Child Mortality and Socioeconomic Status in Sub-Saharan Africa

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Abstract

This paper examines under-five mortality (U5MR) trends in sub-Saharan Africa, and the association between socio-economic status – indicated by per capita income, illiteracy, urbanization – and under-five mortality between 1960 and 2000. It shows substantial decline in U5MR in all Sub-Saharan Africa regions between 1970 and 1990. Regional differentials among West, Central and East Africa that existed in the 1960s have largely disappeared by 1990. However, the decline in U5MR appears to have stalled in 1990s and some countries have experienced increases. The analyses show a consistent negative relationship between U5MR and per capita income, but a given income implies lower U5MR as one moves towards the present. There is also a significant positive association between illiteracy and U5MR, and negative association between urbanization and U5MR. However, the effects of urbanization and illiteracy have diminished in the past decade, while the effect of per capita income has increased.

Under-five mortality (U5MR), the probability of dying between birth and age 5 expressed per 1000 live births, and infant mortality (IMR), the probability of dying before age one expressed per 1000 live births, have been used as measures of children's well-being for many years. Data indicate that some eleven million children under the age of five die annually in the world as a whole, of whom over ten million are in the developing world. Sub-Saharan Africa is the region most affected and accounts for more than one-third of deaths of children under age of five (Hill *et al*., 1999). Nearly three-quarters of the child deaths in the developing world are caused by diseases (predominantly acute respiratory infections, diarrhea and malaria) for which practical, low cost interventions exist, including immunization, ORT use, and antibiotics.

Numerous studies have shown a close association between child mortality and socio-economic status (for example, Preston, 1975 and 1985; Hobcraft *et al.*, 1984; Hill, 1985; World Bank, 1993). Most indicators of socio-economic status used are income per capita, education, urban/rural residence, work status and household assets. For example, in his pioneering work Preston (1975) demonstrated a negative relationship between income and mortality. However possible other determinants were relevant since the observed relationship between income and mortality

shifted over decades and a given income level was associated with better survival for recent decades. Similarly, focusing on 28 developing countries mostly in Asia and Latin America, Hobcraft *et al*. (1984) found that mother's and husband's education; their work status and their type of residence were more or less associated with child survival. Increased socio-economic status – specifically, mother's level of education - was also found to be closely associated with improved child survival in Nigeria (Caldwell, 1979), in Nicaragua (Sandiford *et al.*, 1995) and Costa Rica (Haines *et al.*, 1982).

The quality and quantity of data on child mortality have increased sharply over the last 30 years, particularly in Sub-Saharan Africa. However, the amounts, timeliness and quality of information available vary widely by country. The multiplicity, and in some cases inconsistency, of U5MR estimates from different sources has made the determination of national trends problematic. Hill and Yazbeck (1994), and subsequently Hill, Pande and Mahy (1999) developed and applied an explicit, objective and replicable methodology to derive a single consistent time series of estimates for infant and under-five mortality from the assembled data.

In this paper we update mortality estimates produced by Hill, Pande and Mahy (1999) for Sub-Saharan African countries and describe the relationship between child mortality and socio-economic status in Sub-Saharan Africa. The first part of the paper briefly describes the child mortality trends from 1960 to 2000 and the second part examines the association of socioeconomic variables with the levels of child mortality.

Data and Methods

This paper builds on our previous work on child mortality trends in sub-Saharan African from 1960 and 2000 in which we produced, for each country, time series estimates of infant and child mortality for each year ending with 0 or 5[1]. In the present paper, these estimates are used to assess the association between under-five mortality[2] and selected socio-economic variables. Child mortality estimates for each sub-Saharan African country are included in the data. For a small number of countries – Djibouti, Equatorial Guinea, Cape Verde, Mauritius, Reunion, and the Seychelles – no child mortality estimates were produced because of either lack of appropriate data or for lack of representativeness of sub-Saharan Africa. Only child

[1] Hill, K.; Amouzou, A. "Trends in Child Mortality in sub-Saharan Africa: 1960-2000". Forthcoming. Contact the authors if interested to see the details of the methodology of the estimation.

[2] Under-five mortality represents here the probability for a live born child to die before his or her fifth birthday.

mortality estimates supported by actual data are considered in the analyses[3], that is all estimates based on model extrapolation have been excluded. This exclusion prevents the model estimation assumptions from influencing the results. Thus, results of the analysis reflect actual (though smoothed) figures and trends in the region and are less affected by assumptions underlying the child mortality estimates.

Three socio-economic variables generally used in the literature are considered: per capita income, the proportion of women aged 15 and over who are illiterate and the percent of population living in urban areas. The data on per capita income and illiteracy were taken from the World Bank Development Indicators database[4]; the income indicator used is GNP per capita (constant 1995 US dollars). The GNP per capita was available for the period of 1970 to 2000 and for most Sub-Saharan African countries. Liberia and Somalia do not have any information and the indicator did not cover the whole period 1970-2000 for some countries. No information on illiteracy was available for Angola, Gabon, Guinea, Sierra Leone, Somalia and Sao Tome. The data on urbanization was taken from 1999 revision of the World Urbanization Prospects produced by the United Nations[5]. In sum, there are 254 observations of under-five mortality covering 42 countries, but jointly with the income, illiteracy and urbanization variables, only 169 observations covering 34 countries are included in the multivariate analysis.

Our dependent variable is under-five mortality and the main independent variables are the socio-economic variables described earlier. In order to account for regional differences, we created a categorical variable that distinguishes each region in sub-Saharan Africa. The United Nations definition of region – Middle, East, Southern and West – is used to classify countries into regions (United Nations, 2001). In addition, the period before 1990 is distinguished from the 1990s. The analyses are both descriptive and multivariate. We briefly describe child mortality trends from 1960 to 2000 by region and assess the bivariate association of child mortality and the main independent variables. A multivariate model is fitted to determine the direct effect of each of the independent variables adjusting for the others. In order to account for correlation within and between countries, we fit random effect cross-sectional time series models: a main effect model that includes all the independent variables and an extended model that takes into account interaction between (i) region and the socio-economic variables; (ii) period and the socio-economic variables, and (iii) period and region. The models are fitted using

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[3] An estimate for a particular date is regarded as being supported by the data if there is an observation within two years of the date. Thus for example an estimate for 1970 will be included only if there were an observation between 1968 and 1972.

[4] See http://devdata.worldbank.org/hnpstats/.

[5] United Nations. (2001) "World Urbanization Prospects, the 1999 Revision", *Department of Economic and Social Affairs, Population Division*, New York, 2001, p.156.

the logarithm of the child mortality estimates to satisfy the normality assumption of the outcome variable and the logarithm of the income per capita to account for the decreasing slope of the association between mortality and income. The main effect model indicated no significant difference between the East and the South regions on the one hand and between the West and the Middle regions on the other hand. Thus the East and the South regions were grouped together and the West and the Middle regions were also grouped together. Similarly the extended model showed no significant modification effect between region and income; region and the percent of the population living in urban areas and region and period. We therefore excluded these interactions from the final model.

Trends in Under-five mortality in Sub-Saharan Africa

Figure 1 below presents levels of U5MR at time points separated by 5 years, from 1960 to 2000. For sub-Saharan Africa as a whole there has been a decline in U5MR concentrated largely in the period between 1965 and 1990, during which the median U5MR dropped from 232 to 170 per 1000. Since 1990, the trend seems to have stalled. The pattern of this overall trend also characterizes each region, though at different levels and speeds. The countries of the West region had the highest U5MR in 1960, with a median value around 290 per 1000 live births. This level fell below 200 per 1000 by 1985, a level similar to that of the Middle region, which had a median around 260 per 1000 in 1960. The East region median oscillated around 200 per 1,000 prior to 1975 before declining to 170 per 1000 in 1990. The Southern region had the lowest median U5MR in 1960 (around 200 per 1000) and experienced the sharpest decline to about 60 per 1000 by 1990. Declines appear to have stalled in all regions in the 1990s. The West and Southern regions thus experienced the fastest declines from 1960 to 1990, with the countries of the Middle and East regions showing the slowest improvement.

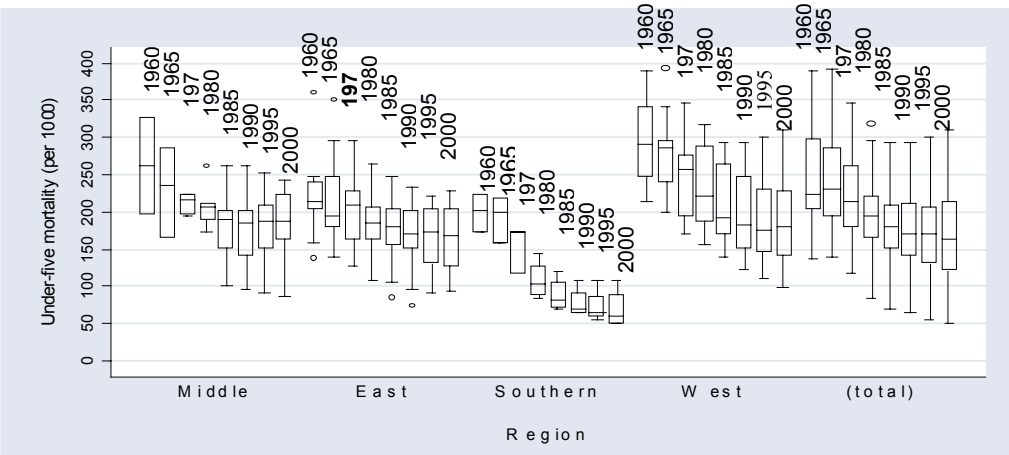

Figure 1: Trends in Under-five Mortality by Five-year Period (Except between 1965 and 1975) and Region, 1960-00

The next section analyses the association of country levels and trends of child mortality with the levels and trends in the GNP per capita, the percent of the population living in the urban areas and the percent of women aged 15 and older who are illiterate.

Child mortality and socio-economic status

Figure 2 below shows the U5MR estimates plotted against the logarithm of per capita income. Different symbols are used to distinguish the points for the 1970s, the 1980s, and the 1990s and later. There is a clear association of higher mortality with lower income, but there is also a great deal of variability, indicating that factors other than income play an important role in determining levels of U5MR.

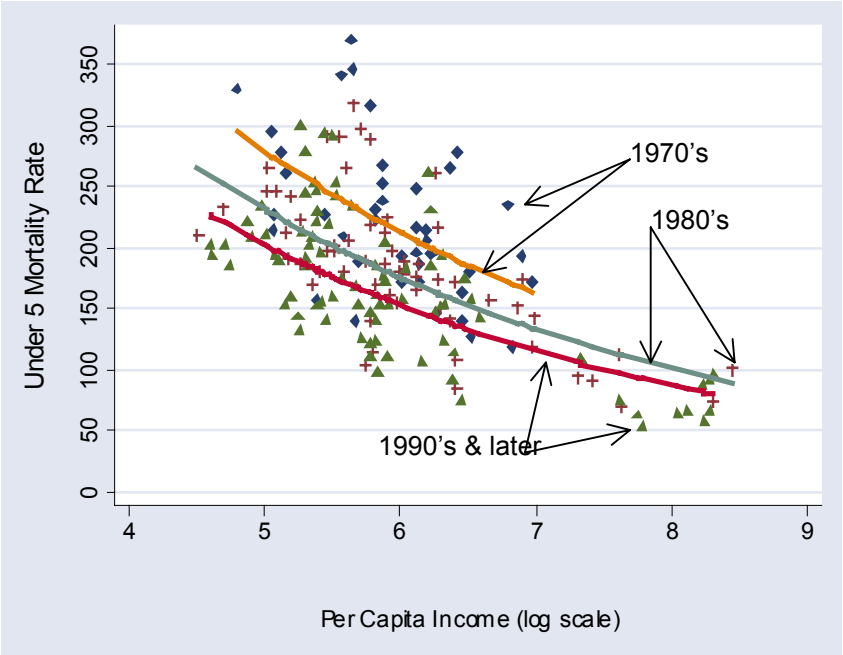

Figure 2: Relation between Under-five Mortality Rates and per Capita Income

Figure 2 includes random effect regression lines showing the average relationship between log(U5MR) and log(income) for each decade. In these regressions, income accounts for between 26% (1970s), 54% (1980s) and 61% (1990s and later) of the overall variability in U5MR. Income therefore seems to explain more variability of child mortality in the recent decade. However, it is interesting to note that the slope of the relation between income and U5MR is very similar for the three periods, but this relation shifts over time such that a given level of income is associated with a lower level of U5MR as we move towards the present. Though income explains

more inequalities in child mortality for the latest decade, the contribution of other factors has made a given income level to be associated with better survival. Overall, the pooled data indicate that one unit increase in the logarithm of per capita income is significantly associated with a 25% reduction in the U5MR, regardless of the time frame[6]. In this model, income explains nearly 50% of the variability in the U5MR.

Similar to income, urbanization and illiteracy affect the U5MR in the expected direction. The higher the percent of the population living in urban areas, the lower the U5MR (figure 3) and the lower the percent of women illiterate, the lower is the U5MR (figure 4). Figure 3 plots the U5MR against the percent of the population in urban areas, overlaid by the predicted U5MR obtained from a random effect regression of income on the percent of the population in urban areas. Here again, there is a large variability for a given level of urbanization despite the significant negative association observed. In fact, urbanization level explains only 19% of the variability in U5MR indicating more prominent effect of other factors. The bivariate model indicates that an increase in the percent urban of 10 points reduces the U5MR by 20% regardless of the time frame, other things being equal.

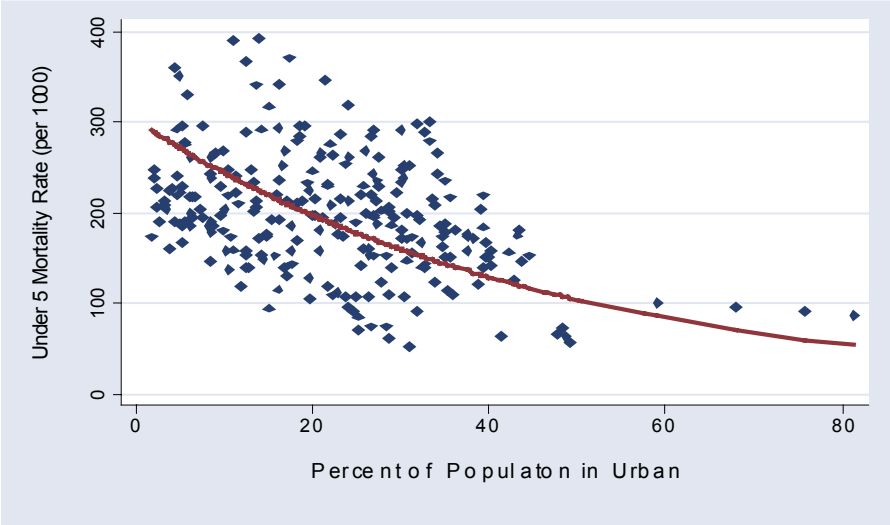

Figure 3: Relationship between Under-five Mortality and the % of the Population Living in Urban Areas

[6] The coefficient of the random effect regression of logarithm of U5MR on logarithm of income is –0.288. This indicates that an increase in the log income of one unit reduces the log U5MR by 0.288. It is easy to see after small transformations that this means that an increase in log income of one unit reduces U5MR by 25%.

Figure 4 indicates the bivariate relationship between the percent of women illiterate and U5MR. Unlike income and urbanization, illiteracy seems to explain much of the variability in the U5MR within and across countries. In fact, the random effect bivariate model indicates that illiteracy accounts for two-thirds (67%) of the overall variability in U5MR. The illiteracy effect is, however, not that large: other things being equal, a reduction of the percent of women illiterate by 10 points reduces U5MR by 13%.

Figure 4: Relationship between Under-five Mortality and the percentage of Women Who Are Illiterate

The next section examines direct effect of each of the socio-economic variables adjusting for others and for region and period. Table 1 shows the coefficients of different regression models. The main effect model, which includes all the variables, indicates a reduction of the effect of all the socio-economic variables compared to the effect observed at the bivariate level. The associations remain, however, in the same direction and significant at the same level. The three socio-economic variables, along with the region and the period variables account for 77% of variability in the U5MR indicating the crucial role of socio-economic status on population health. Controlling for other factors, the main effect model indicates that an increase of 10% in per capita income reduces the U5MR by 1.7%. Similarly an increase in the percent of population living in urban areas by 10 points, or a similar reduction of the percent of women illiterate decreases the U5MR by 10%. There are also significant regional differences and the Middle and the West regions

have 16% higher U5MR than the East and South regions, after adjusting for the socio-economic and the period variables. Difference between the period prior to 1990 and the 1990's and later is only marginally significant with the recent period having 5% lower U5MR.

Table 1: Coefficients of Random Effect Regression Models Examining the Association between Under-five Mortality and Socio-economic Variables

Variable	Bivariate Model	Main Effect Model	Extended Model
Log GNP per capita	-0.29***	-0.17***	-0.14***
% urban	-0.02***	-0.01***	-0.01***
% of women illiterate	0.01***	0.01***	0.01***
Region			
East & South		Ref.	Ref.
Middle & West		0.15**	-0.41**
Period			
Before 1990		Ref.	Ref.
1990's and later		-0.05*	0.75***
Interaction			
Middle & West X % of women illiterate			0.01***
1990's & later X Log GNP per capita			-0.13***
1990's & later X % urban			0.01***
1990's & later X % of women illiterate			-0.003**
Overall R-Square		0.77	0.79

Notes: ***: p < 0.01; **: 0.1 < p < 0.05; *: 0.05 < p <0.10

As shown earlier, mortality levels and trends vary by region, and moreover the 1990s and later period shows a stalling of the levels and even increases are noticeable in some countries. Thus, the main effect model conceals important modification effects between the region and the socio-economic variables on the one hand and between the period and the socio-economic variables on the other hand. The extended model in table 1 takes into account these interaction effects. No significant interaction effect was found between income and region and between illiteracy and region. Therefore, the model was refitted without these interaction terms and the model shown in the fourth column of table 1 is the final parsimonious model. Overall, three conclusions could be drawn from the result: (i) there is a consistent significant negative relationship between per capita income

and U5MR, but the association is stronger during the period after 1990 than the period before, regardless of the region; (ii) the effect of the percent urban and the percent of women illiterate on U5MR is weaker, though significant, during the period after 1990 than the period before; and (iii) the effect of illiteracy is stronger in the Middle and West regions than in the East and South regions. We discuss these conclusions in the next section.

Interpretation of the coefficients of a model that includes interaction terms is somewhat tricky. In interpreting, it is important to keep in mind the reference category, and the main effect can only be interpreted at the reference level of the variable included in the interaction term. Thus, during the period prior to 1990, an increase in the log GNP/per capita of one unit is significantly associated with a reduction of the log U5MR by 0.14, corresponding to a relative reduction of 13%. In 1990s and later, the corresponding absolute reduction is 0.27 or 24% relative reduction. This is consistent with the bivariate results which indicated that income explains more variability in U5MR in the recent decade. This is not, however, the case for urbanization, which showed a weaker effect in the latest period. In fact, while in the period before 1990, an increase in the percent urban by 10 points is significantly associated with a reduction of the log U5MR of 0.1, corresponding to a relative reduction of 10% in the U5MR, only 3% (or a reduction of 0.03 point in the log U5MR) reduction is observed during the 1990s and later. For illiteracy, there is a significant interaction with the region indicating variation of its effect across the two regions considered. During the period prior to 1990, while a reduction the percent of women illiterate by 10 points is associated with a reduction of U5MR by 14% in the Middle and West regions, it is associated with only 6% reduction in the East and South regions. During the 1990s and later, the reduction is lower than during the period prior to 1990 regardless of the region. But it is lower in the East and South region than in Middle and West regions (3% reduction compared to 11%, respectively).

In sum, the analyses indicated that socio-economic factors have strongly contributed to the decline in child mortality in sub-Saharan Africa between 1960 and 2000, and particularly during the period prior to 1990. In the last decade, only income per capita showed a strong effect on child mortality reduction.

Discussion

Improvements in child mortality in sub-Saharan African countries have been very poor in the past decade. Gains observed in the 1970s and 1980s due to socio-economic progress and to some specific low cost interventions for disease control (oral rehydration therapy, vaccines, malaria control) are not sustained in the 1990s. In fact, rates of decline in child mortality have slowed to practically zero since 1990 and one-quarter of all countries are experiencing increases.

This paper demonstrates a close association of socio-economic factors such as income per capita, literacy, and urbanization with child mortality. While women's literacy and urbanization showed weaker effect in the past decade, income per capita's effect increased. The continuous economic crisis, the widespread political instability and civil strife, and since the mid-1980s, the devastating HIV/AIDS epidemic have jeopardized the capacity of response of governmental institutions leading to detrimental effects on the health of the populations. The weak effect of urbanization in the past decade could be due to the rapid increase of urban poverty in such a way that urban poor are losing their health advantages compared to rural residents (APHRC, 2002). The increased effect of income per capita in the 1990s may well be indicating the fact that very poor countries are being more affected than relatively rich countries.

In the 1970s and the 1980s important support from international aid programs to countries substantially contributed to positive and rapid improvement in health and particularly in child survival. The poor performance in the 1990s could also be partly attributed to a "loss of focus" (Jones *et al.*, 2003) from the international agencies and to the conditioning of the aid and economic support on good governance.

A handful of inexpensive interventions of demonstrated effectiveness could, with universal coverage, have prevented well over half the 4.4 million deaths of children under age 5 estimated to have occurred in sub-Saharan Africa in the year 2000 (Jones *et al.*, 2003). Efforts to reduce the U5MR through the widespread use of these inexpensive interventions may have been responsible for the rapid declines seen between 1975 and 1985 in sub-Saharan Africa and the developing world more broadly. Renewed emphasis on these same interventions, with a small number of recent additions such as micronutrient supplementation, can still have a major impact today. However, in order to correctly assess what the 21st century holds for sub-Saharan African countries, it is imperative that more research be conducted to understand the root causes of recent mortality trends and the real impact of the economic crisis and the political instability on countries' health systems. Identification of appropriate means to solve the civil wars and adequate measures to help countries without good governance are also public health priorities in sub-Saharan African countries.

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