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Are boys still short?

A study on sex differences in stunting prevalence over socio-economic status among children in Sub-Saharan Africa

Sushant Vaidik and Jonatan Brink Wenzel

Supervisor: Vincent Somville

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ABSTRACT

Background: Over 150 million children worldwide are stunted. In Sub-Saharan Africa alone more than 1 in every 3 children is stunted due to insufficient food intake, boys being the most vulnerable according to prior research. Although UN has accentuated the negative impact of stunting and included it as part of the Sustainable Development Goal #2 "End hunger", the decline in stunting prevalence is slow partly due to the poverty trap cycle of stunting. The economic costs of stunting are considerable as it precludes economic growth, which is especially damaging for developing countries where stunting prevalence is substantial, resulting in reinforcement of inequality.

Objective: The aim of this thesis is to explore possible determinants of nutritional status and examine if the main significant variables identified can explain the gender gap of stunting prevalence, both current status and development over time, in Sub-Saharan Africa.

Method: Student t-test and multiple logistic regression were employed to test for determinants of nutritional status, the existence of sex differences in stunting and how that differed controlling for socio-economic status proxied by several independent variables. Demographic and Health surveys from 35 Sub-Saharan African countries conducted between 1986 and 2016 provided data for the analysis.

Results: The pooled results display that boys are 1.18 times more likely to become stunted than girls. Country specific results confirms the gender difference is in 33 of 35 countries (OR > 1, 95% CI) indicating a higher risk for boys. We found that wealth, mother's education, polygamous households, mother's age at first birth are important factors in determining children's nutritional status. Although the observed determinants have significant impact, none of the tested variables can explain the gender gap in stunting prevalence.

Conclusion: Our study confirms the gender gap indicated by smaller scale studies and hereby sets an updated benchmark for the region. The study did not find that the exposed moderating factors are playing a significant role in explaining the gender difference in stunting prevalence. Future research should therefore focus on investigating new potential explanations for the gender gap.

Keywords: Stunting, Sub-Saharan Africa, Gender gap, Child malnutrition, Economic growth, Determinants of nutritional status, Sustainable Development Goals

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ABBREVIATION LIST

AOR	Adjusted Odds Ratio
BMI	Body Mass Index
CCT	Conditional Cash Transfers
CDE	Chronic Energy Deficiency
CI	Confidence Interval
CIAF	Composite Index of Anthropometric Failure
DHS	Demographic and Health Survey
FAO	Food and Agriculture Organization of the United Nations
GDP	Gross Domestic Product
HAZ	Height-For-Age Z-Score
OLS	Ordinary Least Squares
OR	Odds Ratio
PCA	Principal Component Analysis
PEM	Protein-Energy Malnutrition
RCT	Randomized Control Trial
SDG	Sustainable Development Goals
SES	Socioeconomic status
SSA	Sub-Saharan Africa
UN	United Nations
UNACC	United Nations Administrative Committee on Coordination
UNICEF	United Nations Children's Fund
WHA	World Health Assembly
WHO	World Health Organization
WHZ	Weight-For-Height Z-Score

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1. INTRODUCTION

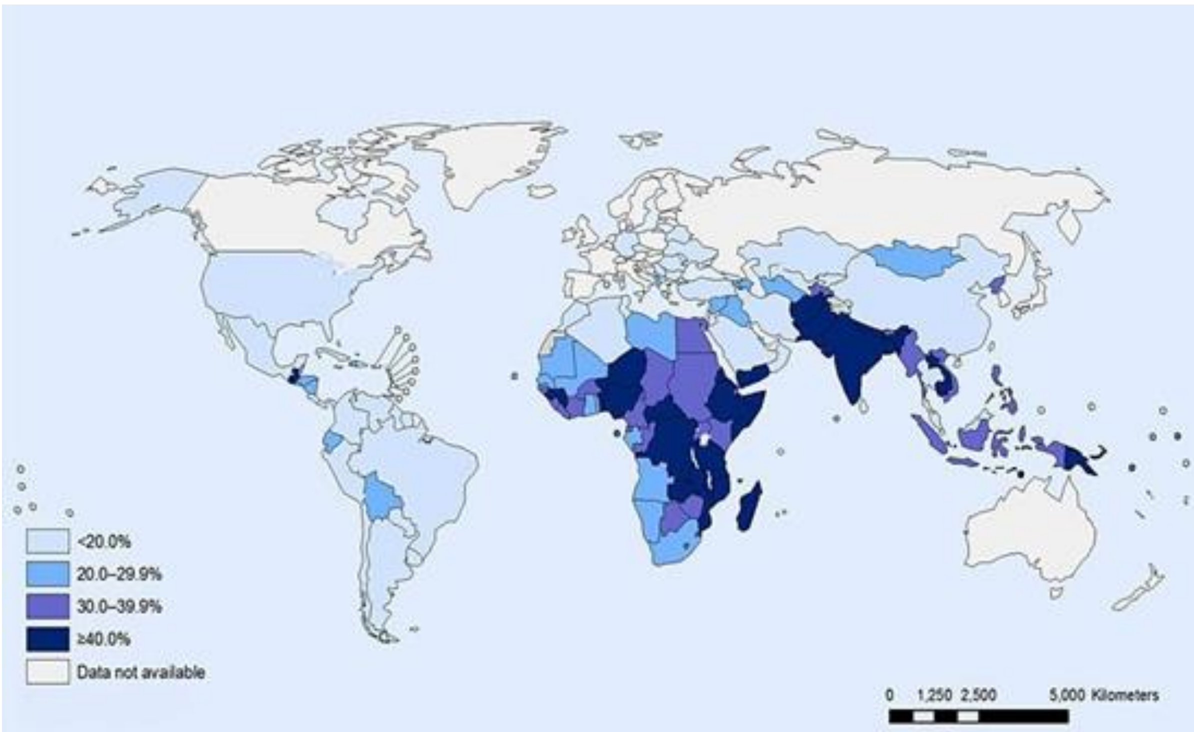
The United Nations' (UN) 17 Sustainable Development Goals (SDG) are linked to each other in several different aspects, particularly goals with objective to improve economic development. It would be impossible to declare a win against poverty (SGD #1) if food insecurity was still present (SDG #2), and through improved economic status there are possibilities to enhance educational quality and keep children in school longer (SDG #4). SDG #5, gender equality, can be applied as a layer to several other SDG to ensure that empowerment of all women and equality is accomplished throughout all aspects of development (UN, 2015). The gender aspect is particularly emphasized in SDG #2, "End hunger, achieve food security and improved nutrition and promote sustainable agriculture", as it endorses addressing the nutritional needs for adolescent girls and pregnant women.

Malnutrition (stunting and wasting) is a consequence of insufficient nutritional intake (SDG #2); long-term of consecutively inadequate food intake (chronic malnutrition) causes stunting or "short height-for-age", while wasting or "low weight-for-height" is usually the result of acute food shortage (UNICEF, 2006). World Health Assembly (WHA), the decision-making body of World Health Organization (WHO), recognized in 2012 a target to reduce stunting prevalence for children under 5 with 40% by 2025. The goal was later adopted by UN and incorporated in the SDG #2 (Galasso et al, 2016). Additionally, the SDG have set aim to end all forms of malnutrition of under-five children by 2030.

Although the proportion of undernourishment worldwide has declined from 15% to 11% between 2002 and 2016, almost 800 million people are still undernourished. The decreasing trend is also present for stunting among children less than 5 years of age; prevalence dropped from 33% in 2000 to 23% in 2016 (UN, 2017). However, current stunting trends show slow decrease in prevalence with around 1.5% per annum which is only enough to reach a reduction of stunting prevalence with 20% by 2025, half of the WHA-SDG target and far from the SDG 2030 goal of eradicating all malnutrition. In 2016 over 150 million children suffered from stunted condition, with Southern Asia and Sub-Saharan Africa accounted for 75% of the stunted children.

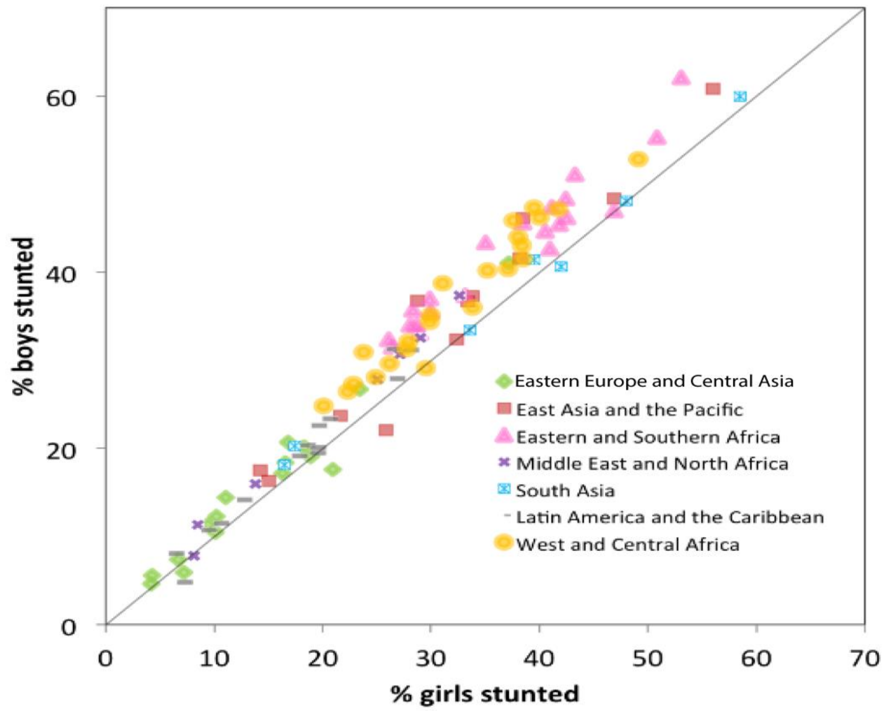
As seen in figure 1 below, there is a correlation between GDP/capita and stunting levels, which will be presented in detail in the following chapter, and this relationship is also present within countries; being born in a developing country (low GDP/capita) and/or in low income households will increase the risk of stunting (Onis et al, 2016). Amid several other determinants of stunting, which will be analyzed and tested for in this study, the gender variable is the main focus for this thesis. Previous research indicate a slightly higher stunting prevalence among boys compared to girls, especially in Sub-Saharan Africa, with few exceptions as portrayed in graph 1 below (UNICEF, 2018).

Figure 1. National prevalence of stunting among children under 5 years of age



(Onis et al, 2016)

Graph 1. Percentage of stunted boys and girls in the world



(UNICEF, 2018. Data from 2012)

The effects of poor nutritional status (stunting) are vast both on individual and national level as it has negative impact on people's wellbeing and economic growth. Consequences are connected in a circular pattern; previous research show that stunting increases the risk of impaired cognitive ability and weakened/shorter performance in school, lowers productivity and reduces lifetime earnings (FAO, 2017; Carba et al, 2009; Martorell et al, 2010). At the same time, childhood malnutrition and stunted condition deteriorates immune system increasing the risk of (deadly) diseases which causes higher health costs (Caulfield et al, 2006). The combined effects and cost of stunted condition have an all-round negative impact on economic growth, GDP/capita, and the circle pattern is closed as low GDP/capita (poverty) increases the risk of malnourishment. Additional factor closing the circle pattern is that previous literature indicates that malnourished mothers are more likely to have underweight children which is associated with stunting (Dewey et al, 2010). Stunting can consequently increase/preserve income inequality as the condition is most prevalent in poor households. To be able to accomplish the SDG and reduce the large societal costs, both direct and opportunity cost of unexploited GDP/capita growth, of stunting it is crucial to first define the determinants and secondly implement policies and interventions directed at the factors with the most severe impact.

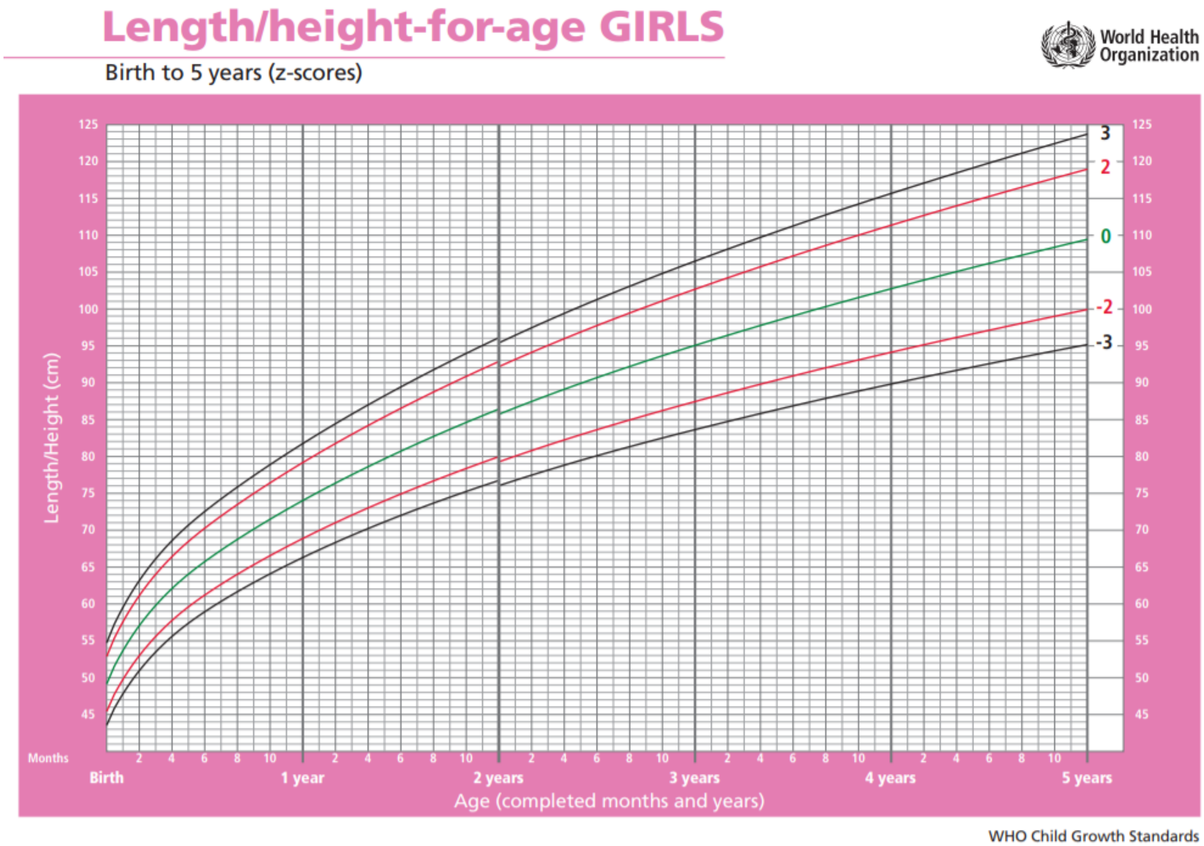
1.1 Definition of stunting

The most commonly used definition of stunting which is used in this study, is based on WHO's Child Growth Standard, an anthropometric measurement developed using data from the WHO Multicentre Growth Reference Study (WHO Multicentre Growth Reference Study Group, 2006). Displayed in graph 2, the measurement shows standard growth curves for children from birth to 5 years of age, separate for each sex. A height-for-age z-score (HAZ) that is more than 2 standard deviations (SD) below median height-for-age of reference populations is the cut-off point for stunting, and a value of more than 3 SD below is classified as severe stunting. Z-score for child "i" is calculated as:

$$\text{Z} - \text{score} = \frac{H_i - H_r}{SD\ of\ reference\ population}$$

Where H_i is the height for child "i" and H_r is the median height of the reference population.

Graph 2. Height-for-age graph from birth to5 years of age for girls



(WHO, 2018)

1.2 Objective

The aim of this thesis is to explore possible determinants of children's nutritional status and examine if the main significant variables identified can explain the gender gap of stunting prevalence, both current status and development over time, in Sub-Saharan Africa using DHS data. Further, the objective is to define the factors with prime impact on stunting levels and analyze the results to suggest strategic policies/interventions targeted at reducing stunting efficiently.

Previous research within the topic of stunting is substantial but, as far as the authors are aware, only spares amount of published studies focus on gender differences in-depth. Although several studies analyze the gender aspect as a possible determinant for stunting, the vast majority are fairly shallow only providing descriptive results of gender differences of stunting prevalence and do not control for the gender difference with other determinants in multivariate models. Additionally, previous studies are either using data from a shorter time period, analyzing fewer countries (i.e. Wamani et al, 2007) or are regional/local designed with significantly smaller data size. This cross-country meta-study will therefore add depth and width to the literature by providing robust evidence of stunting determinants and gender differences due to the scale of data used, time-variable applied, numbers of countries analyzed and choice of multivariate regression model.

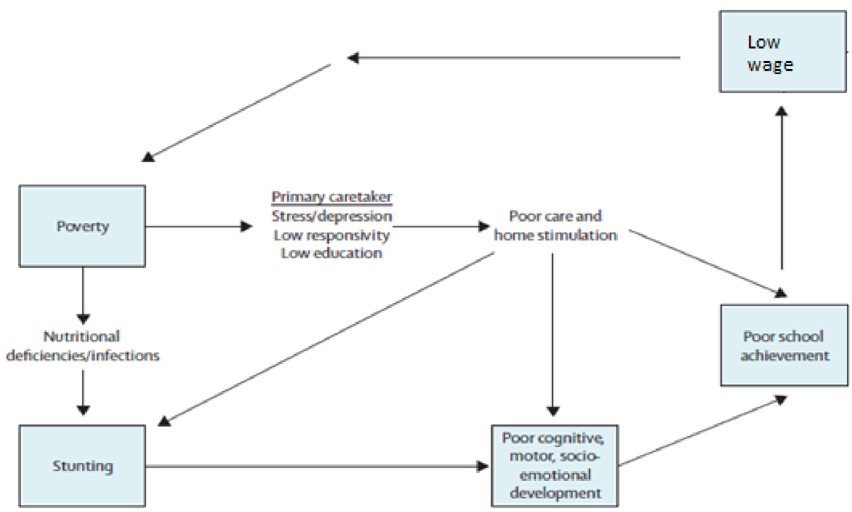
2. LITERATURE REVIEW

Insufficient nutritional intake is not only an acute problem causing starvation, the long term effect of consecutive unmet nutritional needs can have severe impact on nutritional status resulting in stunting (and wasting). Stunting generally occurs prior to 24 months old, and a major negative characteristic is the largely irreversible aspect of the conditions causing the physical consequences to be permanent. Stunted condition is the origin of several negative effects i.e. impaired cognitive function, delayed motor development and poor school performance which, in the long term, have negative impacts on economic growth (UNICEF, 2007). In 2016, the prevalence of stunted children under 5 was 22,9% in the world, and in sub-Sahara Africa alone 34,1% of the children had stunted stature (The World Bank, 2016). Given the large proportion of children suffering from malnourishment, the accumulated negative effect of stunting can have a significant impact on economic development, especially in developing countries. Malnourishment was estimated to cost 11% of the world's GDP in 2014 according to Global Nutrition research (Global nutrition report, 2014). To prevent the negative economic consequences of malnutrition it is crucial to first define the major predictors causing the condition and secondly put effective policies and interventions in place. This chapter will first present literature and research on the effects of nutritional status on economic outcomes and the following part will focus on the main determinants of nutritional status.

2.1 The effects of nutritional status on economic outcomes

Most of the economic outcomes sprung from poor nutritional status have connected effects similar to a domino chain, it is seldom one economic outcome isolated without having spillover consequences affecting several other factors/outcomes. A chain-reaction example on the effects of stunting on economic growth starts with the reduced cognitive ability as a consequence from stunted condition. Lower ability to comprehend and attain skill/knowledge as a child/adolescent will have significant effects on educational level which causes inferior level of human capital. Grantham-McGregor et al illustrated this chain reaction (figure 2 below), and a similar linked relationship is present for the determinants of stunting which will be described in the next chapter.

Figure 2. Circular links between stunting and poverty (poverty trap)



(Adjusted from Grantham-McGregor et al, 2007)

The effects of stunting on economic outcomes are multidimensional and figure 2 only illustrates one of many possible connection but it highlights the common loop feature showing a circular relationship, the poverty trap; lower education (poor school achievement) is associated with lower wages resulting in higher risk of poverty which itself is connected to deteriorated nutritional status. A difficulty encountered in some of the previous research is measuring the exact magnitude of the impact on economic outcomes from each single variable in the chain. The complication is also present when measuring the isolated impact on outcome to outcome due to problematic in defining causality direction (reverse causality) as the effects can be bidirectional. The following section will break down the dominating factors from previous research analyzing the economic outcomes sprung from stunting (and malnutrition).

2.1.1 Individual level effects aggregated level effects and Economic growth

There is a slight separation between individual level (micro) estimates and economic growth (macro) estimates regarding various outcomes as a consequence of stunted condition. The difference is the possibility that an individual level estimate do not account for all aggregated levels such as capital formation, labor markets, investment and savings behavior which makes up the determinants of aggregated output (McGovern, 2017). Therefore, when analyzing the full cost of malnutrition carried by the society (as a decrease in economic growth) it is important to account for all factors and link the variables from micro- to macro-level. This is apparent when applying standard macroeconomic growth models where national income is defined as a function of labor (human capital), capital (investment/savings) and technological progress. The economic outcomes analyzed below will be presented with focus on both micro and macro-level, i.e. variations in wages for individuals and the aggregated effect on GDP growth, for a comprehensive literature review.

2.1.2 Income (wages)

In previous research on stunting, lower income levels is a dominating and reoccurring negative economic outcome as income is a result of several underlying other factors affected by nutritional status. Numerous studies with different approaches, methods, countries of interest, timespan etc. indicate a unanimous negative effect on wages as a consequence of stunted condition. Zere et al (2003) study of stunting in South Africa displays that malnutrition contributes to a significant reduction in lifetime earnings. McGovern et al (2017) have analyzed and compiled literature[1] on the economic effects of stunting from Randomized Control Trial (RTC), quasi-experimental approaches and observational studies in their research paper “A review of the evidence linking child stunting to economic outcomes”. The relationship between poor nutritional status and lower wage is present across the studies but the magnitude differs. Two different RCTs indicate an increase in wages of 25% (Jamaica) and 46% (Guatemala, only significant for men) for children benefitting from nutrition interventions. The discrepancy indicates a strong relationship of poor

[1] 29 summery papers, 21 prospective studies from 14 cohorts, 7 intervention studies, 5 natural experiment papers, 10 quasi-experimental instrumental variable paper, 17 studies using linear regression examine the relationship between wages and adult height

nutritional status and low wages and at the same displays the different impact, and effectiveness, various nutritional interventions have to prevent stunting (McGovern et al, 2017).

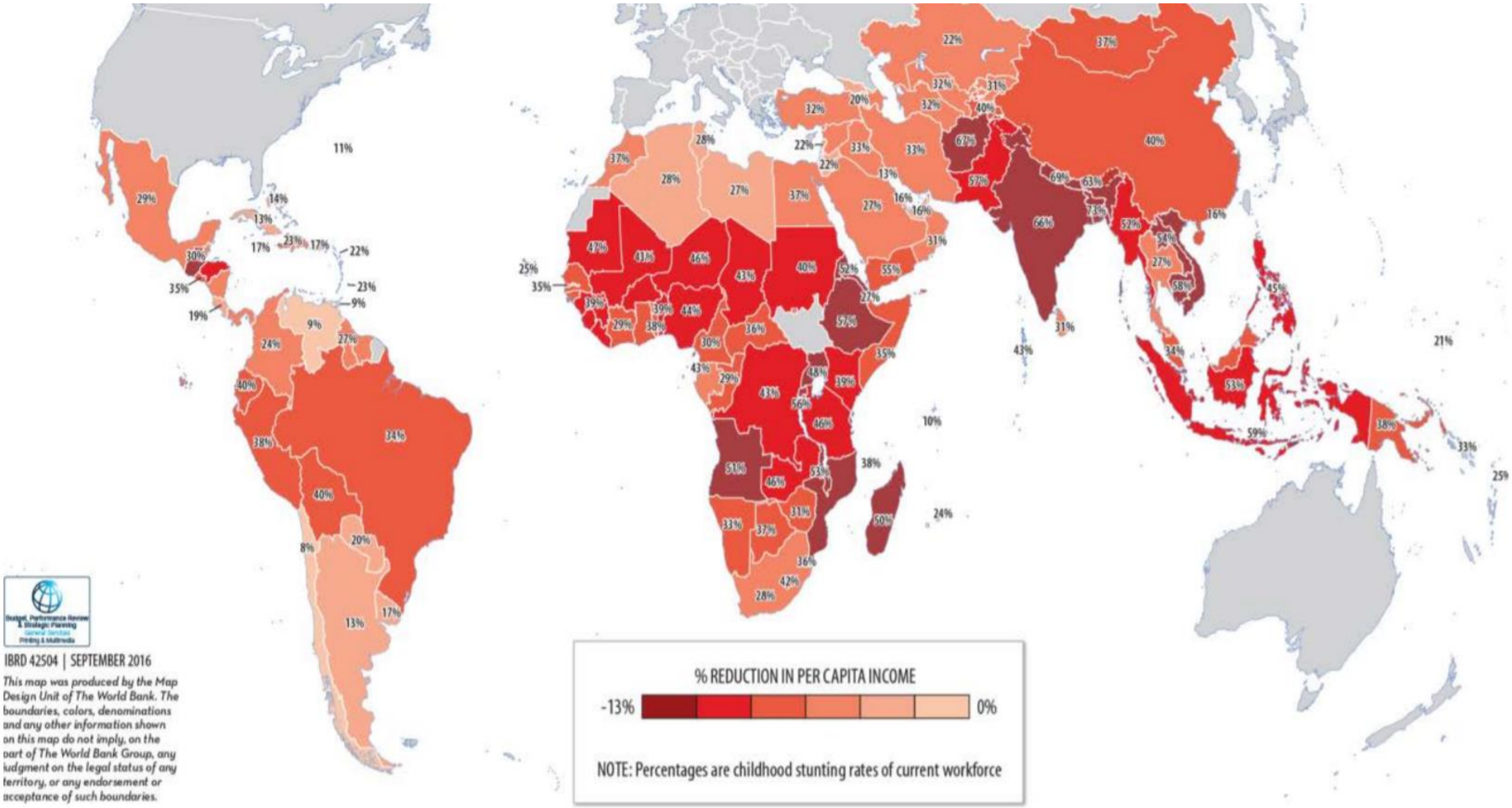
Further research presented by McGovern et al (2017) indicates a 1cm increase in length is equal to 4% and 6% higher wages for men respectively women. Another cross-sectional study in Brazil shows a 1% increase in height was associated with a 2,4% increase in wages which was significant after controlling for educational level and other health indicators such as BMI, per capita energy and protein intake (Duncan et al, 1995). A long standing prospective cohort data study by Victora et al (2008) shows that an increase in 1 standard deviation (SD) in HAZ (mean height for age z-score) raises annual income by 8% for both men and women in Brazil. The same authors found, using the same OLS method, that the obtained effects is 8% for men and 25% for women in Guatemala resulting in an average of 16% raise of income (Victora, 2008). Altogether, even though estimates differ, it indicates a large part of income that is forgone due to stunted condition.

Horton et al (2008) calculates aggregated losses, by using estimates of lower income due to lower productivity and education level as an effect of malnutrition. By assuming wages make up for 50% of national income, the researchers have translated the impact to economic growth estimates. The results imply, on country level, that the annual loss due to undernutrition is upwards 12% in low- and middle-income countries (Horton et al, 2011). The same research estimates that the global GDP loss was 6% in 2000, fallen from 12% in 1900, and estimates for year 2050 is a 6% loss. An intervention eradicating malnutrition would therefore have a positive return if the cost would be below 6% of world GDP.

A research, combining several studies, on economic costs of stunting published by World Bank Group confirms that stunting among children today reduces a country's future income per capita, and a country's per capita income today is lowered to the extent that some of the workers today were stunted in childhood (Galasso et al, 2016). The penalty on per capita income, calculated based on not eliminating stunting among children, is estimated to, on average, 7% globally. Since the prevalence of stunted condition is higher in the labor forces in Africa and South Asia than globally the average penalty cost in the 43 African and 8 South Asian countries examined reached 9 and 10% of GDP per capita respectively. The costs of childhood stunting among today's workforce per country is illustrated in figure 3

There is a strong empirical link between economic standard of living and adult height but the correlation does not mean causality by default. In Akachia's et al (2015) research, DHS data over women's heights in 38 low- and middle-income countries (25 in Sub-Sahara) from 1951-1992 was used to examine if cohort height can be used as inference about economic standard of living. The results show no evidence that the absolute difference in adult height across countries are associated with different economic living standards. However, within countries, faster increases in adult cohort height are associated with more rapid GDP per capita growth; each centimeter gain in height is associated with 6% increase in GPD per capita (Akachia, 2015).

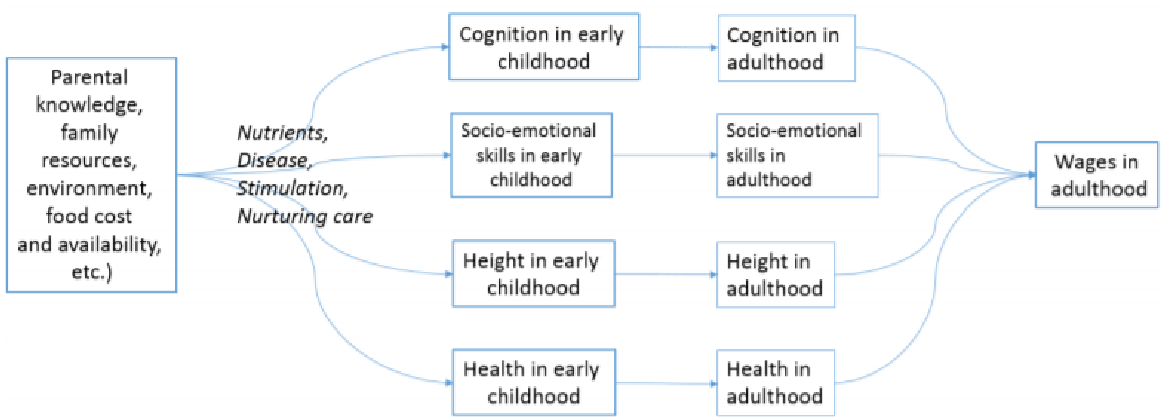
Figure 3. The costs of childhood stunting as a percentage reduction in per capita income



(Galasso et al, 2016)

Figure 4 below illustrates a framework causing stunted condition, a pathway of consequences which eventually impact wages in adulthood (Galasso et al, 2016). The link between the different variables explains why wages is a dominating variable regarding economic outcome of stunting since there are many channels/factors that has direct or indirect impact on wages itself. Further, low wages affects the variables that cause lower wages, which illustrated the bidirectional circle of impacts explained in the introduction to this chapter. Fallouts of lower wages are, among others, higher probability of living in poverty, decreased nutritional status which has an impact on productivity (McGovern et al, 2017). This negative spiral will likely perpetuate income inequalities as malnutrition is more widespread among the poor percentiles, hence the negative economic outcome will therefore largest impact among the poor (Zere et al, 2003).

Figure 4. Causes and effects of stunting



(Galasso et al, 2016)

2.1.3 Productivity and Labor force

Without sufficient nutrition a person's physical and mental capacity will be reduced, which not only causes health issues in the long term but also effects the work productivity regarding quantity of hours manageable, effectiveness and quality of output provided. Altogether, productivity is another major economic outcome sprung from malnourishment that has been researches broadly. Similar to wages, many other factors affected by malnourishment is linked to productivity i.e. health status which explains why productivity is a variable of interest with significant impact on economic outcome.

Among several research papers published in the subject, Satyanarayana's et al (1978) early study in India shows that a low height for age at age 5 was associated with lower work capacity in the teenage years (14-17). It is not only the productivity that is affected by malnourishment, a study by Carba et al found that a higher length-for age z-score at age 2 was associated with increased probability of being engaged in formal work for both men and women in the Philippines. Formal work is associated with regular hours, higher wages and benefits. Research on physical agriculture labor in Brazil examined the relationship between productivity, energy intake and stature. Results from the multilevel regression analysis identified stature as the parameter most associated with productivity, independent of body fat and age. Productivity among the tallest individuals in the study was significantly higher than the shortest even when controlling for energy intake (Florêncio 2008).

Productivity can be quantified as a cost as malnourishment causes reduced productivity (reduction in utilizing maximum capacity), or as a productivity gain of reducing stunting prevalence. Ross et al (2003) used an estimate of the impact of stunting on productivity in China by calculating the total cost savings associated with nutritional interventions to reduce stunting prevalence to zero which would increases productivity level. The conclusion was a productivity gain, from 1991-2001, worth 12 Billion USD (2001 price level) due to reduction in child stunting. Using another estimation method considering malnutrition-associated costs of health, education and productivity for the Peruvian economy, Alcázar et al estimated that the productivity cost of stunting was equal to 2,2% of GDP in 2011. Bagriansky et al used a similar consequence model to estimate the cost of malnutrition in Cambodia based on loss of productivity. The burden of malnutrition was estimated to more than 400 million USD annually which represent 2,5% of GDP.

The loss of productivity due to malnourishment comes at a large alternative cost, which is especially crucial to reduce in developing countries, which prevents economic growth with several percentages each year. The likely positive spillover effects on labor market and productivity by reducing stunting prevalence is therefore important to emphasize when deciding on which policy/intervention to support as nutritional interventions can have substantial returns on human capital and positive spillover effects on economic growth.

2.1.4 Educational performance

Education, both length and quality of it, is an important growth variable, aggregated to human capital on national level which affects economic growth (Jones, 2002). There is a positive relationship between years of schooling and wages, hence a higher level of education will indirectly have positive impact on socio economic status. Stunting, as a consequence of malnutrition, is therefore another major factor of interest that has been researched broadly to analyze any significant effects, long term or short term, on educational performance and economic growth. The dominating hypothesis researched is the relationship between performances and undernourishment using several different outcome variables such as quality (grades), dropout rate, level of education (years of schooling) etc. RCT and data analysis are the most common methods applied, and a substantial part of the available literature in the subject evaluates different kinds of nutritional intervention among school children and its impact on school performance as these interventions generates control groups for comparable effects. Therefore, a significant part of the results from previous research becomes divers as the research provides both an insight of the effectiveness on specific nutritional intervention and also the effects of malnutrition on educational performance. An example of this is Zere et a (2003)l research on school children in South Africa which shows a decreased dropout rate and improved academic performance as a result of the government's Primary School Nutrition Program (PSNP) targeted at reducing malnutrition. What is important to clarify is that although many nutritional programs have positive impact on the children's school performance, the programs do not have profound or sustained impact on the determinants of malnutrition. The separation is that increased nutrition during school years has a positive payoff on performance but as the nutrition status (stunting) is a consequence of prior malnourishment during earlier years with irreversible damages to the child's intellectual development, a higher payoff could be reached by targeting a younger age group with nutritional interventions preventing stunting in advance (Zere et al, 2003).

McGovern et al (2017) consolidated research connecting child stunting and economic outcome indicates an unanimous results where several set of studies provides evidence that child undernourishment affects cognition and schooling in the short run, especially in in low and middle income countries where stunting prevalence is higher. A specific researches that have quantified the effect of malnourishment on education using pooled analysis of 5 cohorts (Brazil, Guatemala, India, The Philippines and South Africa) shows significant lower years of schooling among stunted children (Martorell et al, 2010). In the most conservative estimates, after controlling for confounding variables affecting educational progress such as sex, socioeconomic status and maternal schooling, stunted condition at 24 months old was associated with 0.9 years shorter education and a 16% higher risk of failing at least 1 grade. As previously stated, lower education (diminishing human capital) reduces wages, causes lower socioeconomic standard and is related to poverty and more widespread health problems. The monetary loss, due to lower years of schooling caused by stunted condition, according to Martorell et al (2010) research was estimated to a decreased of 10% in lifetime earnings. The same research also presents malnourishment effects on schooling with regards to weight. A weight gain of 1 SD (0,7kg) between 0-24 months was associated with 0,43 years increase in schooling and a 12% lower risk of grade failing. Weight gain from 0-24 months has the largest impact on years of schooling, followed by weight at birth and lastly weight gain from 24-48 months.

FAO's report "The taste of food security and nutrition in the world" shows result supporting the relationship between stunting and increased risk of impaired cognitive ability and weakened performance at school, which is a major problem as stunting affects almost one in four children under the age of five years (FAO, 2017). UNACC's report is aligned with previous presented results that stunting at 24 months old is significantly associated with later deficits in cognitive ability, which according to their research was particularly present among males. Further, several smaller studies from different countries which have been analyzed and combined indicates, with different magnitude but all statistically significant linked, that an increase in Z-score (mean height-for-age) will lead, on average, to an increase in school enrollment. The same cross national report presents evidence of increased prevalence of stunted children among children who enter primary school at an older age (UNACC, 2000). The findings emphasizes on early interventions to effectually prevent stunting among children to improve educational level.

2.1.5 Health

Major widespread health issues is an obvious struggle for poorly equipped countries without proper health care systems, limited access to treatment, scares supply of medicine and vaccination and diminutive knowledge regarding interventions and behavior to prevent illnesses or spreading of it. Epidemics and outbreaks of severe viruses and sickness have caused suffering and death of millions of lives, especially in developing countries. Stunting is not a sickness that is transmittable peer to peer which can cause rapid outbreaks but the health effects, and economic outcomes, of stunting are both large in number regarding people affected and severe in scale of impacts. In similarity to other major diseases, stunted condition has negative economic outcome; increased (public) health cost to treat malnourishment and related health consequences and as alternative costs when productivity is reduced, wages are lower etc. The condition's negative effects are therefore far more than a shorter stature which will be presented below. The aim is to underline the main findings, not stated in earlier sections, by analyzing previous research focusing on stunted (and malnourished) condition's effect as health related costs and the economic consequences of increased morbidity.

Childhood undernutrition is linked to 45% of all child deaths in 2011 according to Black et al (2013) estimates which includes stunting, fetal growth restrictions, wasting and deficits of vitamin A and zinc along with suboptimal breastfeeding. More research shows that 44 to 60% of all mortalities caused by measles, malaria, pneumonia and diarrhea is an effect of undernourished condition (Caulfield et al, 2006). A data study examining the association between childhood or adult height and mortality in United Kingdom showed that it was a higher relative risk of adult mortality among the shortest quintile compare to the tallest at measurement age of 6 years old (Ong, K.K, 2013). Hence, the loss of life quantified as decreased human capital is a cost to the society; through increased health expenditures (less public savings), opportunity cost of unexploited productivity which can also be classified as a hypothetical cost to eliminate undernourishment to prevent mortalities.

Young children and infants suffering from stunting have a weaker immune system which imposes a higher risk of infectious diseases (Alive & Thrive, 2012 and Frongillo,E. A. Jr., 1999). The connection between stunting and weakened health outlook continues later in life as adults who suffered from undernourishment while young are more likely to suffer from high blood pressure, diabetes, heart diseases, obesity and other nutritional related chronic diseases (WHO, 2017 and Alive & Thrive, 2012). Various treatment costs are a direct consequence for the affected person/family, followed by indirect opportunity costs as the disease can prevent from full time employment. At a national level, the lower health status aggregates to higher public health costs (taxes) and lower productivity which has a negative effect on economic growth as public investments are constrained and human capital is decreased.

The continuous damaged health status among stunted people causes the negative effects to be long lasting. Even though the condition is not infectious there is a higher likelihood that stunted women give birth to small and underweight babies, which closes the negative cycle effect of stunting as low birth weight is associated with shorter stature in adult age (Dewey et al, 2010). A cross-sectional study compiling 54 low and middle income countries' DHS data analyzing the association between maternal stature and health effects on the offspring shows that maternal stature was inversely associated with offspring mortality, underweight, and stunting in infancy and childhood (Özaltin et al, 2010). The difference in absolute risk of dying among children born to the tallest mothers (≥ 160cm) and the shortest (<145cm) was, after adjusting for multiple factors, 5,5% or 40% higher likelihood if being born to a stunted mother. Because infant's nutritional status is affected by the mother's status, the payoff of reducing stunting will have positive spillover effects on future generations as the risk of being stunted reduces with lower level of maternal malnourished status (UNACC, 2000).

Women with stunted stature have a higher risk of experiencing complication during delivery, due to physical constraints, which increased maternal deaths (Merchant, 2003). This is predominantly a problem in developing countries where the appropriate health care resources are scarce and prevalence of home births are more common. The increased complications during births and higher risk of deaths among both infants and mothers are another negative outcome increasing health related costs for a country.

2.1.6 Nutritional based poverty trap – a strong link between determinants of nutritional status and economic outcome

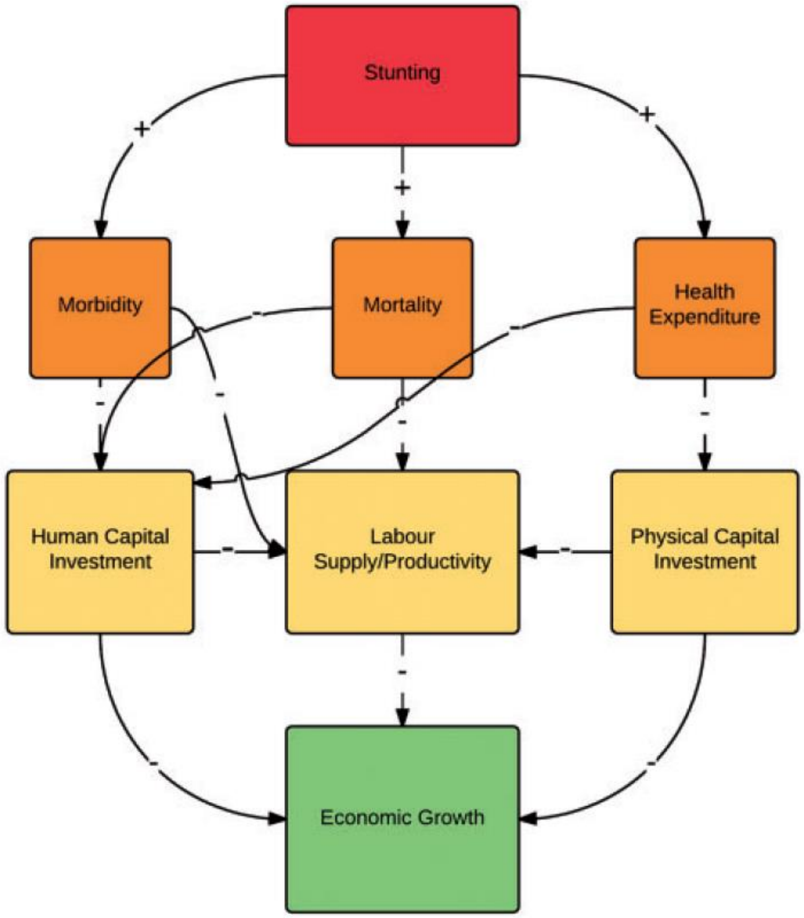
There is an especially strong connection between work-income-productivity exemplified as "nutritional based poverty trap"; work will provide income used to buy food (calories) which provides nutrition and strength needed to be able to be productive and work which generates income. This creates a relationship where income today and income tomorrow are closely dependent. Any interruptions in the chain, or insufficient input, will therefore have a negative effect on future work and income possibilities. Research has discovered a rather problematic scenario among poor people who do not fulfill the daily nutritional target where the elasticity of overall food expenditure is approximately 0.7 (1% increased income increased food budget with 0.7%), but the increased expenditure for food was not only spent on more calories but also on more expensive better tasting food, a 50/50 split (Subramanian et al, 1996). The result of this behavior is an alternative-cost as increased calorie intake is associated with increased productivity and income. Controversially, the consequence of food subsidize programs can create a substitution effect where cheaper subsidized food items will pave way for a larger part of the indirectly increased budget to be spent on better tasting food with lower calorie instead of increasing the total calorie intake. The implications of the nutritional based poverty trap and food preference behavior can cause/sustain (determinant) malnourishment and, at the same time, prevent economic growth (outcome). The connection between determinants and economic outcome will proceed in the next chapter.

2.1.7 Summary –The effects of nutritional status on economic outcomes

The research reviewed in this chapter highlights a few important insights on the effects of nutritional status on economic outcomes;

- The domino- and circular-effect (poverty trap) malnourishment have on economic growth by affecting several different variables (wages, productivity, educational level, health conditions etc.), indirect or direct, which all have an impact on economic growth on macro scale. See figure 5 below for illustration example.
- Previous research studies are more or less unanimous regarding the effects and economic outcome of poor nutritional status, but the estimates and results differ in magnitude
- Research indicates that the most efficient period to target malnourishment with interventions, for most effective outcomes in the long-run, is in the early stages (prior to 24 months old) of a child’s life
- Preventing/decreasing stunted condition for one generation will have positive economic spillover effects on future generations as this would weaken the link of transmitting the condition as well as reducing complications and mortality during births

Figure 5. Stunting's pathway on economic output

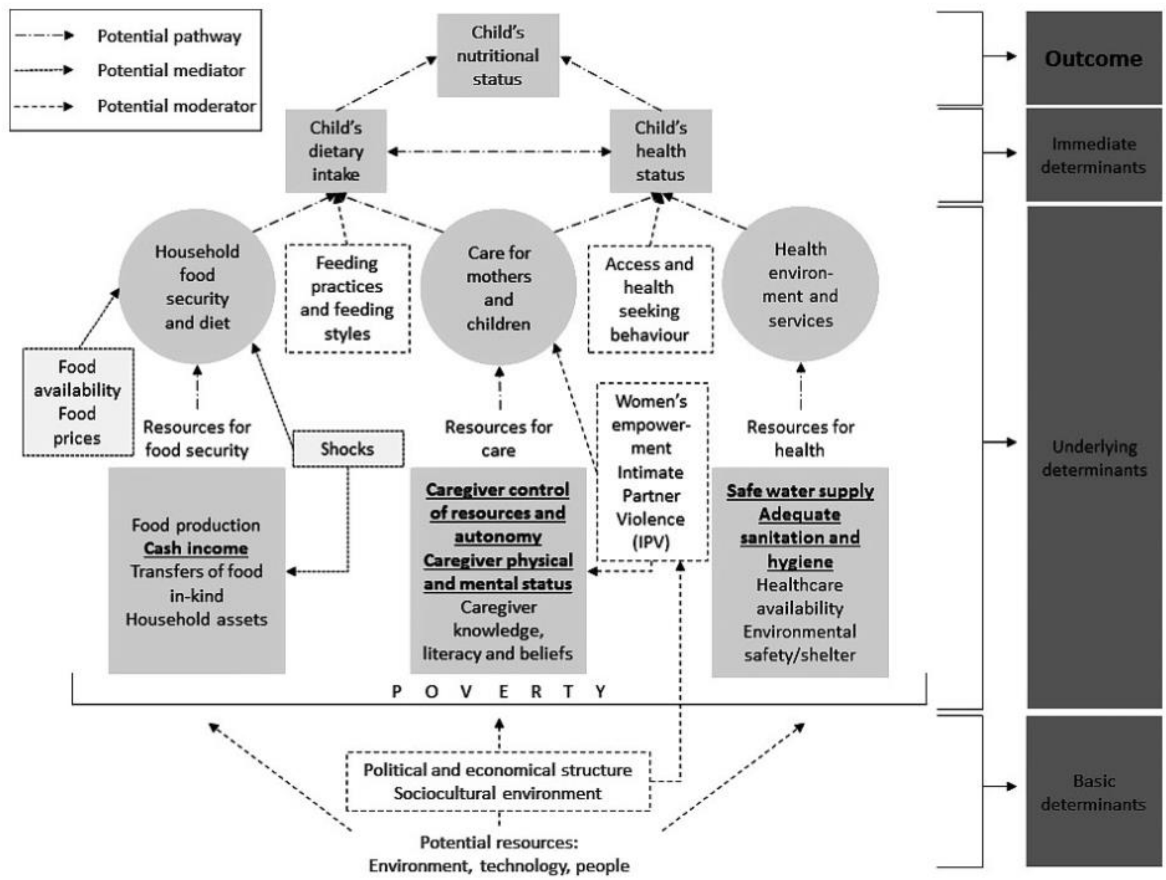


(McGovern, 2017; Adapted from Bloom et al, 2014)

2.2 The main determinants of nutritional status

To be able to construct intervention and policies aimed at efficiently eradicate malnutrition it is crucial to define the main determinants, as they are the starting point of the negative outcomes, and to what degree they affect nutritional status (as presented in the economic outcome section). The subject has been researched broadly, many determinants are reasonably expected while others are more complex and the impact differs depending on previous studies' method, country and time period. As previously explained, there is a connection between the determinants, and their effects, on nutritional status. A simple example where the link is present is between income and education; income is an important determinant of nutritional status and educational level is in turn a main determinant for income level. More detailed connection between nutritional status and determinants is illustrated in figure 6 below which includes several determinants analyzed later in this section.

Figure 6. Connection between nutritional status and determinants



(Groot et al, 2017).

This chapter will present previous research and provide a broad set of variables that are commonly tested as determinants of nutritional status. The variables in this section have been selected based on appearance in publications from various medical journals' search engines using topic-associated keywords[2]. Hence, the variable sample should represent the most common tested factors as potential determinants, but due to limitations some possible determinants have been left out. Further, the depth can vary slightly between the selected variables based on available research and general consensus. Given the different methods/test applied, time period researched, size of data, country selected etc. in previous studies, the results can sometimes be contradicting

[2] Stunting, determinant, development, malnutrition, nutritional status, wasting, child, undernutrition etc.

where variables swing in significance and impact magnitude. Study specific biases and difficulties with data from each research reviewed can also add to the discrepancies in some results. The aim of this literature review is to provide a divers sample displaying potential differences with a sufficient width of references to grasp the current status and knowledge of possible determinants. Additionally, the review of each variable will be consist and result specific leaving out possible reasons for the findings and potential interventions/policies to prevent child malnutrition. A discussion section covering these segments will be provided later, which mainly will be based on results from this paper's data analysis with some inclusion of previous researches' findings.

To enhance this thesis specific topic, slight bias will be towards previous research covering sub-Saharan African countries, nutritional status for children (under 6 years) and stunting will be the main, but not exclusive, focus regarding "malnutrition" which usually is divided in three categories; stunting, wasting and underweight. To highlight this thesis main focus additionally, previous research on prevalence of stunting with gender factor as a possible determinant will be analyzed more comprehensively in the last section of this chapter.

The following chapter will test whether the main factors identified can explain nutritional status in the dataset used for this paper and further test whether the main factors identified can explain the potential gender gap in nutritional status of children. Given the previously published researches, possible absence of data and the gender-gap focus of this paper, not all variables presented below will be tested to diversify and/or deepen the knowledge in the topic.

2.2.1 Socio-economic status (SES) variables

SES is an index measurement of a person's/family's economic and social status, normally consisting of income, education, occupation and sometimes different asset variables. If analyzing a family's SES, household income and earners education and occupation are examined. SES measurement allows for relative comparison with possibility to dived population in different percentile which can generally be a measurement of people's wellbeing as SES is positively associated with better health (Bernheim et al, 2008). Not surprisingly, previous research has shown strong evidence that SES is a major determinant for nutritional status; hence, the likelihood of being stunted is higher in lower SES percentiles. This section will break down the index and provide previous researches' findings on each separate variable.

2.2.1.1 Income/wealth/GDP/economic status

An abundant of research papers using different methods, covering different countries and time spans all point at the same conclusion; economic status (analyzed by different proxy variables) is a major determinant of nutritional status. UNICEF policy paper aimed at providing strategy to improve nutritional status for children and women in developing countries points out that the economic status of a household is one of the most important determinants of child nutritional status (UNICEF, 1990). A comparative descriptive cross-sectional study on child nutrition using DHS data in 19 developing countries resulted in the same conclusion; higher economic status is associated with lower level of child stunting (Sommerfelt et al, 1994). A more recent meta study by Vollmer et al analyzed DHS data in 39 low- and lower-middle-income countries using a Composite Index of Anthropometric Failure (CIAF)[3] variable as outcome variable. The results show that there is a significant 21 percentage points difference in CIAF prevalence between children in the highest and lowest wealth percentile. Further, the difference have been constant during the two time period tested (1990-2000 and 2001-2014) which provides evidence that socioeconomic inequalities in child malnutrition are persistent (Vollmer et al, 2017).

Mushtaq et al (2011) performed a cross-sectional study among primary schoolchildren in Pakistan to assess the prevalence and socio-demographic correlates of stunting and thinness. Linear regression results show, after adjusting for all factors used, that low income neighborhood was associated with lower height-for-age z-score (stunting) and rural area with low SES was associated with lower BMI-for-age z-score (thinness) (Mushtaq et al, 2011). Additionally, low income neighborhood and low SES was significant as determinants for stunting in all regressions performed in the study. Another smaller regional study with 550 mother-child pairs of 6-59 months old children in Ethiopia confirms the findings as the regression results shows that monthly household income is, among others, a significant determinant of nutritional status among children (Demissie et al, 2013).

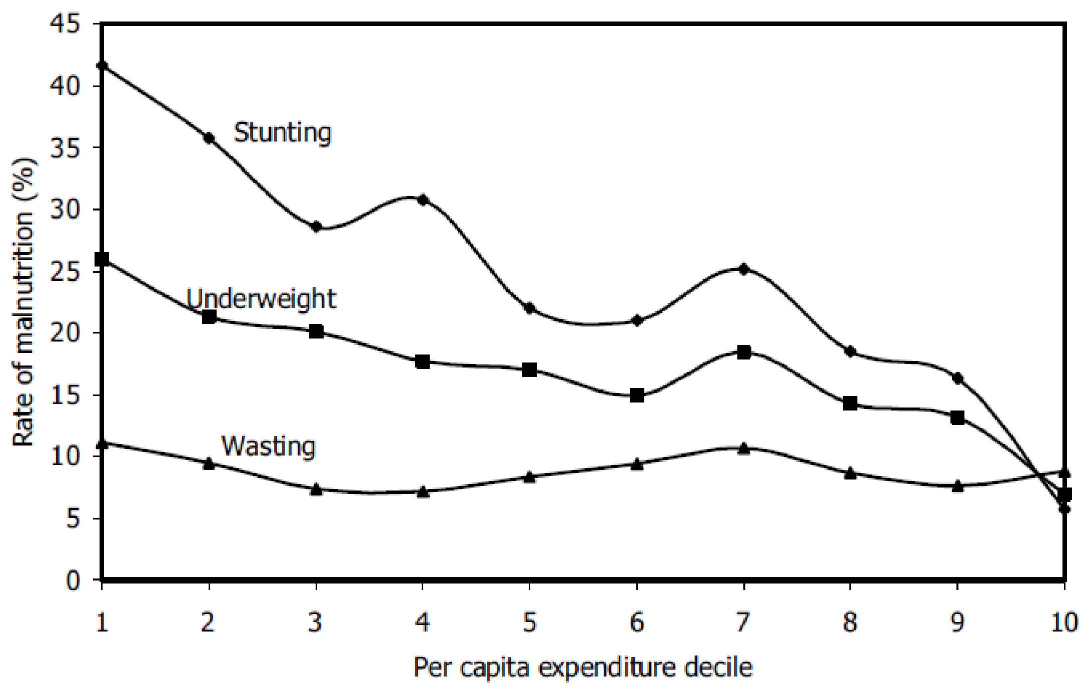
A review study by Keino et al (2014) was performed using data from 18 selected studies listed at PubMed[4] matched with specific keywords[5] in the topic. Results from chi-square tests from the

[3] "The CIAF incorporates the three forms of undernutrition: stunting, underweight and wasting, and thus provides a single aggregate figure of all undernourished children in the population. The CIAF is a binary variable, which is one if a child is either stunted, underweight, wasted or any combination of the three" (Vollmer et al, 2017).

[4] https://www.ncbi.nlm.nih.gov/pubmed/

reviewed studies were clear; household income (and other SES variables) was direct determinants of stunting in Sub-Saharan countries (Keino et al, 2014). Household income, proxied by per capita expenditures was another significant determinant of stunting according to Zere et al (2003) research on child malnutrition in South Africa (Zere et al, 2003). The results from the research, seen in the graph 3 below, indicates that stunting and underweight are responsive to improvement in per capita expenditure (income proxy) while the third state of malnutrition, wasting, does not seem to be sensitive to SES. Additionally, a study of the child malnutrition current status in Ethiopia shows results concurring with previous presented research; household economic status is positively related with child stunting. Compared with higher economic status households, the risk of being stunted for children in very poor or poor households was significant (Woldermariam et al, 2002).

Graph 3. Rate (%) of malnutrition over different per capita expenditure decile



(Zere et al, 2003)

Estimates of lowered stunting levels as an effect of increased GDP has been researches with varied results. Across 6 studies, the impact of a 10% increase in GDP per capita was associated

[5] "stunting, overweight, obesity, Africa, Sub-Saharan Africa, determinants, and prevalence".

with a reduction of stunting with 0-2% (McGovern et al, 2017). Results indicate that although many low- and middle- income countries have experienced GDP per capita growth during the last decades, the stunting prevalence and malnutrition levels is showing small improvements (Harttgen et al, 2013). The common feature in the referenced studies is the short-run aspect displaying a rather weak reduction in malnutrition status. Other research papers with longer timeframe show larger reduction in stunting prevalence; a 10% increase in GDP per capita has an approximate 6% reduction in stunting prevalence (Ruel et al, 2013 and Smith et al, 2015). The combined results shows that economic growth has positive effects on reducing malnourishment, but there is a time lag to experience improved living standard. Additionally, the findings highlights that economic growth alone can unlikely achieve substantial reduction in prevalence of stunting in the short run, and the effects from increase in national income are too small to rely on as a single factor eliminating child malnourishment (McGovern et al, 2017).

Working longer hours or more productive is a standard solution to increase (household) income, but job possibilities might be scarce and required skills limited. Other conventional income increasing possibilities originate from policies and interventions aimed at providing an exogenous income increase such as (food) subsidies, food stamps, social welfare or conditional cash transfers (CCT). As explained by the name "conditional", CCT is a welfare/aid money transfer to a recipient with a condition, customarily locked to a certain product/service which usually is considered important from a health/development perspective but typically not prioritized by the population in developing countries/poor areas. This section will present a few varied results from CCTs with the objective to improve health and nutritional status in developing countries. The CCT intervention can be classified as part of the wage determinants of nutritional status due to its indirect increase of income, hence evaluating the CCT success rate and impact on nutritional status can provide valuable knowledge. A study from low income communities in Mexico was designed to improve nutritional health and promote behavior change through cash transfer conditioned for health requirements and nutritional supplements. Children of household receiving doubling of cash transfer showed significant lower prevalence of stunting (−0.10, 95% CI −0.16 to −0.05; $p<0.0001$), higher HAZ-score (0.20, 95% CI 0.09–0.30; $p<0.0001$) and performed relativity better on motor and cognitive development compare to children in households with lower cash transfer (Fernald et al, 2008). A study comparing the impact of different CCT aimed at improving children's nutritional status show varied results depending on country (and exact

CCT intervention). Out of 5 Latin American countries, three show a statistically significant improvement of HAZ-score among children under 5. If adjusting for children below 3 years of age, four countries show significant positive results (Bassett, 2008). Another meta-study displays the varied results of the CCTs as the evaluation of 15 programs in 10 countries only demonstrates a small but statistically insignificant impact on child anthropometry (Manley et al, 2012). Even though the results differ in magnitude, there is still a cost-effective aspect with CCTs that needs to be incorporated to decide the success of the exogenous income increase has on nutritional status.

2.2.1.2 Education (of mothers/parents)

Due to closed association with the other SES variables, education is broadly researched as a possible determinant of nutritional status. Considering that the prevalence of stunting is more common in lower income level, the most common expected outcome from analyzing education level is that it will have a significant impact on nutritional status as lower education is also predominantly widespread among poor people. The education variable has been defined differently in previous research; mother's education only, father's education only or a combined index of parental education. The results from previous research varies when testing for father's education, but the vast majority of studies testing for mother's education have shown to have significant impact on children's nutritional status. Engels et al (1997) research on caregiving of children in southern and eastern Africa shows not only that education is an important determinants, but it also highlights the part of education defined as "behavior knowledge" such caretaking i.e. appropriate feeding, handling of infants and food preparation etc. as an important aspect in determining a child's nutritional status (Engle, 1997).

A study at regional level in Ethiopia using survey data from the Community and Family Survey of the Southern Nations Nationalities and Peoples Region finds that women's education was an important factor explaining the variation in long-term nutritional status of children (Yimer, 2000). Chakraborty's results, from a study using secondary data from 1992-2006 on child malnourishment in India, are aligned; mother's education is important predictor of the overall nutritional status of children. Same conclusions were made in a smaller research in Cameroon where low maternal educational level was found to be an independent factor increasing the risk for a child to be stunted (Said-Mohamed et al, 2009).

Kabubo-Mariara et al (2008) used pooled sample from 1998 and 2003 DHS data set for Kenya when analyzing determinants of children's nutritional status. The study examined both parents educational level's impact separately and the results indicate that maternal education is more important, and have a larger impact on a child's nutritional status than paternal education. This biased outcome is supported by other studies in the topic regarding parental education's impact (Kabubo-Mariara et al 2008). Estimates from the regressions suggests that equipping all mothers with at least complete secondary education would have substantial impact on children's nutrition; 18% improvement in stunting. Kamiya (2011) examined the determinants of nutritional status of children in Lao's People Democratic Republic using Lao Multiple Indicator Cluster Survey 3, a national-representative data sample for the population. The study showed, contrary to the majority of previous studies, that maternal education did not exert a positive significant impact on child nutritional status when it was estimated with fathers' education (Kamiya, 2011). The high correlation between maternal and paternal education can be a possible cause for the insignificant results, although paternal education on the other hand showed a positive significant effect. When testing maternal and paternal education separately, mothers education has a positive effect on stunting but only with a small statistical significance ($0,05<p<0,1$).

Reed et al (1996) studies the relationship between children's nutritional status and maternal education in different socio-economic levels. The research, using data over 435 children in Benin, show that children to mothers with less than 4 years of schooling was differently affected depending on socio-environment. Among the lowest socio-environment, the relationship between children's weight and maternal education was insignificant, positive and significant in middle socio-environment level, and weakly positive in the upper socio-environment level (Reed, 1996). Surprisingly, the same research shows that among children to higher educated mothers, there is a negative association between nutritional status and socio-environmental levels. The authors suggested explanation to this relationship is that mothers with higher education have been enabled to spend more time outside the household, i.e. formal work and activities, resulting in forgone time to ensure adequate care for children.

A two period study using DHS data from 1986, 1996 and 2006 analyzing change in stunting prevalence in Brazil show results aligned with previously presented research. Out of several variables tested, maternal schooling was the only factor considered particular important for the decline experienced in child undernutrition in both periods (Lima et al, 2010). Another similar time period study from Canada between 1990-2000 analyzed the association between maternal education and neighborhood income, as a proxy to reflect SES, with birth outcomes. Lower level of maternal education was associated with numerous of negative birth outcomes, several linked to stunting and/or malnutrition i.e. low birth weight and small-for-gestational-age (Lou et al, 2006). The study provided evidence that maternal education effects were a stronger, and independent of, those of neighborhood income.

2.2.1.3 Employment

An additional standard component in a SES index is employment/occupation, which is linked to both education and income as explained in previous section regarding effects of nutritional status on economic outcomes; education is positively associated with employment which affects the income. It would be easy to assume that more income would increasing the possibility to provide adequate nutrition to the children, but the paradox in the employment is that if a mother is employed outside her home it reduces her time for childcare which have negative effects on a child’s nutritional status. The employment variable has therefore been researched with aim to examine if it is a significant determinant of nutritional status and estimate the isolated effect. In similarity to the other SES variables, employment can be analyzed regarding the mothers and fathers separate effect or as a combined effect. More nuanced angle, not presented in this paper, in previous research is the impact on nutritional status from increased control of the income by the mother. The section below will provide a few sample of the evidence from previous research focusing on mother’s and father’s employment separately as a determinant for children’s nutritional status.

A study in rural Philippines examined the conflict between a mother’s time spent give care to her child at home versus her time spend out of the house working at jobs incompatible with childcare, with the aim to analyze the net effect on a child’s nutritional status. The results show that it is a net negative effect on the average nutritional status of children less than 6 years of age when substituting childcare at home for outside household employment (Popkin 1980). Another study with similar results was performed using data of nearly 2000 children in rural India. The relative risk to suffer from stunted condition of children of working mothers versus children from non-working mothers was statistically significant; 1,8 for children under 3 and 1,6 for children above

3 (Abbi et al, 1991). Wasting condition was also significantly higher among children of working mothers for children under 3 years of age indicating that child malnutrition is negatively affected by working mothers, at least in rural low-income households. Eshete et al (2017) cross-sectional study in Ethiopia analyzed the prevalence of stunting of over 300 children 6-59 months old in two different categories; employed mother versus unemployed mother. The research showed no statistically significant association between maternal employment and their child's nutritional status (Eshete et al, 2017).

A study analyzing a broader set of family characteristics', father's employment among others, effect on nutritional status was performed in Mexico covering poor households. Results show that in rural a fathers employment as farmer was a determinant for increased risk of stunting (as compare to "other type of job"). In urban areas, increased father's job instability was associated with higher risk of stunting (Reyes et al, 2004). Hammoudeh et al (2013) performed a cross-sectional study in the West bank with data from 2006 and 2010. The aim of the research was to analyze the prevalence of stunting, changes over time and define determinants. In 2010 cohort, there was a 18% reduced risk for a child to be stunted if the father was active in the labor force (Hammoudeh et al, 2013).

The outtakes from the research presented above, including outtakes from additional literature not referenced, indicates that mothers employment in poor households can increase the risk of stunting, while a fathers education is positively associated with lower prevalence of stunting. Possible explanations are that a mother's care of a child to assure adequate nutritional intake is more important than a slight increase in household income. The importance of a father's employment to reduce stunting can be a case where fathers generally spend less time taking care of children hence removing the work/childcare conflict. Further, fathers are usually household heads in developing countries responsible for the household income (impacting SES of the household) making the house more economic vulnerable if they are unemployed compared to mother's situation.

2.2.1.4 Household food security

Although not typically classified as a socio-economic status component, (household) food security is still connected to economic status in a logic reasoning. The standard hypothesis is that lower economic status households have a higher risk of suffering from food insecurity, with possible effects on malnutrition and stunted condition. The variable can therefore be identified as part of the larger SES variable, and possibly even used a proxy for SES status. The definition of food security has been rewritten and debated for many years, but universal definition drafted by FAO states; "Food security [is] a situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life" (FAO, 2002). Food insecurity, the antonym, is when people do not have adequate physical, social or economic access to food as defined. The difference in definition, and survey design when collecting data, causes difficulties to find comparable data, which is why the variable has been dropped in this paper's regression analysis. But numerous of research and studies, with different definition of food (in)security, have been published where most of the results can't reject that food security is a determinant of child malnutrition, but the results are not unanimous. A few research examples are presented below displaying the various results.

In Nigeria, a descriptive cross-sectional study was performed with the objective to assess the influence of household security status (, family size and child care) on children's nutritional status. Over 400 mothers of under-five and their children were surveyed to provide data. The results show that the household defined as food insecure[6] had a significantly higher risk of having stunted children; OR=2.113, 95% CI=1.40-3.37 (Ajao et al, 2010). Further, the likelihood for wasting, another measurement of malnutrition, was even higher in households defined as food insecure (crude OR=5.707, 95 percent CI=1.31-24.85), and households with lower educated mothers were more likely to have malnourished children.

Over 2700 low-income households were used as a sample in Colombia to gather data over food insecurity and its link to anthropometrics and health among preschool children. Food insecurity was defined and collected via a 12 questions survey (CHFSS) about the experiences of food insecurity as a result of financial constraint over the previous month. The risk of stunting showed a statistically significant inverse relationship with household food security status; prevalence (or risk) of stunting increased in a dose-response way as food insecurity became more severe (Hackett et al, 2009).

[6] Food insecurity was defined as; "Mothers who ate less than they desired because of insufficient finances" (Ajao et al, 2010).

A similar, but smaller, study performed in Kenya examined the prevalence of stunting within 165 households suffering from food insecurity[7] divided to into different groups (severely insecure, moderately insecure and mildly insecure). The results show was opposite to the majority of research within the field; the association with stunting was not significantly different among the different food insecure categories (Shinsugi et al, 2015). A possible explanation, according to the authors, to the discrepant results could be a skewed distribution of households towards the food insecure side making it too narrow range, but the study design used could not define the real reasons. Another larger study covering nearly 7000 poor households and children in Kenya's rural area investigates nutritional status its association to food insecurity in different wealth percentiles. The risk of stunting increased with 12% among children from food insecure households (Mutisya, 2015). When the combined effects of food insecurity and wealth status was assessed, the result displayed an even higher risk of stunting among children from severely- and moderately food insecure households ranked in the middle poor wealth status. Looking at the poorest and least poor households, the risk of stunting was not statistically significant, again displaying varied outcomes.

2.2.1.5 Women's nutritional status

Women's nutritional status is closely connected to household food security (some researches uses mother's nutritional status as proxy for SES status or food security) and research has been performed with the objective to analyze if and to what magnitude a mother's nutritional status can influence a child's nutritional status. Different measurements for nutritional status of women has been used in previous literature, the most common are malnourished (stunted, wasted or underweight), mother's height, BMI, chronic energy deficiency (CED) and a woman's daily dietary intake. This section will provide research examples displaying the most frequently reoccurring results.

A study in India had the objective to explore the impact of 'chronic energy deficiency' (proxy BMI) of women on the nutritional status of their children using a national representative sample data from surveys similar to DHS. Chi-square test results, with a significance level at 5%, show that well-nourished (and obesity) women measured from BMI have significant lower risk of having children suffering from stunting, wasting and underweight (Ravishankar, 2006). Children

[7] Food insecurity was defined according to Household Food Insecurity Access Scale (HFIAS) (Swindale et al, 2006)

to mothers with poor nutritional status, indicated by CED, had a higher risk of being wasted and underweight. Further, low birth weight, which can increases a child's risk of stunting, was associated with mother low BMI; mother's with low BMI (<20.0) had 70% of the low weight infants (2000-2499g).

Silva (2005) studied the relationship between household food security, proxied by BMI of mothers, and child nutritional status in Ethiopia using DHS data from year 2000. Mother's with BMI below 18.5, the threshold for unmet food security, was significant and it increased the risk of having an underweight child, but it was not significant for stunting prevalence (Silva, 2005). A child born to a mother with low BMI was 6% more likely to become underweight. Another study from Ethiopia found that maternal BMI was associated with WHZ (weight-for-height z-score) and maternal height was associated with HAZ (height-for-age z-score). The multivariate regression results were significant on a 95% level providing evidence that a mother's nutritional status is an isolated determinant for a child's nutritional status (Negash et al, 2015).

Similar results from multivariate analysis were found in Dekker et al (2010) study of Colombian school children's nutritional status and the link to their mother's status. Maternal height was a strong predictor for prevalence of stunting; children of mothers in the highest height quartile had 78% less change of being stunted compared to children being born to mothers in the lowest quartile ($p<0.0001$) (Dekker, 2010). Children born to mothers with low BMI (<18.5) had a more that two times higher risk of becoming stunted compared to children of adequate nourished women ($p<0.001$), and children of mothers with BMI over 30 had 46% less change of being stunted compared to children of adequate nourished mothers ($p=0.05$).

2.2.2 Environmental variables

2.2.2.1 Water and Sanitation

Among several possible proxies for "wealth" and asset indexes, water access and sanitation facilities are common variables in previous literature. Additionally, the variables have been researched as a predictor for nutritional status, with the link not only being access to adequate sanitation and water facilities as a measurement of household standard, but also with regards to the health aspect. Limited access to, or poor quality of, water and insufficient sanitation facilities can have severe consequences on health such increased morbidity and mortality with rapid spread of diseases, which have negative impact on nutritional status. The section below will present a sample from previous researches' showing mixed results regarding the variables impact on nutritional status.

Kabubo-Mariara et al (2008) research using pooled DHS data from 1998 and 2003 in Kenya had results indicating that neither water access nor sanitation had a significant impact child stunting (Kabubo-Mariara et al, 2008). The definition used for the two variables were "households with piped water" and "households with traditional toilets". The authors point out that even though the variables used are environmental indicators, they may not measure the quality of the water and sanitation facilities, or even to what extent adequately sanitation and water usage behavior is being performed by the children, which will affect the outcome. Example; pipe water access doesn't by default mean that the water is non-contaminated, and access to toilets does not mean usage of them is widespread. A similar research performed in Ethiopia showed mixed results; possession of a tap had a positive effect on height, but access to other sources of drinking water which are generally deemed safe (public taps and protected wells) did not have positive affect. These variables were subsequently omitted in the test, only showing one side of the coin. Further, limited significance was indicated when analyzing the impact of access to flushed toilet on children's nutritional status, which is largely consistent with findings in previous studies (Christiaenoen et al, 2001)

A study with DHS data from 2000 in Ethiopia examined the impact of access to basic environmental services, such as water and sanitation, on children's nutritional status. The study focused on the external impacts of the services by running regressions based on community level accesses (i.e. the percentage of household with access to water and sanitation in a community). Contrary to the findings presented above this research showed that when community level access to water and sanitation is low (33% of households), the external impact on child nutritional status are large (negative sign) and significant, but as the accesses level increased, the magnitude of the coefficient becomes smaller and less significant (Silva, 2005). Hence, the environmental variables are only a significant determinant for stunting when the proportion of household with access to water and sanitation is low. Another research in Ethiopia with data from 1995 showed that non-availability of latrine and unprotected water source was found to increase the risk of protein-energy malnutrition (PEM). Results from the multiple logistic regression analysis indicated a strong association between non-availability of latrine and PEM (Getaneh et al, 1998).

Sommerfelt et al (1994) pooled research over 19 developing countries showed descriptive statistics that children are less likely to be stunted if the household had access to piped water, compare to children where water was collected from public tap/well or surface water, in all but two countries. Median prevalence for all countries was 19, 29, 9 and 31.3% for piped water, public tap/well and surface water respectively. For sanitation, where different kinds of facilities where tested for (flush toilet, latrine and no toilet), the results showed similar outcome with consistent differences in all but one country reading prevalence of stunting and underweight, where flushed toiled, followed by latrine had the least amount of children suffering from malnutrition (Sommerfelt et al, 1994).

In Iran, a survey with over 15.000 children under 6 years of age in both rural and urban areas was deducted to collect data over child malnutrition in 2012-2013. The cross-sectional study identified unsafe water supply as a significant risk factor of all three child under-nourishment types (stunting, wasting and underweight). For stunting the results from OR stats were 1.27 (95% CI: 0.98-1.66) in a binary “safe” versus “non-safe” drinking water classification (Kavosi et al, 2014).

A study in Laos analyzed possible determinants of child nutritional status using a national-representative sample data set and a multilevel linear model with random-intercepts for the estimations. Results showed that the condition of sanitation (measured as latrine coverage) and water were considered determinants of children’s nutritional status, but with different and sometimes low significance level in the three different child undernutrition categories (Kamiya, 2011).

2.2.2.2 Urban-Rural residency

Numerous of studies on various economic topics compares rural with urban population to highlight the different development and status in the respective areas. Although with some exceptions, research has shown that rural areas have a higher prevalence of stunting, making the variable a significant determinate for nutritional status. By not pooling the two areas together in statistical analysis it is possible to derive more specific results and construct precise and efficient policy recommendations/interventions for each location. The research on nutritional status is no exception and many studies add a dummy variable in the analysis as an additional angle to broaden the knowledge, as seen in some parts of the research presented above. A note added to this section is the different definition of “rural” and “urban” in different countries/datasets which can have a small impact on the results when comparing different researches. The following section will provide additional literature investigating urban-rural variable as possible determinants of nutritional status. Due to the common practice to use the rural-urban as a dummy variable with other variables when testing for determinants (multivariate models), the “other” variable can in some cases be a determinant in both urban and rural areas or sometimes only in one, and urban-rural can become significant/insignificant depending on the type of test. This section will provide a few different studies with diverse aspect and tests to get an overview of rural-urban as a possible determinant.

A large cross national study covering 18 low- and middle-income countries (10 in Sub-Saharan Africa) with data collected from DHS in the early 1990-tis examined the prevalence of nutritional status and tested several possible determinants. Urban-rural residence descriptive statistics showed that in 88% (16/18 countries) of the countries rural areas had a larger prevalence of malnutrition[8] among non-pregnant mothers. The opposite nutrition status, obesity, was predominately a manifestation in urban areas (Loaiza, 1997). In the multivariable analysis significance was tested and the results show that in half of the countries urban-rural variable was an important determinant factor of nutritional status.

In Sommerfelt et al (1994) comparative cross-sectional research on child nutrition, using DHS data from 19 developing countries during 1986-1989, the urban/rural factor’s impact on stunting was examined. Although different levels of stunting in the countries tested, in all except one, child stunting was considerably more common in rural areas (Sommerfelt et al, 1994). The country with zero difference, Trinidad and Tobago, has a general low prevalence of stunting (4,8%). Median level of stunting, across all countries, for was 21 and 31% for urban and rural respectively. Similar urban-rural pattern is present for wasting and underweight as well.

Woldermariam et al (2002) research in Ethiopia indicates that although the bivariate analysis shows significant urban-rural differences in stunting among children, the difference is not

[8] Malnutrition was defined as chronic energy deficiency, BMI < 18.5 (Loaiza, 1997)

significant in a multivariate model (Woldermariam et al, 2002). This indicates that, in this study from Ethiopia, rural-urban is not predictor of nutritional status of children when important socioeconomic factors are controlled for.

In a research paper combining 18 selected studies listed at PubMed, urban and rural differences were the most common variable among the reviewed papers as a determinant of stunting and overweight. Further urban-rural setting was shown to be a direct determinant to both stunting and overweight (Keino et al, 2014). Adenuga et al (2017) researched primary school children in Nigeria with the aim to determine the prevalence and predictors of stunting. Significantly higher levels of stunted pupils were found in rural schools compared to schools located in urban areas which promotes urban-rural variable as a significant determinate of nutritional status (Adenuga et al, 2017).

A secondary data analysis using National Health and Family Survey (NFHS) conducted between 1992 and 2006 of children under 35 months in India confirms the previous majority findings; rural residency have a significant higher prevalence of stunting (Chakraborty, 2011). In the multivariate model, rural residency was shown to be a significant and independent predictor of undernutrition.

2.2.3 Demographic/household characteristics variables

SES focuses on the capital aspects of a household while the demographic data portraits the structure of a population/household. SES variables can be considered slightly more straightforward and logical than demographic variables when it comes to linking them to malnutrition. This part will analyze a few common demographic variables and provide previous research connecting them as possible determinants of nutritional status.

2.2.3.1 Household size and Birth intervals

Developing countries have larger families compared to developed countries; average in the western world is fewer than 3 while sub-Sahara Africa has a fertility rate of 4.8 (The World Bank, 2016b) .Unexpectedly, the birth interval (birth spacing) is relatively short in SSA with an average of 2.8 years between births although the preferred length is 3.5 according to a study covering 20 SSA countries (Rafalimanana et al, 2001). Co-residence of children and older persons are more common in Africa and Asia, so called multi generation households. There are many reasons causing the current population status where poor households tend to have larger family due to believed safety-net providing support in later stages of life, lower rate of contraceptive use etc. The following section will present a few selected researches on household size and birth intervals and its effect on nutritional status. As the results from previous studies will show, the general understanding is that children living in larger families, in households with higher number of under-five children and shorter birth intervals have an increasing likelihood of stunting, but the magnitude for each factor differs in the studies although majority with the same direction sign.

Akombi et al (2017) performed a systematic review in 2017 covering 49 selected studies investigating determinants for malnutrition in Sub-Sahara Africa. Among numerous of variables detected, family size and birth intervals were amid the most consistent reported factors associated with stunting, wasting and underweight (Akombi et al, 2017).

A case study in Ethiopia conducted a survey to collect data on approximately 240 children age 24-59 months, divided into one control group with non-stunted children and one case group with stunted children. The aim was to assess the factors associated with stunting including household size and the results were clear; children living in households with many people were more likely to be stunted with an increasing risk for every added family member (Fikadu et al, 2014). Adjusted Odds Ratio (AOR) for families of 8-10 was 4.44 (95% CI: 1.65, 11.95), households with 5-7 people had AOR = 2.97 (95% CI: 1.41, 6.29) compared to families with two to four members. Further, in households with three under-five children the likelihood for children to develop stunting was higher than in households with one under-five child (AOR = 3.77, 95% CI: 1.33, 10.74).

Another study with same objective using similar case control method, regression models and data size from Mozambique by Cruz et al (2017) shows results in line with previous discoveries; larger family size and number of under-five children in the household increased the likelihood of stunting (Cruz et al, 2017). With a strong significant level (p-value of less 0,001), the results displayed that children (under 5) living in extended family household (AOR of 17,3, 95% CI = 7.62 – 39.12) and in household with other children less than 5 years (AOR 28.42, 95% CI = 11.93 – 67.70) were more likely to develop stunted condition.

Nkurunziza et al (2017) study aimed to identifying determinants of stunting in Burundi among children aged 3-24 months by using a baseline survey data set containing over 6000 children. Binary and multivariate logistic regression was performed to identify statistical significance and the results showed that frequent birth (shorter birth space) was found to be a determinant of stunting (Nkurunziza et al, 2017). Children in households with more than two under-five children was more likely to be stunted than children in households with one or two under-five years children (AOR=1.45; 95% CI: 1.1-1.9 for stunting and AOR= 1.5; 95% CI: 1.2-1.9 for severe stunting)

Sommerfelt et al (1994) cross-sectional study covering 28 developing countries examined the association between stunting and preceding birth intervals, where lengths intervals were divided into three categories; less than 24 months, 24-47 months and 48 months or longer. In 75% of the countries tested stunting was most prevalent among children born after short intervals less than 24 months (Sommerfelt et al, 1994). Median stunting prevalence for a pooled sampled across all 38 countries was 32.5, 31 and 24.1% for the three different categories going from shortest to longest interval.

A study by Kismul et al (2018) used DHS data from Democratic Republic of Congo (DRC) to examine the key determinants of stunting. The dataset from 2013 included anthropometric measurement for over 9000 children below 5 years, and the significance of possible determinants variables was tested via bivariate logistic regression and multivariate analyses. Highest odds of stunting was found among children being born when preceding birth interval was less than 24 months followed by in households with higher number of children and the odds increased with increasing number of household members (Kismul et al, 2018).

2.2.3.2 Birth order

Another demographic variable connected to family structure is birth order which have been researched with the aim to find possible association between malnutrition and birth order of children. There are a few contradicting aspect to consider when expecting results for this variable. Firstly, firstborns can be associated with less experience parents that might influence the nutritional status and when a second child is born there is a possibility that firstborns are given less attention to. Secondly, when the number of children are increasing, resources might become scares and a situation where less attention from mothers are given to the new born and other older siblings will provide inadequate care for the newborn which will have an impact on a child's nutritional status. This section will provide previous research that has investigated if birth order is a significant determinant at all, and what birth order has the highest risk for a child to become malnourished.

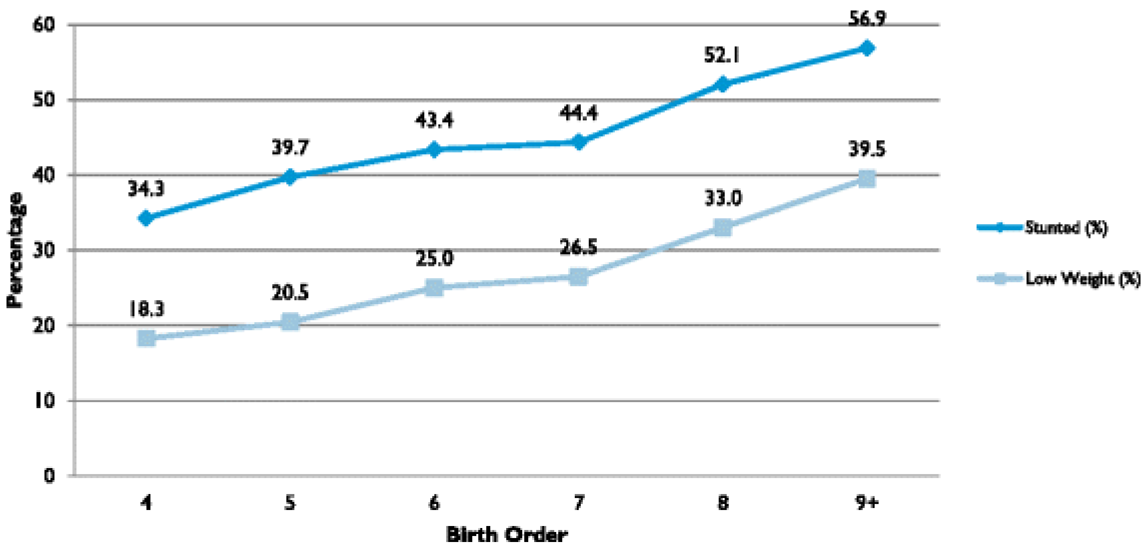
Sommerfelt et al (1994) descriptive study showed that in the Sub-Sahara African countries investigated, there is no consistent pattern of prevalence of stunting regarding birth order, except that stunting is never most common in birth order 2-3. For wasting and underweight, the highest prevalence of stunting is found among children of higher birth orders. Stunting was associated children being born as number 6 or more in the other low income countries in the study. The pooled results, including all countries, showed that higher birth order increased the likelihood of stunting.

A research investigating stunting prevalence and determinants of children's nutritional status in India, with data of nearly 2500 children 5-7 years of age, concur with the previous presented results; higher birth order has a significant impact in determining nutritional status (Jeyaseelan et al, 1997).

With 2011 DHS data from Bangladesh over 4100 last born children younger than 36 months, Mosfequr (2016) tested the association between birth order and child nutritional status. Multivariate analysis displayed a statistically significant increased risk of stunting for children of birth order three, four and five and higher. After controlling for all other variables tested (child's characteristics, mother's characteristics and socioeconomic characteristics) the likelihood of stunting was 25%, 30% and 72% higher for each birth order compared to first born children (Mosfequr, 2016).

A study in 18 African countries investigated if child nutritional status varied by birth order and by how much. DHS data from 2005-2014 with over 700.000 children surveyed was used in the research. Graph 4 below shows descriptive statistics displaying a positive relationship between increased proportion of stunting and higher birth order. Logistic regression was used to assess the statistical significance between birth order and stunting for children 12-59 months old. The results showed a statistically significant association; after controlling for other factors the odds of becoming stunted (and low weight) increases as birth order rises. But the country effects are less often significant when tested separately, 6 of 18 countries showed significant results (Howell et al, 2016)

Graph 4. Percentage of stunting levels over increased birth order



(Howell et al, 2016)

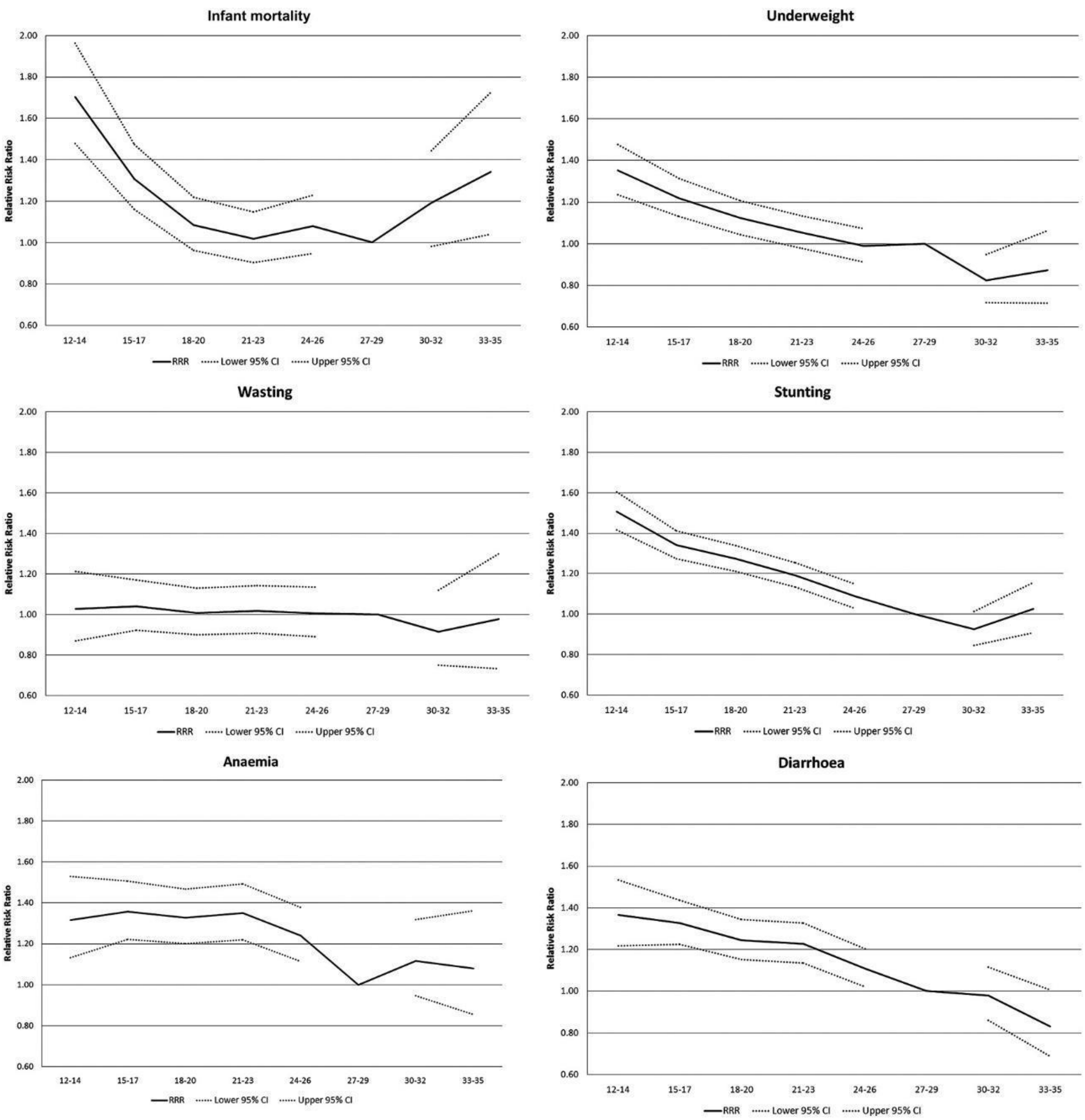
2.2.3.3 Mother's age (at first birth)

There are many reasons for a woman's low age at first birth, and the consequences are both health related and financially negative. The variable is a useful indicator, and a possible proxy-variable, providing information on family planning prevalence and success of interventions to increase contraceptive use, age at first marriage and health status of newborns. There is a large difference between age at first born between developing and developed countries; 20 of the bottom 22 countries are Sub-Saharan African where mother's average age is below 20. In the top, with average age above 26.5 years, are European countries representing 38 of the top 42 spots (Nationmaster, 2013). Results from previous researches aimed at connecting mother's age as a determinant of child nutritional status are consistent across the vast majority of studies; lower age of a mother increases the child's risk of malnutrition. A few selected studies are presented below confirming the findings.

Kenio et al (2014) systematic review paper including 18 studies exploring possible determinants of stunting in Sub-Sahara Africa showed that mother's age at child's birth was a positive and statistically significant determinant of children's height (Keino et al, 2014). The negative health consequences indicate that a delay in childbearing would decrees the prevalence of stunted children. Kabubo-Mariara (2008) research on determinants of children's nutritional status using DHS data in Kenya displays statistically significant results agreeing with Kenio et al (2014) suggesting that as the age of the mother increases the child's nutritional status improves (Kabubo-Mariara et al, 2008). These results are consistent with other research within the topic which indicates that children born to young mothers, especially teenage mothers, are at higher risk of ill health than children born to older (adult) mothers.

A large cross-sectional study using 118 demographic and health surveys conducted between 1990-2008 in 55 low- and middle-income countries provide similar results. After controlling for other characteristics (maternal, paternal, household and SES factors), the lowest risk for poor child health outcome (including stunting and other diseases) are among mother's who have their firstborn between ages of 27-29 (Finlay et al, 2011). First born children to adolescent mothers are at highest risk for poor health status with an improved health outcome with each year up to 29. When a mother's age at firstborn is above 29 an inverse U-shape relationship displays a higher risk of stunting amongst children. Graph 5 below shows the relative risk of different child diseases/conditions with different age of the mother at firstborn (age 27-29 being the reference age). The study finds that older maternal age has a significant impact on stunting and other health conditions.

Graph 5. Relative risk ratio of conditions cause by malnourishment over age of mothers at firstborn



(Finlay et al, 2011)

2.2.3.4 Polygamous households

The last demographic variable researched as a potential determinant of a child's nutritional status is a continuation of family structure. In similarity to family size, polygamous households has a trade-off between more mouths to feed and potential more support for the household as children grow up. There is higher prevalence of polygamous households in developing countries compared to developed countries and this correlates with prevalence of poor nutritional status.

The relationship has therefore brought attention to examine the statistical significance of the variable. Findings from a few selected research papers will be presented below.

A study in Nigeria with data of almost 600 children aged 5-19 years identified polygamous family setting as a risk factor associated with stunting (Senbanjo et al, 2011). The study showed that children/adolescents born in a polygamous households was at higher risk of being stunted (OR 2.11, 95% CI 1.32-3.37, $p<0.001$) compare to monogamy born children. When controlling for other variables in a multiple regression model similar relative risk magnitude was identified, but the significance level decreased ($p=0.053$). A similar study with the same objective surveyed 250 mother-child pairs to collect data in Tanzania showed that women in polygamous was more likely to have undernourished children compared to both monogamously married and unmarried women (Nyaruhucha et al, 2006).

Wagner et al (2011) used household data from 28 African countries to study the effects of polygyny on child health. Empirical evidence shows that a child born in a polygamous household is on average 0.16 standard deviation smaller than their monogamous counterparts. The difference was not driven by other household characteristics such as age of mother and gender. The regression model estimate that moving a child from a monogamous household to a polygamous reduces the child's HAZ (height-for-age z-score) by 8.7% of the sample standard deviation. Hence, polygamy is shown to be a significant variable affecting the child's nutritional status (Wagner, 2011).

A research paper investigated factors associated with stunting using data from over 500 children in Rwanda. Logistic regression showed that, among other previously analyzed factors, monogamous household reduced the risk of stunting (OR 0.43, $p<0.001$) among children below 5 years old (Habimana, 2013). Further, the chi test showed that polygamous husband as household head are strongly associated with stunting on a statistical significant level ($p<0.001$).

2.2.3.5 Breastfeeding and complementary food - Dietary intake among children 0-24 months old

Even though not as widespread knowledge in developing countries as wished for, adequate breastfeeding practice is that breast milk should be the exclusive nutritional intake for the first 6 months of a child's life, followed by breastfeeding and complimentary solid food for the next 18 months. Correct practice has the potential to prevent the death of over 800.000 children each year and further prevent many other diseases such as diarrhea and pneumonia (Victora et al, 2016).

A note to this section is the lack of data in several studies as the prevalence of children who are exclusively breastfed for 6 months or more are relative low in many developing countries. Further, different definitions of "correct feeding procedure" have been used in previous research, where some surveys collect data for "duration of breastfeeding" which does not expose if it is exclusive or not. Additionally, it does not either include when solid complementary food was introduced which also can affect a child's nutritional status. These factors can cause difficulties to assess the duration of exclusive breastfeeding as a determinant, and provide significant results when one part of the nutritional data is incomplete. Yet, the comparable literature available are largely aligned that refraining from exclusive breastfeeding before first 6 months, and a continued combination of breastfeeding with solid food for the next 18 months, will have an negative effect on the nutritional status of a child. This section will present a few selected research papers with the objective to examine the impact different feeding practice haven on children's nutritional status.

Fikadu et al (2014) case study in Ethiopia studied the association between stunting and breastfeeding by comparing 121 cases with 121 control cases. Children who were exclusively breastfed for less than 6 months (AOR = 3.27, 95% CI: 1.21 - 8.82) and more than 6 months [AOR = 7.62, 95% CI: 1.80, 12.23] were more likely to develop stunting condition than children who were exclusively breastfed for 6 months (Fikadu et al, 2014). The results were statistically significant which indicates that introducing supplements before 6 month or after more than 6 months can be an important cause of malnutrition. Ajao et al (2010) findings from Nigeria are consistent with previous research; children who were breastfeed for less than 6 months had a 1.6 times higher risk to be stunted than children who wear breastfed longer (OR=1.640, 95% CI=0.95-2.85, p= 0.073) (Ajao et al, 2010).

Another study from Ethiopia displayed the importance of not only exclusive breastfeeding up until 6 months old, but also introduction of complementary food at 6 months old. There were a significantly higher percentage of stunted children among those who were introduced to complementary solid food first after 12 months compared to other age groups (Teshome et al, 2009). The results were derived with a multivariate regression controlling for other factors to isolate the effects. A larger study with a national representative sample was performed examining the determinants of stunting in Bhutan. The results from multivariate regression analysis showed that children who were not "appropriately complementary fed"[9] was had a higher risk of being stunted (OR 1.81; 95% CI 1.23–2.66) compared to adequate fed children (Aguayo et al, 2014).

2.2.3.6 Pregnancy intentions

A child born unwanted, or unintentionally conceived, can have effects on the wellbeing of both the child and parents as well as impact the caretaking of the child such as prenatal and postnatal care, homebirth prevalence and vaccination ratio etc. Contraceptive use and family planning intention is closely related to pregnancy intentions and has been used as a proxy in several studies to determine if a child is wanted. Research has been performed with the objective to investigate if there is a connection between pregnancy intentions and prevalence of malnutrition, which will be presented below to analyze if the variable is a significant determinant.

Abuya et al (2012) performed a research from the slum (urban area) of Nairobi Kenya, looking at possible determinates for children's nutritional status. Data from over 5000 children below 42 months was collected via Nairobi Urban Health and Demographic Surveillance System (NUHDSS) and multiple logistic regressions was used to define any independent significance of the tested variables . The study differentiated the pregnancy intentions with three categories; wanted, wanted later and not wanted at all. Results show that pregnancy intention was an independent determinant of a child's nutritional status; children categorized as "wanted later" by their mothers had a 38% ($p<0.01$) higher risk of becoming stunted than wanted children (Abuya et al, 2012).

In India, a research with similar objectives was executed covering data of over 1800 children aged 5-21 months. The result from the multivariate logistic regression was consistent with the findings from Kenya; children born after unintended pregnancy was 76% more likely to become stunted (AOR: 1.76, 95% CI: 1.25, 2.48, significance level 5%) compared to wanted (intended) children (Upadhyay et al, 2016). Numerous of similar studies in developing counties indicate similar linkage between pregnancy intentions and stunting, but a few studies have reported zero association. However, the majority of these researches have not controlled for other correlated

[9] no complementary feeding for infants <6 months old and complementary feeding for children 6–23 months old

factors i.e. social support and mental depression associated with unintentional pregnancies. A study in Malawi displayed results contradicting the norm; although there was a higher prevalence of stunting among children categorized as “unwanted” compared to “mistimed” and “wanted (24%, 17,5% and 16,8% respectively), after controlling for other factors the difference was not statistically significant (Baschieri et al, 2017).

2.3 Summary - Determinants of stunting

As seen in the previous research presented above there are several determinants of stunting, many connected to each other. Generally, the determinants impact magnitude can vary slightly depending country/size/time of study, choice of research method/tests and definition of the variable, but the direction signs are commonly unanimous with some exceptions or lower level of significance status. This section will provide a brief summary of the determinants analyzed above.

Economic status is a strong impact variable, richer households/countries have lower prevalence of stunting. Several variables affecting economic status, hence stunting, are linked to economic status such as longer education which increases the odds for higher paid jobs. Household income itself has a direct link to food security, another significant determinant of stunting which also affects mothers’ nutritional status which in turn, if poor, will increase the chance of stunted condition of their offspring.

Mother’s employment’s impact on a child’s risk of becoming is not as straight forward as one could expect it to be seeing that employment would increase household income hence align with previous SES variables and their logic. Research has shown that there is a possible net negative substitution effect for a woman to be employed outside the household as it decreases the quality of caretaking/nutritional intake for the child which is not compensated by the extra income. A father’s employment is on the other hand a significant determinant as fathers a commonly the household heads in developing countries and (sole/main) provider of income.

Water and sanitation access/coverage is usually a robust proxy of SES, but as seen in the results presented above it’s not only the household access of sanitation facilities but also community level access/coverage and the quality of both water and sanitation factices that are vital factors in determining the impact magnitude of the variable on children’s nutritional status. Living location is shown to be a significant variable determining children's nutritional status; the odds of becoming stunted in rural areas are noticeably higher compared to urban areas, which also correlates with a higher prevalence of poverty in rural areas.

Larger family size, families with many children under 5 and short birth intervals (if preceding birth was shorter than 24 months) are all significant determinants of stunting. These three factors are connected to the use of contraceptive and the intentions of a child; if it's planned or not, and wanted or not. Unintentionally conceived/unwanted children are at much higher risk of becoming malnourished compared to planned children. Birth order starts being a significant determinant of stunting after child number three which can be a consequence by inadequate caretaking as older siblings commonly supports with raising younger siblings and the increasing family size.

Children born in polygamous household has increased risk of becoming stunted compared to children of monogamous families. Several reasons have been identified for the connection, which is link to the other household demographic variables. The most dominant reasons being that polygamous households are more pervasive among poor areas/populations, family sizes are larger and commonly a single income earner (male household head) to provide for the larger households.

A child born to young mothers are at increasing risk of becoming stunted (see graph 5 above). Further, "correct" (length and when to introduce solid food) breastfeeding practice will lower the odds for a child to become stunted.

2.4 Gender gap variable

The final variable from the literature review chapter with special interest for this thesis is the gender of the child. A main objective with this paper is to examine the gender differences in stunting prevalence in 36 countries in Sub-Sahara Africa and test the possible determinants of children's nutritional status. Previous research within the field has included the gender factor broadly in regional papers, but there is no recent meta-analysis displaying the potential gender gap and possible difference in gender within other determinants across Sub-Sahara Africa. The following section will provide a broad set of previous studies and focus on the gender effect on nutritional status. One large recent meta-study will be analyzed in more detailed for comparable reasons followed by briefer reviews of additional studies, all combined in a summary table displayed at the end of the chapter.

As apparent in the research presented below, the impact and significance from the gender variable differs depending on country and time-period and when controlling for other factors in multistage regression models i.e. SES, urban/rural area and mother's education etc. The aim with this section is to provide a more detailed overview, compared to previously reviewed variables, of previous research of when/where the gender factor has had, or hadn't, statistically significant impact. Studies previously presented in this literature review will be used together with a few additional papers to identify the general evidence. The results will later be compared with the data analysis results derived from this thesis' dataset for a comprehensive comparison both of trend and between countries. Table 1 below summarizes the findings for a simple overview over prevalence of gender difference, if the difference is statistically significant and if the gender difference is static when controlling for other variables.

To set a general standard for this variable, one of the most recent meta-study from Sub-Sahara Africa will be used as a "reference" as it is comparable to this thesis study, and other smaller and regional research papers will add context to the gender topic further on. Wamani et al (2007) used 16 DHS dataset (1996-2003) from 10 different countries to investigate if there is a systematic sex difference in stunting prevalence among under-five years of age children, and how the difference varies with household SES (proxied by asset index and mother's education). The male mean z-score was lower in all datasets; pooled mean z-score; boys -1.59 & girls -1.46, but the difference was only statistically significant in 12/16 studies. The average prevalence of stunting was higher among male children, but the corresponding OR was statistically significant in 11/16 studies. The pooled stunting prevalence showed that the difference between male and female, 40% and 36%, was statistically significant even after controlling age and individual country/study (AOR 1.18, 95% CI 1.14-1.22, $p<0.001$). The magnitude of stunting prevalence in both sexes varied systematically and inversely with SES variables, and trends for both sexes were statically significant across all countries/studies. A pattern was observed, but not for all countries, where gender differences in stunting was more pronounced among children in the poorest 2 asset quintiles and for children to mother's with no or primary education only. In the higher asset index levels (quintile 3-5) and in the highest educational level (secondary school), the gender differences were not observed. But, the association with SES variables and sex difference in stunting was not statistically significant for either pooled analysis or the individual countries/studies (Wamani et al, 2007).

Keino et al (2014) displayed in their systematic review paper of 18 studies that stunting was more prevalent among boys than girls, with some country exceptions i.e. Cameroon. Stunting was also male dominated in South Africa according to Zere et al (2003) using data from 1993. In Kenya, stunting prevalence was different between the sexes with male being the dominating gender. After controlling for age, the difference was still statistically significant and quit noteworthy; 29% male versus 20% female (Ngare et al, 1999). Another research from Kenya displays key findings that boys suffer more malnutrition than girls; lower z-score among males was statistically significant indicating that boys are more likely to become stunted (Kabubo-Mariara et al, 2008). The results show that boys have a 7% higher risk of being stunted.

Svedberg's (1998) meta-study covering over 55 studies in 20 countries in Sub-Sahara Africa with data from late-1970 to mid-1980 shows that the vast majority of evidence indicates males as most prevalent among stunted children and there are relatively few cases where the opposite applies. Although significance was not tested for in all studies, the large difference indicates that the results are significant in the majority of studies (Svedberg, 1988). This study uses data from later 1970 to early 1980 so there are the results might be outdated but still provide a trend comparison angle.

A large study with almost 10.000 children's characteristics and anthropometric measurement from Ethiopia showed that although the prevalence of stunting was high, 51.9% for boys and 50.5% of girls, the difference was not statistically significant (Woldermariam et al. 2002). Another more recent but smaller research from Ethiopia displayed different results; all three forms of malnutrition was more prevalent among male children between 6-59 months old compared to females, and the results were statistically significant (Demissie et al, 2013). Akombi et al (2017b) performed a study in Nigeria which indicates gender (male) as an independent factor determining children's nutritional status (Akombi et al, 2017b). Additionally, the gender difference was significant after controlling for both age groups (0-23 months and 0-59 months). Similar results are present in Democratic Republic of Congo according to a study by Kismul et al (2018); female children had much lower odds of becoming stunted. The same results was displayed after logistic regression controlling for age, mother's education, places of residency, intermediate factors (i.e. mother's age at delivery, birth intervals, family size etc) and proximal factors (i.e birth order, breastfeeding practice etc.) (Kismul et al, 2018). Atsu et al (2017) used Multiple Indicator Cluster Survey (MICS4) data from Ghana to analyze potential determinant of children's nutritional status. The gender variable was tested, and although a slight male dominated stunting prevalence, there was no statistically significant different between the sexes (Atsu et al, 2017).

A descriptive meta-study by Sommerfelt et al (1994) displays stunting prevalence by gender in 19 low-income countries. The results show that in the 8 Sub-Sahara African countries, 7 have a higher prevalence of stunting among male children, but all the differences were rather small (Sommerfelt et al, 1994). The same trend, the small yet male dominated stunting prevalence difference, was displayed in all age groups but no test was applied to determine the significance level.

A study from Laos showed no significant difference between stunting prevalence of male and female among children below 6 years old (Kamiya, 2011). Kavosi et al (2013) findings from their study in Iran displayed a statistically significant difference between the genders; boys under-six years of age had 41% higher risk of becoming stunted compared to female (OR= 1.41 CI: 1.26–1.58). Noteworthy is that Iran have a much lower prevalence of stunting, 9,53%, compared to most of the African countries studies and there was a significant difference between the sexes (Kavosi et al, 2013). In Pakistan, a study was made with a national representative sample which showed no significant differences between genders regarding stunting prevalence (Mushtaq et al, 2011). Research from India using population representative sample data from 2012 show that the prevalence of stunting was significantly higher in boys compared to girls (25.4% verus 19.3%), but the difference was not tested for together with other variables (Aguayo et al, 2016). More results from previous studies are presented in table X.

From the literature presented, and additional literature not displayed in this paper, there is a light observed pattern. Results indicate that stunting prevalence is, especially in Sub-Sahara Africa, higher among male children. As seen in table X there are exceptions where the difference is not statistically significant, and only very few observations have been made where stunting among female children is higher and statistically significant. Further, in the few researches presented that test the gender difference in multivariate regression and controlling for other variables, the significant level is lowered. This thesis' data analysis will provide additional evidence to the research field with focus on the gender differences.

Table 1. Summary of previous studies' results of stunting prevalence and gender difference

Study	Country/Region	Year(s) of data collection	Stunting prevalence; male or female dominance (i.e. Mean z-score/OR/Bivariate regression)	Statistically significant gender difference (p<0.05)	Control variable(s)	Statistically significant gender difference after controlling for other variables (i.e. Multivariate logistic regression)
Abuya et al	Kenya	2006-2007	Male	Yes	Mother's education, mother's demographics, household SES & community characteristics	Yes
Adenuga et al	Nigeria	2008	None	No	Urban and rural	No
Aguayo el al	Bhutan	2011	Male	Yes	Confounding variables	Yes
Aguayo et al (b)	India	2012	Male	Yes	-	-
Akombi et al	Nigeria	2013	Male	Yes	Age	Yes
Atsu et al	Ghana	2010	None	No	-	-
Demissie et al	Ethiopia	2012	Male	Yes	-	-
Habimana	Rwanda	2012	Male	Yes	-	-
Howell et al	Sub-Sarah Africa (18 SSA countries + Egypt)	2006–2015	Male	Yes (pooled)	-	-
Kabubo-Mariara et al	Kenya	1998 and 2003	Male	Yes	Cluster fixed effect (unobserved community level characteristics)	Yes
Kamiya	Lao	2006	None	No	-	-
Kavosi et al	Iran	2012-2013	Male	Yes	-	-
Keino et al	Sub-Sahara Africa (7 countries/16 studies)	1990-2012	Male (Cameroon exception where female dominated)	Yes (Yes)	-	-
Kismul et al	Democratic Republic of Congo	2013-2014	Male	Yes	Age, distal factors, intermediate factors and proximal factors	Yes
Mosfequr	Bangladesh	2011	None	No	Several variables	No
Mushtaq et al	Pakistan	2009	None	No	-	-
Mutisya et al	Kenya	2006-2012	Male	Yes	Food security and wealth index	Yes
Ngare	Kenya	1999	Male	Yes	Age	Yes
Nkurunziza et al	Burundi	2015-2017	Male	Yes	-	-
Senbanjo et al	Nigeria	2002	None	No	-	-
Sommerfelt et al	Sub-Sahara Africa and other low-income countries (8/19 in SSA)	1985-1990	Male (7/8 in SSA and 8/11 in other)	Not tested for but small differences (0.1-5%)	Age	Not tested for but same small differences with higher prevalence among male children
Svedberg	Sub-Sahara Africa (20 countries/55 studies)	1976-1983	Male (vast majority with few exceptions)	Yes (where not tested for the large difference in results indicate a significant different)	-	-
Teshome et al	Ethiopia	2006	Male	Yes	-	-
Wamani et al	Sub-Sahara Africa (10 Countries/16 studies)	1993-2006	Male	Yes	SES (asset index and mother's education)	No
Woldermariam et al	Ethiopia	2000	None	No	-	-
Zere et al	South Africa	1993	Male	Yes	-	-

3. METHODOLOGY

3.1 Data Source

The DHS surveys were used as data source for this research. DHS are household surveys providing extensive country specific data for a broad set of monitor and impact evaluation indicators covering areas such as population, health, nutrition and anthropometric status. The data is publicly available and collected through interviews in sample households. The surveys are nationally-representative with a sample size of approximately 5.000-30.000 households and the surveys are usually conducted every 5 years (DHS, 2018). In this research a total of 124 Demographic and Health Surveys (DHS) from 35 Sub-Saharan African countries have provided anthropometric and characteristic data of total 413,464 children under five and their mothers. The obtained data have been analyzed both at country specific level and as pooled data which was created by consolidating all countries and surveys to one dataset. Further, the surveys used were conducted from 1986 to 2016 allowing for comparison over time.

Selection criteria, both countries and time period, were based on the aspiration to include all Sub-Saharan African countries, but a few countries were omitted as DHS were not available. The selection process was further refined as some surveys did not contain data with the chosen variables removing additional countries. Due to data limitations, 2 countries (Liberia and São Tomé & Principe) were dropped in the full regression containing all variables, but they were still included in the pooled regression examining stunting prevalence with gender interaction alone. The tested variables (determinants) were elected with the aim to add depth to the gender gap topic by controlling the previously stated major determinants which possibly could increase the likelihood of finding explanations to the observed gender difference. Moreover, the variables selected were also chosen to broaden previous research findings by providing an updated view of determinants of children's nutritional status in the majority of SSA countries setting a new benchmark for future research.

The statistical analyses were performed using STATA 13.0 and parts of the data cleaning and compilation were conducted in R Version 1.1.414.

3.2 Analysis method

3.2.1 T-test and Logistic regression

We employ student t-test to check the statistical significance of sex differences in stunting. We also run logistic regressions with the binary variable indicating if the child is stunted regressed on the binary variable sex. In addition to the statistical significance it also yields the likelihood of being stunted on any variable of interest.

Logistic regression is preferred compared to OLS regression when the dependent variable is binary (0 or 1). Standard linear regression may be problematic, especially with the interpretation of coefficients, as the predicted values can be less than 0 or more than 1. Logistic regression avails the probabilities that an individual fall under the class k ("stunted" in our case) given that it comes from predictor x ("males" for example) where, $\Pr(Y = k|X = x) = \frac{1}{1+e^{(-\beta_0-\Sigma\beta_i x_i)}}$. Logistic regression estimates the log likelihood of odds which "operates a smooth nonlinear logistic transformation over a multiple regression model and allows the estimation of class probabilities" (Venables & Ripley, 2010).

For these advantages, we employ logistic regression not only to test the significance of sex difference alone but also while regressing on all the control variables. The regression coefficient (β_1) is the estimated increase in the log odds of the outcome per unit increase in the value of the independent variable. If the independent variable is also a binary term, which is the case for most of our tested variables, then this can be interpreted as the log odds of the outcome for being in certain category (compared to the base category) of the independent variable. The raw coefficients from logistic regression can be transformed to Odds Ratio (OR) which facilitates the interpretation in terms of comparison. OR is the exponential function of the raw coefficient (e^{β_1}). "The OR represents the odds that an outcome will occur given a particular exposure, compared to the odds of the outcome occurring in the absence of that exposure" (Szumilas, 2010). The OR of 1 indicates the null value (corresponding to value 0 of the raw coefficient), meaning no difference in impact of the independent variable. The values of more than 1 (for example, 2.3) indicate that they are positively associated and an increase in the independent variable by one unit follows with that many times more (in the example 2.3 times more) likely of falling into the main category (category 1) of the dependent variable.

We have defined our dependent variable such that if the child is stunted, the value equals 1 and if not, it is 0.

3.2.2 Principal Component Analysis (PCA)

We employ principal component analysis to develop a wealth index from the information on the household's ownership of assets, the type of their dwellings (floor, roof and wall) and the toilet facility since there is no direct information on income, wages or wealth available from the DHS survey.

PCA is a form of multivariate analysis to summarize down the set of variables by accounting for their variance. The Principal Components are extracted such that the first principal component becomes the linear combination of variables accounting for the maximum variance and then the second principal component would be an orthogonal equation to the first - as this linear combination is uncorrelated with first and can account for the maximum of the remaining total variation - and the third component that accounts for the most from the remaining and so on. Filmer and Pritchett (2001) note that the crucial assumption with using PCA to build asset index is that household long-run wealth explains the maximum variance and covariance in the asset variables. Although this comes from nothing and is purely an assumption, they do show that it produces reasonable results.

Filmer and Pritchett (2001) very lucidly show how information on ownership of assets can be analyzed through the procedure of principal components to determine the weights for an index of asset variables to be used as the wealth index. With a big set of variables from the assets data in the states of India they built different subsets of the variables and show that each of the subsets conclude to the similar index. Moreover, they also show how the index built as such is coherent with the household consumption expenditure in the countries of Indonesia, Nepal and Pakistan where information on both the consumption expenditure and ownership of assets were available. These results from Filmer and Pritchett were widely cited and PCA has been consistently used to build wealth index by researchers (see for example, Restrepo-Méndez, Barros, Black, and Victora (2015) and Wamani, Åstrøm, Peterson, Tumwine, and Tylleskär (2007)). Moreover, DHS itself is creating the wealth index by PCA which is readily available from the data source from the year 2006 (DHS VI, 2013).

3.3 Variables

3.3.1 Stunted

The variable "stunted" is the dependent variable. It equals 1 if the child is stunted and 0 otherwise. Following the WHO definition, we constructed z-score of heights over the age and sex of each child and categorized the ones with less than -2 as stunted. In *Stata 2013* we used the function "zanthro()" as the extension to "egen" function introduced by Vidmar et al (2004) with a WHO standard introduced in the update (Vidmar et al, 2013). The function standardizes the reference population for the child's age and sex just as required to mark the cutoff point following the definition of stunting. The function also removes the observations that are below -5 or above 5 standard deviation which is the WHO practice of removing implausible values.

3.3.2 Sex

Sex too is a dummy variable with value 1 corresponding to males. We simply renamed the variable "sex of the child" from the data source to [0,1] variable. The number of males and females were almost equal in total of the surveys, 49.63% females and 50.38% males.

3.3.3 Wealth Quintile

We developed the Wealth Index by PCA as explained in the methodology. The Index values were then categorized into 5 quintiles. As the index values themselves do not have direct interpretation over magnitude, they are to be used ordinally. This is again in line with both DHS practice and

Filmer and Pritchett (2001). The first quintile indicates the poorest family and wealth increases with each quintile, the fifth indicating the wealthiest. In summary, wealth quintile is the comparative ranking of households' wealth proxied by their ownership of assets (Radio, TV, Refrigerator, Bicycle, Motorcycle, Car, Telephone and access to Electricity), type of dwelling (material of floor, wall and roof) and type of toilet facility.

3.3.4 Mothers Education

The DHS survey collects education attainment status of respondents in 3 ways/steps. The first question inquires about the highest education level attended, with the levels being i) No education, ii) Primary, iii) Secondary, and iv) Higher. Then it asks the highest year of education completed at the given level. It also has education in single years in total constructed from the first two variables. Then finally using all the information, the final variable is created categorized into 6 categories: (i) None, (ii) Incomplete Primary, (iii) Complete Primary, (iv) Incomplete Secondary, (v) Complete Secondary, and (vi) Higher Education.

We however notice that even in the pooled data in total only 1.9% of the observation fall under the last category ("higher education") and 2.9% in the "Complete Secondary" category while almost half (48%) is in "No education". This also means many countries would have no data on some of the categories. The low numbers in the latter categories allow no realistic analysis, hence we create a new variable with 3 categories: (i) No education (same as "No education" category in the source), (ii) Primary (sum of "Incomplete Primary" and "Complete Primary" in the source) and, (iii) Higher than Primary (sum of the rest of the categories in the source).

Table 2. Recategorization of Mothers Educational Attainment

Education (V149) - **DHS's Categorization**	Freq.	Percent
No education	194,789	48.14
Incomplete primary	99,876	24.68
Complete primary	46,432	11.48
Incomplete secondary	45,677	11.29
Complete secondary	11,865	2.93
Higher	5,987	1.48
Total	404,626	100

Education - **Authors' Recategorization**	Freq.	Percent
No education	194,789	48.14
Primary	146,308	36.16
Higher than primary	63,529	15.7
Total	404,626	100

The tables above summarize the frequency of the different categories defined by DHS and when they are summed up after recategorization.

3.3.5 Birth Order

Birth order number gives the order in which children were born. While they range from 1 to 19, 98.5% of the observations are already covered up to the 10th order. We categorize the birth order into 4 categories: (i) First or Second Child, (ii) Third to Fifth Child, (iii) Sixth to Tenth Child, (iv) Tenth or Higher order Child. See Appendix I for the frequency table of birth order in numbers and when categorized.

3.3.6 Preceding Birth Interval

Preceding birth interval is the difference in months between the current birth and the previous birth. It ranges from 0 to 351 but 99% of observations are covered counting the children within 100 months of birth interval. Nevertheless, the observations are widely divided among the months and we therefore use this as a continuous variable as it is after removing the flagged and missing observations.

3.3.7 Mother's Age at First Birth

The mother's age at her first birth is measured in years. In health and medicine field of study, childbirth at young (less than or equal to 19 years old) or advanced maternal age (35 years or higher) are associated with increased risk of adverse birth outcomes. Cavazos-Rehg et al. (2015)

categorize the mothers' age into the age groups as: (i) 11-14 years old,(ii) 15-19 years old, (iii) 20-24 years old, (iv) 25-29 years old, (v) 30-34 years old, (vi) 35-39 years old, and (vii) 40 or higher years old. They find that, after controlling for demographics and clinical confounders, women of 11-18 years had highest risk for complications including preterm delivery, chorioamnionitis, endometritis, and mild preeclampsia, women of 15-19 years had greater risk for eclampsia, postpartum hemorrhage, poor fetal growth, and fetal distress and women above 35 years had higher risk of preterm delivery, hypertension, superimposed preeclampsia and severe preeclampsia, compared to the pregnant women of 25-29 years old.

However, in the data we have less than 1% observation in the 35-39 years old and 40 or higher old category. Hence, we sum up the last two categories into one as "35 years or higher". The rest of the categories are kept the same as Cavazos-Rehg et al. (2015) suggests.

3.3.8 Breastfeeding Duration

The duration of breastfeeding of the child is given in months. It ranges from 0 to 59 and the observations are smoothly spread over the months. We use breastfeeding duration as continuous variable as it is after removing the flagged and missing observations. In health science (for example, Kramer and Kakuma (2002) and, Victora, Fenn, Bryce, and Kirkwood (2005)), six months of sole breastfeeding and then slowly introducing solid food along with breastfeeding up to 24 months is considered optimal for child health. The ideal measure would have been a category variable indicating if the child were solely breastfed until 6 months and/or if the child were still solely breastfed (without feeding solid food) after six months. However, the DHS data on breastfeeding does not avail such details. Hence, we stick to using the months as a continuous variable and acknowledge that the direction of the breastfeeding effect over increasing number of months could go either way.

3.3.9 Polygamy

DHS questionnaire involves several questions regarding marital status of the individuals in the household. Among these, they also provide information about the number of other wives. For the mothers who are in monogamous relationship, the number of extra wives is obviously 0. All other observations with a value of more than 0 were recoded into 1 to generate a dummy variable representing polygamous households. In the pooled data of all countries, over 25% of the families were polygamous.

3.3.10 Whether the Child was Wanted during Pregnancy

The DHS questionnaire contains several questions that may indicate the respondents' socio-economic status by stating their preferences in certain topics. Although it might not function as a proxy for socio-economic status, it would be interesting to examine how the nutritional status of a child is affected dependent on pregnancy intentions. The mothers were asked two similar questions: (i) Whether the child was wanted during pregnancy, and (ii) Whether the child was wanted in the last 3 or 5 years (in the cases where child is already born). Both questions had the same response choices: (i) wanted, (ii) wanted but later, (iii) not wanted at all. We checked correlation between the variables and found that it is 0.87. Since the information on the former (whether the child was wanted during pregnancy) was available for slightly more observation, we use that one in our analysis.

Table 3 below summarizes the descriptive statistics of the variables in the data:

Table 3. Descriptive Statistics of the Control Variables

Sex of the child	Freq.	Percent	Cum.
Female	205,511	49.7	49.7
Male	207,954	50.3	100
Total	413,465	100	

5 quintiles of wealth index	Freq.	Percent	Cum.
1st (Poorest)	40,342	22.34	22.34
2nd	39,200	21.71	44.04
3rd	34,924	19.34	63.38
4th	34,122	18.89	82.28

5th (Wealthiest)	32,010	17.72	100
Total	180,598	100	

Mothers Education	Freq.	Percent	Cum.
No education	194,789	48.14	48.14
Primary	146,308	36.16	84.3
Higher than Primary	63,529	15.7	100
Total	404,626	100	

Birth Order	Freq.	Percent	Cum.
First Child	70,013	16.93	16.93
Second Child	73,506	17.78	34.71
Third to Fifth Child	164,102	39.69	74.4
Fifth to Tenth Child	99,448	24.05	98.45
Tenth or higher order Child	6,396	1.55	100
Total	413,465	100	

Preceding Birth Interval (in months)	Obs.	Mean	Std. Dev.
	342925	38.12	20.19

Mothers Age at First Birth	Freq.	Percent	Cum.
11 to 14 years	27,069	6.55	6.55
15 to 19 years	237,285	57.42	63.97
20 to 24 years	121,103	29.31	93.28
25 to 29 years	23,362	5.65	98.93
30 to 34 years	3,780	0.91	99.84
35 years and above	644	0.16	100
Total	413,243	100	

Breastfeeding Duration (in months)	Obs.	Mean	Std. Dev.
	411354	15.03	8.39

Whether the family is polygamous	Freq.	Percent	Cum.
Non-polygamous family	307,131	74.28	74.28
Polygamous family	106,334	25.72	100

Total	413,465	100	

Whether the child was wanted during pregnancy	Freq.	Percent	Cum.
Wanted then	302,648	74.9	74.9
Wanted but later	72,300	17.89	92.79
Wanted no more	29,130	7.21	100
Total	404,078	100	

Appendix II and III displays details on how observations are distributed over countries and over time.

3.4 The Regression Model

As we have shed light on the variables of interest, categorized them as needed and specified the analysis method, we now present our main regression equation:

Stunted = β_0 + β_1.Sex + β_{2i}.Wealth Quintile + β_{3i}.Sex × Wealth Quintile
+ β_{4i}.Mothers education + β_{5i}.Sex × Mothers education
+ β_{6i}.Birth Order + β_{7i}.Sex × Birth Order
+ β_{8i}.Birth Interval + β_{9i}.Sex × Preceding Birth Interval
+ β_{10i}.Mothers age at first birth + β_{11i}.Sex × Mothers age at first birth
+ β_{12i}.Breastfeeding duration + β_{13i}.Sex × Breastfeeding duration
+ β_{14i}.Polygamy + β_{15}.Sex × Polygamy
+ β_{16i}.Child Wanted + β_{16}.Sex × Child Wanted
+ β_{17i}.Year Dummies
+ β_{18i}.Country Dummies

We are regressing each of the control variables followed by their interaction with sex as we are primarily interested is sex difference in stunting over different factors. Each of the βs corresponds to the coefficient (log likelihood) of the corresponding variable. All the variables are factors variables except for Birth Interval and Breastfeeding duration which are kept as continuous variables, both measured in months. The β_{N_i}s are the set of coefficients for each of the categories (dummies) of the variable where $i = 1$ to k, k being the total number of the categories (minus the base category). The variables are also controlled for the country dummies.
The regression was run controlling for each of the year (except base year 2016) as the time dummies. We did not treat the data as panel data (and run fixed or random effects) because although there has been data for the same country throughout few years, these are not exactly

from the same households or even same geographical locations. All the surveys in total are thus treated as cross-sectional data. Nevertheless, we control with the year dummies to examine if there is any significant trend over the time period.

4. DATA ANALYSIS AND RESULTS

4.1 Sex and Stunting

We check if the prevalence for stunting is statistically different and higher for males compared to the females. The stunted t-test shows that it is indeed the case for the pooled data.

Total		
Obs.	Stunted Percentage	Std. Dev.
643077	0.3584252	0.479538

Female			Male			Difference		t-value
Obs.	Stunted Percentage	Std. Dev.	Obs.	Stunted Percentage	Std. Dev.	Stunted Percentage	Std. Error	-31.9317***
319134	0.3392023	0.473439	323943	0.377363	0.4847276	0.0381603	0.001195	

*** p<0.01, ** p<0.05, * p<0.1

The stunting prevalence, while stands at 35.8% among total children, it is actually 33.9% among females and 37.7% among the males. The difference t-value is significant at all the conventional confidence intervals.

The difference is also significant at all the confidence intervals while we test upon the data country wise except for Angola, Central African Republic, Sao Tome & Principe and Sierra Leone. For Angola and Central African Republic, the difference is still statistically significant at 95% confidence interval while that for Sierra Leone is significant only at 90% confidence interval. Sao Tome & Principe is the only candidate that indicates the difference other way around (females being more stunted) however it is not statistically significant. The country also has a very small sample size (856 observations) compared to the rest. Refer to Appendix IV for country wise t-test results.

The bar graphs below illustrate the sex differences in stunting in each of the 35 countries.

Graph 6. Country-wise bar graphs of stunting prevalence

Next, we run the logistic regression regressing the binary variable "stunted" on the binary variable "sex". For "stunted" the value 1 indicates the child being stunted and 0 indicates otherwise. For the "sex" dummy, 1 indicates male and 0 the female. Logistic regression facilitates better interpretability of coefficient with the OR. If the OR is more than 1 for sex, it indicates that the males are more likely to be stunted than females. Below is the result of the regression as we run them in the pooled data.

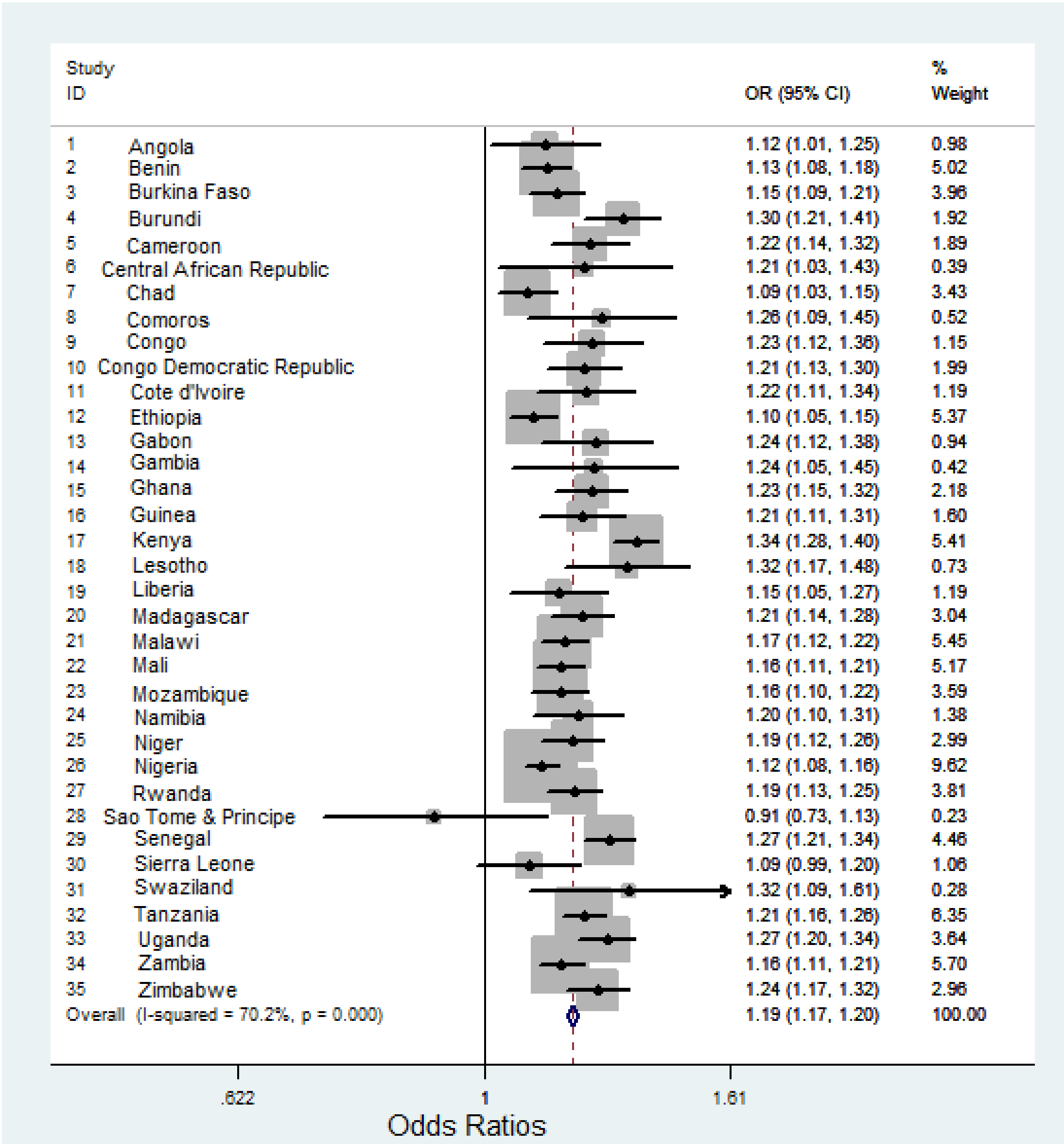
Table 4. Coefficient and OR of sex regressed on stunted

VARIABLES	(1) Coeff stunted	(2) Oddsratio stunted
stunted		.
		(.)
sex	0.1661***	1.1807***
	(0.0052)	(0.0061)
Constant	-0.6669***	0.5133***
	(0.0037)	(0.0019)
Observations	643,077	643,077

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The above result is from the logistic regression for pooled data of all countries and all surveys. As with the t-test, the results show that the sex coefficient is statistically significant. The OR value tells that the odds of being stunted is 1.18 times higher for boys than for girls.
The logistic regression was then run country-wise (see Appendix V). Below is the forest plot summarizing the results.

Graph 7. Forest plot of ORs of country-wise logistic regression of sex on stunted



Graph 7 above is the forest plot of the 35 countries indicating the rate of higher (or lower) stunting among male children compared to that among females. The vertical dashed line represents the OR of the overall (pooled) studies, with the width of blue diamond (small blue-outlined square shape at the end of the dashed line) representing the confidence interval. The solid vertical line corresponds to the OR being one for the reference of null value (meaning no stunting difference over sex). Each of the horizontal lines are the confidence interval of stunting prevalence on each country with the country names mentioned to the left of the lines respectively.

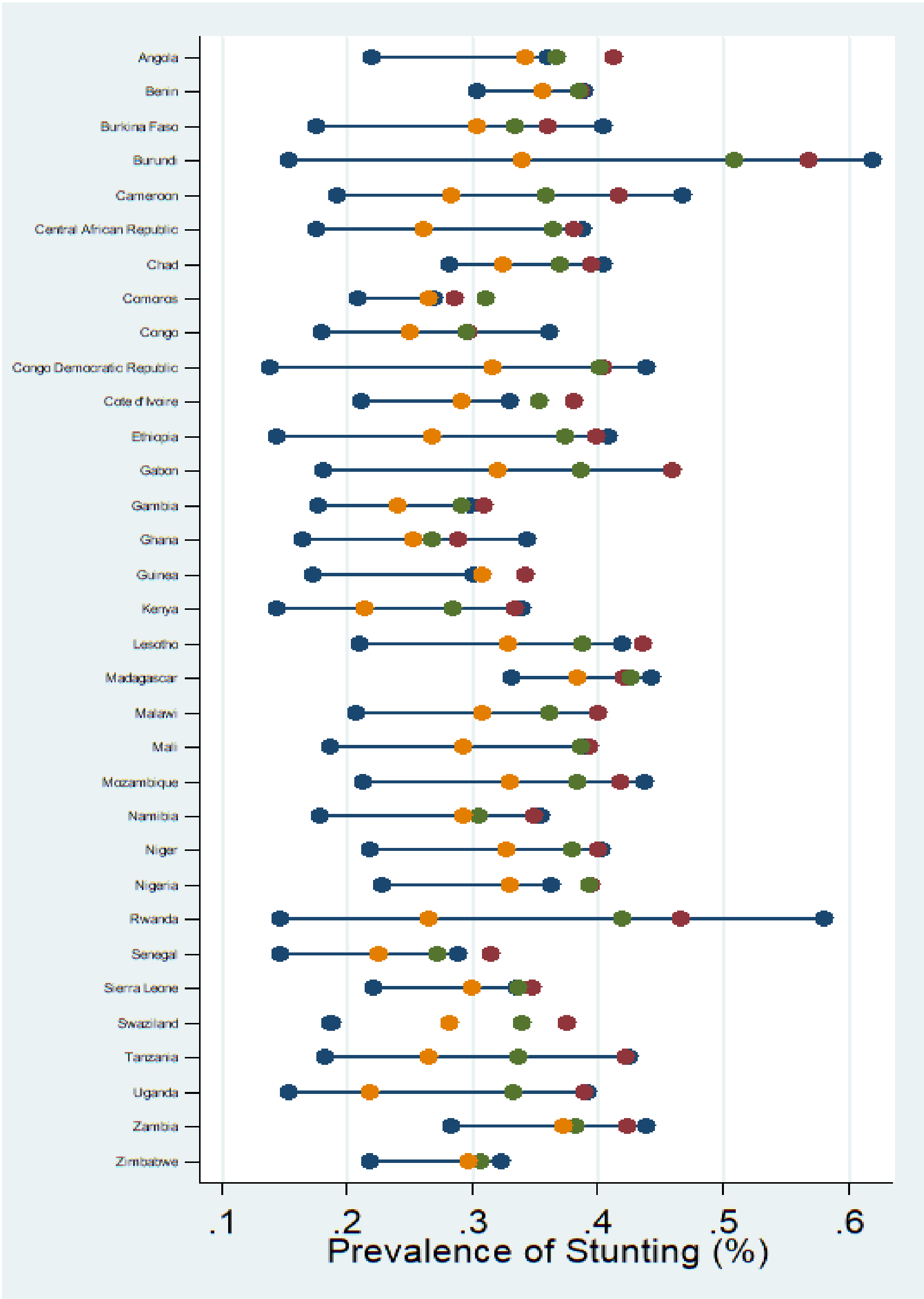
The dot in the middle is the mean value and the size of the grey box around reflects the size of the sample. The bigger boxes thus are with higher number of observations. We can see that for all of the countries the ORs is above the null value of 1, except for Sao Tome & Principe. However, Sao Tome & Principe had a small sample size (856 observations and only one survey) compared to most of the other countries. Having OR of more than 1 means that the boys are more likely to be stunted than the girls. In Benin for example, boys are 1.13 times more likely to be stunted than girls. The lower value of the 95%confidence interval for Sierra Leone's sex coefficient reaches the OR of 1, indicating that the difference in stunting is not statistically significant for the country at that confidence interval.

4.2 Sex, Stunting and Socio-economic Status

Now we investigate the impact on stunting by the socio-economic status. We will be using wealth index and mother's education as proxy to socio-economic status (following Wamani et al. (2007)). As we move to the deeper analysis, we are left with 33 countries as the data on Liberia and Sao Tome & Principe failed to provide enough details to generate the households' wealth quintiles. We are also short of many surveys in other countries compared to our preliminary analysis due to similar data availability issue. The analysis and results henceforth, are from 33 countries and 61 surveys in total that provide enough information for all of the control variables of interest.

The figure below shows how the stunting prevalence differs among wealth quintiles in different countries.

Graph 8. Stunting prevalence in 33 countries over wealth quintiles



Graph 8 shows the stunting prevalence among children from poorest to least poor family. The blue dots to the left corresponds to the highest quintile (wealthiest) and the blue dots on the right corresponds to the lowest quintile (poorest). The three dots in the middle with yellow, green and dark red color correspond to second, third and fourth quartile respectively. For all the countries, it is very obvious with the wealthiest family, that they have the least stunting rates and the difference is big with the family in 4th quintile while the differences among other quintiles is not as big for most of the countries. The blue dots to the right, representing the poorest quintile, are not furthest to the right for all countries indicating that even the 2nd or 3rd poorest quintiles could have equal or even higher stunting prevalence compared to the poorest quintile. Rwanda seems to have the highest difference over quintiles and Benin and Zimbabwe the least. Burundi has the highest stunting prevalence among the poorest family and Madagascar has the highest among the richest family.

Now we present the regression results of the full regression with all the control variables chosen for this study. The total of dummy variables and their interactions along with a couple of continuous variables as well as the year and country dummies produces a big table. Since it is difficult to go over all of the variables and identify each of the categorical variables' base category all at once, we present the table but in parts, following the discussion upon each of the control variables one by one. It is important to note that all of the parts (A to I, except mentioned otherwise) is in total the output from one regression, not the variables added one after another. The full table is reported in Appendix VI. We report only the ORs as it is enough to determine the direction of the effect and facilitates the interpretation of comparison.

4.2.1 Wealth Quintile

Table 5. OR of Sex, Wealth Quintile and their interaction extracted from the full regression output (Appendix VI)

Stunted *(1=Stunted)*	**OR**	**Std. Err.**	**P>|z|**
Sex			
1 *(Male)*	1.2133***	0.0771	0.002
Wealth Quintile - Dummy (wealth_q)			
Base Variable: 1st Quintile			
2nd Quintile	0.9904	0.0241	0.693
3rd Quintile	0.8605***	0.0222	0.000
4th Quintile	0.7429***	0.0208	0.000
5th Quintile	0.5845***	0.0192	0.000
Interaction: Sex*Wealth Quintile			
(sex#wealth_q)			

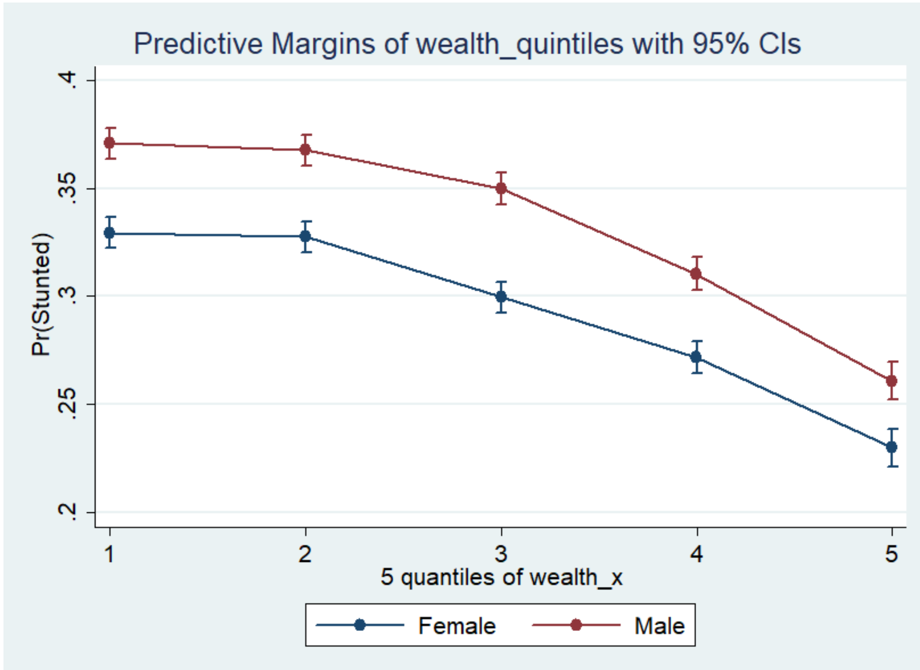
*Male*2nd Quintile*	0.9951	0.0332	0.883
*Male*3rd Quintile*	1.0542	0.0369	0.131
*Male*4th Quintile*	1.0075	0.0376	0.841
*Male*5th Quintile*	0.9866	0.0428	0.756
*** p<0.01, ** p<0.05, * p<0.1			

First, we note that even after controlling for all the variables of socio-economic status and interest, the stunting prevalence is still higher among the boys. The boys are 21% more likely to be stunted than the girls.

When added the wealth quintile, we can see that the difference in stunting is decreasing with the increased wealth (higher wealth quintiles). Although it is not statistically significant while moving from the 1^{st} (base) quintile to the 2^{nd}, as the family progresses over wealth quintiles to the 3^{rd} and above, there is statistically significant reduction in stunting prevalence compared to being in the poorest wealth index (1^{st} wealth quintile). For example a child in the least poor quintile is only likely to be stunted 0.5845 times than the one in poorest quintile is likely to be so.

Next, are the coefficients of interaction variables. Although the numbers for males in 3^{rd} and 4^{th} quintile seem to indicate certain prevalence of higher male stunting over higher quintiles, we cannot conclude that they are significantly different from zero. A male child in richer family may not be more likely to be stunted than a female child in the poorest family.

Graph 9. Predicted Probability of stunting among male and female children over wealth quintiles



The graph above shows the predicted value of stunted (margins) at each of the wealth quintiles for males and females. The vertical lines at each dot represent the values within 95% confidence interval. While the stunting probability reduces with the increased wealth quintile, throughout all the quintiles the male children have higher probability of being stunted.

4.2.2 Mother's education

Table 6. OR of Mother's education and its interaction with Sex extracted from the full regression output (Appendix VI)

Stunted *(1=Stunted)*	**OR**	**Std. Err.**	**P>|z|**
Mothers education - Dummy (new_edu)			
Base Variable: No Education			
Primary Education	0.9065***	0.0183	0.000
Higher Education	0.7367***	0.0222	0.000
Interaction: Sex*Mothers Education			
(sex#new_edu)			
Male*Primary Education	1.0365	0.0272	0.173
Male*Higher Education	0.9897	0.0390	0.793

*** p<0.01, ** p<0.05, * p<0.1

Not surprisingly, the stunting prevalence is lesser for the children of educated mothers. The mother with higher than primary education is likely to have her child stunted only 0.74 times as much as the mother with no education is likely to have hers.

The stunting difference over sex however is not more (or less) pronounced over the mothers' education. The male child from educated mother is not statistically significantly more (or less) likely to be stunted than a female child from non-educated mother.

4.2.3 Birth Order

Table 7. OR of Birth Order and its interaction with Sex extracted from the full regression output (Appendix VI)

Stunted *(1=Stunted)*	**OR**	**Std. Err.**	**P>|z|**
Birth Order - Dummy (new_bird)			
Base Variable: First & Second Child			
Third to Fifth Child	1.0145	0.0226	0.519
Fifth to Tenth Child	1.0019	0.0255	0.941
Tenth or higher order Child	0.9930	0.0668	0.917
Interaction: Sex*Birth Order			
(sex#new_bird)			
Male*[Third to Fifth Child]	0.9293**	0.0286	0.017
Male*[Fifth to Tenth Child]	0.9225**	0.0324	0.021
Male*[Tenth or higher order Child]	0.9829	0.0934	0.856
*** p<0.01, ** p<0.05, * p<0.1			

Stunting is not found to be statistically different over the birth order. The child in the later order of the birth than being the first or second child is not more likely to be stunted but the statistically significant interaction term tells that the males in third to tenth order (third to sixth and fifth to tenth) are actually less likely to be stunted than the females in the first or second order. This is again not significant for the males born in tenth order or later.

4.2.4 Preceding Birth Interval

Table 8. OR of Birth Interval and its interaction with Sex extracted from the full regression output (Appendix VI)

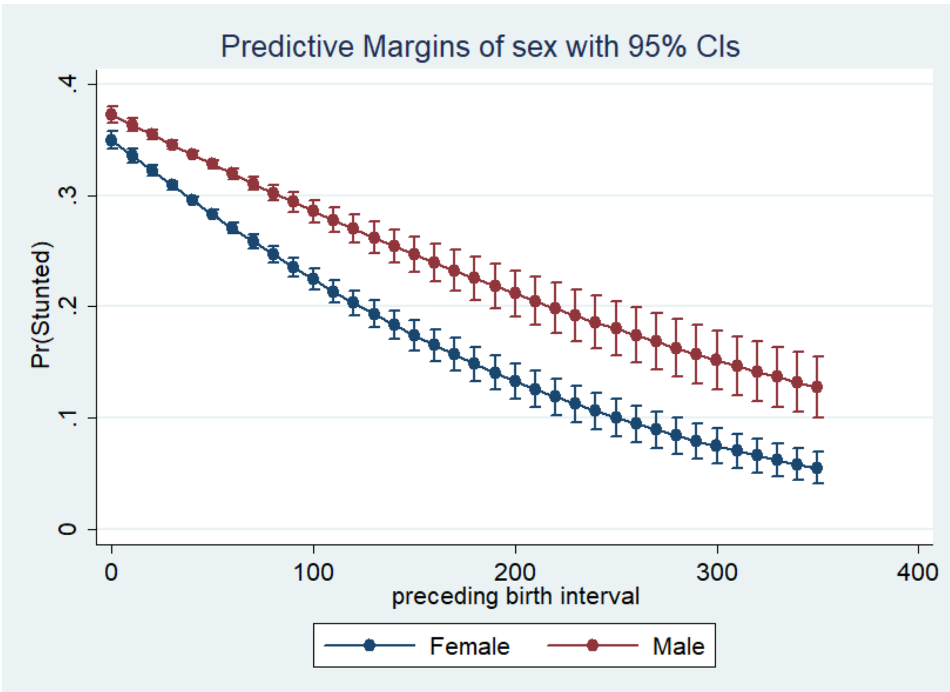
<table>
<tr><th>Stunted (1=Stunted)</th><th>OR</th><th>Std. Err.</th><th>P>|z|</th></tr>
<tr><td>Preceding Birth Interval (b11)</td><td></td><td></td><td></td></tr>
<tr><td>Birth Interval (continous variable)</td><td>0.9933***</td><td>0.0005</td><td>0.000</td></tr>
<tr><td>Interaction: Sex*Preceding Birth Interval</td><td></td><td></td><td></td></tr>
<tr><td>(sex#c.b11)</td><td></td><td></td><td></td></tr>
<tr><td>Male*Birth Interval</td><td>1.0025***</td><td>0.0006</td><td>0.000</td></tr>
<tr><td>*** p<0.01, ** p<0.05, * p<0.1</td><td></td><td></td><td></td></tr>
</table>

Preceding Birth Interval is the continuous variable measured in months. Children overall are slightly less likely to be stunted as they are born a bit later than their preceding child. On average, a child would be 0.9933 times likely to be stunted than the child who is born a month earlier compared to his/her preceding sibling.

The interaction variable shows that the positive impact of birth interval is less on male children than the females. The males are still 0.25% more likely to be stunted than the females are over the increasing birth interval while the overall likelihood of stunting is decreasing overall over the birth interval.

The following graph (Graph 10) shows the declining rate of stunting over increasing birth interval. We can see that for male is higher and the difference is increasing over the increasing months of birth interval.

Graph 10. Probability of stunting among male and female children over their birth interval (preceding) in months.



The probability of being stunted is higher for male at any birth interval period. While the likelihood goes down for both with increasing interval, the effect on females rather goes down at higher rate. The vertical lines over the dot show values within confidence interval at each additional 10 months of birth interval.

4.2.5 Mother's Age at First Birth

Table 9. OR of Mother's Age at First Birth and its interaction with Sex extracted from the full regression output (Appendix VI)

Stunted *(1=Stunted)*	**OR**	**Std. Err.**	**P>|z|**
Mothers Age at First Birth - Dummy (new_mage)			
Base Variable: 11 to 15 years			
15 to 19 years	0.9547	0.0310	0.153
20 to 24 years	0.9366*	0.0325	0.059
25 to 29 years	0.8732***	0.0432	0.006

30 to 34 years	0.9467	0.0941	0.582
35 years and above	1.1163	0.3053	0.687
Interaction: Sex* Mothers Age at First Birth			
(sex#new_mage)			
Male*[15 to 19 years]	0.9932	0.0449	0.880
Male*[20 to 24 years]	1.0008	0.0483	0.986
Male*[25 to 29 years]	1.0306	0.0702	0.658
Male*[30 to 34 years]	0.9469	0.1296	0.690
Male*[35 and above]	0.4932*	0.1880	0.064
*** p<0.01, ** p<0.05, * p<0.1			

Mother's age at first birth was categorized into 6 age groups. The results above show that mothers who delivered first at the age of 25-29 years are least likely to have their children stunted compared to the 11-14 years age group. The age group 20-24 is also less likely to have the children stunted, although the difference is significant only at 90% confidence interval. The differences in stunting among the children from the mothers giving their first birth at the age among all the other age groups are statistically insignificant. This indicates that the children from the mothers who gave their first birth at 15-19 years or above 30 years are as worse (risky to having stunted children) as the ones at 11-14 years group.

All of the interaction variables with the sex of the child, too have statistically insignificant coefficients implying that the sex difference in stunting is however not different over the age of the mother when she was first pregnant. In other words, males from say, the mothers who had their first delivery at the age of 20-24 years are not more (or less) likely to be stunted than the females from the mothers having their first delivery at the age of 11-15 years.

4.2.6 Breastfeeding Duration

Table 10. OR of Breastfeeding Duration and its interaction with Sex extracted from the full regression output (Appendix VI)

Stunted *(1=Stunted)*	**OR**	**Std. Err.**	**P>|z|**
Duration of Breastfeeding (m5)			
m5 (continuous variable)	1.0639***	0.0011	0.000

Interaction: Sex*Duration of Breastfeeding			
(sex#c.m5)			
Male*Breastfeeding Duration	0.9966**	0.0014	0.019
*** p<0.01, ** p<0.05, * p<0.1			

The breastfeeding duration is a continuous variable measured in months. The positive coefficient on the breastfeeding duration, at a first glance, comes as a bit of surprise.

As previously mentioned, it is problematic to determine if a child was optimally fed based on the number of breastfeeding months alone. Therefore, we adjusted the variable to only include observations with children who were breastfed for six months or less. We created a sub-sample of children who were breastfed for six months or less and among those, children who were still being breastfed were removed too. The sample size however was reduced to only 6,491 observations. The breastfeeding coefficient came out insignificant from the regression with this smaller adjusted sample (see Appendix VII for the full results). Although we would expect a negative correlation in the sub-sample, this nevertheless indicates that the positive coefficient on the duration in our original regression (all data) may in fact be not a surprise after all as it indicates that the observed effect comes from children being breastfed more than 6 months, which, if not complemented with solid food, is suboptimal.

When analyzing the results from the interaction regression with sex (in the full data), it shows that males are in fact less likely to be stunted than females over the breastfeeding duration. The increment of breastfeeding duration by one month makes males 0.9966 times likely to be stunted than females. In other words, the (negative) effect of longer breastfeeding is 0.4% less for boys than it is for girls. A possible explanation to the gender difference could be that boys are being fed solid supplements better or that the male sibling in a family gets more amount of breast milk. To control for possible gender bias regarding breastfeeding practice we tested if the duration varied by sex of the child. The OLS regression result (see Table 11 below) shows that males are actually being breastfed slightly longer (significant at 95% confidence interval).

Table 11. Coefficient of sex regressed on Breastfeeding Duration

VARIABLES	(1) m5
sex	0.0584**
	(0.0262)
Constant	15.00***
	(0.0186)
Observations	411,354
R-squared	0.000

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The table shows the results of sex dummy regressed on breastfeeding duration. The results are significant at 95% confidence interval; males are, on average, breastfed 0.6 months longer than females in the overall pooled data.

4.2.7 Polygamy

Table 12. OR of Polygamous family and its interaction with Sex extracted from the full regression output (Appendix VI)

Stunted *(1=Stunted)*	**OR**	**Std. Err.**	**P>|z|**
Polygamy - Dummy			
1 (Polygamous family)	1.0867***	0.0218	0.000
Interaction: Sex*Polygamy			
(sex#polygamous)			
Male*Polygamous family	0.9945	0.0274	0.840
*** p<0.01, ** p<0.05, * p<0.1			

Polygamous is a binary variable with 1 indicating that the husband (of the mother) had more than one wife. The coefficient of polygamous family is positive and significant on stunting. A child in a polygamous family is 8.7% more likely to be stunted that a child in monogamous family. The interaction of polygamy with sex however is not significant.

4.2.8 Whether the child was wanted during pregnancy

Table 13. OR of child need and its interaction with Sex extracted from the full regression output (Appendix VI)

Stunted *(1=Stunted)*	**OR**	**Std. Err.**	**P>|z|**
Whether the Child was Wanted during Pregnancy - Dummy (m10) ***(Base Variable: Wanted)***			
Wanted but later	0.9823	0.0226	0.437
Wanted no more	0.9572	0.0326	0.199
Interaction: Sex*[Whether child wanted]			
(sex#m10)			
Male* Wanted but later	1.0363	0.0327	0.258
Male* Wanted no more	1.0538	0.0491	0.261
*** p<0.01, ** p<0.05, * p<0.1			

Having preferred to have the child later or not at all when the mothers were actually pregnant did not seem to impact on stunting however. Although the coefficients are negative (OR less than 1) for the child's likelihood of being stunting for having born when the mother did not want to give birth, the results are not statistically significant at any of the conventional confidence intervals.

4.2.9 Time

In the pooled data of all the countries the year dummies' coefficient came out to be significant.

Table 14. OR of each year dummies extracted from the full regression output (Appendix VI)

Stunted *(1=Stunted)*	**OR**	**Std. Err.**	**P>|z|**
Year Dummy			
1996	1.7506***	0.1189	0.000
2000	2.0415***	0.1536	0.000

2001	1.4498***	0.1114	0.000
2004	1.6828***	0.0953	0.000
2005	1.5872***	0.0776	0.000
2006	1.6074***	0.1403	0.000
2007	1.7603***	0.1558	0.000
2008	1.8087***	0.1294	0.000
2010	1.6108***	0.0762	0.000
2011	1.2985***	0.0666	0.000
2012	1.0109	0.0756	0.885
2013	1.5358***	0.1192	0.000
2014	1.2760***	0.0746	0.000
2015	1.0556	0.0549	0.298
2016	1.0000	(omitted)	
*** p<0.01, ** p<0.05, * p<0.1			
Constant	0.2295***	0.0217	0.000

The table above summarizes the time coefficients in our regression model. Note that the years before 1996 have been dropped out because of the missing observations in some of the other control variables as explained before. We can see that all the years before 2016 have had higher stunting prevalence compared to the year. All the coefficients are significant except for the year 2012 and 2015. In 1996, for example children were likely to be stunted 1.75 times higher than they were likely to be so in 2016. There does not seem to be a particular trend over the years continuously, however. Year 2000 had more likelihood of stunting than 1996 and it keeps fluctuating over the later years.

4.2.9.1 Time and Country-specific Regression

As not all countries were surveyed in all of the years above, it makes more sense to look at the time trends in the countries individually. It will also not aggregate the country-wise differences. We hence run the full regression on each of the countries also with an added interaction term between sex and year, so we can check the evolution of sex differences in stunting over time. Appendix VII presents the table of the OR for each of the control variables for each of the countries. We note that in the country-wise regression, for many of the countries even the sex coefficient is not significant. But this could be affected highly due to the missing observations. Some of the assets, for example, are completely unavailable in some of the countries and when we generate an index through principal component analysis in the pooled data, it drops out those observations in overall. Another alternative would be to employ wealth index created by DHS itself. However, those are available for surveys only after 2006 and would thus not fully facilitate our interest of examining time trend. In addition, many surveys have no answer available on variables such as whether the child was wanted during pregnancy. Using the regression with all the control variables at once causes loss of those observations too.

Nevertheless, as we run the same regression with all the control variables for each of the countries that have observation available for more than one year (17 countries) we still get to the significant year coefficients for many countries. Chad in 2004, Congo in 2011, Gabon in 2012, Rwanda in 2014, Sierra Leone in 2013, Zambia in 2013 and Zimbabwe in 2010 have statistically insignificant differences in the stunting rate compared to each of their base years. For rest of the years, the coefficients are significant at least at 90% significance level.
The three adjacent tables in Table 14 below summarize the ORs of each country's relevant year dummy.

Table 15. Results from separate country-wise regressions over all the control variable and interaction dummy between sex and year.

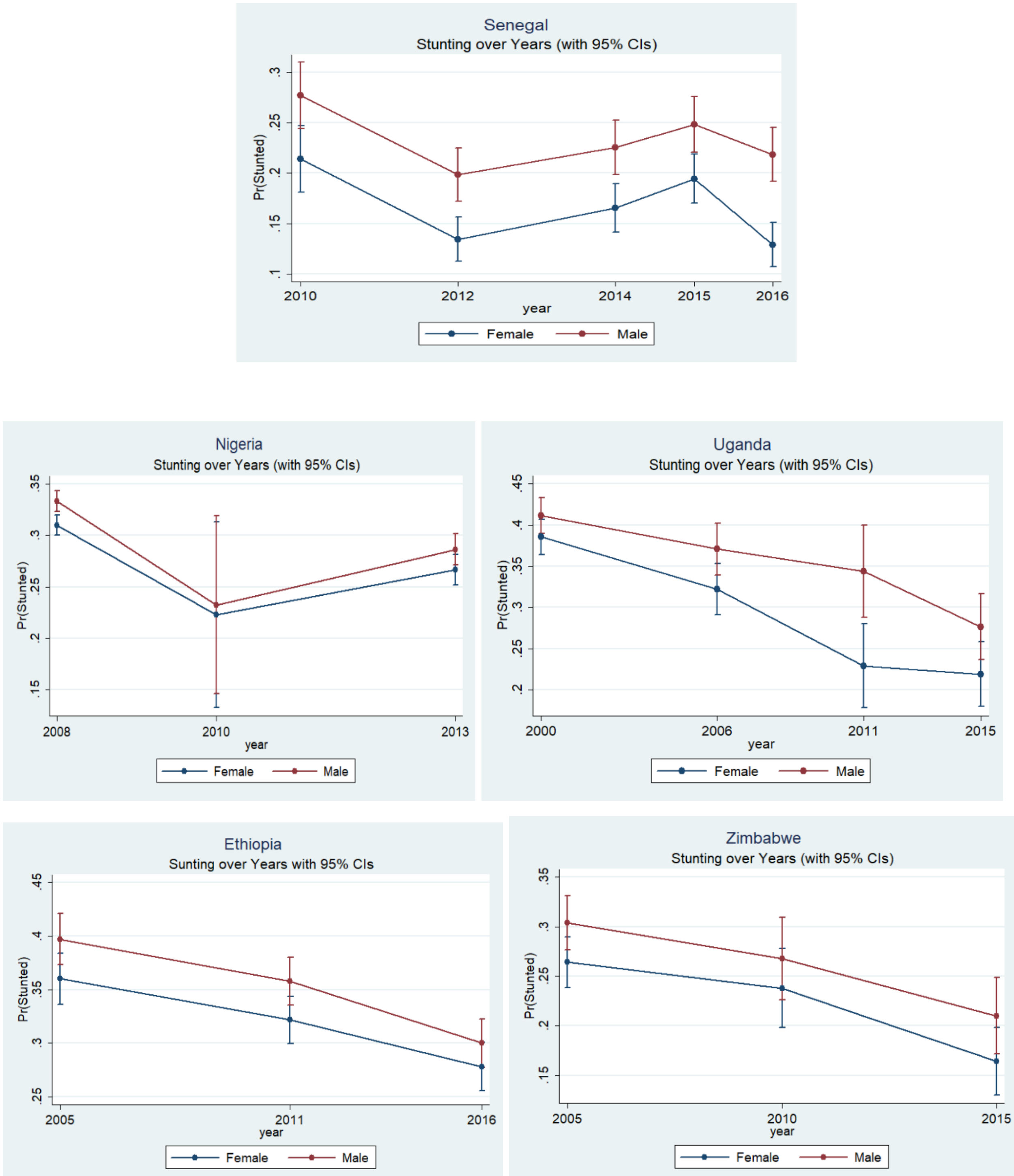
Country⇨	Benin (Base Year 2001)		Burundi (Base Year) 2010		Chad (Base Year 1996)		Congo (Base Year 2005)		Ethiopia (Base Year 2005)		Gabon (Base Year 2000)	
Year ⇩	Year	Sex*Year	Year	Sex*Year	Year	Sex*Year	Year	Sex*Year	Year	Sex*Year	Year	Sex*Year
2004					0.9111	1.0121						
					(0.0722)	(0.1119)						
2006												
2010												
2011	0.8512*	0.9456					0.9267	0.8904	0.8199**	1.0096		
	(0.0746)	(0.1144)					(0.1404)	(0.1829)	(0.0695)	(0.1181)		
2012											0.7750	1.0156
											(0.1496)	(0.2699)
2013												
2014					0.8412**	0.9372						
					(0.0684)	(0.1058)						
2015												
2016			0.5667***	1.1073					0.6457***	0.9525		
			(0.0685)	(0.1862)					(0.0583)	(0.1186)		

Country⇨	Ghana (Base Year 2008)		Kenya (Base Year 2008)		Malawi (Base Year 2010)		Nigeria (Base Year 2008)		Rwanda (Base Year 2010)		Senegal (Base Year 2010)	
Year ⇩	Year	Sex*Year	Year	Sex*Year	Year	Sex*Year	Year	Sex*Year	Year	Sex*Year	Year	Sex*Year
2004												
2006												
2010							0.6217*	0.9499				
							(0.1744)	(0.3630)				
2011												
2012											0.5405***	1.1496
											(0.0824)	(0.2303)
2013							0.8002***	0.9917				
							(0.0389)	(0.0673)				
2014	0.5863***	1.0770	0.6688***	1.2952***					0.9154	0.9738	0.7054**	1.0497
	(0.1161)	(0.2823)	(0.0472)	(0.1252)					(0.1338)	(0.1909)	(0.1045)	(0.2043)
2015					0.5439***	0.9065					0.8751	0.9717
					(0.0630)	(0.1470)					(0.1240)	(0.1828)
2016											0.5128***	1.3820
											(0.0798)	(0.2777)

Country⇨	Sierra Leone (Base Year 2008)		Tanzania (Base Year 2004)		Uganda (Base Year 2000)		Zambia (Base Year 2007)		Zimbabwe (Base Year 2005)	
Year ⇩	Year	Sex*Year	Year	Sex*Year	Year	Sex*Year	Year	Sex*Year	Year	Sex*Year
2004										
2006					0.7413***	1.1199				
					(0.0682)	(0.1432)				
2010			0.9914	0.9990					0.8651	0.9619
			(0.0625)	(0.0882)					(0.1236)	(0.1908)
2011					0.4507***	1.6244**				
					(0.0733)	(0.3542)				
2012										
2013	1.0169	0.9000					0.9333	0.8779		
	(0.1349)	(0.1675)					(0.0563)	(0.0750)		
2014										
2015			0.6509***	1.0555	0.4240***	1.2301			0.5343***	1.1185
			(0.0615)	(0.1387)	(0.0566)	(0.2212)			(0.0810)	(0.2339)
2016										

The tables above present the coefficients on relevant year variables for each country, with regressions run individually. The horizontal legend below the name of country indicates the year in which the coefficients are compared to. Children in Uganda, for example, were 0.74 times likely to be stunted in 2006 compared to 2000 (base year). Note that, for each of the country the base year is the oldest survey with information available in the relevant variables. All of the years that have significant coefficient are with the OR less than 1 indicating that the stunting rate in at least 12 countries have gone down compared to their base year respectively. For the countries with data on more than two years, there does not seem to be a particular trend however. Nigeria for example, experienced higher stunting prevalence in 2013 than in 2010 and that for Senegal keeps fluctuating over the recent years (2012 to 2016). Ethiopia, Uganda and Zimbabwe nevertheless exhibit decreasing trend in stunting prevalence over their subsequent surveys. The graph below presents the probabilities of stunting for males and females for these countries.

Graph 11. Stunting prevalence over the years in Senegal, Nigeria, Ethiopia, Uganda and Zimbabwe

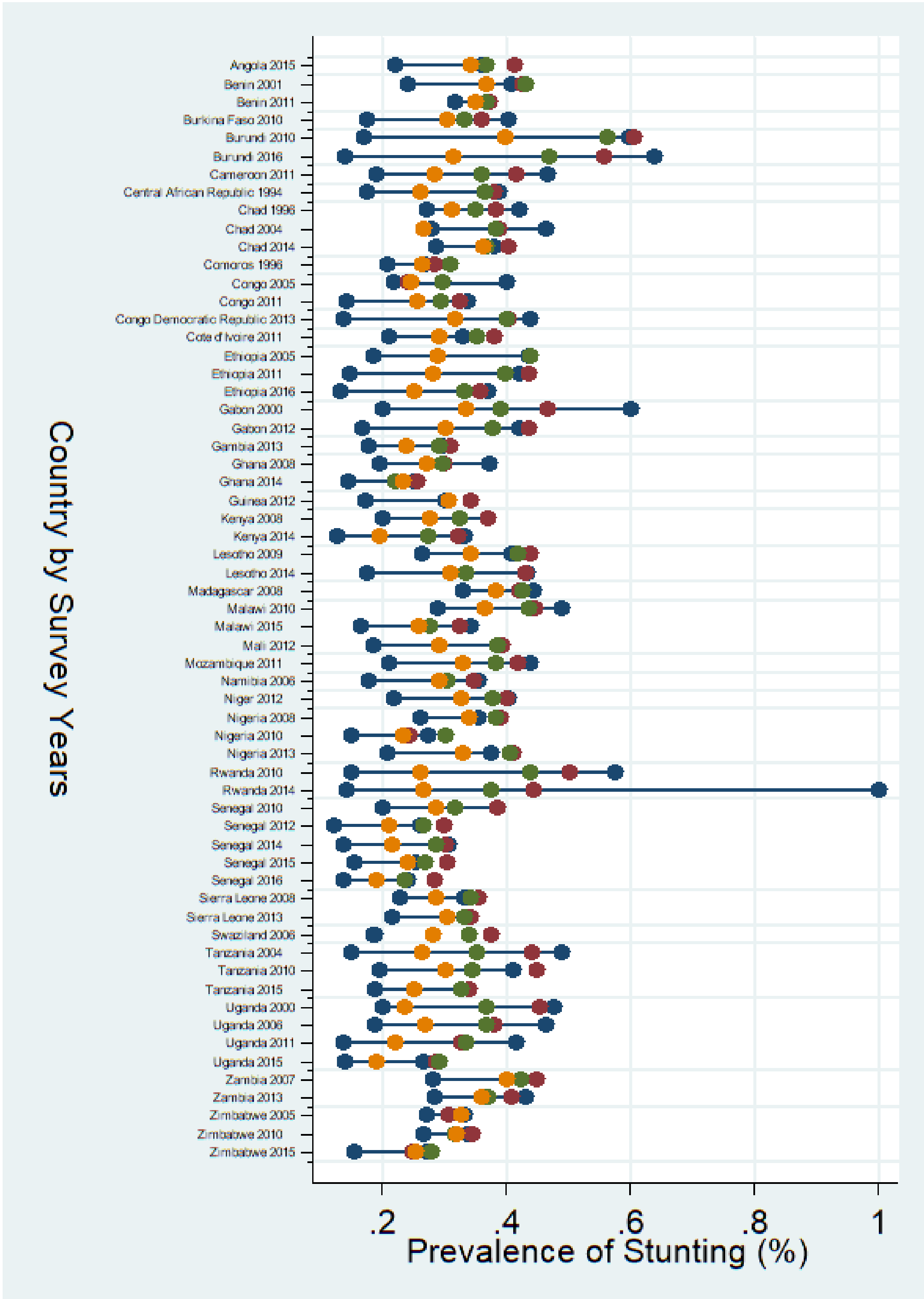


The interaction term in the regression between sex and year are mostly statistically insignificant.

Except for Kenya in 2014 and Uganda in 2011 the likelihood of male stunting has not statistically significantly changed compared to the females in the base years. In sum, while there have been some changes in stunting in general over time, the sex difference in stunting however has stayed more or less the same.

Finally, we have a figure below summarizing the stunting prevalence over the economic index - the wealth quintiles for each of the country and survey.

Graph 12. Stunting prevalence among different wealth quintile in countries over different period



5. DISCUSSION

5.1 Data Results Comparison Analysis

The data results described in previous section have both shown reaffirming and slightly unexpected evidence of determinants of nutritional status compare to previous studies, and at the same time magnified the gender difference and the variables deficiency as explanatory factor of gender gap in stunting prevalence. This section will offer a brief comparison between our data results and previous research's main findings divided into a "Determinant" and a "Gender difference" part. Were suitable, plausible explanations clarifying the data results will be presented. Table 16a and 16b below provides a summary of the findings from this meta-study for an easy overview.

Table 16a. Summary of regression results; Stunting and sex

Regression	Pooled		Country specific	
	Results	Significance level/CI	Results	Significance level/CI
T-test	Higher prevalence among boys compared to girls (35,8% versus 33,9%)	***	Higher prevalence among boys in 31/35 countries	***
Logistic regression (odds ratio)	18% higher risk for boys to become stunted	***	33/35 countries show higher risk (odds ratio > 1) for boys to become stunted (Sierra Leon show insignificant results and Sao Tomé show higher risk for girls)	CI (95%)

Table 16b. Summary of regression results; Stunting, all variables and sex interaction term

Variable	Multivariate regression (pooled results)			Multivariate regression controlling for all determinants with gender dummy (pooled results)			
	Determinant of nutrtional status	Significance level	Comment	Gender difference	Higher risk for stunting (gender)	Significance level	Comment
SES	Yes	***	Statistically significant lower risk of stunting in wealth quintile 3, 4, 5 compared to quintile 1 (poorest)	No	-	-	
Mother's education	Yes	***	Childred of mother's with longer education have lower risk to become stunted	No	-	-	
Birth order	No	-		Yes	Female	**	Significant for children of birth order 3-5 and 6-10
Preceding Birth Interval	Yes	***	Small impact (< 1%)	Yes	Male	***	Small gender difference (< 1%)
Mother's age at first birth	Yes	*** / *	Lower risk of stunting compared to age group 11-14; p<0.01 for 25-29 years of age, p<0.1 for 20-24 years of age	No	-	-	
Breastfeeding Duration	Yes	***	Due to incomplete data missing information regarding exclusive breastfeeding and solid food supplements, results should be interpret with caution	Yes	Male	**	Small gender difference (< 1%)
Polygamous household	Yes	***	Large impact variable, incraesed risk of stunting among children in polygamous households	No	-	-	
Whether the child was wanted during pregnancy	No	-	No statistically significant difference between "unwanted, "wanted later on" or "wanted"	No	-	-	

5.1.1 Determinants

5.1.1.1 Wealth index

As expected and supported by the majorities of studies indicating unanimous results (no matter data size, time of research or (developing) country/ies selected), evidence show that SES is a main determinant, and large impact variable, of children's nutritional status in our study as well. Keino et al (2014) comparative study compiling 18 studies in Sub-Sahara Africa and Vollmer et al (2017) study covering 39 low and lower-middle-income countries concur with our findings showing similar impact magnitude in the pooled data. Even though the different studies' SES/income/wealth index are not consisting of exactly the same components, the results emphasizes that lower economic status increases the risk of stunting and that stunting levels can be used as a proxy for SES in developing countries. The data results displays a larger difference between the wealthiest quintile (5) and the second wealthiest (4) compared to difference between the three poorest (3, 2, 1) quintiles for the majority of the countries examined. The relative large difference in stunting prevalence over the wealth quintiles indicates noticeable income inequality (high gini coefficient) within the countries as well as across the countries. Further, the pooled results show that the two poorest quintiles are not statistically different from each other indicating an abundance of severe widespread poverty in SSA. Moreover, it demonstrates signs of the problematic "poverty trap" behavior among poor people where increased income is not optimal allocated to increase the calorie intake to prevent stunted condition and increase economic growth as explained by Subramanian et al (1996).

5.1.1.2 Mother's education

Another expected significant determinant with strong impact is mother's education level. As seen in the data results, a child's risk of becoming stunted decreases significantly with mother's increased level of education. These findings are in line with majority of previous research from different countries using different test methods and time periods (among others Yimer, 2000; Said-Mohamed et al, 2009). The rather surprising finding from Reed et al (1996) indicating a negative relationship between mother's education level and stunting prevalence is not present in our results. A possible explanation for that scenario presented by Reed et al was that at higher level of education mothers priorities work outside the household which will affect child nursing negatively. The marginal gain of potential extra income was not enough to balance the marginal loss of insufficient childcare. The data results for our study show that the marginal utility from graduating secondary education is larger than the marginal utility from primary education indicating a larger return of investing in secondary education. The reason for this result can be a possible threshold where secondary schooling fills the minimum requirement for more and better skilled jobs outside the household resulting in higher wages. Further, secondary education might provide an increased behavior knowledge affecting the students' behavior regarding i.e. health aspects, the importance of nutritional food, optimal child care and contraceptive which are determinants of stunting. This possible scenario is what Engle (1997) defined as important factors in his study, although not specifically associating the behavior knowledge to secondary schooling.

5.1.1.3 Birth order

Birth order did not show any significant difference (on 1% level) hence it cannot be considered as a determinant for children's nutritional status in SSA. Results from previous research demonstrate mixed outcomes. Sommerfelt et al (1994) 19 country study displayed no consistent pattern of stunting prevalence except that being born as number 2-3 was never the age category with higher risk of stunting. Jeyaseelan et al (1997) and Mosfequr (2016) find evidence that higher birth order is associated with higher prevalence of stunting. Howell et al (2016) find that although pooled data in 18 African countries show increased risk with higher birth order, the country effects are rarely statistically significant. The mixed results, both from our study and previous literature highlight the two possible contradictive scenarios. Being born with a higher birth number could potentially increase the risk of becoming stunted as more children would requires more resources to provide sufficient food for the household and with more children the mother's attention might decrease moving caretaking responsibilities to older siblings resulting in inadequate nutritional intake. Yet, firstborns can be associated with inexperienced and young parents which also can influence the nutritional status. As the results show, there is no clear "winner" of these two potential explanations, but on a 95% significant level there is a bias towards less risk of stunting among higher birth orders.

5.1.1.4 Preceding Birth Interval

Although the pooled results from our study show a statistically significant lower risk of stunting when being born with larger interval of preceding birth, the impact is fairly small. The results are aligned with previous findings (Sommerfelt et al, 1994; Kismul et al, 2018) but the magnitude from our results are noticeably smaller. Previous research has occasionally used “children under five in the household” as a proxy for birth interval or “birth spacing” which shows similar results (Nkurunziza et al, 2017). According to several studies, large family size is associated with higher risk of stunting which is also correlated with shorter birth interval (Cruz et al, 2017). Hence, this relationship could partly explain our results displaying evidence for preceding birth intervals as a determinant of children’s nutritional status.

5.1.1.5 Mother's Age at First Birth

The vast majority of previous studies demonstrate that as the mother’s age increases the nutritional status for the child improves in a U-shape trend; peak of lowest risk around 25-29 years of age with older mothers slowly increasing the risk (Keino et al, 2014; Kabubo-Mariara et al, 2008). Finlay et al (2008) showed statistically significant evidence that the lowest risk of stunted children is when the mother delivers her firstborn between the age of 27-29. Our findings mainly agree with the preceding results indicating that a mother’s age of 25-29 years during first born is the period with lowest risk of stunted children, with a rather large impact of approximately 13% compared to base year of 11-14. Unexpectedly, our results indicate that this is the only age bracket that is statistically significant different from our base year. On 90% significance level mother’s age 20-24 show a lower risk but age bracket 15-19, 30-34 and 35 and above show no difference in risk compared to mother’s aged 11-14 at firth birth. The slightly surprising results from our study showing insignificant difference between the above mentioned age brackets could possibly be explained by choice of variable investigating; mother’s age at first born child as compared to mother’s age for every child delivered. Although different in definition, both variables fill a purpose to investigate as determinants of stunting prevalence. Considering that SSA has the lowest age of mother’s at firstborn it is interesting and will add value to previous research to test if it is a determinant for nutritional status.

5.1.1.6 Breastfeeding Duration

As previously described, this variable is rather complex to analyze due to use of different survey questions for data collection, altered variable definition and varied criteria for inclusion in the sample analyzed (which in our two cases are firstly the whole sample size and secondly only children below 7 months). Consequently, this leads to output that is difficult to compare with other studies using different approaches, definition or methods.

Our first regression results, with the full sample data, indicate that increased length of breastfeeding will increase the risk for the child of becoming stunted, and it is a statistically significant determinant of nutritional status. However, the DHS data used for this study do not track if the breastfeeding is exclusive or when/if it is complimented with solid food following “optimal feeding practice”. Hence the interpretations of the results should be made with caution. Our results are contradictive to a numerous of other studies which applies data that is comprehensive enough to examine if “optimal breastfeeding” lowers risk for stunted condition, which is what is commonly observed (Aguayo et al, 2014; (Ajao et al, 2010); Fikadu et al, 2014). The association between stunting and prolonged breastfeeding observed in our results does not necessarily mean that “optimal breastfeeding” is not in fact optimal. Although speculative, it is plausible that our results indicate that resources to buy solid food supplement for children are limited among poor people. The limited budget could therefore force the parents to resort in prolonged exclusive breastfeeding practice as the only option to provide food for the child. Additional explanation to our findings is the possibility that children with bad health status could act as an unobserved cofounding variables which could bias the result; bad health determines both stunting and breastfeeding. If a child is in bad health, i.e. not growing as expected, the mother might prolong breastfeeding in hopes of health improvement unknowingly that this is not the solution. These explanations could therefore reason with our results as our data is not comprehensive enough to either confirm or reject “optimal breastfeeding” practice as a determinant of stunting. An investigation of breastfeeding duration as determinant of nutritional status demands deeper insights in health and nutritional science, with data possibly controlling for other nutritional intakes of the child during their growth period, both during and after breastfeeding.

Our results indicate, albeit small and only significant on 95% level, a gender difference in stunting over the breastfeeding duration where girls are at disadvantage. Further, our findings show statistical significant results that girls are being deprioritized with a shorter length of breastfeeding compared to boys. The preference for boys is well documented in previous literature, especially in South Asia (see for example, Vinod, K., and D. (2004) and, Jayachandran and Kuziemko (2011)).

5.1.1.7 Polygamy

Our findings indicating that children born in polygamous households are more likely to be stunted compared to children of monogamous parents are not surprising after reading other studies. It is indeed a significant determinant with large effect on nutritional status although prior studies showed varied impact magnitude (Senbanjo et al, 2011; Habimana, 2013). Our results suggest that the negative effects of more mouths to feed outweighs the potential positive effect of more people contributing to the household economy which is a proposed trade-off as polygamous households commonly relies on a single male household head to be the main provider for a large family.

5.1.1.8 Whether the child was wanted during pregnancy

Our pooled findings show zero significance between increased risk of stunting and pregnancy intentions. This is contradictive to previously published research which commonly indicated a noteworthy increased risk of stunting prevalence among children who very conceived unintentionally (Abuya et al, 2012; Upadhyay et al, 2016).

5.1.2 Gender variable

Prior awareness of high stunting prevalence in Sub-Saharan Africa and gender difference (see figure 1 and graph 1) has been confirmed in this meta-study, both as an update of the current status and over time. The results show a statistically significant gender difference in both the pooled tests as well as in the vast majority of countries tested highlighting the gender inequality regarding nutritional status as boys are at noticeable at higher risk of becoming stunted than girls which will halt their economic prosperity. These findings are aligned with Wamani et al (2007), Akombi et al (2017), Howell et al (2016) etc. (see figure 16b for more comparison of previous findings) but our results show a larger occurrence of gender difference as 33/35 countries indicated a statistically significant gender difference in stunting prevalence. A possible reason explaining other studies non-standard gender difference results (insignificant difference or even higher prevalence among women) can be due to limitations in sizable data not providing a population representative sample as opposed to the vigorous DHS data used in this larger study.

When analyzing the gender variable as a factor explaining stunting prevalence (multivariate regression controlling for all variables with gender dummy) in previous studies the results are mixed, with no clear outcome indicating a mutual explanation. Further, previous research within the topic is scare, especially studies with large datasets covering several countries. Therefore, which is a part of the objective with this research, it is a need to broaden the evidence and hopefully find common explanatory variable/s to address the gender imbalance of stunting. However, the results from this study are, similar to previous research, varied with no strong explanatory factor; the main observed determinants of nutritional status are not significant in explaining the gender gap in stunting prevalence, which although itself is a finding worth noticeable awareness. Even though several variables were found to be determinant of children's nutritional status, when controlling for gender difference it was not statistically significant in most multivariate regressions. In the few cases where there was an indication of difference between the gender, the effect was either very small (Preceding birth interval and Breastfeeding duration[10]), low significance level[11] (Breastfeeding duration and Birth order) or, unexpectedly, biased towards a higher risk of stunted condition for girls (Preceding birth interval and Breastfeeding). Comparing to some of the previous published studies (displayed in table 16b) shows that our findings are aligned with Wamani et al (2007) (no significance wealth index gender difference) but the results are partly contradicting to Abuya et al (2016) (indicating mother's education gender difference) and Mutisya et al (2016) (indicating wealth index gender difference).

5.2 Policy and Intervention analysis

Fundamentally, stunting is a condition cause by chronic malnourishment which hypothetically would be possible to eradicate by supplying food to households with a limit amount of daily nutritional intake. Unfortunately the reality is not that simple as there are limitations i.e.; who should pay and distribute the food? Therefore, practicality plays a pivotal role when deciding what policies/interventions, aimed at reducing stunting prevalence, are conceivable to implement. But the limitations do not stop with constrained supply of money (for food) as previous research has shown evidence that improved income does not automatically translate to increased calorie intake thus preserving suboptimal eating habits among poor people (Subramanian et al, 1996). Further, knowledge regarding optimal calorie intake and ideal breastfeeding is inadequate in many countries resulting improper eating behavior which can cause increased risk of stunting (Fikadu et al, 2014). When compiling these limitations it is obvious that there is a need not only to create policies/interventions aimed at improving food access or increasing income for poor people, but additionally also increase nutritional knowledge and generate behavior change of spending preference.

As presented in chapter 2, stunting is an origin for halted economic development which, in addition to diminish hunger, makes it a universally important reason to process to reduce

[10] Gender gap was observed when testing for full sample which has its limitations as explained previously in the discussion chapter. Thus, the results should be interpret with caution
[11] Low meaning: ** - 95% or * - 90%

poverty and inequality. Successful policies or interventions would therefore reduce the cost of stunting, improve the economic outcomes (increased GDP growth, lower health costs, higher wages, more productive workforce, better educational performance) and progress the livelihood for the most vulnerable people and potentially bringing them out of the poverty trap loop.

Policy and intervention selection and creation is a complex procedure as there are several aspects to consider; costs of intervention, what determinant to target based on its impact on stunting and what potential adaption rate the policy/intervention have proven to results in. The combination of all three aspects gives an "efficiency score" (cost*impact*adaption rate) which needs to be analyzed, evaluated and compared with other potential policies/interventions before implementing for most efficient strategy. Further, policies and interventions that display successful results in one country/location might not be applicable in another setting (i.e. rural versus urban), hence adaption of policies might be needed. In similarity to other policies, stunting reduction policies should be drafted based on research and evidence of these three aspects. This study has provided strong evidence regarding what the main determinants are (both pooled and country specific) and their impact magnitude. Additional studies calculating costs and researching adaption rate of different interventions needs to be incorporated for a comprehensive foundation to base policy/intervention decisions on. This section will continue by analyzing potential policies or interventions that could reduce stunting prevalence in SSA, with main focus on operations addressing the exposed determinants of nutritional status from our study. Our study only indicated one significant determinant (on 1% level) explaining the gender gap, only with minimal impact. Therefore any policies or interventions refining gender equality regarding nutritional status have been excluded due to not applicable according to our results.

As observed in the results there is a connection between many of the determinants which should be incorporated when creating a policy/intervention. Thus, addressing one factor could have positive outcomes on one, or several, other determinants giving a multiplying effect. This is apparent when analyzing potential interventions presented in this section. Further, important aspects to consider when creating policies is the fact that stunting generally occurs prior to 24 months (UNICEF, 2007) and that the condition is inheritable from the mother depending on her health status (Ravishankar, 2006).

Implementing food programs to reduce malnourishment, i.e. school meal programs, have shown to have positive effect on children's health, increased school achievement and an incentive to send children to school (WFO 2016). Although these results will improve the outlook in life for the benefitted children it is too late to address stunted condition as it occurs prior to school age and the stunted children have already been affected with lower cognitive ability (McGovern et al, 2017). Therefore, the effect on stunting prevalence from food programs targeting older children is delayed. The intervention increases the chance of longer education for the present generation, but the decreased prevalence would be observable first in the next generation as being born to mothers with longer education has a reduced risk of stunting according to our findings. Although the effects of food programs have proven to be successful in many aspects, it could be more efficient to target younger children to prevent stunting levels for the present generation, which consequentially also will lower stunting levels for future generations and break the negative loop. Correct breastfeeding practice have proven to be a significant and important determinant of nutritional status, although this is not the case for our study which most likely is due to inadequate data not including comprehensive information of the entire feeding practice including solid foods and exclusivity of breastfeeding. There is a strong need to spread the optimal feeding practice knowledge and when to introduce solid food supplements to generate behavior change; either in schools and include this in the curriculum, through community based sensitization education, at hospitals/clinics or other channels to reach a larger part of the population. Food programs should also redirected focus and target younger children under 24 months as this could improve the nutritional gains. Further, the food programs should include more knowledge based learning to generate behavioral change as evidence indicate that even though there might be room in the budget for more nutritional food, the money is spent on other products.

School food programs serve a two-fold purpose as it both improves the health among children and also incentivizes parents to send children to school. Other policy/intervention, even though they might "only" improve school attendance and education length, they should be supported by governments and NGOs. Our findings show a significant decreasing risk of stunting as the mother's educational level increases, and the impact was especially large if mothers have reached secondary school or higher. SES is another main deciding variable for children's nutritional status according to our research, which is closely associated with educational level. Improving the schooling situation would therefore improve SES through the possibility of access to better jobs generating higher wages.

There are several options/interventions to prolong education length, improve quality and increase attendance; more schools with better reach to smaller communities, food program incentivizing attendance, free education removing poverty as a reason not to attend, increased teacher density to decrease teacher/student ratio to improve the quality etc. Obvious problem with these interventions is the cost which is decisive especially for a developing country with limited resources. This research, supported by many other, displays evidence of the large cost of stunting, which governments in SSA need to realize, and that future return of investing in education is most likely positive. Improved education level has a multiple effect as it is a deciding factor for economic growth and simultaneously reducing stunting prevalence which subsequently will decrees the cost of stunting reinforcing GDP growth. Further, Engle (1997) show evidence that there is not only a need for longer education, but also introducing “behavior knowledge” regarding appropriate feeding and importance of adequate nutritional intake in the curriculum. Hence, the curriculum in schools should be tweaked to include subjects improving knowledge about nutritional intake, and possibly. If successful, when the students are aware of the positive payoff (as increased calorie intake would improve future wages through higher productivity), this could improve both optimal breastfeeding frequency and increase consumption preference towards more nutritional food.

An interesting intervention concept displaying mostly positive effects in reducing poverty (increasing SES) is CCT (i.e. The World Bank, 2016b). As previously explained cash transfer based on a condition is often designed to improve health and reduce poverty which “forces” the recipient to follow stated rules. CCT reduces the risk of aid money being spent on suboptimal products/services. Conditions strategized to increase calorie intake or earmark money for education could therefor set of a positive change reaction by becoming more productive at work/perform better in school which is associated with higher wage and lower stunting prevalence which is confirmed by our results. Possible specific CCT intervention should condition money for solid food supplements as this could increase the amount of children being breastfeed optimally and address previous recourse constraints preventing children from receiving solid food supplement and thus was exclusively breastfeed for a longer time than optimal. The drawback of CCT is the possible substitution effect that could happen i.e. CCT conditioned for food would act as indirect savings for the recipient as they no longer have to use their own income for food, which increases their budget for other products that might results in suboptimal purchasing behavior resulting in a total effect that is not improving their nutritional status. Additionally, even though results are mostly positive from implementing a CCT program, the cost-benefit results needs to be evaluated thoroughly.

Several of the potential determinants tested for in our research, and additionally variables not tested for, are household characteristics regarding the mother's relationship with children and partners. Our results show that several of the variables are significant determinants of a child's nutritional status; birth interval, mother's age at (first) births, polygamous household. These factors are connected internally, and also to other determinants, which should be taken into consideration when designing polices or interventions as certain implementations could have multiple effects on several determinants resulting in efficient strategies to reduce stunting prevalence. The main connection between these variables is women's empowerment and family planning.

For example, mother's age at (first) birth is a significant determinant; 25-29 years of age is associated with lowest risk to develop stunted condition according to our study. This is supported by the majority of other studies examining both connection mother's age at first birth and mother's age at all births. A study covering 11 countries in East Africa showed that the median value for married women wanting to postpone childbearing was 72% in 2004, which displayed an increased trend from 56% in 1992 (Cleland, 2010). The same study shows that 63% of the women are in couples where both partners approve of family planning methods, but there was a large gap between approval by the woman and her perceived approval by her partner indicating an uncertainty among women about their partner's willingness to use contraceptive. Further, the study showed that there is a low knowledge among women about family planning options; only 64% of women not using contraceptive were familiar with pills and injectable and who also knew where to seek family planning services. These results show several aspects that are connected to mother's age at (first) birth which is associated with stunting prevalence. Firstly, there is a wish among women to delay childbearing, many married women were in a relationship where use of contraceptive is not approved and the knowledge about family planning was very low among women not using it. Consequently, there is a need to empower women to be able to independently choose when they want to have a child and also educate the population (especially women) about family planning methods. This could be difficult due to several reasons i.e. religious and cultural stigmatization around family planning in many countries in SSA. Therefore, there is a need for large international organizations, NGOs and other countries to lobby for these criteria to convince governments to include sexual education in schools, provide community based sensitization and supply access to contraceptives. The same reasoning for use of contraceptive is applicable to increase birth intervals, another significant determinant indicating that shorter birth spacing or more children under-five in a household will increase the risk of stunting among children. Hence policies and interventions promoting knowledge use of family planning methods and supplying contraceptives would decrease stunting prevalence, and, as Cleland (2010) and Rafalimanana et al (2001) studies showed, there is an unmet demand for contraceptives among women who preferred longer birth interval and postponed childbearing.

Our results also show that children being born in polygamous households have a significant higher risk of becoming stunted, and the effect is large, compared to being born in monogamous households. Around 10% of women in Africa lived in polygamous households in 2011 and the unions are legal in majority of African countries and where it is illegal the practice is not fully criminalized (UN, 2012). Though not simple to execute, making polygamy illegal and provide knowledge of the negative impact could reduce stunting prevalence. Again, there is a need to lobby to governments that stunting is a large cost (decreased economic growth) which is partly triggered by polygamy. Although child marriage has not been tested as a possible determinant of nutritional status in this research, it is strongly linked to both polygamy and adolescent pregnancy (young age of mothers at first birth) which are associated with higher risk of stunting according to our results. Looking at the countries with the highest rates of child marriage in the world, Sub-Saharan Africa countries represent 18 of 20 spots with rates as high as 76% in Niger (Girls not Brides, 2017). 90% of adolescent births in the developing world are to girls who already are married and child brides are more likely to be 2nd or 3rd or 4th wife with little decision-making power regarding pregnancy intentions and use of contraceptive (WHO, 2011). When combining the statistics it is obvious that the problem is immense, thus an enforcing law forbidding child marriage could therefore not only prevent immoral and injustice misconducts ruining young girls lives, it could also decrease stunting prevalence hence improving economic development. Yet again, this is an argument that needs to be imposed to persuade governments to act. Additionally, the connection between women's empowerment and independence and lower stunting prevalence is linked through a few factors that mentioned policies could improve. Providing education and prolong the attendance in school for girls is the main intervention promoted to reduce child marriage as it is associated with better job options later in life which empowers women. Previous research has also shown that mother's education level is more important than father's to decrease the risk of stunted children reinforcing the positive effect on stunting prevalence (Kabubo-Mariara et al, 2008).

Summary of suggested policies and interventions

- Create policies/interventions targeting children under 24 months. Addressing older children would "delay" the decrease of stunting prevalence to the next generation
- Provide nutritional knowledge on the importance of high calorie intake and optimal breastfeeding practice and solid food supplements; included in school curriculum, information services at hospitals, community based sensitization programs and other channels
- CCT programs with conditioned money for food supplements to increase optimal breastfeeding practice prevalence among poor people that might not have resources for solid food hence prolonging exclusive breastfeeding
- Governments should support and provide interventions and policies that will improve school attendance, quality and education length; food programs, free admission, higher teacher/student ratio, more accessible schools etc.
- Governments should promote and supply access to family planning services and contraceptives, include sexual education in school curriculum and community based sensitization programs
- Forbid polygamy and child marriage and enforce the law and provide education with the negative effects in schools and communities

Large NGOs and other governments should lobby for these policies/interventions by emphasizing on the large economic benefit of reducing stunting prevalence (increased GDP growth, lower health costs, higher wages, improved human capital and higher productivity) to convince SSA governments about to act in the right direction

5.3 Limitations

Missing information on the ownership of assets for the countries of Liberia and Sao Tome & Principe was the obvious limitation in terms of data availability, so the full regression could not be conducted for those countries. Also missing information in one or more of the control variables in some of the countries limited our observations to smaller number for full regression in the pooled data. While the prevalence of sex differences in stunting could be examined in 35 countries and 124 surveys, they could be investigated over all the control variables of socio-economic status only from 61 surveys in 33 countries. Also, due to this, the year dummies in the pooled data regression output may not facilitate the interpretation of trend as we would want them to. Similarly, as explained with the results in Data Analysis section, the breastfeeding duration on itself is not an ideal measure of optimal breastfeeding. Lack of coherent information on if the child was solely breastfed or together with other food over the breastfeeding period is a limitation for us to understand the positive correlation that we have witnessed.

6. CONCLUSION

A few smaller scale studies researching stunting through a gender perspective have indicated a potential gender gap in stunting prevalence in SSA where boys seem to be affected at a higher rate. Our study, using large scale data over 35 countries in SSA, can confirm the gender gap and hereby set an updated benchmark for the entire region. Although several significant determinants of nutritional status was found, our study did not find that these presumed moderating factors are playing a substantial role in explaining the gender gap. It is therefore proposed that future research should focus on investing new potential explanations for the gender gap.

A possible explanation worth examining is:
If:
a) boys are more vulnerable compared to girls during infant stage (an accepted medical fact) and
b) there is a preference to favor boys over girls regarding nutritional practice, health aspects and childcare etc.
then one would observe that the girls who survived against tougher odds, and are surveyed and measured for the data, are stronger than the average boys that has been “spoiled”. Thus, testing this theory by i.e. the use of cohort data to track children from birth could in principle explain the observed gender gap.

Further, our study has revealed that stunting prevalence in 2016 was at all-time low in SSA but the levels are far from SDG aspirations. The high stunting prevalence comes at a substantial cost due to the condition's economic outcomes resulting in negative impact on GDP growth, which is vital aspect to emphasize when deciding where and how to allocate time and resources to stimulate economic development. Important determinants of nutritional status have been exposed in this study (wealth, mother's education, mother's age at first birth and polygamous households) with several appropriate policies and interventions which potentially could loosen up the poverty trap that stunted condition creates. Future actions by Governments and NGOs should be focusing on implementing and evaluating proposed polices and interventions, especially programs targeting malnutrition of children below 2 years of age.

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8. APPENDIX

Appendix I

Frequency table of Birth Order in pooled data of all countries, in the order numbers and authors' recategorization

Birth order - **Number**	Freq.	Percent	Cum. Percent
1	70,013	16.93	16.93
2	73,506	17.78	34.71
3	64,922	15.7	50.41
4	54,773	13.25	63.66
5	44,407	10.74	74.4
6	35,040	8.47	82.88
7	26,345	6.37	89.25
8	18,807	4.55	93.8
9	12,112	2.93	96.73
10	7,144	1.73	98.45
11	3,718	0.9	99.35
12	1,770	0.43	99.78
13	593	0.14	99.92
14	209	0.05	99.97
15	66	0.02	99.99
16	30	0.01	100
17	7	0	100
18	2	0	100
19	1	0	100
Total	413,465	100	

Birth order – **Categories (Authors')**	Freq.	Percent	Cum. Percent
First or Second Child	143,519	34.71	34.71
Third to Fifth Child	164,102	39.69	74.4
Fifth to Tenth Child	99,448	24.05	98.45
Tenth or Higher Child	6,396	1.55	100
Total	413,465	100	

Appendix II

Total observations for each country.

Country	Freq.	Percent	Cum.
Angola	1,690	0.41	0.41
Benin	22,200	5.37	5.78
Burkina Faso	20,101	4.86	10.64
Burundi	5,656	1.37	12.01
Cameroon	10,750	2.6	14.61
Central African Republic	2,016	0.49	15.1
Chad	13,259	3.21	18.3
Comoros	1,764	0.43	18.73
Congo	3,805	0.92	19.65
Congo Democratic Republic	5,734	1.39	21.04
Cote d'Ivoire	5,118	1.24	22.27
Ethiopia	18,803	4.55	26.82
Gabon	2,841	0.69	27.51
Gambia	1,307	0.32	27.82
Ghana	12,039	2.91	30.74
Guinea	8,035	1.94	32.68
Kenya	22,232	5.38	38.06
Lesotho	337	0.08	38.14
Liberia	4,117	1	39.13
Madagascar	13,515	3.27	42.4
Malawi	24,871	6.02	48.42
Mali	27,584	6.67	55.09
Mozambique	12,280	2.97	58.06
Namibia	4,397	1.06	59.12
Niger	13,792	3.34	62.46
Nigeria	39,709	9.6	72.06
Rwanda	15,482	3.74	75.81
Sao Tome and Principe	1,322	0.32	76.13
Senegal	17,344	4.19	80.32
Sierra Leone	3,243	0.78	81.11
Swaziland	898	0.22	81.32
Tanzania	24,520	5.93	87.25
Uganda	15,544	3.76	91.01
Zambia	27,030	6.54	97.55
Zimbabwe	10,130	2.45	100
Total	413,465	100	

Appendix III

Total observations over time

Year	Freq.	Percent	Cum.
1986	597	0.14	0.14
1987	3,278	0.79	0.94
1988	4,954	1.2	2.14
1990	5,866	1.42	3.55
1991	8,064	1.95	5.5
1992	24,633	5.96	11.46
1993	10,530	2.55	14.01
1994	6,642	1.61	15.62
1995	13,468	3.26	18.87
1996	13,422	3.25	22.12
1997	5,463	1.32	23.44
1998	16,490	3.99	27.43
1999	6,537	1.58	29.01
2000	29,681	7.18	36.19
2001	17,886	4.33	40.51
2003	29,588	7.16	47.67
2004	20,376	4.93	52.6
2005	17,593	4.26	56.85
2006	30,544	7.39	64.24
2007	10,248	2.48	66.72
2008	34,058	8.24	74.96
2010	18,700	4.52	79.48
2011	17,014	4.11	83.59
2012	8,338	2.02	85.61
2013	24,680	5.97	91.58
2014	15,578	3.77	95.35
2015	10,982	2.66	98
2016	8,255	2	100
Total	413,465	100	

Appendix IV

Stunting and sex difference in stunting (with t-value) among 35 Sub-Saharan African Countries.

S.N.	Country	Total		Female		Male		t-value
		Obs.	Stunted Percentage	Obs.	Stunted Percentage	Obs.	Stunted Percentage	
1	Angola	6563	0.3246991	3268	0.3108935	3295	0.338392	-2.3793**
2	Benin	32074	0.3616013	15826	0.3467079	16248	0.376108	-5.4813***
3	Burkina Faso	24905	0.3662317	12147	0.3498806	12758	0.3818	-5.2289***
4	Burundi	11495	0.4994345	5659	0.4654533	5836	0.532385	-7.1907***
5	Cameroon	13105	0.3149943	6594	0.2926903	6511	0.337583	-5.5377***
6	Central African	2453	0.370159	1215	0.3465021	1238	0.393376	-2.4058**
7	Chad	20943	0.3855226	10451	0.3755621	10492	0.395444	-2.9562***
8	Comoros	3717	0.2792575	1842	0.2562432	1875	0.301867	3.1031***
9	Congo	8594	0.2659995	4197	0.2451751	4397	0.285877	-4.2725***
10	Congo Democratic Republic	12070	0.3941176	6070	0.3713344	6000	0.417167	-5.1573***
11	Cote d'Ivoire	8420	0.2852732	4235	0.2654073	4185	0.305376	-4.0646***
12	Ethiopia	32251	0.4027162	15862	0.3911234	16389	0.413936	-4.1771***
13	Gabon	7063	0.2598046	3534	0.2391058	3529	0.280533	-3.9735***
14	Gambia	3374	0.2362181	1635	0.2165138	1739	0.254744	-2.6147***
15	Ghana	15294	0.2927292	7565	0.271117	7729	0.313883	-5.8174***
16	Guinea	10658	0.3203228	5119	0.2990819	5539	0.339953	-4.5219***
17	Kenya	37389	0.3015325	18529	0.2705489	18860	0.331972	12.9683***
18	Lesotho	4496	0.3738879	2284	0.3423818	2212	0.40642	-4.4455***
19	Liberia	7857	0.3268423	3795	0.3106719	4062	0.34195	-2.9549***
20	Madagascar	17623	0.4765363	8795	0.4530984	8828	0.499887	-6.2246***
21	Malawi	31969	0.4424912	16056	0.42358	15913	0.461572	-6.8431***

22	Mali	32861	0.3503241	16258	0.3335589	16603	0.366741	-6.3075***
23	Mozambique	21615	0.4010641	10830	0.3834718	10785	0.41873	-5.2914***
24	Namibia	9698	0.2923283	4798	0.2734473	4900	0.310816	-4.0483***
25	Niger	17951	0.4084452	8632	0.387164	9319	0.428158	-5.5873***
26	Nigeria	62956	0.3296906	31168	0.3173126	31788	0.341827	-6.5439***
27	Rwanda	22331	0.4435986	11145	0.4220727	11186	0.465046	-6.4687***
28	Sao Tome and Principe	1712	0.265771	858	0.2750583	854	0.25644	0.8716
29	Senegal	36686	0.2297607	18108	0.2080848	18578	0.250888	-9.7558***
30	Sierra Leone	7035	0.3179815	3562	0.3088153	3473	0.327383	-1.6720*
31	Swaziland	2110	0.2616114	1057	0.2346263	1053	0.288699	-2.8297***
32	Tanzania	38288	0.399603	19114	0.3766349	19174	0.422499	-9.1708***
33	Uganda	22786	0.3643465	11478	0.3372539	11308	0.391847	-8.5751***
34	Zambia	33624	0.429931	16887	0.4118553	16737	0.448169	6.7294***
35	Zimbabwe	21111	0.2838331	10561	0.261623	10550	0.306066	-7.1697***

*** p<0.01, ** p<0.05, * p<0.1

Appendix V

Appendix V

Country-wise output of logistic regression (raw coeffecient and OR) regression stunted (1= if stunted) on sex (1 = male).

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Angola		Benin		Burkina Faso		Burundi		Cameroon		Central African	
VARIABLES	Logit coeff	Oddratio	Logit coeff	Oddratio	Logit coeff	Oddratio	Logit coeff	Oddratio	Logit coeff	Oddratio	Logit coeff	Oddratio
stunted		.		.		.		.		.		.
		(.)		(.)		(.)		(.)		(.)		(.)
sex	0.1255**	1.1337**	0.1274***	1.1359***	0.1376***	1.1476***	0.2681***	1.3075***	0.2083***	1.2315***	0.2013**	1.2230**
	(0.0528)	(0.0598)	(0.0233)	(0.0264)	(0.0263)	(0.0302)	(0.0374)	(0.0489)	(0.0377)	(0.0464)	(0.0838)	(0.1025)
Constant	-0.7959***	0.4512***	-0.6335***	0.5307***	-0.6196***	0.5382***	-0.1384***	0.8707***	-0.8824***	0.4138***	-0.6345***	0.5302***
	(0.0378)	(0.0171)	(0.0167)	(0.0089)	(0.0190)	(0.0102)	(0.0267)	(0.0232)	(0.0271)	(0.0112)	(0.0603)	(0.0320)
Obs.	6,563	6,563	32,074	32,074	24,905	24,905	11,495	11,495	13,105	13,105	2,453	2,453
Standard errors in parentheses												
*** p<0.01, ** p<0.05, * p<0.1												

	Chad		Comoros		Congo		Congo Democratic		Cote d'Ivoire		Ethiopia	
VARIABLES	Logit coeff	Oddratio	Logit coeff	Oddratio	Logit coeff	Oddratio	Logit coeff	Oddratio	Logit coeff	Oddratio	Logit coeff	Oddratio
stunted		.		.		.		.		.		.
		(.)		(.)		(.)		(.)		(.)		(.)
sex	0.0839***	1.0876***	0.2272***	1.2550***	0.2090***	1.2325***	0.1921***	1.2118***	0.1962***	1.2168***	0.0949***	1.0995***
	(0.0284)	(0.0309)	(0.0733)	(0.0920)	(0.0490)	(0.0604)	(0.0373)	(0.0452)	(0.0483)	(0.0588)	(0.0227)	(0.0250)

Constant	-0.5084***	0.6014***	-1.0656***	0.3445***	-1.1245***	0.3248***	-0.5265***	0.5907***	-1.0181***	0.3613***	-0.4426***	0.6424***
	(0.0202)	(0.0121)	(0.0534)	(0.0184)	(0.0359)	(0.0117)	(0.0266)	(0.0157)	(0.0348)	(0.0126)	(0.0163)	(0.0105)
Obs.	20,943	20,943	3,717	3,717	8,594	8,594	12,070	12,070	8,420	8,420	32,251	32,251
Standard errors in parentheses												
*** p<0.01, ** p<0.05, * p<0.1												

	Gabon		Gambia		Ghana		Guinea		Kenya		Lesotho	
VARIABLES	Logit coeff	Oddratio	Logit coeff	Oddratio	Logit coeff	Oddratio	Logit coeff	Oddratio	Logit coeff	Oddratio	Logit coeff	Oddratio
stunted		.		.		.		.		.		.
		(.)		(.)		(.)		(.)		(.)		(.)
sex	0.2158***	1.2408***	0.2126***	1.2369***	0.2069***	1.2299***	0.1882***	1.2070***	0.2926***	1.3399***	0.2739***	1.3151***
	(0.0544)	(0.0675)	(0.0815)	(0.1008)	(0.0356)	(0.0438)	(0.0417)	(0.0503)	(0.0226)	(0.0303)	(0.0618)	(0.0813)
Constant	-1.1576***	0.3142***	-1.2861***	0.2763***	-0.9890***	0.3720***	-0.8517***	0.4267***	-0.9918***	0.3709***	-0.6527***	0.5206***
	(0.0394)	(0.0124)	(0.0600)	(0.0166)	(0.0259)	(0.0096)	(0.0305)	(0.0130)	(0.0165)	(0.0061)	(0.0441)	(0.0230)
Obs.	7,063	7,063	3,374	3,374	15,294	15,294	10,658	10,658	37,389	37,389	4,496	4,496
Standard errors in parentheses												
*** p<0.01, ** p<0.05, * p<0.1												

	Liberia		Madagascar		Malawi		Mali		Mozambique		Namibia	
VARIABLES	Logit coeff	Oddratio	Logit coeff	Oddratio	Logit coeff	Oddratio	Logit coeff	Oddratio	Logit coeff	Oddratio	Logit coeff	Oddratio
stunted		.		.		.		.		.		.
		(.)		(.)		(.)		(.)		(.)		(.)
sex	0.1424***	1.1530***	0.1877***	1.2065***	0.1541***	1.1666***	0.1459***	1.1571***	0.1468***	1.1582***	0.1809***	1.1983***

	(0.0482)	(0.0556)	(0.0302)	(0.0364)	(0.0225)	(0.0263)	(0.0232)	(0.0268)	(0.0278)	(0.0322)	(0.0447)	(0.0536)
Constant	-0.7970***	0.4507***	-0.1882***	0.8285***	-0.3081***	0.7348***	-0.6921***	0.5005***	-0.4748***	0.6220***	-0.9772***	0.3764***
	(0.0351)	(0.0158)	(0.0214)	(0.0177)	(0.0160)	(0.0117)	(0.0166)	(0.0083)	(0.0198)	(0.0123)	(0.0324)	(0.0122)
Obs.	7,857	7,857	17,623	17,623	31,969	31,969	32,861	32,861	21,615	21,615	9,698	9,698
Standard errors in parentheses												
*** p<0.01, ** p<0.05, * p<0.1												

	(49)	(50)	(51)	(52)	(53)	(54)	(55)	(56)	(57)	(58)	(59)	(60)
	Niger		Nigeria		Rwanda		Sao Tome and Principe		Senegal		Sierra Leone	
VARIABLES	Logit coeff	Oddratio	Logit coeff	Oddratio	Logit coeff	Oddratio	Logit coeff	Oddratio	Logit coeff	Oddratio	Logit coeff	Oddratio
stunted		.		.		.		.		.		.
		(.)		(.)		(.)		(.)		(.)		(.)
sex	0.1699***	1.1852***	0.1110***	1.1174***	0.1742***	1.1903***	-0.0954	0.9090	0.2426***	1.2746***	0.0856*	1.0894*
	(0.0304)	(0.0361)	(0.0170)	(0.0190)	(0.0270)	(0.0321)	(0.1095)	(0.0995)	(0.0249)	(0.0318)	(0.0512)	(0.0558)
Constant	-0.4592***	0.6318***	-0.7661***	0.4648***	-0.3143***	0.7303***	-0.9691***	0.3794***	-1.3365***	0.2628***	-0.8057***	0.4468***
	(0.0221)	(0.0140)	(0.0122)	(0.0057)	(0.0192)	(0.0140)	(0.0765)	(0.0290)	(0.0183)	(0.0048)	(0.0363)	(0.0162)
Obs.	17,951	17,951	62,956	62,956	22,331	22,331	1,712	1,712	36,686	36,686	7,035	7,035
Standard errors in parentheses												
*** p<0.01, ** p<0.05, * p<0.1												

	(61)	(62)	(63)	(64)	(65)	(66)	(67)	(68)	(69)	(70)
	Swaziland		Tanzania		Uganda		Zambia		Zimbabwe	
VARIABLES	Logit coeff	Oddratio	Logit coeff	Oddratio	Logit coeff	Oddratio	Logit coeff	Oddratio	Logit coeff	Oddratio

stunted		.		.		.		.		.
		(.)		(.)		(.)		(.)		(.)
sex	0.2807***	1.3240***	0.1913***	1.2109***	0.2360***	1.2662***	0.1482***	1.1598***	0.2190***	1.2448***
	(0.0995)	(0.1317)	(0.0209)	(0.0253)	(0.0276)	(0.0349)	(0.0220)	(0.0256)	(0.0306)	(0.0381)
Constant	-1.1824***	0.3066***	-0.5039***	0.6042***	-0.6756***	0.5089***	-0.3563***	0.7003***	-1.0376***	0.3543***
	(0.0726)	(0.0223)	(0.0149)	(0.0090)	(0.0197)	(0.0100)	(0.0156)	(0.0109)	(0.0221)	(0.0078)
Obs.	2,110	2,110	38,288	38,288	22,786	22,786	33,624	33,624	21,111	21,111

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Appendix VI

Output (OR) from the full logistic regression with stunted regressed on all the control variables and their interaction with sex along with controlling for the year and time dummies.

Stunted *(1=Stunted)*	**OR**	**Std. Err.**	**P>|z|**
Sex			
1 *(Male)*	1.2133***	0.0771	0.002
Wealth Quintile - Dummy (wealth_q) ***Base Variable: 1st Quintile***			
2nd Quintile	0.9904	0.0241	0.693
3rd Quintile	0.8605***	0.0222	0.000
4th Quintile	0.7429***	0.0208	0.000
5th Quintile	0.5845***	0.0192	0.000
Interaction: Sex*Wealth Quintile (sex#wealth_q)			
*Male*2nd Quintile*	0.9951	0.0332	0.883
*Male*3rd Quintile*	1.0542	0.0369	0.131
*Male*4th Quintile*	1.0075	0.0376	0.841
*Male*5th Quintile*	0.9866	0.0428	0.756
Stunted *(1=Stunted)*	**OR**	**Std. Err.**	**P>|z|**
Mothers education - Dummy (new_edu) ***Base Variable: No Education***			
Primary Education	0.9065***	0.0183	0.000
Higher Education	0.7367***	0.0222	0.000
Interaction: Sex*Mothers Education (sex#new_edu)			
Male*Primary Education	1.0365	0.0272	0.173
Male*Higher Education	0.9897	0.0390	0.793
Stunted *(1=Stunted)*	**OR**	**Std. Err.**	**P>|z|**
Birth Order - Dummy (new_bird) ***Base Variable: First & Second Child***			
Third to Fifth Child	1.0145	0.0226	0.519
Fifth to Tenth Child	1.0019	0.0255	0.941
Tenth or higher order Child	0.9930	0.0668	0.917

Interaction: Sex*Birth Order			
(sex#new_bird)			
Male*[Third to Fifth Child]	0.9293**	0.0286	0.017
Male*[Fifth to Tenth Child]	0.9225**	0.0324	0.021
Male*[Tenth or higher order Child]	0.9829	0.0934	0.856

Stunted *(1=Stunted)*	**OR**	**Std. Err.**	**P>|z|**
Preceding Birth Interval (b11)			
Birth Interval (continous variable)	0.9933***	0.0005	0.000
Interaction: Sex*Preceding Birth Interval			
(sex#c.b11)			
Male*Birth Interval	1.0025***	0.0006	0.000

Stunted *(1=Stunted)*	**OR**	**Std. Err.**	**P>|z|**
Mothers Age at First Birth - Dummy (new_mage) ***Base Variable: 11 to 15 years***			
15 to 19 years	0.9547	0.0310	0.153
20 to 24 years	0.9366*	0.0325	0.059
25 to 29 years	0.8732***	0.0432	0.006
30 to 34 years	0.9467	0.0941	0.582
35 years and above	1.1163	0.3053	0.687
Interaction: Sex* Mothers Age at First Birth			
(sex#new_mage)			
Male*[15 to 19 years]	0.9932	0.0449	0.880
Male*[20 to 24 years]	1.0008	0.0483	0.986
Male*[25 to 29 years]	1.0306	0.0702	0.658
Male*[30 to 34 years]	0.9469	0.1296	0.690
Male*[35 and above]	0.4932*	0.1880	0.064

Stunted *(1=Stunted)*	**OR**	**Std. Err.**	**P>|z|**
Duration of Breastfeeding (m5)			
m5 (continuous variable)	1.0639***	0.0011	0.000
Interaction: Sex*Duration of Breastfeeding			
(sex#c.m5)			
Male*Breastfeeding Duration	0.9966**	0.0014	0.019

Stunted *(1=Stunted)*	**OR**	**Std. Err.**	**P>|z|**
Polygamy - Dummy			
1 (Polygamous family)	1.0867***	0.0218	0.000
Interaction: Sex*Polygamy			
(sex#polygamous)			
Male*Polygamous family	0.9945	0.0274	0.840

Stunted *(1=Stunted)*	**OR**	**Std. Err.**	**P>|z|**
Whether the Child was Wanted during Pregnancy - Dummy (m10) ***(Base Variable: Wanted)***			
Wanted but later	0.9823	0.0226	0.437
Wanted no more	0.9572	0.0326	0.199
Interaction: Sex*[Whether child wanted]			
(sex#m10)			
Male* Wanted but later	1.0363	0.0327	0.258
Male* Wanted no more	1.0538	0.0491	0.261
Country Dummy			
Benin	0.9097	0.0897	0.337
Burkina Faso	0.6139***	0.0544	0.000
Burundi	1.5627***	0.1337	0.000
Cameroon	1.1209	0.1082	0.237
Central African Republic	1.4660***	0.1440	0.000
Chad	0.7942***	0.0652	0.005
Comoros	0.5936***	0.0776	0.000
Congo	0.7708***	0.0728	0.006
Congo Democratic Republic	0.7228***	0.0777	0.003
Cote d'Ivoire	0.6944***	0.0872	0.004
Ethiopia	0.8256**	0.0699	0.024
Gabon	0.8807	0.0895	0.212
Gambia	0.5582***	0.0701	0.000
Ghana	0.4985***	0.0507	0.000
Guinea	0.7036***	0.0866	0.004
Kenya	0.6858***	0.0595	0.000
Lesotho	1.1883	0.2142	0.339
Madagascar	0.9230	0.0913	0.418

Malawi	0.9145	0.0712	0.251
Mali	0.9804	0.1116	0.862
Mozambique	1.1303	0.1122	0.217
Namibia	0.8304	0.1028	0.133
Niger	1.1099	0.1241	0.351
Nigeria	0.7928**	0.0738	0.013
Rwanda	0.8841	0.0776	0.160
Senegal	0.7071***	0.0544	0.000
Sierra Leone	0.7206***	0.0739	0.001
Swaziland	0.6653***	0.0906	0.003
Tanzania	0.8449**	0.0634	0.025
Uganda	0.7979**	0.0707	0.011
Zambia	0.9566	0.0956	0.657
Zimbabwe	0.8482**	0.0709	0.049

Stunted *(1=Stunted)* **Year Dummy**	**OR**	**Std. Err.**	**P>|z|**
1996	1.7506***	0.1189	0.000
2000	2.0415***	0.1536	0.000
2001	1.4498***	0.1114	0.000
2004	1.6828***	0.0953	0.000
2005	1.5872***	0.0776	0.000
2006	1.6074***	0.1403	0.000
2007	1.7603***	0.1558	0.000
2008	1.8087***	0.1294	0.000
2010	1.6108***	0.0762	0.000
2011	1.2985***	0.0666	0.000
2012	1.0109	0.0756	0.885
2013	1.5358***	0.1192	0.000
2014	1.2760***	0.0746	0.000
2015	1.0556	0.0549	0.298
2016	1.0000	(omitted)	
Constant	0.2295***	0.0217	0.000

*** p<0.01, ** p<0.05, * p<0.1

Appendix VII

Output (OR) from the full logistic regression in the sub-sample of children who are breastfed 6 months or less (excluding the children still being breastfed).

VARIABLES	Stunted OR
stunted	.
	(.)
1.sex	0.7398
	(0.4829)
2.wealth_quintiles	1.1552
	(0.2925)
3.wealth_quintiles	1.2463
	(0.3400)
4.wealth_quintiles	0.6296
	(0.1800)
5.wealth_quintiles	0.4169***
	(0.1220)
0b.sex#1b.wealth_quintiles	1.0000
	(0.0000)
0b.sex#2o.wealth_quintiles	1.0000
	(0.0000)
0b.sex#3o.wealth_quintiles	1.0000
	(0.0000)
0b.sex#4o.wealth_quintiles	1.0000
	(0.0000)
0b.sex#5o.wealth_quintiles	1.0000
	(0.0000)

1o.sex#1b.wealth_quintiles	1.0000
	(0.0000)
1.sex#2.wealth_quintiles	1.4278
	(0.5185)
1.sex#3.wealth_quintiles	1.5954
	(0.6098)
1.sex#4.wealth_quintiles	2.5031**
	(0.9670)
1.sex#5.wealth_quintiles	1.9269
	(0.7746)
1.new_edu	1.2221
	(0.2430)
2.new_edu	1.0328
	(0.2638)
0b.sex#0b.new_edu	1.0000
	(0.0000)
0b.sex#1o.new_edu	1.0000
	(0.0000)
0b.sex#2o.new_edu	1.0000
	(0.0000)
1o.sex#0b.new_edu	1.0000
	(0.0000)
1.sex#1.new_edu	0.6101*
	(0.1641)
1.sex#2.new_edu	0.4400**
	(0.1517)
3.new_bird	1.1480
	(0.2146)
4.new_bird	1.0579
	(0.2448)
5.new_bird	0.6985

	(0.5132)
0b.sex#2b.new_bird	1.0000
	(0.0000)
0b.sex#3o.new_bird	1.0000
	(0.0000)
0b.sex#4o.new_bird	1.0000
	(0.0000)
0b.sex#5o.new_bird	1.0000
	(0.0000)
1o.sex#2b.new_bird	1.0000
	(0.0000)
1.sex#3.new_bird	1.1188
	(0.2999)
1.sex#4.new_bird	1.0505
	(0.3492)
1.sex#5.new_bird	0.2954
	(0.3888)
b11	0.9974
	(0.0030)
0b.sex#co.b11	1.0000
	(0.0000)
1.sex#c.b11	0.9942
	(0.0045)
2.new_mage	0.8342
	(0.2609)
3.new_mage	0.8217
	(0.2735)
4.new_mage	0.8772
	(0.3875)
5.new_mage	0.5284
	(0.4452)

6.new_mage	0.9737
	(1.2938)
0b.sex#1b.new_mage	1.0000
	(0.0000)
0b.sex#2o.new_mage	1.0000
	(0.0000)
0b.sex#3o.new_mage	1.0000
	(0.0000)
0b.sex#4o.new_mage	1.0000
	(0.0000)
0b.sex#5o.new_mage	1.0000
	(0.0000)
0b.sex#6o.new_mage	1.0000
	(0.0000)
1o.sex#1b.new_mage	1.0000
	(0.0000)
1.sex#2.new_mage	1.8280
	(0.8449)
1.sex#3.new_mage	2.0757
	(1.0111)
1.sex#4.new_mage	1.6342
	(1.0311)
1.sex#5.new_mage	7.5578*
	(8.4837)
1o.sex#6o.new_mage	1.0000
	(0.0000)
m5	1.0378
	(0.0434)
0b.sex#co.m5	1.0000
	(0.0000)
1.sex#c.m5	0.9618

	(0.0556)
1.polygamous	1.4301*
	(0.2869)
0b.sex#0b.polygamous	1.0000
	(0.0000)
0b.sex#1o.polygamous	1.0000
	(0.0000)
1o.sex#0b.polygamous	1.0000
	(0.0000)
1.sex#1.polygamous	0.6944
	(0.1915)
2.m10	0.7729
	(0.1712)
3.m10	0.8262
	(0.2328)
0b.sex#1b.m10	1.0000
	(0.0000)
0b.sex#2o.m10	1.0000
	(0.0000)
0b.sex#3o.m10	1.0000
	(0.0000)
1o.sex#1b.m10	1.0000
	(0.0000)
1.sex#2.m10	1.3920
	(0.4075)
1.sex#3.m10	1.3095
	(0.4989)
2.country_num	1.9995
	(2.1601)
3o.country_num	-

4.country_num	1.0464
	(0.9920)
5.country_num	5.7706*
	(5.6409)
6.country_num	2.4580
	(2.7063)
7.country_num	0.2030
	(0.2082)
8o.country_num	-
9.country_num	1.3404
	(0.8012)
10.country_num	0.1507
	(0.2205)
11o.country_num	-
12.country_num	0.9595
	(0.5461)
13.country_num	1.2791
	(1.2420)
14.country_num	0.1910
	(0.3175)
15.country_num	0.0917*
	(0.1145)
16o.country_num	-
17.country_num	0.2192
	(0.2438)
18o.country_num	-
20.country_num	0.2244

	(0.2619)
21.country_num	0.5415
	(0.4762)
22o.country_num	-
23.country_num	4.0632
	(6.1402)
24.country_num	0.9374
	(0.9725)
25o.country_num	-
26.country_num	0.1577
	(0.1785)
27o.country_num	-
29.country_num	0.3339
	(0.3103)
30.country_num	0.2502
	(0.2954)
31.country_num	1.3975
	(1.5025)
32.country_num	0.5473
	(0.5011)
33.country_num	2.0118
	(1.8350)
34.country_num	1.3460
	(1.7138)
35o.country_num	-
1996.year	14.0901**
	(16.0394)

2000.year	1.7504
	(1.8674)
2001.year	1.4472
	(1.6899)
2004.year	10.4914**
	(10.6143)
2005.year	1.9441
	(1.0012)
2006.year	2.1214
	(2.4053)
2007.year	2.7777
	(3.9269)
2008.year	14.5207**
	(16.7511)
2010.year	6.6498**
	(6.2170)
2011.year	0.4002
	(0.3689)
2012o.year	-
2013.year	3.9400
	(5.0625)
2014.year	8.1275*
	(9.2267)
2015.year	0.8664
	(0.6126)
2016o.year	-
Constant	0.1811**
	(0.1475)

Observations	2,125

seEform in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Appendix VIII

Output (OR) from full Regression (with all control variables and their interaction with sex) run country-wise. Presented by countries under 3 tables VII.1, VII.2 and VII.3 as follows.

VII.1 Full Regression [Benin, Burundi, Chad, Congo, Ethiopia, Gabon]

VARIABLES	(1) Benin	(2) Burundi	(3) Chad	(4) Congo	(5) Ethiopia	(6) Gabon
stunted	.	.	.	.	.	.
	(.)	(.)	(.)	(.)	(.)	(.)
1.sex	0.8595	2.7248	1.1768	1.7224	1.4154	1.0766
	(0.2851)	(1.9767)	(0.2572)	(0.9345)	(0.3705)	(1.4735)
2.wealth_quintiles	1.1578	0.7832	0.9406	0.7420	1.0224	0.6774
	(0.1851)	(0.1327)	(0.0771)	(0.1812)	(0.0883)	(0.6271)
3.wealth_quintiles	0.9022	0.5142***	0.9550	0.8692	0.9787	0.5918
	(0.1304)	(0.0844)	(0.0852)	(0.1961)	(0.0921)	(0.4834)
4.wealth_quintiles	0.9767	0.3701***	0.8716	0.8565	0.5810***	0.5375
	(0.1317)	(0.0954)	(0.1162)	(0.1922)	(0.0955)	(0.4376)
5.wealth_quintiles	0.7232*	0.1065***	0.7026*	0.5731**	0.3950***	0.3077
	(0.1205)	(0.0580)	(0.1278)	(0.1532)	(0.1003)	(0.2508)
0b.sex#1b.wealth_quintiles	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
0b.sex#2o.wealth_quintiles	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
0b.sex#3o.wealth_quintiles	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
0b.sex#4o.wealth_quintiles	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
0b.sex#5o.wealth_quintiles	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
1o.sex#1b.wealth_quintiles	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
1.sex#2.wealth_quintiles	0.8237	1.2504	1.0453	1.0238	1.0368	1.0661
	(0.1830)	(0.2951)	(0.1196)	(0.3376)	(0.1239)	(1.5033)
1.sex#3.wealth_quintiles	1.3714	1.2620	0.9709	0.8743	1.1802	0.9057
	(0.2766)	(0.2840)	(0.1210)	(0.2637)	(0.1534)	(1.1689)
1.sex#4.wealth_quintiles	1.0144	1.3936	0.8364	0.6459	1.0995	0.8921
	(0.1923)	(0.4824)	(0.1540)	(0.1952)	(0.2470)	(1.1474)
1.sex#5.wealth_quintiles	1.3319	3.1210*	1.1280	1.0599	1.0023	0.7859
	(0.3046)	(2.0250)	(0.2829)	(0.3702)	(0.3500)	(1.0096)
1.new_edu	1.0259	0.8943	0.6471***	0.7014*	0.9359	1.7360*
	(0.1219)	(0.1055)	(0.0526)	(0.1461)	(0.0839)	(0.5542)
2.new_edu	1.1214	0.6831	0.5159***	0.5635***	0.6040**	1.3187
	(0.2138)	(0.2262)	(0.0897)	(0.1213)	(0.1353)	(0.4377)
0b.sex#0b.new_edu	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
0b.sex#1o.new_edu	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
0b.sex#2o.new_edu	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
1o.sex#0b.new_edu	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
1.sex#1.new_edu	0.7226*	1.0537	1.1782	1.1893	0.9719	0.8752
	(0.1202)	(0.1723)	(0.1329)	(0.3416)	(0.1208)	(0.3748)
1.sex#2.new_edu	0.5962*	1.0594	1.1660	1.2086	1.3682	0.8839
	(0.1592)	(0.4366)	(0.2661)	(0.3571)	(0.4228)	(0.3927)
3.new_bird	1.0223	1.0710	1.0400	1.2614	1.1468	1.1329
	(0.1093)	(0.1641)	(0.0899)	(0.2065)	(0.1127)	(0.2297)
4.new_bird	0.9444	1.0176	0.9607	1.1879	1.2491**	1.2701
	(0.1167)	(0.1795)	(0.0889)	(0.2361)	(0.1349)	(0.2794)
5.new_bird	0.5430	1.2177	1.0717	1.6203	1.3009	0.4723
	(0.2497)	(0.6198)	(0.2345)	(1.1227)	(0.3530)	(0.2746)
0b.sex#2b.new_bird	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
0b.sex#3o.new_bird	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
0b.sex#4o.new_bird	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
0b.sex#5o.new_bird	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
1o.sex#2b.new_bird	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
1.sex#3.new_bird	0.8880	0.7757	0.9912	0.8168	0.8157	0.7989
	(0.1295)	(0.1609)	(0.1172)	(0.1783)	(0.1101)	(0.2231)
1.sex#4.new_bird	1.0218	0.8276	0.9021	0.8035	0.7677*	0.7556
	(0.1740)	(0.1977)	(0.1146)	(0.2151)	(0.1144)	(0.2284)
1.sex#5.new_bird	2.3040	1.7691	1.0800		0.6100	2.8308
	(1.3284)	(1.2622)	(0.3506)		(0.2374)	(2.1389)
b11	0.9931***	0.9983	0.9901***	0.9955	0.9941***	0.9844***
	(0.0023)	(0.0038)	(0.0020)	(0.0028)	(0.0018)	(0.0043)
0b.sex#co.b11	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
1.sex#c.b11	1.0081***	1.0045	0.9997	1.0020	1.0008	1.0047
	(0.0031)	(0.0053)	(0.0028)	(0.0037)	(0.0025)	(0.0057)
2.new_mage	0.8601	1.4833	0.8925	1.1346	0.7986*	0.9069
	(0.1253)	(0.7186)	(0.0815)	(0.3192)	(0.0993)	(0.2392)
3.new_mage	0.9564	1.5474	0.9197	0.8598	0.9598	0.7559
	(0.1483)	(0.7481)	(0.0966)	(0.2601)	(0.1283)	(0.2381)
4.new_mage	0.9153	1.3612	0.8497	1.2340	1.0199	0.7579
	(0.1932)	(0.6986)	(0.1663)	(0.4897)	(0.2069)	(0.3744)

5.new_mage	0.6895	0.6418	1.3176	2.5716	1.1737	1.5512
	(0.2955)	(0.5292)	(0.5644)	(2.1021)	(0.4782)	(1.3621)
6.new_mage	0.2730	1.5270		1.8738		7.8294
	(0.3206)	(1.8465)		(2.7723)		(12.6778)
0b.sex#1b.new_mage	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
0b.sex#2o.new_mage	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
0b.sex#3o.new_mage	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
0b.sex#4o.new_mage	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
0b.sex#5o.new_mage	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
0b.sex#6o.new_mage	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
1o.sex#1b.new_mage	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
1.sex#2.new_mage	1.2476	0.5006	1.2537*	0.8268	1.0969	1.2226
	(0.2569)	(0.3309)	(0.1631)	(0.2946)	(0.1925)	(0.4288)
1.sex#3.new_mage	1.1056	0.4095	1.2094	0.7120	0.8530	1.4195
	(0.2400)	(0.2702)	(0.1807)	(0.2758)	(0.1613)	(0.5920)
1.sex#4.new_mage	0.9104	0.4356	1.2329	0.4312	0.7886	1.4745
	(0.2696)	(0.3048)	(0.3416)	(0.2532)	(0.2267)	(1.0703)
1.sex#5.new_mage	2.2916	2.0865	0.8352	0.1675	1.0214	
	(1.3171)	(2.2114)	(0.5201)	(0.1929)	(0.6045)	
1.sex#6.new_mage	9.7629*	0.9974				
	(13.1433)	(1.7119)				
m5	1.0580***	1.0887***	1.1032***	1.0548***	1.0699***	1.0677***
	(0.0053)	(0.0072)	(0.0048)	(0.0102)	(0.0035)	(0.0141)
0b.sex#co.m5	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
1.sex#c.m5	0.9925	0.9884	0.9863**	1.0031	0.9944	1.0254
	(0.0068)	(0.0088)	(0.0059)	(0.0132)	(0.0045)	(0.0193)
1.polygamous	1.2005**	1.1142	1.0304	0.9712	0.9076	1.1600
	(0.1013)	(0.2822)	(0.0655)	(0.1737)	(0.0921)	(0.2278)
0b.sex#0b.polygamous	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
0b.sex#1o.polygamous	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
1o.sex#0b.polygamous	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
1.sex#1.polygamous	0.8179*	1.2334	1.0477	1.0559	1.1722	1.3157

	(0.0952)	(0.4200)	(0.0927)	(0.2543)	(0.1676)	(0.3560)
2.m10	1.1318	1.0020	1.1149	0.8679	1.0271	0.8488
	(0.1329)	(0.1361)	(0.1069)	(0.1409)	(0.0960)	(0.1437)
3.m10	1.0980	1.1888	0.7675	1.3180	0.9175	0.9156
	(0.1957)	(0.2407)	(0.2227)	(0.3893)	(0.1082)	(0.2442)
0b.sex#1b.m10	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
0b.sex#2o.m10	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
0b.sex#3o.m10	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
1o.sex#1b.m10	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
1.sex#2.m10	0.9233	1.2352	0.9398	1.2387	0.9720	0.9811
	(0.1501)	(0.2300)	(0.1249)	(0.2667)	(0.1276)	(0.2256)
1.sex#3.m10	0.9737	1.1716	1.0023	1.0295	0.9470	0.6678
	(0.2323)	(0.3416)	(0.4082)	(0.4086)	(0.1549)	(0.2645)
2011.year	0.8512*			0.9267	0.8199**	
	(0.0746)			(0.1404)	(0.0695)	
0b.sex#2001b.year	1.0000					
	(0.0000)					
0b.sex#2011o.year	1.0000			1.0000	1.0000	
	(0.0000)			(0.0000)	(0.0000)	
1o.sex#2001b.year	1.0000					
	(0.0000)					
1.sex#2011.year	0.9456			0.8904	1.0096	
	(0.1144)			(0.1829)	(0.1181)	
2016.year		0.5667***			0.6457***	
		(0.0685)			(0.0583)	
0b.sex#2010b.year		1.0000				
		(0.0000)				
0b.sex#2016o.year		1.0000			1.0000	
		(0.0000)			(0.0000)	
1o.sex#2010b.year		1.0000				
		(0.0000)				
1.sex#2016.year		1.1073			0.9525	
		(0.1862)			(0.1186)	
6o.new_mage			-		-	
1o.sex#6o.new_mage			1.0000	1.0000	1.0000	1.0000
			(0.0000)	(0.0000)	(0.0000)	(0.0000)
2004.year			0.9111			
			(0.0722)			
2014.year			0.8412**			
			(0.0684)			
0b.sex#1996b.year			1.0000			
			(0.0000)			

0b.sex#2004o.year	1.0000			
	(0.0000)			
0b.sex#2014o.year	1.0000			
	(0.0000)			
1o.sex#1996b.year	1.0000			
	(0.0000)			
1.sex#2004.year	1.0121			
	(0.1119)			
1.sex#2014.year	0.9372			
	(0.1058)			
1o.sex#5o.new_bird		1.0000		
		(0.0000)		
0b.sex#2005b.year		1.0000	1.0000	
		(0.0000)	(0.0000)	
1o.sex#2005b.year		1.0000	1.0000	
		(0.0000)	(0.0000)	
1o.sex#5o.new_mage				1.0000
				(0.0000)
2012.year				0.7750
				(0.1496)
0b.sex#2000b.year				1.0000
				(0.0000)
0b.sex#2012o.year				1.0000
				(0.0000)
1o.sex#2000b.year				1.0000
				(0.0000)
1.sex#2012.year				1.0156
				(0.2699)
0b.sex#2008b.year				
1o.sex#2008b.year				
2015.year				
0b.sex#2015o.year				
1.sex#2015.year				
2010.year				
2013.year				
0b.sex#2010o.year				
0b.sex#2013o.year				
1.sex#2010.year				

1.sex#2013.year						
0b.sex#2004b.year						
1o.sex#2004b.year						
2006.year						
0b.sex#2006o.year						
1.sex#2006.year						
0b.sex#2007b.year						
1o.sex#2007b.year						
Constant	0.2985***	0.2835**	0.2254***	0.2630***	0.2587***	0.4314
	(0.0705)	(0.1510)	(0.0350)	(0.1060)	(0.0489)	(0.3831)
Observations	6,222	3,297	10,955	3,161	8,947	2,265

seEform in parentheses
*** p<0.01, ** p<0.05, * p<0.1

VIII.2 Full Regression [Ghana, Kenya, Malawi, Nigeria, Rwanda, Senegal]

VARIABLES	(7) Ghana	(8) Kenya	(9) Malawi	(10) Nigeria	(11) Rwanda	(12) Senegal
stunted	.	.	.	.	.	.
	(.)	(.)	(.)	(.)	(.)	(.)
1.sex	0.3796	0.9767	1.0593	1.2250	0.0071***	1.6617
	(0.2936)	(0.2522)	(0.4161)	(0.2001)	(0.0130)	(0.6282)
2.wealth_quintiles	0.5894	0.9926	0.8030*	1.2076**	0.6333	0.9725
	(0.2278)	(0.1111)	(0.0933)	(0.0961)	(0.2678)	(0.1623)
3.wealth_quintiles	0.6256	0.8329	0.7274***	1.1936**	0.6149	0.9204
	(0.1924)	(0.1074)	(0.0860)	(0.0891)	(0.2549)	(0.1394)
4.wealth_quintiles	0.4606***	0.5946***	0.6975**	1.0015	0.3493**	0.6720***
	(0.1378)	(0.0817)	(0.1084)	(0.0743)	(0.1611)	(0.0963)
5.wealth_quintiles	0.4064***	0.4314***	0.3710***	0.8512**	0.3268*	0.4811***
	(0.1328)	(0.0790)	(0.1034)	(0.0668)	(0.1872)	(0.0705)
0b.sex#1b.wealth_quintiles	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
0b.sex#2o.wealth_quintiles	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
0b.sex#3o.wealth_quintiles	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
0b.sex#4o.wealth_quintiles	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
0b.sex#5o.wealth_quintiles	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
1o.sex#1b.wealth_quintiles	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
1.sex#2.wealth_quintiles	1.7262	0.9451	1.0786	1.0220	3.9927**	1.0110
	(0.9405)	(0.1466)	(0.1770)	(0.1137)	(2.4617)	(0.2297)
1.sex#3.wealth_quintiles	1.3565	0.8585	1.2663	0.9928	3.9604**	1.0501
	(0.5920)	(0.1522)	(0.2108)	(0.1035)	(2.4041)	(0.2113)
1.sex#4.wealth_quintiles	1.9736	1.0537	0.9008	1.0087	3.7869**	1.2460
	(0.8333)	(0.1978)	(0.1943)	(0.1045)	(2.5194)	(0.2362)
1.sex#5.wealth_quintiles	1.8451	1.1633	1.6355	0.9134	4.2007*	1.0953
	(0.8355)	(0.2856)	(0.6149)	(0.0997)	(3.3280)	(0.2148)
1.new_edu	1.1406	1.2319**	0.7836**	0.9326	0.6898**	0.9274
	(0.2332)	(0.1229)	(0.0933)	(0.0508)	(0.1227)	(0.1202)
2.new_edu	0.7506	0.9031	0.6246**	0.7018***	0.4644**	0.8668
	(0.1643)	(0.1238)	(0.1192)	(0.0477)	(0.1655)	(0.2096)
0b.sex#0b.new_edu	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
0b.sex#1o.new_edu	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
0b.sex#2o.new_edu	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
1o.sex#0b.new_edu	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
1.sex#1.new_edu	0.9757	1.0393	1.0844	1.0440	1.2776	1.0395
	(0.2654)	(0.1433)	(0.1830)	(0.0791)	(0.3059)	(0.1763)
1.sex#2.new_edu	1.0387	0.8962	1.0956	1.0522	0.8745	0.5778*
	(0.3023)	(0.1676)	(0.2888)	(0.0978)	(0.4027)	(0.1863)
3.new_bird	1.0647	1.0960	1.0612	1.0142	0.9079	1.0766
	(0.2077)	(0.0972)	(0.1180)	(0.0574)	(0.1452)	(0.1374)
4.new_bird	1.0044	1.1275	0.8640	1.0242	0.9385	1.0586
	(0.2476)	(0.1201)	(0.1222)	(0.0646)	(0.1956)	(0.1512)
5.new_bird	0.5048	0.6749	0.8054	1.0926	0.3960	0.8095
	(0.5798)	(0.2157)	(0.3454)	(0.1510)	(0.4779)	(0.3485)
0b.sex#2b.new_bird	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
0b.sex#3o.new_bird	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
0b.sex#4o.new_bird	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
0b.sex#5o.new_bird	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
1o.sex#2b.new_bird	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
1.sex#3.new_bird	0.9920	1.0191	0.8863	0.9701	1.2559	0.9052
	(0.2593)	(0.1228)	(0.1382)	(0.0765)	(0.2745)	(0.1509)
1.sex#4.new_bird	1.0937	1.1750	1.0646	0.9256	1.4420	0.9889
	(0.3589)	(0.1710)	(0.2113)	(0.0816)	(0.4039)	(0.1855)
1.sex#5.new_bird	1.1263	2.1829*	1.7715	1.1163	2.4367	1.2007
	(1.6613)	(0.9664)	(1.1835)	(0.2205)	(3.5330)	(0.6552)
b11	0.9856***	0.9916***	0.9942**	0.9957***	0.9948	0.9911***
	(0.0040)	(0.0017)	(0.0025)	(0.0011)	(0.0036)	(0.0027)
0b.sex#co.b11	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
1.sex#c.b11	1.0098*	1.0012	0.9979	1.0022	1.0043	1.0078**
	(0.0052)	(0.0023)	(0.0035)	(0.0016)	(0.0049)	(0.0036)
2.new_mage	1.1741	0.7645**	0.9393	1.0287	0.0967*	0.9917
	(0.4732)	(0.1023)	(0.1770)	(0.0734)	(0.1252)	(0.1962)
3.new_mage	1.1371	0.7327**	0.8926	0.8968	0.1178*	0.9772
	(0.4665)	(0.1047)	(0.1805)	(0.0709)	(0.1519)	(0.2012)
4.new_mage	1.0989	0.7101	1.4190	0.7732**	0.0898*	0.7818
	(0.5192)	(0.1534)	(0.4964)	(0.0824)	(0.1166)	(0.2114)
5.new_mage	1.1540	0.5234	0.4313	0.9299	0.0430**	1.0552
	(0.8141)	(0.2992)	(0.3104)	(0.1797)	(0.0618)	(0.5791)
6.new_mage			1.7484	0.9470	0.2848	0.8126
			(2.5404)	(0.5524)	(0.4571)	(0.9587)
0b.sex#1b.new_mage	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
0b.sex#2o.new_mage	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
0b.sex#3o.new_mage	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
0b.sex#4o.new_mage	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
0b.sex#5o.new_mage	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
0b.sex#6o.new_mage	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
1o.sex#1b.new_mage	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
1.sex#2.new_mage	1.2661	1.0420	1.1078	0.8961	45.1198**	0.7579
	(0.7140)	(0.1903)	(0.3040)	(0.0889)	(77.4696)	(0.1951)
1.sex#3.new_mage	1.2758	1.0609	1.1204	1.0099	30.3280**	0.6955
	(0.7318)	(0.2064)	(0.3279)	(0.1103)	(51.9263)	(0.1874)
1.sex#4.new_mage	1.3078	1.1885	1.6242	1.0772	58.2266**	0.9384
	(0.8599)	(0.3388)	(0.7785)	(0.1589)	(100.4003)	(0.3330)
1.sex#5.new_mage	0.6573	1.1612	16.4915**	0.7090	126.1312***	0.5768
	(0.6737)	(0.8776)	(21.5480)	(0.1940)	(236.1836)	(0.4037)
1.sex#6.new_mage				0.3295		
				(0.2643)		
m5	1.0687***	1.0279***	1.0465***	1.0559***	1.0484***	1.0872***
	(0.0104)	(0.0043)	(0.0056)	(0.0032)	(0.0060)	(0.0066)
0b.sex#co.m5	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
1.sex#c.m5	0.9916	1.0008	1.0012	0.9955	1.0003	0.9904
	(0.0127)	(0.0057)	(0.0076)	(0.0042)	(0.0078)	(0.0079)
1.polygamous	0.8363	1.0972	0.8299	1.1314***	1.4337	1.3201***
	(0.1601)	(0.1037)	(0.1041)	(0.0516)	(0.3639)	(0.1243)
0b.sex#0b.polygamous	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
0b.sex#1o.polygamous	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
1o.sex#0b.polygamous	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
1.sex#1.polygamous	1.3790	0.8922	1.2001	0.9784	0.8238	0.8633
	(0.3512)	(0.1169)	(0.2132)	(0.0622)	(0.2781)	(0.1087)
2.m10	0.7110*	0.8654	1.1453	1.0886	1.2240	1.0414
	(0.1415)	(0.0777)	(0.1285)	(0.1025)	(0.1895)	(0.1242)
3.m10	0.8091	0.8319	1.0088	0.9937	0.9555	1.3457

	(0.2162)	(0.0941)	(0.1185)	(0.1265)	(0.1983)	(0.2871)
0b.sex#1b.m10	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
0b.sex#2o.m10	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
0b.sex#3o.m10	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
1o.sex#1b.m10	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
1.sex#2.m10	1.6435*	1.0374	0.9703	0.9628	0.7436	0.9979
	(0.4344)	(0.1266)	(0.1535)	(0.1247)	(0.1584)	(0.1580)
1.sex#3.m10	1.1065	1.1240	1.1765	0.8525	0.9204	0.7017
	(0.3970)	(0.1737)	(0.1923)	(0.1540)	(0.2565)	(0.2015)
2011.year						
0b.sex#2001b.year						
0b.sex#2011o.year						
1o.sex#2001b.year						
1.sex#2011.year						
2016.year						0.5128***
						(0.0798)
0b.sex#2010b.year			1.0000		1.0000	1.0000
			(0.0000)		(0.0000)	(0.0000)
0b.sex#2016o.year						1.0000
						(0.0000)
1o.sex#2010b.year			1.0000		1.0000	1.0000
			(0.0000)		(0.0000)	(0.0000)
1.sex#2016.year						1.3820
						(0.2777)
6o.new_mage	-	-				
1o.sex#6o.new_mage	1.0000	1.0000	1.0000		1.0000	1.0000
	(0.0000)	(0.0000)	(0.0000)		(0.0000)	(0.0000)
2004.year						
2014.year	0.5863***	0.6688***			0.9154	0.7054**
	(0.1161)	(0.0472)			(0.1338)	(0.1045)
0b.sex#1996b.year						
0b.sex#2004o.year						
0b.sex#2014o.year	1.0000	1.0000			1.0000	1.0000
	(0.0000)	(0.0000)			(0.0000)	(0.0000)

1o.sex#1996b.year						
1.sex#2004.year						
1.sex#2014.year	1.0770	1.2952***			0.9738	1.0497
	(0.2823)	(0.1252)			(0.1909)	(0.2043)
1o.sex#5o.new_bird						
0b.sex#2005b.year						
1o.sex#2005b.year						
1o.sex#5o.new_mage						
2012.year						0.5405***
						(0.0824)
0b.sex#2000b.year						
0b.sex#2012o.year						1.0000
						(0.0000)
1o.sex#2000b.year						
1.sex#2012.year						1.1496
						(0.2303)
0b.sex#2008b.year	1.0000	1.0000		1.0000		
	(0.0000)	(0.0000)		(0.0000)		
1o.sex#2008b.year	1.0000	1.0000		1.0000		
	(0.0000)	(0.0000)		(0.0000)		
2015.year			0.5439***			0.8751
			(0.0630)			(0.1240)
0b.sex#2015o.year			1.0000			1.0000
			(0.0000)			(0.0000)
1.sex#2015.year			0.9065			0.9717
			(0.1470)			(0.1828)
2010.year				0.6217*		
				(0.1744)		
2013.year				0.8002***		
				(0.0389)		
0b.sex#2010o.year				1.0000		
				(0.0000)		
0b.sex#2013o.year				1.0000		
				(0.0000)		
1.sex#2010.year				0.9499		
				(0.3630)		
1.sex#2013.year				0.9917		
				(0.0673)		

0b.sex#2004b.year						
1o.sex#2004b.year						
2006.year						
0b.sex#2006o.year						
1.sex#2006.year						
0b.sex#2007b.year						
1o.sex#2007b.year						
Constant	0.3415*	0.5674***	0.5831*	0.2598***	5.6187	0.1694***
	(0.1900)	(0.1081)	(0.1619)	(0.0303)	(7.5682)	(0.0494)
Observations	2,500	9,299	4,857	23,381	2,512	8,032

seEform in parentheses
*** p<0.01, ** p<0.05, * p<0.1

VIII.3 [Sierra Leone, Tanzania, Uganda, Zambia, Zimbabwe]

VARIABLES	(13) Sierra Leone	(14) Tanzania	(15) Uganda	(16) Zambia	(17) Zimbabwe
stunted	.	.	.	.	.
	(.)	(.)	(.)	(.)	(.)
1.sex	1.1387	1.5172	1.3395	1.0223	2.3258
	(0.5321)	(0.4196)	(0.4239)	(0.2753)	(1.3768)
2.wealth_quintiles	1.0857	0.9853	0.9674	0.9588	0.9932
	(0.2120)	(0.0686)	(0.0993)	(0.0750)	(0.1951)
3.wealth_quintiles	0.9181	0.6601***	0.6824***	0.8004***	1.0067
	(0.1793)	(0.0607)	(0.0878)	(0.0673)	(0.1740)
4.wealth_quintiles	0.7711	0.4958***	0.4781***	0.8111**	1.0343
	(0.1587)	(0.0553)	(0.0859)	(0.0722)	(0.1504)
5.wealth_quintiles	0.7146	0.3086***	0.4615***	0.6835***	0.8445
	(0.2337)	(0.0531)	(0.1266)	(0.0684)	(0.1397)
0b.sex#1b.wealth_quintiles	1.0000	1.0000	1.0000	1.0000	1.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
0b.sex#2o.wealth_quintiles	1.0000	1.0000	1.0000	1.0000	1.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
0b.sex#3o.wealth_quintiles	1.0000	1.0000	1.0000	1.0000	1.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
0b.sex#4o.wealth_quintiles	1.0000	1.0000	1.0000	1.0000	1.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
0b.sex#5o.wealth_quintiles	1.0000	1.0000	1.0000	1.0000	1.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
1o.sex#1b.wealth_quintiles	1.0000	1.0000	1.0000	1.0000	1.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
1.sex#2.wealth_quintiles	0.7700	0.9677	0.8147	0.9746	0.9603
	(0.2104)	(0.0948)	(0.1165)	(0.1086)	(0.2559)
1.sex#3.wealth_quintiles	1.0391	1.0537	1.0510	0.9424	1.0747
	(0.2840)	(0.1356)	(0.1870)	(0.1131)	(0.2620)
1.sex#4.wealth_quintiles	0.9864	1.0982	1.0943	0.9114	0.9379
	(0.2816)	(0.1673)	(0.2627)	(0.1128)	(0.1893)
1.sex#5.wealth_quintiles	0.7174	1.0940	0.6444	0.8533	0.9114
	(0.3416)	(0.2536)	(0.2441)	(0.1210)	(0.2124)
1.new_edu	0.8051	1.0348	0.7439***	1.0116	1.2224
	(0.1592)	(0.0688)	(0.0668)	(0.0838)	(0.3395)
2.new_edu	0.5336**	0.7533**	0.6228***	0.9643	1.1079
	(0.1534)	(0.1033)	(0.1007)	(0.1005)	(0.3179)
0b.sex#0b.new_edu	1.0000	1.0000	1.0000	1.0000	1.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
0b.sex#1o.new_edu	1.0000	1.0000	1.0000	1.0000	1.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
0b.sex#2o.new_edu	1.0000	1.0000	1.0000	1.0000	1.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)

1o.sex#0b.new_edu	1.0000	1.0000	1.0000	1.0000	1.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
1.sex#1.new_edu	1.3064	0.9232	1.1832	1.0392	0.6940
	(0.3628)	(0.0865)	(0.1485)	(0.1236)	(0.2615)
1.sex#2.new_edu	1.5381	0.9096	1.2780	1.0080	0.6990
	(0.5716)	(0.1696)	(0.2815)	(0.1500)	(0.2719)
3.new_bird	0.9733	0.9133	0.9460	0.9133	1.0523
	(0.1590)	(0.0687)	(0.0977)	(0.0678)	(0.1215)
4.new_bird	0.8905	0.8413**	0.9862	0.8589*	1.0928
	(0.1740)	(0.0709)	(0.1151)	(0.0736)	(0.1985)
5.new_bird	0.4776	0.9085	1.0705	1.0681	5.2620**
	(0.3928)	(0.2088)	(0.3056)	(0.2380)	(4.0403)
0b.sex#2b.new_bird	1.0000	1.0000	1.0000	1.0000	1.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
0b.sex#3o.new_bird	1.0000	1.0000	1.0000	1.0000	1.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
0b.sex#4o.new_bird	1.0000	1.0000	1.0000	1.0000	1.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
0b.sex#5o.new_bird	1.0000	1.0000	1.0000	1.0000	1.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
1o.sex#2b.new_bird	1.0000	1.0000	1.0000	1.0000	1.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
1.sex#3.new_bird	0.7858	0.9278	0.8458	0.9806	1.1555
	(0.1744)	(0.0979)	(0.1219)	(0.1031)	(0.1857)
1.sex#4.new_bird	0.8205	1.0749	0.7405*	0.8721	0.8559
	(0.2234)	(0.1270)	(0.1205)	(0.1058)	(0.2185)
1.sex#5.new_bird		1.0719	0.5428	0.5551*	0.3151
		(0.3347)	(0.2144)	(0.1899)	(0.3144)
b11	1.0011	0.9934***	0.9916***	0.9933***	0.9958*
	(0.0028)	(0.0015)	(0.0024)	(0.0017)	(0.0023)
0b.sex#co.b11	1.0000	1.0000	1.0000	1.0000	1.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
1.sex#c.b11	0.9966	1.0034	1.0017	1.0022	1.0023
	(0.0036)	(0.0021)	(0.0034)	(0.0023)	(0.0031)
2.new_mage	0.9890	1.0868	1.1277	0.8786	1.0269
	(0.1967)	(0.1751)	(0.1663)	(0.1151)	(0.3073)
3.new_mage	0.8926	1.2309	1.1589	0.8372	1.0188
	(0.1949)	(0.2044)	(0.1877)	(0.1175)	(0.3138)
4.new_mage	0.6170	1.3289	1.1318	0.6102**	1.4417
	(0.1964)	(0.2841)	(0.3322)	(0.1384)	(0.5305)
5.new_mage	1.5051	1.5822	1.4434	0.7497	0.7428
	(0.7082)	(0.8142)	(1.2234)	(0.4475)	(0.5345)
6.new_mage	0.6381	1.5783	0.8728	2.4376	
	(0.7685)	(2.5371)	(1.3860)	(3.4802)	
0b.sex#1b.new_mage	1.0000	1.0000	1.0000	1.0000	1.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
0b.sex#2o.new_mage	1.0000	1.0000	1.0000	1.0000	1.0000

	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
0b.sex#3o.new_mage	1.0000	1.0000	1.0000	1.0000	1.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
0b.sex#4o.new_mage	1.0000	1.0000	1.0000	1.0000	1.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
0b.sex#5o.new_mage	1.0000	1.0000	1.0000	1.0000	1.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
0b.sex#6o.new_mage	1.0000	1.0000	1.0000	1.0000	1.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
1o.sex#1b.new_mage	1.0000	1.0000	1.0000	1.0000	1.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
1.sex#2.new_mage	1.2778	0.7532	0.7701	1.1000	0.6623
	(0.3802)	(0.1679)	(0.1609)	(0.2113)	(0.2581)
1.sex#3.new_mage	1.4390	0.8028	0.6216**	1.1592	0.8232
	(0.4595)	(0.1847)	(0.1420)	(0.2380)	(0.3308)
1.sex#4.new_mage	1.8277	0.6064*	0.6414	1.2228	0.4190*
	(0.8157)	(0.1812)	(0.2498)	(0.3905)	(0.2136)
1.sex#5.new_mage	1.1032	0.8756	0.7678	0.8664	0.4451
	(0.7530)	(0.6000)	(0.8496)	(0.6796)	(0.4865)
1.sex#6.new_mage	1.8121				
	(3.1719)				
m5	1.0662***	1.0618***	1.0526***	1.0496***	1.0520***
	(0.0086)	(0.0041)	(0.0054)	(0.0044)	(0.0079)
0b.sex#co.m5	1.0000	1.0000	1.0000	1.0000	1.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
1.sex#c.m5	0.9964	0.9999	1.0098	1.0046	0.9955
	(0.0115)	(0.0055)	(0.0073)	(0.0059)	(0.0103)
1.polygamous	0.8772	0.9432	1.1049	1.2135**	1.1683
	(0.1184)	(0.0653)	(0.0925)	(0.0994)	(0.1759)
0b.sex#0b.polygamous	1.0000	1.0000	1.0000	1.0000	1.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
0b.sex#1o.polygamous	1.0000	1.0000	1.0000	1.0000	1.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
1o.sex#0b.polygamous	1.0000	1.0000	1.0000	1.0000	1.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
1.sex#1.polygamous	1.5667**	1.0524	1.0234	0.8166*	1.0715
	(0.2904)	(0.1016)	(0.1194)	(0.0951)	(0.2204)
2.m10	0.8753	0.9347	1.0046	1.0172	1.1175
	(0.1696)	(0.0684)	(0.0888)	(0.0664)	(0.1427)
3.m10	1.0282	1.0672	0.8167	0.9090	1.1382
	(0.2762)	(0.1527)	(0.1023)	(0.0985)	(0.1973)
0b.sex#1b.m10	1.0000	1.0000	1.0000	1.0000	1.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
0b.sex#2o.m10	1.0000	1.0000	1.0000	1.0000	1.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
0b.sex#3o.m10	1.0000	1.0000	1.0000	1.0000	1.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)

1o.sex#1b.m10	1.0000	1.0000	1.0000	1.0000	1.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
1.sex#2.m10	1.5868*	0.9041	1.0787	1.1458	0.8829
	(0.4386)	(0.0914)	(0.1332)	(0.1049)	(0.1555)
1.sex#3.m10	1.0045	0.9134	1.4998**	1.1686	1.0257
	(0.3750)	(0.1845)	(0.2591)	(0.1776)	(0.2473)
2011.year			0.4507***		
			(0.0733)		
0b.sex#2001b.year					
0b.sex#2011o.year			1.0000		
			(0.0000)		
1o.sex#2001b.year					
1.sex#2011.year			1.6244**		
			(0.3542)		
2016.year					
0b.sex#2010b.year					
0b.sex#2016o.year					
1o.sex#2010b.year					
1.sex#2016.year					
6o.new_mage					-
1o.sex#6o.new_mage		1.0000	1.0000	1.0000	1.0000
		(0.0000)	(0.0000)	(0.0000)	(0.0000)
2004.year					
2014.year					
0b.sex#1996b.year					
0b.sex#2004o.year					
0b.sex#2014o.year					
1o.sex#1996b.year					
1.sex#2004.year					
1.sex#2014.year					
1o.sex#5o.new_bird	1.0000				

	(0.0000)				
0b.sex#2005b.year					1.0000
					(0.0000)
1o.sex#2005b.year					1.0000
					(0.0000)
1o.sex#5o.new_mage					
2012.year					
0b.sex#2000b.year			1.0000		
			(0.0000)		
0b.sex#2012o.year					
1o.sex#2000b.year			1.0000		
			(0.0000)		
1.sex#2012.year					
0b.sex#2008b.year	1.0000				
	(0.0000)				
1o.sex#2008b.year	1.0000				
	(0.0000)				
2015.year		0.6509***	0.4240***		0.5343***
		(0.0615)	(0.0566)		(0.0810)
0b.sex#2015o.year		1.0000	1.0000		1.0000
		(0.0000)	(0.0000)		(0.0000)
1.sex#2015.year		1.0555	1.2301		1.1185
		(0.1387)	(0.2212)		(0.2339)
2010.year		0.9914			0.8651
		(0.0625)			(0.1236)
2013.year	1.0169			0.9333	
	(0.1349)			(0.0563)	
0b.sex#2010o.year		1.0000			1.0000
		(0.0000)			(0.0000)
0b.sex#2013o.year	1.0000			1.0000	
	(0.0000)			(0.0000)	
1.sex#2010.year		0.9990			0.9619
		(0.0882)			(0.1908)
1.sex#2013.year	0.9000			0.8779	
	(0.1675)			(0.0750)	
0b.sex#2004b.year		1.0000			
		(0.0000)			
1o.sex#2004b.year		1.0000			
		(0.0000)			
2006.year			0.7413***		
			(0.0682)		
0b.sex#2006o.year			1.0000		
			(0.0000)		

1.sex#2006.year			1.1199		
			(0.1432)		
0b.sex#2007b.year				1.0000	
				(0.0000)	
1o.sex#2007b.year				1.0000	
				(0.0000)	
Constant	0.2179***	0.3244***	0.5509***	0.4901***	0.1720***
	(0.0717)	(0.0648)	(0.1231)	(0.0915)	(0.0766)
Observations	2,673	11,739	6,943	11,313	4,439

seEform in parentheses

*** p<0.01, ** p<0.05, * p<0.1