The International Wealth Index and stunting in sub-Saharan Africa

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Ilse van Lith
S4578708
Supervisor: Sandor Schrijner
Radboud University Nijmegen

Abstract.

Existing empirical evidence does not show a unanimous, negative relationship between an increase in absolute income and child's stunting and suggests that this depends on the socio-economic circumstances of the household. Due to inequalities, an increase in income does not always reach the poorest people in society, this indicates that relative measures of wealth might be more important for decreasing stunting rates. I study the relationship between the International Wealth Index (IWI), which is a measure of relative socio-economic status, and the stunting rate in sub-Saharan Africa (SSA) while taking into account the household characteristics. The results indicate that the effect of the IWI varies, but is almost always negatively related to the average stunting rate. Besides the asset index, maternal education, the presence of grandparents and the mean age difference between husband and wife are other important determinants for stunting outcomes. My findings indicate that promoting the possession of several consumer durable goods should be taken into account when designing policies that are aimed at improving the health status of children in sub-Saharan Africa.

Keywords: stunting, international wealth index, sub-Saharan Africa, household characteristics, socio-economics status

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1. Introduction

In 2015 the United Nations introduced the Sustainable Development Goals. These are 17 goals that are aimed at making the world a better place for all people by promoting prosperity and protecting the environment. All members of the United Nations adopted these goals and recognized that ending poverty must go hand in hand with strategies that address social needs, like education and gender equality, while also preserving the earth's forests and oceans. Goal number two of the Sustainable Development Goals, and one of the most important ones, is to end hunger everywhere in the world. A target that is included here is to end all forms of malnutrition, among which stunting, by 2030 (United Nations, 2015). To achieve this, households need more resources to fulfill the needs of their children to ensure they receive the right nutrients. It is expected that an increase in income would lead to a decrease in poverty and to a better health status of children (Heltberg, 2009; Smith & Haddad, 2002). However, due to inequality issues, it is not always the case that this increase in income actually reaches the poorest people of a society. This might be especially true for developing countries, as these countries have to deal with bigger inequality issues than other areas of the world (Harttgen, Klasen & Vollmer, 2013). In recent years there has been more attention for the effects of non-monetary and socio-economic factors on poverty levels and its consequences. One such factor is the International Wealth Index (IWI), which takes into account the consumer durable goods a household possesses and the housing quality. This papers examines the relationship between the IWI and linear growth failure, or ''stunting'' of children.

Stunting is a form of child undernutrition and it is the most prevalent form of malnourishment worldwide. This makes it a major global health problem that needs to be addressed (De Onis & Branca, 2016). The magnitude of this problem has long been unrecognized, since short stature is so common in these communities that it is considered normal. This creates difficulties for visually identifying stunted children. However, after years of neglect, there is now more international attention for this major health problem and it is the focus point of several high profile initiatives like the Zero Hunger Challenge by the United Nations and Scaling Up Nutrition, which is a movement and collaboration between several governments, NGO's and other organizations. Stunting means that a child has linear growth failure and is physically not developing properly. This has severe short- and long-term socio-economic consequences that are widely known. In the short-term, it is associated with cognitive deficits and low educational performance (Crookston et al., 2011). This leads to poor economic productivity in adulthood, which hampers not only the development of the individual, but it also affects the economic development of nations (Akombi et al., 2017; De Onis & Branca, 2016; Monteiro et al., 2009). Although there have been remarkable advances in public health, a lot of people still remain vulnerable to undernutrition and most of them are living in developing countries that are still struggling with extreme poverty (Hong, Banta & Betancourt, 2006). According to the World Health Organization (2020) 144 million children under the age of 5 were affected globally by stunting in 2019.

Although Asia is still the continent with the most stunted children, it has made impressive progress in decreasing the amount of stunted children from 49% in 1990 to 28% in 2010. In Africa, the

proportion of stunted children has circled around 40% the last decades. However, the absolute number of stunted children is increasing, due to population growth (Prendergast & Humphrey, 2014). This raises the question why Asia has been successful in reducing the number of stunted children and Africa has not? The paper of Headey, Hoddinott & Park (2016) sums up the most important reasons for this difference. First of all, especially among women, there has been a rapid expansion of education in Asia. As will be explained later on, parental schooling are important determinants for stunting outcomes, so improvements in this have a substantial influence on stunting rates. Secondly, increasing access to sufficient healthcare has also made a significant contribution to the declining stunting rates in Asia. Finally, Headey, Hoddinott & Park (2016) include a wealth index, which is based on the ownership of assets and the quality of the house. For India and Pakistan, the value of this index rose by 50% from late 1990s to 2011 and for Bangladesh and Nepal this increase was even more than 100%. All of these factors combined, have caused the improvements in the stunting rate of Asia and it would be interesting to see if this could also be the case for Africa. Since, on the one hand the severe negative consequences of stunting are widely known, but on the other hand it remains a world-wide issue that still affects millions of children, especially in sub-Saharan Africa. Gaining insights in the driving factors behind stunting is also extremely important to improve policies that are aimed at reducing stunting rates.

Although sub-Saharan Africa has experienced substantial income growth in the last decades, this has not lead to an equal decline in child undernutrition rates (Harttgen, Klasen & Vollmer, 2013). This has inspired researchers to look for other factors that might affect stunting rates. Gaining insight into the role of non-monetary, socio-economic variables has -therefore- become increasingly important. However, studies on this topic are scarce and the lack of a unanimous index to represent socio-economic status makes it impossible to compare the results of the different studies. The aim of the current paper is to partly fill up this gap in the literature by using an asset index that is comparable across place and time and to provide new insights into the underlying determinants of stunting. With this purpose, the strength of the relationship between the International Wealth Index (IWI) and children's stunting is determined. Furthermore, it is expected that the strength of this relationship will also depend on the specific characteristics of the household, for example the location and housing quality. Therefore, it will also be examined how the circumstances in which the household is situated influences this relationship. With this, the goal is to provide new empirical knowledge that might make a contribution to the design of policies that are aimed at improving the health situation of children. By running multilevel regressions at the regional level for as many sub-Saharan African countries as possible, the aim is to answer the following research questions:

- What is the relationship between the International Wealth Index (IWI) and children's stunting?
- To what extent is this relationship influenced by the socio-economic, demographic and environmental characteristics of the household?

So far, most literature that has examined stunting of children primarily focused on the effect of monetary variables, like e.g. the increase in income or GDP per capita (Haddad et al., 2002; Harttgen, Klasen & Vollmer, 2013; Smith & Haddad, 2002; Subramanyam et al., 2003; Vollmer et al., 2014). This is unfortunate, since it might be that other household and environmental factors of the household, such as the educational level of the mother, access to clean drinking water and the number of household members, are also important. There exists literature that examines the influence of non-monetary variables on children's stunting. Both the papers of Harttgen, Klasen & Vollmer (2013) and Headey, Hoddinott & Park (2016) include in their regression an asset based wealth index, which is composed by looking at the different consumer durable goods a household possesses. They both conclude that these indices, that represent an indicator of relative socio-economic status, are important determinants for stunting outcomes. Hong, Banta & Betancourt (2006) do not include a separate asset index, but instead look at wealth inequalities between households, rather than absolute income. They come to the same conclusion. These studies show that instead of focusing on absolute income levels to bring down stunting rates, we rather should be focusing on these wealth indices that are more a representation of the relative wealth status of households. However, one big disadvantage of the asset based indexes that are used in these studies is that they differ per survey. This means that every asset index is based on different questions and is calculated in a different way. As a consequence it is hard to compare the results of studies that make use of different surveys. I want to solve this comparison problem by using the International Wealth Index as asset index. Since the IWI is based on the same questions and calculated the same way for every country and thus adds the possibility to compare households across place and time, it is preferable over the other indices. Using the IWI as an index that is comparable across countries and the fact that I created a new cross sectional data base with not only a large amount of countries, but also regions, which makes the results more reliable and generalizable, is what makes this research unique.

In the next section, the importance of stunting and its consequences will be discussed. Furthermore, the theoretical framework of my research will be presented and from this I will formulate my hypotheses. Section 3 describes the choice of data and method. The results that follow are presented and discussed in section 4. At the end, there is a concluding section.

2. Theoretical framework

As stated before, goal number two of the Sustainable Development Goals is to end hunger everywhere in the world. A specific target that is included in this goal is to ensure that no child is suffering from stunting by 2030 (United Nations, 2015). Although stunting rates have improved since the adoption of the SDG's, we are still far from a world without stunting.

In this chapter I will first describe and analyze how stunting rates have developed the last decades and since the adoption of the Sustainable Development Goals. Furthermore, the emergence of stunting and its short- and long-term consequences will be discussed. The final section of this chapter contains information on previous studies that have analyzed the determinants of stunting. These range from phenomena that start already in utero, e.g. the eating habits of the mother, to poverty and income levels and to the environmental and social characteristics of the household. The variables that will be included in my research will be introduced, as well as my expectations about their association with the stunting rate.

2.1 Prevalence and consequences of stunting

For a third consecutive year, the number of people suffering from hunger rose again in 2017, with the highest prevalence of undernourishment in Africa. Although, stunting rates globally declined from 199.5 million children under 5 in 2000 to 144 million in 2019, we are still far from a world without malnutrition and the rates are declining too slowly (WHO, 2020). More than half of all stunted children live in Asia and about 40% in Africa. However, Asia has made impressive progress in bringing down the number of stunted children, while Africa is the only region in the world where stunting rates have risen.

According to the World Health Organization, a child is considered stunted if its height-for-age Z-score (HAZ) is two standard deviations below the median of the reference population (WHO, 2006). Stunting means that a child is too short for its age and this has severe consequences, both in the short- and in the long-run. Poor nutrition, both in utero and early childhood, are the direct causes of stunting. The result is that the brain of these children that suffer from stunting may never develop to its full cognitive potential and this leads them to begin their lives with a huge disadvantage. They will likely have learning difficulties in school, which leads to low productivity in adulthood as well, which in turn leads to a lower income (Akombi et al., 2017; De Onis & Branca, 2016; Monteiro et al., 2009). Furthermore, to be able to participate in their communities they will have to face more barriers than non-stunted children, this can lead to severe psychological issues (WHO, 2020). Stunting also has severe consequences on the macro-level, since this low productivity in adulthood affects the economic development of the entire country. According to Mary (2018), a one percentage point increase in stunting rates leads to a 0.4% decrease in GDP per capita. Calculations suggest that on average the costs of stunting for developing countries is 13.5% of GDP.

Stunting can be seen as an intergenerational cyclical process that is extremely difficult to break (Martorell & Zongrone, 2012). Since these strong intergenerational effects are known, there has been more interest in the concept of stunted families rather than just stunted children. Being born to poor parents is the strongest risk factor for being poor yourself. Women who themselves suffered from stunting in their childhood often have to deal with poverty and reduced human capital in adult life and tend to have stunted offspring. Since the fetus is solely dependent on the mother and her nutritional status in the utero, stunting begins here already and continues for at least the first two years of the child's life, postnatal. Stunting is, therefore, considered a condition that is determined in the first 1000 days. Furthermore, in these first two years of life, environmental and socio-economic factors, such as maternal nutritional status, feeding practices, access to healthcare and hygiene and sanitation, are the major determinants of growth (Prendergast & Humphrey, 2014). Study also shows that the first few months of life are critical for long-term neurodevelopment. Proper nutrition is therefore essential for the development of the brains, without it, the brains will not reach their full cognitive potential (Pongcharoen et al., 2012). Not only insufficient nutrition can lead to stunting in utero, but if the body of the mother is too small, limited room to grow can also obstruct the development of the fetus. The 6-24 month age period is of special importance because most of the decline in the length-for-age takes place during this complementary feeding period. In this period the child is introduced to other foods than breastmilk. The environmental factors that have an influence on growth and development are now playing a bigger role, since the child becomes more independent and mobile (Stewart et al., 2013).

As becomes clear, the origin of stunting depends on a great deal of factors on different levels. To illustrate this, the WHO has developed a conceptual framework on childhood stunting: Context, Causes and Consequences. The complete framework can be found in the appendix. It shows that in the first place inadequate complementary feeding, breastfeeding, infection and household and family factors are the direct causes of stunting. However, on a higher level, the context, that includes community, cultural and societal factors, in turn affects these causes. The causes and consequences of stunting are thus a complex web of different factors on different levels that all play a role. It is, therefore, extremely hard to design one effective policy that is sufficient to deal with this global health issue. Rather, a combination of different policies that are focused on different aspects of the framework is preferred. I will now go into more detail on the different determinants of stunting.

2.2 Determinants of stunting

Although it is clear that poor nutrition is the direct cause of stunting, to be able to tackle the problem, we need to know the underlying determinants of stunting. Since it might not be the case that the presence of proper nutritional foods is the problem, but rather the fact that mothers do not know how to properly nurture themselves during pregnancy and their children later on. The paper of Bhutta et al. (2008) analyzes the effect of several interventions aimed at reducing maternal and child undernutrition. These measures include promotion of breastfeeding, promotion of food supplements that contain the right

vitamins for pregnant women and children, general strategies to improve family and community nutrition, promotion of handwashing and promotion and education of complementary feeding. Although the promotion of breastfeeding has a substantial influence on survival rates of children, its effect on stunting is rather small. In contrast, the promotion of complementary feeding and the provision and education of proper food supplements, did have an effect on the height-for-age scores of children. Other papers that analyze the effect of provision of food supplements for communities with the right vitamins and minerals to enhance the nutritional status of the children come to the same conclusion (Black et al., 2013; Hoddinott et al., 2008). Hoddinott et al. (2008) even add to this that improvements in early childhood nutrition can affect long-term economic growth. They show that as a result of investments in early childhood nutrition, wage rates for men increased substantially. However, all of these interventions have in common that they do have an impact on stunting, but on their own they are not enough to completely solve this problem. These interventions should be supplemented with policies aimed at improving other underlying determinants of undernutrition, such as poverty.

There exists a long line of research that analyzes the effect of an increase in income on undernutrition or stunting rates, since it is expected that higher income will lead to better health, both at the macro- and micro-level. At the macro-level, it is expected that a higher GDP will lead to higher aggregate investments in healthcare by the government. At the micro-level, higher income means that parents have more resources to invest in the nutrition of their children. However, due to inequality, the benefits of a higher GDP per capita might not always reach the poorest people and thus there are no improvements in the health status of these children (Harttgen, Klasen & Vollmer, 2013). It remains, therefore, an open and highly debated topic of what the role of economic growth is in decreasing child undernutrition. Both the papers of Haddad et al. (2002) and Smith & Haddad (2002) model the relation between child underweight and GDP per capita. Both of them conclude that income growth is able to produce a sizable reduction in child underweight, but at the same time admit that income growth alone is not enough to completely solve the problem. However, these papers use underweight as a proxy for undernutrition. This is a problem because of a worldwide transition to food that is higher in sugar and fat, this is called the nutrition transition. This means that although the weight of children might have increased, their nutritional status has not improved. Therefore, I prefer to focus on stunting in this study, because this is the most prevalent form of undernutrition and it is a good reflection of children's long-term nutritional status. Klasen (2008), who examines the determinants of stunting, also concludes that GDP per capita has a robust influence on undernutrition, but that this effect is small.

There are, however, also plenty of papers that do not find a strong, negative relation between income growth and child undernutrition (e.g. Harttgen, Klasen & Vollmer, 2013; Mary, 2018; Subramanyam et al., 2003; Vollmer et al., 2014). Besides income growth, the paper of Harttgen, Klasen & Vollmer (2013) also includes an asset index that is based on the consumer durable goods a household possesses to determine its material status and indicators to represent the housing quality. This index not only represents monetary wealth, but is a broader indicator of relative socio-economic status. The

authors conclude that not an increase in absolute income, but rather this index is a far more important determinant of child undernutrition. The papers of Headey, Hoddinott & Park (2016) and Hong, Banta & Betancourt (2006) are in line with these findings. Their study also shows that household socio-economic characteristics, wealth and parental education in particular, have an influence on child health and early cognitive development, factors that are a result of stunting (Paxson & Schady, 2007). Children of wealthier and higher educated parents in Ecuador performed considerably better on a vocabulary test used to assess language ability. All of these papers show that not income growth, but individual and household characteristics (for example: education of the mother, location of the household, assets of the house) are very important determinants for child undernutrition outcomes. However, all of these papers suffer some limitations. The asset indexes that are included in Harttgen, Klasen & Vollmer (2013) and Hong, Banta & Betancourt (2006) are based on the durable assets a household owns and contain no further information on the household's access to clean drinking water or sanitation. The paper of Headey, Hoddinott & Park (2016) does include more information on the environmental circumstances of the household, but their findings are limited to only four South Asian countries.

As said, studies that analyze the relation between the assets and the characteristics of the household and child undernutrition are scarce. In particular, there is no existing paper that researches the relation between the International Wealth Index (IWI) and child stunting. The IWI is an index that is computed by Smits & Steendijk (2015). The IWI is quite similar to the wealth indices that are included in the Demographic and Health Surveys (DHS), but it adds the possibility to compare households across place and time. Therefore, it is the first asset based index that can be used to evaluate and compare the long-term economic status of households across all regions of the developing world. This property of comparability is thus an improvement in comparison to the asset index based on the DHS surveys and makes broad and comparative research possible. The IWI is constructed with information that is collected through household surveys on the possession of consumer durables, access to basic services and the characteristics of the house. It can have a value between 0 and 100, where 0 means that the household has none of the assets and the lowest quality housing and 100 if the household has all of the assets and the highest quality of housing. As stated above, it is crucial to understand the determinants of child stunting and since previous research shows that asset ownership could be an important indicator, analyzing the relation between this improved asset index, the IWI, and child stunting can have important implications for policy makers. Therefore, the IWI is the major independent variable and stunting is the dependent variable of this study. I hypothesize a negative relation between these two variables. This means that in regions where households possess more consumer durables and housing quality is higher than in other regions, the value of the IWI will be higher, and the stunting rate in these regions will be lower. This hypothesis is based on the knowledge that all of the aforementioned researches that included the asset based index of the DHS program found significant results that this indicator of socio-economic status is more important for determining stunting outcomes than absolute income. Besides earlier studies of Harrtgen, Klasen & Vollmer (2013) and Headey, Hoddinott & Park (2016), there are a few more

researches that take the socio-economic characteristics into account. Wamani et al. (2004) conclude that the education of the mother is the most important determinant for child health inequalities in Uganda, but that the asset index is the second most important indicator. Several other studies that are conducted in different African countries all highlight the importance of socio-economic factors on the nutritional status of children. They conclude that a low socio-economic status of the family is associated with a higher risk of being stunted (e.g. Kikafunda et al., 1998; Ukwuani & Suchindran, 2003; Vella et al., 1994; Zere & McIntyre, 2003). Since the IWI is in essence the same as the asset index that is included in the DHS, but has the advantage that it can compare households across time and place, my expectation will be that, just as the asset index, the IWI will be an important determinant for stunting outcomes.

As stated above, the IWI takes into account the consumer durables a household possesses, how easy the access to basic services is and the characteristics of the house, by doing this, it measures the material well-being of a household. The material well-being of a household is closely related to its economic situation. Since buying more consumer durables or a house of better quality comes at a price, and wealthier households have more possibilities to pay this price. This close relation between the economic and material well-being of a household has resulted in a strong growth in the use of wealth indices that measure the economic status of households by using information on asset ownership. They are considered to be effective in indicating the long-term socio-economic position of a household and often perform better in explaining variations in education, nutrition, health care use and child mortality (Howe, Hargreaves & Huttly, 2008). Just as the IWI, the prevalence of stunting is also a good indicator of inequalities in human development. Countries with a higher stunting rate, also tend to have larger socio-economic inequalities (Prendergast & Humphrey, 2014). As they are both indicators of inequalities in socio-economic status, the IWI can also be a good predictor for stunting rates. For example, one of the consumer durable goods that included in the construction of the IWI, is whether or not the household owns a fridge. You can imagine that owning a fridge can have an influence on the nutritional status of the children and thus on their chance of being stunted. Since a fridge means that you can store your food in a cool place, so it will spoil less quickly and keep its nutrients. Another way the IWI can have an influence on stunting rates is through the access to basic services, which is also a component of the wealth index. Having easy access to water, for example, means that you can wash your fruit and vegetables in clean water to get rid of any bacteria. However, more important is that the children have access to clean drinking water. If this is not the case, there is a higher chance on infections and diarrhea. This could mean that the body is occupied with fighting the disease and has less energy to focus on the development of the child, which could result in stunting. The IWI can thus have an influence on stunting rates through the different components that are included. However, the extent to which this is possible will also depend on the specific characteristics of the household.

2.3 The role of the circumstances

Previous research has shown that there is great variation in the way stunting rates are influenced by the asset index (e.g. Harttgen, Klasen & Vollmer, 2013; Headey, Hoddinott & Park, 2016; Schrijner & Smits, 2018). Therefore, there is also an important focus in this paper on what kind of role the circumstances play in this relation. The extend to how important the asset index is, depends on specific characteristics of the household and its members and the context it is placed in. Different factors that are supposed to have an influence on stunting rates are discussed here: parental education, presence of grandparents, characteristics of the household, characteristics of the child. Furthermore, there are also some control factors that will be taken into account.

2.3.1 Parental education

There has been a lot of attention in previous research for the effect of parental education on child undernutrition outcomes. Parental education, and the mothers education in particular, is the variable that is present in all other researches in this area and has a significant impact on child stunting (e.g. Akombi et al., 2017; Alderman & Headey, 2017; Harttgen, Klasen & Vollmer, 2013; Headey, Hoddinott & Park, 2016; Hong, Banta & Betancourt, 2006; Keino et al., 2014). Higher educated mothers and fathers are expected to provide better protection for their child in comparison to parents with less education. Higher maternal education is associated with greater healthcare utilization and adoption of modern medical practices, which leads to better health-related decisions that improve the nutritional status of the children. Furthermore, a higher education of the father leads to a higher household income and food security. However, depending on the different settings, the relative importance of maternal and paternal education levels might vary. For example, in Bangladesh the position of women is very weak, so here the paternal level of education is more important than that of the mother (Semba et al., 2008). Since, in most African countries the mothers are the primary caregivers for the children, it is expected that the maternal level of education will have a stronger effect on stunting than that of the fathers (Sear & Mace, 2008). Since all other researchers found a significant effect between a higher maternal education level and stunting outcomes, I also expect to find a negative relation. Researches where an asset index was included, also showed an association between parental education and the asset index (Alderman & Headey, 2017). Higher educated women are more able to efficiently use limited household resources. I will, therefore, also include an interaction effect between the IWI and the educational level of the woman to see what the effect of this is on the stunting rate.

2.3.2 Presence of grandparents

Another important determinant for child stunting outcomes, could be the presence of grandparents. It is known that there is a substantial number of children in sub-Saharan Africa that are living in the same household as their grandparents. There are several reasons why this number is so high in sub-Saharan Africa particularly. One of these is the overall high mortality rate of SSA. If children

loose one or both of their parents, it is very common that they come to live with their grandparents. In some areas it is also quite common that parents migrate to work elsewhere and the grandparents take over the care of the children. A final reason could be tradition, in some tribes it is common use that the children move into the grandparents' home after marriage (Schrijner & Smits, 2018). If the grandparents are co-residing, they have a low threshold to help in taking care of the children and since they already have experience with raising children, they can give valuable advice that would increase the well-being of the children and thus also reduce the chance of stunting (Gibson & Mace, 2005; Mtshali, 2015; Schrijner & Smits, 2018). Based on this knowledge, I expect to find a negative association between the presence of grandparents and stunting rates. Just as with experience in raising children, grandparents might also have experience in how to use household resources in the most efficient way. Furthermore, they might have better knowledge on what consumer durables get priority when the household can afford a new purchase. Therefore, I will also take into account an interaction effect between the IWI and the presence of grandparents.

2.3.3 Characteristics of the household

For the characteristics of the household, there are two indicators in particular that are important. Namely, the number of people living in the household and the location of the household. With respect to the number of people living in the household, there is evidence of a positive relation between the number of people living in the house and the odds of being stunted (Darteh, Acquah & Kumi-Kyereme, 2014). With more people and children living in the household, there are more mouths that need to be fed and this means that the average amount of calories per person decreases. Especially when the mother is pregnant, she has less attention for the other children and thus they are at more risk of being stunted (Harttgen, Klasen & Vollmer, 2013). My expectation is to find a positive relation between the number of people living in the household and stunting rates.

The other characteristic of the household that is important to take into account, is its location, in particular whether it is situated in a rural or urban area. Living in a rural area usually means that the availability and access to essential food groups that contain the proper vitamins and nutrients is lower than living in an urban area, where there are more grocery stores to get food supplies. Therefore, children that live in a rural area have a higher chance of being stunted (Akombi et al., 2017); Darteh, Acquah & Kumi-Kyereme, 2014). Furthermore, in rural areas the access to a safe source of drinking water, health services and sanitary facilities are also lower. This exposes children living in these areas to higher chances of getting diarrhea and infectious diseases, which increase the odds of being stunted (Chirande et al., 2015; Headey, Hoddinott, & Park, 2016).

2.3.4 Characteristics of the child

Finally, there are two indicators that are related to the characteristics of the individual child that are important for stunting outcomes: the sex of the child and if and how long a child is breastfed.

Breastfeeding is extremely important for the development of babies in the first months of their lives. However, it is also important that breastfeeding does not continue for too long, because after six months the child needs different nutrients and a more diversified diet (e.g. Akombi et al., 2017; Tumwine & Obala, 2002; Ukwuani & Suchindran, 2003). In developing countries it is often the case that mothers do not have the right knowledge and education to transfer from breastfeeding to complementary foods and this means that these children have a higher chance of suffering from stunting. The other important individual characteristic is the sex of the child. Study shows that in African countries boys are more stunted than girls (Akombi et al., 2017; Chirande et al., 2015; Darteh, Acquah & Kumi-Kyereme, 2014; Wamani et al., 2007). The paper of Wamani et al. (2007) proposes two different reasons for this difference in stunting prevalence. The first one is that there is a historical preference for females because of the high value placed on the agricultural labour women. The second one is a biological explanation, namely that boys in general are more vulnerable to diseases and have a higher morbidity rate. It remains unclear why boys are in general more stunted than girls.

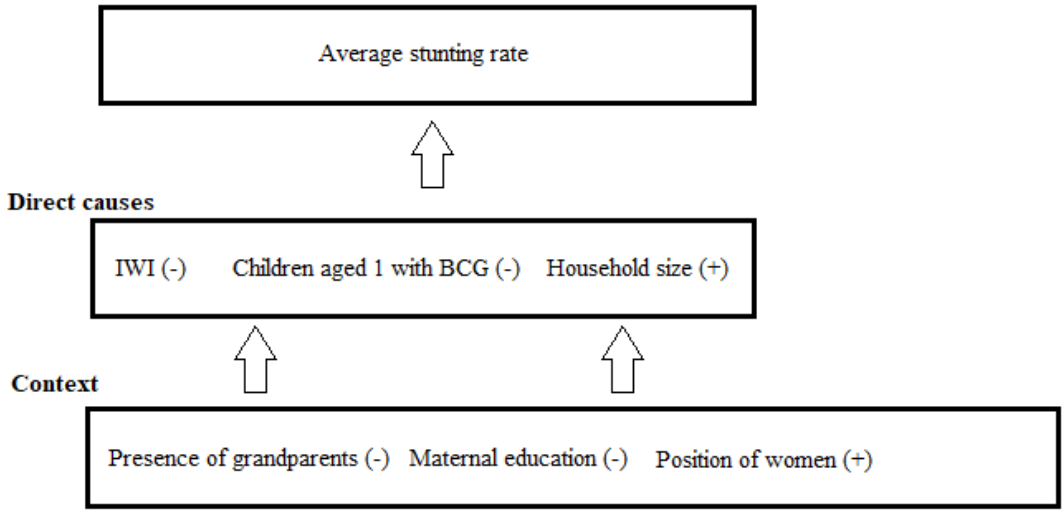
2.3.5 Control factors

Other factors that may affect stunting are whether or not a child has been vaccinated with BCG and the relative position of women. Besides the specific target of the BCG vaccine, it also has some side effects. For example, it increases the immune responses and protects the child against other, unrelated pathogen (Berendsen et al., 2016). Therefore, it could be that being vaccinated early on in life with BCG could reduce the chance of being stunted. The percentage of children that is vaccinated with BCG might also interact with the value of the IWI, since the travel time to healthcare posts that provide the vaccines turns out to be a barrier for remoted communities (Okwaraji et al., 2012). In the composition of the IWI, the location of the household (rural vs. urban) and the possession of consumer durable goods, for example a car, are taken into account. This means that wealthier households have more opportunities to get their children vaccinated and this decreases the chance of being stunted.

Study shows that better health outcomes for children is associated with a stronger position of women (Mahapatro, 2012; Mukherjee & Das, 2008). In most SSA countries, the women are not only responsible for raising and educating the children, but also for their economic support. If women have a stronger position and have more freedom to nurture the children in their own way, this could lead to a lower percentage of stunted children. Furthermore, study indicates that there could exist an interaction between the relative position of women and the household size. Family life in sub-Saharan Africa is characterized by a tradition of polygyny, which in turn is associated with marriage at an early age for women (Locoh, 1988). Due to the big age difference between husband and wife, which is a proxy for the position of women, widowhood is common. However, since these women also remarry rapidly, this results in a high fertility rate and thus a higher average of household members (Timæus & Reynar, 1998). This higher average of household members can, in turn, lead to a higher chance of being stunted, since the household resources have to be divided between more children. This means that I expect a

positive association between the position of women and the average stunting rate, but a negative association when the position of women is taken up in an interaction term with the household size. Figure 1 is an illustration of the model which I will analyse in this paper. It also shows the expected associations with the average stunting rate. As you can see, I differentiated between factors that have a direct effect on the stunting rate and contextual factors. The IWI directly influences the chance of being stunted, since, for example, the presence of a fridge affects the condition of the food, as is explained above. The same goes for children that are vaccinated with BCG and the household size, since the BCG vaccine directly influences the health status of children and the household size determines the division of the household resources. On the contextual level there are also three factors that influence the stunting rate, but in a more indirect way. If the grandparents are present, they can advise the mother to spent the household resources in an efficient way or encourage her to get her children vaccinated and in this way they can influence the chance of being stunted. The same applies to the educational level of the mother, a higher education might mean that she has more knowledge of the benefits of vaccines or the most efficient way to spent her income. Finally, the position of women can also indirectly influence the stunting rate through, for example, the household size. As is explained above, a weaker position of women is usually combined with a higher household size and this means that there are more mouths to feed. To control for this, I will also include interaction effects in my model.

Figure 1 Illustration of the model



3. Data and method

3.1 Data

For this study, combined datasets from the Global Data Lab have been used (GDL; https://globaldatalab.org/). The Global Data Lab was founded by Jeroen Smits, who is also one of the authors of the paper on the construction of the IWI (Smits & Steenwijk, 2015). This data lab combines many large-scale representative household surveys that have been conducted in developing countries. These include the Demographic and Health Surveys, the UNICEF Multiple Indicator Cluster Surveys and some other sources (PAPFAM, LSMS, ILO-IPEC, IPUMS). These different surveys are not only brought together and enriched with contextual data, but they are also made comparable. These surveys contain information for millions of individuals on their demographic, socio-economic and health situation. More than that, they also include the socio-economic and environmental characteristics of the household. At the moment, over 135 countries from all regions of the developing world are covered in the data that is collected from all of these different surveys. Apart from national data, they also provide context information for 1200 sub-national regions within these developing countries.

From the Global Data Lab site I have extracted the available stunting data for 40 SSA countries for the period 2000-2018. For each country only the years in which the surveys actually have been conducted are taken into account. This way, I only make use of real values and the number of missing data points in minimal. This data is complemented with the data on the control variables. Since, I also want to take into account the difference between the urban and rural areas, I do not only make use of national data, but also the sub-national regions. This has the additional benefit that it increases the number of data points. Initially the data set contained 40 sub-Saharan countries, however due to missing values seven countries had to be removed from the data set. These countries are: Botswana, Central African Republic, Djibouti, Guinea Bissau, Somalia, South Sudan and Sudan. For each of these countries one or several variables were missing for all of the survey years. For the remaining 33 countries, there were also some years that were missing one or more variables. For these countries, the variable adjustment method has been used. The mean of the missing variable is based on the survey years of that country that were available. After these adjustments there were 1346 data points left.

3.2 Method and variables

For my research, I will use child stunting as the dependent variable. This is measured as the average stunting rate for each country and region. Other researches in this field preferred to focus on undernutrition by combining the indicators stunting, wasting and underweight (Akombi et al., 2017; Harttgen, Klasen & Vollmer, 2013; Subramanyam et al., 2011). However, due to the aforementioned nutrition transition, underweight is not a sufficient indicator for the nutritional status of children. Furthermore, since stunting is the most prevalent form of undernutrition worldwide and it reflects the long-term nutritional status and development of children, in contrast to wasting, which is more focused

on the short-term (Black et al., 2013), I choose to focus solely on stunting in my research. With this approach, I follow several other studies in this field that have done the same (e.g. Chirande et al., 2015; Headey, Hoddinott & Park, 2016; Hong, Banta & Betancourt, 2006). To determine whether a child is stunted or not, the growth standards set by the World Health Organization (WHO) are taken into account. The WHO has developed the HAZ-score, which is the height for age score, and when the HAZ-score of a child is 2 standard deviations below the median of the reference population, a child is considered stunted (WHO, 2006). Most studies in this field use data from the Demographic Health Surveys (DHS) program to conduct analyses on the individual level. However, since my main explanatory variable is the IWI, and this is only available at the household and regional level, this is not possible for my research.

The main explanatory variable in my research will be the International Wealth Index (IWI). This is a wealth index that it based on the possession of consumer durables and housing characteristics. Because asset based wealth indices are relatively easy to compute and the measurement is reliable, since it is easy to see whether or not someone owns a car, they are widely used instruments to measure the economic situation of households. Most of the household surveys that are available, among which the DHS, do include such an asset based wealth index. However, one big problem they all suffer from is that the indexes are not comparable between surveys. Each survey has its own wealth index with different measurement scales, this makes it impossible to study differences in household wealth among countries. With this purpose, the IWI was created. This general index uses the same scale for each household and each country, so the economic situation of households in all regions of the developing world can be measured. The IWI is constructed with information that is collected through household surveys on the possession of consumer durables, access to basic services and the characteristics of the house. It can have a value between 0 and 100, where 0 means that the household has none of the assets and the lowest quality housing and 100 if the household has all of the assets and the highest quality of housing. Because of the fact that the IWI uses the same formula for each household regardless of the country it is in and that it is based on the information of nearly two million households, I prefer to use the IWI instead of the asset index that is included in the DHS.

As mentioned before, there are numerous other variables that are of importance for child stunting outcomes and it will be interesting to see how these affect the relation between the IWI and stunting. Therefore, as control variables I want to include the educational level of the mother, the number of people living in the household, with in particular the presence of grandparents, whether or not a child is vaccinated with BCG and the relative position of women. For the educational level of the mother, the mean years of education of women aged 20+ will be used. The number of people living in the household is indicated by the average household size. To control for the fact whether or not there are co-residing grandparents, the percentage of households where couples live with parents of the wife will be included. This is preferred over the percentage of households where couples live with the parents of the husband, because study shows that the maternal grandmother is more likely to take on the role of the traditional

supportive grandparent and improves the survival rate of children (Gibson & Mace, 2005; Mtshali, 2015; Sear & Mace, 2008). The percentage of children aged 1 that is vaccinated with BCG will control for the potential side effects of this vaccine. The mean age difference between husband and wife will serve as a proxy for the relative position of women. With this approach, I follow earlier research (Luz & Agadjanian, 2015; Schrijner & Smits, 2018; Spierings, Smits & Verloo, 2010).

The data on child stunting, the IWI and the control variables will be merged for the time period from 2000 till the latest data available for sub-Saharan African countries. With this multilevel data set I will perform my analysis. As said before, most papers use the individual stunting data from the DHS program and perform logistic regressions. Since it is impossible to match an individual stunting rate with an IWI score for the regional level, I will not follow this approach. The IWI scores are also available at the household level, however the data on child stunting, as well as all of the control variables, are only available at the regional level. This results in a data set with two levels, e.g. the country and regional level, where the regions are nested in the different countries. Although all of the included countries are situated in sub-Saharan Africa, they still differ greatly in terms of their level of development. Therefore, I prefer to use the random coefficient model instead of the random intercept model. This model allows the effect of the explanatory variable, the IWI, to vary between the different countries (Hox, Moerbeek & Van de Schoot, 2010). This is based on the expectation that the effect of an extra point on the IWI scale in a country where the level of development is relatively higher will be smaller in comparison to countries with a lower development. To run the regression I have used Stata 16 for Windows.

4. Results

4.1 Descriptive statistics

Table 1 shows the desriptive statistics of all of the included variables. The mean stunting rate at the regional level of all countries present in this sample is 35.22%. With the highest stunting rate of 70.80% being registered in the Kebbi region in Nigeria in 2003 and the lowest of 7.3% in Senegal, Dakar in 2017. The IWI, which has a maximum of 100, ranges from 4.02 to 86.3. The lowest value is recorded in Northeastern Kenya in 2003. However, 5 years later this value has already increased to 14.4. The Western Cape in South Africa in 2016 is the region with the wealthiest households. Another thing that stands out is that the percentage of children aged 1 that is vaccinated with BCG ranges from 0 to 100, but that the mean is 85.61%. This shows that most children in sub-Saharan Africa are vaccinated with BCG.

Table 1 Descriptive statistics of the included variables

Variable	Observations	Mean	Standard deviation	Minimum	Maximum
Average stunting rate	1346	35.22	11.64	7.3	70.8
International Wealth Index	1346	31.19	15.54	4.02	86.3
Education females 20+	1346	4.10	2.47	0.13	11
Mean age difference	1346	7.88	2.42	0.13	14.3
Matrilocal households	1346	1.92	1.37	0	10.5
Household size	1346	7.14	2.25	4.09	20.4
Children aged 1 with BCG	1346	85.61	16.02	0	100

In table 2 the correlations between all of the included variables are shown. The highest correlations are between the stuntingrate and the international wealth index (-0.6715), which makes sense, since previous studies that include a similar asset-based index also found a strong negative association with the stunting rate (Harttgen, Klasen & Vollmer, 2013; Headey, Hoddinott & Park, 2016; Schrijner & Smits, 2018), and between the average household size and the mean age difference between husband and wife (0.6783). This higher correlation can be explained by the fact that family life in sub-Saharan Africa is characterized by a tradition of polygyny, which in turn is associated with marriage at an early age for women (Locoh, 1988). Due to the large age difference between husband and wife, widowhood is common. However, since these women also remarry rapidly, this results in a high fertility rate and thus a higher average of household members (Timæus & Reynar, 1998). None of the correlations are high enough to cause any problems during my analysis.

Table 2 Correlations between all variables

	1	2	3	4	5	6	7
Stunting rate (1)	1.0000						
International Wealth Index (2)	-0.6715***	1.0000					
Education females 20+ (3)	-0.4105***	0.5524***	1.0000				
Mean age difference (4)	-0.1368***	0.0546**	-0.5195***	1.0000			
Matrilocal households (5)	-0.2075***	0.0865***	0.1277***	-0.1290***	1.0000		
Households size (6)	-0.1736***	0.1014***	-0.4970***	0.6783***	0.0276	1.0000	
Children aged 1 with BCG (7)	-0.3324***	0.2127***	0.3220***	-0.3344***	0.2001***	-0.0210	1.0000

***P<0.01 **P<0.05

Before I started my mutlilevel analysis, I checked whether all of the included variables were normally distributed. For some variables the normal distribution improved considerably when they were transformed to the log or exponential form. This is the case for the international wealth index, matrilocal households, the household size and children aged 1 with BCG. The IWI, matrilocal households and the household size are transformed to the log function and the children aged 1 with BCG to the exponential form. Next, I run a normal OLS regression to check whether the data was suitable for a more advanced analysis and this regression also formed the base for the multicollinearity, autocorrelation and possible influential outliers test. In this regression and all of the other models, I included a year dummy. This is to control for time trends that affect to whole sample. The results of the multicollinearity test can be found in the appendix. If this critical value is between the five and ten, there is multicollinearity. Since the variance inflation factor is 2.11, there is no multicollinearity in the data, what also became evident form the correlation table.

I also tested for autocorrelation by performing the Durbin-Watson test. With 8 explanatory variables and almost 1350 data points, the critical dL value is 1.862 and the dU is 1.885. Considering the d-statistic from the Durbin-Watson test of 1.211, I concluded that there was autocorrelation in my data set. To treat this, I run a Prais-Winsten regression. The results of both the OLS and Prais-Winsten regression can be found in table 4. Although, the coefficients change somewhat in their strength, none of them change in direction or become insignificant after the transformed Durbin-Watson statistic.

Table 3 Results of the Prais-Winsten regression

	OLS regression	Prais Winsten regression
Dependent variable:	(1) Average stunting rate	(1) Average stunting rate
International Wealth Index	-8.923***(0.634)	-6.418***(0.663)
Education females 20+	-1.256***(0.152)	-1.767***(0.169)
Matrilocal households	-1.867***(0.248)	-2.034***(0.272)
Household size	-1.600(1.293)	-2.291(1.432)
Mean age difference	-1.622***(0.140)	-1.659***(0.161)
Children aged 1 with BCG	-0.00106***(0.000109)	-0.008***(0.000)
Year	-0.160***(0.0477)	-0.249***(0.064)
Constant	416.5***(95.30)	589.6***(128.53)
Observations	1,326	1,326
R-squared	0.566	0.530
Standard errors in parentheses		Durbin-Watson statistic (original) 1.211
*** p<0.01, ** p<0.05, * p<0.1		Durbin-Watson statistic (transformed) 2.216

I also checked partial plots between the stunting rate and all of the included variables to see whether outliers or influential cases have to be removed from the data set. None of the plots show any signs of clustering and since the data set contains almost 1350 data points, it is very unlikely that one data point will be an influential case.

4.2 Multivariate analysis

Table 4 presents the results of the multilevel random coefficient regression analysis with the average stunting rate as dependent variable, both with and without interaction terms. The associations of the control factors with the stunting variable are mostly in line with the literature and my expectations. The average stunting rate is lower if the mother has followed education, they live with the parents of the mother, the mean age difference between husband and wife is higher and the child is vaccinated with BCG. A higher number of people living in the household is associated with a higher stunting rate, which results in the expected positive relation. However, the log function of the household size and children aged 1 with BCG are the only variables that are not significant on a 10% level. The only association that is not according to my expectations is the relation between the stunting rate and the mean age difference between husband and wife. I expected to find a positive relation, but the table shows a negative relation. An explanation for this could be that when the position of women is relatively weak, they are likely to also have a lower education and low employment opportunities. This means that they can focus all their attention and time on nurturing the children and this would result in a lower stunting rate.

Regarding the relationship between my main explanatory variable, the IWI, and the stunting rate I observe a significant negative association. When controlling for circumstantial factors, a one-point increase in the value of the IWI, is associated with a 4.91 drop in the average stunting rate. The intra-

class correlation is 0.526 which means that 52.6% of the intercepts are captured by the level 2 variable, which is the country level. This means that most differences are per country and not per region.

Table 4 Random coefficient model with and without interactions

	Random coefficient model without interactions	Random coefficient model with interaction
Dependent variable:	(1) Average stunting rate	(1) Average stunting rate
International Wealth Index	-4.905***(0.794)	0.476(1.518)
Education females 20+	-2.147***(0.286)	-1.911***(0.273)
Matrilocal households	-1.131***(0.401)	-1.056***(0.402)
Household size	0.0355(1.723)	-12.48***(4.509)
Mean age difference	-0.922***(0.205)	-3.438***(0.927)
Children aged 1 with BCG	-0.000260(0.000194)	0.00201***(0.000590)
Year	-0.305***(0.0432)	-0.313***(0.0430)
IWI * Children aged 1 with BCG	-	-0.000768***(0.000186)
Household size * Mean age difference	-	1.303***(0.468)
Constant	682.8***(86.35)	705.0***(87.30)
Observations	1,326	1,326
ICC	0.526	0.468
Wald Chi2	389.63	502.20

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

To control for any interactions between the explanatory variables, I also performed the random coefficient model with interactions. Only the interactions that resulted in a significant effect were kept in de model. There are a few things that stand out in comparison to the random coefficient model without the interactions. The first is that the coefficient of my main explanatory variable, the IWI, not only becomes insignificant, but also changes from a negative to a positive association. However, this is negligible since in this model the IWI is included in an interaction term, which has the expected negative sign and is significant. Also the household size variable changes from sign, but now from positive to negative and is now significant on a 1% level. This negative association is against my expectations, however, the interaction term between the average household size and the mean age difference between husband and wife does have the expected positive sign and is also significant on a 1% level. A final thing worth noticing is the value of the Wald Chi, this increases from 389.63 in the model without interactions to 502.20 in the model that does include interaction terms. This shows that the random coefficient model that does include interactions is a better fit. For this model, the intra-class correlation is 0.468, which means that now the most differences are per region and not per country. This is most likely due to the interaction terms, and the one between the IWI and children aged 1 with BCG in particular. Table 1 shows that the IWI ranges from 4 to 86 and children aged 1 with BCG from 0 to 100.

With two variables combined with such large variations, this leads not only to differences between countries, but also between regions.

4.3 Robustness check

Since 160 out of 1346 of my observations come from Nigeria, which is 11.89%, I ran the same model, but this time Nigeria was left out as a robustness check. The results of this can be found in table 6 in the appendix. If I compare these results with those in table 4, I can conclude that most of my findings stay consistent. Although, the coefficients change somewhat in their value, almost all of them, except household size, do not change so much that it would indicate that Nigeria has a large influence on the sample. If Nigeria is left out of the sample there are two things that change: (1) in the model without interactions the household size variable changes from an insignificant positive relation to a negative association that is significant on the 10% level and (2) in the model with interactions, the interaction term between the household size and the mean age difference is no longer significant on the 1% level, but on the 5% level. Overall, I can say that my results stay the same, this enhances the external validity of this research.

5. Conclusion and discussion

Using a unique database with information provided by the Global Data Lab on 1346 different countries and regions for the period 2000-2018, I examined the relationship between the value of the International Wealth Index (IWI) and children's stunting in 33 SSA countries. This paper is the first to conduct such a broad comparative research that includes such a large amount of included countries and regions. Besides an interest in the general association between the value of the IWI and the average stunting rate, I also wanted to know how the socio-economic, environmental and cultural characteristics of the household would influence this relationship.

I found broad evidence that the average stunting rate is significantly lower for regions where the value of the IWI is higher in comparison with household that are less wealthier. This finding is in line with my hypothesis that I formed in chapter 2, where I expected to find a negative association between the IWI and the average stunting rate. This was based on the expectation that the IWI can influence the stunting rate through all of the different components that are taken into account in the composition of the index. For example, whether or not the household is in possession of a fridge can have a substantial influence on the chance of the children being stunted, since this protects the food from rotting. Another critical point is the access to clean drinking water, which is also included in the IWI and is of great importance for the health status of children.

Since all previous literature found a negative association between the educational level of the mother and the stunting rate (e.g. Akombi et al., 2017; Alderman & Headey, 2017; Harttgen, Klasen & Vollmer, 2013; Headey, Hoddinott & Park, 2016; Hong, Banta & Betancourt, 2006; Keino et al., 2014), I also expected to find this relation and this hypothesis was indeed confirmed by the data. Mothers with a higher education have a better understanding of modern medicines and have more knowledge about the proper way to nurture their children. The same goes for when the grandparents, and the grandmother in particular, are present. They have experience with raising children and can give valuable advice, which results in a positive influence on the chance of stunted children (Gibson & Mace, 2005; Mtshali, 2015; Schrijner & Smits, 2018). Following previous studies, I therefore expected to find a negative association between the households where the couple lives with the parents of the mother and the average stunting rate. In all of the models this negative relation was confirmed, which means that besides the value of the IWI, the presence of grandparents is also an important determinant for stunting outcomes. A final variable that turns out to be important for stunting outcomes, is the mean age difference between husband and wife, which serves as a proxy for the relative position of women. The negative association I found, was against my expectation, but can be explained by the fact that if women have a stronger position, they are more likely to have more employment opportunities and less time to raise the children. I have no knowledge about any other studies that found the same negative association, more research is needed to analyze how the relative position of women contributes to decreasing the stunting rate. Furthermore, the interaction term between the household size and the mean age difference had a positive association with the stunting rate, which indicates that a higher age difference combined

with a higher number of household members can lead to a higher stunting rate. In African countries girls often marry at a young age and the phenomena of polygamy is common, which leads to a higher average of household members. Besides, Strassmann (2011) shows that the odds of being stunted are higher for children in polygamous families, because this leads to more conflicts. A final interaction term that has a significant effect with the average stunting rate is the one between the IWI and children aged 1 with BCG. Again, I do not know of any studies that found this association as well. An explanation could be that wealthier households have more resources to get their children vaccinated, for example a car to get to the hospital, and this lowers the chance of being stunted.

Although these findings are interesting, this study does suffer from some limitations. First of all, due to how the data is collected, only the country and regional level are taken into account. It would be even more interesting if the data on stunting and the IWI would be analysed on the household level. This way a more in-depth analysis is possible, that shows where the household wealth inequalities are located and what should be the focus point for new policies. The fact that my analysis is based on pooled cross sectional data, forms another important limitation. Even though important new information on the relationship between the value of the IWI and the average stunting rate is obtained, it is not possible to draw any conclusions in terms of causal relations. A final limitation is related to the selection of countries that are included in the sample. Due to a lack of political stability or economic capacity some of the poorest sub-Saharan African countries are not capable to conduct a large-scale survey on which the IWI and the other included variables are based. The result of this is that the sample is an oversampling of economically relatively successful countries. For future research I would recommend to try to include these countries as well to see if these results also hold in these poorer circumstances. Furthermore, it would be interesting to decompose the durable consumer goods that are taken up in the construction of the IWI to gain more insight into which goods have the most influence and should be focus points for policy makers.

In general, I can conclude that the value of the International Wealth Index, that is a measure of relative socio-economic status, plays an important role in reducing the average stunting rate in sub-Saharan African countries. By using a cross-country comparable yardstick for wealth instead of GDP per capita, I have taken a new approach with this study. Since previous literature was divided about the effect of GDP on stunting rates, taking a measure of socio-economic status seems to be a better fit to decrease stunting rates among children. Besides this index, the educational level of the mother, the presence of grandparents, the mean age difference between husband and wife and the interaction terms between the household size and the mean age difference and between the IWI and children aged 1 with BCG are other important determinants.

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7. Appendix

Figure 2 WHO conceptual framework on Childhood Stunting: Context, Causes and Consequences, with an emphasis on complementary feeding

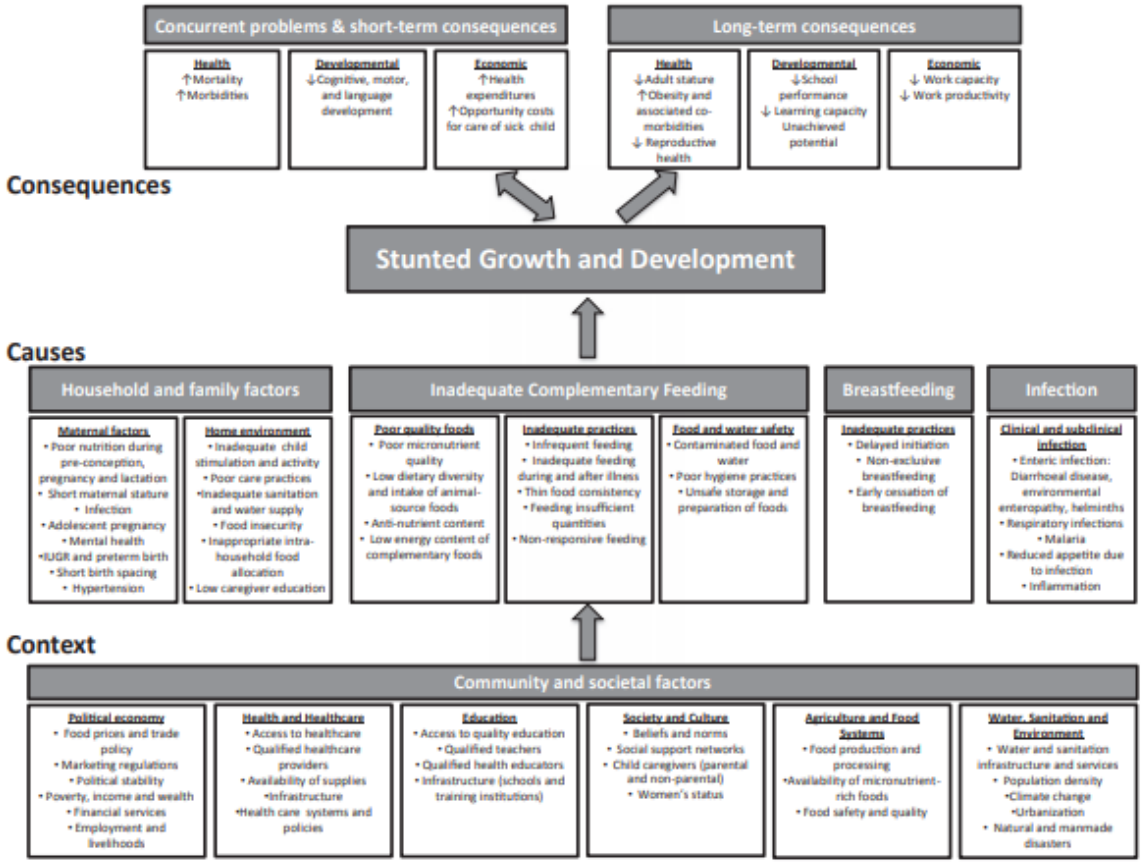

Table 5 Multicollinearity test

Variable	VIF	1/VIF
Education females 20+	3.09	0.32
Household size	2.53	0.39
Mean age difference	2.52	0.40
IWI	2.13	0.47
Children aged 1 with BCG	1.32	0.76
Matrilocal households	1.07	0.94
Mean VIF	2.11	

Table 6 Robustness Check

Dependent variable	Random coefficient model without interactions and Nigeria (1) Average stunting rate	Random coefficient model with interaction, without Nigeria (1) Average stunting rate
International Wealth Index	-4.752***(0.777)	0.596(1.573)
Education females 20+	-2.261***(0.291)	-2.004***(0.275)
Matrilocal households	-0.917***(0.321)	-0.877***(0.334)
Household size	-3.078*(1.767)	-13.59***(4.414)
Mean age difference	-0.992***(0.212)	-3.144***(0.915)
Children aged 1 with BCG	-9.06e-05(0.0001992)	0.00211***(0.000590)
Year	-0.385***(0.0452)	-0.392***(0.0450)
IWI * Children aged 1 with BCG	-	-0.000752***(0.000190)
Household size * Mean age difference	-	1.105**(0.457)
Constant	848.3***(90.63)	865.1***(91.09)
Observations	1,182	1,182
Number of groups	32	32

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