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Low Malnutrition but High Mortality: Explaining the Puzzle of the Lake Victoria Region*

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Comparing DHS data from 235 regions in 29 Sub-Saharan Africa countries, we find that the combination of low levels of malnutrition together with dramatically high rates of mortality, encountered in Kenya's Lake Victoria territory, is unique for Sub-Saharan Africa. This paper explores the causes of this phenomenon in the Kenyan context. Our identification strategy consists of two parts. First of all, we apply multilevel regression models to control simultaneously for family and community clustering of the observed malnutrition and mortality outcomes. Secondly, to address unobserved but correlated factors, we exploit information from GIS and malaria databases to construct variables that capture additional components of children's geographic, political and cultural environment. Our analysis reveals that beneficial agricultural conditions and feeding practices lead to the observed sound anthropometric outcomes around Lake Victoria. In contrast, high mortality rates rest upon an adverse disease environment (malaria prevalence, water pollution, HIV rates) and a policy neglect (underprovision of health care services). Even after controlling for these factors, a significant effect of the local ethnic group, the Luo, on mortality remains.

Key words: Child mortality, undernutrition, multilevel modeling, Kenya.

***JEL* codes:** I10, I30, O12, R12.

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1 Introduction

There are a small number of regions in Sub-Saharan Africa that show very high levels of mortality given the anthropometric status of their population. Among these regions Nyanza, the principal Kenyan Lake Victoria province, is an exception of its own. In no other region in Sub-Saharan Africa (SSA) is the pattern of low levels of malnutrition together with dramatically high rates of mortality as pronounced as in Nyanza. Furthermore, the unique position of Nyanza is not only puzzling for Sub-Saharan Africa, but as well in the Kenya specific context. While Nyanza ranges on the upper limit of the mortality scale, most other Kenyan provinces depict comparatively low mortality rates given their levels of malnutrition.

In this paper we investigate the role of cultural, geographic, and political factors on the relationship of anthropometric outcomes of children and under-5 mortality rates in Kenya with an explicit focus on the unique situation of Nyanza and the territory around Lake Victoria. In order to disentangle the underlying mechanism that lead to the observed outcomes we analyze the factors driving mortality, stunting, and wasting jointly. Since parameter estimation can seriously suffer from endogeneity problems we adopted 3 strategies to mitigate this problem. First of all, we estimate reduced form regressions and therefore exclude any explanatory variable that we would expect to cause problems of simultaneous causality. Secondly, we augmented our DHS data by generating appropriate variables on malaria, health provision and Lake Victoria in order to mitigate problems arising from potential omitted variable bias. Thirdly, we use mixed model representations to further address unobserved heterogeneity issues on the family and community level.

Our findings point to a unique interaction of cultural, geographic and political factors in the Lake Victoria region which are responsible for causing the described puzzle. Particularly, high mortality rates are found to rest upon the disease environment in the territory in combination with unfavorable cultural habits of the local ethnic group with respect to sexual, and pre- and post natal behavior. Political discrimination against this group resulting in reduced access to health infrastructure further exacerbates the mortality situation in the region. Nonetheless, even after controlling for other factors a significant ethnic specific influence on mortality remains although the effect is much smaller than found in previous studies. On the other hand, the area around Lake Victoria displays extraordinary positive conditions - fertile soils, a high level of food security and high protein availability (fish) - that contribute to children's advantageous nutritional outcomes.

In this regard the existing study adds an important new example and further insights to the few existing mortality-malnutrition paradoxes. For instance, the famous South Asia vs. Sub-Saharan Africa enigma (Ramalingaswami et al., 1996; Klasen, 2008) refers to the observation that anthropometric outcomes of children are on average much better in SSA than in South Asia, while on the other hand child mortality rates are significantly higher in SSA compared to South Asia.[1] Our study contributes to this literature

[1]In another mortality-malnutrition puzzle Williamson (1990) finds that during the British industrial

for a variety of reasons. First of all, we are the first to explicitly state the puzzling discordance of malnutrition and mortality outcomes around Lake Victoria and to analyze it comprehensively. Secondly, the study illustrates that not only in the context of potential large genetic differences (Klasen, 2008) such a puzzle can arise, but that an interaction of cultural, geographic and political factors can reverse the observed bivariate relationship between a good nutritional status and the survival chances of children. Thirdly, in contrast to previous empirical studies on the South Asia vs. SSA enigma we explicitly control for factors related to the disease environment, e.g. HIV and malaria, and cultural factors and therefore are in a better position to obtain unbiased coefficients of our estimates. Fourthly, we use recent advances in multilevel modeling techniques that allow for the estimation of 3-level models which enables us to separate effects working at the individual, household, and community level. Moreover, this study is to our knowledge the most complete and accurate one analyzing the current determinants of under-5 mortality and anthropometric outcomes in Kenya.

Examining the nature of the Nyanza anomalies is further interesting and important since this example seems to question main findings in a variety of academic disciplines. In epidemiology, malnutrition, in particular wasting, is considered to be the main driver of mortality in developing countries and historical Europe (Fogel, 1994). Pelletier et al. (1995) claim that wasting is the underlying cause of more than 50% of all child deaths in the world. This individual relationship is usually assumed to hold even on a higher aggregate level. Thus, areas with high prevalence of malnutrition rates are expected to have higher mortality rates. Regarding the Kenyan context we find the exact opposite pattern. While rates of wasted children gradually decrease with proximity to Lake Victoria, mortality rates steadily increase reaching its peak in Nyanza.

In health and labor economics the interest of studying the growth process of children has more recently been motivated by the findings that taller populations are economically better-off, more productive, and live longer (Bozzoli et al., 2009; Deaton, 2008). This result can partly be attributed to the prevailing disease environment. If on the one hand the child growth process and therefore adult heights and on the other hand life expectancy are positively correlated with the lack of certain diseases then for instance a simple Beckerian type of quantity-quality trade-off models can explain higher incomes of taller populations through the human capital formation process. The relationship between adult height and economic well-being might therefore only be valid if adult height is at the same time a good proxy for the mortality environment of a certain area or a country. In the absence of this later condition the relationship might be seriously flawed and this is what we partly observe in the Kenyan context.

Furthermore, there exist several studies in the field of economic history that make inferences about economic conditions during a specific time period based on mean height measures of population or population subgroups. Since height is expected to be an increasing but concave function of income, average height will be negatively correlated with initial income inequality (Steckel, 1995). Hence, income inequality has an effect

revolution the population in urban areas suffered from much higher mortality rates than the rural population despite their much better anthropometric status.

on the dispersion of heights, so that inequality in height might function as an indicator of income inequality in the absence of data on the latter one, while mean height might serve as an indicator of mean income (Deaton, 2008). Obviously this inference does only hold if there are no other third factors that alter the relationship in an important way. Although this point has been recognized in the relevant literature, it is often neglected or downplayed due to a lack of data that can function as control variables. Again the case of Nyanza and Lake Victoria illustrates that such an inference can simply go wrong.

The paper is structured as follows: Section 2 amplifies and describes the extent of the puzzling situation in Nyanza and Lake Victoria in the Kenyan and Sub-Saharan African setting with respect to stunting, wasting and under-5 mortality. Section 3 discusses the theoretical model and outlines the identification strategy. Section 4 provides a detailed literature review on the most relevant cultural, geographical, and political particularities of the Kenyan context in order to explain the construction and interpretation of additional variables not included in DHS surveys. Section 5 provides descriptive statistics on the data sets and variables used in this study and comprises the multivariate analysis. Section 6 summarizes and concludes.

2 The Puzzle

Evidence from the demographic and health literature suggests that there exists a positive relationship between a good nutritional status of a child and its chances of survival. From this observation it is often inferred that this individual relationship holds as well at a higher aggregate level, e.g. regions or countries.

However, the validity of this inference seems to be seriously challenged considering the spatial distribution of malnutrition and mortality in Kenya. First of all, children in Nyanza score very well regarding anthropometric indicators, while infant and child mortality rates are extremely high in the region. Secondly, the mere extent of the within country variation in mortality rates astonishes. Interestingly, although some authors occasionally have mentioned either the high mortality rates (Colony and Protectorate of Kenya, 1923) or the favorable anthropometric outcomes (Moradi, 2009) on the shores of Lake Victoria, to our knowledge no study exists that combines these two findings.
Moreover, it has not been clear whether the described puzzle is even unusual for a larger geographical context. In order to address this issue we gathered data on stunting, wasting, and mortality indicators on the regional level for all SSA countries where Demographic and Health Survey (DHS) data was available. The final data set comprises 235 regions in 29 SSA countries.[2]

Table 1 depicts under-5 mortality, stunting, and wasting rates for all regions with an under-5 mortality rate of 200 per 1,000 live births or more. Of these 36 regions only Tambacounda province in Senegal shows better stunting rates than the Nyanza

[2]If more than one DHS round was available for a country, we only took the latest round into consideration. For the sake of comparison we recalculated stunting and wasting prevalence rates using the new WHO child growth reference standard for all regions whenever the data set included the old standard (WHO, 2006).

province while with respect to wasting only Tete and Niassa provinces in Mozambique show lower prevalence rates. Moreover, it is interesting to note that all regions in the table that achieve prevalence rates in one of the anthropometric indicators similar to those in Nyanza, score much worse than Nyanza in the other anthropometric indicator. Therefore and most notably, Nyanza seems to be the only region in SSA that scores extremely well in stunting and wasting given the level of mortality.

[insert Table 1]

Even more striking is the result when focusing on the area in close proximity to Lake Victoria. Using the 2003 DHS round for Kenya jointly with the provided GIS data we calculated under-5 mortality rates and the two anthropometric indicators for all children born within a distance of 20km from Lake Victoria. In this area under-5 mortality rates strongly increase by approximately 50% to 306 per 1,000 live births compared to the Nyanza average while stunting rates even fall to 26.6% with wasting rates increasing slightly to 3.9%.

Furthermore, the extreme position of the Lake Victoria region and Nyanza is illustrated in Figure 1 which depicts the bivariate relationship between stunting and under-5 mortality for all 235 regions and the Lake region as defined above. Figure 1 underscores the unusual high mortality level of Nyanza given its stunting rates and much more important the unique position of the Lake area in the SSA context with an overwhelmingly high under-5 mortality rate given the level of stunting. A similar conclusion can be derived from Figure 2 which presents the bivariate relationship between wasting and under-5 mortality.

[insert Figures 1 & 2]

Besides highlighting the extraordinary situation of the Lake Victoria region, all 2 figures further show a remarkable within-country distribution of under-5 mortality rates. While Nyanza is situated far on the upper bound of the under-5 mortality rates given its level of stunting or wasting, several Kenyan provinces find themselves on the opposite side, showing very low mortality rates given its level in the respective anthropometric indicators. Accordingly the dashed line in Figure 1 which represents the bivariate relationship of the Kenyan context is even downward sloping in contrast to the overall SSA context (solid line). This high divergence of mortality levels within one country is highly unusual even for the SSA context. Column 9 in Table 1 presents the coefficient of variation (CV) based on the separate calculation for each country. Out of the whole sample Kenya shows the highest level of dispersion given its level of mortality.

The simultaneous appearance of very low levels of malnutrition (in both indicators) together with tremendously high rates of mortality in Nyanza and in particular the Lake Victoria region is unique in the SSA context. Moreover, the appearance of this phenomenon in a national context of relatively low mortality rates is further surprising and led us to call it 'The Puzzle'.

3 Theoretical Framework

In order to analyze the described puzzle we estimate reduced forms of child health and mortality production functions. The choice of our theoretical model relies on earlier work in this field done by Rosenzweig and Wolpin (1988) and in particular Behrman and Deolalikar (1988). An overview on the general relationships of underlying (exogenous) and proximate factors affecting health and mortality outcomes is presented in Figure 3 which is guided by the frameworks as outlined in Mosley and Chen (1984). The conceptual core of the framework is the idea that all background variables (cultural, socioeconomic or geographic) have to operate through a limited set of proximate determinants (environmental contaminations, maternal factors, infant feeding habits, and preventive health care practices) which in turn directly influence the risk of disease and the outcome of the disease process.

[insert Figure 3]

The relationship among health inputs and child health outcomes can be written as follows:

$$H_{ijk} = H(E_i^o, P_i^o, v_k, u_{jk}, \varepsilon_{ijk}), \tag{1}$$

where the health of individual i in household j and community k (H_{ijk}) is produced by observed underlying factors (E_i^o), observed proximate factors (P_i^o) and certain unobserved underlying and proximate factors ($v_k, u_{jk}, \varepsilon_{ijk}$).

Further on, equation 2 depicts the mortality production function for individual i, with mortality (M_{ijk}) resulting if health falls below some critical level H^*.[3]

$$M_{ijk} = M(H_{ijk} - H^*) \tag{2}$$

In the empirical analysis, the estimation of parameters for the health and mortality production functions can suffer from three types of problems. First of all, since all health related input variables are treated as exogenous, a bias might arise if we fail to control for simultaneously determined health inputs in the estimation of the health production function. Secondly, health and mortality outcomes are influenced by several individual, family, and community variables. Some of these variables can be observed; others cannot. Table 2 shows how the observed and unobserved factors can be classified in our particular case. The simple association between, for example, the stunting score of a child and the mother's educational level holds if the observed indicator (e.g. educational status) is not correlated with unobserved variables (such as labor market conditions) that affect the stunting score. However, if the unobserved factor affects the child's stunting status and is correlated with the educational attainment of the mother, the estimated effect is biased together with false standard errors for our parameter estimates. Thirdly, our obtained coefficients can be biased and our standard errors can be false, even if the unobserved factor affects only the outcome variable but is completely uncorrelated

[3] Empirically we will model M as the risk of mortality at time t.

with the observed explanatory variables. This might be the case if in the incidence of clustering the mortality risk among siblings and among children residing in the same community is partially due to children sharing the same family and community characteristics. However, the correlation may persist after controlling for observed factors such that the remaining correlation is a consequence of genetic, behavioral, and environmental factors that are common to all children in a particular community or family but that are unobserved. As a consequence, the still correlated observations violate a standard assumption of independence in statistical analyses, resulting in standard errors that are understated and, in the case of non-linear models such as a hazard models, parameter estimates that are both biased and inconsistent (Trussel and Rodriguez, 1990).

To mitigate this problem we adopted 3 strategies. First of all, in order to circumvent the first problem we estimate reduced form regressions and therefore exclude any explanatory variable that we would expect to cause such a problem, which in our case results in dropping the length of breastfeeding from our regression equations. Secondly, we construct and include malaria, health care and a Lake Victoria variable, indicating whether a child lives within 20km around Lake Victoria in order to better capture the specific nutrition and disease environment as explained in more detail in section 4. Thirdly, as explained more in detail in section 5, we use mixed model representations to further address unobserved heterogeneity issues on the family and community level.

[insert Table 2]

4 Geography vs. Ethnicity: The Kenyan Context

This section motivates the construction of those variables that we include in our analyses in addition to those available from the Kenyan DHS. While two of these four additional variables (malaria prevalence and health expenditures per capita) are comparatively clear and easy in its interpretation, this is not the case with the Lake Victoria variables that we introduce later on. From this section it becomes clear why the distance to Lake Victoria enters as an indicator variable based on a 20km boundary from Lake Victoria into the mortality and stunting regressions, while in the wasting regressions distance enters in a continuous form. Moreover, based on the literature review it becomes explicit that the Lake Victoria variables are very likely to reflect causal factors rather than being mere statistical artifacts.

4.1 Nutritional Environment

The two most widely used anthropometric indices regarding children are stunting (low height for age) and wasting (low weight for height) which both serve a different purpose. Stunting is claimed to be an indicator of chronic undernutrition resulting of prolonged food deprivation or illness, meanwhile wasting is supposed to reflect acute undernutrition as a result of more recent food deprivation or illness.

In addition to this there exist further factors that manifest themselves in both anthropometric indicators very differently. In particular the type of food consumed in the first months of life plays an important role in the growth process of children and hence affects the stunting indicator while the wasting indicator remains relatively unchanged. For the transformation of energy into body growth, certain micro- and macronutrients are very essential like iron, calcium, iodine, vitamin A or proteins (Moradi, 2009). An important food that makes a vital contribution to the body growth of children is fish which provides quality proteins and fats (macronutrients) and vitamins and minerals (micronutrients). Furthermore, it is notable that not fish consumption per-se drives the higher than average growth process. Biomedical research shows that the growth effect due to fish consumption does only seem to occur in combination with a well balanced compositional diet (Marques et al., 2008).

The Lake Victoria region in fact offers the advantageous conditions just mentioned. Soils are mostly of good quality resulting in agricultural production surpluses what led Fearn (1961) to call the region the 'granary of East Africa'. Moreover, fish is largely available in at least close proximity to the lake despite the strong export orientation of the fishing industry in the context of the nile perch boom.

In general reliable administrative data on soil quality, frequency of rain and agricultural production for Kenya is not available. Motivated by the absence of such data in most developing countries, USAID created the Famine Early Warning System (FEWS). FEWS generates the so called Water Requirement Satisfaction Index (WRSI) and the Normalized Difference Vegetation Index (NDVI). The WRSI for Kenya is used as an indicator of maize performance based on the availability of water to the crop during the growing season. Maize has been selected since it is the most important cereal crop in Sub-Saharan Africa and due to its properties to be cheaper, less water intensive and climatical more robust than other cereals which makes the WRSI a good indicator of food security. Looking at the map of the WRSI, Figure 4, two things are remarkable. First of all, the areas close to Lake Victoria indicating a very food secure situation. Secondly, the level of food security deteriorates steadily the further a location is away from Lake Victoria an exception being the coastal area around Mombasa (FEWS-Net, 2004). The same conclusions can be obtained by considering the map portrays of the NDVI for Kenya, Figure 5, which is based on meteorological NASA satellites in order to indicate the density of vegetation at the earth's surface.

[insert Figures 4 & 5]

Relying on the two proxies for food security described above, two main implications can be derived from the previous considerations. Due to a general increase in food security and food availability the closer one gets to Lake Victoria, wasting and stunting indicators should show improvements reaching their lowest values in the area around Lake Victoria. Furthermore, the incidence of stunting should be extraordinary low on the shores of Lake Victoria since fish is widely available as a staple food around this area.

4.2 Epidemiological Factors

Child mortality levels in Kenya declined rapidly after its independence and reached its minimum levels in the late 1980s. From then on the trend reversed and mortality levels were continuously increasing up to 115 per 1,000 in the 2003 DHS round (CBS, MOH, and ORC Macro, 2004). This adverse trend was accompanied by stagnant growth of per capita income, declining levels of immunization, falling school enrollment, and foremost the emergence of the AIDS epidemic (Hill et al., 2004). One of the salient findings of the 1998 and 2003 DHS rounds is the enormous variation of child mortality rates among the provinces reaching 54 per 1,000 in the Central Province and 204 per 1,000 in Nyanza in the 2003 round.

A first major reason that helps to explain this variation is the unequal distribution of malaria prevalence within the country - as depicted in Figure 6 - due to regional variations in temperature, humidity, and the existence of bodies of water. Although malaria is epidemic in several areas in Kenya, the Lake Victoria region is the only endemic region in the country with a transmission period that lasts over the whole year (MARA, 2004). Moreover, it is important to note that the risk of malaria infection does not decline in a continuous way starting from Lake Victoria. Due to the elevations of the East African rift valley arising about 20km away from Lake Victoria a natural malaria barrier exist in the east that drastically reduces the risk of malaria infection in these regions. In all other regions climatical conditions do not favor the reproduction of female anopheles mosquitoes over the whole year due to long periods without rain in these areas.

[insert Figure 6]

A second major aspect that affects health and mortality outcomes of young children is the quality of drinking water. Despite being the second largest fresh water lake in the world, the water of Lake Victoria is not safe for drinking and several cases of outbreaks of waterborne diseases are reported each year (Omwega et al., 2003).

The third major difference of the Lake Victoria region compared to other regions in Kenya is the high prevalence of HIV/Aids in the area. Recent studies point to the social erosion of family norms among people around the shores of Lake Victoria. The nile perch boom in the area, starting in the mid 1990s, and the resulting demand for male labor forces in the fishing industry led to a strong influx of migrants into the region which was accompanied by a growing prostitution business (Béné and Merten, 2008). Further on, Nyanza province is situated on thriving trade and migration routes connecting the economically powerful central area of Kenya with Tanzania. Together with the high urbanization rates in the Nyanza this is likely to contribute to the higher HIV/Aids rates in the area (Oster, 2008).

Taking into account the spatial distribution of mortality drivers as outlined above, we would expect strongly increasing mortality rates in close proximity to Lake Victoria the main reasons being among others the comparatively high HIV/AIDS prevalence and the much stronger predisposition to infectional diseases like Malaria in that area.

4.3 Cultural Factors

Ethnic belonging affects mortality and undernutrition levels in Kenya through a variety of mechanism. Since most ethnic groups in Kenya live spatially concentrated in a very particular region of the country, current administrative provincial boundaries were usually drawn based on the location of a certain ethnicity. The Lake Victoria region is predominantly part of the Nyanza province which is predominantly inhabited by the Luo ethnic group. Although Luo have several cultural practices in common with most other ethnic groups in Kenya, there exist three noteworthy differences.

Firstly, while most ethnic groups in Kenya practice male circumcision, Luo are known for not being circumcised thereby substantially increasing their risk of related mortality (Chesoni, 2006). Secondly, Luo have benefited from the beneficial food availability and protein situation around Lake Victoria for a long time span, therefore showing significantly better mean height values for men in historical data compared to all other Kenyan ethnic groups (**?**). Given the long time span of settlement close to Lake Victoria, one might speculate over emerging genetic differences among the Luo and other ethnic groups. Following a recent WHO study genetic factors seem to play a minor role in explaining the disparities in physical growth among children (WHO, 2006).[4] Thirdly, fish consumption in Kenya is not only determined by availability aspects but as well by cultural habits. While Luo use fish as a staple food, it is viewed with considerable suspicion among ethnic groups in Central and Eastern Kenya (Oniang'o and Komokoti, 1999).

Furthermore, ethnic belonging plays a crucial role on the allocation process of public resources in Kenya due to the prevailing kinship structures and patron-client relationships (Miguel and Gugerty, 2005; Weinreb, 2001). The Luo represent about 13% of the Kenyan population and constitute the third largest ethnic group in Kenya whereby only the Kikuyu with 23% and the Luhya with about 14% tend to have higher shares in the overall population. Despite this high share Luo ethnic groups have been politically under-represented at national political levels and except very recently not being part of any coalition at the national level since 1965 which has resulted in a limited access to public funds level and lead to a steady under-investment of health and schooling facilities in the Nyanza region (Alwy and Schech, 2004; Nyanjom, 2006).

Bearing in mind the circumcision behavior of ethnic groups in Kenya, we would expect the highest HIV/AIDS prevalence among the Luo ethnic group. In addition, the political situation in Kenya is likely to further aggravate mortality levels of the Luo due to worse access to health care facilities (Cutler et al., 2006). Since discriminatory practices in the allocation process of public resources probably occurs in practice on a provincial level, there should be an unfavorable effect on mortality levels for all ethnic groups living in Nyanza.

[4] To further investigate this issue, we compared children's mean stunting scores between Luo and other ethnicities outside the Lake Victoria Region and additionally outside Nyanza and Western province. Based on an oneway ANOVA, differences in height for age scores turned out to be statistically insignificant for this setting. Therefore, we conclude that genetic differences do not explain the observed growth differential for children in our context.

5 Empirical Findings

5.1 Data

In the empirical analysis we use data from the 2003 round of the Kenyan Demographic and Health Survey (KDHS).[5] For the first time the KDHS includes data from all provinces of Kenya as well as data on HIV testing. In every second household sampled, women and men were asked to voluntarily participate in the HIV testing. 76% of all eligible women agreed to undergo the test.[6]

In addition to the variables directly derived from the household questionnaires, we calculate the distance of each cluster to the shores of Lake Victoria using the GPS coordinates provided by ORC Macro. We define the Lake Victoria region as the area within a 20km boundary to the shores of the lake. Furthermore, we exploit the MARA (2004) database on endemic malaria to obtain district level information on malaria prevalence in Kenya.[7] Since we could not obtain data on the health care sector in Kenya on the district level, we relied on data published in Nyanjom (2006) who reports information on the number of people per medical officer and public health expenditures per capita on provincial level for the time period 1995 - 1998.[8]

The selection of variables for descriptive statistics and the undernutrition and mortality regressions is guided by the frameworks outlined in the previous section and the discussion of the role of ethnical, political and geographical factors in section 4 of this paper. An overview of variables used in this article including its coding is provided in Table 3.

[insert Table 3]

From the economic literature as well as from our theoretical framework, it becomes clear that the variables described in Table 3 are important to study the determinants of undernutrition as well as the context of under-5 mortality. Thus, we use the same list of covariates in the multivariate analysis of undernutrition and mortality.[9] In addition, the

[5] The mortality sample consists of 1368 mothers reporting 2697 births in the last five years. 605 of these children died. The respective undernutrition sample remains with 1218 (1217) mothers who reported data on 1704 (1701) living children at the time of the survey for the stunting (wasting) regressions.

[6] The official KDHS 2003 report provides several descriptive and multivariate examinations on whether non-participation in HIV testing is systematically related to other variables. No systematic relationship was found (CBS, MOH, and ORC Macro, 2004) and therefore we expect our results not to be effected by sample selection bias when using the reduced HIV sample.

[7] The same data base from http://www.mara.org.za/ was used in Oster (2007) to calculate regional malaria prevalence rates. Moreover, at the country level these malaria measures are closely correlated with climate-determined malaria susceptibility, as used in Sachs and Malaney (2002).

[8] Note that the oldest children in our analysis were born in 1998. Moreover, regional differences in health care spending are likely to have stayed the same until the elections in end of 2007 when a new government coalition was put in place which now includes the Luo.

[9] The final model specifications include squared terms whenever the respective coefficient showed a statistically significant value. Otherwise squared terms were excluded.

different regression results become easier to compare when in principle using the same set up of control variables. [10]

5.2 Descriptive Statistics

Summary statistics on the variables used in this study are provided in Table 4, where we distinguish between different geographical and ethnical specifications. Column 1 depicts statistics based on the Lake Victoria region, the area within a 20km distance of the shores of the lake, while column 2 provides information based on overall Kenya except the Lake Victoria region. Column 3 and 4 refer exclusively to the Lake Victoria region. In column 3 summary statistics are provided for the Luo ethnicity while statistics on the remaining ethnic groups in the area are shown in column 4. In addition, columns 5-12 comprise information on the same set of variables for overall Kenya and for each of the eight Kenyan provinces.

[insert Table 4]

Malnutrition

Table 4 demonstrates that average rates in stunting and wasting are far below average in the Lake Victoria region. As stated before this is likely to be due to much higher dietary intake in the Lake Victoria region than in the rest of the country, arising from higher food availability at the shores of Lake Victoria. The observed (see Table 4) higher than average intake of local grains and vitamin A rich fruits, like mango or papaya, can be attributed to the fertile soil found in the lake basin in combination with enough rainfall, facilitating a large supply of these products.

On the other hand, we observe that 38% of Luo mothers in the Lake Victoria region allocate protein rich food to their children at least once a week, compared to only 26% of mothers belonging to other ethnic groups in the region and to a national average of 22%. This remarkable and statistically significant difference between Luo and other ethnic groups within the Lake Victoria region might partly be explained by food preferences differing among ethnicities as outlined in section 4.3 whereby other ethnic groups do not use fish as a staple crop. In the DHS, data on protein intake is not further disaggregated into its share of fish, meat or eggs. We use secondary data to stress the relevance and availability of fish. Data from the Kenya Integrated Household Budget Survey (KIHBS) 2005/2006 shows that fish consumption is highest in Nyanza province. In addition, households in Nyanza seem to spend 6.1% of their budget for food on fish compared to a national average of 2.1% (KNBS, 2006). Considering the large Luo population in Nyanza, this result might further hint at an impact of ethnicity on nutritional preferences and nutrition outcomes.

[10] The KDHS includes some further variables, e.g. information on children's protein intake or pre- and post natal care, which are only used for descriptive purposes since these variables exhibit a very large number of missing observations leading to a too strong reduction in the sample size for the multivariate analysis.

Mortality

Table 4 depicts considerably higher malaria, HIV and diarrhea prevalence in the Lake Victoria region than in all other parts of Kenya. This result confirms the findings from the literature review in section 4. The incidence of diarrhea in the Lake Victoria region (25.1%) is clearly above the Kenyan average and increases by about 7 PP compared to the Nyanza average which might indicate the poor quality of drinking water of Lake Victoria and in its connected open waters. Further on, HIV rates in Nyanza and in particular in the Lake Victoria region are much higher than in any other area of the country which seems to be partly due to its comparatively high level of urbanization and its extraordinary position as a traffic hub between Tanzania and Central Kenya.

The Lake Victoria region is – besides its unfavorable disease environment – characterized by being predominantly populated by the Luo ethnic group.[11] Distinguishing between ethnic groups within the Lake Victoria region, enables us to disentangle the effect of geographical and cultural factors. The Luo exhibit significantly worse outcomes in several proximate factors of child mortality than the other ethnic groups around Lake Victoria. 26.4% of all Luo mothers are tested HIV positive, compared to a national average of 8.4% and to an average of 7.9% for the remaining ethnic groups in the Lake Victoria region, the size of the differences between ethnic groups in the Lake Victoria region astonishes and clearly points at a strong relationship between cultural habits of the Luo and HIV infection which is in line with the arguments raised in section 4. A similar picture emerges from maternal factors and the pre and post natal behavior of the Luo. Luo mothers seem to start much earlier with bearing children than Luhya and most other ethnic groups. In addition, birth intervals between consecutive children are considerably shorter, reflecting higher total fertility rates among Luo than among any other ethnicity (CBS, MOH, and ORC Macro, 2004). Furthermore, the average number of child deliveries and caesarean sections as well as pre-birth visits in official health centers all show the lowest value for Luo. The latter outcomes may also point to discriminatory practices against the Luo from the national level resulting in a low level of health care provision. Such an interpretation is supported by our data on the Kenyan health care sector which indicates that Nyanza receives the lowest amount of public health expenditures per capita and further on has the highest ratio of inhabitants per physician among all Kenyan provinces.

The descriptive findings are in line with the considerations undertaken in section 4. Thus, geographical, cultural and political factors seem to contribute jointly to the high mortality rates in the Lake Victoria region compared to the rest of Kenya. In the following section, we will use regression analysis to examine causal relationships going from the observed covariates to the malnutrition and mortality outcomes, while putting a special emphasis on geographic and cultural factors.

[11] The Luo represent 81% of the total Lake Victoria population and 94% of the Lake Victoria population in the province of Nyanza. The small upper northern part of the Kenyan Lake Victoria region belongs to Western province and is mainly populated by the Luhya ethnic group who also represent almost the entire remaining population of Nyanza (17%).

5.3 Method

The objective is to explain the main drivers of the observed undernutrition and mortality outcomes on the individual level, and to shed light on the remarkable regional differences in theses outcomes. To accomplish this objective we run, similar to Jalan and Ravallion (2002), individual level regressions using household level data. Moreover, we augment this data set with aggregate data at different (nested) spatial levels. To link outcomes on the individual level to observed heterogeneity on the regional level we adopt an identification strategy where the sign, size, and significance level on the variables capturing geographic (malaria and diarrhea prevalence, distance to the Lake/Lake region), ethnic-specific cultural (Luo dummy, HIV variable) or political (health care access variables) features are used to explain differences across households and across regions. For example in the simple linear individual level regression set-up, a positive and statistically significant coefficient on diarrhea prevalence will not only explain, to some extent, heterogeneity in mortality outcomes across children; knowing that diarrhea prevalence is higher in Nyanza province than in Eastern province will also explain part of the variation in observed mortality differences across these two provinces.[12] Analogously, variables capturing cultural or political characteristics are used to explain the observed individual level as well as regional variations in undernutrition and child mortality arising from ethnic factors.

We can rule out potential endogeneity in the estimation due to people choosing the province they live in because there is little geographic mobility across provinces stemming from the mentioned ethnic cleavages in the country.

Since we need to rely on data that is largely cross-sectional, we only can test for geographic and ethnic effects on living standards at one point in time. Therefore, one cannot say with absolute conviction that the observed geographic and ethnic effects are not in fact proxies for some unobserved household variables. However, we use specifications that are best suited to provide robust results to all testable sources of bias and that are efficient. To control for unobserved factors at the community and family level we apply multi-level random intercept models. While the multi-level modeling strategy controls for those unobserved factors that are uncorrelated with the included other regressors, we expect that the large set of control variables from the DHS together with those from other data sources (malaria, health access) and those from the literature review (distance to Lake Victoria) keep the potential bias low.

One important argument in favor of the adopted multilevel modeling strategy aims at the hierarchical collection of data at the family and community level resulting in clustering of undernutrition and mortality outcomes. Individuals located in the same household or community will inevitably share common characteristics. As described in section 3, the health outcome of an individual is produced by observed as well as unobserved factors. Controlling for intragroup clustering in a regression framework calls, therefore, for consideration of both types of factors. The extent of clustering can be illustrated by the observed under-5 mortality outcomes. In our sample 2915 (67%) of the 4346 interviewed women did not experience any child deaths, while 941 (21.7%) women

[12] Despite some care needed in non-linear models (here the Cox model) the basic reasoning remains valid.

had to suffer from the death of exactly one child. Those 184 (4.2%) women, however, who experienced three or more child deaths in the five years preceding the survey account for more than 30% of all deaths, showing a substantial amount of correlated outcomes and clustering within families. A similar pattern arises at the community level. 62% of the 400 clusters under consideration contribute to 26% of all dead children, while on the other hand 21% of the communities account for more than 50% of all child deaths.

A frequently applied empirical strategy to overcome the issue of hierarchical clustering due to latent characteristics is the introduction of fixed effects, i.e. dummy variables. In recent studies authors have tended to introduce mother fixed effects (mfe) into regressions on children's health status based on DHS data, e.g. Bhalotra (2009). However, such an approach is likely to induce a selection bias in our case since all mothers with less than two children under the age of five will be excluded from the analysis. Moreover, all control variables that are measured on the household level, e.g. asset wealth, ethnicity need to be excluded which might introduce additional biases. Moreover, since we are interested in the coefficient on the ethnic variable the mfe approach is not a feasible option. In addition, the mfe approach would largely reduce the total degree of freedom (over-parametrization) and the number of observations leading to an overestimation of standard errors.

Likewise, community fixed effects would reduce the variation in the data substantially by focusing on the within community variation and lead to the exclusion of some variables (e.g. health access). Since communities are rather homogenous in their ethnic composition the significance level on the Luo variable is likely to be seriously underestimated in a community fixed effects approach.

As mentioned above we therefore rely on a linear multilevel regression model, while in the context of under-5 mortality we use a (non linear) multilevel Cox proportional hazard model. We use three-level models, controlling for correlated outcomes among siblings, i.e. on the household level, and among communities.

5.3.1 The multilevel models

To analyze the driving factors of malnutrition, we use a linear multilevel regression model.[13]

Our three level random intercept model reads:

$$y_{ijk} = (\gamma + \beta_1 x_{ijk}) + (v_k + u_{jk} + \varepsilon_{ijk}) \qquad (3)$$

with $i = 1, ..., I$ individuals, $j = 1, ..., J$ households and $k = 1, ..., K$ communities. u_{jk} is the household random effect, v_k the community random effect.[14]

In the case of child mortality we rely on Cox proportional hazard models, proposed

[13]See Goldstein (2003) and Hox (1995)for a comprehensive overview of the statistical theory underlying multilevel modeling.

[14]The models are estimated using the "xtmixed" command implemented in Stata.

by Cox (1972) which are the standard models used in child mortality analysis. In a proportional hazard model, the hazard rate is the instantaneous risk of death in t conditional on survival up to t:

$$\lambda(t|x) = \lambda_0(t)exp(x'\beta). \tag{4}$$

The multivariate kindred frailty model has been developed by Vaupel (1990). The two-level model was applied to study the effect of unobserved shared family characteristics on survival. Sastry (1997b) and later on Bolstad and Manda (2001) extended the model to the multilevel case. In a standard frailty model, a frailty, z, is an unobserved random effect which works multiplicatively on the hazard function.

$$h(t|x,z) = z\lambda(t|x). \tag{5}$$

In economic survival analysis, the frailty is usually referred to as a shared frailty since it is a random effect which is the same for all members of a group, for example a family or a community effect. Transferred to the three level model with unobserved frailty on the household and community level, the hazard function reads:

$$h_{ijk}(t|x_{ijk}, u_{jk}, v_k) = u_{jk}v_k\lambda(t|x_{ijk}), \tag{6}$$

with individuals $i = 1, ..., I$, $j = 1, ..., J$ households and $k = 1, ..., K$ communities. u_{jk} is the household random effect, v_k the community random effect. The individual (child) frailty is absorbed in the baseline hazard.[15]

The family frailty effect measures the variation in family specific exposure to risk across families after controlling for observed variables. Children of families with a large frailty have, ceteris paribus, a larger risk of dying. This excess risk would be triggered by unobserved behavioral or genetic family specific factors.[16]

5.4 Regression Results

5.4.1 Undernutrition

Results of stunting and wasting regressions are shown in Table 5. The first model displayed in the table corresponds to the baseline model including the Luo variable before all further geographic and ethnic-related variables are entered. Model 2 to 3 both use the full set of suitable variables but differ in the inclusion of random effects.

Stunting

Switching from Model 1 to Model 2 already reduces size and significance level of the coefficient on belonging to the Luo ethnic group. Controlling for clustering and unobserved heterogeneity on the community and mother level renders the coefficient on Luo

[15] The unobserved frailty is assumed to be independently distributed of all covariates and to follow a Gamma distribution with mean 1 and variance θ (Sastry, 1997b).

[16] The model is estimated using the "coxme" command of the kinship package in R (Therneau, 2006).

statistically insignificant. Therefore, we can rule out that cultural (e.g. food and feeding preferences) or genetic differences are responsible for the observed remarkable variation in stunting values across Kenyan provinces and the low incidence observed in Nyanza.

[insert Table 5]

Likewise, geographical variables that proxy the disease environment like hiv, diarrhea and malaria do not seem to have any influence on children's stunting outcomes. In contrast, children residing in close distance to Lake Victoria are showing significantly better height for age outcomes which is in line with our claim developed in sections 2 & 5.2 that the availability of fish in combination with very advantageous agricultural conditions are likely to be one of the main reason for this extraordinary low prevalence of stunted children in the Nyanza/Lake Victoria region.[17] In conclusion, it seems that neither ethnic-specific effects nor disease environmental effects are causing the observed strong differences in the incidence of stunting across provinces but rather geographical factors related to food availability.

Wasting

Diseases tend to have a short-term impact on children's health outcomes. While the long-term indicator stunting may therefore fail in displaying any significant negative relationship, wasting outcomes could be much stronger affected by such short term factors. However, as displayed in Table 5 all geographic variables related to the disease environment turn out to be statistically insignificant. Likewise, no ethnic specific effect can be observed. It is noteworthy, that the coefficient on distance to Lake Victoria turns out to be negative and statistically significant which underscores our reasoning on the relationship of food availability and nutrition outcomes in the country and that there is a reasonable causal interpretation of the Lake Victoria variables.[18]

5.4.2 Mortality

Results of the under-5 mortality regressions are presented in Table 6.[19]

[insert Table 6]

[17]The Lake Victoria dummy does not only capture food availability issues but as well the disease environment (malaria). However, since the disease environment does not seem to affect stunting outcomes, the 'disease' effect in the Lake Victoria dummy seems to be clearly overcompensated by the 'food availability' effect.

[18]As explained in section 4.1 we would expect the distance effect to vary continuously with respect to wasting outcomes. Robustness checks which are not reported here confirm that distance to Lake Victoria only seems to matter when captured continuously. In the full model the distance effect when included as a dummy variable always turned out to be statistically insignificant.

[19]Hazard rates, the probability of death in t conditional on survival up to t, are to be interpreted in relation to 1. Thus, a hazard ratio of 1.2 implies a 20% higher risk of death.

The introduction of geographic variables that proxy for the disease environment like diarrhea, malaria and the Lake Victoria dummy[20] help to explain an important part of the variation in child mortality. All these variables are statistically significant and take signs (values larger/smaller than 1) as expected from our discussion before. Therefore, the higher disease environment in Nyanza and in the Lake Victoria region compared to the rest of Kenya already contributes to disentangle some of the observed child mortality differences across Kenyan provinces.

Considering ethnic-related factors we find that both of our health access variables turn out to be statistically significant and both showing that better access to health care substantially reduces the mortality risk of children. As stated before health access in Nyanza and the Lake Victoria region is undersupplied due to ethno-political reasons in the country which therefore explains part of the very high mortality rates in the region. The hiv-status variable, which captures both behavioral as well as cultural factors, helps further to explain the observed mortality differences.

Interestingly, even after controlling for the disease environment, the undersupply of health care services, hiv-status and unobserved but uncorrelated heterogeneity at the community and mother level a strong Luo-specific effect on under-five mortality remains. However, this effect (Model 3) is much smaller than in the baseline model (Model 1) and much smaller than found in comparable studies (Omariba et al. (2007). Although the Luo-coefficient might point to further ethnic-specific unobserved but correlated factors, it is difficult to state a particular reason. One potential explanation for the observed coefficient could be the lower demand for health care services or alternatively less knowledge about health care services among the Luo. Looking back at Table 4 we found that when comparing different ethnic groups within the Lake Victoria region Luo mothers tend to have less pre-birth visits to doctors as well as more home-births which would suggest such line of reasoning.

Summarizing, the results from mortality regressions confirm by and large the theoretical considerations and descriptive findings of sections 4 and 5.2. The very high mortality rates of the Lake Victoria region and Nyanza rest upon a *simultaneous* impact of unfavorable geographic and ethnic-specific behavioral, cultural and political factors.

5.4.3 Robustness Check

To see whether our results are driven by the decision to model unobserved heterogeneity and the clustering of health outcomes using random effects, we compare our previous baseline model to a community fixed effect (Model FE) and a community random effect (Model RE) specification.[21] We do not investigate mother fixed effects since as stated before we would introduce an additional sample selection effect which together with a much lower sample size would make the results difficult to interpret. Results for the

[20]Remember that the Lake Victoria variable proxies directly the malaria belt which comes from the natural elevations of the East African rift valley

[21]The fixed effect approach requires to drop all variables measured on the community and provincial level. Moreover, we decided to drop the hiv variable because hiv prevalence is highly correlated with the community effect.

stunting and under-5 mortality regressions are shown in Table 7.

[insert Table 7]

In the regressions related to stunting (first three columns) coefficients and significance levels remain largely unaffected by the decision to include fixed or random effects. As in the previous section, we do not find any ethnic related effect on stunting even when using the specification with the coefficient on Luo being close to 0 and statistically insignificant.

Regarding the mortality regression it is important to note that both, FE and RE specification, correct the size and significance level of the coefficient on Luo into the same direction. However, in the FE specification the coefficient on Luo becomes statistically insignificant.

From a statisticians point of view we do not worry about this difference since the FE specification clearly absorbs the ethnic-specific effect on mortality given the high level of ethnic homogeneity in the composition of communities.

From an economist point of view the insignificant coefficient on Luo in the FE specification is likely to point to an ethnic-specific effect operating on the community instead of the mother level. Given that the coefficient on Luo remained statistically significant even after controlling for differences in the disease environment together with HIV and health care access (section 5.4.2) the FE specification is likely to capture non-geographical/non-disease factors which are very likely to be ethnic-related as, for instance, it is largely the case with the provision of public goods in the Kenyan context.

6 Conclusion

Kenya's Lake Victoria region is marked by an interesting puzzle. Under-5 mortality rates are by far the highest in the country, while at the same time anthropometric indicators of children show remarkable good values. The extent of this abnormity becomes even more astonishing when comparing the Lake Victoria area to other regions in Sub-Saharan Africa. Nowhere else in the whole of SSA we find such a strong disconnection of anthropometric and mortality outcomes.

In order to examine and understand the causes of this unusual phenomenon we undertake the uncommon step to analyze the determinants of mortality and undernutrition jointly. Moreover, to reduce the likelihood of obtaining biased and inefficient estimates in our multivariate regressions we construct a new set of context specific variables that supplements the conventional DHS data. In addition we apply suitable multilevel modeling techniques.

Our findings point to a unique interplay of cultural, geographical and political factors in the Lake Victoria region which are responsible for causing the described paradox. Concerning the under-5 mortality pattern in Kenya and around Lake Victoria we find that a salient disease environment characterized by extremely high malaria prevalence, polluted water sources and high rates of infectious diseases like HIV/AIDS is one of the key drivers of the massive under-5 mortality rates in the lake region. Furthermore, we see that even after controlling for mother's age at birth, birth spacing, birth order and HIV-status an ethnic specific effect remains. Being born to a Luo mother affects survival chances adversely, most likely based upon unfavorable unobserved pre and post natal behavior. Ethnic-related political discrimination does also seem to be an important factor of the spatial variation in under-5 mortality rates through lower access to health care in Nyanza province. Our results are robust to different econometric specifications.

A similar interplay of geographic conditions and cultural factors is found to constitute the extremely low incidence of stunting and wasting in the Lake Victoria region. While fish consumption in combination with an overall food secure situation spurs the growth process of children close to the lake and therefore leads to the much higher body height of children in the Lake Victoria area, the food security situation per se leads to ceteris paribus better wasting rates in the area.

Our findings demonstrate the relevance of considering and understanding the country specific context, when data on child mortality and malnutrition is analyzed on a more aggregated level. We do not challenge the epidemiological literature in the sense that we do not question that on the individual level a causal relationship between nutritional and mortality outcomes exists. The analysis raises a serious concern when using children's height status as a reliable proxy for health or income. This is only advisable when geographic, cultural and political contexts are comparable and this is often unlikely to be the case in cross-country or cross-regional analysis.

Moreover, this study illustrates that targeting of health initiatives based on only one or few indicators on a highly aggregated geographical level (e.g. on the district or province level) can easily lead to a misallocation of resources. Since aggregated health outcomes for different indicators can be strongly negatively correlated,the overreliance on one or a few health indicators is likely to lead to a too strong concentration of resources on some districts/provinces at the unjustified expense of other provinces.

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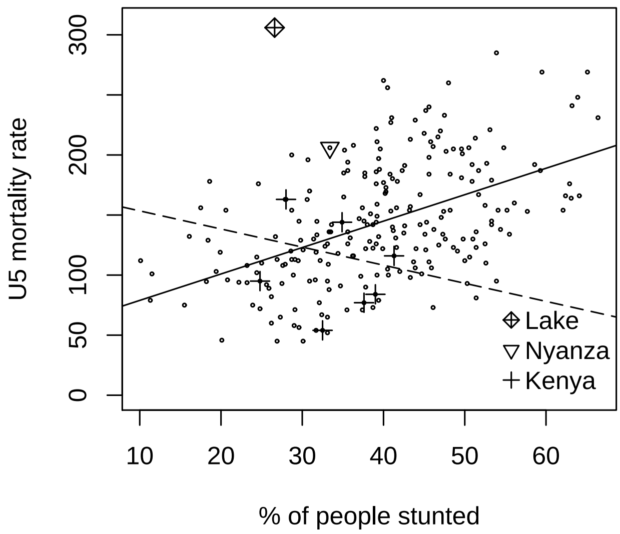
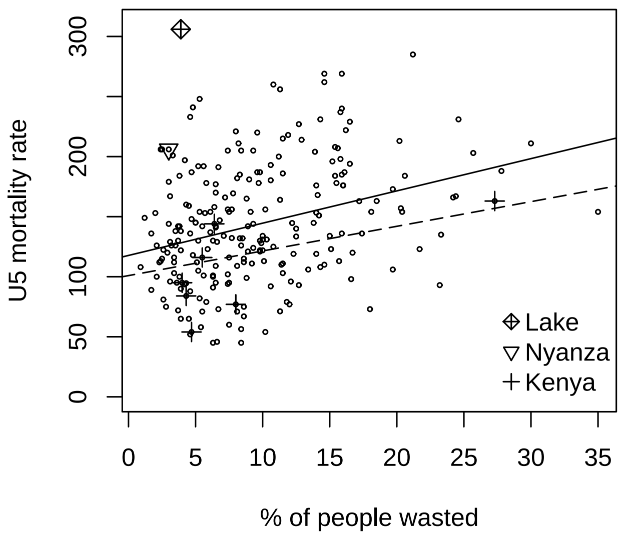
7 Figures and Tables

Figure 1: Stunting rates in SSA



Source: Authors' calculations

Figure 2: Wasting rates in SSA



Source: Authors' calculations

Figure 3: Theoretical Framework

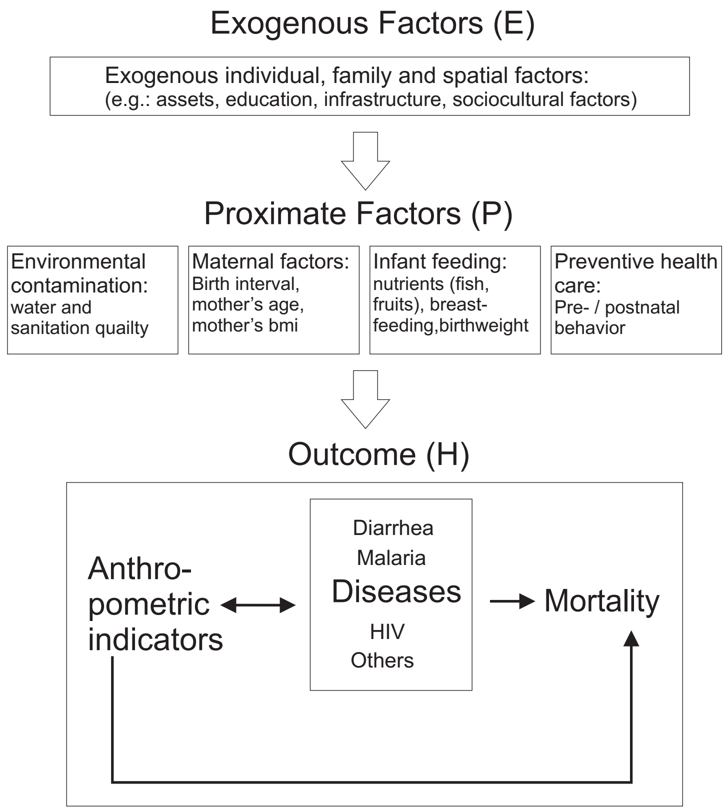
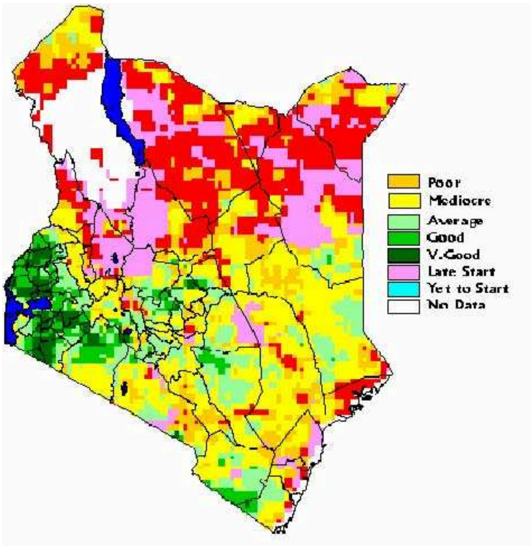
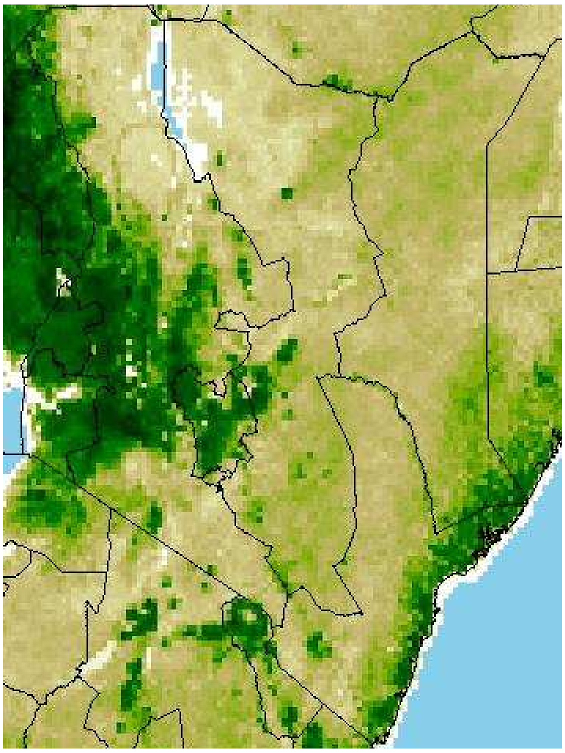


Figure 4: Water Requirement Satisfaction Index (WRSI) Derived Crop Conditions



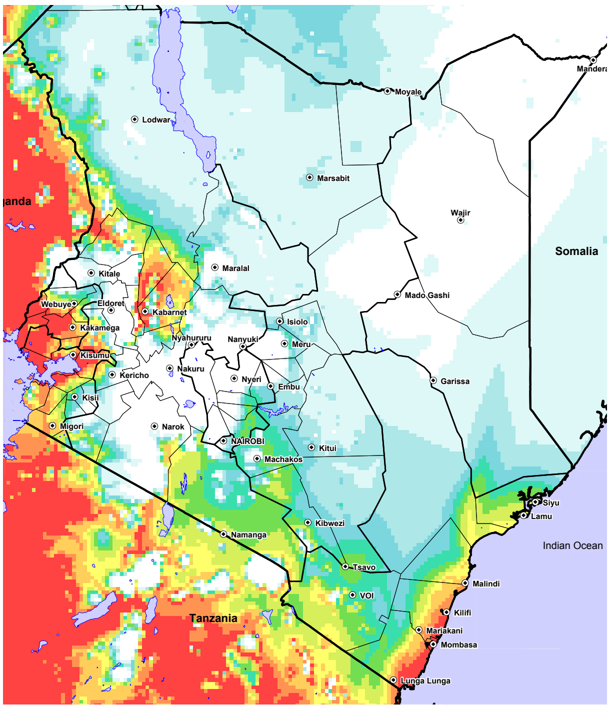
Source: FEWS-Net (2004)

Figure 5: Normalized Difference Vegetation Index - Kenya



Source: FEWS-Net (2004)

Figure 6: Climate Suitability for Endemic Malaria



Source: MARA (2004)

Table 1: Mortality and undernutrition rates in the SSA context

No.	Country	Region	Year	Mortality	Stunting	Wasting	Range	CV
1	Senegal	Tambacounda	2005	200	28.7	11.2	-126	0.31
2	Zambia	Western	2001	201	49.7	3.3	-118	0.22
3	Burkina Faso	Sud-Ouest	2003	203	47.7	25.7	-166	0.22
4	Chad	Zone8	2004	204	35.2	13.9	-122	0.20
5	Cameroon	Nord	2004	205	49.6	8.4	-130	0.27
6	Senegal	Kolda	2005	205	39.6	9.3	-126	0.31
7	Mozambique	Sofala	2003	205	48.6	7.4	-152	0.28
8	**Kenya**	**Nyanza**	**2003**	**206**	**33.4**	**3**	**-152**	**0.40**
9	Mozambique	Tete	2003	206	54.8	2.5	-152	0.28
10	Mozambique	Niassa	2003	206	50.5	2.4	-152	0.28
11	Guinea	Kankan	2005	207	46.1	15.6	-126	0.21
12	Ghana	Upper West	2003	208	36.3	15.4	-133	0.34
13	Guinea	Kindia	2005	211	39.2	8.2	-126	0.21
14	Burkina Faso	Cascades	2003	211	45.8	30	-166	0.22
15	Burkina Faso	Centre-Ouest	2003	213	43.3	20.2	-166	0.22
16	Niger	Tahoua	2006	214	51.3	12.9	-158	0.29
17	Niger	Dosso	2006	215	46.7	11.5	-158	0.29
18	Guinea	NZérékoré	2005	218	45	11.9	-126	0.21
19	Mozambique	Nampula	2003	220	47	9.6	-152	0.28
20	Malawi	Mulanje	2004	221	53.1	8	-109	0.18
21	Mali	Koulikoro	2006	222	39.1	16.2	-154	0.25
22	Mali	Mopti	2006	227	40.9	12.7	-154	0.25
23	Mali	Tombouctou	2006	229	43.9	16.5	-154	0.25
24	Burkina Faso	Nord	2003	231	41	24.6	-166	0.22
25	Niger	Maradi	2006	231	66.4	14.3	-158	0.29
26	Ruanda	East	2005	233	47.5	4.6	-109	0.20
27	Mali	Sikasso	2006	237	45.2	15.8	-154	0.25
28	Chad	Zone5	2004	240	45.6	15.9	-122	0.20
29	Mozambique	Cabo Delgado	2003	241	63.2	4.8	-152	0.28
30	Zambia	Luapula	2001	248	63.9	5.3	-118	0.22
31	Chad	Zone7	2004	256	40.5	11.3	-122	0.20
32	Nigeria	North East	2003	260	48	10.8	-166	0.36
33	Mali	Segou	2006	262	40	14.6	-154	0.25
34	Nigeria	North West	2003	269	59.5	14.6	-166	0.36
35	Niger	Zinder	2006	269	65.1	15.9	-158	0.29
36	Burkina Faso	Sahel	2003	285	53.9	21.2	-166	0.22

Source: Authors' calculations based on latest DHS surveys of respective countries.
Note: CV relates to the coefficient of variation and Range to the difference between the minimum and maximum value within a country. Both measures refer to under-five mortality rates.

Table 2: Classification of Variables Influencing Health and Mortality Outcomes

Variables	**Observed by analysts**	**Unobserved by analysts**
Individual	Health indicators (anthropometric measures, Mortality outcome, reported diarrhea) Health related practices (birth interval, Clinical birth, caesarian section, vaccinations, Retro-viral drugs, duration of breastfeeding, Death of previous child) Age, gender, twin status	Genetic endowment, HIV status, Nutritional intake
Family	Mother's education in years, ethnic belonging, Mother's age at birth, marital status, Mother's BMI and HIV status, Household size, asset possession, Water and sanitation access	Genetic factors, Innate ability for child care, Parental time devoted to child care, General knowledge and mental capability, Income and expenditure levels, Intra-household resource allocation
Community	Geographic location Rural or urban	General disease and health environment Public Infrastructure (availability and quality of education and health care facilities, roads,...), water quality Cultural habits Labor market conditions
District	Malaria suitability	Political factors
Province	Health access (People per Physician, Health expenditures per capita)	Political factors

Table 3: Description on variables of interest

Variable	Characteristic	Database	Level
Indicators			
Under5-mortality	Child alive (0), died before age of 5 (1)	DHS	Child
Stunting	Stunting z-score[22] (used in regression analysis)	DHS	Child
Wasting	Wasting z-score (used in regression analysis)	DHS	Child
Stunted	Stunting z-score: > -2 standard deviations (sd) (0), < -2 sd (1)	DHS	Child
Wasted	Wasting z-score: > -2 sd (0),< -2 sd (1)	DHS	Child
Child Factors			
Female	Child is male (0), female (1)	DHS	Child
Twin	Child is twin: no (0), yes (1)	DHS	Child
Previous child died	Previously born child of mother died before birth of index child[23]: no (0), yes (1)	DHS	Child
Birth interval	No. of months between birth of index child and birth of preceding child[24]	DHS	Child
Breastfeeding	No. of months child was breastfed	DHS	Child
Diarrhea	Child suffered from diarrhea within last two weeks: no (0), yes (1)	DHS	Child
Family Factors			
Rural	Mother lives in urban area (0), rural area (1)	DHS	Mother
Birth age	Age of mother at birth of index child	DHS	Mother
Married	Single mother (0), married mother (1)	DHS	Mother
HH Size	No. of household members	DHS	Mother
Asset index	Index based on principal component analysis derived by ORC macro	DHS	Mother
Water index	Index: open water (0), uncovered well (1), covered well (2), piped water (3)	DHS	Mother
Toilet index	Index: no facility (0), latrine (1), flush toilet (2)	DHS	Mother
Mother's Education	Years of education of mother	DHS	Mother
Mother's BMI	Mother's BMI status	DHS	Mother
Mother's HIV Status	HIV status of mother based on blood test: HIV negative (0), HIV positive (1)[25]	DHS	Mother

[22] Z-scores on stunting and wasting are based on the new WHO child growth reference standard (WHO, 2006).

[23] Variable is expected to capture the household specific mortality risk that might arise from potential unobserved genetic, geographic and cultural factors (Sastry, 1997b; Bolstad and Manda, 2001; Omariba et al., 2007). In our econometric set-up the coefficient on previous child died is likely to be biased as pointed out by Arulampalam and Bhalotra (2006). However, since we are not interested in the interpretation of this variable, our principal results remain unaffected.

[24] To avoid a substantial reduction in the sample size we adopted the same strategy as introduced in Sastry (1997a) and Bolstad and Manda (2001). Preceding birth interval dummies were set to zero for the first born child in a family and in addition a dummy variable was generated to capture the status of a first born child. Likewise, the survival status of the previous child was set to one if the child was of birth order 1.

[25] Since the HIV status of children has not been collected, it remains unclear whether the AIDS virus has been transmitted to the child during pregnancy or breastfeeding period and whether the mother already had the virus at the time of the birth of the child. The HIV status of the

Lake Region	Household lives within a distance of 20km of Lake Victoria: no (0), yes (1)[26]	DHS	Mother
Distance to Lake	Distance of household to Lake Victoria (used in wasting regression)	DHS	Mother
Higher Level Factors			
High diarrhea	Estimated diarrhea prevalence > 50%: no (0), yes (1) (used in mortality regression)	DHS	Community
Malaria Prevalence	Estimated prevalence of malaria	MARA	District
High prevalence	Estimated malaria prevalence > 50%: no (0), yes (1) (used in mortality regression)	MARA	District
People/Physician	Number of people per clinical officer	Nyanjom	Province
Health Expenditures p.c.	Annual national government spending per capita 1995 till 1998	Nyanjom	Province
Pre-/Postnatal Fact.			
Clinical birth	Child was born at home (0), born in health center (1)	DHS	Child
Pre birth visits	No. of times mother visited health center prior to birth of index child	DHS	Child
Caesarian	Child was born without section (0), under caesarian section (1)	DHS	Child
Retro viral drugs	Drug intake to prevent HIV transmission to child during pregnancy: no (0), yes (1)	DHS	Child
Vaccination index	Newborn (0-1 months) received no vaccination (1), at least one vaccination (1)	DHS	Child
	Infant (2-11 months) received no vaccination (0), at least one vaccination (1)	DHS	Child
	Child (12-59 months) did not receive all vaccinations (0), all vaccinations (1)	DHS	Child
Nutritional Indicators			
Protein	Child receives meat, fish or eggs at least once a week: no (0), yes (1)	DHS	Child
Grain	Child receives food made from local grain at least once a week: no (0), yes (1)	DHS	Child
Vitamin A	Child receives vitamin A rich fruits at least once a week: no (0), yes (1)	DHS	Child

Source: Based on KDHS 2003

mother is therefore likely to yield a downward biased coefficient with a lower significance level. Moreover, the HIV status of the mother does not only measure a direct epidemiological effect on children but as well a socioeconomic one. In particular, children in a HIV affected household might suffer from diminishing capacities of their main caregivers to purchase certain key inputs for the children due to a loss of household income as a result from the disease.

[26] Since most of our health environmental and geographical variables are either only on provincial or district level and moreover might not be free of measurement error, we would still expect to have an effect on our distance variables. In order to measure these effects appropriately we include this dummy variable.

Table 4: Descriptive statistics on variables of interest

	Lake Region	Rest of Kenya	Lake Region		Kenya	Nairobi	Centr.	Coast	East.	Nyanza	Rift Val.	West.	North East.
			Luo	Oth. Ethn.									
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII
Indicators													
Under5-mortality	32.9%	9.3%	31.5%	38.2%	11.6%	7.8%	5.0%	13.%	9.7%	20.8%	6.8%	16.2%	14.6%
Stunted	29.4%	38.8%	27.9%	36.1%	38.1%	22.9%	38.2%	36.0%	40.6%	39.2%	40.8%	34.9%	38.3%
Wasted	4.9%	5.4%	3.8%	9.4%	5.4%	0.4%	5.1%	4.3%	1.3%	2.7%	7.7%	8.5%	26.2%
Child Factors													
Female	46.1%	48.7%	46.5%	43.8%	48.4%	50.4%	51.2%	48.0%	53.2%	45.7%	46.2%	50.5%	45.2%
Twins	2.0%	4.6%	1.0%	7.8%	4.3%	4.2%	3.4%	7.6%	3.6%	4.3%	2.4%	6.8%	6.0%
Prev. child died	22.0%	10.9%	23.2%	15.0%	12.2%	7.1%	3.4%	15.5%	9.0%	20.6%	8.0%	12.4%	20.3%
Birth interval	28.70	33.90	27.23	37.25	33.30	36.69	40.06	33.06	36.80	30.18	33.04	31.12	27.90
Breastfeeding	13.00	14.62	13.30	11.65	14.47	12.71	15.73	13.64	16.17	13.66	14.43	14.49	11.42
Diarrhea	25.1%	16.0%	22.5%	37.5%	16.7%	14.5%	6.5%	20.6%	12.1%	17.7%	17.6%	25.7%	16.2%
Family Factors													
Rural	94.5%	83.7%	95.0%	91.9%	85.0%	0.0%	88.1%	68.2%	96.3%	94.3%	85.7%	92.8%	81.7%
Birthage	25.59	25.34	25.65	25.26	25.37	24.42	25.94	24.68	26.12	25.35	25.05	24.98	27.81
Married	77.5%	77.3%	76.0%	86.5%	77.3%	74.3%	74.4%	77.9%	83.3%	71.6%	72.9%	86.3%	97.6%
HH size	5.70	5.96	5.79	5.16	5.93	5.14	5.21	6.76	6.51	6.00	5.80	5.64	6.18
Asset index	-0.63	-0.40	-0.63	-0.63	-0.42	1.51	-0.14	-0.31	-0.60	-0.63	-0.42	-0.68	-0.89
Water index	1.80	2.02	1.75	2.08	1.99	3.83	2.19	2.69	1.96	1.61	1.98	1.67	1.42
Toilet index	1.51	1.83	1.45	1.88	1.80	2.54	2.06	1.59	1.84	1.70	1.68	1.99	1.05
Mother's education	5.65	5.92	5.72	5.25	5.89	9.15	8.30	4.26	5.92	5.87	5.68	5.90	0.08
Mother's Bmi	22.55	22.40	22.51	22.74	22.42	25.31	23.62	22.40	21.85	22.45	22.10	22.34	20.08
Mother's Hiv status	23.7%	8.4%	26.4%	7.9%	10.2%	18.5%	7.5%	7.5%	7.9%	18.3%	8.5%	5.3%	0.0%
High. Level Fact.													
Malaria Prevalence	49.3%	24.5%	50.4%	43.2%	27.4%	4.7%	6.4%	27.9%	22.6%	49.1%	19.2%	36.5%	7.7%
People/Physician	1102	949	1100	1111	966	813	705	819	848	1100	917	1114	1646
Health exp. p.c.	1.05	1.59	1.03	1.13	1.53	1.37	1.77	2.43	1.50	1.03	1.70	1.17	2.50
Pre/Postnat. Behav.													
Clinical Birth	35.0%	38.5%	34.4%	37.6%	38.2%	78.5%	64.3%	34.7%	30.2%	36.9%	35.3%	28.5%	7.6%
Pre birth visits	5.34	6.34	3.66	12.02	6.26	6.64	5.19	7.25	6.36	6.63	7.18	4.96	1.20
Caesarian	2.0%	3.4%	0.8%	7.8%	3.3%	8.7%	4.9%	5.5%	2.6%	2.3%	3.3%	1.1%	2.9%
Retro viral drugs	37.8%	38.0%	36.9%	43.8%	38.0%	55.3%	47.6%	20.9%	26.7%	39.3%	38.7%	47.4%	0.9%
Vaccination index	59.4%	72.3%	57.3%	69.1%	71.3%	77.8%	88.1%	75.6%	79.7%	60.2%	72.8%	64.3%	18.3%
Nutritional Ind.													
Protein	30.8%	20.8%	32.6%	22.5%	21.5%	34.5%	12.8%	26.4%	23.5%	27.4%	16.7%	24.1%	5.2%
Grain	69.3%	67.7%	68.9%	71.1%	67.8%	61.7%	75.9%	56.3%	82.1%	71.1%	56.5%	76.4%	43.8%
Vitamin A	24.0%	21.5%	26.9%	10.4%	21.7%	23.7%	16.5%	21.7%	37.3%	26.5%	15.5%	16.7%	4.7%
Observations	243	2789	207	35	3032	132	281	258	425	687	735	420	94

Source: Authors' calculations based on KDHS 2003. Weights provided by ORC Macro applied to calculate descriptive statistics.

Table 5: Determinants of stunting and wasting

	Stunting						Wasting					
	Model I		**Model II**		**Model III**		**Model I**		**Model II**		**Model III**	
	Est.	p-val.	Est.	p-val.	Est.	p-val.	Est.	p-val.	Est.	p-val.	Est.	p-val.
Fixed Effects												
Female	0,33	0,00	0,32	0,00	0,30	0,00	0,00	0,94	0,00	0,97	0,00	0,99
Twins	-0,68	0,01	-0,76	0,00	-0,62	0,02	-0,16	0,39	-0,09	0,64	-0,09	0,67
Rural	-0,13	0,31	0,00	0,99	-0,02	0,88	0,07	0,48	-0,06	0,58	-0,05	0,70
log(Mother's BMI)	0,70	0,01	0,75	0,00	0,70	0,01	13,64	0,00	13,51	0,00	12,01	0,01
log(Mother's BMI 2)							-1,97	0,00	-1,96	0,00	-1,74	0,02
Asset index	0,13	0,14	0,20	0,03	0,18	0,07	-0,05	0,49	-0,06	0,41	-0,03	0,66
Mother's education	0,09	0,02	0,11	0,00	0,10	0,02	0,07	0,01	0,04	0,18	0,04	0,25
Water index	0,10	0,01	0,12	0,00	0,11	0,01	0,04	0,20	0,04	0,15	0,05	0,12
Toilet index	-0,10	0,30	0,01	0,96	0,02	0,88	0,27	0,00	0,17	0,06	0,16	0,10
Birth age	0,01	0,48	0,01	0,42	0,01	0,45	0,01	0,28	0,01	0,34	0,01	0,31
Birth order	-0,01	0,83	-0,02	0,66	-0,03	0,41	-0,02	0,45	-0,01	0,60	-0,02	0,58
First child	0,22	0,06	0,22	0,05	0,15	0,15	0,13	0,15	0,12	0,19	0,07	0,41
Birth interval	0,00	0,22	0,00	0,10	0,00	0,13	0,00	0,31	0,00	0,52	0,00	0,86
Previousdead	0,18	0,37	0,08	0,69	0,16	0,40	0,39	0,01	0,42	0,01	0,34	0,03
Luo	0,00	0,99	-0,31	0,06	-0,24	0,20	0,22	0,03	0,19	0,10	0,15	0,27
HIV			0,16	0,32	0,14	0,42			-0,11	0,35	-0,10	0,44
High Prevalence			0,13	0,44	0,06	0,76			0,20	0,12	0,19	0,21
Diarrhea			-0,07	0,51	-0,06	0,53			-0,12	0,14	-0,07	0,38
log(People/Pysician)			1,30	0,00	1,12	0,00			-0,83	0,00	-0,80	0,00
Health Expenditures p.c.			0,16	0,17	0,14	0,30			0,01	0,97	-0,03	0,88
Lake Region			0,46	0,03	0,46	0,07						
Distance to Lake Region									0,00	0,08	0,00	0,10
Constant	-4,09	0,00	-13,75	0,00	-12,21	0,00	-24,40	0,00	-17,87	0,01	-15,53	0,04
Random Effects												
Cluster random effect					0,20						0,06	
Family random effect					1,01						0,62	
Individual random effect					1,30						0,89	
Observations	1704		1704		1704		1701		1701		1701	
Integrated log Likelihood	-3221		-3199		-3152		-2792		-2775		-2771	
LR-Test chisq(1)					13,0						3,5	
LR-Test chisq(2)					660,0						101,1	

Source: Authors' calculations based on KDHS 2003

Table 6: Determinants of under5-mortality

	Model I		**Model II**		**Model III**	
	Est.	p-value	Est.	p-value	Est.	p-value
Fixed Effects						
Female	0,84	0,04	0,84	0,04	0,82	0,03
Twins	1,40	0,07	1,47	0,04	1,53	0,05
Rural	1,07	0,63	1,08	0,60	1,14	0,50
log(Mother's BMI)	16,17	0,53	2,50	0,83	0,23	0,80
log(Mother's BMI 2)	0,78	0,72	1,06	0,93	1,64	0,58
Asset index	0,78	0,02	0,87	0,20	0,89	0,37
Mother's education	0,59	0,00	0,56	0,00	0,47	0,00
Mother's education 2	1,06	0,04	1,07	0,02	1,10	0,00
Water index	1,06	0,14	1,09	0,04	1,08	0,12
Toilet index	1,07	0,52	0,98	0,88	0,98	0,86
Birth age	0,94	0,00	0,94	0,00	0,83	0,00
Birth order	1,05	0,13	1,06	0,09	1,10	0,31
First child	0,78	0,05	0,78	0,05	0,73	0,06
Birth interval	0,96	0,00	0,96	0,00	0,96	0,00
Birth interval 2	1,00	0,00	1,00	0,00	1,00	0,00
Previousdead	1,44	0,00	1,43	0,00	1,14	0,30
Luo	2,49	0,00	1,52	0,00	1,57	0,01
HIV			1,51	0,00	1,54	0,01
High Prevalence			1,34	0,02	1,36	0,10
High Diarrhea			1,91	0,00	1,94	0,02
log(People/Pysician)			1,92	0,00	2,13	0,01
Health Expenditures p.c.			0,74	0,01	0,74	0,04
Lake Region			1,28	0,09	1,43	0,09
Random Effects						
Cluster random effect					0,16	
Family random effect					0,42	
Observations	2697		2697		2697	
Integrated log Likelihood	-4333		-4309		-4277	
LR-Test chisq(1)					3,85	
LR-Test chisq(2)					16,42	

Source: Authors' calculations based on KDHS 2003

Table 7: Robustness checks: determinants of stunting and under5-mortality

	Stunting						**Mortality**					
	Model I		**Model FE**		**Model RE**		**Model I**		**Model FE**		**Model RE**	
	Est.	p-value	Est.	p-value	Est.	p-value	Est.	p-value	Est.	p-value	Est.	p-value
Fixed Effects												
Female	0,33	0,00	0,33	0,00	0,30	0,00	0,84	0,04	0,84	0,06	0,81	0,03
Twins	-0,68	0,01	-0,67	0,01	-0,58	0,02	1,40	0,07	1,52	0,06	1,43	0,05
Rural	-0,13	0,31	-3,34	0,13	-0,13	0,40	1,07	0,63	1,09	0,52	1,12	0,53
log(Mother's BMI)	0,70	0,01	0,71	0,02	0,65	0,02	16,17	0,53	15,91	0,62	0,74	0,96
log(Mother's BMI 2)							0,78	0,72	0,81	0,81	1,30	0,74
Asset index	0,13	0,14	0,17	0,28	0,13	0,19	0,78	0,02	1,20	0,36	0,78	0,07
Mother's education	0,09	0,02	0,11	0,02	0,08	0,04	0,59	0,00	0,39	0,00	0,26	0,00
Mother's education 2							1,06	0,04	1,13	0,00	1,10	0,00
Water index	0,10	0,01	0,10	0,09	0,09	0,03	1,06	0,14	1,17	0,02	1,06	0,26
Toilet index	-0,10	0,30	-0,07	0,67	-0,09	0,47	1,07	0,52	0,72	0,06	1,06	0,66
Birth age	0,01	0,48	0,01	0,69	0,01	0,48	0,94	0,00	0,94	0,00	0,84	0,00
Birth order	-0,01	0,83	0,00	0,97	-0,03	0,49	1,05	0,13	1,01	0,77	0,99	0,79
First child	0,22	0,06	0,24	0,04	0,15	0,16	0,78	0,05	0,73	0,02	0,58	0,00
Birth interval	0,00	0,22	0,01	0,02	0,00	0,21	0,96	0,00	0,95	0,00	0,96	0,00
Birth interval 2							1,00	0,00	1,00	0,00	1,00	0,00
Previousdead	0,18	0,37	0,13	0,54	0,23	0,22	1,44	0,00	1,09	0,50	1,11	0,40
Luo	0,00	0,99	-0,01	0,97	0,01	0,95	2,49	0,00	1,43	0,27	2,02	0,00
Constant	-4,09	0,00	-2,74	0,13	-3,85	0,00						
Observations	1704		1704		1704		2697		2697		2697	

Source: Authors' calculations based on KDHS 2003