the association with the cognitive outcome directly.

Other standard approaches to include height at different life-stages of children are to subtract later height from earlier height as a measure of change in height and add this to a multivariate regression model with earlier height and the outcome. This kind of model is problematic in regards to the phenomenon of regression to the mean. The relative position of subjects with lower heights in earlier childhood will tend to increase and that of children with taller heights in later childhood will tend to decrease over time. So this approach is not adopted. There is also an approach suggested by Lucas et al, 1999 that proposed four regressions similar to the approach we are adopting. The important difference however is that the Lucas models adjusted with actual height. The interpretation of the coefficients is difficult as we have discussed above. The later height is in part determined by earlier height and will be attenuated upon adding later height to the model.

The residual height in later childhood is calculated by subtracting the expected (predicted) height from the actual height. The expected height is estimated by a regression model using earlier height. For further details of the algebraic explanation of this model, see Keijzer-Veen et al, 2005.

5.6 Results

Children's cognitive test results by age

First we start by examining the descriptive results for the cognitive test results in IFLS 3 (in the year 2000) for the children in our cohort that are between 7 and 10 years of age in that data wave. Table 16 shows the mean percentage of correct answers for each one-year cohort of children. So, for example, the 7-year-old children have 41% of the cognitive test scores correct.

Table 16: Percentage of correct cognitive test answers for children aged 7-10

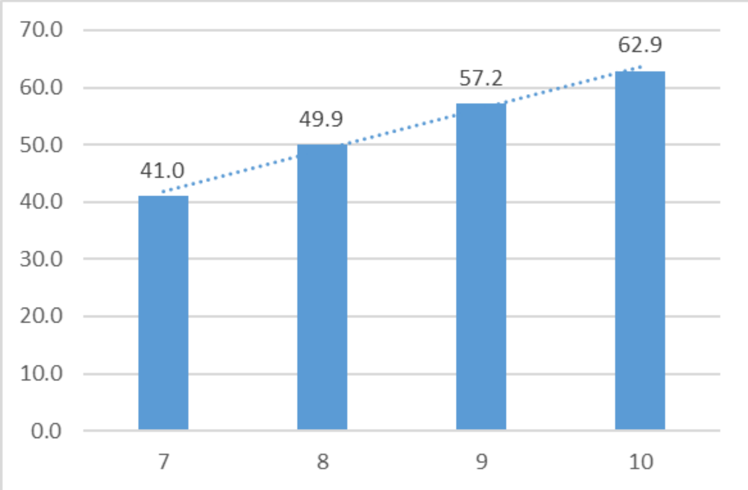
Age	N	% Correct answers	Difference
7	149	41.0	
8	379	49.9	9.0
9	352	57.2	7.2
10	157	62.9	5.7
Total	**1,037**		

Notes:

- n= 1,037 children who have test result in 2000 and were between 3-36 months in 1993

As we assumed, the test results vary by age. The youngest age-group of children, the 7-year- olds, have on average 41% of the test results correct. In contrast, the oldest cohort of children, aged around 10 years, have on average around 63% of the test questions correct. This is a difference in cognitive test scores between youngest and oldest age-group of almost 22 percentage points. This could be due to children having a spurt in cognitive development due to the stimulation in primary school with Indonesian children entering primary school at the age of 7. The differences flatten out the older children become – probably as the test of pattern recognition and mathematics is still quite a basic one.

Figure 16: Correct answered cognitive test results (in %) in 2000 of panel cohort



Source: (n=1,037)

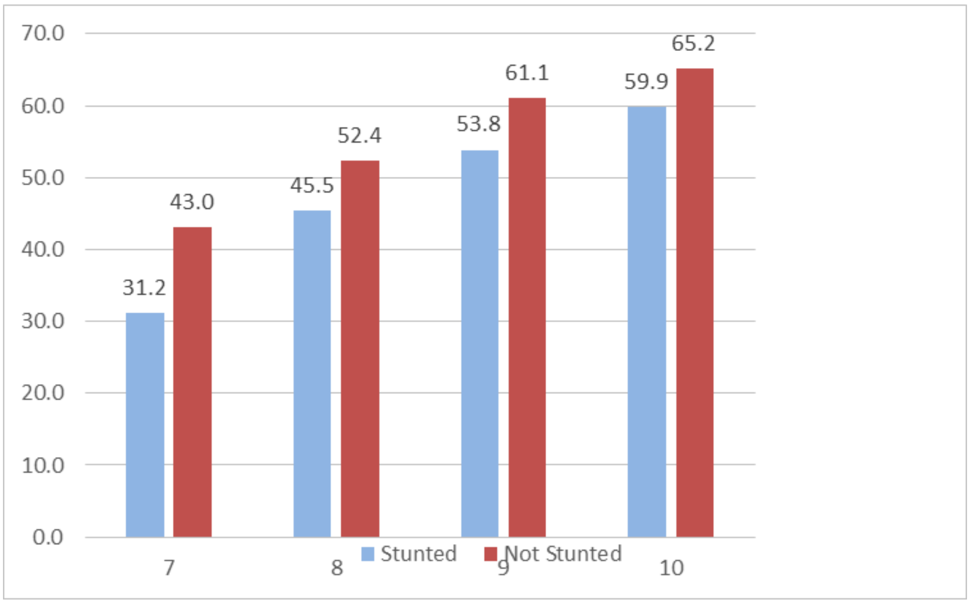
As the cognitive test consist of two different elements – the pattern recognition and the math test, we also check if the age pattern is different if we look at these two sets of tests separately rather than combining them into one test score. However, the age pattern that we discussed above for the combined test is mirrored in the mathematics and pattern recognition test as well (results not shown).

We also check for gender differences (results not shown) and as expected do not find differences in the cognitive test results for girls or boys.

Cognitive test results by early childhood stunting status

As both the probability of being stunted and the cognitive test scores vary by age we present the stratification of the cognitive test results in the different age groups.

Figure 17: Cognitive test scores for children aged 7-10 by early stunting (0-3 years)



Notes:

- Stunted in 1993 (light bars), not stunted in 1993 (dark bars)
- N= 1,037 children who have test result in 2000 and were between 3-36 months in 1993 and have valid height-for-age information in 1993

Overall, children who were stunted in early childhood in 1993 aged between 0-3 years (light bars in Figure 17) are performing worse in the test scores than children who were not stunted in 1993 (dark bars). Averaged over all age groups, the difference between stunted and not stunted children for their cognitive test scores is around 8%. The difference is most pronounced for the youngest age groups of 7-year-olds with a difference of nearly 12% between stunted and not-stunted children in early childhood. One possible explanation of the difference between the two groups of children could be related to the fact that seven is the age when children start school in Indonesia. So children will not have had much exposure to school at that age compared to their older peers. This could suggest that schooling has some equalising effect to make up for the disadvantages from stunting in early childhood. Another interpretation could be that the 7-year-olds are the youngest children and would have been in their first years of life when experiencing stunting. Hence, the difference could also suggest that they suffered most impairments to their cognitive development.

Table 17: Cognitive test scores by early childhood stunting status

Age	% Correct answers by stunted in early childhood	% Correct answers by not stunted in early childhood	Difference
7	31.2	43.0	11.8
8	45.5	52.4	6.9
9	53.8	61.1	7.2
10	59.9	65.2	5.3

In order to follow up on these descriptive results, we are running a multivariate regression to see how stunting in early childhood is related to cognitive outcomes and how other factors are associated. 18 displays the results from the regression analysis with the outcome of the percentage of correctly answered questions of the cognitive test. The sign of stunting in early childhood is in the expected direction. For children that are stunted in early childhood when they are between 0-3 years of age score on average 2.2 percentage points lower on the cognitive test scores when they are aged between 7-10 years in 2000. However, this result is not significant. We will see in later analysis that stunting when children are between 4-7 in 1997 or current stunting levels in 2000 are all significantly associated with cognitive test scores in 2000.

Table 18: Linear regression for cognitive test scores in 2000 with stunting in 1993

Independent variables	Coefficient	95% Confidence interval
Age of child in years	0.0583***	[0.0428, 0.0739]
Stunted in 1993 (d)	**-0.0222**	**[-0.0535, 0.00904]**
Mothers years of schooling	0.00554**	[0.000127, 0.0109]
Fathers years of schooling	0.00506**	[0.000460, 0.00965]
Household size	0.00847**	[0.00109, 0.0159]
Household has electricity (d)	0.0750***	[0.0405, 0.110]
Drinking water source indoors (d)	0.0434**	[0.00507, 0.0817]
Religion (= Muslim) (d)	-0.0821***	[-0.130, -0.0345]
Ethnicity (= Javanese) (d)	0.0389**	[0.00770, 0.0701]
Child in school in 2000 (d)	0.242***	[0.155, 0.330]
Constant	-0.313***	[-0.475, -0.151]
Observations	933	
R^2	0.205	

Marginal effects; 95% confidence intervals in brackets, (d) for discrete change of dummy variable from 0 to 1
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

As we are also interested in examining the other factors that are associated with children's cognitive scores, we also displayed the significant variables that we found in Table 18. Age of the child is significant as we had expected and observed in the descriptive results. So with each year children on average score nearly 6 percentage points higher on the cognitive test scores. In terms of parental socio-economics resources we find that both parents education is significantly associated with children's cognitive test scores. With each year of maternal schooling children score on average 0.6 percentage points higher on the cognitive test. The size of the coefficient is only slightly lower for fathers' years of schooling. The association with the highest significant coefficient on children's cognitive test scores is for school attendance. So if a child currently attends school they score on average 24 percentage points higher than children who are not attending school.

We also find significant results for measures of children's direct measures of their living environment. Children living in a household that has electricity, they score on average 7.5 percentage points higher on the cognitive test, and with indoor drinking water they score 4.3 percentage points higher. This could be a proxy for how stimulating children's environment is, as we do not have direct measures on if the household owns books and educational toys, etc. Being Muslim compared to other religions decreases test scores on average by 8.2 percentage points, and living in Java by nearly 4 percentage points.

Table 19 shows the linear regression results using current stunting levels, which we can see are significant. So for children that are currently stunted they score on average 5.6 percentage points lower on cognitive test scores. The other results are very similar to what we observed in Table 19.

Table 19: Cognitive test scores and current stunting levels

Independent variables	**Coefficient**	**95% Confidence interval**
Age of child in years	0.0597***	[0.0445,0.0750]
Currently stunted (d)	-0.0556***	[-0.0862,-0.0249]
Mothers years of schooling	0.00548**	[0.000107,0.0108]
Fathers years of schooling	0.00436*	[-0.000225,0.00894]
Household size	0.00874**	[0.00141,0.0161]
Household has electricity (d)	0.0722***	[0.0379,0.107]
Drinking water source indoors (d)	0.0405**	[0.00249,0.0786]
Religion (= Muslim) (d)	-0.0796***	[-0.127,-0.0323]
Ethnicity (= Javanese) (d)	0.0363**	[0.00529,0.0674]
Child in school in 2000 (d)	0.237***	[0.150,0.324]
Constant	-0.300***	[-0.461,-0.138]
Observations	933	
R^2	0.214	

Marginal effects; 95% confidence intervals in brackets
(d) for discrete change of dummy variable from 0 to 1
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Cognitive test scores and catch-up growth

Next we are interested to see whether children that experience catch-up growth also improve their cognitive test scores. Table 20Table displays the regression results. It is important to remember that the sample for catch-up growth is limited to children being stunted in early childhood. Those that are not stunted in adolescence experience what we call catch-up growth.

Indeed, we find a significant association between children experiencing catch-up growth who on average score nearly 4 percentage points higher on their cognitive test scores than children that stay stunted. Interestingly, only mothers schooling stays significantly associated, and neither is children's direct living environment any longer significant in the regression analysis.

Table 20: Linear regression result for cognitive test scores and catch-up growth

Independent variable	Coefficient	95% Confidence interval
Age of child in years	0.0543***	[0.0271,0.0815]
Child experiences catch-up growth (d)	0.0393*	[-0.00754,0.0862]
Mothers years of schooling	0.00761*	[-0.00103,0.0163]
Fathers years of schooling	0.00554	[-0.00188,0.0130]
Household size	0.0133**	[0.00216,0.0245]
Household has electricity (d)	0.0285	[-0.0221,0.0792]
Drinking water source indoors (d)	0.0298	[-0.0382,0.0979]
Religion (= Muslim) (d)	-0.0914**	[-0.167,-0.0155]
Ethnicity (= Javanese) (d)	0.0491*	[-0.000102,0.0983]
Child in school in 2000 (d)	0.275***	[0.154,0.397]
Constant	-0.362***	[-0.627,-0.0968]
Observations	384	
R^2	0.209	

Marginal effects; 95% confidence intervals in brackets
(d) for discrete change of dummy variable from 0 to 1
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 21: Linear regression on cognitive test scores with residual height

Independent variable	Coefficient	95% Confidence interval
Age of child in years	0.0604***	[0.0449,0.0758]
Heigth-for-age z-scores in 1993	0.0100**	[0.00109,0.0190]
Residuals of HAZ in 2000 (change between 1993-2000)	0.0383***	[0.0220,0.0546]
Mothers years of schooling	0.00520*	[-0.000151,0.0105]
Fathers years of schooling	0.00406*	[-0.000506,0.00862]
Household size	0.00916**	[0.00184,0.0165]
Household has electricity (d)	0.0700***	[0.0357,0.104]
Household has drinking water source indoors (d)	0.0370*	[-0.00101,0.0750]
Religion (= Muslim) (d)	-0.0723***	[-0.120,-0.0248]
Ethnicity (= Javanese) (d)	0.0375**	[0.00654,0.0684]
Child in school in 2000 (d)	0.234***	[0.147,0.321]
Constant	-0.311***	[-0.472,-0.150]
Observations	933	
R^2	0.222	

Marginal effects; 95% confidence intervals in brackets
(d) for discrete change of dummy variable from 0 to 1
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

We also look at the other factors and their association with cognitive outcomes:

Gender. In the full model girls score on average 2.6 percentage points lower on the cognitive test scores compared to boys. This result is a bit surprising, as research in Indonesia often does not find a gender bias/disadvantage despite being a Muslim country. It changes its significance level in the different regression models. It is not significant in the regression models with HAZ on its own (maybe because of the fact that HAZ scores are already gender and age-specific). The association becomes stronger and more significant the more control variables are added.

Attending kindergarden. We do not have a lot of information about childcare facilities and childcare rearing practices. But as a basic indicator that we can use is if children attended kindergarden. In the final model, children that attended kindergarden on average score 2.8 percentage points better on the cognitive score than children that did not attended kindergarden. The coefficient was even 6.8 percentage points in the 2nd model but decreased when including parental and household characteristics. Maybe attending kindergarden is also a wealth indicator and not only the stimulation that children receive that are beneficial for their cognitive development and thus their cognitive test scores. (Kindergarden are very expensive in Indonesia and very often only used by middle and upper classes. So without controlling for parental characteristics the coefficient of attendance could capture these parental characteristics.

In School (2000). We also control if children attend school when taking the cognitive test. Attending school and receiving education has a positive influence on cognitive skills but probably also on abilities that make taking tests easier – such as receiving instructions from an adult that are followed and being exposed to these learning and testing situations. The coefficient is the highest of all the factors related to cognitive test scores. Children that attended school on average score 27.5 percentage points higher on the cognitive scores. The coefficient does not change that much in size.

Parental education. We now move from the individual child characteristics to the parental characteristics with parent's education - their years of schooling. In the final model, with each year of mothers education children would score 0.5 percentage points higher on their cognitive scores. The size of the coefficient does not change that much. The interpretation would be that mothers with more schooling are probably interacting more (or that schooling in the absence of direct child rearing information) gives us some idea of how mothers interact with their children. For father’s education, the effect is smaller as the one of maternal education with 0.4 percentage points for each year of fathers’ education that children score higher on cognitive scores. This is significant at 10percent level. The significance level diminishes when we control for other household factors - so paternal educational level could be a proxy for the housing quality.

Paternal height. Maternal and paternal heights are in the last model negatively related to children's cognitive scores. For each centimetre in maternal height, 0.02 percentage points score lower on cognitive scores. This is not significant. For fathers it is 0.2 percentage points lower per each centimetre and significant at 10% level (not shown).

Financial resources. In the final model there is a positive association but not a significant one. When we first include financial resources into the model, it is significant and the size of the coefficient is higher. But when we introduce other household characteristics such as if the house uses electricity and has an indoor water source, then financial resources (the per capita household consumption) becomes insignificant. So controlling for these household characteritics seems important and not the financial resources. A possible explanation could be that these indicators give a good proxy for how stimulating the living environment is for children. Or it could be that they are the reliable indicators for the wealth of a household and that the consumption variable is more error prone due to misreporting etc.

5.7 Conclusions

In this chapter, we investigated the link between malnutrition and children's cognition.

The general framework introduced in section 5.1 established the fact that children's cognition is a result of an interplay of immediate and proximate factors. For instance, malnutrition and children's cognitive test results are linked through the channels of *children's brain structure and functions.* Moreover, malnutrition can lead to damage of brain tissue, growth retardation, and reduction in synapses and neurotransmitters. The brain areas and functions which are most affected by malnutrition are the *hippocampus* and *cerebellum* with associated cognitive functions of short and long-term memory, attention, language and mental imagery as well as the *cerebral cortex* – the brain region most closely linked to cognitive and intellectual functioning. The window for vulnerability due to malnutrition spans pre- and postnatal periods with for example the *cerebral cortex* and the *white matter* (essential for uniting different regions of the brain) continuing to mature during childhood and adolescence. We also briefly reviewed how behavioural and parental resources via malnutrition, caregiving practices and living environment could be linked to children's cognition.

The existing empirical evidence of children's nutritional status and cognition was summarised as follows. Several studies that used a wide range of cognitive tests – verbal and non-verbal – found a link between children's nutritional status and different cognitive abilities. The size of the coefficients varies between these studies – probably due to different study designs, ages of children tested, and the specific test used to measure cognitive abilities. Moreover, different cognitive abilities are likely to be affected differently by malnutrition depending on the area and functioning of the brain. The Ravens matrices test, a cognitive non-verbal test for perceptual reasoning, problem solving and the working memory, has mixed results for links to children's nutrition. Studies from India, Bangladesh and Indonesia (using the IFLS) find an association with children's nutritional status. Studies from intervention studies in Vietnam and a cross-section study from Indonesia do not find one. Ravens scores are also stratified by parental socio-economic resources, although only few studies include these controls. With regards to the timing, duration and dynamics of malnutrition there are only few studies that investigate the link between these aspects of children's nutritional status and children's non-verbal cognitive skills. Some studies find a significant association between duration of stunting with verbal score but not with non-verbal results of matric reasoning. Results from long-term effects of nutritional interventions in early childhood on later cognitive outcomes are mixed, all studies show short term benefits to cognition in early childhood. However, long term (e.g. eight years after the interventions in middle childhood and adolescent) were not significant for Jamaica. However, those long term effects could be observed for nutritional intervention that started during pregnancy and continued for at least first three years of life in Guatemala and Colombia. In general, evidence for Indonesia is limited and the majority of studies were not large scale longitudinal studies that looked at children's nutritional status changes from early childhood to adolescence.

The results obtained in this chapter can be summarised as follows:

- Early height-for-age (HAZ) has an independent effect (even after controlling for later height) on cognitive processes which could support the hypothesis on early sensitive periods for cognitive process development and the important role of prenatal influences up to the early childhood measure.
- However, what happened to children after first five years of life (i.e. the changes in height during middle and later childhood) is also significant supporting insights from neuroscience that brain development is more complex than previously thought and plasticity of the brain an important factor.
- The association between early HAZ and cognitive outcomes survives, but is attenuated by later HAZ in a substantial way.
- We suspect that the observed relation would even be stronger, if instead of Raven's test results (a measure of general cognition) more specific tests for working memory would be available (the area that is most effected by malnutrition).
- As for parental resources, schooling and financial resources do not stay significant in the full model, only housing conditions do. This could have two reasons: first, there is no relationship, or secondly, these are not good measures of parental resources (but still the best available).
- The results still reveal some insights on factors that are associated with cognition and there are not many studies for Indonesia; for example we find that pre-school experience, presence of grandparents, quality of living environment and being Muslim are associated with test results.
- There seems to be a gender bias.

- We also find a rural area disadvantage that seems fully accounted for once we include electricity and indoor water facilities.

As pointed out in Chapter 2, the data used in the analysis has several limitations which requires caution in the interpretation of the results.

For instance, unobserved characteristics correlated with the likelihood of exposure to malnutrition could account for cognitive deficiencies – most relevant is probably caregiving behaviour. In the general framework put forward by the Centre of the Development of the Child this is subsumed under what they called the ‘environment of relationships’ – i.e. interaction between child and parents as well as other members in and outside of the family. Examples include nurturing behaviour (one sided, but responsive) and interactive stimulation. We cannot control for these possible influences due to limitations in the data.

Furthermore, the Levine Study showed that stimulation is important for child development. So an effect we pick up between malnutrition and cognition might be due to stimulation or rather the lack of it (or could at least be mitigated). To further clarify the role of stimulation should therefore inform further data collection efforts.

However, even with the present variables, a complex interrelationship emerges, as outlined by the Harvard framework: The general framework adds the interaction of genes and environment (which reflects the two sides in the “nature versus nurture” debate). More specifically, children’s experience in the three domains of relationships, environments and nutrition interact with the genetic predispositions. The more detailed framework developed and adopted in this chapter is helpful to understand the connection between the different elements of the framework and to realise that cognition is a result of the interplay of many factors. While we do not have data on all the building blocks from the framework, we nevertheless think it important to map them out to in detail to better interpret and discuss results. It will also be useful for discussing the limitations of our research and formulate recommendation for future research and what kind of data should be collected in Indonesia to shed more light on this important issue. Due to the complex interrelations among malnutrition, environmental factors (such as socioeconomic status and education) it is difficult to determine the unique contribution of malnutrition to cognitive development.

The results presented here are relevant for improving children's health and nutrition. These are important development objectives in their own right, and many international organisations such as World Bank are prioritising improvements in child health and nutrition. Increasing schooling attainments is also part of the commitment to the Millennium Development Goal of Universal Primary Education by 2015. Here, our results imply that that improvements in pre-school health status and primary education are not competing objectives. Rather, improved nutrition will facilitate meeting the education objectives. Furthermore, improving children's nutritional status enhances the acquisition of knowledge at school and leads to higher attained height as adults. These improvements have added value, assuming a positive association between schooling and productivity and height and productivity (Alderman, Hoddinott et al. 2006).

CHAPTER 6: Children's lung capacity

6.1 *Introduction and Motivation for the Research*

In Chapter 4 we investigated the relationship between parents' resources and children's growth status early in life and their growth dynamics into adolescence. We have shown that children experience dynamics of malnutrition between their earlier childhood and adolescence and that this influences their height in adolescence. Chapter 5 examined the relationship between parental resources, malnutrition and cognitive outcomes and has shown that malnutrition is associated with children's non-verbal cognitive outcomes in terms of Ravens coloured progressive matrix test scores.

As child development is multidimensional, we are also interested to see whether there is a relationship between parental resources, malnutrition and an outcome measure for physical health of children. Therefore, we make use of a unique feature of the IFLS in this chapter: the availability of a measure of children's lung capacity collected by a trained nurse for all children older than nine years. Conceptually the relationship between malnutrition and children's lung capacity goes via the route of organ development that can be hindered by malnutrition. As discussed in chapter 4, malnourished children are more prone to illnesses such as respiratory illnesses which can affect children's lung capacity – this can be especially critical in tropical countries such as Indonesia where the humid climate re-enforces infections of the respiratory system. Respiratory illnesses are still a major cause for child death in developing countries. Furthermore, physical health of children is related to their physical health as adults, which in turn is related to what kind of jobs they are able to perform, thus influencing labour market outcomes (Strauss and Thomas 1995). Household surveys and even demographic health surveys very rarely collect these kind of physical measures of lung capacity in developing countries. Using this unique feature of the Indonesian Family Life Survey to examine an aspect of children's physical wellbeing that has potential long lasting effects may therefore even have broader significance that goes beyond the Indonesian context.

Main research question

The aim of this chapter is to investigate the relationship between parental resources, children's earlier malnutrition and the dynamics of malnutrition between earlier childhood and adolescence with the physical heath measure of children's lung capacity. We are interested to see whether children's malnutrition in early life is negatively associated with children's lung capacity in later life. Furthermore, we ask whether there are differences in children's lung capacity by children's nutritional dynamics and parental resources, especially as we have the unique chance of using parental lung capacity as well to look at intergenerational relationships.

Structure of the chapter

This chapter is structured as follows. Section 6.2 will outline the conceptual framework for children's lung capacity and how it is related to parental resources and children's nutritional status. Section 6.3 gives a brief overview of the few studies that are available that investigate children's lung capacity and their nutritional status. Section 6.4 then outlines the research question for the chapter. Section 6.5 gives an overview of the methods outlining the measures of lung capacity, how the data are collected in the IFLS and how we set up the models of analysis. Section 6.6 contains the results, both descriptively and from the regression analysis on children's lung capacity and malnutrition status. Section 6.7 concludes the chapter.

6.2 *Conceptual framework for children's lung capacity*

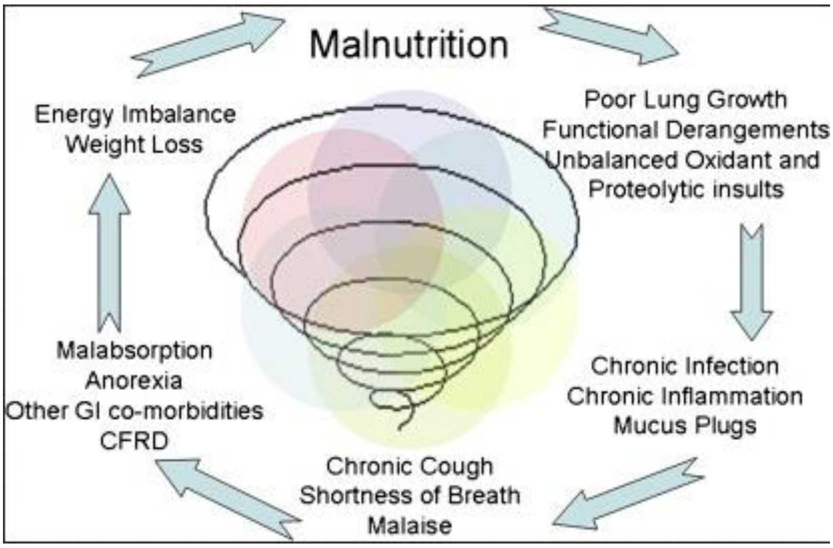
This section gives an overview of the conceptual framework we are using for the analysis. We will in particular look at what is known about the determinants of children's lung capacity as measured by their peak flow meter results. A peak flow meter device measures the rate in which air flows out of the lungs when the individual blows forcefully into the device. More details are discussed in section 6.5 below. We are also interested to know how children's nutritional status, measured by their height-for-age z-scores (HAZ), and growth dynamics such as growth recovery are related to children's lung capacity. Furthermore, we are interested how parental resources are conceptualised to be related to children's lung capacity.

Children's lung capacity generally increases by age, as the lungs are still growing in size and physical activity increases by child's age, which also enhances lung capacity. The differences by gender are also substantial with male children having much larger lungs than females (Stanojevic, Wade, and Stocks 2010; Taussig, Harris, and Lebowitz 1977). The living environment, especially when considering hazards such as air pollution, can have a direct effect on children's lung capacity (Kaur Rajneet 2012; Milla 2007; Ji et al. 2013).

Relationship between malnutrition and children's lung capacity

There are not many conceptual framework that explicitly link malnutrition and children's lung capacity. We review one from Milla, 2007 in Figure 18 that depicts a conceptual framework for how malnutrition and lung capacity could be related. Conceptually, the relationship between malnutrition and children's lung capacity goes via the route of organ development that can be hindered by malnutrition and result in poor organ growth – especially reduction in lung volume due to ventilatory muscle wasting and the weight of the diaphragm (Milla 2007; Kaur Rajneet 2012).

Figure 18: Conceptual link between malnutrition and children's lung capacity



(Milla 2007)

As reviewed and discussed in chapter 4 malnourished children are more prone to illnesses such as respiratory illnesses which can affect children's lung capacity – this can be especially critical in tropical countries such as Indonesia where the humid climate enforces infections of the respiratory system (Cameron and Williams 2009; Thomas, Contreras, and Frankenberg 2002). Chronic infections can be a result, which can lead to chronic coughs, shortness of breath and other physical limitations. This, in turn, can then reinforce malnutrition via the difficulties of absorbing nutrients from food etc. The various factors in this interrelationship can reinforce each other over the different life stages of children.

Relationship between parental resources and children's lung capacity

There could be a direct and an indirect conceptual link between parental resources (including their own lung capacity) and that of their children. Genetically, the relationship could work through the route of organ growth and size, which is partly genetically influenced. Indirectly, there could be a link between parental lung capacity and that of their children as parents are exposed to the same hazards as their children (Putte-Katier et al. 2011). For example, air pollution through forest fires or indoor pollution (such as due to a stove in the house) can affect children's lung capacity (Azizi and Henry 1990; Jedrychowski et al. 2005). Mothers as the main caregivers spend more time in the same environment as their children, so we would expect a closer relationship between maternal lung capacity and that of their child. Parental smoking behavior could be another factor that reduces not only their own lung capacity but through passive smoking that of children as well. In Indonesia, smoking is predominantly a male activity, so we would assume paternal smoking to be more prevalent and linked to their children's lung capacity (Witoelar, Rukumnuaykit, and Strauss 2005). Obviously, children's and adolescents' own smoking behavior is relevant, too. The role model of parental smoking behavior is probably also relevant for children's own smoking behavior.

Having similar pattern of physical exercise for both parents and children – again through parents acting as role models – could influence children's lung capacity (Putte-Katier et al. 2011). The health awareness of parents is also likely to influence how health aware children are and what kind of mobility patterns are most common (e.g. which mode transport is used, etc.). Further, respiratory disease exposure and the risk of contagion from parents to children (or vice versa) is also likely to influence children's lung capacity through prolonged or repeated infection of the respiratory system.

Other parental resources are often the underlying household-level causes working through these channels on children's lung capacity. For example, it is assumed that a child of parents with adequate financial resources is provided with better quality and quantity of household food, and parents are able to afford sufficient preventative and curative care as well as healthy living environments. Maternal schooling is conceptualised to mainly work through the route of adequate childcare. As mothers are main child carers their schooling influence is thus assumed to be of greater magnitude than paternal education. Further, more educated mothers might have better health and nutrition related knowledge and better able to provide better quality food or better health habits (even if we hold the financial resources constant).

Factors outside of the family also have been shown to be related to children's lung capacity. A study of 622 children in Jamaica showed for example, that total lung capacity and vital capacity averaged respectively 6% greater and 7% greater in rural than in urban children of equal height. The authors main explanation is due to "increased habitual physical activity" (Miller et al. 1977). This is likely to relate to the more manual labour in rural areas and less motorised transport facilities that make more physical movement necessary.

There are not many studies that investigate the relationship between dynamics of children's nutrition and their lung functions. So it is still not unclear if catch-up growth in growth restricted children influences lung function. Weight-catch-up growth is related to children's better lung capacity at age 8 and 9 years (Kotecha et al. 2010). Similar results are found by other studies (Friedrich et al. 2007; Mansell, Levison, and Bailey 1983). However, all of them use weight-catch-up growth as measure and do not look at other anthropometric measures.

6.3 *Literature review on children's lung capacity*

To the best of our knowledge, there are no studies that investigate the links between children's nutritional status, parental resources, and children's lung capacity in Indonesia. More generally, in the literature, there is comparatively sparse evidence for links between lung capacity and children's nutritional outcomes – especially dynamics of children's nutrition such as catch-up growth. Partly, this is due to the fact that taking lung capacity measurements is costly. However, there is more evidence for links between health and wellbeing outcomes and respiratory diseases in general.

Malnutrition and children's muscle development in gross and fine motor skills

Children's lung capacity is related to their muscle development. As there are some parallels with muscle development in gross and fine motor development and evidence for lung capacity is limited we review findings on fine motor skills (children's ability to use small muscles, i.e. their hands and fingers to pick up small objects, etc.) and gross motor skills (children's ability to use large muscles, for example to sit or pull up, etc.).

In the child development area of physical development there is evidence in both directions whether malnutrition negatively affects motor skills or not. A study from India employing a wide range of child development tests (Kar, Rao, and Chandramouli 2008) finds no difference for adequately nourished and malnourished children in a test of fine motor skills. The test, a finger tapping test, is part of a so called NIMHANS neuropsychological battery for children and was developed for assessment of children in the age range of 5–10 years[45]. Not finding an association between malnutrition and fine motor skills in this study however, could be due to the fact that the test of motor speed and coordination is very basic one and not able to detect the effects of nutritional deficiencies, especially for the age range of children studied. Further, the data used is not very strong, i.e. just cross-sectional data and a very small sample size (n=40). So we would caution on the conclusion here.

Contrary to these findings, better quality evidence from a small scale random control intervention from Indonesia provides supporting evidence for a link between nutrition and motor development. Husaini and colleagues examine a three months supplemented feeding intervention in the 1980s. They find that stunted children who receive short term

[45] Children are asked to tap the mounting key on a finger-tapping instrument as rapidly as possible using the index finger of the preferred hand and then with the non-preferred hand for 10 seconds (Kar et al, 2008)

supplementation improve their motor development (Husaini et al. 1991). The so called ‘Bayley Scales of Mental and Motor Development (BSMMD)’ is used and an index developed that includes relevant items for gross motor development (e.g. standing, walking, and jumping) and fine motor movements (finger prehension of pellet, etc.). The supplemented group who experienced a large, positive weight change (i.e. from -1.66 SD to -1.37 SD in their Weight-for-age z-scores)[46] also shows improvements in the motor development index (from 94.7 points before the intervention to 110.8 after). The index for the control group in comparison barely changes (from 102.6 to 105.3 points). Due to the focus of the paper (i.e. evaluation of the supplementation intervention in undernourished children) we can only compare the changes within the stunted children. Comparisons to another control group of non-stunted children would have been interesting to see the difference to their motor development index.

Children’s nutritional status and their lung capacity

Faridi et al (2012) study the effects of nutritional status on lung function of children. They studied 122 Indian children aged between 5 and 11 years, with 80 of them malnourished. While they found significantly reduced lung function in malnourished children, they urge to interpret their results cautiously.

Primhak and Coates (1988) have performed early - country research on the effects of malnutrition on the growth of lung function. As in the IFLS, they used measurements of the peak expiratory flow rate (PEFR) for lung capacity and height for age (HFA) and weight for height (WFH) scores. They studied 376 Indian schoolchildren aged between 6 and 12 years. They summarise their results as follows: 'After standardizing for height and sex, the PEFR of 30 wasted children (WFH below 80%) was significantly reduced ($p<0.01$), but that of 135 stunted children (HFA below 90%) was higher than average ($p<0.05$). It is concluded that current malnutrition has a negative effect on PEFR, possibly due to impaired muscle function, but that past or chronic malnutrition affects growth of lung function less than it affects somatic growth.' (Primhak and Coates 1988, p. 801).

Rajneet (2012) study the effect of malnutrition on lung volumes. They investigate 208 children in Jammu, India (male and female, aged between 7 and 14 years), 110 of them

[46] WAZ = Weight-for-Age Z-scores; No significant change in HAZ for both groups. However, change in height would not really be expected after such a short period of supplementation. And as the authors note, due to the effect of supplemented feeding on weight they would expect that if the intervention had lasted longer there would have been noticeable effects on height as well (p.803).

wasted and stunted. For the wasted and stunted children they found significantly reduced lung volumes (as compared to normal children).

Ji (2013) investigate the association between physical activity and lung function in children. The aim of this study was to evaluate children's lung function growth in relation to their level of physical activity. They studied 1713 children in Guangzhou, China with an average age of slightly below 10 years. They found a positive association between physical activity and lung function growth.

Overall, the evidence on the relationship between malnutrition and children's lung capacity is limited with only cross sectional studies investigating the relationship. Several of these studies found a negative relationship between current malnutrition and lung capacity. We are not aware of any studies for Indonesia investigating this relationship and also no studies that study the intergenerational link between parental resources and children's lung capacity. Providing some evidence with the unique feature of the IFLS is therefore a gap that we want to contribute to closing in this chapter.

6.4 *Research questions*

The aim of this chapter is to investigate the relationship between parental resources, children's earlier malnutrition and the dynamics of malnutrition between earlier childhood and adolescence with children's lung capacity.

Firstly, we are interested in examining the lung capacity of a cohort of children and see to what extent it is related to parental lung capacity and other socio-economic resources. We further examine to what extent children's nutritional status in earlier life and the patterns of children's nutritional changes over time (e.g. complete, partial or no recovery from earlier malnutrition) are associated with children's lung capacity. We discuss these two main research questions in more detail below.

Relationship between parental resources and children's lung capacity

To what extent are parental resources (individual-level: lung capacity, height, education; family-level: consumption, quality of living environment and family structure) associated with children's lung capacity (result from peak flow meter) in late childhood/ adolescence?

Some sub-questions that are examined as well are:

- Which parental resources show the strongest association?
- Are there differences in the association by paternal or maternal resources?
- Are there differences in the association by the age or gender of the child?

Relationship between malnutrition and children's lung capacity

To what extent are children's nutritional statuses in early childhood associated with the child's lung capacity in later childhood? For instance, do malnourished children fare worse in the lung capacity tests than children that were not malnourished in early childhood? To what extent are children's growth dynamics associated with their lung capacity? For example, do children that are chronically malnourished also fare worse in the lung capacity test?

Are there independent effect of malnutrition on later lung capacity after controlling for other features of children's background?

To our knowledge, there are no studies that explore children's lung capacity and its relationship with parental socio-economics resources and malnutrition for Indonesia. Using the IFLS data, we are able to use the unique feature of this physical health measurement and link children's early life experiences with outcomes in later childhood and adolescence. There are only very few studies from other countries and most of them are cross-sectional, not allowing to look at the dynamics of nutritional status (stunting) and its relationship with lung capacity.

6.5 Methods

Outcome variable: Children's lung capacity

Lung capacity was measured as part of a range of physical health assessment in the IFLS2 and onwards. A specially trained nurse who takes anthropometric measures, such as weight, height, blood pressure, pulse, lung capacity, and hemoglobin level, accompanies each household interviewing team. For lung capacity, measurements were taken for all individuals aged older than 9 years, using a peak flow meter. Such a device measures the rate in which air flows out of the lungs when the individual blows forcefully into the device. It is expressed as the peak expiratory flow rate measured in litre per minute (L/min). In medical assessments, peak flow meters are used to determine different respiratory capacities and can also help determine the extent and severity of asthma conditions in patients. The lung capacity measurement was repeated three times in IFLS2 and onwards. In this chapter, we use the average of the three values of these repeated measurements.

Figure 19: Device to measure children's lung capacity: peak flow meter

[Source: Authors photos taken during the piloting phase of IFLS4, on 17.11.2007, in Solo, Indonesia]

Multivariate regression model with unexplained residuals of later height

Similar to chapter 5, we are interested to assess the influence of nutrition in early childhood (proxy: height-for-age) on lung capacity as well as the influence of changes in height during later in childhood.

We follow the approach suggested by Keijzer-Veen et al, 2005. To be able to explore the association with lung capacity, we use a multivariate regression model containing height-for-age in earlier childhood and residual height in later childhood. We use the method of residual height instead of using the actual height in later childhood. The coefficients of such a multivariate regression model show the association with the outcome of lung capacity directly.

Analytical sample (Cohorts of children 3-36 months in 1993)

Similar to the other chapters 3 and 4 we use one 3-year-age-cohort that was 0-3 years old in 1993. Table 22Table shows the age of the 3-year cohort that we have chosen and the child outcomes that are available at different rounds.

Table 22: Ages of younger cohort in different IFLS rounds and child outcomes

Round 1 (1993)		**Round 2 (1997)**		**Round 3 (2000)**		**Round 4 (2007)**
~ 0-3 years (3-36 months)	Survey gap: ~ 4 years	~ 4-7 years	Survey gap: ~ 3 years	~ 7-10 years	Survey gap: ~ 7 years	~ 14-17 years
- Height & Weight - Lung Capacity: *not collected*		- Height & Weight - Lung Capacity: *not collected*		- Height & Weight - ≥9: Lung capacity		- Height & Weight - ≥9: Lung capacity

[Source: compiled by author based on IFLS documentation such as user guides, codebooks and questionnaires.] Notes: n=1,037

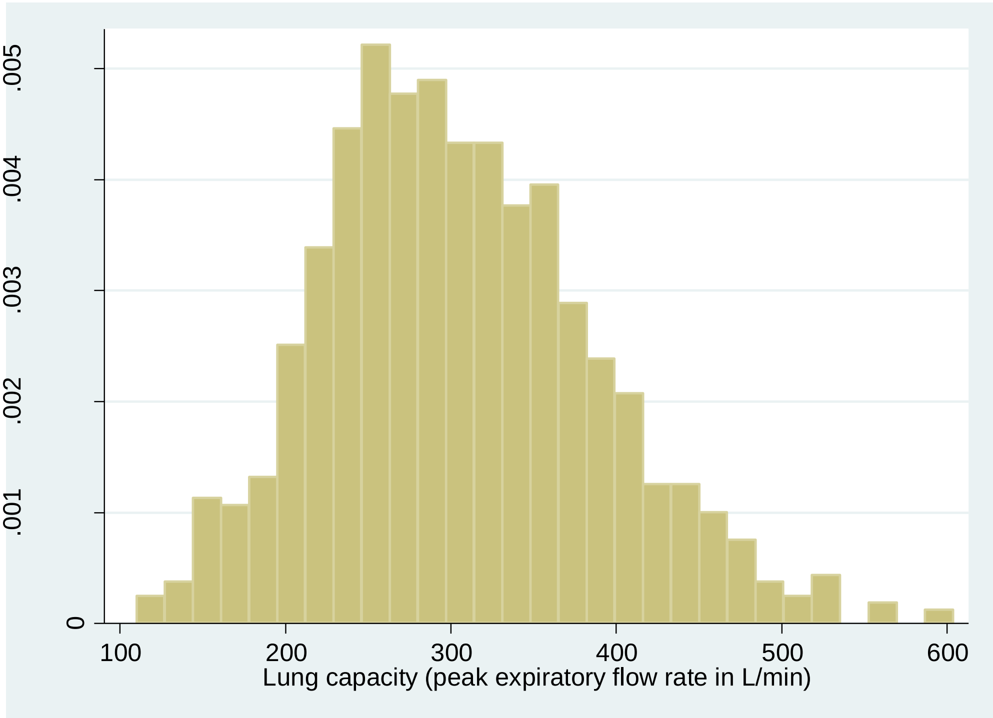
The table also shows which measures were only introduced in later rounds of the IFLS. Further, a lot of the measures in the IFLS are only available for school aged children or older. For example, the lung capacity measure is only collected from age 9 years onwards. Thus for round 3 in 2000 there are too few children over 9 years of age, so we concentrate on lung capacity in 2007 when all children are over 9 years and thus measured for their lung capacity.

6.6 Results

Descriptive results for children's lung capacity (14-17 years old)

Figure 20 displays the histogram for the outcome variable of children's lung capacity measured as their peak expiratory flow rate which is in the unit of litre per minute. As the histogram shows the range is from around 100 L/min to around 600 L/min. These substantial differences are probably due to the different ages we have in one cohort, namely 14 to 17 year olds but also as the differences between girls and boys are substantial with boys having on average bigger lungs and thus higher lung capacity than girls.

Figure 20: Children's lung capacity (peak expiratory flow rate in L/min)



[Source: compiled by author based on IFLS data in 2007]

Relationship between parental resources and children's lung capacity

We start by examining the results from linear regressions for the potential link between parental and child lung capacity measured by their peak expiratory flow rate (unit in litre per minute (L/min)). As discussed in 6.2 conceptually there could be direct and indirect links between parental and child lung capacity. Directly through organ growth and size, which is partly genetically influenced. Indirectly, as parents are exposed to the same hazards as their children – such as air pollution through forest fires or indoor pollution due to indoor stoves and parental smoking.

Table 23: Linear regression Lung capacity in 2007 (14-17yrs)

Independent variables	**Coefficient**	**95% Confidence Interval**
Age in years in 2007	15.54^{***}	[9.963, 21.11]
Female	$- 167.3^{**}$	[-39.21, -295.3]
Female * Age in years in 2007	14.87^{***}	[23.22, 6.510]
Father's lung capacity 2007	0.214^{***}	[0.158, 0.269]
Mother's lung capacity 2007	0.327^{***}	[0.269, 0.386]
Constant	-76.12^{*}	[-162.0, 9.743]
Observations	655	
R^2	0.582	

Marginal effects; 95% confidence intervals in brackets, (d) for discrete change of dummy variable from 0 to 1, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Lung capacity: mean of three measurements.

Table 23 shows the result from the linear regression analysis for children's lung capacity in IFLS 4 in 2007 when the cohort of children was aged 14-17 years old and their parental lung capacity. Children's age is positively significantly associated. For each year in age children's lung capacity increases by around 15 L/min. This is in line what we would expect as lungs are still growing in size and physical activity increases by child's age, which also enhances lung capacity. Similar expected is the differences in children's gender with females having a much smaller lung capacity due to smaller lungs. In our sample of 14-17 years old females have on average 167 L/min less lung capacity. The interaction between age and gender of the child is also significant.

Fathers and mothers own lung capacity are both significantly positively associated with children's lung capacity. The higher lung capacity of mothers and fathers the higher children's lung capacity. This could be due to the various routes we discussed under 6.2 via direct genetically links or via similar living environments, health behaviours and potential health treads. What is interesting is that the coefficient for maternal lung capacity is greater than that of fathers. A possible explanation could be that mothers as the main caregivers spend more time in the same environment as their children, so we would expect a closer relationship between maternal lung capacity and that of their child. Mothers probably also serve more as role model in health behavior than fathers who have a limited care responsibility. Relevant role model behavior could be in regards to physical exercise and mobility patterns (e.g. which mode transport is used, etc.).

Relationship between malnutrition and children's lung capacity

Table 24 shows the regression results for children's lung capacity in 2007 aged 14 to 17 years old with stunting status in early childhood added.

Table 24: Lung capacity in 2007 (14-17 years) and 1993 Stunting

Independent variables	**Coefficient**	**95% Confidence Interval**
Age in years in 2007	15.36***	[9.801,20.91]
Female	- 165.0**	[-37.39,-292.5]
Female * Age in years in 2007	14.78***	[23.10,6.451]
Father's lung capacity 2007	0.208***	[0.152,0.263]
Mother's lung capacity 2007	0.324***	[0.266,0.383]
Stunting 1993 (aged 0-3 years)	**-10.12****	**[-18.26,-1.984]**
Constant	-65.48	[-151.4,20.49]
Observations	655	
R^2	0.586	

Marginal effects; 95% confidence intervals in brackets; (d) for discrete change of dummy variable from 0 to 1
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

The results for age, gender and parental lung capacity are similar to what we reported in Table 23, so we just concentrate on the newly added variable if children were stunted in early childhood in 1993 when aged 0-3 years old. As the regression results show, children that have been stunted in early childhood have a significantly reduced lung capacity by 10 L/min compared to children that were not stunted in early childhood. This association could support the conceptual link we have described in section 6.2 with malnourished children being more likely to experience illnesses such as respiratory illnesses which can affect children's lung capacity. Malnutrition has also been reported to lead to poor organ growth of lungs themselves but also the wasting of important muscles necessary for respiratory functioning (Kaur Rajneet 2012).

Lung capacity & dynamics of stunting

We follow the categorisation of stunting dynamics used by similar studies for Peru (Crookston, Penny et al. 2010) and Philippines (Adair 1999) on catch-up growth.

Table 25: Lung capacity by dynamics of stunting

Dynamics of Stunting	n	Lung capacity (in L/min)
Never: Not stunted in early childhood nor adolescence	444	316.9
Catch-up: Stunted in early childhood not adolescence	211	313.9
Deteriorate: Not stunted in early childhood but in adolescence	110	273.8
Chronic: Stunted in early childhood and in adolescence	171	287.3
Total	936	100.00

Figure 21: Lung capacity by stunting dynamic

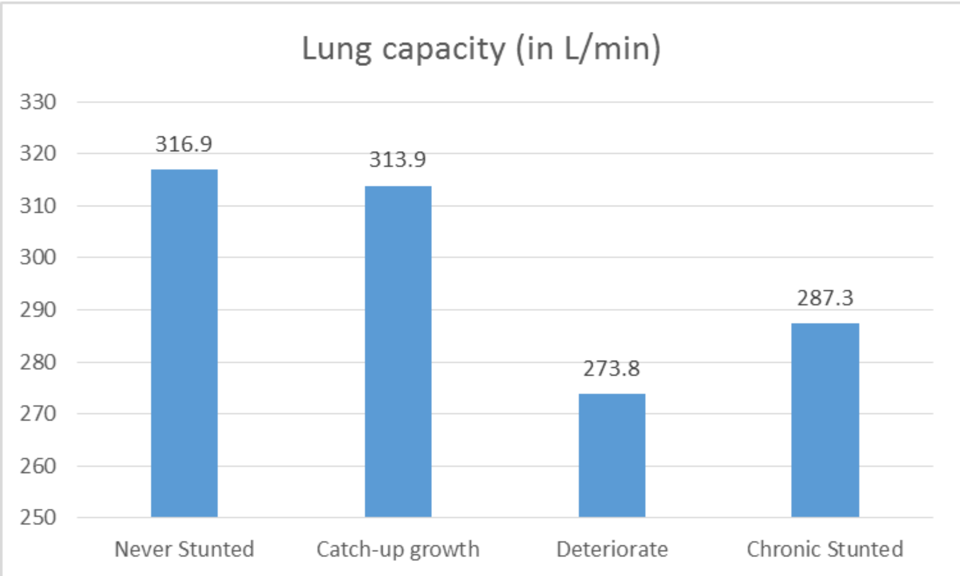


Table 25 shows the descriptive results of the lung capacity of children by their stunting classification. As expected the never stunted children, those that were not stunted in early childhood, aged 0-3years and not stunted in adolescence, aged 14-17 years, have the higest lung capacity with around 317 L/min peak expiratory flow rate. The chronic stunted who were stunted in early and later childhood have a lung capacity of around 30 L/min lower with 287.3 L/Min. This however is not the lowest measure. The lowest lung capacity is for children whose nutritional status deteriorates, i.e. that were not stunted in early childhood but are stunted in adolescence. These children have a lung capacity measure of 43 L/min lower than the never stunted. These results are similar to what we find with the cognitive outcomes where the children whose nutritional status determinate are also the worst of in their outcomes. This could suggest that there is a sort of resilient mechanism for the chronic children that protects them from the worst case outcomes. And that for the children that deteriorate in their nutritional status do not display this resilience.

Table 26: Lung capacity in 2007 (children aged 14-17 years)

Independent variable	Coefficient	95% Confidence interval
Age of child in years (2007)	10.58***	[4.969, 16.19]
Female (d)	-41.85***	[-59.07, -24.63]
Female*Age	-0.973**	[-1.774, -0.171]
HAZ (1993)	**0.641**	**[-1.750, 3.031]**
Residual HAZ (2000)	**4.600****	**[0.148, 9.052]**
Mothers lung capacity (2007)	0.335***	[0.275, 0.396]
Fathers lung capacity (2000)	0.212***	[0.155, 0.269]
Mother's years of schooling	1.135**	[0.0606, 2.210]
Constant	63.99**	[13.96, 114.0]
Observations	611	
R^2	0.601	

(d) for discrete change of dummy variable from 0 to 1 ; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

A key result from table 26 is that in terms of parental resources there is a strong positive association between father's and mother's lung capacity and their children in adolescence. Also maternal years of schooling is significantly associated. We did not find a significant positive association between initial/early height-for-age (HAZ) and lung capacity. This would work against the hypothesis on early sensitive periods and rather point to the importance of changes in growth after early childhood for children's lung capacity development. The changes in growth into middle childhood (residual HAZ) is significant positive associated with children's lung capacity. These result differ from what we have found for cognitive outcomes were early growth status and changes in growth were both relevant.

6.7 Conclusions

Childhood disadvantages in health and nutrition can have long lasting effects over the life-course and even be transmitted over generations. This chapter has asked to what extent children's nutritional outcomes in early childhood and their dynamic (i.e. change over time) as well as parental resources influence children's lung capacity in adolescence.

To the best of our knowledge, there are no studies that investigate the links between children's nutritional status, parental resources, and children's lung capacity in Indonesia. More generally, in the literature, there is comparatively sparse evidence on children's lung capacity partly due to the fact that taking lung capacity measurements is costly. The few studies that exist often only use cross sectional studies.

We used a unique feature from the Indonesian Family Life Survey (IFLS) – the peak flow meter results for children's and parents lung capacity. The IFLS is a rich panel data set consisting of four waves of data which spans over a period of 14 years. We studied a cohort of 1,037 children who were between 3 and 36 months old in the first wave of the IFLS in 1993 and for whom we can observe health outcomes in all four waves. Providing some evidence with the unique feature of the IFLS is therefore a gap that we wanted to contribute to in this chapter.

We started by examining the results from linear regressions for the potential link between parental and child lung capacity measured by their peak expiratory flow rate (unit in litre per minute (L/min)). Conceptually there could be direct and indirect links between parental and child lung capacity. Directly, through organ growth and size, which is partly genetically influenced. Indirectly, as parents are exposed to the same hazards as their children. We find that father's and mother's own lung capacity are both significantly positively associated with children's lung capacity. What is striking is that the coefficient for maternal lung capacity is greater than that for fathers. A possible explanation could be that mothers as the main caregivers spend more time in the same environment as their children, so we would expect a closer relationship between maternal lung capacity and that of their child.

We also examined whether children who were stunted in early childhood in 1993 when aged 0-3 years old have worse lung capacity than children who were not stunted in infancy. Children that have been stunted in early childhood have a significantly reduced lung capacity by 10 L/min compared to children that were not stunted in early childhood. This association could support the conceptual link we have described in section 6.2 with malnourished children being more likely to experience illnesses such as respiratory illnesses which can affect children's lung capacity. Malnutrition has also been reported to lead to poor organ growth of lungs themselves but also the wasting of important muscles necessary for respiratory functioning (Kaur Rajneet 2012).

As for the relationship between nutritional dynamics of children and their lung capacity, we report descriptive results by children's stunting classification. As expected, the never stunted children, those that were not stunted in early childhood, aged 0-3years and not stunted in adolescence, aged 14-17 years, have the highest lung capacity with around 317 L/min peak expiratory flow rate. The chronic stunted who were stunted in early and later childhood have a lung capacity of around 30 L/min lower with 287.3 L/Min. This however is not the lowest measure. The lowest lung capacity is for children whose nutritional status deteriorates, i.e. that were not stunted in early childhood but are stunted in adolescence. These children have a lung capacity measure of 43 L/min lower than the never stunted. These results are similar to what we find with the cognitive outcomes where the children whose nutritional status determinate are also the worst of in their outcomes. This could suggest that there is a sort of resilient mechanism for the chronic children that protects them from the worst case outcomes. And that for the children that deteriorate in their nutritional status do not display this resilience.

A key result is that in terms of parental resources there is a strong positive association between father's and mother's lung capacity and their children in adolescence. Also maternal years of schooling is significantly associated. We did not find a significant positive association between initial/early height-for-age (HAZ) and lung capacity. This would work against the hypothesis on early sensitive periods and rather point to the importance of changes in growth after early childhood for children's lung capacity development. The changes in growth into middle childhood (residual HAZ) is significant positive associated with children's lung capacity. These result differ from what we have found for cognitive outcomes were early growth status and changes in growth were both relevant.

To conclude, we provided to the best of our knowledge, first evidence concerning the possible links between children's nutritional status in early childhood and dynamics into adolescence, parental own lung capacity and children's lung capacity in Indonesia.

CHAPTER 7: Conclusion

"Children are one third of our population and all of our future."
~ Panel for the Promotion of Child Health, 1981

The majority of children in the developing world are suffering from hardship and poverty, and are not able to reach their full developmental potential. Nutrition, cognition and physical health outcomes are key human capitals that are important both as an end in their own right and as a means to achieve wellbeing (Sen 1999). They have been identified as some of the main routes for changes in well-being over the life-course and seen as significant pathways for breaking intergenerational poverty cycles and reversing disadvantaged starts in life. This thesis has focused on the relationship between parental socio-economic resources and children's outcomes in the areas of nutrition, cognition, and physical health over children's life-courses.

This chapter is the concluding chapter of the thesis and summarises the main points of the thesis and discusses the implications for future research and policy. It is structured as follows. Section 7.1 reviews the research questions, summarises the findings and discusses the limitations of the research. Section 7.2 discusses recommendations for future research; for example, how new data collection efforts in Indonesia could contribute to closing evidence gaps on children's life chances identified in this thesis. We address the following issues in more detail: Firstly, the lack of birth cohort data. Secondly, we review briefly some good practices and examples how such data could be collected – e.g. similar to the Young Lives Dataset for India, Vietnam, Peru and Ethiopia. Section 7.3 addresses the implications for policy covering recommendations for more holistic interventions, the kind of support given and targetting of vulnerable children.

7.1 *Summary of the research questions, findings and limitations*

Summary of the research questions

The overall aim of the thesis was to shed some light on life chances of children growing up in Indonesia in the areas of nutrition, cognition and physical health. Evidence on children's life chances from Indonesia is very limited and we set out to make a contribution in providing evidence on some child outcomes that are uniquely featured in the Indonesian Family Life Survey (IFLS), which collected measures of children's nutritional, cognitive and physical health outcomes. This data represents some of the most reliable parts of the IFLS. To the best of our knowledge, there are very few previous studies for Indonesia that investigate these child outcomes, especially with the focus of the intergenerational link with parental resources.

Chapter 4 investigated the link between parental resources and 1) children's malnutrition (stunting) in early childhood and 2) children's malnutrition dynamics over childhood and young adolescence. There is an ongoing debate in the literature whether children are able to recover from earlier nutritional shocks or whether that damage is irreversible.

Chapter 5 builds on chapter 4 by focusing on the consequences of children's nutritional outcomes on children's cognitive outcomes. More specifically, we investigated the link between parental resources, children's early and later nutritional status and their cognitive outcomes. The cognitive outcome that we focused on was the results from the Raven's colour progressive matrices test conducted by the IFLS team.

Chapter 6 also builds on chapter 4 by focusing on the consequences of children's nutritional outcomes on another important area of children's wellbeing – their physical health outcomes. We investigated the link between parental resources, children's early and later nutritional status and their physical health outcomes. The physical health outcomes chosen were the lung capacity of children. A specially trained nurse accompanies each household interviewing team and assesses lung capacity for all survey respondents older than nine years, using a peak flow meter.

Summary of findings from the three empirical chapters

Chapter 4 investigated the link between parental resources and children's malnutrition (stunting) in early childhood and children's malnutrition dynamics over childhood and young adolescence. Of the cohort of 1,037 children that are in our analytical sample, 416 children (40.1% of the sample) are stunted in early childhood aged 3-36 months. From the results of the transition tables for the stunting prevalence in early, later childhood, and in adolescence we have seen that the majority of children stay stunted but there are still around 30% of the children that are able to recover from stunting. For parental resources, we found that maternal human resources are consistently higher and more significantly associated with children's nutritional status than father's resources. This could be due to the important role of mothers during pregnancy and breast-feeding periods but also due to them being the main carers for their children with feeding and health behaviour and knowledge. While mother's characteristics are more closely associated with children's outcomes, fathers' human resources nevertheless have a consistent and independent effect on children's malnutrition even after controlling for maternal human resources. Often surveys do not collect information on father's characteristics and thus cannot examine the extent father's resources have for children's outcomes.

Apart from parental human resources, we also found that direct measures of living standards (like cleanliness, indoor water sources) have a stronger association than more indirect measures such as financial resources (i.e. per capita consumption). Conceptually finding a stronger relationship for direct measures of living standards on children's nutritional status makes sense, as cleaner living environment and indoor water sources reduce the risk of illnesses such as diarrhoea, which in turn protects children from nutritional deficits. It also could reflect that financial resource data is difficult to collect and is measured with more error. Family structure was another important factor as well, that is not looked at very often in other studies. The number of children and the birth order are factors that are associated with children's likelihood of being malnourished and being less likely to recover from stunting later on. For dynamics of stunting, such as the reversal of stunting between early childhood and adolescence, maternal height is again significantly associated with children having higher probability of experiencing reversal of stunting. Similarly to stunting in childhood, father's height is also significant, but the effect size is smaller. Parental education is not significant for the probability of reversal but financial resources are. While the effect size and significance level was low in the stunting model for early childhood, for recovery from stunting it is significant.

After we have examined children's nutritional status we were then interested to see what the consequences are for other areas of children's wellbeing. The next chapter therefore looked at the consequences on children's cognitive outcomes.

Chapter 5 investigated the link between parental resources, children's early and later nutritional status and their cognitive outcomes. The cognitive outcomes are test results from the Raven's colour progressive matrices test - a non-verbal problem solving skills test.

We found that early height-for-age (HAZ) has an independent effect (even after controlling for later height) on cognitive processes which could support the hypothesis on early sensitive periods for cognitive process development and the important role of prenatal influences up to the early childhood measure. However, what happened to children after first five years of life (i.e. the changes in height during middle and later childhood) is also significant supporting insights from neuroscience that brain development is more complex than previously thought and plasticity of the brain an important factor. The association between early HAZ and cognitive outcomes survives but is attenuated by later HAZ in a substantial way. We suspect that the observed observation would even be stronger, if instead of Raven's test results (a measure of general cognition) more specific tests for working memory would be available (the area that is most effected by malnutrition).

As for parental resources, schooling and financial resources do not stay significant in the full model, only housing conditions do. This could have two reasons: firstly, that there is really no relationship or Secondly, that these are not good measures of parental resources (but the best one that is available).

The results still reveal some insights on factors that are associated with cognition and there are not many studies for Indonesia; for example we find that pre-school experience, presence of grandparents, quality of living environment and being Muslim are associated with test results. We also find a rural area disadvantage that seems fully accounted for once we include electricity and indoor water facilities.

After we have examined the consequences of parental resources and children's nutritional status on cognitive outcomes, we turned to an outcome for children's physical health to see if there are similar associations to cognitive outcomes.

Chapter 6 investigated the link between parental resources, children's early and later nutritional status and their physical health outcomes. The physical health outcomes chosen were the lung capacity of children. To the best of our knowledge, there are no studies that investigate the links between children's nutritional status, parental resources, and children's lung capacity in Indonesia.

We started by examining the results from linear regressions for the potential link between parental and child lung capacity measured by their peak expiratory flow rate (unit in litre per minute (L/min)). Conceptually there could be direct and indirect links between parental and child lung capacity. Directly, through organ growth and size, which is partly genetically influenced. Indirectly, there could be links, because parents are exposed to the same hazards as their children. We find that father's and mother's own lung capacity are both significantly positively associated with children's lung capacity. What is striking is that the coefficient for maternal lung capacity is greater than that for fathers. A possible explanation could be that mothers as the main caregivers spend more time in the same environment as their children, so we would expect a closer relationship between maternal lung capacity and that of their child.

We also examined whether children who were stunted in early childhood in 1993 when aged 0-3 years old have worse lung capacity than children who were not stunted in infancy. Children that have been stunted in early childhood have a significantly reduced lung capacity by 10 L/min compared to children that were not stunted in early childhood. This association could support the conceptual link with malnourished children being more likely to experience illnesses such as respiratory illnesses which can affect children's lung capacity. Malnutrition has also been reported to lead to poor organ growth of lungs themselves but also the wasting of important muscles necessary for respiratory functioning (Kaur Rajneet 2012).

As for the relationship between nutritional dynamics of children and their lung capacity, we report descriptive results by children's stunting classification. As expected, the never stunted children, those that were not stunted in early childhood, aged 0-3years and not stunted in adolescence, aged 14-17 years, have the highest lung capacity with around 317 L/min peak expiratory flow rate. The chronic stunted who were stunted in early and later childhood have a lung capacity of around 30 L/min lower with 287.3 L/Min. This however is not the lowest measure. The lowest lung capacity is for children whose nutritional status deteriorates, i.e. that were not stunted in early childhood but are stunted in adolescence. These children have a lung capacity measure of 43 L/min lower than the never stunted. These results are similar to what we find with the cognitive outcomes where the children whose nutritional status deteriorates are also the worst off in their outcomes. This could suggest that there could be a resilient mechanism at work for the chronic stunting children that protects them from the worst case outcomes. The children that deteriorate in their nutritional status do not display this resilience.

Limitations of the research due to the IFLS Data

Here, we discuss a few limitations of the research presented in this thesis, to facilitate careful inferences and appropriate conclusions for policy making. We focus on limitations due to the nature of the collected data.

As unrivalled effort to collect longitudinal household data in developing countries, IFLS is an invaluable resource with unique features to study children's life chances. However, the very nature of the data collection in a developing country setting, and the particular design of IFLS entail a number of limitations in the data that are important to take into account. We discuss the most important ones in the following, and also mention how we dealt with them.

Gaps between the different survey waves

We do not know what happens to children between the survey rounds and before 1993. However, follow up studies in developing countries into later childhood and adolescence all suffer from this problem and there is no alternative to this. This leaves us to be cautious about the claims of how persistent stunting is or how circumstances changed in between survey rounds. In response to this limitation, we chose stunting as it is a long-term measure with less fluctuations than weight or occurrence of illnesses – this could help us to be more confident that gaps between the data points are not as relevant.

No information on the onset (i.e. timing) of stunting

The IFLS does not have the information on the timing when children first experienced stunting. For correct information on this, one would need to follow children (especially in the first two years of life) with a higher frequency. For example, the CEBU study from the Philippines collected bimonthly data on children's anthropometrics. However, the IFLS is not a one-year birth cohort but a multi-cohort study that was not designed for the specific purpose of assessing children's nutrition and health status. Furthermore, it is much larger in scope trying to be nationally representative – the CEBU study for example only covers the metropolitan area of the CEBU island in the Philippines. While it is understandable that it was not in the scope of the IFLS to provide this data, research from the Philippines has shown that the onset of stunting has a significant effect on cognitive scores in later childhood (Mendez and Adair 1999). We only know whether children were stunted or not at the time of the survey. In response to this problem, we chose the sample so that children are likely to have experienced stunting (e.g. after 24 months – as previous research has shown that children's stunting peaked at two years). As explained above, we do not know when onset of stunting happened. However, as the research from the Philippines has shown, the onset of stunting is related to the severity of stunting. As they show, children that experienced stunting earlier were also more likely to be more severely stunted by the age of 2. So including the severity of stunting does to some extent capture the effect of when the onset of stunting happened.

IFLS is not specifically designed for child development issues

The Indonesian Family Life Survey was not specifically designed with a focus on children. It is a household survey with multiple cohorts encompassing all ages from 0 to 99 years. It is a multi–purpose study that has a very wide range of topics it covers from agriculture, use of contraceptives, consumption, crime (since IFLS4), farm and non-farm businesses, migration etc. Thus, the IFLS does not contain a battery of child specific outcomes let alone specific for their developmental stage. This is important to keep in mind when comparing it to birth cohort studies that solely study one age cohort and follow them over time. Birth cohort data allows collecting very specific and numerous data on children's cognitive and behavioural outcomes with developmental specific batteries of tests and questions. For example in the IFLS, there is a the lack of detailed information on childcare practices, maternal mental health, learning environment of the child or aspirations of parents – all likely processes through which parental socio-economic resources influence children's outcomes.

All things considered, IFLS is a nationally representative, longitudinal dataset and has very low attrition and is thus a good quality dataset. It also contains some information on children's outcome and quite detailed information on socio-economic resources – much more detailed than in most birth cohort studies. One recommendation for data collection in Indonesia would therefore be to have a longitudinal birth cohort dataset that can focus more closely on child specific development outcomes and detailed information on processes of child care etc. Another valuable extension would be to expand the child specific outcomes that are collected in the IFLS to introduce some more detailed and age specific child outcome measures.

7.2 Implications for future research

Extend intragenerational research with the life-course perspective

A key concern of this thesis is to study the intergenerational determinants of child outcomes, that is, asking to what extent parental resources are linked to the level of children's nutrition, cognition, and health. Further, we also investigated the intra-generational link – that is to what extent earlier nutritional status is linked to later growth and other cognitive and health outcomes over children's life-course.

Combining the intergenerational and life-course perspective is important as the link between children and parents is not a static one but rather dynamic in nature as is children's development. So bringing these two perspecitves together – the intergenerational and children's life-course – is an important area for future research.

Data collection to close the evidence gap on children's life chances in Indonesia

The research presented in this thesis suggests several avenues for future research. First and foremost, there are suggestions for data collection in Indonesia, as we have found several limitations of the evidence base for investigating children's life-chances in Indonesia.

How could new data collection efforts in Indonesia contribute to closing the evidence gap on children's life chances? Especially lacking are both birth cohort data and randomised control trial (RCT) evaluation for child and family interventions.
For the former, there are some good practices to build on, such as the "Millenium Cohort Study" in the UK or for developing countries the "Young Lives Study" led by a team of researchers at the Univeristy of Oxford and partners in the four developing countries the study is conducted – i.e. Ethiopia, India, Peru and Vietnam. For more information visit: www.younglives.org.uk.

A similar birth cohort study for Indonesia would allow more child specific and developmental age appropriate measures for children's outcomes and a large enough sample size as well as rich parental socio-economic and other control variables measured at the same age of the child.

Smaler scale randomised control trial (RCT) of evaluation for child and family interventions with baseline data and longer follow-up could be another options to extend the research on children's live chances in Indonesia.

Investing in making the IFLS more user-friendly

Any type of empirical research – but especially longitudinal – faces many challenges in developing countries: data collection, re-contact rates and attrition are particular difficult. However, for the purpose of my thesis, I have identified a data set, the Indonesian Family Life Survey (IFLS), which is a longitudinal study with four waves of data, spanning a period of 14 years and low attrition rates: a rare data set in a developing country context. Using the IFLS data set has allowed me to study children's outcomes over their life-course stages of early childhood into adolescence.

While the availability of longitudinal data from IFLS is very important, the setup and design of the data has presented an enormous challenge. Unlike with longitudinal datasets from developed countries, such as the British Household Panel Survey (BHPS) or the cohort studies, the IFLS data is presented more or less in raw form only. A lion's share of the research time has gone into preparing the raw data for quantitative analysis. And all researcher wanting to work with the IFLS are faced with the same problem. A better example is to centrally preparing the data to make it more userfriendly and more accessible for a wide range of researcher as it is done with the BHPS by ISER.

However, for the IFLS the data management and cleaning is nearly entirely left for each single user. This is not only a waste of value research time but also a source for errors and a tremendous barrier for researchers to use the dataset. And the IFLS is underused as a result of this.

Nevertheless, in light of the importance of the topic at stake, and in light of the fact that one of the most difficult steps in the whole process -- the collection of longitudinal data over 14 years in a developing country -- have already been completed, it would be a key contribution to get the financial resources from donor countries to have a team of ISER-like data managers to convert the IFLS into a more user-friendly and accessible dataset. Other alternatives could be to encourage and facilitate the open-source sharing of STATA do-files and a recognition of data management and programming work similar to cited references for other research outputs.

Donor support for capacity building in local analysis skills of datasets like the IFLS

Relatedly to the above point, data analysis skills of local researchers in developing countries are not supported enough. Often donors just provide the financial resources for data collection and as we have discussed not even data management and making it more user friendly let alone financing the capacity building of local researchers to analyse the IFLS data.

What I have observed during my research visits in Indonesia and heard in numerous discussions with Indonesian researchers is that data collection is mostly driven by donor countries with little skills developed locally in Indonesia to analyse the existing data. Moreover, decisions about what research questions are asked and the focus of surveys are linked to active research being conducted – with the IFLS this is mostly done in developed countries, even more centralised – mostly in the US with a high concentration around the universities and research institutes of the principal investigators of the IFLS. Building local capacity of quantitative analysis skills in Indonesia together with efforts to make the IFLS more user-friendly would increase the use of one of the few longitudinal datasets available and help to close urgently needed evidence for developing countries.

7.3 Implications for policy

Towards more holistic policy interventions and evaluations

As the results from this thesis indicate, children's nutrition and growth throughout childhood is important not only for its own sake but also for the link to cognitive ability and lung capacity – this should be reflected in the holistic design of interventions and impact evaluations.

The thesis has shown that children's nutritional status and growth is dynamic – i.e. that there are movements in and out of stunting between early childhood and adolescence. Furthermore, the results in the thesis point to the interrelationship with other areas of child development. This could have policy implications in designing more holistic policy interventions that cover more than one child development area.

Several reviews of child interventions emphasis this holistic approach by advocating to combine children's nutritional, health, hygiene and early cognitive development intervention (Engle et al. 2011; Vazir et al. 2013; Hamadani et al. 2014; Ngure et al. 2014; Baker-Henningham and López Bóo 2010; Black and Dewey 2014). Especially the review by Engle et al. details numerous interventions in developing countries that successfully integrated health and nutrition services with early learning in child and family interventions (Engle et al. 2011).

Also for evaluating the impacts of intervention a more holistic arroach should include wider areas of child development that are investigated due to the interrelationships between children's outcomes.

Assess kind of support – monetary or in-kind improvements of living standards

We found that the role of financial resources (indirect measures) and various aspects of living conditions (direct measures) have varying importance in the recovery from stunting. This raises interesting questions about whether support should be primarily monetary or in-kind improvements to the living environment such as sanitation, indoor water supply and the cleanliness of the living environment. There are some indications from other studies that point to the importance of hygiene and improving direct living standards that support this point (Ngure et al. 2014; Ruel and Alderman 2013; Hamadani et al. 2014). Combining financial resources, providing in-kind improvements of the living environment and encourage behaviour and knowledge of nutrition, health and early cognitive stimulation could be implemented with conditional cash transfers. However the evidence is mixed with positive results from evaluations in Mexico and negative from Brazil with families fearing to loose benefit if child grew well (Engle et al. 2011). Good communication about benefit elegibility and programme setup seem crucial in this respect.

Targeting of disadvantaged families – especially with older children

As the results have shown, stunting in early childhood is more universal in Indonesia and in adolescence is it more stratified by parental resources. This implies the potential for targeting resources at families with older children who experienced disadvantage earlier in childhood, to run alongside preventative measures for younger children. Family-level interventions could also be beneficial as the results for lung-capacity showed with a strong association between parents' and childrens' lung capacity. How important the success of interventions is that is implemented through families and caregivers and winning families as partners is concluded by several reviews of child and family interventions in developing countries (Engle et al. 2011; Baker-Henningham and López Bóo 2010).

Conclusions

This chapter discussed recommendations for future research; for example, how new data collection efforts in Indonesia could contribute to closing evidence gaps on children's life chances identified in this thesis by for example collecting birth cohort data or extending the IFLS. We also address implications for policy covering recommendations for more holistic childhood interventions, the kind of support provided and targetting of vulnerable children.

Evidence on children's life chances from Indonesia is very limited. I set out to make a contribution in providing evidence on child outcomes that are uniquely featured in the Indonesian Family Life Survey (IFLS). My key concern has been studying the intergenerational determinants of child outcomes, that is, asking to what extent parental resources are linked to the level of children's nutrition, cognition, and health but also the intra-generational link – that is to what extent nutritional status is linked to later growth dynamics and other child outcomes such as cognitive and health outcomes.

To the best of my knowledge, there are very few previous studies for Indonesia that investigate these child outcomes, especially with the focus on the intergenerational and life-course determinants for these important child outcomes. It is worth noting that the implications of the results presented in the thesis extend beyond the Indonesian context, especially in so far as the analysis of stunting dynamics – in itself and in relation to other child outcomes such as cognitive abilities and lung capacity are important and rare.

Appendices

Appendix 2.1: Grid of studies on children's outcomes from Indonesia

I) Pre-School-Age Outcome: Health – e.g. Service use of prenatal and delivery care, reported morbidities

Study (Author, Date, Title)	**Data** (time period); [Sample size]	**Independent Variables**	**Outcomes** (by life-stage)	**Control variables**	**Analytical Sample & Estimation method**	**Key results**	**Notes**
(Beegle, Frankenberg, & Thomas, 2001): *"Bargaining power within couples and use of prenatal and delivery care in Indonesia"*	Indonesian Family Life Survey (1997, 2nd wave) [<7,500 hh & <30,000 individuals]	Woman's status relative to that of partner: - Wife's relative assets shares reported by wife in three categories 0-25%, 26-75%, 76-100% [derived from 5 most commonly assets: house, vehicles, appliances, jewellery, furniture & utensils], - women better educated than their husbands, - at time of marriage woman from family of higher social status - wife's father better educated than her father-in-law	Service use of prenatal and delivery care: - Pre-natal care - five outcomes: if any care received; number of check-ups (negative binominal); timing of visits in trimesters – logit regression) - delivery care (location of and assistance at birth – e.g. at home with traditional birth attendance)	- overall value of assets (spline with knots at each quartile) - overall level of education (in years and indicator variables for each year of education) of husband and wife - age of husband and wife - residence - year of pregnancy & year of birth	Group most likely to use pre-natal care: married women aged 15-49 in 1997 and their husbands & who had a child in the last five years (e.g. between 1993-1997): 1679 couples - negative binominal regressions, logit and multi-nominal regressions (clustered at the hh level) and robust to heteroskedasticity estimators	<u>For prenatal care:</u> - women with assets shares (up to the 25% - ca. half the sample) are more likely to use pre-natal services, assets beyond 25% yield little advantage; - women from families with higher social status obtain more prenatal care and 5% more likely to receive care in 3rd trimester - if father is better educated has no independent effect on pre-natal care choices - better educated women use more services (especially early in the pregnancy – 9% more in first trimester) - overall education shows that women's education positive and significant and men's positive but not significant and also effect smaller in size <u>For delivery care:</u> - relative to reference category (birth delivered at home with traditional midwife), asset ownership up to 25% more likely to give birth in hospitals or private clinic or have trained midwife at home; also more likely if father more educated than father-in-law & if from higher social status	- context: reproductive health programmes not universal; maternal mortality rates relatively high - power variables collected from 2nd wave of the IFLS on - Questions: Not clear why they chosen the three categories of women's share the way they did. Also no control for current hh expenditure. - For my own research: good context of reproductive health systems in Indonesia (p. 131-133) - Table 1 & 2 useful (e.g. for details on assets owned etc.)
(Cameron & Williams, 2009): *"Is the Relationship Between Socioeconomic Status and Health Stronger for Older Children in Developing Countries?"*	IFLS 3 (2000)	Alternative measures of hh financial resources (p. 306) 1) Log of annual hh income (sum of earnings, asset incomes, transfers, pensions, scholarships, etc.) 2) Log of annual hh consumption: food and nonfood– bought and self-produced 3) Log of hh wealth: sum of current value of hh assets & business assets (house, land, livestock, etc.)	Different measures of child health (p. 306): 1) Parent reported (subjective): "In general, how is health now?" [Combined category 1,2 & 3,4]; p. 306; 2) Nurse assessed assessment (subjective) (categories 1,2,3 combined & 8,9) 3) Nurse measured (objective): height, weight, haemoglobin (but only in sensitivity analysis)	(p.306-307) – Appendix A1 (p.322-323): child age, sex; parental age, education, presence in the hh; hh religion, location (rural/urban), hh size (log), person who answered health assessment	- children aged 0-14 (limit sample to these as hh resources endogenous when children work and contribute to hh resources); use age groups: all ages; 0-3; 4-7; 8-11; 12-14 - nonparametric, locally weighted regressions (p. 307 & figure 1 p. 308-309) for health status & HH resources - ordered probit regressions for child health status (1=very healthy, 2=somewhat healthy, etc.) - Sensitivity analysis (p. 311ff): 1) parents vs child health report differ; 2) Sample selection bias due to	- low income adversely affects health, e.g. doubling hh income is associated with an average increase in the probability of reporting being very healthy by 1.1 percentage points or 10.4% (p. 313) - but this does not differ by age of the child (i.e. impact of income upon health does not seem to accumulate over time of child's life). Results differs to developed countries – authors show that acute conditions like diarrhoea and respiratory infection (higher prevalence and severity in younger children) rather than chronic ones (which are also more likely to affect older children) affect Indonesian parent's assessment of their children's health (p.305) - Summary statistics appendix A1, p. 322-323 - maternal education (mother completed primary school) has an important determinant of general health status of children under age of 3 years (p. 311) - even after controlling for health at birth (birth weight) household resources are still significant determinant of health status – p. 317	- RQ: Does the effect of income differ for different ages of children – e.g. is stronger for older children? - Mechanisms for relationship between parental income and child health (p.303): provide better nutrition, medical care, health insurance, access to safer environments - Other parental characteristics that are correlated with income: poor genetics, health related behaviour - Good discussion on different health measures (p. 304-305) - parent-reported and nurse assessed health data only collected from 2nd wave onwards, nurse assessed health data not publicly available) – p. 306 - Good example for sensitivity analysis but quite abbreviated text - only 50% of sample have birth weight available and less likely to be available from poor hh (p. 316) - Q: How exactly they constructed financial resources variables (Find out if aggregated files available from authors?)

					infant mortality (include age & lowest health status for dead children); 3) error in parent health reports; 4) poor health at birth (birth weight less then 2500g (7.6% sample); 5) Poor parent health	- including parental health shows large and significant effect of parental health on child health – e.g. a mother who reports being "very healthy" has 19 percentage points higher chances of reporting good health as well (p. 318). The coefficient of hh resources are largely unaffected by this inclusion	- They never included all measures in one regression just as alternative measures of resources
(Nobles & Frankenberg, 2006): "*Mother's Community Participation and Child Health"*	IFLS2&3 (p.11f)	mothers' access to social capital via participation in community key community programs: community meetings, cooperatives, voluntary labor, village improvement activities, and the village women's association (p.15) - log of per capita monthly household expenditures, - maternal education (dummy if 6yrs of education or less, p.15)	children's health: (1) *Child Height-for-Age*	- age, and number of children, the child's gender and age, and household location (urban or rural). - measures of maternal kin support (p.15)	- n= 5,144 children whose height was measured in 2000 and whose 3,281 mothers provided data in the 1997 wave of the IFLS (p.11) community fixed effects	- children from families with relatively low levels of human and financial capital fare better with respect to health status when their mothers are more active participants in community organizations. - the association between maternal participation and child health is strong and positive only for children from relatively disadvantaged backgrounds, as measured by their mothers' educational and household economic resources	- Q: age of children is 0-14?
(Park, 2007)	- IFLS3 - Indonesian Population Census 2000	- current sex ration - premarital assets - non-labour income - hh income - hh assets	- child's height 0-37months	• For details below (school-aged educational outcomes)			
(Thomas, Contreras, & Frankenberg, 2002): *"Distribution of power within the household and child health"*	Indonesian Family Life Survey (1993, 1997 – 1st and 2nd wave) [1st wave: 7,200hh & 2nd wave: 7,500 hh (containing 800 split off households]	- mother's and father's assets at the time of marriage - current household income (p.14)	- reported morbidities in 1993 (cough, fever, diarrhoea/or nausea and all other) for children aged under 10years	- maternal age, education, child's sex, age and residence	- linear probit models (also with jack-knifed estimates of variance-covariance matrix)	- Table 1 (p. 30): correlates of reported child morbidities – all signs and effects in the expected direction, except more educated mothers (years of education) the more likely to report a cough (p.12-13), more aware of respiratory problems? [use family fixed effects to address this reporting anomaly – p.13] - reject the unitary model of household decision making for Java and Sumatra but not for the rest of Indonesia - in Java and Sumatra mothers who are more powerful (brought relative more assets into marriage) have son's that have fewer episodes of illnesses (cough & fever) compared to their daughters; there is no difference for diarrhoea and other morbidities	- micro-economic model of hh decision making (p. 3-11) - Household resources seem to only include current household income (how measured?) and no consumption, wealth and assets measure, but not clear from the paper, how variables were constructed! - not sure if it is convincing that authors reject unitary decision making just on 2 morbidities while others support unitary decision making - unnecessarily technical written

II) School-Age Outcome: Health – e.g. subjective (general health) and objective measures (height, weight, haemoglobin)							
Study	**Data**	**Independent V.**	**Outcomes**	**Control V.**	**Sample +Estimation**	**Key results**	**Notes**
(Cameron & Williams, 2009)	IFLS 3 (2000)	- hh consumption - hh income - hh wealth	- General health (parent & nurse reported) - Height, weight, haemoglobin (Nurse measured)	• For details see above (Pre-school-Age: health outcomes)			
(Dandan Chen, 1999): *"Health, productivity, and household resource allocation between child health and schooling"*	IFLS 1 (1997)		Health & Schooling	• Not published but inquired with the author about getting access.			
(Nobles & Frankenberg, 2006)	IFLS 2 & 3	- mothers participation in key community programs - hh expenditures, - maternal education	children's health: (1) *Child Height-for-Age*	• For details see above (Pre-school-Age: health outcomes)			
(Daniel Suryadarma, Pakpahan, & Suryahadi, 2009)	IFLS 1, 2, 3	- dummy if father died - dummy if mother died - if chronically poor - per capita expenditure - HH head education - HH head is working	- height in centimetre	• For details see below (School-Age: educational outcomes)			
(Thomas et al., 2002)	IFLS 1 & 2	- mother's and father's pre-marital assets - current hh income	- cough, fever, diarrhoea/or nausea, etc.	• For details see above (Pre-school-Age: health outcomes)			
(Xu, 2008)	IFLS 3	- pre-marital assets - per capita expenditure	- fever/respiratory problems (cough) in the past year	• For details see above (School-Age: educational outcomes)			

III) School-Age Outcome: Education– e.g. Probability of transition to the next level, educational expenditure, current enrolment rates							
Study	**Data**	**Independent V.**	**Outcomes**	**Control V.**	**Sample +Estimation**	**Key results**	**Notes**
(Alisjahbana, 1999): *"Does Demand for Children's Schooling Quantity and Quality in Indonesia Differ across Expenditure Classes?"*	IFLS1	- hh expenditure classes in quintiles (based on per capita expenditure, ftnote5, p. 3) - fathers and mothers education	Quantity of schooling: - enrolment dummy in primary, jun, sec Quality of schooling: - Log annual hh schooling expenditure per child (low, middle, high), p.6 & p.3, ftnote 5 (list of variables – p. 16/19-20)	- gender of child, age of child, hh size (to capture intrahh allocation), rural/urban, availability of school facilities & infrastructure (at district level), region (Dum var for Java & Bali, Sumatra, Sulawesi & Kalimantan omitted	- Maximum likelihood estimation	- parental education & hh per capita consumption are the strongest determinants of schooling (qual & quant) across schooling levels - mother education stronger benefit (but seems not to differ across expenditure classes) - gender: male children have a higher probability of being enrolled & more educational expenditure at secondary level (jun & sen) for lower hh expenditure classes; effect weaker and almost not existent for middle and higher level of hh expenditure (e.g. gender discrimination for poorer hh's)	- good background discussion and figures (p.1) - IFLS overview (p.2) - good example for descriptive - Def. of age specific enrolment rates (p.5, ftnote 6), p. 7 from hh roster - constructs an school level quality indicator for each school level – aggregates at the district level (see p. 5, Ftnote 7 for how constructed) - School production & demand function – p. 4 - Model (p.5) - she only uses the IFLS hh roster (because of sampling frame of IFLS1)
(Chang, 2006): *"Determinants of Child Labour in Indonesia: The Roles of Family Affluence,*	- IFLS 2 & 3	- both parents education (years of schooling) - parents bargaining (education ration: mothers share of total education by	- likelihood to currently attending school - likelihood to ever have work (child	- gender of child, age of child,age2, community level average wage for male and female adults, no	- pooled data of IFLS 2 & 3 - children between 5-14 years - probit (dprobit) with	- Tab5.1.1 (p.11): descriptive stats of hh characteristics - Tab 5.1.2. (p.12): mean working hours by gender and year & Tab5.1.3 (p.13): average hours worked per week by age group and type	- ILO Def of child labour (p. 1) of under 15 years of age - Child labour context in Indonesia (p.2-3) with ILO figures for 2000 - Indonesian Children Welfare Indicator for

Bargaining Power and Parents' Educational Attainments”		couple) - log per capita expenditure - land ownership	labour)	of children >=5, 6-14, 15-59, 60+, dummy on first born, urban/rural, 2000 year dummy (1997 base year), interactions, religion (p.8-9, 14)	binary response variables (p.6) - bivariate probit to capture any interrelationship between working and studying	of business (family or wage) - Tab 5.2.1(p.14): Probit outputs on children's working status; Tab5.2.2 by subsample female/male (p.17) - Tab5.2.3 (p.19): Probit for school enrolment & by female/male (Tab5.2.4, p.21) - Tab5.2.5 (p.26): Bivariate probit on working and school attendance & by female/male (Tab 5.2.6, p.29)	2000 (BPS) – p. 2 - Justification why expenditure and not incomes are used (p.5, p.8-9) and not income, assets, etc. - Lit review (p.5) - size of land not published & how many children work in 1997 (p.10)
(Dandan Chen, 1999)	IFLS 1 (1997)		Health & Schooling	• For details see above (school health outcomes)			
(Dandan Chen, 2009): *“Vocational Schooling, Labor Market Outcomes, and College Entry”*	- IFLS 2 & 3 - SUSENA & SAKERNAS (for descriptive statistic)	In 1997: - Attending vocational school (*Sekolah Menengah Kejuruan*, SMK) compared to general academic schools (*Sekolah Menengah Atas*, SMA)	In 2000: 1) Probability of employment 2) Wage rates 3) Probability of entering college 4) Value added in cognitive achievements (EBTANAS) - see summary statistics for variables (Tab2, p.11)	rural in 1997, sex, age in 1997, married in 2000, highest edu level of parents/or hh head if parents absent 1997,HH annual income 1997, junior secondary EBATANAS score, number of hh members 0-5; 6-14 & >=15 in 1997, % of SMK schools & public high schools among frequently mentioned high schools by households in village (2000) [p. 11]	- cohort of 958 high school students in IFLS2 tracked IFLS3 - Controls for censoring of general academic schools (SMA) students who continue to tertiary education (Censored probit model – p.13) - Heckman's 2-step procedure to correct the sample selection bias (p.15) - systematic differences between types of student who attend SMK and SMA respectively (uses instrumental variable: presence of SMK in village – p.16)) to correct for endogenity bias of school choice and labour returns - binary choice model (tab6, p. 17) of who attends SMK vocational schools - T-test results for EBTANAS scores for SMA & SMK students (Fig.5, p.20)	- After correcting for sample biases, he finds no advantage or disadvantage for probability of employment and wage rates but lower probability to enter college due to lower cognitive scores - Fig3: Rates of returns by level of schools (1994-2007) – by 2007 returns in the labour market converged (p.7) - Tab1 (p.9) & Fig4 (p.10): distribution of activities of the 1997 cohort in 2000 – ca. 40% enrolled in vocational SMK, 60% in SMA in 1997; unemployed: 57% SMA graduates and 43% vocational SMK graduates; tertiary education participation: 29% of the sample participated in tertiary education, only 20% attended vocational SMK in 1997 - After controlling for sample selection due to college entry, the positive effect of vocational SMK on employment is no longer significant (p.13) - Heckman's 2-step procedure to correct the sample selection bias, this male SMK wage premium becomes insignificant (Table 5, p.15). - participation in tertiary mostly influenced by parent's educational attainment, total EBTANAS score in junior secondary and hh income for boys, but not of girls (p.19) - vocational SMK students have lower final junior secondary school examination results - this difference grows in senior secondary school: controlled for junior secondary school examination score, attendance at SMK adds much less value in terms of educational attainment as measured by examination results (Fig.5, p. 20).	- discussion on pro and cons of vocational education (2-4), well structured lit review - Indonesian context of vocational schooling (p.5-8): declining enrollment rates in vocational schools from 2000-2006 - Q: COMFAS sampling frame based on most frequent attended schools or randomly sampled schools? (p.16)
(Chernichovsky & Meesook, 1985): *“School enrollment in Indonesia”*	- SUSENA: Nat. socio-economic hh survey (May round of 1978) [ca. 6,000 hh] - FADES : Village Social	- household socio-economic characteristics: (1) Log of hh monthly per capita consumption expenditure (2) Education of hh head and spouse	- Log of formal labour market returns to education (hourly wage) – p. 6-8 - primary and secondary school	- Age, age2, - education: 1) no schooling (ref cat.), 2) incomplete primary, 3) Secondary school (gen), 4) secondary (voc), 5) higher	- linear regression on log of hourly wage by sex (Tab2, p. 7) - Descriptive: proportions of children from different socio-economic groups	- Returns to education (table 2, p. 7): higher education levels yields higher hourly wage. Above primary school, returns are higher for women than men. For women: vocational training in secondary school yields higher returns compared to general training. - Only 20% of male children and 10% of	RQ: Characteristics of children who do not attend school and the reasons for not attending [Investigate household (demand) & community (supply) factors - short summary on educational system especially INPRES-SD programme (p. 1-3) and other data [Population census, Intercensal

	facilities census ; (1976/77) [ca. 60,000 villages]	(3) Occupation of hh head - school availability: (1) Dummy = 1 if primary school in the village) (2) Dummy = 1 if junior secondary school in the village) (3) Dummy = 1 if senior secondary school in the village)	enrolment – p. 8-10 - household educational expenditure (direct costs of schooling) – p. 10-14 - activities of school aged children (10-25 years of age) to approximate indirect costs of schooling (Tab6, p. 15) - reasons for not attending school (Tab7, p. 16 & Tab8, p.18) by age, sex and region - level of educational attainment	education; - residence (urban/rural); - region (Java, etc.) - sex of the child - availability of schooling facilities - hh size	attending school by age and sex (Tab3, p.9) - linear regression of household monthly school expenditure (Tab4, p. 12 & Tab1, Appendix, p.27) - Descriptive: HH monthly expenditure on schooling by location (Tab5, p. 13) - linear regression for whether child is attending secondary school or not by different age groups (Tab9, p. 21) [Q: Why not used logistic reg?] - linear regression on the years of schooling completed by different age groups (Tab10, p. 22)	female children of parents with no education attend senior secondary school compared to full attendance (100%) of parents with higher education (p.9); - great variation by occupation of household head: only children of administrative, executive and managerial class full attendance at all schooling levels; children (and especially females) from agricultural and blue collar workers underrepresented at junior and senior secondary school level – e.g. only 19% females from agriculture workers attend senior secondary school (p. 9-10) - variations in school enrolment by location, parent's schooling and household per capita expenditure more pronounced for older children, enrolment rates consistent higher for males than females with greatest gaps in poorer and less educated hh (p. 10) - self-reported reasons for being out of school: 50% stating economic reasons (e.g. no funds available) or school to far (partly monetary as well) – p. 14-17 - two effects of age combined – p. 20ff: (1) propensity to enrol in school falls with age as both direct and indirect costs rise; (2) younger cohorts have better schooling opportunities - richer parents prefer general high school more than vocational training (poor: other way around) - presence of junior secondary school has positive effect on primary school education (p.25)	Pop. Survey (p.4)] - report problems with monthly hh expenditure as many hh with children in school do not report any hh expenditure (p. 11, 13) - children's over 10yrs asked about activities (includes housework) 7 days prior to survey [more than one activity can be reported (in IFLS only primary activity, which leaves out children that go to school and work)– p. 14 - brief conceptual considerations (p. 17-20) with quantity-quality tradeoff by Theil & direct and indirect costs of education - hypotheses: 1) schooling is positively associated with hh wealth, e.g. more schooling and probably higher returns to schooling; 2) parents might choose to substitute the number of children for the average level of education 3) hh characteristics and other factors that increase the costs of education will lower the propensity to educate children - good discussion of regression results (p. 20-25)
(Deolalikar, 1993)	- SUSENA: 1987 - POTENSI DESA: 1986	- parental non-labour income - education of hh head & spouse	- Being enrolled in school	• For details see below (post-school educational outcomes)			
(Newhouse & Beegle, 2005): *"The Effect of School Type on Academic Achievement: Evidence from Indonesia"*	IFLS 1993 & 1997 & 2000	school type (public or private)	- academic achievement of junior secondary school students (grades 7-9)		OLS, fixed-effects, and instrumental variable estimation strategies	- Students that graduate from public junior secondary schools, controlling for a variety of other characteristics, score 0.15 to 0.3 standard deviations higher on the national exit exam than comparable privately-schooled peers. - Muslim private schools, including Madrassahs, fare no worse on average than students attending secular private schools	
(Park, 2007): *"Marriage market, parents' bargaining powers, and children's nutrition and education"*	Indonesian Family Life Survey (3rd wave, 2000) [10,500 hh], uses both individual and community survey - Indonesian Population	- current sex ration in the marriage market (age-to-age sex ration; 11-year-band-sex ration, p. 779f) - parental premarital assets - non-labour income (sum of pension, scholarship, insurance claims, lottery, etc. in previous year, p. 780) - hh income	- child's height for age Z scores for children younger than 37 months - child's education (1) individual educational expenditure for 7-14 yr olds, 2) hh educational expenditure,	- community: average hh income& wealth in community (p.778), no of elementary, junior and senior secondary school - age in month & age2 of child, child sex dummy, no of hh members 0-6, 7.12, 13-18, 19-24, 25-55,	- 4 samples (p.781f; 788): (1) 0-37 months for height measure, n=1135 (2) 7-18 children of hh head for enrolment model, n=2657 (3) 7-14 year old for individual expenditure data, n=1649	- for nutrition and educational expenditure the unitary decision making model is rejected - mother's higher bargaining power has positive effect on nutritional status and school expenditure for children - for school enrolment it is not rejected - household decision seems to differ depending on the type of decision to be made	- economic model of resource allocation (p.776-778) - empirical model (p. 778-779) - excludes couples before 1978 as no consistent price data available which is needed for pre-marriage assets (p. 780) - only very small number of people report to have a positive non-labour income – e.g. 5% of fathers, 2% of mothers (p.780) - justification why stunting only a good measure for younger children (p. 781), could

	Census 2000 (to construct sex ration at province level – p. 779)	- hh assets	3) school enrolment for 7-24yr olds (p.778)	56older, mothers' age, year of each parent's schooling, each parent's height, urban dummy (p.783)	(4) households with 1 member who is 8-18years for hh school expenditure, n=1467 - OLS clustered at the household level for all equations except enrolment status (p.779) - for enrolment status: probit models - also tried Heckman first stage with child health status but almost identical to OLS (p.779)		help over the problem, that data not available in second wave - how are hh assets (p.783) operationalised?
(Pradhan, 1998): *"Enrolment and delayed enrolment of secondary school age children in Indonesia"*	- SUSENAS: Nat. hh survey; (1992) [80,000 households, containing 40,166 children of secondary school age] (p.414-415)	- parental education (years of schooling) & literacy (if they can read and write), - occupation (mother/father in agriculture) - household expenditure	- secondary school enrolment - delayed school enrolment (as 9% average repetition rate in primary school, p. 413)	- provision of education (distance to nearest school, fees) - birth order - dummy for age/sex - number children 0-6 - all explanatory variables interested with sex variable - if mother present - age of parents - interaction (Appendix2, p. 430; p.421)	- Multinomial logit fixed effects (p. 415): 1.Not enrolled, 2. Delayed enrolment, 3. enrolment at appropriate age) - unbalanced panel, Weibull distribution (p.416) - uses predicted probability figures to visualise results (Fig1,2,3 – p. 424)	- Tab1, p.415: descriptive statistic by age and sex - higher parental education reduces probability of non-enrolment or delayed entry; with fathers having more effect on enrolment and mothers on reducing delayed enrolment - effects of parental education stronger for boys - first born receive more education & mother in agriculture reduces probability for girls to be enrolled - Tab5: results by province (p.426) – considerable difference by province, with Yogyakarta having lowest non-enrolment rates	- short discussion of Indonesian educational system (p. 414) - quite technical in some parts (e.g. estimation strategy, p. 418-420) - Definition of variables in appendix2, p. 430 quite useful template - Q: because they use fix effects, does this mean that they do not need variables like distance to school, rural/urban? - Q: What is the definition of delayed school enrolment and how constructed this measure?
(Quisumbing & Maluccio, 2003): *"Resources at marriage and intra-household allocation: Evidence from Bangladesh, Ethiopia, Indonesia, and South Africa"*	- special designed survey's for each country - e.g. for Indonesia: West Sumatra; 2002 [268 hh] (p. 298)	- husbands & wife's schooling (years of education) - log of assets (land) at the time of marriage of husband & wife (paddy, forest)	- expenditure shares for education & child's completed schooling compared to same aged children	Female, age, age2, husbands/wife's age/age2, interactions, (Tab3, p.299f& Tab9, p. 317f)	- sample: children between 7-21, 178 children from 88 hh (p.318) - regressions with and without fixed effects	- for Indonesia: women's asset at marriage positive effect on son's schooling but not on daughters (but daughters inherit more land & get returns from land) (p.315-316 & Tab9, p. 317f)	- comparative study for Bangladesh, Ethiopia, Indonesia & South Africa - similar but less in detail to 2001 study
(Daniel Suryadarma, 2009): *"Why are Muslims Left Behind in Education? Evidence from Indonesia"*	- IFLS 1,2,3,4 (p. 5-6), - PODES 1993, 1996, 2000 - SAKERNA 1993, 1996, 2000	- Muslim - Socio-economic (1) Father graduated from junior secondary (father education missing) (2) Mother graduated from junior secondary (mother education missing) (3) Log per capita expenditure in '93/'97/'00 (4) Own a house in '93/'97/'00	- enrolment in junior, senior and post secondary enrolment - graduation from junior, senior and post secondary school	- Female, EBATANAS score, worked in primary/junior/senior school, attended public primary/junior/senior school, no of repeated grades in primary/junior/senior school, Share of male/female Muslims/non-Muslims graduated from JSS in parent's generation, Hh size in '93/'97/'00, No of female/male in '93/'97/'00,	- n=1586 (? – p. 30) - cohort that were in grade 3-6 in primary school in 1993 and graduated from primary school, match with 2007 (p. 7-8) - reduced form probit model (p.11-12) - robustness checks: (1) migration, (2) Muslims vs Christians (p. 19-20, Tab12,13,14, p. 37-39)	- Muslim male face inferior chance of enrolling in tertiary education compared to non-Muslim male, female gap is largest at the senior secondary level - educational achievement scores and parental characteristics are main reasons for this gap (with no household wealth effect) - Fig2: Progression rates (p. 8, 28): 86% who graduate from primary school enrol in junior secondary. Of these 95% graduate from junior secondary. Most attrition occurs between schooling levels (few dropouts) - Fig3: religious gaps in progression rates (p. 8-9, 28): Muslim Males 11.6% lower progression rate to senior secondary school and 26.3% in tertiary education. Muslim	RQ: What is the gap between Muslim and non-Muslims in the progression between schooling levels and what are the reasons behind this? - good overview of primary and secondary school system in Indonesia (p. 3-4; Fig1, p.27) - conceptual framework discussion (p. 4-5) - Advantages of IFLS (p.6-7) - very useful in terms of descriptive and regression methods that could be a good template for what I would like to do - discusses some policy implications (p.10), e.g. credit and scholarship programmes, education investment

				Lived in Java, lived in Rural, Access to schools in 1993 (No of JSS/SSS in district, share of private JSS/SSS in district), Community conditions (district unemployment rate in '93/'97/'00, share of villages with permanent market/ asphalt roads, electricity (Tab3, p. 29-30)		females have a 6.5% lower progression rate to junior secondary school and 12.2% at senior secondary level (but not statistically significant at this level and tertiary level). - Tab2 (p.9, 29): Final educational attainment of Muslim and Non-Muslims compared (2 cohorts from 1993 & 2007) shows that over 14years religious inequality in senior secondary level has diminished but gap in tertiary has magnified - Tab 5 (p.12, 31): regression result for religious gap with male Muslims. Raw gap at senior secondary level is 11.6%, after equalising (controlling for) scholastic abilities (EBTANAS) reduces gap to 8.1% points and removes statistical significance. Equalising parental education and group education reduces gap to 3.5%. After equalising hh conditions the gap is reduced to 1.4% and the rest of the observables to 0.6%. - Tab7 (p.13-14, 33): returns to tertiary education for Muslims compared to non-Muslims. No difference in regards to labour market returns, both lower labour force participation rates than senior secondary school educated. Tertiary educated Muslim less likely to be self-employed compared to non-Muslim. Wage premium for tertiary educated male Muslim is 50.4% while it is 107.7% for non-Muslim males. This is the strongest explanation for the religious gap in tertiary education.	- detailed regression and descriptive results table in the appendix (p.41-60)
(Daniel Suryadarma et al., 2009): *"The effects of parental death and chronic poverty on children's education and health: evidence from Indonesia"*	IFLS 1, 2, 3	- dummy if father died between 1993-1997 - dummy if mother died between 1993-1997 Socio-economic (1) if chronically poor (below poverty line 2 out of 3 survey waves) (2) Per capita expenditure in quintiles (3) HH head education (yrs of completed schooling) (4) HH head is working	- school enrolment - years of education completed - height in centimetre (p.8 & Appendix1, p.20)	- female - dummy for year - dummies for age - hh size - number of hh members working/in school - dependency ration - house floor made from dirt - rural - interaction terms (Appendix1, p. 20)	n= 5,314 children (consisting of 34 maternal orphans & 118 paternal orphans & 5162 non-orphans) – p. 7 - who were between 2-12 years old in 1993 - had full set of parents in 1993 - lost a parent between 1993-1997 - two age groups: 2-6 & 7-12 - distinguish between short and long-term effects as it allows them to only use two waves at a time (p.8) - fixed effects (to account for time-invariant unobserved characteristics like innate health condition and cognitive ability):	- Maternal orphans have worse educational outcomes compared to non-orphans, with the effect getting worth over time - no significant health effect of orphan hood - chronic poor children have worth health and educational outcomes on average - for young children (2-6) maternal orphan hood has worse effect on education than chronic poverty - chronically poor orphans do not suffer adverse effects beyond the effects of chronic poverty	- RQ: What are the short and long-term effects of maternal and paternal death on children's school enrolment, years of completed schooling, height? How do these effects compare to chronic poverty? - poverty lines (officially published & deflated) – p. 7 - brief discussion on height as health measure (p.8) - IFLS2 no publicly available measure for height! - background on schooling (including stats for 2004/2005) – p. 9-10 - discussion of potential biases (p.8-9) – time-varying unobservables: e.g. care arrangements, other living conditons (only proxy it with education of hh head)

					p. 8 - linear probability models - to not loose child sex as variable, they interact it with the year dummy		
(Daniel Suryadarma, Suryahadi, & Sumarto, 2006): *"Causes of low secondary school enrolment in Indonesia"*	- IFLS panel data; (1993-97; wave 1&2) [ca. 6,500 hholds], - SUSENAS: Nat. hhold survey (2004) [200,000 households] - SAKERNA: Nat. labour force survey (1993); [15,000 individuals] - PODES: Village census (1993) [ca. 65,000 villages]	Socio-economic: (1) log per capita monthly expenditure (p. 19), (2) father highly educated (9years or more), mother highly educated, (3) own farm business, own non-farm business – [Tab3 p. 25]	- probability of transition from primary to junior secondary school (p.18)	- Child: age, working status, gender, EBTANAS scores, fail grade in primary (p.18); - HH variables: Muslim, high dependency ration, female headed, - Community: rural, off-Java, availability of public transport and fresh-food markets; number of junior secondary schools and student-teacher-ratio at district level, employment rate (measure of work opport.)	- n=874 children (p.21) - standard reduced-form probit model with probability of transition as dependent variable - clustered at the district level	Descriptive results: - Tab1: Self-reported reasons for not continuing to Junior Secondary School (from IFLS2) with 71% stating cost as the primary reason (p.21) - Tab2: Characteristics between children that continuing to the Junior Secondary and those that do not (p.22) with higher expenditure and higher EBTANAS scores Regression results: Tab3: Determinants of Continuation to Junior Secondary School: p. 25 - household welfare level is significant associated with low secondary enrolment - children from Muslim families have lower probability of transition to secondary school - children in areas with relatively abundant employment opportunities have higher probability of dropping out of secondary school - girls have significant lower chance of continuing to secondary schooling	RQ: (1) What are the causes of low junior secondary schooling in Indonesia? = Answer by authors: mainly attrition between primary and junior secondary level (with SUSENAS data) (2) What are the causes for attrition (e.g. why children do not continue) to junior secondary school after having completed primary school? (with IFLS and PODES data) - Introduction and school system section useful (p. 1-4) & lit review on school enrolment data in Indonesia (p.5-11) - Appendix 1: 1993 Poverty Line in Indonesia (p.34); Appendix 2: Description of the Explanatory Variables (p.35)
(Xu, 2008): "*Intra-household bargaining and children's educational outcomes: Evidence from Indonesia"*	IFLS 3 (2000): individual and community survey of the IFLS	Socio-economic status: (1) value of assets brought to household when parents married (in constant Indonesian rupiah – p.32) (2) log of per capita expenditure	- children's educational expenditure as share of total hh expenditure (input of parents) - mathematics scores (output that also captures other inputs) - cognitive assessment scores - whether child repeated a grade - whether child had fever/respiratory problems (cough) in the past year	Demographic family characteristics: - hh size - children's age - whether or not attending school - religion,	- "Almost Ideal Demand System (AIDS) adapted by Quisumbing & Maluccio (2003) expenditure share function using generalised linear model with maximum likelihood estimator (p.32) - sample: 7-14 year (school-aged children) - household fixed effects (to control for families with more than one child) – p.34 - instrument school choice with average local community schooling costs (incl. school fees, transportation costs, etc.) – p. 33, 46 from COMFAS - subsample analysis for urban/rual;	- maternal economic resources (proxied by assets brought to marriage) relative to paternal significant positive effects on children's education expenditure shares, mathematic and cognitive performance - no observable gender favouritism by either mother or father in general - parental preferences tend to convergence the longer the marriage	- most studies between family background and children's education based on unitary household framework (=pooling of resources and same preferences between mothers & fathers) - RQ: DO mothers and fathers have heterogeneous preferences over their children's education in Indonesia? (p. 4 and sub-questions p. 5) - Literature review on unitary and non-unitary decision making models (p.8-23) - uses IFLS as cross-section (p.24) - Discussion of IFLS: p. 29-32 - Cannot control for some important input factors for educational outcomes (e.g. supportive family environment (p.32) - no price data available for health facilities from COMFAS but uses individual accounts (p.46-47) - cognitive scores redesigned between IFLS2 & 3 (p.47) - Appendix tables: Tab2: HH Re-Contact Rates(p.96)

					Java/Non-Java & child gender (p. 34)		

IV) Post-School-Age Outcome: Education – e.g. returns to education (wage/hour), employment probability, entering tertiary education & Poverty							
Study	**Data**	**Independent V.**	**Outcomes**	**Control V.**	**Sample +Estimation**	**Key results**	**Notes**
(Dandan Chen, 2009)	- IFLS 2 & 3 - SUSENA & SAKERNAS	- Attending vocational compared to general academic schools	- Employment Pr. - Wage rates - Tertiary enrol	• For details see above (school educational outcomes)			
(Chernichovsky & Meesook, 1985)	- SUSENA '78 - FADES '76/77	- hh expenditure - education of head/ spouse - occupation of hh head - school availability	- hourly wage - final educational attainment	• For details see above (school educational outcomes)			
(Deolalikar, 1993): *"Gender differences in the returns to schooling and in school enrolment rates in Indonesia"*	SUSENA: Nat. hh survey (1987) [50,000 hh, 250,000 individuals] (p.902-903) POTENSI DESA (1986): Economic Census of Villages [for infrastructure variables but only possible to merge at district level (kabupaten) not village level	- log of parental non-labour income (wage or labour income not used as school & work choices made jointly – p. 904) - education of household head & spouse [- this round (Jan '87) of SUSENAS no information on assets, occupation, etc. (p.903)	- relative returns to education in monthly earnings - participation in labour force - Being enrolled in school	- single-year age dummies (non-linear relationships tested), age of hh head and spouse, urban/rural residence - community characteristics: proportion of villages having JSS/SSS, accessible by all-weather road/water (p.904) [details p. Tab3, p. 916f]	- for returns to schooling: wage-earning adults older than 15 but currently not at school and earning a wage: 28,624 (p. 908f) - for school enrolment model: 6-23yrs olds (p.903), n=89,089 (p.925); 4 age groups: 6-11, 12-14, 15-17, 18-23, all explanatory variables interacted with gender dummy variable - maximum likelihood logit estimation method - OLS for wage function (p.906)	<u>Returns to schooling:</u> - higher relative returns to secondary and tertiary schooling levels for females compared to men (especially Diploma1 & vocational secondary) - estimated returns also greater for older cohorts than for younger, e.g. tertiary education for older cohort (55+) is 214.1% than women compared to 11% in the younger cohort (15-24years) – p. 907 <u>Enrolment rates:</u> - women have acquired relatively more secondary and tertiary education than men but in absolute numbers still gap between female and male enrolment at the higher educational levels - could be due to lags in household and individual responses to perceived returns of schooling for females	- confirm results of an earlier study with Behrman & Deolalikar, 1990: "Are there Differential Returns to Schooling by Gender? - states gap in studies that analyse intra-household difference of schooling (p.900) - Conceptual framework for school enrolment: (1) reduced-form demand function for schooling with price of schooling (direct and indirect); (2) schooling production function with child and parental time input, conditional on parental education and community influence; (3) bargaining framework Folbre - model would yield different demand equation for each child due to age and gender, genetic endowments and different educational production function (p.900f) - Hypotheses: p. 901 - reasons for gender differences in returns to schooling (difference in opportunity costs (providing child care, housework – esp. older female siblings), gender specialisation in jobs, cultural norms, etc. (p.901)
(Maralani, 2004): *"Family size and educational attainment in Indonesia: A cohort perspective"*	IFLS 1&2	family size and composition	educational attainment			The results show that the relationship between family size and children's schooling was positive or neutral for earlier cohorts in Indonesia while, for more recent cohorts, family size and schooling are negatively correlated. Moreover, these relationships differ by urban/rural status. Very large families were associated with better educational outcomes for rural cohorts ages 40 to 49 but are associated with poorer educational outcomes in recent urban cohorts.	
(Pakpahan, Suryadarma, & Suryahadi, 2009): *"Destined for Destitution:*	IFLS 1,2,3 (p. 3-4)	Chronic poverty during childhood (poor in two of the years 1993, 1997, 2000)	Being poor in adulthood (hh consumption below the poverty line in 2000)	- Split Off: If adult children live away from their parents after marriage - yrs of schooling,	n= 945 (children and not yet married in 1993, who get married between 1997-2000 and were spouse data is available	Transition matrix – p.4: - 9.6% (75) adult children become poor (e.g. where not chronically poor as children but are not in 2000) - 51.9% (85) adult children escape poverty	- RQ: Do adult children (=those that are married between 1997-2000) inherit poverty status (e.g. being in poverty in 2000) from their parents in Indonesia? - very short paper with very abbreviated

Intergenerational Poverty Persistence in Indonesia"				- working - sector of occupation, - age in 2000, - female, - marriage tenure, - spousal characteristics, - rural, - migrated, - hh size in 1993, - provincial dummies [appendix p. 10]	[50 cases not available]) - poverty transition matrix (p. 4) between being chronically poor as child and being poor as adult - probit regression models (p. 3 & p. 5 - try to control for selection bias and omitted variable bias (p.3)	(e.g. where chronically poor as children but are not in 2000) - 48.1% (79) adult children remain in poverty (e.g. where chronically poor as children and are poor in 2000) - 90.4% (707) adult children are never poor (e.g. where chronically poor as children and are not in 2000) Regression results – p. 5-6: - chronic poor, yrs of schooling, marriage tenure and migration seems significant	information on models and variables - definitions of adult: "those that are married" - def of chronically poor: if poor two years out of 1993, 1997, 2000 (so even people who are 1993 & 2000, but not 1997?), also have to assume that in between the waves poverty status does not change – no other information - don't understand their sample selection criteria (because of leaving the parental household when married?) - Dependent and independent variable can overlap when children do not move out of the household (for 34% of the sample the case!)
(Quisumbing & Otsuka, 2001): *"Land Inheritance and Schooling in Matrilineal Societies: Evidence from Sumatra"*	- Specially designed retrospective household survey of inheritance in two regions of West Sumatra (matrilineal); (2000) [120 households] (p.2094, 2097ff)	- parental schooling (years of schooling) - wealth of parents at time of marriage (inherited holdings of lands)	Transfers: - completed years of schooling - inherited land (paddy, agro forestry, bush-fallow land) – p. 2096	Birth year, dummies for eldest and youngest child, daughter dummy, number of brothers/sisters (Tab6, p. 2101)	- n= 120hh - both fixed- and random effects models to test if family unobservable or individual heterogeneity are important (p.2097) - tobit used for land regression (as land transfers subject to censoring) - interaction terms for time-invariant explanatory variables (p.2097)	- shift from communal land tenure to individualised one in parallel with shift from matrilineal to bilateral regime - find no gender gap in land inheritance but less investment in schooling of girls (this gender gap however decreases for younger birth cohorts)	- emphasises the point of the two main intergenerational transfers from parents to heir children: education & land (important for employment opportunities) - conceptual framework: Becker's wealth model of transfers (p.2094ff) - Q: What is the age of the sample?
(Daniel Suryadarma, 2009)	- IFLS 1,2,3,4 - PODES & SAKERNA '93, '96, '00	- Muslim -Father/mother graduated from junior secondary - Per capita expenditure in '93/'97/'00 - Own a house in '93/'97/'00	- enrolment in tertiary - graduation from tertiary	• For details see above (School-Age educational outcomes)			
(Daniel Suryadarma et al., 2009)	IFLS 1, 2, 3	- dummy if father died - dummy if mother died - if chronically poor - per capita expenditure - HH head education - HH head is working	education completed	• For details see above (School-Age educational outcomes)			

Appendix 3.1: Map of IFLS survey sites

Figure 22: Map of survey sites for the Indonesian Family Life Survey (IFLS)

Source: http://www.rand.org/labor/FLS/IFLS/

Appendix 4.1: Grid of previous empirical research on children's nutrition

Study (Author, Date, Title)	**Country** (Year, data)	**Independent Variables**	**Outcomes**	**Controls/ confounders**	**Analytical Sample & Estimation method**	**RQ & Results**	**Notes**
(Alderman, Hoddinott et al. 2006): "*Long term consequences of early childhood malnutrition"*	***Zimbabwe:*** rural ***Year:*** 1983-2001 ***Data:*** longitudinal study of 400 households in 20 villages - baseline: Jul'83-Mar'84; -follow-up: '87, '92, '93, '94, '01) - p.454ff.	***At preschool age:*** (6months – 6yrs): -malnutrition (height for age)	***In adolescence:*** Health & educational attainment - height - number of grades attained, - age started school	Due to estimation technique (i.e. maternal fixed effects – sibling difference – instrumental variable estimator) not used	***Sample:*** - Full sample: 665 (p.457) - adolescent height sample: 340 (p.464) - grades attained: 569 ***Method:*** - maternal fixed effects – sibling difference – instrumental variable estimator (p.460) - Instruments for initial nutritional status: transitory exogenous shocks prior to age 3 (war & draughts)	***RQ:*** - How are improvements in height-for-age in pre-schoolers associated with health and educational attainment (i.e. increased height as young adults & the number of grades of schooling completed)? ***Main results on children's growth*** - Had a median pre-school child in this sample had the stature of a median child in a developed country, by adolescence, she would be 3.4 cm taller, had completed an additional 0.85 grades of schooling and would have commenced school six months earlier ***Other relevant results:*** - - Present calculations that suggest that loss of stature, schooling & potential work experience results in loss of lifetime earnings of around 14%	***Strengths:*** - get closer to causal relationships with their estimation technique – especially the siblings difference method (i.e. have nutritional status information of siblings at similar ages as the main sample) ***Weaknesses:*** - no conceptual framework linking independent & outcome variable ***Other:*** - no direct measure of cognitive attainment
(Cameron and Williams 2009) *"Is the Relationship Between Socioeconomic Status and Health Stronger for Older Children in Developing Countries?"*	***Indonesia*** ***Year:*** 2000 ***Data:*** IFLS 3	***At age years: 0-14*** Alternative measures of hh financial resources (p.306) 1) Log of annual hh income (sum of earnings, asset incomes, transfers, pensions, scholarships, etc.) 2) Log of annual hh consumption: food and nonfood– bought and self-produced 3) Log of hh wealth: sum of current value of hh assets & business assets (house, land, livestock, etc.)	***At age years: 0-14*** Different measures of child health (p. 306): 1) Parent reported (subjective): "In general, how is health now?" [Combined category 1,2 & 3,4]; p. 306; 2) Nurse assessed assessment (subjective) (categories 1,2,3 combined & 8,9) 3) Nurse measured (objective): height, weight, haemoglobin (but only in sensitivity analysis)	(p.306-307), Appendix A1 (p.322-323) ***Child level:*** - age, sex ***Parental level***: - age, education, presence in the hh ***Household level:*** - hh religion, location (rural/urban), hh size (log), person who answered child health assessment	***Sample:*** - children aged 0-14 (limit sample to these as hh resources endogenous when children work and contribute to hh resources) - use age groups: all ages; 0-3; 4-7; 8-11; 12-14 ***Method:*** - nonparametric, locally weighted regressions (p. 307 & figure 1 p. 308-309) for health status & HH resources - ordered probit regressions for child health status (1=very healthy, 2=somewhat healthy, etc.) - Sensitivity analysis (p. 311ff): 1) parents vs child health report differ; 2) Sample selection bias due to infant mortality (include age & lowest health status for dead children); 3) error in parent health reports; 4) poor health at birth (birth weight less than 2500g (7.6% sample); 5) Poor parent health	***RQ:*** - Does the effect of income on child health differ by ages of children – e.g. is it stronger for older children? ***Main results on children's growth:*** - low income adversely affects subjective health, e.g. doubling hh income is associated with an average increase in the probability of reporting being very healthy by 1.1 percentage points or 10.4% (p. 313) - but this does not differ by age of the child (i.e. impact of income upon health does not seem to accumulate over time of child's life). Results differs to developed countries ***Other relevant results:*** - authors show that acute conditions like diarrhoea and respiratory infection (higher prevalence and severity in younger children) rather than chronic ones (which are also more likely to affect older children) affect Indonesian parent's assessment of their children's health (p.305) - Summary statistics appendix A1, p. 322-323 - maternal education (mother completed primary school) has an important determinant of general health status of children under age of 3 years (p. 311) - even after controlling for health at birth (birth weight) household resources are still significant determinant of health status – p. 317 - including parental health shows large and significant effect of parental health on child health – e.g. a mother who reports being "very healthy"	- Mechanisms for relationship between parental income and child health (p.303): provide better nutrition, medical care, health insurance, access to safer environments - Other parental characteristics that are correlated with income: poor genetics, health related behaviour - Good discussion on different health measures (p. 304-305) - parent-reported and nurse assessed health data only collected from 2nd wave onwards, nurse assessed health data not publicly available) – p. 306 - Good example for sensitivity analysis but quite abbreviated text - only 50% of sample have birth weight available and less likely to be available from poor hh (p. 316) - Q: How exactly they constructed financial resources variables (Find out if aggregated files available from authors?) - They never included all measures in one regression just as alternative measures of resources

Study (Author, Date, Title)	Country (Year, data)	Independent Variables	Outcomes	Controls/ confounders	Analytical Sample & Estimation method	RQ & Results	Notes
						has 19 percentage points higher chances of reporting good health as well (p. 318). The coefficient of hh resources are largely unaffected by this inclusion	
(Crookston, Dearden et al. 2011): *"Impact of early and concurrent stunting on cognition"*	***Peru*** ***Year:*** 2002-2007 ***Data:*** p.399 - birth cohort (Young Lives study), - 1st round (in 2002): 6-18months old - 2nd round (in 2006/2007): 4.5-6years old	***At age 6-18 months/4.5-6 yrs:*** - HAZ round 1 - HAZ round 2 (p.401ff)	***At age 4.5-6 years:*** p.400ff - verbal test (Peabody Picture Vocabulary test) - quantitative test (Cognitive Development Assessment; quantity subtest of notion of amount)	***Child level:*** p.401-402 - pre-school attendance - primary school attendance - age - sex ***Parental level:*** - maternal age - maternal education ***Household level:*** - urban location - region - nº of siblings - wealth index (composite of housing qualities, consumer durables and services (e.g. drinking water, toilet, electricity) - religion ***Other:*** /	***Sample:*** - n=1,649 (p.402) ***Method:*** - EpiNut module for Z-score calculation - international WHO reference (p.401-402) - mixed effect regression using SAS - Wald test to compare coefficients for HAZ in two different rounds	***RQ:*** - What is the effect of early stunting and concurrent stunting on cognitive ability? Hypothesis: Early stunting has a greater impact on cognition than concurrent stunting (p.402) ***Main results of nutrition on cognition:*** - Verbal scores: 1 SD increase in concurrent HAZ associated with increase in child's score on PPVT by 2.35 points - Quantitative score: 0.16 increase - concurrent HAZ stronger association than early HAZ but only significant with verbal scores ***Other relevant results:*** - other predictors of cognition: older mothers, higher education, urban areas, attended pre-school, fewer siblings, wealthier background score higher on both assessments	***Strengths:*** - Have birth-cohort with big enough sample size ***Weaknesses:*** - no discussion on their finding why concurrent stunting better predictor of cognition - Do not use interpretation of the early and later HAZ in one model – interpretation ***Other:*** - compared to their study in 2010 (see below) they are using HAZ (continuous variable) and not stunting (a bit confusing form their title and what they do in the regressions) - also use two measurements separate but not the dynamics - not clear if they interacted early and concurrent stunting to get some idea on the dynamics
(Crookston, Penny et al. 2010): *"Children who recover from early stunting and children who are not stunted demonstrate similar levels of cognition"*	***Peru*** ***Year:*** 2002-2007 ***Data:*** - birth cohort (Young Lives study), - 1st round (in 2002): 6-18months old - 2nd round (in 2006/2007): 4.5-6years old	***At age 6-18 months/4.5-6 yrs:*** *Dynamics* of stunting between infancy and childhood: - not stunted - stunted in infancy but not in childhood (catch-up) - stunted in childhood - stunted in infancy & childhood	***At age 4.5-6 years:*** p.1997 - Peabody Picture Vocabulary Test (125 questions) - Cognitive Development Assessment (quantitative reasoning – 15 items to measure perception of amount)	***Child level:*** p. 1998 - child age & sex - preschool attendance ***Parental level:*** - maternal age, height, education ***Household level:*** - urban/rural, region - ethnicity - composite wealth indicator - number of siblings ***Other:*** - /	***Sample:*** - n= 1,649 (p. 2000) ***Method:*** - Mixed regression models to account for cluster design (p.1998)	***RQ:*** - Do children that demonstrate catch-up growth between infancy and childhood experience cognitive deficits compared to children that were never stunted? - Which factors are associated with catch-up growth ***Main results of nutrition on cognition:*** p. 1999-2000 - unadjusted regression models predicting verbal vocabulary scores, the reference group (not stunted) score significantly higher than the three other groups (when adjusted for control variables, catch-up group and not stunted did not differ), the chronic stunted & those who got stunted significantly lower scores) - for unadjusted models predicting quantitative cognition, children who were not stunted and those that experience catch-up growth do not differ - for unadjusted model children that are stunted in childhood have slightly worse vocabulary scores than those that are chronic stunted – this reverses to the expected order in the adjusted model - overall, results suggest that the long-term effects of stunting can be mitigated when children experiencing catch-up growth – contrary to other research that showed that children cannot recover from the consequences of stunting	***Strengths:*** - birth cohort data - that they look at the dynamics of stunting ***Weaknesses:*** - 6-18 year olds & stunting dynamics: as stunting peaks at around 24 months not clear if this selection of sample is the best one to choose - no paternal information ***Other:*** - only follows children's development into childhood (e.g. until they are 4.5-6 but not later childhood or adolescence

Study (Author, Date, Title)	**Country** (Year, data)	**Independent Variables**	**Outcomes**	**Controls/ confounders**	**Analytical Sample & Estimation method**	**RQ & Results**	**Notes**
						Other relevant results: - Factors that are related with catch-up growth: taller mothers, grandparents at home,	
(Husaini, Karyadi et al. 1991): *"Developmental effects of short-term supplemetary feeding in nutritionally-at-risk Indonesian infants"*	***Indonesia:*** West Java (six tea plantations) ***Year:*** 1986 ***Data:*** - follow-up of 113 infants in 20 child centres, 9 centres received supplement, 11 did not	***At age 6-20 mo:*** - Intervention of supplementary feeding over 3 months in day care centres with high calorie snacks - dietary supplement: twice a day, ca. 400 kcal and 5g protein/d. (p.800)	***At age 10-24 mo:*** - Mental & motor development: Bayley Scales of Mental and Motor Development (BSMMD) – see notes for details - post-treatment anthropometry (weight, length)	***Child level:*** - n/a ***Parental level:*** - n/a ***Household level:*** - n/a ***Other:*** - n/a Not applicable, as this is not a regression analysis, but due to random control design	***Sample:*** - n=113; 78 children that received supplements and 38 were in the control (only focuses on younger children) ***Method:*** - randomised control trial design - just compare the mean before and after the intervention between treatment & control	***RQ:*** - Does supplemented feeding improve children's mental and motor development? ***Main results of nutrition on cognition:*** - benefit for motor but not mental development - absence of effects on the mental scale supports previous research that items tested by the BSMMD not very sensitive to nutritional factors (p. 803) ***Other relevant results:*** - in undernourished children, nutritional supplementation has benefit for weight gain (from -1.66 WAZ to -1.37 compared to control group with constant -1.55 WAZ) but not for height – p. 802 (however, only 14 weeks of supplementation and measured effect after 4 months not expected to affect the long-term measure of height, but because of the effect on weight, it is expected that if the intervention would have lasted longer there would have been an effect on lengths as well – p.803) - interactive term of treatment and body size for motor scale was not significant suggestion that effect of treatment was independent of body size (p.802-803) - results suggest that not path from supplementation → weight gain → motor development but rather simultaneously affected both domains - however, hypothesise, that improved motor maturation can broaden children's natural developmental involvement with immediate environment thereby affecting subsequent cognitive developments (p.804)	***Strengths:*** - randomised control trial design - Dietary survey preceded the experimental intervention (children also measured for their baseline anthropometry etc.) ***Weaknesses:*** - Intervention might have been too short and effects measured too early ***Other:*** - evaluation survey – 4 months after start of the study (p.800) - the intervention setting of tea plantation quite homogenous in terms of SES and large number of day care centres (p.800) - older children (21-59mo): Peabody Picture Vocabulary Test and Oddity Learning Tasks – but part of a different paper (reference not supplied) - BSMMD mental scale: performance on wide range of behaviour: e.g. dangling a ring, pushing a toy car, etc. - motor scale: gross motor (e.g. standing, walking, jumping), fine motor movements (finger prehension of pellet) (p.801) - motor scale more heavily loaded with gross-motor movements which justifies relationship with energy supplementation effect - theory link on brain activation through energy intake (p.804)
(Mendez and Adair 1999): "Severity and timing of stunting in the first two years of life affect performance on cognitive tests in late childhood"	*Philippines (metropolitan Cebu)* *Year: 1983 - 1995* *Data:* *- one-year birth cohort* *- Cebu Longitudinal Health and Nutrition Study*	*At age 0-2:* *- prospective bimonthly data from birth till 2* *- severity (moderate vs severe – p.1557)* *- timing (i.e. age of onset of stunting, grouped in 6months intervals)* *- persistence (between 0-2 and 8y): persistent stunted, catch-up, late onset, never stunted*	*At age 8 & 11:* *- age specific z-scores of cognitive test (Philippines Nonverbal Intelligence Test – 100 cards, 5 objects, 1 differs in a meaningful way – p.1557)* *- School outcomes (e.g. delay in initial enrolment; higher absenteeism; higher grade*	*Child level:* *- sex of the child* *- % of fat in diet at 8* *- type of school (public vs. private)* *Parental level:* *- Several indices of SES during infancy (p. 1557): household income quartile* *- highest grade completed by mother and father* *- maternal height* *- weather main carer mother* *Household level:* *- type of house* *- change in hh income*	*Sample: p. 1557* *- n = 2,131 (stunting data and test scores at age 8 y)* *- n = 2,048 (also test scores at age 11 y)* *Method:* *- t-test (compare 2 groups), chi-square (3 or more groups)* *- models: crude, schooling adjusted, multivariate adjusted, (p. 1557)* *- additional models (p. 1558)* *- Heckman two stage model to evaluate selectivity bias due to attrition or missing data*	*RQ:* *- What is the relationship between stunting in the first 2 years of life and later cognitive development, focusing on the significance of severity, timing and persistence of early stunting?* *Main results of nutrition on cognition:* *- stunting at age 2: significant lower mean in cognitive test scores than non-stunted children with greater difference at age 8 y than at age 11 y* *- severity of stunting at age 2: (in unadjusted model) severely stunted children had 0.61 SD below the mean of cognitive tests compared to non-stunted children; mildly – 0.25 SD lower (p.1559)* *- timing of stunting: earlier onset of stunting more likely to have severe stunting (difficult to disentangle the effect) – worse cognitive results at age 8 (if stunted in first 6 months vs never stunted in first 2 years – 0.6 SD lower); for children 18-24 months – 0.19 SD)*	*Strengths:* *- prospective bimonthly data from birth till 2years of age, that allows to examine different dimensions of stunting* *- specific designed birth-cohort study that only focuses on children* *Weaknesses:* *- is only one region in Philippines, not national representative* *Other:* */*

Study (Author, Date, Title)	**Country** (Year, data)	**Independent Variables**	**Outcomes**	**Controls/ confounders**	**Analytical Sample & Estimation method**	**RQ & Results**	**Notes**
			repetition, highest grade achieved at time of cognitive test)	*quartile over time - parity (birth order indicator) - number of younger siblings Other:/*		*- persistence of stunting through age 8: lower scores than never stunted children and catch-up - children's cognitive test scores at age 11y were strongly correlated with scores on English (reading comprehension) and Mathematics achievements tests which were also administered at age 11y (p. 1557) Other relevant results: - interaction between stunting and schooling not significant – i.e. effect for schooling on cognitive scores does not differ for stunted vs non-stunted children (p. 1557)*	
(Nobles and Buttenheim 2006): "*Mother's Community Participation and Child Health*	***Indonesia*** ***Year:*** 1997-2000 ***Data:*** IFLS 2&3 (p.11f)	***At age years:***	***At age years:***	***Child level:*** - ***Parental level***: - ***Household level:***	***Sample:*** - n= 5,144 children whose height was measured in 2000 and whose 3,281 mothers provided data in the 1997 wave of the IFLS (p.11) ***Method:*** - community fixed effects		
		mothers' access to social capital via participation in community key community programs: community meetings, cooperatives, voluntary labor, village improvement activities, and the village women's association (p.15) - log of per capita monthly household expenditures, -maternal education (dummy if 6yrs of education or less, p.15)	children's health: (1) *Child Height-for-Age*	- age, and number of children, the child's gender and age, and household location (urban or rural). - measures of maternal kin support (p.15)		- children from families with relatively low levels of human and financial capital fare better with respect to health status when their mothers are more active participants in community organizations. - the association between maternal participation and child health is strong and positive only for children from relatively disadvantaged backgrounds, as measured by their mothers' educational and household economic resources	- Q: age of children is 0-14?
(Pollitt, Watkins et al. 1997): *"Three-month nutritional supplementation*	Indonesia West Java (six tea plantations) Year: 1986-	At age: 6-59months - short-term (3months) supplementary	At age: ~9years - anthropometry (height, weight, head, skinfold) - haemoglobin,	Child level: - age, sex Parental level: - made no socio-economic adjustments,	Sample: - overall: n=231 (125 supplemented, 106 control) - sub-sample: n=73 for under 18months old during treatment	RQ: - Does short-term supplementary feeding during infancy and childhood have long-lasting benefit for working memory in undernourished children?	Strengths: - randomised control trial design Weaknesses: - small sample sizes for sub-sample of under 18months olds (n=73)

Study (Author, Date, Title)	**Country** (Year, data)	**Independent Variables**	**Outcomes**	**Controls/ confounders**	**Analytical Sample & Estimation method**	**RQ & Results**	**Notes**
in Indonesian infants and toddlers benefit memory function 8 y later"	1995 Data: - follow-up of the 3months supplement study (see Husaini et al, 1991 above)	feeding intervention with high calorie snacks in day care centres	iron status - Peabody Picture Vocabulary Test - arithmetic test - Computerized (Touchscreen) Cognitive Abilities Tests: 1) simple & choice reaction time; 2) Sternberg test of working memory; 3) probe recall; 4) tachistoscopic threshold (two figures in rapid succession,decide if identical – used as stressor to also test emotionality	as the group was very homogeneous (p. 1358) Household level: - / Other: - tester	Method: - randomised control trial design - compare the mean between treatment & control for different tests, just controlling for age, sex of the child and the tester	Main results of nutrition on cognition: - for total sample, no difference between treatment and control group for different cognitive measures except for sub-group of younger children that received supplementation before 18months of age (n=73) - These supplement children performed better on working memory test (Sternberg) – e.g. greater scanning speed of working memory - those supplemented before 18months of age (9years) were as fast as oldest supplemented age group (~12years) [p. 1361] Other relevant results: - No difference for anthropometry, haemoglobin, vocabulary test and arithmetic between supplemented and non-supplemented children	- Intervention might have been too short (3months only) Other: - Peabody Picture Vocabulary Test – Sundanese version: four pictures, given a word and then asked to point to appropriate one
(Walker, Grantham-McGregor et al. 2000): "Effects of growth restriction in early childhood on growth, IQ, and cognition at age 11 to 12 years and the benefits of nutritional supplementation and psychosocial stimulation"	*Jamaica* *Year: not mentioned* *Data:* *- birth cohort of children aged 9-24 months in 1987* *- followed up 8 years later*	*At age 9-24mo:* *- Randomised intervention* *- psychosocial stimulation (weekly home visits when play and home-made toys was demonstrated)* *- nutritional supplementation (1kg of milk-based formula provided weekly)*	*At 11 & 12 y: (8 years after trial) – p. 37:* *- IQ (Wechsler Intelligence Scales for Children-Revised: verbal and performance subscales, age-specific)* *- 10 cognitive function tests (see notes for details), one of them is Raven's* *- children's growth*	*Child level:* *- birth weight* *Parental level:* *- PPVT of mothers* *- caretakers education* *Household level:* *- home stimulation (p. 39: factor analysis: Factor 1: table & chair to do homework, adult help with homework, visits public library, goes on trips); factor2: number of toys and games, adults play indoor and outdoor games with child: factor 3: number of books, child reads newspaper)* *Other:* *- housing condition (factor analysis of household possessions, crowding, sanitation)*	*Sample:* *- n= 127 growth restricted children* *- 116 growth-restricted children (91.3%) followed; 80 non-growth restricted children (95.2%) (HAZ>-2SD)* *Method:* *- Randomised control trial*	*RQ:* *- What are the long-term benefits to growth and cognition for intervention of psychosocial stimulation and nutritional supplementation in early childhood?* *Main results of nutrition on cognition:* *- nutritional supplementation had short-term benefits but no significant long-term (8years after intervention) benefit to growth, cognition or IQ [contrast to benefits from intervention that started during pregnancy and continued for at least first 3 y of life in Guatemala and Colombia (p.39)]* *- supplementation might have been necessary to continue throughout childhood (p.40)* *- growth restricted children had significantly poorer performance than non-growth restricted children on 9 of 10 cognitive tests (digital span forward only exception) – growth restriction has long-term functional consequences (p.39)* *Other relevant results:* *- home-based stimulation for growth restricted children small but significant long-term benefit to IQ (WISC-R), reasoning ability (Ravens), vocabulary test, (p.39,40)* *- no interaction between stimulation and caretakers PPVT score* *- birth weight not significant in any of the models (p. 39) and did not change results – some indication that postnatal growth restrictions has long term functional consequences (p.40)*	*Strengths:* *- Randomised control trial* *- That they have data on stimulation and nutritional supplementatio* *Other:* *- invention of 2 years for growth restricted children between 9-24 months randomly assigned to groups (p.37):* *1. Control* *2. Supplemented* *3. Stimulated* *4. Both treatments* *5. 32 non-growth restricted children matched to control group for age, sex, neighbourhood (at follow-up 4 years added another 52 – p. 37)* *- stimulation aimed at improving teaching techniques of mothers and quality of verbal interaction, also concepts of colour, shape, size, number and position were taught (p. 37)* *Cognitive function tests (p.37):* *- visual reasoning (Ravens Matrices),* *- PPVT (language comprehension),* *- verbal analogies,* *- vocabulary test: modified Stanford Binet,* *- auditory working memory tests (digital span forward/backward),* *- visual-spatial memory (Corsi blocks),* *- search test,* *- modified Stroop test*

Appendix 4.2: Weight-for-age z-scores (WAZ)

Table 27: Summary statistics on Weight-for-age z-score (WAZ) for children between the age of 0 and 59 months in 1993, 1997, 2000, 2007 (repeated cross-sectional data)

Years	**Birth year**	**n**	**WAZ<-2 in %**	**Mean WAZ**	**Mean Difference**
1993	~ 1988-1993	2994	28.72	-1.31	0.036*** (1997-1993)
1997	~ 1992-1997	2722	29.76	-1.28	0.105*** (2000-1997)
2000	~ 1995-2000	3953	24.08	-1.17	0.282*** (2007-2000)
2007	~ 2002-2007	4845	19.40	-0.89	0.423*** (2007-1993)

- Source: compiled by author based on IFLS 1993, 1997, 2000, 2007
- *** significant at 1%, ** significant at 5%, * significant at 10%

Table 28: Summary statistics on Weight-for-age z-score (WAZ) for children between the age of 5 and 10 years in 1993, 1997, 2000, 2007 (repeated cross-sectional data)

Years	**Birth year**	**n**	**HAZ<-2 in %**	**Mean HAZ**	**Mean Difference**
1993	~ 1974-1988	3221	40.89	-1.69	0.036*** (1997-1993)
1997	~ 1978-1992	3279	39.37	-1.69	0.105*** (2000-1997)
2000	~ 1981-1995	3614	38.27	-1.63	0.282*** (2007-2000)
2007	~ 1988-2002	4373	29.98	-1.29	0.423*** (2007-1993)

- Source: compiled by author based on IFLS 1993, 1997, 2000, 2007
- *** significant at 1%, ** significant at 5%, * significant at 10%

Appendix 5.1: Grid of previous research on child cognition

Study (Author, Date, Title)	**Country** (Year, data)	**Independent Variables**	**Outcomes**	**Controls/ confounders**	**Analytical Sample & Estimation method**	**RQ & Results**	**Notes**
(Alderman, Hoddinott et al. 2006): "*Long term consequences of early childhood malnutrition"*	***Zimbabwe:*** rural ***Year:*** 1983-2001 ***Data:*** longitudinal study of 400 households in 20 villages - baseline: Jul'83- Mar'84; -follow-up: '87, '92, '93, '94, '01) - p.454ff.	***At preschool age:*** (6months – 6yrs): - malnutrition (height for age)	***In adolescence:*** Health & educational attainment - height - number of grades attained, - age started school	Due to estimation technique (i.e. maternal fixed effects – sibling difference – instrumental variable estimator) not necessary	***Sample:*** - Full sample: 665 (p.457) - adolescent height sample: 340 (p.464) - grades attained: 569 ***Method:*** - maternal fixed effects – sibling difference – instrumental variable estimator (p.460) - Instruments for initial nutritional status: transitory exogenous shocks prior to age 3 (war & draughts)	***RQ:*** - How are improvements in height-for-age in pre-schoolers associated with health and educational attainment (i.e. increased height as young adults & the number of grades of schooling completed)? ***Main results of nutrition on cognition:*** - N/a: No direct measure of cognition ***Other relevant results:*** - Had a median pre-school child in this sample had the stature of a median child in a developed country, by adolescence, she would be 3.4 cm taller, had completed an additional 0.85 grades of schooling and would have commenced school six months earlier - Present calculations that suggest that loss of stature, schooling & potential work experience results in loss of lifetime earnings of around 14%	***Strengths:*** - get closer to causal relationships with their estimation technique – especially the siblings difference method (i.e. have nutritional status information of siblings at similar ages as the main sample) ***Weaknesses:*** - no conceptual framework linking independent & outcome variable ***Other:*** - no direct measure of cognitive attainment
(Berkman, Lescano et al. 2002): *"Effects of stunting, diarrhoeal disease, and parasitic infection during infancy on cognition in late chsildhood: a follow-up study"*	***Peru***: Lima outskirts ***Year:*** Sep 1989 – Nov 1991: weekly visits - 1999 follow-up round (p. 564-565) ***Data:*** birth cohort of 239 children	***At age 0-2years:*** - stunting - episodes of diarrhoea and parasitic infections (For more details, see notes column)	***At age 9 years:*** - cognitive tests (Wechsler intelligence scale revised (WISC-R) (p. 565)	***Child level:*** p. 565-566 - severe stunting - schooling information (grade when cognitive test; public/private school; class size) - attended kindergarten, - age at school entry - grade retention; - study habits), - if child worked - ***Parental level***: info on maternal birth place, education, language spoken, parity at birth, profession of main source of income, main caregiver, co-residency of father - ***Household level:*** SES (weekly food & non-food expenses, water quality, floor type, sanitation	***Sample:*** - 143 (69% of full sample) ***Method:*** p.566 - ANOVA for univariate analysis of cognitive test scores - sequential multivatiate ANOVA - F-test	***RQ:*** - What is the effect of stunting, diarrhoeal disease, and parasite infections during infancy on cognitive function in childhood (i.e. age 9)? ***Main results of nutrition on cognition:*** - children severely stunted in 2nd y of life, scored 10points lower on WISC test than other children ***Other relevant results:*** - during first 2 y of life, 32% of children were stunted - children with more than one episode of G lamblia infection per year, scored 4.1 points lower than children with 1 or less episode - neither diarrhoea & C parvum infection was associated with WISC-R scores	- ***Strengths:*** strong empirical base for independent variables: collected stool samples weekly and measured children's height every 30days in the first 2 years Information from the first 2 years: - severity of stunting - age at first stunting - stunting prevalence - stunting persistence - diarrhoea & parasites episodes ***Weaknesses:*** no conceptual framework linking independent & outcome variables; simple regressions – causal relationship; do not seem to control for income/expenditure (mention it in the text but not in the regression tables, etc.) - ***Other:*** parasitic infections examanimed: (Cryptosporidium parvum [C parvum] & Giardia lamblia [G lamblia]) - used EPINUT programme to calculate Z-scores
(Cheung 2006): *"Growth and Cognitive Function among Indonesian Children: Zero-inflated Proportion Models"*	**Indonesia** ***Year:*** 1993-2000 ***Data:*** IFLS 1 and 3	***At age 0-1:*** Weight-for-age (WAZ) (in IFLS1 in 1993) - WAZ at age 7 (in IFLS3 in 2000)	***At age 7:*** - Count of correct answers to 17 cognitive questions at age 7 (IFLS3 in 2000)	***Child level:*** p. 3014 - child's age (in months in 2000) centred at mean, - gender - if child attended school in 2000 ***Parental level:***	***Sample:*** p.3014 - n=355 (7 year olds in 2000) ***Method:*** - zero-inflated count models (more appropriate for upper bound models (e.g. 17 is the upper bound for cognition	***RQ:*** - Are the growth status in infancy and age 7 related to cognitive function of children age 7? Is there a critical window for cognitive function? - Methodological: Which zero-inflated count models performs best? ***Main results of nutrition on cognition:***	***Strengths:*** - useful to employ Lucas et al: early, later, combined and interaction model (p. 3013) for interpretation of coefficients for early and later body size in one regression model - method for count data used

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				- mother's education (3categories: none, primary and secondary & above) ***Household level:/*** ***Other: /***	assessment) - tests two versions 1) ZIP = zero-inflated Poisson model; 2) ZIBB = zero-inflated beta binominal model – one part of the model predicts zero-inflation (e.g. having zero's for the test) and other part predicts proportions of correct answers - use multiple imputations for sensitivity analysis	table II, p.3018 - correct answers predicted by WAZ at 7, not by earlier WAZ, mother education, attending school - interaction early and later WAZ not significant - results do not support critical window hypothesis, WAZ in infancy not significant - rather suggest that lack of catch-up growth after poor growth in infancy is hazardous and that weight gain is influential regardless of weight in infancy (p. 3019) ***Other relevant results:*** - ZIBB regression performed best - *zero inflation predicted by*: lower maternal education & child not attending school - sensitivity analysis of missing values: coefficient not changed substantially but WAZ in late childhood not significant anymore	***Weaknesses:*** - covariates are rather limited (e.g. no paternal information, no income/expenditure, etc.) - no conceptual framework - uses US reference data – e.g. 2000 U.S. Centres for Disease Control and Prevention (p.3014) ***Other:*** - no explanation/justification why only used WAZ and not HAZ - also not clear why only used 0-1 year olds, could have looked at 2 or even 3 year olds as well - no discussion if the insignificant results of WAZ and cognitive test scores could also mean that this type of cognitive test is not sensitive to pick up the effect
(Chowdhury and Ghosh 2011): *"Nutritional and socioeconomic status in cognitive development of Santal children of Purulia district, India"*	***India:*** West Bengal (remote area) ***Year:*** not mentioned ***Data:*** cross-sectional data	***At age 5-12:*** - nutritional status: HAZ, WAZ, WHZ (categories: 1) well-nourished, 2) mildly, 3) moderately, 4) severely under-nourished) - socio-economic status (SES): Kuppusswami scale (based on income, parental education and occupation (p. 189)	***At age 5-12:*** Raven's coloured progressive matrices (RCPM)	***Child level:*** - gender ***Parental level:*** - / ***Household level:*** - / ***Other:*** - / - not applicable, as only use descriptive analysis (p. 189)	***Sample:*** - n=838 children aged 5-12 years, - randomly selected from primary and secondary schools; ***Method:*** p. 189 -use descriptive and bivariate analysis (one-way ANOVA) but not multivariate models (p. 189)	***RQ:*** - What is the relationship of nutritional and socioeconomic status (SES) to cognitive development in 5-12year old Santal tribal children? ***Main results of nutrition on cognition:*** - RCPM gradually reduced with the increased grade of stunting, wasting & underweight (p.189) - RCPM stratification by SES - form IQ classes based on RCPM – around 43% of children intellectually deficient (have less than 40% of the questions correct) – p. 190 ***Other relevant results:*** - n/a	***Strengths:*** - uses Ravens scores as outcome - multiple categories for the nutritional status variable ***Weaknesses:*** - cross-sectional data – so outcome and independent variable assessed at the same time - use old WHO reference data (p. 189) - only descriptive analysis – not controlled for a lot of cofounding variables - age range of 5-12 very large as both cognition and nutritional status are sensitive to age ***Other:*** - Santals, tribe in India in remote areas, poor, illiterate, nutritional problems (p.188) - Kuppusswami scale (based on family income, parental education and occupation (p.189) – divide into upper and lower but no details on how created the index measure or how and why divided into dichotomous variable
(Crookston, Dearden et al. 2011): *"Impact of early and concurrent stunting on cognition"*	***Peru*** ***Year:*** 2002-2007 ***Data:*** p.399 - birth cohort (Young Lives study), - 1st round (in 2002): 6-18months old - 2nd round (in	***At age 6-18 months/4.5-6 yrs:*** - HAZ round 1 - HAZ round 2 (p.401ff)	***At age 4.5-6 years:*** p.400ff - verbal test (Peabody Picture Vocabulary test) - quantitative test (Cognitive Development Assessment; quantity subtest of notion of amount)	***Child level:*** p.401-402 - pre-school attendance - primary school attendance - age - sex ***Parental level:*** - maternal age - maternal education ***Household level:*** - urban location	***Sample:*** - n=1,649 (p.402) ***Method:*** - EpiNut module for Z-score calculation - international WHO reference (p.401-402) - mixed effect regression using SAS - Wald test to compare coefficients for HAZ in two	***RQ:*** - What is the effect of early stunting and concurrent stunting on cognitive ability? Hypothesis: Early stunting has a greater impact on cognition than concurrent stunting (p.402) ***Main results of nutrition on cognition:*** - Verbal scores: 1 SD increase in concurrent HAZ associated with increase in child's score on PPVT by 2.35 points - Quantitative score: 0.16 increase - concurrent HAZ stronger association than early	***Strengths:*** - Have birth-cohort with big enough sample size ***Weaknesses:*** - no discussion on their finding why concurrent stunting better predictor of cognition - Do not use interpretation of the early and later HAZ in one model – interpretation ***Other:***

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	2006/2007): 4.5-6years old			- region - nº of siblings - wealth index (composite of housing qualities, consumer durables and services (e.g. drinking water, toilet, electricity) - religion ***Other:*** /	different rounds	HAZ but only significant with verbal scores ***Other relevant results:*** - other predictors of cognition: older mothers, higher education, urban areas, attended pre-school, fewer siblings, wealthier background score higher on both assessments	- compared to their study in 2010 (see below) they are using HAZ (continuous variable) and not stunting (a bit confusing form their title and what they do in the regressions) - also use two measurements separate but not the dynamics - not clear if they interacted early and concurrent stunting to get some idea on the dynamics
(Crookston, Penny et al. 2010): **"***Children who recover from early stunting and children who are not stunted demonstrate similar levels of cognition"*	***Peru*** ***Year:*** 2002-2007 ***Data:*** - birth cohort (Young Lives study), - 1st round (in 2002): 6-18months old - 2nd round (in 2006/2007): 4.5-6years old	***At age 6-18 months/4.5-6 yrs:*** *Dynamics* of stunting between infancy and childhood: - not stunted - stunted in infancy but not in childhood (catch-up) - stunted in childhood - stunted in infancy & childhood	***At age 4.5-6 years:*** p.1997 - Peabody Picture Vocabulary Test (125 questions) - Cognitive Development Assessment (quantitative reasoning – 15 items to measure perception of amount)	***Child level:*** p. 1998 - child age & sex - preschool attendance ***Parental level:*** - maternal age, height, education ***Household level:*** - urban/rural, region - ethnicity - composite wealth indicator - number of siblings ***Other:*** - /	***Sample:*** - n= 1,649 (p. 2000) ***Method:*** - Mixed regression models to account for cluster design (p.1998)	***RQ:*** - Do children that demonstrate catch-up growth between infancy and childhood experience cognitive deficits compared to children that were never stunted? - Which factors are associated with catch-up growth ***Main results of nutrition on cognition:*** p. 1999-2000 - unadjusted regression models predicting verbal vocabulary scores, the reference group (not stunted) score significantly higher than the three other groups (when adjusted for control variables, catch-up group and not stunted did not differ), the chronic stunted & those who got stunted significantly lower scores) - for unadjusted models predicting quantitative cognition, children who were not stunted and those that experience catch-up growth do not differ - for unadjusted model children that are stunted in childhood have slightly worse vocabulary scores than those that are chronic stunted – this reverses to the expected order in the adjusted model - overall, results suggest that the long-term effects of stunting can be mitigated when children experiencing catch-up growth – contrary to other research that showed that children cannot recover from the consequences of stunting ***Other relevant results:*** - Factors that are related with catch-up growth: taller mothers, grandparents at home,	***Strengths:*** - birth cohort data - that they look at the dynamics of stunting ***Weaknesses:*** - 6-18 year olds & stunting dynamics: as stunting peaks at around 24 months not clear if this selection of sample is the best one to choose - no paternal information ***Other:*** - only follows children's development into childhood (e.g. until they are 4.5-6 but not later childhood or adolescence
(De Neubourg and De Neubourg 2011): **"***The Effects of Malnutrition and Post Traumatic Stress Disorder on the Learning Capacity of Children"* *[preliminary draft of paper]*	***Indonesia:*** Banda Aceh ***Year:*** not mentioned ***Data:*** p. 4-5 - cross-sectional survey, 9-13 year olds (in grade 5 and 6 of UNICEF primary school); 90	***At age 9-13:*** - Post-Traumatic Stress disorder (PTSD) - Malnutrition - General intelligence (Raven's coloured progressive matrices)	***At age 9-13:*** - Cognitive tests for working memory: 1) digital span tasks, 2) coding tasks (both subtasks of the Wechsler Intelligence Scale for Children (WISC), 3) Bourdon-Vos task (p.7, 17-18)	***Child level:*** - / ***Parental level:*** - / ***Household level:*** - / ***Other:*** - / - not clear from the paper, do not seem to control for any (e.g. no parental resource variables etc.)	***Sample:*** - n=79 (13 stunted, 66 not stunted) from original sample of 473 children - stratified sample from different PTSD categories ***Method:*** - simple one-way ANOVA for stunted vs not stunted & linear regression for digital span forward	***RQ:*** - What is the relationship between malnutrition, working memory and intelligence? ***Main results of nutrition on cognition:*** - stunted children significantly score lower on the digital span forward test (immediate repeating of a series of digits) - also perform worse in the coding task, the digital span backward and the Raven's test, but difference is not significant (very small sample size increases standard errors) except for Bourdon-Vos average time per line, Coding error (both showing no difference between stunted and not stunted	***Strengths:*** - Have very specific cognitive task to test working memory - clear conceptual framework ***Weaknesses:*** - cross-sectional data – e.g. concurrent stunting is related to working memory performance - Very small sample size and wide age range - limited control variables ***Other:*** - main interest of the study was to

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	children					children) ***Other relevant results:*** - Of the 79 children 13 stunted (16.5%), 66 not stunted (83.5%) – p. 7	examine Post Traumatic Stress disorder (PTSD), hence the selection of Banda Aceh (December 2004 earthquake & tsunami & armed conflict) but look at malnutrition as well
(Dercon and Sanchez 2011): **"***Long-term implications of under-nutrition on psychosocial competencies: evidence from four developing countries"*	***Countries:*** India, Vietnam, Peru, Ethiopia ***Year:*** 2002-2007 ***Data:*** - Young Lives project - 2 birth cohorts (6-18 months; 7-8 years in first round (in 2000)	***At age 7/8 years:*** - HAZ	***At age 11/12:*** - psychosocial competencies that are linked to adult earnings (p.7-9): 1) self-efficacy 2) self-esteem 3) educational aspiration	***Child level:*** - 1st model: child's age, gender, birth order, mother tongue, ethnicity, disability - 2nd model: current BMI, current HAZ ***Parental level:*** - 1st model: caregiver's age, gender, ethnicity, education - 2nd model: maternal psychosocial competencies (p.2) ***Household level:*** - 1st model: hh size, housing quality (wall, floor and roof) access to basic services, durable goods (p.2; 9) - 2nd model: current hh expenditure, lagged hh shocks ***Other:*** - use community fixed effects to account for time-invariant community characteristics (p.2)	***Sample:*** - n = 3,300 (p.1) ***Method:*** - OLS with fixed community effects - sensitivity analysis for sub-sample of children in communities where stunted children are not a minority (test if relative height as bullying might occur) - sensitivity analysis by adding lagged levels of reading and writing skills and age of school enrolment for proxies of cognitive skills	***RQ:*** - What are the roles of health and nutrition status in the formation of non-cognitive skills? (p.1) ***Main results of nutrition on cognition:*** - Increasing height-for-age by 1SD, increases school aspirations by 7.8%, self-efficiency by 5.8% and self-esteem by 3.4% (p. 3, table A3, p.19) ***Other relevant results:*** *p.3* - same across all four study countries – reinforces hypothesis that there is an underlying mechanism - household consumption and maternal non-cognitive skills main correlates of a child's non-cognitive skills - only a small part of the nutritional effect seems to be mediated by cognitive channel	***Strengths:*** - use outcome variables that have not researched very much but important for children's opportunities in life - also have data for maternal psychosocial competencies ***Weaknesses:*** - no clear conceptual framework linking independent and outcome variable ***Other:*** - The self-esteem and self-efficiency index is derived averaging the answers to various statements using 4-point Likert scale that range from strong agreement to strong disagreement (p.8) - self-esteem – adapted Rosenberg Self-Esteem scale on housing, clothing, work, school - e.g. "I feel proud to show my friends or other visitors where I live" - self-efficiency: "I have no control about the work I do" - Educational aspiration is the child's reported highest grade of education that they hope to achieve
(Gandhi, Ashorn et al. 2011): *"Height gain during early childhood is an important predictor of schooling and mathematics ability outcomes"*	***Malawi:*** (rural, South) ***Year:***1995 - 2008 ***Data:*** - 813 children from the Lungwena Child Survival Study (LCSS), 1995-1996 (baseline), p. 1114	***At infancy:*** - HAZ at 1months, conditional height gain between 1-6, 6-18, 18-60 months (regression and using the residual – p. 1114)	***At age 12 years:*** - highest school grade completed, - number of times repeated grade, - percentage of correctly answered mathematical questions (based on the ones used in IFLS – p. 1114)	***Child level:*** - gender - gestational duration ***Parental level:*** - fathers and mother's literacy - father's occupation - wealth index - 3 levels (p. 1114) ***Household level:*** - / ***Other:*** -	***Sample:*** - 325 children that could be followed until 12 years of age, and no missing values in outcome variable and exposure and covariates (p.1114) ***Method:*** - ordinal logistic and multiple linear regression	***RQ:*** - What is the association between height gain at different stages of early childhood and schooling and cognitive outcomes in 12-year-old Malawian children? ***Main results of nutrition on cognition:*** - conditional height gain during 18-60 months was positively associated with mathematical results ***Other relevant results:*** - height negatively related with number of times repeating grades - not significantly associated with highest grade completed if those who never attended school were included as having completed zero grade, but positive associated among those that ever attended school (p. 1115-1116)	***Strengths:*** - Use outcome variable that is based on IFLS measure - use of conditional height gain (regression & residual method) as independent variable ***Weaknesses:*** - Quiet imitated control variables: possible confounding factors ***Other:*** - chosen age of 12 years, as primary school is normally completed at this age and often this is the final stage of schooling to many African's (p.1114) - do not look at the height-gain between 60 months & 12 years of age
(Grantham-McGregor, Cheung et al. 2007): **"***Developmental potential in the first 5*	***Country*** - Indonesia, Philippines, Jamaica, Brazil ***Year:*** not	***In early childhood:*** - Poverty (wealth quintiles, 1st vs 3rd – p.64, 67) - stunting status	***In later childhood/adolescence:*** p.61,63 - IND: at age 9 - Ravens matrices &	***Child level:*** - n/a ***Parental level:*** - n/a ***Household level:***	***Sample:*** - INA: (IFLS, 9 yrs, n=368), - PHI (8years old, n=2,489) - JAM (17-18 yrs, n=165) - RSA (7 yrs, n=603)	***RQ:*** - Is stunting in early childhood related to later measures of cognition and grade attainment? ***Main results of nutrition on cognition:*** - stunting in early childhood is related to later	***Strengths:*** - Comparison of different countries and the similar results, supports hypothesis for underlying mechanism between stunting and cognition

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years for children in developing countries"	mentioned ***Data:*** p.63 Longitudinal data – e.g. birth cohorts and household studies - INA: IFLS (not mentioned which data waves used)	(e.g. not [>-1SD], mildly, moderately or severely [<-2SD] stunted)	arithmetic - Cognitive tests (vocabulary, reading , Wechsler Intelligence scales, Stanford Binet & Griffiths test) - school outcomes (e.g. attained grades by age 18; dropped out before grade 11, ever repeated a grade by age 14 years, reading & arithmetic score at 17)	- n/a ***Other:*** - n/a Not enough detail in the paper on this aspect	- BRA (18 yrs, n=2,041) - PER (9 yrs, n=72) ***Method:*** - Mostly review other studies but do reanalyse longitudinal data from 4 countries (PHI, JAM, PERU, IND) and for 2 countries not done before (RSA, BRA) [p.63] - Mostly descriptive results (not enough detail in the paper on this aspect)	measures of cognition and grade attainment in all studies (unadjusted, descriptive differences used only; p. 63-64) - being moderately/severely stunted compared with not stunted was associated with a difference between 0.4 to 1.05 SD in cognitive test results in different studies (p.64) ***Other relevant results:*** - the gap between top and bottom wealth quintile ranged from 0.70 to 1.24 SD for cognitive and school outcomes (p.64) - Estimate that 200 million children under 5 years fail to reach their full cognitive potential due to poverty or stunting (p.64-66) - BRA only: being stunted & in lowest income quintile compared to not stunted & highest quintile – deficit: 2.15 school grades (p.66) - 2.15 grade deficit has percentage loss in yearly income of 19.4% (assumes 9% per grade based on estimates of other developing countries) (p.67)	***Weaknesses:*** - as their focus is on an international comparison, they only use very limited variables – for example do not control/adjust their results for parent's schooling or health, etc. – also only descriptive results no multivariate analysis
(Husaini, Karyadi et al. 1991): *"Developmental effects of short-term supplemetary feeding in nutirtionally-at-risk Indonesian infants"*	***Indonesia:*** West Java (six tea plantations) ***Year:*** 1986 ***Data:*** - follow-up of 113 infants in 20 child centres, 9 centres received supplement, 11 did not	***At age 6-20 mo:*** - Intervention of supplementary feeding over 3 months in day care centres with high calorie snacks - dietary supplement: twice a day, ca. 400 kcal and 5g protein/d. (p.800)	***At age 10-24 mo:*** - Mental & motor development: Bayley Scales of Mental and Motor Development (BSMMD) – see notes for details - post-treatment anthropometry (weight, length)	***Child level:*** - n/a ***Parental level:*** - n/a ***Household level:*** - n/a ***Other:*** - n/a Not applicable, as this is not a regression analysis, but due to random control design	***Sample:*** - n=113; 78 children that received supplements and 38 were in the control (only focuses on younger children) ***Method:*** - randomised control trial design - just compare the mean before and after the intervention between treatment & control	***RQ:*** - Does supplemented feeding improve children's mental and motor development? ***Main results of nutrition on cognition:*** - benefit for motor but not mental development - absence of effects on the mental scale supports previous research that items tested by the BSMMD not very sensitive to nutritional factors (p. 803) ***Other relevant results:*** - in undernourished children, nutritional supplementation has benefit for weight gain (from -1.66 WAZ to -1.37 compared to control group with constant -1.55 WAZ) but not for height – p. 802 (however, only 14 weeks of supplementation and measured effect after 4 months not expected to affect the long-term measure of height, but because of the effect on weight, it is expected that if the intervention would have lasted longer there would have been an effect on lengths as well – p.803) - interactive term of treatment and body size for motor scale was not significant suggestion that effect of treatment was independent of body size (p.802-803) - results suggest that not path from supplementation → weight gain → motor development but rather simultaneously affected both domains - however, hypothesise, that improved motor maturation can broaden children's natural developmental involvement with immediate environment thereby affecting subsequent cognitive developments (p.804)	***Strengths:*** - randomised control trial design - Dietary survey preceded the experimental intervention (children also measured for their baseline anthropometry etc.) ***Weaknesses:*** - Intervention might have been too short and effects measured too early ***Other:*** - evaluation survey – 4 months after start of the study (p.800) - the intervention setting of tea plantation quite homogenous in terms of SES and large number of day care centres (p.800) - older children (21-59mo): Peabody Picture Vocabulary Test and Oddity Learning Tasks – but part of a different paper (reference not supplied) - BSMMD mental scale: performance on wide range of behaviour: e.g. dangling a ring, pushing a toy car, etc. - motor scale: gross motor (e.g. standing, walking, jumping), fine motor movements (finger prehension of pellet) (p.801) - motor scale more heavily loaded with gross-motor movements which justifies relationship with energy supplementation effect - theory link on brain activation through energy intake (p.804)
(Ivanovic, Pérez et al. 2004):	***Chile*** ***Year:***	***At age: 6-17*** - different	***At age: 6-17*** - scholastic	***Child level:*** -	***Sample:*** - 4,509 school-aged children	***RQ:*** - What is the relative effects of nutritional status,	

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"Scholastic Achievement: A Multivariate Analysis of Nutritional, Intellectual, Socioeconomic, Sociocultural, Familial, and Demographic Variables in Chilean School-Age Children"	- collected 1986- 1987 - but data processing lasted until 2002 ***Data:*** - cross-sectional data	anthropometric indicators, - detailed nutritional intake, - intellectual, educational variables, - exposure to mass media (e.g. radio, newspaper, books, etc.), socio-economic, family characteristics and demographic variables	achievement. (i.e. Spanish and math test scores (p. 2004).	***Parental level:*** - ***Household level:*** - ***Other:*** - n/a as only use simple regression	(elementary to high school level) ***Method:*** - It seems that instead of basing their model on a conceptual framework, they rather test in a first step using univariate (or bivariate?) analysis (Pearson's correlation coefficient) which of the independent variables most strongly associated with SA. In a second step they then include these variables in a multiple regression.	intellectual ability, exposure to mass media, and socioeconomic, sociocultural, familial, demographic, and educational variables on scholastic achievement (e.g. Spanish & Math test scores)? ***Main results of nutrition on cognition:*** - ***Other relevant results:*** - Main determinants of scholastic achievement are: intellectual ability, level of maternal schooling, head circumference-for-age Z score, book reading, in-door plumbing, level of paternal schooling, type of school, quality of housing, height-for-age Z score, and calcium intake - In most grades, IA was the independent variable with the greatest explanatory power in SA variance	
(Kar, Rao et al. 2008): *"Cognitive development in children with chronic protein energy malnutrition"*	***India*** (Bangalore) ***Year:*** 2004 ***Data:*** - cross-sectional data	***At age 5-10:*** - Stunted Growth	***At age 5-10:*** - NIMHANS (neuropsychological battery for children sensitive to the effects of brain dysfunction and age related improvement was employed): motor speed, attention, visuospatial ability, executive functions, comprehension and learning and memory (p.4-6)	***Child level:*** - age, gender ***Parental level:*** - no info ***Household level:*** - no info ***Other:*** - no info	***Sample:*** - n=40 - 20 malnourished and 20 adequately nourished in the age groups of 5–7 years and 8–10 years were examined	***RQ:*** - What is the effect of stunted growth on the rate of development of cognitive processes? ***Main results of nutrition on cognition:*** - Malnourished children performed poor on tests of attention, working memory, learning and memory and visuospatial ability except on the test of motor speed and coordination. - Age related improvements only in attention, visual perception, and verbal comprehension but still lacking compared to adequately nourished children ***Other relevant results:*** - Development of cognitive processes appeared to be governed by both age and nutritional status Conclusion: Chronic protein energy malnutrition (stunting) affects the ongoing development of higher cognitive processes during childhood years rather than merely showing a generalized cognitive impairment. - Stunting could result in slowing in the age related improvement in certain and not all higher order cognitive processes and may also result in long lasting cognitive impairments.	***Strengths:*** - Employed very comprehensive tests (i.e. neuropsychological measures) that have shown to be sensitive to the effects of brain dysfunction ***Weaknesses:*** - very small sample size - cross-sectional data
(Mendez and Adair 1999): *"Severity and timing of stunting in the first two years of life affect performance on cognitive tests in late childhood"*	***Philippines*** (metropolitan Cebu) ***Year:*** 1983 - 1995 ***Data:*** - one-year birth cohort - Cebu Longitudinal Health and Nutrition Study	***At age 0-2:*** - prospective bimonthly data from birth till 2 - severity (moderate vs severe – p.1557) - timing (i.e. age of onset of stunting, grouped in 6months intervals) - persistence (between 0-2 and 8y): persistent stunted, catch-up,	***At age 8 & 11:*** - age specific z-scores of cognitive test (Philippines Nonverbal Intelligence Test – 100 cards, 5 objects, 1 differs in a meaningful way – p.1557) - School outcomes (e.g. delay in initial enrolment; higher absenteeism; higher	***Child level:*** - sex of the child - % of fat in diet at 8 - type of school (public vs. private) ***Parental level:*** - Several indices of SES during infancy (p. 1557): household income quartile - highest grade completed by mother and father - maternal height - weather main carer mother	***Sample:*** p. 1557 - n = 2,131 (stunting data and test scores at age 8 y) - n = 2,048 (also test scores at age 11 y) ***Method:*** - t-test (compare 2 groups), chi-square (3 or more groups) - models: crude, schooling adjusted, multivariate adjusted, (p. 1557) - additional models (p. 1558) - Heckman two stage model to evaluate selectivity bias	***RQ:*** - What is the relationship between stunting in the first 2 years of life and later cognitive development, focusing on the significance of severity, timing and persistence of early stunting? ***Main results of nutrition on cognition:*** - *stunting at age 2*: significant lower mean in cognitive test scores than non-stunted children with greater difference at age 8 y than at age 11 y - *severity of stunting* at age 2: (in unadjusted model) severely stunted children had 0.61 SD below the mean of cognitive tests compared to non-stunted children; mildly – 0.25 SD lower (p.1559) - *timing of stunting*: earlier onset of stunting more	***Strengths:*** - prospective bimonthly data from birth till 2years of age, that allows to examine different dimensions of stunting - specific designed birth-cohort study that only focuses on children ***Weaknesses:*** - is only one region in Philippines, not national representative ***Other:*** /

Study (Author, Date, Title)	**Country** (Year, data)	**Independent Variables**	**Outcomes**	**Controls/ confounders**	**Analytical Sample & Estimation method**	**RQ & Results**	**Notes**
		late onset, never stunted	grade repetition, highest grade achieved at time of cognitive test)	***Household level:*** - type of house - change in hh income quartile over time - parity (birth order indicator) - number of younger siblings ***Other:/***	due to attrition or missing data	likely to have severe stunting (difficult to disentangle the effect) – worse cognitive results at age 8 (if stunted in first 6 months vs never stunted in first 2 years – 0.6 SD lower); for children 18-24 months – 0.19 SD) - *persistence of stunting through age 8:* lower scores than never stunted children and catch-up - children's cognitive test scores at age 11y were strongly correlated with scores on English (reading comprehension) and Mathematics achievements tests which were also administered at age 11y (p. 1557) ***Other relevant results:*** - interaction between stunting and schooling not significant – i.e. effect for schooling on cognitive scores does not differ for stunted vs non-stunted children (p. 1557)	
(Pollitt, Watkins et al. 1997): *"Three-month nutritional supplementation in Indonesian infants and toddlers benefit memory function 8 y later"*	***Indonesia*** West Java (six tea plantations) ***Year:*** 1986-1995 ***Data:*** - follow-up of the 3months supplement study (see Husaini et al, 1991 above)	***At age: 6-59months*** - short-term (3months) supplementary feeding intervention with high calorie snacks in day care centres	***At age: ~9years*** - anthropometry (height, weight, head, skinfold) - haemoglobin, iron status - Peabody Picture Vocabulary Test - arithmetic test - Computerized (Touchscreen) Cognitive Abilities Tests: 1) simple & choice reaction time; 2) Sternberg test of working memory; 3) probe recall; 4) tachistoscopic threshold (two figures in rapid succession,decide if identical – used as stressor to also test emotionality	***Child level:*** - age, sex ***Parental level:*** - made no socio-economic adjustments, as the group was very homogeneous (p. 1358) ***Household level:*** - / ***Other:*** - tester	***Sample:*** - overall: n=231 (125 supplemented, 106 control) - sub-sample: n=73 for under 18months old during treatment ***Method:*** - randomised control trial design - compare the mean between treatment & control for different tests, just controlling for age, sex of the child and the tester	***RQ:*** - Does short-term supplementary feeding during infancy and childhood have long-lasting benefit for working memory in undernourished children? ***Main results of nutrition on cognition:*** - for total sample, no difference between treatment and control group for different cognitive measures except for sub-group of younger children that received supplementation before 18months of age (n=73) - These supplement children performed better on working memory test (Sternberg) – e.g. greater scanning speed of working memory - those supplemented before 18months of age (9years) were as fast as oldest supplemented age group (~12years) [p. 1361] ***Other relevant results:*** - No difference for anthropometry, haemoglobin, vocabulary test and arithmetic between supplemented and non-supplemented children	***Strengths:*** - randomised control trial design ***Weaknesses:*** - small sample sizes for sub-sample of under 18months olds (n=73) - Intervention might have been too short (3months only) ***Other:*** - Peabody Picture Vocabulary Test – Sundanese version: four pictures, given a word and then asked to point to appropriate one
(Tarleton, Haque et al. 2006): "*Cognitive effects of diarrhea, malnutrition, and entamoeba histolytica infection on school age children in Dhaka, Bangladesh"*	***Bangladesh*** (Dhaka, urban slum) ***Year:*** not mentioned ***Data:*** survey linked to 4-year longitudinal health surveillance	***At age 2-5y:*** Episodes and duration of: - Diarrhoea, - malnutrition (HAZ, WAZ) - intestinal parasite (entamoeba histolytica)	***At age 6-9 y:*** - non-verbal test: Raven's coloured progressive matrices - Verbal: Wechsler abbreviated scale of intelligence (WASI) and [p.476]	***Child level:*** p.475-476 - age, sex - schooling: start date, duration in months & type of schooling & if repeated a grade - participation in drawing, music, sports classes - part-time, full-time work - iron level - immunisation	***Sample:*** - 191 children, 6-9 years old ***Method:*** - simple and multiple regression (adjusted for demographics and socio-economic factors) - interaction between age & malnutrition (figure 1, p.480)	***RQ:*** - What is the association between diarrhoea, malnutrition, and social factors with cognitive scores? ***Main results of nutrition on cognition:*** - baseline stunting sig. associated with cognitive test scores (baseline HAZ as continuous outcome even stronger association; simple regression) - sig. interactions b/w child's age & baseline malnutrition for Raven's but not verbal scores (Figure 1, p.480): older children stunted at baseline	***Strengths:*** - That they are able to link their survey to 4-year longitudinal health surveillance survey with detailed malnutrition history (every 4months) and diarrhoea (every other day in first 3 years) ***Weaknesses:*** - Use longitudinal variables but not models to tease out causal relationships ***Other:***

Study (Author, Date, Title)	Country (Year, data)	Independent Variables	Outcomes	Controls/ confounders	Analytical Sample & Estimation method	RQ & Results	Notes
	survey			***Parental level:*** - education, age, ***Household level:*** - possession of TV or radio - income - family size, number of siblings ***Other:*** /		little difference with younger stunted children, while those without baseline stunting significant differences based on age (p.477) - duration of stunting during 4 years not significantly associated with Raven's but with verbal score [p. 479] – more influential on child's language development ***Other relevant results:*** - 29% of children were stunted, 64% of those remained stunted over entire 4 years [p.476] - Raven's scores significantly associated (in simple regression) with age, mothers' & fathers' education, lowest income group - episodes or duration of diarrhoea significantly associated with Raven's scores before but not after controlling for SES - duration of intestinal parasites significant[p.478] - in multiple regression maternal education completely accounted for father's education and other socio-economic variables [p.477]	- duration of stunting (def. percentage of study time that child was stunted [p.477]
(Walker, Grantham-McGregor et al. 2000): *"Effects of growth restriction in early childhood on growth, IQ, and cognition at age 11 to 12 years and the benefits of nutritional supplementation and psychosocial stimulation"*	***Jamaica Year:*** not mentioned ***Data:*** - birth cohort of children aged 9-24 months in 1987 - followed up 8 years later	***At age 9-24mo:*** - Randomised intervention - psychosocial stimulation (weekly home visits when play and home-made toys was demonstrated) - nutritional supplementation (1kg of milk-based formula provided weekly)	**At 11 & 12 y:** (8 years after trial) – p. 37: - IQ (Wechsler Intelligence Scales for Children-Revised: verbal and performance subscales, age-specific) - 10 cognitive function tests (see notes for details), one of them is Raven's - children's growth	***Child level:*** - birth weight ***Parental level:*** - PPVT of mothers - caretakers education ***Household level:*** - home stimulation (p. 39: factor analysis: Factor 1: table & chair to do homework, adult help with homework, visits public library, goes on trips); factor2: number of toys and games, adults play indoor and outdoor games with child: factor 3: number of books, child reads newspaper) ***Other:*** - housing condition (factor analysis of household possessions, crowding, sanitation)	***Sample:*** - n= 127 growth restricted children - 116 growth-restricted children (91.3%) followed; 80 non-growth restricted children (95.2%) (HAZ>-2SD) ***Method:*** - Randomised control trial	***RQ:*** - What are the long-term benefits to growth and cognition for intervention of psychosocial stimulation and nutritional supplementation in early childhood? ***Main results of nutrition on cognition:*** - nutritional supplementation had short-term benefits but no significant long-term (8years after intervention) benefit to growth, cognition or IQ [contrast to benefits from intervention that started during pregnancy and continued for at least first 3 y of life in Guatemala and Colombia (p.39)] - supplementation might have been necessary to continue throughout childhood (p.40) - growth restricted children had significantly poorer performance than non-growth restricted children on 9 of 10 cognitive tests (digital span forward only exception) – growth restriction has long-term functional consequences (p.39) ***Other relevant results:*** - home-based stimulation for growth restricted children small but significant long-term benefit to IQ (WISC-R), reasoning ability (Ravens), vocabulary test, (p.39,40) - no interaction between stimulation and caretakers PPVT score - birth weight not significant in any of the models (p. 39) and did not change results – some indication that postnatal growth restrictions has long term functional consequences (p.40)	***Strengths:*** - Randomised control trial - That they have data on stimulation and nutritional supplementation ***Weaknesses:*** - ***Other:*** - invention of 2 years for growth restricted children between 9-24 months randomly assigned to groups (p.37): 1. Control 2. Supplemented 3. Stimulated 4. Both treatments 5. 32 non-growth restricted children matched to control group for age, sex, neighbourhood (at follow-up 4 years added another 52 – p. 37) - stimulation aimed at improving teaching techniques of mothers and quality of verbal interaction, also concepts of colour, shape, size, number and position were taught (p. 37) Cognitive function tests (p.37): - visual reasoning (Ravens Matrices), - PPVT (language comprehension), - verbal analogies, - vocabulary test: modified Stanford Binet, - auditory working memory tests (digital span forward/backward), - visual-spatial memory (Corsi blocks), - search test, - modified Stroop test

Study (Author, Date, Title)	**Country** (Year, data)	**Independent Variables**	**Outcomes**	**Controls/ confounders**	**Analytical Sample & Estimation method**	**RQ & Results**	**Notes**
(Watanabe, Flores et al. 2005): "*Early Childhood Development Interventions and Cognitive Development of Young Children in Rural Vietnam"*	***Vietnam*** (rural province of Thanh Hoa) ***Year: 1998 - 2004*** ***Data:*** - Combine survey with previous data from intervention from Save the Children Japan	***At age 0-36 mo & 4-5 y:*** - nutritional intervention (0-3 y) [p.1919] - Early childhood development (ECD) intervention during preschool (4-5 y)	***At age 6.5-8.5 y:*** - Raven's progressive matrices - height-for-age (HAZ)	***Child level:*** - childcare (pre-schooling history) ***Parental level:*** - maternal age, education, number of birth, occupation ***Household level:*** - number of children and family members - presence of grandparents - monthly income (commune level secondary data) [p. 1919] ***Other:*** - /	***Sample:*** - 313 children; 6.5-8.5 y (grade 1, 2 in primary school) that could be matched with baseline data from 1998; ***Method:*** - Bivariate analysis, multivariate analyses (= generalised estimating equation for proportion of stunted children, generalised linear model for continuous variable) [p.1920]	***RQ:*** - Does an early childhood development intervention ***Main results of nutrition on cognition:*** - no significant results of the nutritional intervention on cognitive outcomes ***Other relevant results:*** - ECD intervention on cognitive test scores was large for the most nutritional deprived children whose HAZ declined or remained in stunted range	***Strengths:*** - Can link it to previous data ***Other:*** - Nutritional and Early Childhood intervention from 1999-2003 implemented by Save the Children Japan; using positive deviance inquiry (PDI); teaching about nutritional and health seeking behaviour, locally available nutritional food - ECD: pre-school based activities, parenting education – promote play corners at home, local library for parents [p.1919]

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