ERASMUS UNIVERSITY ROTTERDAM

Erasmus School of Economics

Bachelor Thesis: Health Economics

Analysis of socioeconomic inequality in childhood undernutrition in Niger and Kenya

Matthew Vanpoucke

456602

Supervisor: Jenny. E. Kudymowa

Second assessor: Max Coveney

Abstract

This thesis analyses the distribution of childhood undernutrition in Niger and Kenya. The years 2008 and 2014 are studied and compared for Kenya, while 2006 and 2012 are studied and compared for Niger. Data from from the Demographic Health Surveys is used. The surveys on wealth and nutrition are used for analysis. Childhood undernutrition is measured using height-for-age Z-scores. Socioeconomic inequality is measured using the standard and Erreygers' concentration index. Both countries exhibit pro-poor inequality in childhood undernutrition. A test for concentration curve dominance was conducted, but no dominance was found for both countries. The Bennett bidirectional test of stochastic dominance is used to test whether the latter year stochastically dominates the former year in terms of the distribution of undernutrition. This is the case for Niger, but not for Kenya. The same test is conducted to test for stochastic dominance across wealth quintiles, results varied per country. Key takeaway of this descriptive study is that it is important to consider distributional patterns when analysing and comparing undernutrition of (different) countries, so that in that way specific policies to reduce undernutrition in the most efficient way can be designed.

July 4th 2019

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Introduction

In 2015, the United Nations established 17 Sustainable Development Goals (SGDs), designed to achieve a better and more sustainable future for everyone in the world. Goal number two is zero hunger. Although progress in pursuing this goal has been made in the past, the proportion of undernourished people worldwide saw an increase in 2015-2016 (United Nations, 2018), after having declined in previous years.

Undernutrition can have severe consequences, especially for children. Maternal and child undernutrition has been found to contribute to infant and child mortality (Pelletier, Frongillo, & Habicht, 1993) (Bredenkamp, Buisman, & Van de Poel, 2014), and increase the overall disease burden (Black, et al., 2008). Undernutrition is also associated with lower human capital. This lower human capital can translate into lower educational attainment (Alderman, Hoddinot, & Kinsey, 2006), with a decreased potential earnings later in life as a result (Victora, et al., 2008).

The damage inflicted by undernutrition early in life has been found to be permanent and irreversible, due to its effect on brain and body development (Smith & Haddad, 2015). It is also likely to affect future generations as well, which can result in a cycle of poverty.

Undernutrition is a collective name of three conditions. Wasting, which is a low weight for height. Stunting, low height for age. And underweight, which is a low weight for age (World Health Organization, 2018). Wasting indicates recent and severe weight loss. Stunting is the result of consistent or recurrent undernutrition.

The most commonly used measure for undernutrition in children under 5 is stunting. Stunting reflects endured malnutrition, and also nutritional deficiencies that occurred early in life. The prevalence of stunting is measured by the height-for-age z-score. Children are considered to be stunted if their height-for-age is two or more standard deviations below the median of the Child Growth Standards defined by the WHO in 2006 (Bredenkamp, Buisman, & Van de Poel, 2014). This corresponds with a height-for-age z-score smaller than or equal to -2.

Malnutrition is mostly concentrated in Asia and Africa, where respectively 55% and 39% of all stunted children live. Stunting trends show large disparities between sub-regions (UNICEF, WHO, The World Bank, 2019). Estimates from the WHO illustrate that stunting rates have been following a downward trend in both regions in 2013-2018.

Despite the decrease in the prevalence of stunting, absolute numbers were on the increase in Africa. Where the proportion of stunted children decreased from 38% to 32%, the number of children increased from 50.4 to 58.5 million between 2000 and 2015. (World Health Organization, 2017).

The MDG is *zero* hunger, indicating a desired reduction in the absolute number of children suffering from malnutrition. In reality, the world is moving further away from reaching that goal, instead of coming closer to achieve it.

These global targets tend to focus on reducing overall levels of undernutrition, i.e. stunting rates. Van de Poel et al conclude that this does not necessarily lead to a reduction in socioeconomic inequality in childhood malnutrition (Van de Poel, Hosseinspoor, Speybroeck, Van Ourti, & Vega, 2008).

Undernutrition has been found to be concentrated among the poor (Bredenkamp, Buisman, & Van de Poel, 2014). In most countries, the relative reductions in stunting were higher among the rich (Restrepo-Mendez, Barros, Black, & Victora, 2015). This contradiction shows that current policies/interventions to reduce undernutrition may result in more socioeconomic inequality.

Little evidence has been provided whether the distribution of childhood undernutrition has been improving, rather than overall levels. It could be the case that average level of stunting is decreasing in a country, but that this is the result of a large decrease for the higher socioeconomic classes accompanied by a smaller increase for the lower socioeconomic classes. Assuming it is not only preferred that less children are undernourished on average, but also that it is preferred that children are more equally nourished, the described case would not necessarily imply an improvement.

This thesis aims to analyse socio-economic inequality in childhood undernutrition in Niger and Kenya. Niger is one of the countries in Sub-Saharan Africa that has a very high (≥40%) stunting rate, where Kenya has a medium (20-29%) stunting rate (World Health Organization, 2017).

Several studies describe the relationship between socio-economic status (or: wealth) and nutrition. Wagstaff and Watanabe found that poor people tend to have higher malnutrition rates. The inequalities they found were statistically significant in all countries (Wagstaff & Watanabe, 2000). This result corresponds with the findings of Van de Poel et al. Petrou and Kupek found a statistically significant relationship between childhood undernutrition and poverty in the four countries they studied (Petrou & Kupek, 2010).

Recent studies have assessed trends in socioeconomic inequality in undernutrition in sub-Saharan Africa (Asuman, Ackah, & Agyire-Tettey, 2019) (Akombi, Agho, Renzaho, & Merom, 2019). Asuman, Ackah and Agyire-Tettey provide evidence on trends in socioeconomic inequalities in malnutrition for ten countries. Despite Niger being one of the countries with the highest stunting rate, it is not included. This thesis aims to shine light on socioeconomic inequalities in undernutrition in Niger, and compare it with a country with a relatively low stunting rate, Kenya.

The research question is:

How is childhood undernutrition distributed among socioeconomic classes in Niger and Kenya?

To be able to provide an answer to this research question, the following hypotheses will be tested. Hypothesis 1: *In both Niger and Kenya, there is pro-poor inequality in childhood undernutrition* Hypothesis 2: *In both Niger and Kenya, childhood undernutrition has become more equally distributed over the years studied.*

The findings indeed conclude pro-poor inequality in undernutrition in both countries. Hypothesis 2 cannot be verified based on the results. There is less inequality in the latter year for Niger, but this is not the case for Kenya where no dominance of either year was found.

The rest of the thesis is structured as followed. Firstly, the data is described. Then, the methods of testing are explained. The results of these tests can be found in the results section. In the next section, a conclusion is based upon these results.

Data

The data is provided by the Demographic and Health Surveys (DHS) program. These surveys are nationally-representative household surveys that contain data on various topics such as education, HIV prevalence, mortality etc. (DHS Program, 2). For this thesis, data on household wealth and child nutritional status is used.

The nutritional status survey contains information on child anthropometric measures, i.e. information on height, weight, age. The household wealth survey contains data on household ownership of assets, consumer items and other characteristics that are related to wealth status (DHS Program, 1).

Stunting is used to measure childhood undernutrition. To measure the severity of stunting, the child anthropometric measures are converted into the height-for-age z-score (HAZ). The HAZ-score can be defined as followed:

$$HAZ - score = \frac{Height_i - Median_i}{\sigma_i} \tag{1}$$

Where $Height_i$ is the height for child *i*, $Median_i$ is the median height of a child that has the same age and gender in a well-nourished reference population. σ_i is the standard deviation value of the reference population (Sahn & Stifel, 2002). As earlier mentioned, a child is considered stunted if the HAZ-score is equal to or less than -2. A child is considered severely stunted if the HAZ-score is below -3 (Grace, Davenport, Funk, & Lerner, 2012).

The standard deviation of Z-scores of anthropometric indicators is relatively constant across populations, irrespective of nutritional status (Mei & Grummer-Strawn, 2007). Using Z-scores has multiple advantages compared to other methods and it is recognized as the best system for analysis of anthropometric data (de Onis & Blossner, 1997).

The children in the samples were measured using a measurement board. Children that were older than 24 months were measured standing up, where children younger than 24 months were measured lying down.

For this analysis, the HAZ-scores will be used as continuous variables. A binary variable is used for stunting. Since this thesis focusses on undernutrition rather than nutrition in general, the distributions are censored at zero. Sample weights will be used to make the results nationally representative.

To construct the wealth index, a household is assigned a standardized score for each asset owned. Generally, any item that reflects economic status is used to ensure households are not concentrated on certain index scores (Rutstein & Johnson, 2004). Principal components analysis is applied to assign weights to the wealth indicators. Distinction is made between urban and rural households. The scores are summed up, and households are ranked. The total population is divided into five equal wealth quantiles based on the ranking of scores (DHS Program, 1).

Only Standard DHS Surveys are used, these have sample sizes that range from 5,000 to 30,000 households. Since these surveys are conducted about every 5 years, it is possible to compare over time (DHS Program, 2). For Kenya, Standard DHS Surveys from 2008 and 2014 are used for analysis. For Niger, data from 2006 and 2012 is used.

In 2006, 7,660 households participated in the Niger DHS program. 10,750 households participated in 2012. Household response rates were high for both years, namely 98% for both years (Institut National de la Statistique, 2007; Institut National de la Statistique, 2013). These reports contain data on respectively 4,185 and 5,481 children under the age of 5. After correcting for missing values and HAZ-score values that equal less than -6 or more than +6, which are considered biologically implausible by the WHO, respectively 3,765 and 4,935 children remain.

In Kenya, 9,057 and 36,430 households participated in 2008 and 2014. Household response rates were also high for both years in Kenya, respectively 98% and 99% (Kenya National Bureau of Statistics, 2010; Kenya National Bureau of Statistics, 2015). These reports contain data on respectively 5,470 and 18,968 children under the age of 5. After correction, the dataset contains data on respectively 5,210 and 18,825 children.

The mean HAZ-score of Niger in 2006 is -1.93, which is almost at the stunting threshold value. The mean score of 2012 is a bit better, -1.60. When censoring the data around 0, these means become -2.09 and -1.80.

Kenya's mean HAZ-score in 2008 is -1.20, and -1.17 for 2014. When censoring the data around 0, these means become -1.39 and -1.35.

The proportion of stunted children for Kenya is 28.1% in 2008 and 25.9% in 2014. For Niger, 54.7% in 2006 and 42.7% in 2012. Both countries saw a reduction in the overall stunting rate. It is interesting that the stunting rate of Niger saw a much bigger procentual decrease than Kenya.

A two sample independent t-test assuming unequal variance was conducted to check whether the height-for-age z-scores significantly differ across these countries. The two most recent years are compared, finding the HAZ-scores to be significantly different, $t(6659) = 20.27, p < .001$. A proportion test pointed out that the stunting rates of Niger and Kenya are also significantly different. The same tests were conducted comparing both years per country, significant differences were also found for both countries. The results of these tests can be found in appendix A.

Table 1-4 contain information on the size of socioeconomic classes and how stunting is divided among socioeconomic classes. It is notable that stunting is quite equally distributed among wealth quintiles in Niger, as stunting percentages lie close to 20% except for the richest. This is not the case for Kenya, where stunting is more concentrated among the lower wealth quintiles.

Note that table 1-4 on page 8 show how stunting is divided among wealth quintiles, and say nothing about stunting percentages per wealth quintile (as figure 3 and 5 do). 20.26% in table 1 means that 20.26% of the stunted children can be categorized in the poorest wealth quintile.

Table 1

Wealth quintile	*Size*	*Stunting prevalence*	
	Percentage	*Frequency*	*Percentage*
Poorest	19.57%	381	20.26%
Poorer	20.57%	411	21.83%
Middle	20.52%	409	21.74%
Richter	20.47%	409	21.74%
Richest	18.88%	272	14.43%

Table 1: Socioeconomic classes and division of stunted children of Niger in 2006

Table 2

Wealth quintile	*Size*	*Stunting prevalence*	
	Percentage	*Frequency*	*Percentage*
Poorest	19.93%	435	21.12%
Poorer	19.90%	455	22.12%
Middle	21.40%	418	20.27%
Richter	21.25%	466	22.63%
Richest	17.52%	285	13.86%

Table 2: Socioeconomic classes and division of stunted children of Niger in 2012

Table 3

Wealth quintile	*Size*	*Stunting prevalence*	
	Percentage	*Frequency*	*Percentage*
Poorest	24.90%	567	31.20%
Poorer	20.79%	427	23.51%
Middle	18.89%	339	18.69%
Richter	17.88%	264	14.52%
Richest	17.54%	219	12.07%

Table 3: Socioeconomic classes and division of stunted children of Kenya in 2008

Table 4

Wealth quintile	*Size*	*Stunting prevalence*	
	Percentage	*Frequency*	*Percentage*
Poorest	24.24%	1,733	33.45%
Poorer	20.98%	1,271	24.54%
Middle	18.37%	940	18.15%
Richter	17.13%	719	13.88%
Richest	19.27%	517	9.98%

Table 4: Socioeconomic classes and division of stunted children of Kenya in 2014

Methodology

Concentration index

Earlier research pointed out an unequal distribution of childhood undernutrition among socioeconomic classes. For this research, it is assumed it is preferred children are better nourished on average and also more equally nourished.

To measure inequalities in childhood undernutrition among wealth quantiles, the concentration index (CI) is used. The concentration index is equal to twice the area between the concentration curve and the 45^{0} line. The concentration curve plots the cumulative proportion of childhood undernutrition against the cumulative proportion of the population ranked by wealth (O'Donnel, O'Neill, Van Ourti, & Walsch, 2016). The concentration index can be defined as followed:

$$C = \frac{2}{n \cdot \mu} \sum_{i=1}^{n} y_i R_i - 1 \quad (2)$$

Where n is the sample size, y_i is the malnutrition indicator for person i, μ is the mean level of malnutrition, and R_i refers to the fractional rank of the wealth variable (Wagstaff, 2002).

In this case, the malnutrition indicator y_i is the HAZ-score. For computations of the CI, the HAZ-scores will be multiplied by -1, such that all values become positive. The higher the value, the more malnourished the child is considered.

C can take any value on the interval$[-1,\ 1]$. A negative C indicates pro-poor inequality, where a positive C indicates pro-rich inequality. A C equal to zero would imply an equal distribution among wealth groups.

However, several shortcomings of the standard Concentration Index, as described above, have been addressed. Wagstaff mentions that when using binary variables, the bounds of the standard Concentration Index depend upon the mean of the variable of interest, this complicates comparisons of concentration indices of populations that have different means (Wagstaff, 2005).

Furthermore, the concentration index is sensitive to using a health variable, or an ill-health variable (Clarke, Gerdtham, Johannesson, Bingefors, & Smith, 2002).

Erreygers proposed a correction version, which performs better than the standard CI and its' modified versions when using binary variables as proven in his article (Erreygers, 2009a). The standard CI only satisfies the transfer property, whereas the Erreygers Concentration Index satisfies all four rank-dependant indicator requirements. The standard CI measures relative inequality, the correction proposed by Erreygers is a measure of absolute inequality (Erreygers, 2009b)

To correct for difference in means, the Erreygers Concentration Indices (ECI) are computed. The ECI can be defined as followed:

$$E(h) = \frac{8}{n^2(b_h - a_h)} \sum_{i=1}^{n} z_i h_i \quad (3)$$

Where n is the sample size, h refers to the health variable, a_h and b_h are the lower and upper bound of the health variable and $\sum_{i=1}^{n} z_i h_i$ expresses the rank-dependence character. The values that the ECI can take are the same as those of the standard CI.

A test of concentration curve dominance is performed to check whether there is less socio-economic inequality in the later year studied. Concentration curve *A* dominates curve *B* if *A* lies above *B* at all points. If the curves cross, no dominance can be concluded. When *A* dominates *B*, and therefore lies further away from the 45^{o}-line, there is less socioeconomic inequality in *B* (O'Donnel, van Doorslaer, Wagstaff, & Lindelow, 2007).

To test whether this dominance is statistically significant, tests of dominance are carried out using DAD, a statistical package for dominance testing, as described in (O'Donnel, van Doorslaer, Wagstaff, & Lindelow, 2007), and following the multiple comparison approach. This method takes multiple testing into account by using critical values from the studentized maximum modulus distribution. Because multiple comparisons are being made when comparing concentration curves with each other, the null hypothesis of nondominance would be overrejected when using conventional critical values (O'Donnel, van Doorslaer, Wagstaff, & Lindelow, 2007).

Stochastic dominance

To test for improvement in childhood nutrition over the years, it is tested whether the distribution in the most recent year stochastically dominates the distribution in the earlier year. Wealth quintiles are also compared with each other to see whether there is less inequality in the richer quintiles. Stochastic dominance tests have the advantage of being robust to the choice of the poverty line, which in this case is the stunting threshold (Sahn & Stifel, 2002). The HAZ-scores censored at zero will be used for tests of stochastic dominance.

The distributions are characterized by their cumulative distribution functions (CDFs). The value of the CDF at point y can be interpreted as the proportion n of people that exhibit a HAZ-score which is not greater than y.

Distribution B stochastically dominates distribution A at first order if, for any y, $F_A(y) \geq F_B(y)$. Where F_X is the CDF of distribution X. This also means that for every stunting threshold value, there is always more malnutrition in A than in B (Davidson, 2006). First-order stochastic dominance implies dominance at all higher orders.

To statistically test for first-order stochastic dominance, the Bennet bidirectional test of stochastic dominance will be used, as described in (Bennett, 2013). The test is a modification of the BTF procedure introduced by Bishop et al, and is better able to distinguish between dominance, equality and crossing of the distributions. The test is conducted in two stages. Firstly, the hypothesis of equality is tested using two-sided Kolmogorov-Smirnov statistics, if this hypothesis is accepted the distributions are considered statistically identical.

If this hypothesis is rejected, the second stage of the test determines whether the distributions cross or which distribution is dominated by the other. The test is based on the minimum of the one-sided Kolmogorov-Smirnov statistic. When a large value is observed, this is interpreted as a crossing of the distributions. The sign of the minimum one-sided Kolmogorov-Smirnov statistics determines the direction of dominance.

Results

Pro-poor inequality

After censoring the data around 0, and multiplying the HAZ-scores by -1, the standard concentration indices can be calculated. The concentration indices can be found in table 5.

Table 5

Country	Year	CI	Standard Error	P-value
Niger	2006	-0.03970343	0.00729438	0.0000
	2012	-0.03439175	0.00710001	0.0000
Kenya	2008	-0.08072004	0.00878528	0.0000
	2014	-0.10771559	0.00465031	0.0000

Table 5: Standard concentration indices for Niger and Kenya

Every concentration index is negative, thus implying pro-poor inequality in childhood undernutrition. For both countries, there a significant difference between the years $Niger: F = 7.9810852, p = 0.0047; Kenya: F = 5.7227178, p = 0{,}0168$. It stands out that the relative inequality decreases in Niger and increases in Kenya.

The Erreygers concentration indices are displayed in table 6. The ECIs are calculated using a binary variable for stunting.

Table 6

Country	Year	Erreygers CI	Standard Error	P-value
Niger	2006	-0.10326132	0.01866283	0.0000
	2012	-0.08001402	0.01622618	0.0000
Kenya	2008	-0.17864883	0.01510593	0.0000
	2014	-0.18285064	0.00725688	0.0000

Table 6: Erreygers concentration indices for Niger and Kenya

The ECIs also show pro-poor absolute inequality in childhood undernutrition. The ECIS are significantly different for both years for both countries $Niger: F = 8.9783662, p = 0.0027; Kenya: F = 12.743775, p = 0.0004$. The ECIs show the same pattern as the CIs.

Figure 1 displays the concentration curves for both countries. The grey area marks the 95% confidence interval. All curves lie above the 45^{o}-line, thus implying pro-poor inequality as already confirmed by the concentration indices. There is no clear difference between concentration curves, as the curves of both years lie very closely together for both countries.

Figure 1

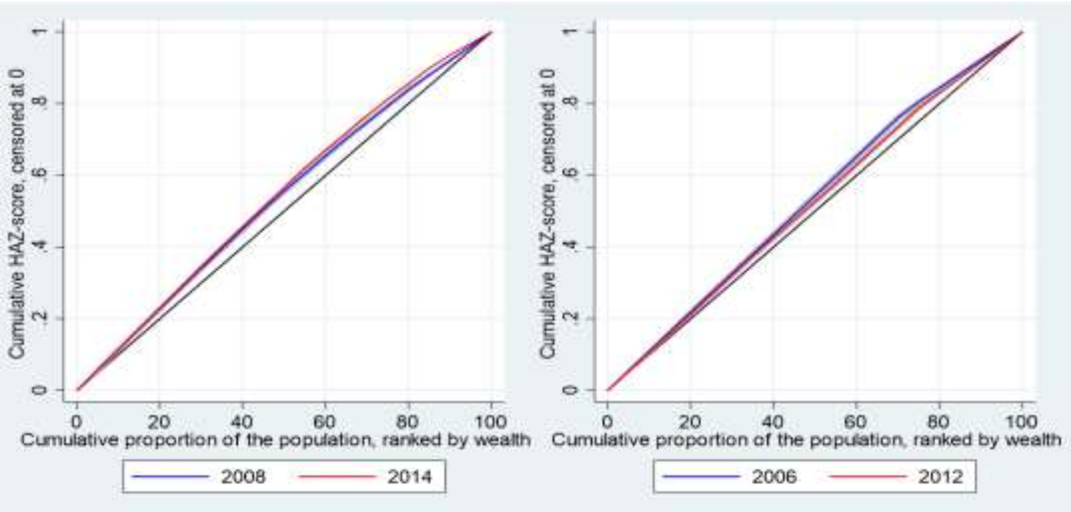

Figure 1: Concentration curves of Kenya (left) and Niger (right). The black diagonal displays the 45^{o}-line

For Kenya, the concentration curve of 2014 lies above that of 2008 at all points. For Niger, the curve of 2012 lies below that of 2006 at all points. Note that the differences are all very small. This would imply concentration curve dominance of the years 2014 and 2006, and less inequality in 2008 and 2012. The graph displaying the difference in concentration curves, together with its coefficients and p-values can be found in appendix B.

As earlier mentioned, this inspection is not sufficient to conclude statistically sufficient dominance. The concentration curve dominance test following the multiple comparison approach concluded that there is no dominance in any direction for Kenya, and a crossing of the curves for Niger. A significance level of 5% was used.

Distribution of childhood undernutrition in Kenya

The CFDs of Kenya can be found in figure 1 below. The functions cross when almost reaching the HAZ-score of 0. This means that for every HAZ-score until the point of crossing, there is a smaller proportion of undernourished children in 2014. 2014 does not seem to stochastically dominate 2008. The Bennett test confirms the absence of stochastic dominance, and concludes a crossing of the distributions.

Figure 2

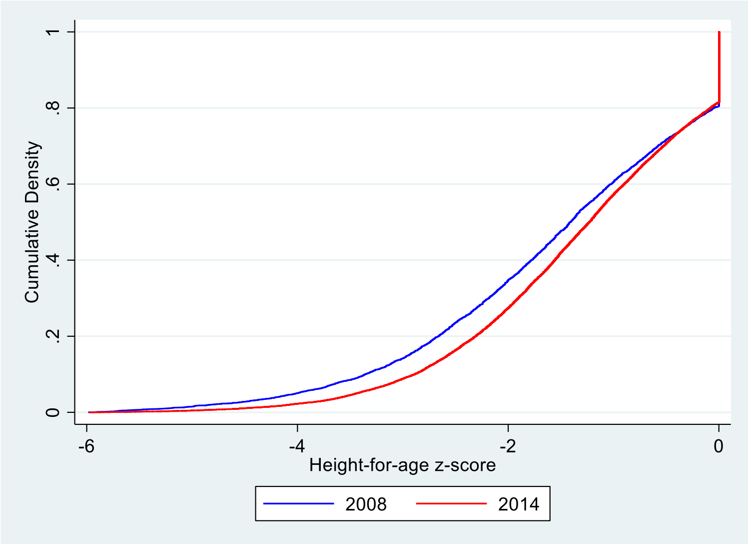

Figure 2: Cumulative distribution functions of the censored HAZ-score for 2008 and 2014

This implies that in terms of the distribution of the HAZ-scores, Kenya is not entirely better off in 2014. Figure 2 displays the proportion of stunted children per wealth quintile for both years. The prevalence of stunting declines monotonically with higher socio-economic status, with a big difference between the richest and the poorest quintile. The prevalence of stunting is also lower for each wealth quintile in 2014, the difference in percentage points is close to 2% for each quintile.

Figure 3

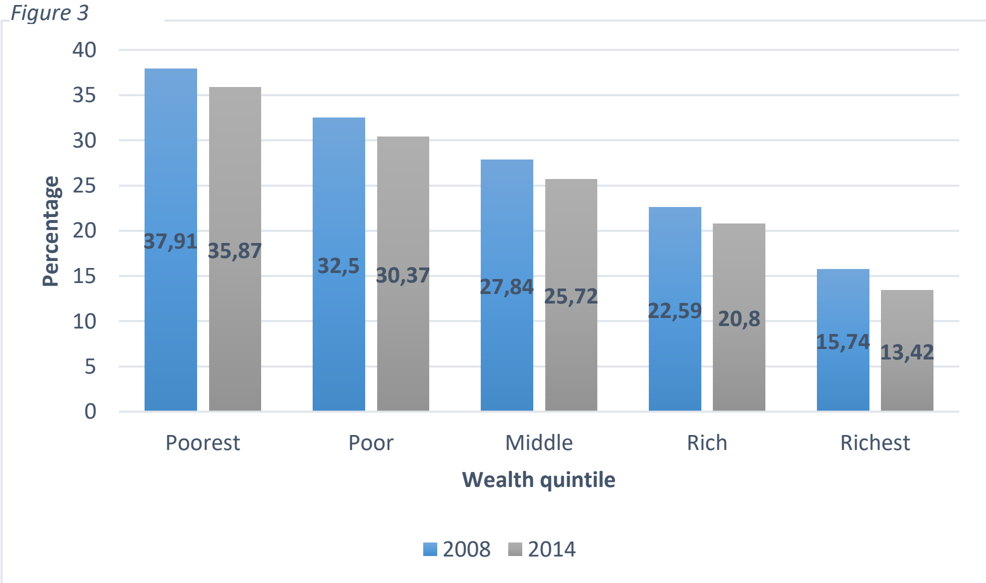

Figure 3: Proportion of stunted children per wealth quintile in 2008 and 2014

The Bennett test is also used to test for stochastic dominance across wealth quintiles, the results of this test can be found in table 7. The results for both years are the same. The distribution functions on which the results are based can be found in appendix C. The pattern is clear since the lines lie clearly apart from each other. There appears to be less inequality in undernutrition in the richer wealth quintiles, since the wealthier quintiles systematically dominate the worse-off quintiles, except when comparing Poor to Poorest.

Table 7

	Rich	Middle	Poor	Poorest
5th quintile (Richest)	>>	>>	>>	>>
4th quintile (Rich)		>>	>>	>>
3rd quintile (Middle)			>>	>>
2nd quintile (Poor)				Cross Cross

Table 7: Stochastic dominance of censored HAZ-scores across wealth quintiles in Kenya. The black symbols indicate the direction of dominance in 2008, where the red symbols are indicators for 2014. A significance level of 1% is used for the first stage, and 10% for the second stage of the test. “>” indicates that the row quintile stochastically dominates the column quintile. “Cross” indicates that the distributions cross and one does not stochastically dominate the other.

Distribution of childhood undernutrition in Niger

The CFDs of Niger can be found in figure 3 below. The CFD of 2012 lies entirely below that of 2006, thereby indicating that for every HAZ-score, there is a smaller proportion of undernourished children in 2012. The Bennett test also concludes that 2012 stochastically dominates 2006. Figure 4 displays the proportions of stunted children per wealth quintiles for both years. The prevalence of stunting does not monotonically decline with wealth, whereas this was the case for Kenya. Also notable is that the stunting rate is not the highest in the poorest quintile, but in the poor quintile, and the same for rich-middle. One would expect stunting prevalence to be higher in the poorer segments, due to the relationship between socio-economic status and stunting.

Figure 4

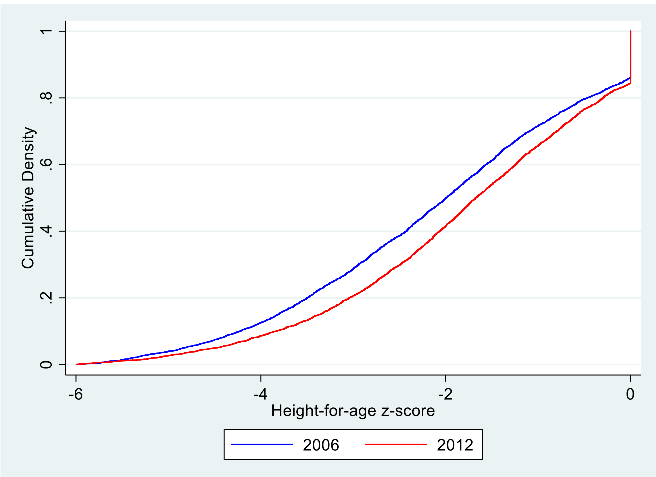

Figure 4: Cumulative distribution functions of the censored HAZ-score for 2006 and 2012

Figure 5

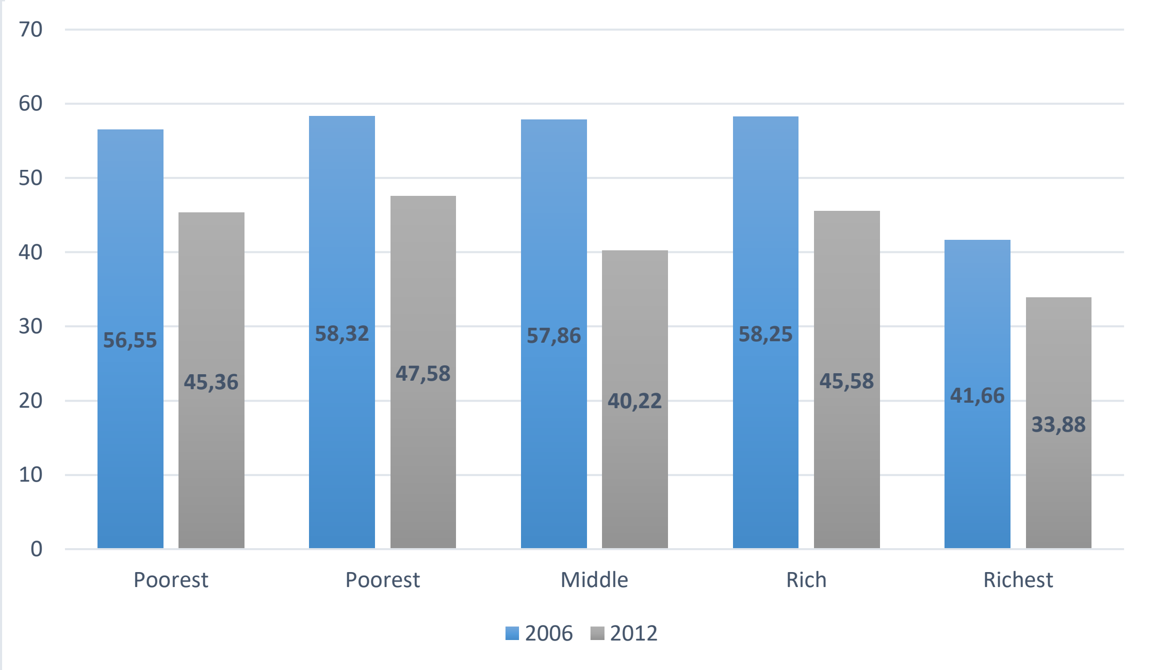

Figure 5: Proportion of stunted children per wealth quintile in 2006 and 2012

The results of the Bennett test for stochastic dominance across wealth quintiles can be found in table 8. The results for both years are again the same. The distribution function on which the results are based can be found in appendix C**.** Here it can be evidently seen that the line of the richest quintile lies below and apart of the lines of the other quintiles, which all lie close to each other and it is harder to separate. It is notable that only the richest quintile stochastically dominates other quintiles, and that no dominance was found when comparing the rich to the poorest quintile. This indicates that undernutrition is quite equally distributed among socio-economic classes in Niger, with only the richest quintile being an exception.

Table 8

	Rich	Middle	Poor	Poorest
5th quintile (Richest)	>>	>>	>>	>>
4th quintile (Rich)		==	==	==
3rd quintile (Middle)			==	==
2nd quintile (Poor)				==

Table 8: Stochastic dominance of censored HAZ-scores across wealth quintiles in Niger. The black symbols indicate the direction of dominance in 2006, where the red symbols are indicators for 2012. A significance level of 1% is used for the first stage, and 10% for the second stage of the test. “>” indicates that the row quintile stochastically dominates the column quintile. “=” indicates that hypothesis of equality of the distributions could not be rejected.

Conclusion

Aim of this thesis was to analyse socio-economic inequality in childhood undernutrition in Niger and Kenya, and hereby going further than solely looking at absolute numbers of undernutrition. Reason for choosing these countries was that Niger falls within the group of Sub-Saharan countries with the highest stunting rates and Kenya within the countries with lower stunting rates. If distributions among socio-economic classes differ, this could imply that specific interventions to reduce childhood undernutrition, that focus on particular groups in society, can be more effective than interventions that are meant to reduce stunting rates overall.

The normal and Erreygers' concentration indices pointed out that there is indeed pro-poor inequality in stunting in both countries, as hypothesis 1 assumed. These results are not surprising, given the relationship between socio-economic status and stunting. Figure 4 supports this relationship due to the monotonical decrease in stunting for each wealth quintile. Niger, however, shows a different pattern, and the poorest group is not the group which is affected most.

Test of stochastic dominance and concentration curve dominance were carried out to see whether these countries did not only see an improvement in the overall stunting rate, but also experienced less socioeconomic inequality in childhood undernutrition. No significant concentration curve dominance was found for both countries.

For Kenya, also no stochastic dominance was found. This means that it cannot be concluded that stunting is more equally distributed in the latter year. Despite having a lower overall stunting rate, Kenya shows larger disparities in undernutrition than Niger. The reduction in stunting is more or less the same in percentage points for each wealth quintile. The Bennett test per wealth quintile concluded less socioeconomic inequality for the higher wealth quintiles in both years. No shifts were observed when comparing wealth quintiles to each other as the Bennett test yielded the same results for both years.

Stochastic dominance of the latter year was found for Niger. The CFD of 2012 lies clearly below that of 2006, indicating that stunting has become more equally distributed. However when comparing the wealth quintiles, the richest quintile stochastically dominates the other quintiles, but no stochastic dominance was found when comparing the other quintiles with each other. No shifts were observed when comparing wealth quintiles to each other as the Bennett test yielded the same results for both years. Socioeconomic inequality in stunting is lower in Niger than in Kenya. The wealth quintiles with the highest stunting rates also saw the biggest decreases in stunting rates.

Both countries saw different developments equality-wise, despite showing the same pattern in absolute stunting rates. This finding supports the earlier made statement that different countries therefore require different interventions to decrease stunting overall while also reducing socio-economic inequality.

Discussion

The results of this thesis correspond with the concentration indices found in (Akombi, Agho, Renzaho, & Merom, 2019) and (Asuman, Ackah, & Agyire-Tettey, 2019). Different trends in socioeconomic inequalities are observed when comparing Niger and Kenya, just as Asuman, Ackah as Agyire-Tettey concluded in their multi-country comparison.

This is something policymakers have to take into account when designing a policy intended to reduce stunting. The country-specific trends call for specially designed programs targeting stunting in a most effective way.

A drawback of this research could be the wealth index that is used. This wealth index is based on owned assets which are ranked after which these scores are summed up in order to enable a ranking of the observations. There are more indicators for socioeconomic status that might have yielded different results. This thesis only uses the wealth index applied by the DHS program.

Another drawback is that data is out-of-date at the point of writing. In order to paint a complete picture of recent trends in socioeconomic inequality the tests have to be performed on more recent dataset, what is also a recommendation for further research.

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Appendix

Appendix A[1]

Table A.1

Country	Observations	Mean	Std. Err.	Std. Dev.	95%-CI	
Kenya	18,825	-1.16826	0.0106844	1.465944	-1.189202	-1.147317
Niger	4,935	-1.603585	0.0255562	1.795315	-1.653686	-1.553483
Difference		0.4353248	0.0276998		0.3810245	0.4896251
H_a: Diff < 0		**H_a: Diff ≠ 0**			**H_a: Diff > 0**	
Pr (T < t) = 1.000		Pr (|T| > |t|) = 0.000			Pr (T > t) = 0.000	

Table A.1: independent t-test assuming unequal variance to test whether the HAZ-scores significantly differ across countries. The years 2014 (Kenya) and 2012 (Niger) are used for comparison. The corresponding T-value is 15.7158 and degrees of freedom are 6,755.42.

Table A.2

Country	Mean	Std. Err.	95%-CI	
Kenya	0.2732537	0.0032479	0.2668878	0.2796195
Niger	0.4139818	0.0070114	0.4002397	0.4277238
Difference	-0.1407281	0.0077271	-0.155873	-0.1255832
H_a: Diff < 0	**H_a: Diff ≠ 0**		**H_a: Diff > 0**	
Pr (Z < z) = 0.000	Pr (|Z| > |z|) = 0.000		Pr (Z > z) = 1.000	

Table A.2: proportion test to test equal rates of stunting across countries. The years 2014 (Kenya) and 2012 (Niger) are used for comparison. The corresponding Z-value is -19.156

Table A.3

Year	Observations	Mean	Std. Err.	Std. Dev.	95%-CI	
2008	5,210	-1.303626	0.0242581	1.750954	-1.351182	-1.25607
2014	37,650	-1.16826	0.0072652	1.465925	-1.183068	-1.153452
Difference		-0.135366	0.254073		-0.1851729	-0.085559
H_a: Diff < 0		**H_a: Diff ≠ 0**			**H_a: Diff > 0**	
Pr (T < t) = 0.000		Pr (|T| > |t|) = 0.000			Pr (T > t) = 1.000	

Table A.3: independent t-test assuming unequal variance to test whether the HAZ-scores are significantly different in both years studied for Kenya. The corresponding T-value is -5.3278 and degrees of freedom are 6,260.34

Table A.4

Year	Mean	Std. Err.	95%-CI	
2008	0.34541056	0.0065863	0.3321966	0.3580145
2014	0.2732537	0.0022966	0.2687523	0.277755
Difference	0.0718519	0.0069753	0.0581807	0.0855232
H_a: Diff < 0	**H_a: Diff ≠ 0**		**H_a: Diff > 0**	
Pr (Z < z) = 1.000	Pr (|Z| > |z|) = 0.000		Pr (Z > z) =0.000	

Table A.4: proportion test to test equal rates of stunting across both years studied for Kenya .The corresponding Z-value is 10.8027

[1] For each test: H_0: difference = 0

Table A.5

Year	Observations	Mean	Std. Err.	Std. Dev.	95%-CI	
2006	3,765	-1.925039	0.300563	1.844243	-1.983967	-1.86611
2012	4,935	-1.603585	0.255562	1.795315	-1.653686	-1.553483
Difference		-0.3214539	0.0195501		-0.3987912	-0.2441166

H$_a$: Diff < 0	**H$_a$: Diff ≠ 0**	**H$_a$: Diff > 0**
Pr (T < t) = 0.000	Pr (|T| > |t|) = 0.000	Pr (T > t) = 1.000

Table A.5: independent t-test assuming unequal variance to test whether the HAZ-scores are significantly different in both years studied for Niger. The corresponding T-value is -8.1479 and degrees of freedom are 7,988.56

Table A.6

Year	Mean	Std. Err.	95%-CI	
2006	0.497468	0.0081486	0.4815058	0.5134477
2012	0.4139818	0.0070114	0.400239	0.4277238
Difference	0.083495	0.0107498	0.0624257	0.1045643

H$_a$: Diff < 0	**H$_a$: Diff ≠ 0**	**H$_a$: Diff > 0**
Pr (Z < z) = 1.000	Pr (|Z| > |z|) = 0.000	Pr (Z > z) =0.000

Table A.6: proportion test to test equal rates of stunting across both years studied for Niger .The corresponding Z-value is

Appendix B

Figure B.1

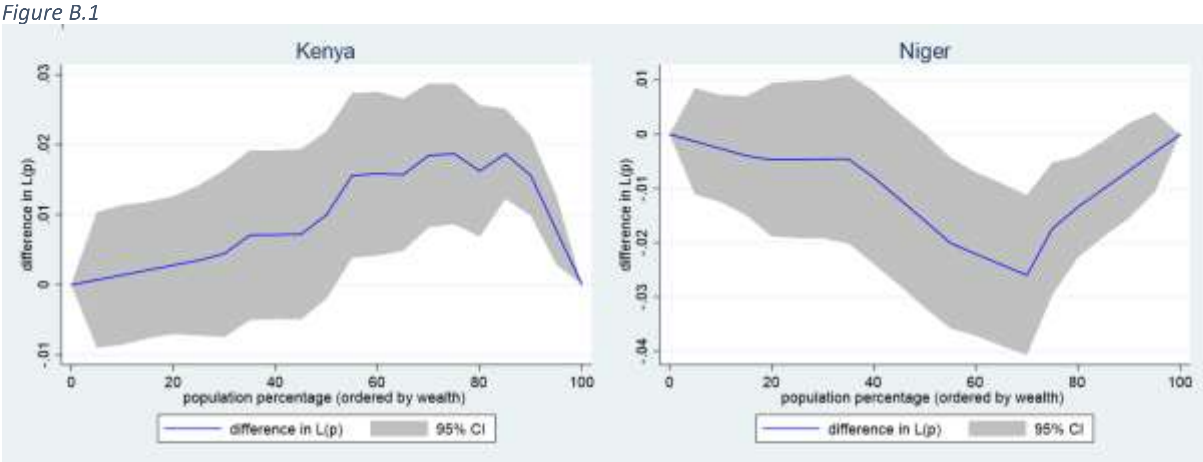

Figure B.2: Differences in concentration curves of Kenya (left) and Niger (right), the grey area marks the 95% confidence interval. No conclusions can be drawn based on these results since coefficients are not statistically significant (see tables B.1/B.2)

Table B.1

HAZ-score	Coefficient	Std. Err.	t	P > |t|	95%-CI	
0	0	(omitted)				
5	0.0006991	0.0049307	0.14	0.887	-0.0089652	0.0103634
10	0.0013981	0.005076	0.28	0.783	-0.0085505	0.0113471
15	0.0020972	0.0049605	0.42	0.672	-0.0076254	0.0118199
20	0.0027963	0.0050114	0.56	0.577	-0.0070261	0.0126187
25	0.0034954	0.0054746	0.64	0.523	-0.007235	0.0142257
30	0.0044641	0.0060755	0.73	0.462	-0.007444	0.163723
35	0.0070899	0.006183	1.15	0.252	-0.0050289	0.0192087
40	0.0071465	0.0061359	1.16	0.244	-0.0048801	0.19173
45	0.0072031	0.0061957	1.16	0.245	-0.0049406	0.0193468
50	0.0100042	0.0060871	1.64	0.100	-0.0019266	0.0219351
55	0.0156031	0.0059991	2.60	0.009	0.0038448	0.273614
60	0.0158395	0.0059476	2.66	0.008	0.0041821	0.274968
65	0.0157112	0.0055408	2.84	0.005	0.0048512	0.265711
70	0.0184739	0.0052391	3.53	0.000	0.0082052	0.0287426
75	0.0186816	0.005121	3.65	0.000	0.0086444	0.0287189
80	0.0162475	0.004794	3.39	0.001	0.0068511	0.0256439
85	0.0186836	0.0032735	5.71	0.000	0.0122674	0.0250998
90	0.0155648	0.0032735	5.36	0.000	0.0098683	0.0212612
95	0.0077824	0.0025047	3.11	0.002	0.0028732	0.0126916
100	0	(omitted)				

Table B.1: Coefficients and p-values of the line displaying the differences in concentration curves of Kenya. The coefficient resembles the difference between the most recent concentration curve and that of the preceding year.

Table B.2

HAZ-score	Coefficient	Std. Err.	t	P > |t|	95%-CI	
0	0	(omitted)				
5	-0.0013168	0.0050119	-0.26	0.793	-0.0111414	0.0085078
10	-0.002336	0.0050259	0.52	0.600	-0.0124856	0.0072184
15	-0.0039504	0.005592	-0.71	0.480	-0.0149121	0.0070113
20	-0.0047103	0.0072072	-0.65	0.513	-0.0188381	0.0094175
25	-0.0046501	0.0073862	-0.63	0.529	-0.191228	0.0098285
30	-0.00459	0.0074322	-0.62	0.537	-0.0191589	0.0099788
35	-0.0045474	0.0079402	-0.57	0.567	-0.0201121	0.0110174
40	-0.0079492	0.0081403	-0.98	0.329	-0.0239061	0.0080077
45	-0.0119437	0.008114	-1.47	0.141	-0.027849	0.0039616
50	-0.0159382	0.008199	-1.94	0.052	-0.0320102	030001338
55	-0.0200688	0.0080308	-2.50	0.012	-0.0358111	-0.0043265
60	-0.0221013	0.0076816	-2.88	0.004	-0.037159	-0.0070435
65	-0.0240432	0.007643	-3.14	0.002	-0.0390378	-0.0090487
70	-0.0259852	0.0075048	-3.46	0.001	-0.0406965	-0.011274
75	-0.0173582	0.0062116	-2.79	0.005	-0.0295344	-0.005182
80	-0.0134006	0.0047443	-2.82	0.005	-0.0227007	-0.0041006
85	-0.0100505	0.0045018	-2.23	0.026	-0.018751	-0.0012258
90	-0.0067003	0.004459	-1.50	0.133	-0.0154409	0.0020403
95	-0.0033502	0.003767	-0.89	0.374	-0.0107344	0.0040341
100	0	(omitted)				

Table B.2: Coefficients and p-values of the line displaying the differences in concentration curves of Niger. The coefficient resembles the difference between the most recent concentration curve and that of the preceding year.

Appendix C

Figure C.1

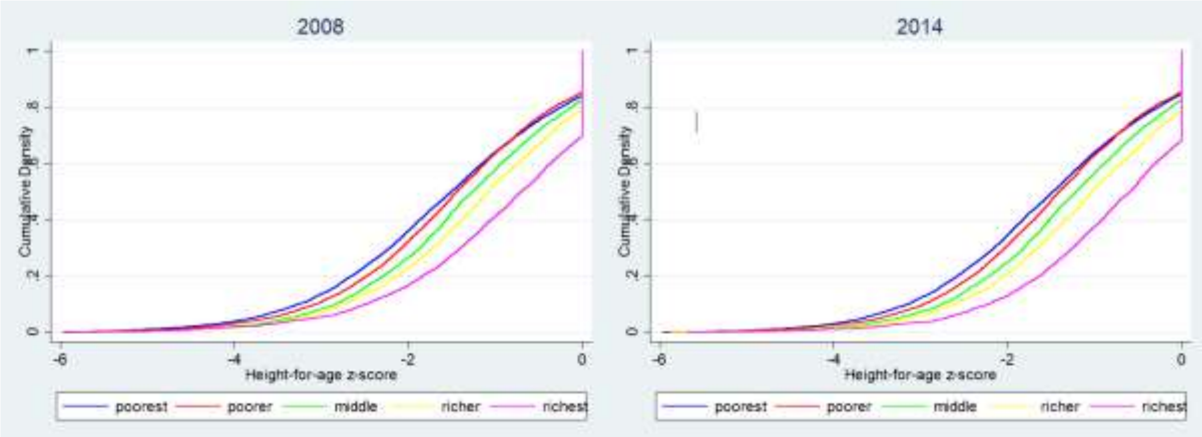

Figure C.1: Cumulative distribution functions per wealth quintile of Kenya

Figure C.2

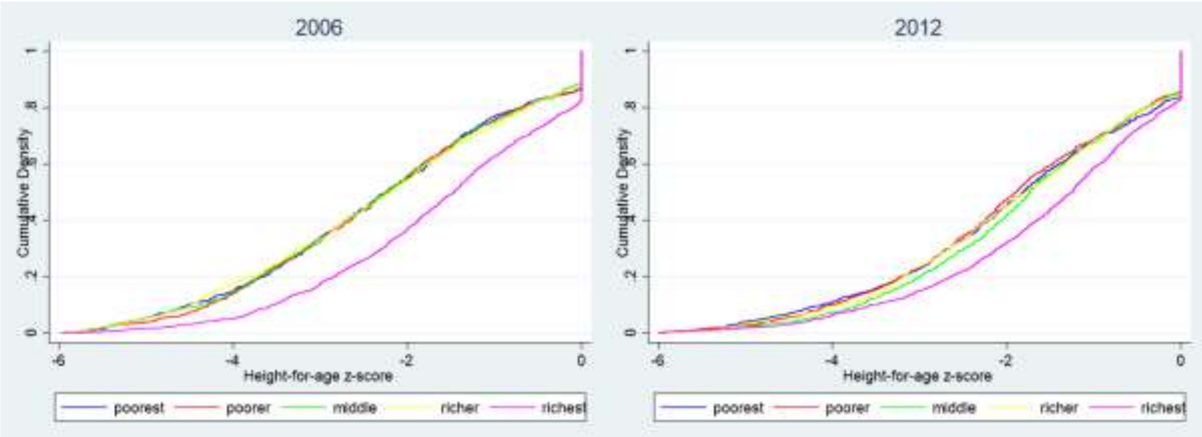

Figure C.2: Cumulative distribution functions per wealth quintile of Niger