HEIGHT AND HEALTH OF WOMEN IN SUB-SAHARAN AFRICA AND SOUTH-ASIA 1950-1980

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Paper to be presented at the European Social Science History Conference 2002 to be held in The Hague, 27 February - 2 March

Abstract
How well the Sub-Sahara African and South Asian societies caught up to the developed countries is a much-discussed topic. Based on heights as an indicator for a society's well being this article presents evidence that there is still a long way to achieve a convergence.
Additionally, we explore the impact of various socio-economic, nutritional and health variables like GDP per capita, infant mortality rates, national food supply on heights.
The most remarkable result is that the heights of the African societies stagnated or followed an inverted U indicating a nutritional or health crisis especially in the years 1965-1975. Therefore, this region appears as an important exception from the worldwide trend of upward-sloping heights. The height of South Asian women, in contrast, rises in spite of distinct gender discrimination.
The panel data set was derived from the Demographic and Health surveys (DHS) conducted by Macro International. Although designed for other purposes, namely fertility and health issues, heights of approximately 120000 mothers were recorded. In order to determine the magnitude of potential biases we compared the heights of mothers with the heights of women exemplary for the Ivory Coast.

Acknowledgements:
I would like to thank Jörg Baten and Uwe Fraunholz for helpful comments on earlier drafts and for their review of this paper. I am also grateful to Macro International for kindly providing access to their database. Finally, many thanks to Alexander Staus and Deni Franjkovic for excellent research assistance.

1. Importance of Heights in Determining the Living Standard

Scholars of economic history, development and health economics frequently used mean heights as an indicator for nutritional well-being of a population. Final adult height is a function of conditions in youth, especially of the nutritional quality and quantity as well as the epidemiological environment or workload, which the individuals have faced during their period of growth.

The advantages of considering heights have contributed to the spread of its use. First, it measures the outcome of the above-mentioned inputs, which many regard as an integral part of well-being. Second, the high comparability across time and often even nations makes it a useful proxy to apply. And last but not least, height records are available for periods where other reliable data is missing.

The applicability of this measure was impressively demonstrated by the relationships found by many economic historians, but also the WHO has promoted the use of heights for assessing undernutrition and targeting individuals at risk.[1]

However, heights of adults living in the less developed countries were seldom recorded, only covering some countries of Sub-Saharan Africa and South Asia.[2] The recently published and very comprehensive DHS surveys changed the matter and offer for the first time the opportunity to compare the development of the nutritional status measured by height in these regions, while other reliable data describing well-being is missing especially for the early second half of the 20th century.

Our study starts with discussing the data and determining the magnitude of a potential bias due to the selection of mothers instead of women in general. In the sections thereafter, we focus on how well the Sub-Sahara African and South Asian societies caught up to the developed countries in terms of nutritional status and which determinants favour such a desired convergence. Methodologically, the variation of heights between and within states is considered separately. The article closes with a summary.

[1] See for example Fogel, R.W. (1994), Steckel, R (1979, 1994), Komlos, J. (1987), Baten, J. (2002) and WHO (1983)

[2] See the studies of heights of Straus, J. and Thomas, D. (1998) for Côte d’Ivoire, McDonald, J. (2002) as well as Srikantia, S.G. (1989) for India and Higgins, P.A. and Alderman, H. (1997) for Ghana

2. Data and Bias due to Selection of Mothers

Mean heights were derived from the Demographic and Health Surveys (DHS) conducted by Macro International.[3] The samples of households are nationally representative but only the heights of mothers instead of women in general were recorded. From approximately 120000 mothers mean heights were calculated for each birth year and country. If more than one survey was available for a single country the data was pooled.

The age of the mothers does never exceed 50 years, which is often considered as the edge for individuals beginning to loose stature.[4] In contrast, mothers younger than 18 years were included in this section. Since they have certainly not reached their final height we use Height for Age Z-scores instead, which compare each individual's height to the median one of identical sex and age in a healthy non-deprived reference population.[5]

Since all mothers are women but not all women are mothers there is potentially a scope for a bias. In order to determine the extent we employed two strategies.

Exemplary for the Ivory Coast, we compared the DHS heights with the ones of women in general recorded in the four Côte d'Ivoire Living Standards Surveys (CLSS) from 1985/86/87 and 88.[6] Figure 1 shows the 95% confidence intervals of the mean heights of both sources. Although there are no significant differences, a pattern can be observed. A gap of 0,5 centimetre appears for the first birth cohort. This gap is decreasing and finally increasing again for the last birth cohort. However, the regression presented in table 1 improves the accuracy and indicates that there is probably no selectivity. There is neither a significant difference in the absolute term nor in the trend of heights. Still left is the issue for the younger DHS mothers because CLSS women older than 19 years were born before 1970, which means that DHS mothers younger than 25 years lack for a comparison. Furthermore, the results may be valid only for the special case of the Ivory Coast, although similar conclusions seem likely for societies with similar norms of maternity.

Since heights vary according to social affiliation we additionally compared the frequency of primary educated mothers in the DHS-data with the gross primary school enrolment rate[7] for

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[3] See Macroint (2000)

[4] See Baten, J. and Murray, J. (2000). The age distribution of the mothers is somewhat skewed to the left with a mean between 27 and 29 years.

[5] See WHO Working Group (1986) as well as Gorstein, J. et al. (1994) for a more comprehensive discussion. In the case of full-grown adults Height for Age Z-scores are a linear transformation of heights.

[6] available at http://www.worldbank.org/lsms/

[7] the gross primary school enrolment rate is defined as the total enrolment in primary schools, *regardless of age*, expressed as a percentage of the official primary school-age population in a given school year. The net rate is only available for some countries for 1981 onwards.

females given by the World Bank (1999).[8] In doing so, we related the enrolment rate of a specific year to the percentage of at least primary educated mothers, which were probably in the school age for this year, generally assumed to be born 6-12 years prior to the reporting year of the enrolment rate.

The mean frequencies of primary educated mothers appear on average to be very similar to the mean school enrolment rates except for the birth cohorts 1968-79, where a gap of about 12% becomes visible, see figure 2.[9] Even after taking into account that gross enrolment rates higher than 100% cannot be reached by the frequency measure derived from the DHS data set and therefore were set to 100% the gap becomes only 2% smaller.

Although the difference is statistically significant at the 1% level, substantial biases are unlikely. Based on the observed average height difference of one centimetre between at least primary educated and non-educated females, an under representation of educated females in the size of 10% would amount in a downward bias of only one millimetre which seems rather negligible.

However, only the average was concerned so far. Almost in every country the decrease occurs in the last two reporting years 1975 and 1980, see table 2. Significant decreases in the schooling share of the DHS mothers compared with the aggregated World Bank data took place in Benin, Comoros, Kenya, Nepal, Niger, Nigeria, Senegal, Tanzania and Togo, where on average 20% of educated women are missing among the youngest two birth cohorts when assuming the consistency of this approach. The real extent can still deviate for all countries. Especially for the younger mothers, the net enrolment rate seems more appropriate since one would expect their school attendance to be happened during the official school age with a higher probability. Considering the available net enrolment rates, the missing percentage of educated women becomes smaller. The extent would amount in Tanzania 18%, in Benin 9% and in Senegal 7% and thus reducing the gap extremely.

Summing up, there are hints for a selection bias concerning mothers younger than approximately 20-25 years. Although the extent seems in most countries negligible one

[8] Education is most suitable for this procedure since it is the only information we have, which is related to the youth of the mother. However, there may be positive as well as negative deviations, which do not indicate any selection bias. One reason is that we do neither know when exactly the mothers have attended the primary school nor the number or age pattern of pupils that were enrolled but were beyond the school age. For example, adults may attend literacy programmes. If they were included in the rate, it occurs in a later reporting year than they were in the official school age. In that case, we would overestimate the share of primary educated mothers in the first school-age period and underestimate it in the later one. Another reason may be high drop out rates before the pupils were counted and the mothers are recorded as primary educated in the DHS sample but not by the World Bank.These biases differ from country to country and may even be subject to temporal variation.

[9] The larger deviation for 1960 is due to the small number of mothers born between 1948 and 1951 that should be less primary educated and therefore resulting in an upward bias of the frequency of primary educated mothers.

should take the representativity of the computed mean heights for these age groups not for granted. This concern applies especially to the age group younger than 20 years, which were consecutively entirely excluded from the analysis.

Other sources for heights, which are readily available like records of health facilities, are certainly more constrained because the access is in most of the selected countries still a privilege of the rich and therefore the poor and probably shorter people might be extremely underrepresented.

The data for the determinants of the heights were taken from a couple of sources. From Maddison, A. (2001) we obtained GDP per capita for the years 1950-80. Infant mortality rates were derived from UN Population Division (1996). The nutritional variables, which are only available from 1961 onwards, the percentage of urban population as well as the total population is from the FAO Statistical Data Base.[10]

3. Variation between Countries

The height differences of the women are presented in figure 3. Strikingly, the South Asian women are much shorter than most of the African ones. Are these differences determined by genetical height maxima?

The first scholars who emphasized the greater impact of environmental conditions instead of genetics for peoples in less developed countries were Habicht, J. et al. (1974) as well as Eveleth, P. and Tanner, J. (1976). However, Agarwal, D.K. and Agarwal, K.N. (1994) found that even the growth path of Indian elites is significantly below that of the NCHS reference population. But this may also be due to the fact that elites stay not unaffected by poor conditions in general.[11] Moreover, Shams, M. and Williams, R. (1997) showed that generational changes in heights of immigrants in Glasgow mostly from Punjab are increasingly offsetting the difference in heights between the British and South Asians. Since the heights are also far from stable for almost all of the selected countries the differences noticed during this snap-shot could vanish in future. Therefore, we adopt the general view that the growth potential of the ethnic groups selected in this article do not differ very much.

[10] available at http://apps.fao.org/

[11] See also Klasen, S. and Moradi, A. (2000). In comparing the height differences between elites and non-elites in the Indian states, in which the genetic growth potential can be considered as equal, they presented evidence that the height of elites are a positive function of the heights of non-elites in the same state.

Nevertheless, we will control for differences between South Asia and Africa with a dummy variable.

Most of the South Asian women fall below 152 cm, the height that was reached by female Dutch underprivileged like orphans and factory workers born in 1849.[12] The heights in the majority of countries, however, exceed the 158 cm reached by Bavarian women born between 1865 and 1879.[13] In Chad and Senegal the women are almost as tall as modern US citizens.[14] Summing up, the nutritional status of women studied in this paper could be assumed to be some 20-100 years behind OECD standards in the 1960s if approximated by height.

Using GDP per capita as a measure of living standard one would judge more extremely. Only in Namibia, Mozambique, Nigeria, Zimbabwe, Côte d'Ivoire, Ghana and Senegal the GDP per capita in 1973 exceed the one of the USA in 1820 and except for Namibia all countries are well below the level which was realized by the USA in 1871.[15] Additionally, the ranking of the countries would substantially differ. Mali, Chad and Burkina Faso for example belong to the poorest countries in terms of GDP per capita although their mean heights suggest that the nutritional status may not be as poor.

The lack of correlation between GDP and height is also clearly visible in the regressions presented in table 1, where we considered levels and therefore ran them separately for each five-year period to avoid misinterpretations due to trends or cluster formation. Although coefficients of the same variable are certainly correlated, clear trends in the significance and magnitude could indicate changes in the importance of the determinants.

GDP per capita becomes never statistically significant. In contrast, Brinkmann, H. and Drukker, J.W. (1998) found a significant and robust negative relationship between stunting of children (age 0-5) and GDP per capita in less developed countries in the mid-1980's.[16] Since the prevalence of stunting is negatively correlated with mean adult heights, one would had expected a significant positive relationship between GDP per capita and final heights if the influence of the level of per capita GDP is independent of time and the sample of countries. However, Brinkmann, H. and Drukker, J.W. (1998) included 46 countries, most of them from other regions than South Asia and Sub-Saharan Africa, thus we have only 11 countries in common. Moreover, they did not include Mali, Chad, Ivory Coast, Namibia and Mozambique, which do obviously deviate from the expected GDP/height relationship. There are also some

[12] see Van Wieringen, J.C. (1972), table 9.2
[13] see Baten, J. and Murray J. (2001), figure 1
[14] See WHO (1983)
[15] see Maddison, A. (2001), pp. 185/ 215/ 224
[16] Stunting is defined as the percentage of children under five years, which are more than two standard deviations below the median height of the NCHS reference population. Brinkmann, H. and Drukker, J.W. (1998) referred to Maddison, A. (1995) as their source for GDP per capita.

hints that their result may be unique to the years 1985-1990. In some African countries GDP per capita changed from 1975 to 1985 dramatically. In Madagascar and Ghana, for example, it fell by 27% respectively 37%, in Cameroon, in contrast, it rose by about 50%. Interestingly, there is a strong positive correlation between the stature of a population in 1971/75 and the increase in GDP per capita from 1975 to 1985, see figure 4a.[17] This may be a random result since the pattern applies only when ignoring the South Asian countries, but it explains why we would expect to find a positive relationship between GDP per capita and heights in the mid 80’s, even when heights did not change at all during this period.[18]

In contrast, daily protein supply per capita is a robust and significant positive predictor of final female height, which is in line with the results of other authors.[19] Protein is mostly an element of high quality food like meat, fish, eggs and milk. The latter is often fed to infants. All of them have in common that they have further important nutrients like calcium, iron and phosphorus, which are important inputs for muscle and bone formation and therefore favour growth in particular.[20] The strong relationship is also clearly visible in the scatter plot in figure 4b, where Madagascar and Malawi are obviously outliers.

There are two more aspects worth to note. First, a sufficient protein supply is not conditional on a high GDP per capita per se. In 1961/65, for example, Chad and Mali are the sample’s poorest countries but are nevertheless among the countries with the highest protein supply. In contrast, Ghana and Mozambique are among the richest and had the lowest protein supply. However, in the subsequent decade the protein supply tends to increase in the richer countries and to fall in the poorer countries, turning the weak negative to a finally weak positive correlation.

Second, proteins are a positive function of calories. However, calories cannot explain the observed height differences. That means, that increasing food supply in quantitative terms alone is insufficient to prevent the population from growth retardation, although it is likely that they gain weight instead.

As a surprising result of the regression, primary education turns out to be negatively correlated with height over time. It is very implausible, that this finding reflects a causal relationship since educated women are about one centimetre taller on average within a population. Obviously, the countries with the shorter heights had made more successful

[17] Brinkmann, H. and Drukker, J.W. (1998) referred to the level of GDP per capita. Therefore, the difference of levels is the proper measure to address the reason for the different results. Nevertheless, when considering the percental change of GDP per capita, the relationship gets even more pronounced for the African countries.

[18] In using often a dummy variable, the South Asian region is treated as divergent from general rules.

[19] See Baten, J. (1999), Brinkmann, H. and Drukker, J.W. (1998).

[20] See Moradi, A. (2001)

efforts to improve the educational system. This will certainly result in benefits changing heights in the long run, if education is influencing the household's net nutrition positively.

The dummy variable for South Asia is significantly negative indicating that the heights of South Asian women are smaller given the relationship and their values in the exogenous variables. Although the magnitude of the coefficient is decreasing over time indicating that the gap in height is closed by about half a centimetre, the birth cohort of the early 1970's are still more than eight centimetres shorter. This seems always to be the case when anthropometric indices are used in cross-sectional analysis based on macro level data and give raise to a puzzle known as the 'Asian Enigma'.[21] In an analysis of micro level data, Moradi, A. (2001) found that the height difference could partly be explained by differences in the immediate determinants (food intake, prevalence of diseases) affecting child undernutrition. Accordingly, in the 1990's undernutrition in Sub-Saharan Africa is more due to a high prevalence of diseases whereas in South Asia it is more due to insufficient food intake, especially caused by a longer adherence to breastfeeding. Unfortunately, no data is available to test this hypothesis for the period 1950-1980.

The infant mortality rate was included as a proxy for medical care. Although the regression coefficient has the expected negative sign in the periods from 1961/65 onwards, there is no statistically significant relationship. Additionally, the coefficient is very sensitive, for example, when changing the model specification slightly by using a dummy variable for the desert countries Niger, Mali and Chad or Malawi and Madagascar.

[21] see for example Brinkmann, H. and Drukker, J.W. (1998), Smith, L.C. and Haddad, L. (2000) as well as Klasen, S. (1999). A list of possible reasons for the Asian Enigma gives Ramalingaswami, V. et al. (1996)

4. Variation within Countries

Height trends provide information on the development of the nutritional status. Any decrease of mean height indicates a severe crisis. Moreover, as Baten, J. (2002) argued, even a stagnation of height in the 20th century could be considered as an indication of economic problems since we would expect that the spread of knowledge on hygiene and medical care results in lower energy expenditures and in more energy left for growth. Thus, a stagnation of mean height may only occur if food consumption of a sufficiently large number of individuals does decrease either quantitatively or qualitatively.

In fact, there is evidence for a considerable transfer of medical knowledge: infant mortality rates were declining steadily in all countries except for Madagascar. However, there are also hints that progress does not occur continuously or uniformly for all countries. Large-scale benefits were realized for example in the 80's when oral rehydration products for treating children with diarrhoea became available and the pace of immunization coverage was accelerating with Sub Saharan Africa lagging five years behind.[22] Similarly, the share of population with access to safe water varies in a spatial and temporal dimension without a clear tendency of improvement for all countries.[23]

The likely selectivity within the age groups younger than approximately 25 years complicates the assessment of trends, since the ends of the slopes cannot be treated as certain. An adjustment was made by

(1) $H\_adj._{71/75,i} = H_{71/75,i} + [(H_{pe} - H_{no\ pe})_{61\text{-}70,i} * (DIF_{61\text{-}70,i} - DIF_{1971/75,i})]$ for each country i

where H refers to the mean height, DIF to the difference between gross primary school enrolment rate for females and the share of primary educated mothers, pe denotes primary education and the indices of years denote the period on which the values are based.

The first term within the squared bracket is equivalent to the country specific height difference between primary and non primary educated women, observed in the two birth cohorts prior to the biased one. In this period the difference is extremely stable and a bias in height even within the primary educated group in 1971/75 cannot be fully excluded. For example, assume that each member of the economic elite is primary educated but these women do nevertheless give birth later than others and are therefore not included in the DHS

[22] see UNICEF (1996; 2002)
[23] based on World Bank data for the period 1980-98

surveys. Then, the height of the primary educated women in that cohort lacks the influence of the elite members and is probably shorter.

The second term within the squared bracket refers to the share of missing educated women compared to the World Bank figures. Again, we took only the divergence from the 'usual' share of missing or additional primary educated women, which we have observed in the two birth groups before.[24]

However, the effect of this adjustment procedure is small in general. Only in Togo, Zimbabwe, Comoros and Nepal the adjusted heights exceed the original ones at approximately four millimetres.

In many African countries mean heights follow an inverted U, see figure 5. The increase stops in these cases mainly in the birth group 1961/65, only in Tanzania and Senegal the trend reversal occurs five years later. For half of these countries, namely Madagascar, Benin, Uganda, Zambia and Burkina Faso, the mean height in the last birth cohort is the same or smaller than in the first birth cohort.

For another group of countries either a downward or no clear trend can be observed, see figure 6. Decreasing heights can be seen in Chad, Malawi and Ghana where the earliest birth cohort is approximately one centimetre taller than the latest. Less extremely is the fall in height by about half a centimetre in Mozambique and Niger. In contrast, in Togo the mean heights are nearly constant throughout the entire period and in Zimbabwe and Cameroon the heights varied somewhat but without any increase compared to the first birth cohort.

The only Sub Sahara African countries that show a clear upward trend at least in the last three birth cohorts are Mali, Comoros and Kenya, see figure 7. However, in the case of Comoros and Mali the gain did not offset the sharply fall during the 1950's.

In Nepal, India and Bangladesh the mean heights were rising, although with differences in pace and magnitude. Indian heights recovered slowly after a fall in the birth cohort 1956/60 and reached finally 151,2 centimetres,[25] half a centimetre more than in the first birth group. Bangladesh experienced a steady rise in mean height in the 50's and 60's, but fall somewhat behind in the last birth group. Nevertheless, the total gain amounts to one centimetre. The Nepalese heights show a similar increase, although the birth cohorts 1956-1970 point to a phase where heights stagnated.

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[24]Note, that the shape of the slopes do not change when alternatively an adjustment was made for each period by (2) $H\_adj._{t,i}=H_{t,i} + [(H_{pe} - H_{no\ pe})_{t,i} * DIF_{t,i}]$ for each country i and five-year period t. The difference to the observed heights is normally distributed with zero mean and maximal ranging between –5 and +5 millimetres.

[25] The Indian heights are based on only 45% of the population. Therefore, a representative value may slightly differ. But there is no hint that the inclusion of the other states would fundamentally change the observed height trend, see Vijayaraghavan, K et al. (2002)

In summary, the Sub-Saharan region appears as an important exception from the worldwide trend of upward-sloping heights indicating, that the second half of the 20th century cannot be treated as a period where progress in essential human needs took place almost naturally. Although some African countries made steps forward in the period 1951-65, in the decade thereafter almost the entire Southwest and the Southeast of the African continent stick in a nutritional or health crisis as indicated by the fall of female mean heights. Thus, on the way to a convergence in nutritional terms the gap has widened again. In contrast, the South Asian region shows a considerable development especially as gender discrimination against women is found to exclude females from new realized benefits.[26] However, the question remains unsettled, how the nutritional status would have been in absence of discrimination.

The determinants, which are likely to drive these variations, are presented in table 4.

Obviously, the development of mean heights is not generally influenced by growth in GDP per capita. Although there are some countries, which do fit rather well into a positive correlated pattern like Bangladesh, India, Senegal and Zambia, other countries' development of mean height deviate to such an extent from their economic performance, that in sum no relationship can be found. These countries are particularly Benin, Comoros, Mozambique, Namibia and Niger.

Therefore, the finding of Brinkmann, H. and Drukker, J.W. (1998) who questioned the existence of a divergent development between nutritional status and GDP for developing countries seems to be restricted to the mid-80's. In general, cross-sectional studies seem not appropriate to settle this problem, since country specific developments are insufficiently taken into account.[27]

The extent of the decline in infant mortality fails to explain the observed height trends, too. A straightforward reason might be, that the fall in infant mortality occurs on relatively constant rates for almost all countries. Therefore, it is doubtful, that this variable approximates health conditions in all its manifold aspects. Energy absorbing diseases like monthly diarrhoea or fever episodes, which were not as severe that the mother bears the costs to take her child to the health facilities, are not covered. Nevertheless, life expectancy is evenly an element of the Biological Standard of Living. The fact of its rise as indicated by the fall in infant mortality rates as well as the faster pace compared to developed countries during their industrialization should be regarded as a great progress.[28]

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[26] see for example Sen, A. and Sangupta, S. (1983) as well as Batliwala, S. (1987)

[27] Reasons for a divergent developments between the physical stature and the economy were reviewed in Komlos, J. (1998). In fact, all studies who found a divergence considered only one country.

[28] see Brinkmann, H. and Drukker, J.W. (1998). Based on the World Bank (1999) data, 72% of the variance of the life expectancy at birth can be explained by infant mortality rates for this sample of countries.

The role of education reveals an interesting effect on height. The more education the mothers received on average, the more the growth in the mean stature. The mean number of school years proves to be a better predictor than the percentage of primary educated mothers as indicated by the higher t-values in a joint regression, probably because high drop out rates are weighted by the former and neglected by the latter.

However, the result is not as straightforward as it looks. According to the birth year-orthodoxy, final height is mainly determined by nutritional and health conditions in the first year of life. However, school years are collected definitively later. Two explanations are noteworthy.

First, the birth year orthodoxy may not apply and the school attendance might have changed the net nutrition in such a manner that catch-up growth becomes possible. Likely pathways are school feeding programmes or health education. These were put into practice relatively early in the 60's, although a large scale and more efficiently implementation occurred certainly later.[29] The regression results are in line with this argument. The corresponding coefficient and statistical significance of education is higher in the regressions (6) and (4), where the birth cohorts 1951-1961 respectively 1965 were excluded due to missing data on milk supply. However, a large impact on the height of the whole population was never documented.

Second, the finding does not challenge the birth year orthodoxy. In accordance with economic theory the girl's education can be considered as an investment in her future undertaken by her parents. Hereby, the return of education would be higher the better the nutritional or health status of their child is.[30] Thus, it would be purely rational to invest also during the first year of life. This view is quite deterministic, but can nevertheless hold in the vast majority of cases.

Similarly but without referring explicitly to an economic rationale, the education later received by the child might be only a proxy for the general ability of the parents to offer care during the first year of life.

However, the long-term benefits are not included yet. Better educated mothers tend to provide better care and their children are less likely to be malnourished.[31] A lagged effect of more than 20 years is likely.

[29] see Vince-Whiteman (2001) et al.

[30] a correlation between the nutritional status and the ability to learn was frequently cited. See for example UNICEF (1996)

[31] The education of the mother does affect her child's nutritional status positively in almost every study on child undernutrition. See for example Sahn, D.E. (1994), Moradi, A. (2001) as well as Smith, C.S and Haddad, L. (2000) for a cross sectional analysis.

The effect of urbanization on nutritional status is a negative one. One could have expected both signs. On the one hand income prospects and access to health facilities are better in urban centres, on the other hand disadvantages emerge from a worse epidemiological environment and a dependence on food prices. The regression results indicate that factors like the latter might had offset the potential gain. Evenly plausible and an argument in favour of the conditions in cities is that a high pace of urbanization is a proxy for poor rural conditions, which led to the decision of many rural dwellers to remove and seek their future in the urban centres. Consequently, disproportionately falling heights in rural areas may have induced a decrease in mean heights. That would explain, why we found urban residents to be taller in almost all countries.

Moreover, the influence of urbanization varies and seems to peak in the period 1966-70, suggesting that different and changing reasons must be taken into account.

The nutritional intake was approximated by daily calorie and protein as well as yearly milk supply per capita, where available data is limited to the years 1961 onwards. Therefore, in an attempt to extend the analysis to the period 1961-65, average growth rates were used in regression (5) and (6) instead of growth rates from period to period. The results did not change.

Calories and proteins are highly correlated. Excluding one of these variables results in the insignificance of the other. Milk, however, proved to be robust and seems to be a better proxy for the food consumption of a child anyway. Although the levels of consumption do differ heavily between the countries, milk proves to be a significant positive predictor of final height. The decrease in the growth rates of milk supply in the period 1971/75, which is additionally accompanied by a fall in protein supply, deserves to speak from a nutritional crisis. This crisis was certainly reflected by the fall in final heights.

5. Nutritional and Health Crisis before the AIDS pandemic?

We started our analysis with examining the extent of a bias due to the selection of mothers instead of women in general. The results suggest that younger women cannot be considered as representative for all women. Consequently, we excluded mothers younger than 20 years from the analysis and adjusted the heights for the mothers approximately younger than 25 years based on the extent and influence of the missing primary educated women.

The variation of heights between countries can be explained to a big part by differences in protein supply per capita. In contrast, the variation within the countries is positively affected by education and milk supply and negatively by urbanization. However, we could not find any general influence of GDP per capita, although there are hints that a positive relationship is valid for some countries and might additionally exist in the periods thereafter.

In the last decade much attention was paid by the international community to the disturbing effects of the AIDS pandemic, which was held responsible for the decline of life expectancy in many African countries.[32] The results presented in this paper suggest that a nutritional or health crisis existed in Sub-Saharan Africa between 1966 and 1975, at least one decade in advance of the AIDS pandemic. However, this crisis was not characterized by a fall in life expectancy but by a decrease or stagnation of mean heights.

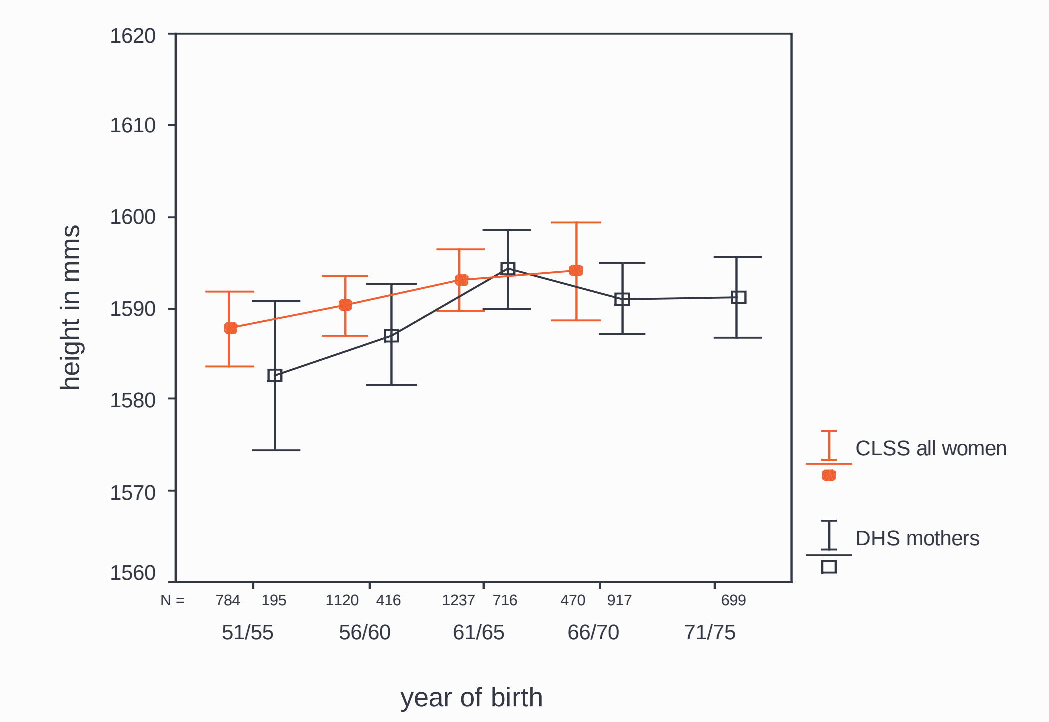
Moreover, almost all African countries investigated in this paper were hit by this crisis some of them still widely unaffected by the AIDS pandemic like Chad or Niger. Although, the effects were far from being comparable to the AIDS pandemic, the experience to the human body, which the girls have faced during their growth period, must have nevertheless been very painful.

Despite the fall in milk and protein supply and its significant effects on height, we could not certainly ascribe this crisis to a purely nutritional one, because more powerful health indicators than infant mortality rates are not available.

We conclude that there is still a long way to achieve a convergence in the Biological Standard of Living. But the struggle includes also other challenges than only the AIDS pandemic.

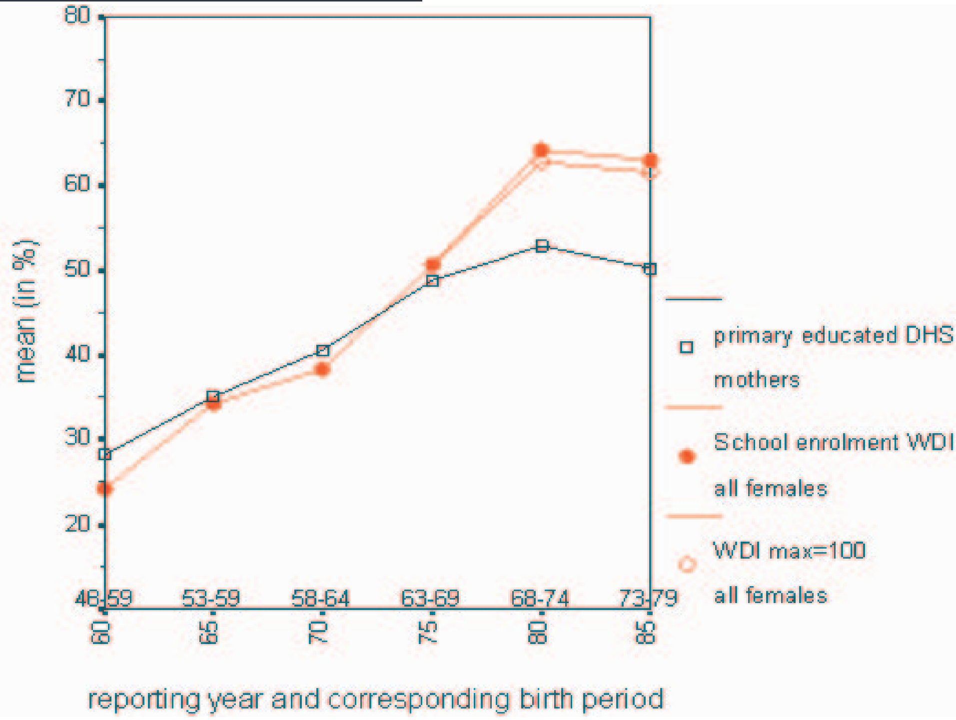
[32] See for example UN Population Division (1996) and UNICEF (1997)

Figure 1: Differences in mean heights between DHS mothers and CLSS women / Ivory Coast



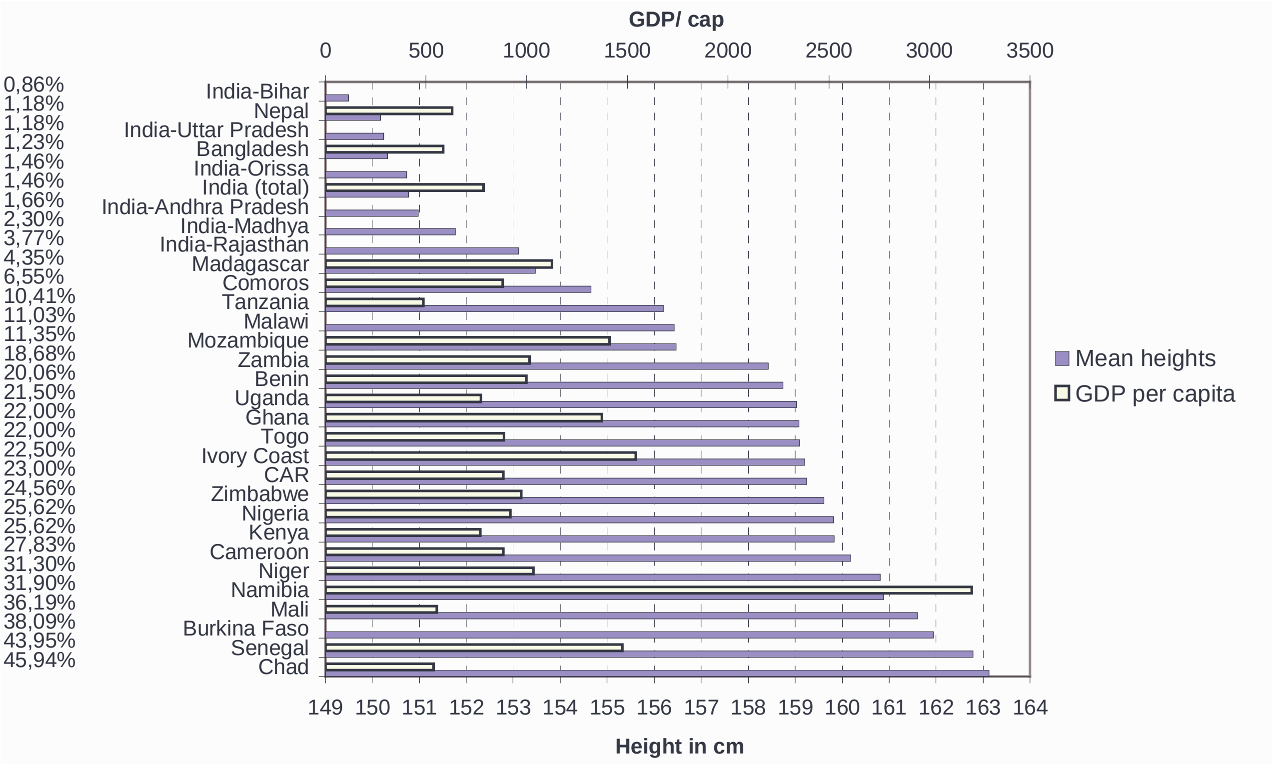
Note: Error bars indicate the 95% confidence interval of the mean height. The four Côte d'Ivoire Living Standard Surveys were pooled. Only women older than 19 years were included. The few heights that were measured twice in the CLSS surveys (~30%) and differ more than two centimetres were excluded. In all other cases the record of the first round was selected.

Figure 2: Mean frequency of primary educated mothers in the DHS-data and gross primary school enrolment rate for females



Note: The percentage of primary educated mothers is generally based on the birth period 6-12 years prior to the reporting year. Thus, the selected mothers can be considered in the school age for the reporting year of the gross enrolment rate. Since it exceeds 100% in 1980 & 1985 in some countries, these figures were set to 100% (WDI max=100) to ensure that these cases do not exert too much influence on the mean gross enrolment rate. No data was available for Namibia.

Figure 3: Interstate variation in GDP per capita and mean heights of mothers (1960-69)



Note: Values on the left show the corresponding percentile of NCHS girls at age 18 for these heights. India (total) is a mean of the six included Indian states weighted by their population. These states represent approximately 45 % of the total Indian population.

Figure 4a: Change in GDP 1975/85 according to height

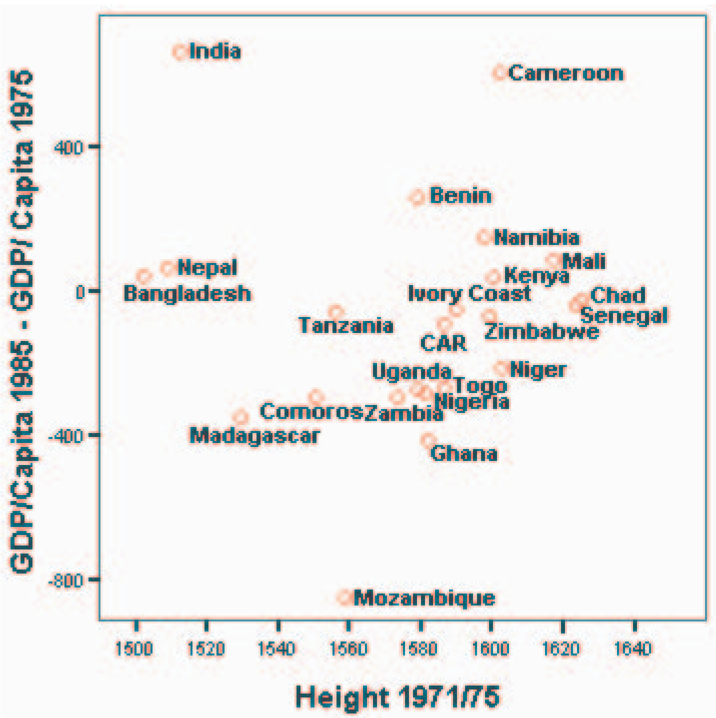


Figure 4b: Protein supply and heights in 1961/65

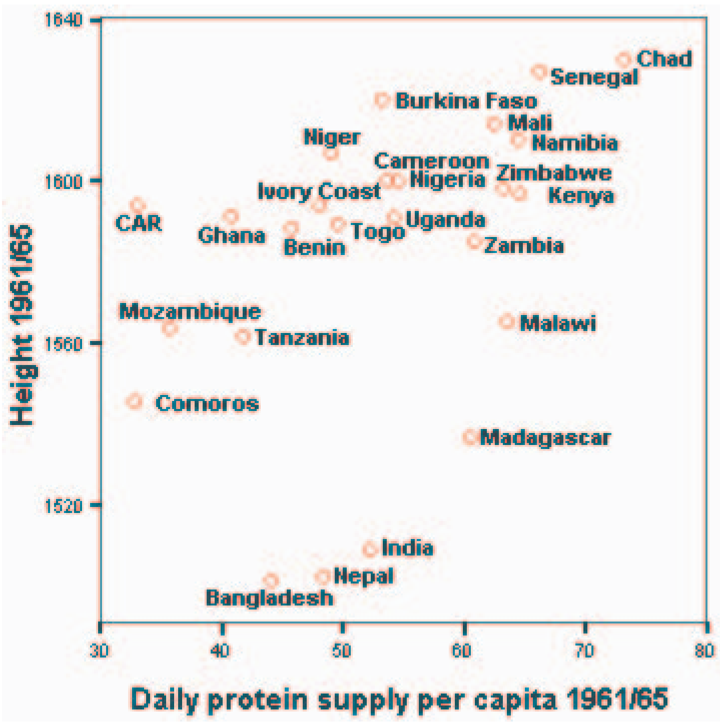
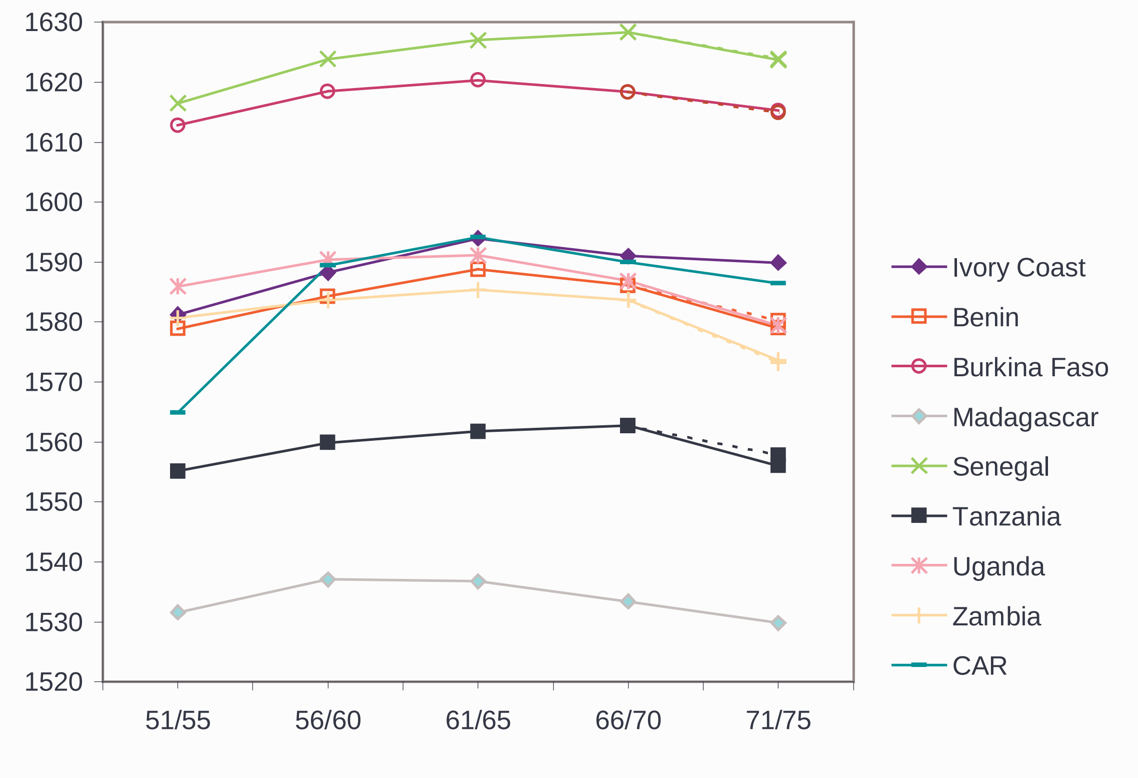
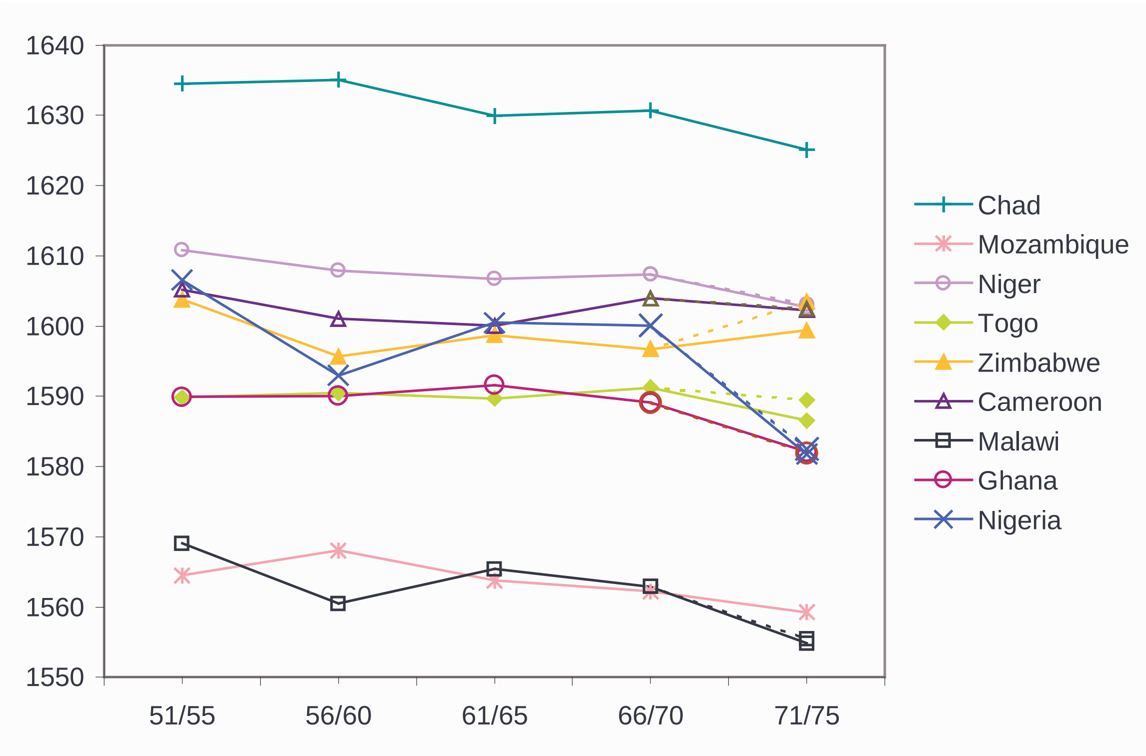


Figure 5: Height trends: Inverted U



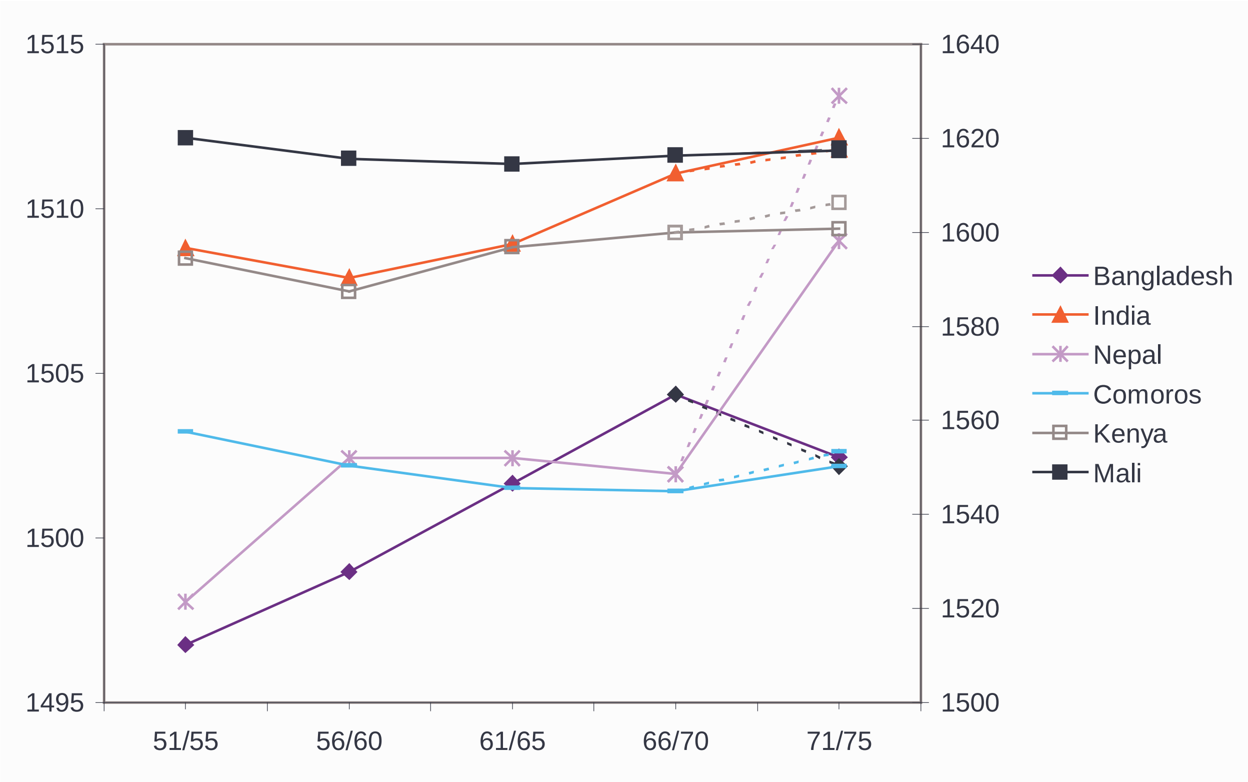
Note: Adjusted heights according to equation (1) in dotted lines. Only mothers older than 20 years were included.

Figure 6: Constant & downward trends in height



Note: Adjusted heights according to equation (1) in dotted lines. Only mothers older than 20 years were included.

Figure 7: U shape and Upward trends in height:



Note: Adjusted heights according to equation (1) in dotted lines. Only mothers older than 20 years were included. Axis for Bangladesh, India and Nepal on the left hand side, axis for Comoros, Kenya and Mali on the right hand side

Table 1: Differences in heights between DHS mothers and CLSS women / Ivory Coast

	Coefficients	t-values		CLSS	DHS
Constant	1347,204	10,17	Mean (1950-69)	1590,35	1590,39
year of birth	7,584	1,68	N	3767	2081
SQ(year of birth)	-0,058	-1,52	T-Test for equal		
DHS	25,041	0,11	means (p-value)	0,981	
DHS*year of birth	-0,786	-0,10	Levene Test for equal		
DHS*SQ(year of birth)	0,006	0,09	variances (p-value)	0,984	
Cook-Weisberg test (p-value)	0,99				
F-Test for a joint significance of DHS related variables (p-value)	0,84				

Note: Since women younger than 20 years were excluded the last birth included in the CLSS surveys occurs in 1969. To prevent a bias due to the weight of DHS mothers born afterwards only the period 1950-69 was considered.

Table 2: Univariate Regressions for each country determining significant decreases in the prevalence of primary educated women in the DHS samples

country	constant	period 1980/85, birth year1968-74/ 1973-79 (1=yes)	t-value	Selection Bias	(gross-net rate) for 1985
Bangladesh	-2,60	2,71	0,79	no	5
Benin	-8,50	-12,86	-6,46	yes	9
Burkina Faso	3,78	-2,57	-0,94	no	3
Cameroon	-13,74	-6,32	-1,33	no	
CAR	7,27	-7,39	-1,20	no	10
Chad	7,21	-0,33	-0,11	no	
Comoros	2,29	-22,02	-10,90	yes	
Ghana	-1,13	-7,40	-0,69	no	
India	-34,44	-3,14	-0,50	no	
Ivory Coast	-14,33	-3,55	-0,88	no	
Kenya	21,07	-25,24	-2,63	yes	
Madagascar	0,97	-18,67	-1,49	no	
Malawi	18,39	-2,13	-0,56	no	11
Mali	1,11	-2,97	-1,47	no	
Mozambique	-0,83	-6,37	-0,52	no	29
Nepal	-1,13	-20,16	-7,63	yes	
Niger	3,12	-2,40	-3,26	yes	1
Nigeria	5,68	-45,65	-4,14	yes	
Senegal	-9,47	-11,13	-2,06	yes	7
Tanzania	27,84	-28,76	-5,03	yes	18
Togo	-17,54	-21,36	-2,22	yes	
Uganda	25,72	11,54	0,79	no	
Zambia	17,69	-21,18	-1,45	no	
Zimbabwe	-0,46	-2,87	-0,18	no	

Note: The dependent variable is the difference between the frequency of primary educated mothers born 6-12 years prior to the reporting year and the gross school enrolment rate for females given by the World Bank (1999). Enrolment rates higher than 100% were set to 100%. No data was available for Namibia.

Table 3: Determinants of Interstate Variation in Heights

Period	1951/55	1956/60	1961/65	1966/70	1971/75	1971/75 adjusted
Constant	1603,40	1578,50	1566,92	1643,17	1646,21	1658,89
Ln(GDP/Cap)	-3,489 (-0,20)	-0,415 (-0,03)	1,290 (0,11)	-4,704 (-0,43)	-4,477 (-0,41)	-4,808 (-0,44)
Infant mortality rate	0,022 (0,06)	0,055 (0,19)	-0,130 (-0,56)	-0,266 (-1,01)	-0,228 (-1,04)	-0,257 (-1,18)
% of primary educated mothers in the sample	-0,110 (0,28)	-0,162 (-0,48)	-0,420 (-1,71)	-0,524* (-2,07)	-0,549* (-2,44)	-0,558* (-2,49)
Urban/ total population	0,953 (0,96)	1,022 (1,20)	0,657 (0,91)	0,407 (0,70)	0,130 (0,21)	0,042 (0,07)
Daily calorie supply/ cap			-0,010 (-0,35)	-0,017 (-0,59)	-0,020 (-0,76)	-0,022 (-0,82)
Daily protein supply/ cap (gr.)			1,298* (3,07)	1,443* (3,27)	1,395* (2,95)	1,387* (2,95)
Asia	-90,419* (-5,04)	-87,830* (-5,58)	-90,021* (-6,66)	-88,16* (-6,28)	-84,620* (-6,25)	-85,268* (-6,34)
R^2-adj.	0,54	0,61	0,76	0,75	0,72	0,72
F-test (p-value)	0,85	0,59	0,29	0,63	0,72	0,66
Cook-Weisberg test (p-value)	0,27	0,32	0,64	0,88	0,82	0,81

Note: OLS-Regression
The percentage of primary educated mothers in the sample was included instead of gross primary school enrolment rates for females because they are anyway positively correlated ($R^2 \approx 0,80$) and the former is available for all periods. Using gross enrolment rates instead do not change the results.
The last birth cohort born in 1976/1980 was excluded due to the selection bias.
F-test for joint exclusion of insignificant variables marked without an asterisk; t-values in parentheses.

Table 4: Determinants of temporal Variation in Heights

	(1)	(2)	(3)	(4)	(5)	(6)
Constant	1,104 (0,44)	-0,746 (-0,93)	-0,179 (-0,07)	-0,475 (-0,41)	-2,059 (-0,92)	-1,089 (-1,29)
Ln(GDP/ Capita)	-0,019 (-0,31)		-0,033 (-0,54)			
Infant mortality rate	-0,056 (-0,88)		-0,046 (-0,54)		-0,037 (-0,84)	
% of primary educated mothers in the sample	0,039 (0,25)		0,144 (0,85)		-0,026 (-0,19)	
Mean education in single years	2,629* (1,61)	2,685* (2,54)	2,233* (1,38)	3,791* (3,59)	2,970* (2,18)	3,725* (4,90)
Urban/ total population	0,069 (0,17)		-1,174* (-2,06)	-1,175* (-2,72)	-0,369* (-0,98)	-0,698* (-2,30)
Urban/ total population 1966-1970	-0,834* (-1,68)	-1,004* (-2,40)	-0,300 (-0,51)		-0,693 (-1,64)	
Ln (Daily calorie supply/ cap)			20,995 (1,06)		1,355 (1,90)	
Ln (Daily protein supply in grams)			-0,276 (-1,57)		-1,228 (-2,09)	
Ln (Milk supply/ year/ capita in l)			11,727* (2,16)	10,783* (2,63)	0,149* (1,06)	0,273* (2,30)
Population	-0,212 (-1,29)		-0,041 (-0,26)		0,126 (0,17)	
Nigeria	-7,513* (-2,76)	-6,886* (-2,75)	-11,184* (-3,37)	-9,900* (-3,66)	-4,978* (-2,03)	-5,499* (-2,43)
N	92	92	46	46	75	75
R^2-adj.	0,19	0,20	0,40	0,42	0,32	0,33
F-test (p-value)	0,70		0,73		0,32	
Cook-Weisberg test (p-value)	0,27	0,63	0,58	0,31	0,60	0,78

Note: OLS-Regression. All variables in growth rates except in the regression (5) and (6), where average growth rates for annually available variables are taken in an attempt to include the period 1961/65 when the effect of nutritional variables are estimated.
The percentage of primary educated mothers in the sample was included instead of gross primary school enrolment rates for females because they are highly positively correlated ($R^2 \approx 0,80$) and the former is available for all periods. Using gross enrolment rates instead do not change the results.
The last birth cohort born in 1976/1980 was excluded due to the selection bias.
F-test for joint exclusion of insignificant variables marked without an asterisk; t-values in parentheses.

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