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Malnourished and surviving in South Asia, better nourished and dying young in Africa: What can explain this puzzle?

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Abstract

This paper examines the factors explaining the very different relationship between anthropometric shortfall and child mortality in South Asia and Sub Saharan Africa. While in the former, very high rates of anthropometric shortfall coexist with comparatively lower child mortality rates, rates of anthropometric shortfall in Sub Saharan Africa are much lower, yet under five mortality is much higher than in South Asia. This puzzle is examined using a panel data set of undernutrition, mortality, and their correlates. The analysis suggests that the unusually high rates of anthropometric shortfall in South Asia are partially due to the use of a US-based reference standard which appears to generate misleading international comparisons of undernutrition. The very high rates of under five mortality in Africa seem to be mostly due to very high fertility, high and rising HIV prevalence, and a possible multiplicative interaction of risk factors.

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1. Introduction

South Asian countries have the worst indicators of childhood anthropometrics in the world. As shown in Table 1, all anthropometric indicators suggest the highest rates of severe and moderate wasting (insufficient weight for height, an indicator of acute undernutrition), the highest rates of severe and moderate stunting (insufficient height for age suggesting chronic undernutrition) and by far the highest rates of underweight (insufficient weight for age, commonly used as a summary indicator of undernutrition, UNICEF, 1998; Smith and Haddad, 1999). Similarly, South Asian children have by far the highest incidence of low birth weight (see Table 1). Indicators of anthropometric shortfall in Sub-Saharan African are some 40-70% lower than in South Asia. In fact, on some indicators, they are also lower than rates in East Asia and the Pacific (Table 1).

When it comes to infant and under five mortality, which is held to be closely related to undernutrition (e.g. Pelletier, 1998), the data in Table 1 give a very different impression. Now Sub-Saharan Africa has infant mortality rates that are 30% higher than in South Asia, and under five mortality is some 60% higher in Africa. The puzzle can be best illustrated by considering the relation between low birth weights and infant mortality. Data from the US suggest that birth weights below 2500g lead to perinatal mortality that is at least 10 times larger than for children with median birth weights (3300g). For birth weights below 2000g, the rate is even 40 times larger.[1] This would suggest that the higher prevalence of low birth weight babies alone should raise infant mortality rates in South Asia by at least 18 per thousand, compared to Sub-Saharan Africa. Yet South Asia's infant mortality rate is some 20 per 1000 *lower* than in Sub-Saharan Africa.

Similarly, East Asia and Pacific have, on average, similar anthropometric indicators to Sub Saharan Africa, yet mortality rates are some 60-70% lower than in Africa. In fact, there appear to be two patterns of the relationship between anthropometric shortfall and childhood mortality indicators, a South and East Asian pattern where high rates of anthopometric shortfall co-exist with comparatively low infant and child mortality, and an African, Middle Eastern and Caribbean pattern where comparatively better anthropometric indicators are associated with higher infant and childhood mortality rates. South Asia and Sub Saharan Africa are the most extreme examples of these patterns and will therefore be the focus of the analysis. This is also borne out by Figure 1. While the scatter plot clearly suggests that underweight is associated with higher under five mortality, the South Asian countries and, to a lesser extent, East Asian countries cluster around comparatively low under five mortality and high underweight, while the reverse is the case for Sub

[1] 177 per 1000 instead of 4.8 per 1000 for median birth weight children, see WHO, 1995.

Saharan Africa. Similarly, this contrast is not just apparent in recent data from these regions, but can be seen in data from previous decades as well.[2]

These very different patterns in the relationship between childhood anthropometry and childhood survival, particularly the contrast between South Asia and Sub-Saharan Africa, constitute a major puzzle. Parts of this puzzle, the unusually high rates of anthropometric shortfall in South Asia have been examined by a variety of studies (Ramalingaswami, 1996; UNICEF, 1998, Martorell, 1995; Svedberg, 1991; Osmani, 1997; Smith and Haddad, 1999). While some of these studies have speculated that the low status of women and their resulting poor health and nutrition might account for the high rates of reported childhood undernutrition, quantitative tests of the theory have been unable explain the very high rates of anthropometric shortfalls in South Asia. For example, Osmani (1997) finds that low female status in South Asia is associated with higher incidence of low birth weight, but the dummy variable for South Asia remains large and significant, accounting for most of the high incidence of low birth weight there. Similarly, Smith and Haddad, in an very thorough econometric analysis of the issue using cross-country time series regressions, also find that low female status (proxied by the female-male difference in life expectancy) is associated with poor anthropometric outcomes in children, but that most of the unusually high rates of reported undernutrition in South Asia are "accounted" for by the fixed effects, which they describe as the "black box of unobserved, time-invariant country-specific factors" (Smith and Haddad, 1999). They, and others, speculate that the Monsoon climate, recurrent flooding, crowding, cultural beliefs and practices regarding breast-feeding and weaning may be able to explain the black box, which they see as a high research priority (Smith and Haddad, 1999; Ramalingaswami et al., 1996).

Focusing on one part of the puzzle, the high rates of anthropometric shortfall, is important, but misses out on the other half of the puzzle, namely the comparatively low mortality rates in South Asia despite the high undernutrition (and the converse relationship in Africa). In particular, most of the factors that are held to account for the high rates of reported undernutrition in South Asia, such as low female status, poor infant feeding practices, and crowding should not only lead to undernutrition but raise childhood mortality rates there as well. In addition, low birth weight and

[2] In South Asia, anthropometric indicators have improved considerably from even worse levels in previous decades; similarly, infant and child mortality rates have fallen sharply in recent decades. In contrast, both undernutrition indicators and mortality indicators have improved by much less in Africa (e.g. UNICEF, 1998: de Onis et al. 1993; Smith and Haddad, 1999). But the contrast in the relationship between childhood anthropometry and childhood mortality has remained the same, with South Asia doing far worse in the former, and Sub-Saharan Africa doing worse in the latter.

undernutrition itself is seen by many to be a major risk factor that should raise to childhood mortality rates in South Asia.

To the best of my knowledge, the other half of the puzzle is has only rarely been analyzed in the literature. Sen (1999) mentions the contrast in mortality and undernutrition when comparing the two regions, but does not analyze its causes. Ramalingaswami et al. (1996) suggests that greater access to better quality health services might account for the lower mortality in South Asia. But this theory is also not analyzed in detail.

Logically, this puzzle can be due to four different factors, some of which will be explored in the present analysis. First, it may be the case that the way undernutrition is measured--actual childhood anthropometric indicators compared to a reference standard based on US children-- does not measure undernutrition well. This would be a particular problem if this measurement error differed by region, possibly due to regional differences in terminal height and weight potential, or differences in the growth process towards this terminal height and weight. Second, undernutrition may pose a lower than generally presumed mortality risk. This may be related to adaptation to undernutrition (e.g. Seckler, 1982; Sukhatme, 1982; Osmani, 1990; Waterlow 1988) or other factors that disrupt the presumed linkage between undernutrition and mortality. Third, other risk factors dominate the impact of undernutrition on mortality. Possible factors could be higher childhood HIV-AIDS in Africa, less access to health care, higher fertility, greater poverty and inequality, and worse educational levels in Sub-Saharan Africa, compared to South Asia. Table 2 shows that SubSaharan Africa fares indeed worse in some, though not all, of those indicators. A variant of this factor is a theory proposed by Pelletier and co-authors (1993, 1994, 1998) who argue that the same level of undernutrition leads to much higher mortality if the 'baseline' mortality is higher, as the various risk factors have a potentiating effect. Finally, the same risk factors may have a different impact on mortality, e.g. identical fertility levels have a larger impact on mortality in Africa, compared to South Asia. In other words, the 'model' of childhood mortality may have different parameters in the two regions.

This different relationship between undernutrition and mortality is of considerable policy significance. First, to the extent that this relationship differs between different regions, it is unclear which indicators are to be preferred to assess deprivation in developing countries. For example, some commentators have emphasized South Asia's poor record of anthropometric indicators as a very important shortfall that should heavily influence assessments of well-being in the region (e.g. Sen, 1999; Svedberg, 1991). While clearly undernutrition would remain an important indicator of deprivation due to its intrinsic[3] and instrumental significance[4], to the extent that arguably mortality (or rather, its converse, longevity) is the most fundamental indicator of well-being as proposed, for example, by Sen (1998), we should be more concerned about high mortality in Sub- Saharan Africa than high undernutrition in South Asia.

Second, an important rationale of significant investments by national and international development organizations in the monitoring of childhood anthropometry, both at the individual child's level as well as at the national level, is the close presumed linkage between anthropometry and mortality (e.g. UNICEF, 1998; World Bank, 1993). If this link is weaker than presumed, and differs across regions, the nature of these investments and may have to be reassessed and possibly modified.

Third, if the linkage between the two indicators is more variable, policy interventions have to treat these two problems separately as they can no longer presume that addressing one will successfully deal with the other in all contexts.

Apart from the policy significance of the different linkages, the *causes* for these differences between the two patterns described above also carry important policy implications. If it turns out that undernutrition is not measured well using the current reference standards, this would have major implications for development research and practice. Currently, WHO and UNICEF have invested heavily in ensuring growth and weight monitoring of children in poor countries based on the current reference standards. If revisions of the reference standard were necessary, this might necessitate a major chance in this practice.[5]

If it turned out that adaptation is a possibility that carries few health risks, the focus on anthropometrics as a health indicator may have to be reassessed. This would particularly be the case for the use of the stunting indicator as growth retardation (rather than weight loss) appears to be the most important form of adaptation in chronically malnourished children (Osmani, 1990). If it turns out that other risk factors dominate the impact of undernutrition, or that the impact of the same risk factors differs by country, then these other risk factors or their differing importance should receive much greater attention by policy-makers.

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[3] Undernutrition, or the persistent lack of adequate nutrition, reduces well-being, even if it has an only small impact on mortality.

[4] It is held to be associated with poor intellectual and motoric development and possibly higher morbidity and mortality (e.g. Osmani, 1990).

[5] It should be pointed out that growth and weight monitoring itself would not be challenged by the outcome of this debate. Also, at the individual level, evidence of undernutrition is usually based on growth faltering or failure to thrive over a period of time which is also unaffected by this debate as it relates to rates of change rather then levels of anthropometric performance. What would be affected are assessments of undernutrition based on anthropometric levels which is sometimes used for an assessment of undernutrition, particularly for children who have not been monitored

This paper attempts to provide a preliminary assessment of the evidence. It focuses on an analysis of a recently assembled cross-country time series data set of aggregate data on anthropometric shortfall of children, infant and child mortality, and its determinants.[6] The data set consists of a combination of the recently assembled first internationally comparable WHO Global Database of Child Growth and Malnutrition (WHO, 1997) and other published statistics on mortality, economic, social , and health conditions in 100 developing countries. I estimate cross-section and fixed effects panel models for the various anthropometric indicators and models for infant and child mortality, with anthropometric indicators as one among several regressors.[7] The analysis suggests that a combination of the factors mentioned above appear to account for this puzzle. In particular, I find considerable support for the view that the measurement of undernutrition using anthropometric shortfall might overestimate undernutrition in South Asia, compared to Sub Saharan Africa. Moreover, while I find little evidence of successful adaptation as the solution to the puzzle, there is evidence of a potentiating effect between undernutrition and other risk factors which may lead to elevated mortality rates in Africa. Finally, it appears that high fertility is associated with Africa's high childhood death rates, and there is some evidence that high fertility has a greater impact on child mortality in Africa than elsewhere.

2. Measuring and Assessing Undernutrition

When measuring undernutrition among children, one has to distinguish between clinical and statistical methods. Clinical assessments of undernutrition are ideally based on the *changes* in weight and height of children over time. Growth faltering and failure to gain weight are usually considered the most reliable signals for undernutrition (WHO, 1995; 1983). Where information on changes is unavailable, it is suggested to focus on the less reliable assessment of *levels* of achieved height and weight and compare them to a reference standard. This mode of assessment is also the recommended practice for monitoring nutrition intervention programs, where the follow-up of individual children may be very costly (WHO, 1983). Focusing on *levels* of height and weight is less reliable as its interpretation relies on a probabilistic assessment. While in most cases this assessment is likely to be correct, there may well be individual children are too short or too light but still are not undernourished, if they falls short of the reference standards due to a variety of genetic

continuously or report for the first time. Moreover, it would challenge the current basis for comparative assessments of undernutrition in populations and sub-populations.

[6] This study is part of a larger project investigating this puzzle. Later stages of the project will focus on an analysis of these linkages using micro data from the Demographic and Health Surveys and smaller longitudinal micro studies.

[7] See also Smith and Haddadd (1999) which also use the WHO Database to estimate models of undernutrition.

(and possibly some environmental) factors.[8] Conversely, some children that are above the cut-off defined by the reference standard but may still be undernourished.

For statistical analyses of *populations*, there are usually no comparable and reliable statistics on growth and weight faltering so that all analyses of undernutrition at the population level are based on measured levels of height and weight of children in comparison to a reference standard. To measure anthropometric performance among children, three indicators that are typically used: insufficient weight for height (wasting), insufficient height for age (stunting), and insufficient weight for age (underweight).[9] The recommended method for evaluation is based on the Z-score which is defined as:

$$\mathbf{Z = \frac{AI_i - MAI}{\sigma}}$$

where AI_i refers to the individual's anthropometric indicator (weight at a certain height, height at a certain age, or weight at a certain age), MAI refers to the median of the reference population, and σ refers to the standard deviation of the reference population (see for example Gorstein at al., 1994, WHO, 1995). The Z-score thus measures the distance, expressed in standard deviations of the reference population, between the individual's anthropometry and the median of the reference population, where both populations are presumed to be normally distributed.

WHO recommends a Z score of less than -2 as an indicator of moderate wasting, stunting, or underweight, respectively, while a Z score of less than -3 would indicate severe wasting, stunting, or underweight.[10] The share of the population suffering from moderate and severe undernutrition is then usually the statistic that is reported.[11]

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[8] For example, short parents have shorter children who will have a greater likelihood to be misdiagnosed as malnourished when one compares them to a reference standard. Similarly, there is some evidence that high altitude and climate affects height and weight without necessarily being related to undernutrition (Bogin, 1988; Eveleth and Tanner, 1990).

[9] For adults, there are other measures such as the body mass index.

[10] The choice of -2 is related to the fact that, in a well-nourished population, only about 5% of children should have a Z-score that falls outside of two standard deviation above or below the median. This means that there is only about a 2.5% chance that a child with a score below 2 standard deviations is wrongly classified as undernourished. Sometimes, a percent of median approach is used and an idividual score that is less than 90% of the reference median is considered moderate undernutrition, one less than 80% of the reference median is considered severe undernutrition. This method is usually not recommended as 80% and 90% of the median has no direct statistical interpretation and differs systematically from the Z-score approach. A related approach is to use the percentile of the reference population but this theoretically more precise measure is rarely reported at the population level (although it is often used at the individual level, Gorstein et al. 1994).

[11] There is some criticism of that approach as well as it only considers those who fall below 2 or 3 standard deviations from the median and neglects the rest of the height and weight distribution. Alternative methods have been proposed and applied that consider either the median of the studied population or the entire distribution of the studied population

The crucial question in the determination of undernutrition using this method is the choice of the reference standard. Since 1978, WHO has recommended the use of a single international reference standard for all countries of the world (WHO, 1983). The standard used was created by the US National Center for Health Statistics and the Centers for Disease Control and is based on the interspliced experience of two populations of US children. For children under 24 months, data from a study of white, largely bottle-fed middle-class children from the longitudinal Fels study from 1929-1974 were used, while for older children the standard is based from several nationally representative sample of children in the US in the 1960s and early 1970s (WHO, 1995).

This US-based reference standard thus implicitly suggests that all children in the world have, by genetic disposition, the same mean and the same distribution of height and weight potential (and the same growth process towards these final heights and weights) so that any shortfalls (or excess) from these standards observed in a population are related to nutrition. This claim was backed up by a variety of individual studies and the editorial opinion of major medical journals (Lancet, 1984; Lancet, 1980; Graitcer et al., 1981; Habicht et al, 1974). In particular, it was argued that environmental factors had a much larger impact on observed global differences in anthropometry than genetic factors. This claim was supported by studies showing that the difference between privileged children from developing countries and the US reference standards were small compared to the vast difference in anthropometry between privileged and underprivileged children in developing countries (Martorell et al, 1988; Habicht et al, 1974; Graitcer et al, 1981; WHO, 1995; Ramalingaswami, 1996). This view of one reference standard for all children in the world has been reiterated by a WHO Expert Committee in 1995 that had been charged to revisit the reference standards issue (WHO, 1995; see also WHO, 1997).[12]

While this appeared to be the consensus view, it has never been fully accepted by everyone and appears to have come under increasing criticism recently (e.g. Davies, 1988; Eveleth and Tanner, 1990; Bogin, 1988; MacFarlane, 1995). One line of criticism accepts that environmental factors are more significant than genetic differences in explaining differences in anthopometric

in an assessment of undernutrition (e.g. Monteiro, 1991: Svedberg, 1991). Using statistical terminology, relying on a cut-off of 2 standard deviations leads to a low type 1 error (a child is well nourished despite being below 2 standard deviations) of only 2.3% while raising the possibility of a much larger type 2 error (a child is malnourished but found to be within 2 standard deviations and thus not identified as malnourished). In the medical literature, the type 1 error is often referred to as the specificity of a test, while the type 2 error relates to the sensitivity of a test. While these issues are important questions in the measurement and interpretation of undernutrition, they do not greatly impinge on the present analysis of international comparisons of undernutrition which are based on the same reference standard and cut-off rules and thus suffer from the same potential for type 1 and type 2 errors.

[12] The Export Committee did, however, recommend that a new universal reference standard be created that should also include populations of developing countries. The case for one standard was largely made on pragmatic grounds and it was argued that the genetic differences in growth between populations were small enough not to warrant the costly and difficult development of local reference standards. See WHO (1995).

shortfall between populations, but holds that the genetic differences are important enough to be considered, particularly when anthropometric indicators are used in international comparisons.

In this context, it should be pointed out that the preferred measure for international comparisons, the share of children below a Z score of -2 or -3 is highly sensitive to even small differences in the appropriate reference standard. For example, even those who favor one standard suggest that genetic differences between South Asian and US children amount to about 1 cm of height difference by age five (WHO, 1995). Other researchers believe that the difference is a bit larger, on the order of 1-3 cm (Bogin, 1988; Davies, 1988; Eveleth and Tanner, 1990).[13] 1 cm constitutes less than 1% of the median height at age 5 for boys (109.9 cm), and even 3 cm would be less than 3% (WHO, 1983). In a population such as South Asia's, where nearly 50% of the population are stunted, a difference of only 1 cm in the reference standard, however, would lead to an over 8 percentage point drop in the share of children held to be chronically malnourished. In other words, if we believe that South Asian children are, by genetic disposition, about 1 cm shorter at age 5, the correct stunting rate would fall from 45% to 37%. If we believed the difference is 3 cm, it would fall from 45% to about 24%, a figure that is below the rate observed for Sub Saharan Africa, where there is no evidence of a similar genetic difference in the growth of children.[14] Thus a large share of the South Asian undernutrition enigma would simply disappear. The reason for this surprising sensitivity of the undernutrition rates to small changes in the reference standard is related to the fact that in a country where a large share of children clusters around the cut-off point for undernutrition (as it does in South Asia where the majority of the population is close to the cut-off point for undernutrition), a small change in the cut-off point affects the classification of a large number of children.[15]

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[13] Bogin (1988) assumes a short-fall of some 2.5 cm based on an assessment of Pakistani children in England. Despite considerable catch-up in terminal height in recent decades (which appears to have subsided since), Japanese children are still believed to be some 3-6 cm shorter than US children (Bogin, 1988). Martorell et al. (1988) suggests that Asian children, including South and East Asians, are some 3.5cm shorter by age 7.

[14] In fact, most evidence suggests that some groups of African children grow slightly faster than the reference standard and might therefore be more undernourished than suggested by the reference standard. These differences are slight, however, compared to the much larger difference between Asians and the reference standard (Martorell et al, 1988).

[15] The only assumption used in these illustrative calculations is that South Asian children have roughly the same (normal) distribution of heights as those found in the reference standard, which has typically been found to be a reasonable assumption. This would mean that the distribution of South Asian heights is simply shifted to the left where the median height is close to (and slightly above) the cut-off point, leading to some 45% of children undernourished. If the median is close to the cut-off point this also means that most children, who cluster around the median in a normal distribution, are also close to the cut-off point and any change in the cut-off point will therefore affect a large number of children. From the tables provided in WHO (1983: 64) one can deduce that for 5 year old boys the median stature in the reference standard is 109.9. Around the median, a 1 cm reduction in the expected median stature would shift nearly 10 percent of the reference population above the median. It would also lead to about a 1 cm shift in the cut-off point to the left (from 102.3 to 101.3). If the entire distribution centered on the cut-off point (as is that case when reported stunting rates are 50%) such a shift would reduce the reported stunting rate by nearly 10 percentage points. As South Asia's distribution is not squarely centered on the cut-off point but slightly to the right of it (with 45% reported stunting and

A second line of criticisms examined particular populations and found that there appear to be quite significant differences between well-to-do children in different parts of the world. MacFarlane (1995) shows, for example, that well-to-do Nigerian children (from the Yoruba ethnic group) were significantly taller, yet lighter than the reference standard, while well-to-do Pakistani children were significantly shorter and also lighter than the reference standard. A third line of attack comes from evolutionary biologists who claim that genetic diversity differs in different population groups and should therefore lead to different *distributions* of heights and weights. Since the assessment of undernutrition is based not only on an assumption of median heights and weights but also depends crucially on their distribution, differences in the distribution between populations also bias the assessment of undernutrition.[16] In particular, and consistent with the theory of humanity's origin in East Africa, genetic diversity, and thus the distribution of heights and weights, is greater in Africa than elsewhere. Thus it would not be appropriate to use reference standards of more homogenous non-African groups of children for genetically very diverse African populations (Kidd et al., 1996). More generally, differences in genetic diversity between population groups might necessitate the use of locally generated standards.

Most of the studies that challenged the view of one reference standard found that children from South Asia (and also, to a lesser extent, East Asia) appear to be considerably shorter and lighter than one would expect given environmental conditions, and that children from Africa appear generally taller, but lighter, and displaying a greater diversity in their height and weight distributions (Eveleth and Tanner, 1990; Davies, 1988; MacFarlane, 1995; Kidd et al. 1996; Brinkman, et al. 1997; Martorell, 1995).

In addition to these fundamental criticisms of the international reference standards, there are a range of particular criticism with the way the standard was derived. The splicing of two data sets to form one continuous standard causes considerable discontinuity at age 2, after which children suddenly appear a lot better nourished. Moreover, the reference standard which is based virtually entirely on bottle-fed children implies faster growth and weight gain between about 3 and 6 months than is usually the case in breast-fed children. This led to the paradoxical finding that parents that followed the WHO guideline of six months breast-feeding saw their children fall behind in the growth and weight charts and appear increasingly undernourished (de Onis and Habicht, 1996). These two problems prompted the WHO Expert Committee to call for the development of a new

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underweight rates), a 1 cm reduction in the reference standard would thus reduce measured undernutrition by over 8 percentage points.

[16] For example, if an African country had the same median height, but, for evolutionary reasons, a wider distribution of heights than the US reference standard, we would erroneously classify too many as undernourished as a larger share of the population would fall outside two standard deviations of the US-based norm.

international reference standard that would be based on children that follow WHO recommended feeding practices and that are based on a continuous monitoring from birth to adolescence (WHO, 1995; de Onis and Habicht, 1996). Such a new reference standard has yet to be developed and WHO, as well as other agencies and countless doctors and healthworkers all over the world, continue to use the NCHS-CDC standard to determine undernutrition of children.

3. Modeling the Determinants of Undernutrition and Childhood Mortality

Both undernutrition and infant and child mortality are the result of an interplay of several distinct economic, social, environmental, and epidemiological factors that operate at the individual, the household as well as the community level. In order to model these complex interactions, UNICEF (1998) has proposed a conceptual framework that distinguishes between immediate, underlying, and basic causes (see also Smith and Haddad, 1999). While the immediate causes of undernourishment are inadequate dietary intake and disease that prevent absorption, dissipate nutrients, or increase requirements, the underlying causes for these two factors are insufficient access to food, inadequate maternal and child care practices, and poor water, sanitation, and health services. These factors, in turn, are held to depend on the economic, human, and organizational resources as well as the potential resources of a society.

While these distinctions are theoretically very useful, it is not always easy to find good measures for each of the factors at the various levels of causation. In particular, when examining macro data on undernutrition and its determinants, one has few variables at one's disposal that clearly distinguish between underlying and basic causes.[17] For example, women's education can be a proxy for both the human resources of the population, a basic cause, as well as maternal and child care practices, an underlying cause. Similarly, per capita income may proxy the economic resources of a society, a basic cause, as well as proxy the access to health care services which require user fees or the quality of sanitation facilities, both underlying causes.

While keeping in mind the distinctions proposed by UNICEF, I will offer a more parsimonious model of undernutrition that includes female education, the fertility rate, population density, and (the log of) GNP per capita (adjusted for purchasing power parity) in the basic specifications.[18] The importance of female education in improving the health and well-being of children has been demonstrated in many studies (e.g. Murthi et al. 1995; Smith and Hadad, 1999;

[17] Smith and Haddad (1999), for example, model the underlying determinants using access to safe water, female secondary enrolments, and per capita dietary energy supplies, and the female to male life expectancy ratio, while they use per capita GDP and an index of democracy as proxies for the basic determinants.
[18] We use the log of income under the presumption of a declining marginal impact of higher incomes on undernutrition. Empirically, this turns out to be the better specification.

Summers, 1994; Klasen, 1999). It affects undernutrition directly through better health knowledge and care, and indirectly through better access to resources for children. High fertility may lead to greater undernutrition as it reduces the time, energy, and resources (physical and emotional) available for each individual child. Population density is included for three reasons. High population density is a proxy for crowding which may increase the spread of diseases and thus undernutrition. Moreover, high population density may proxy for the relative costs of calories. In densely populated areas where the ratio of people to arable land is very high, the relative costs of calories may be larger leading to lower quality and poorer diets that can cause undernutrition. Third, high population density may proxy for the availability of physical resources per member of a society. Finally, GNP per capita is a proxy for the economic resources at the disposal of the society, and it also serves as a crude proxy for resources available at the household level.[19]

In addition, I will include access to sanitation and a measure of breast-feeding. Clearly, better access to adequate sanitation should reduce undernutrition. While exclusive breast-feeding early on is likely to lead to lower undernutrition, the measure of breast-feeding I use, the proportion of children still breast-fed at 20-23 months might actually be associated with higher undernutrition as such late breast-feeding may be debilitating to the mother which can particulatly translate into low birth weights (Ramalingaswami et al., 1996).

To capture the fact that some of the independent variables are themselves causally related (for example, female education tends to reduce fertility rates, higher incomes tend to increase access to sanitation), I will also run 'reduced form' regressions that only include female education, income, and population density to capture the full effect of these variables on undernutrition. To the extent one can make the distinction between underlying and basic causes, these reduced form regressions are also attempts at estimating the basic causes of undernutrition with the three variables proxying for, respectively, the human, economic, and physical resources a society has at its disposal.

The determinants of childhood mortality are likely to be closely related to the factors causing malnutrition. Also here, one may distinguish between immediate, underlying, and basic causes. Abstracting from non-natural causes of death, the immediate causes of death are illnesses that overcome the body's defense mechanisms. Among the underlying causes of death are the disease environment, the ability of the person to combat these diseases, and the care received by the child. The disease environment may be related to geographic factors as well as the state of access to basic services such as water and sanitation, and the resistance of the person may be related to the physical

[19] Anand and Ravallion (1993) note that increased GDP per capita allows both greater reductions of poverty as well as greater spending on public health care, both of which were found to reduce mortality rates (and presumably

health and nutritional status of the person as well as the access to effective preventive and curative health care. The care received may depend on the number of children, the knowledge and situation of the care-giver, as well as the availability of health care.

The basic causes are, once again, the environmental, economic, human, and technological resources and potential resources a society has as its disposal to provide adequate nutrition, care, and services to its people.

While most of these determinants are rather uncontroversial, there are long-standing debates about the importance of mild to moderate chronic undernutrition as a risk factor for mortality. In particular, some researchers have argued that mild to moderate stunting, the result of moderate chronic undernutrition, is the body's optimal adaptation to low nutrient intake and may not signify a health problem at all (Seckler, 1982; Sukhatme 1982). On the other hand, others have argued that all forms of anthropometric shortfall, including the moderate versions of them, are risk factors causing increasing mortality and other health hazards (e.g. UNICEF, 1998; Pelletier et al., 1993; WHO, 1995). In particular, Pelletier argues that undernutrition has a potenitiating effect on other risk factors so that undernutrition is particularly a problem in areas where other risk factors are also elevated. This is modelled by presuming that risk factors are in a mulitplicative (or even exponential) relationship rather than the usually presumed linear relationship (Pelletier et al, 1993, see below). If Africa has a higher 'baseline' mortality due to the presence of other risk factors, even lower rates of anthropometric shortfall could multiply with the other risk factors to lead to higher observed mortality rates. There is a middle position that suggests that low birth weight constitutes a major risk factor, as does moderate and severe wasting and severe underweight, while stunting pose fewer health risks but may retard the motoric and intellectual development of children (Osmani, 1990; 1997; UNICEF, 1998).

Apart from considering the controversies surrounding the impact of undernutrition on mortality, it is important to investigate the factors that could be responsible for the particularly high infant and child mortality rates in Sub Saharan Africa. Three likely candidates are the much higher prevalence of childhood HIV and AIDS in Africa, less access to effective health care, and high fertility (see Table 2). Let me discuss these issues briefly in turn. HIV-AIDS is far more prevalent in Sub Saharan Africa than in South Asia (or anywhere else). With a transmission rate from mother to child of 15-40% and the near certainty that an infected child will, without access to expensive medical treatments, die in the first two years (World Bank, 1997), a difference in the adult prevalence of HIV of 5 percentage points between the two regions could lead to a difference in

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undernutrition). Measures of poverty would be preferred as proxies for resources at the households level but are infant mortality rates of some 10/1000.[20] While these gruesome calculations suggest that the differences between infant mortality rates in the two regions will widen dramatically in coming years as HIV prevalence continues to rise faster in Africa than in South Asia, HIV can only account for a portion of the observed differences, as HIV currently has a very high prevalence only in a small number of countries in Eastern and Southern Africa, and as the differences in the relation between undernutrition and mortality predate the onset of high rates of childhood HIV.[21]

Differential access to health care also could be at the heart of the different relationship between undernutrition and mortality. But this can only be the case if access to health care has a large impact on mortality, but only a negligible impact on anthropometric indicators.[22] The type of health interventions that are likely to have little impact on anthropometrics but a potentially larger impact on mortality are acute curative interventions to deal with potentially life-threatening conditions (such as persistent diarrhea or acute respiratory infections). If children in South Asia have much better access to such health care, it could account for the different relationship between undernutrition and mortality in the two regions.

Third, differences in fertility may also lead to higher mortality in Sub Saharan Africa, compared to South Asia. Sub Saharan Africa has much higher fertility levels than South Asia and is only at the beginning of the fertility transition (see Table 2). In contrast, fertility levels on South Asian countries have fallen rapidly. Empirically, there appears to be a close inverse correlation between fertility rates and infant and child mortality rates which could then account for the unusually high mortality in Sub Saharan Africa.[23]

In order to shed light on these debates, I will estimate several simple empirical model of under 5 mortality. In the basic specification, I will include per capita income, female education,

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unavailable on an internationally comparable basis.

[20] Assuming a 5 % prevalence among women of child-bearing ages (see Table 2) multiplied with a 25% mother to child transmission means that 1.25% (or 12.5/1000) children will meet a certain death before age 1; assuming that some would have died in any case (some 10% or 1.25 per thousand), this would still lead to a difference of 11/1000.

[21] The extent of the widening depends on the relative speed of the spread of the disease in the two regions which is uncertain at present, particularly in South Asia where HIV prevalence is still comparatively low. Some countries, most notably Botswana have seen their infant mortality double as a result of HIV, which has also reduced their life expectancy at birth by some 10 years (UNDP, 1998).

[22] Many health interventions at the primary level, particularly immunizations, nutrition support, oral rehydration, other health prevention and promotion should reduce infant mortality and reduce measured rates of undernutrition as healthier children are able to absorb nutrition better and should suffer from fewer anthropometric shortfalls *and* lower mortality. This could then not explain the different relationship *between* undernutrition and mortality in the two regions. Similarly, differences in feeding practices are also unlikely to account for much of the difference as they should also affect anthropometric indicators and mortality at the same time (e.g. Ramalingaswami, 1996).

[23] One may imagine that some of the factors that generate the link between fertility and child mortality, such as the high poverty in large families, the lack of parental investment in 'quality', and the health hazards for the mother, may also lead to higher rates of undernutrition. Empirically, it turns out that the bivariate relationship between fertility and infant and child mortality is much stronger than between fertility and undernutrition.

fertility, and population density[24] as measures of the underlying and basic determinants of mortality. To that I will add measures of immunization coverage as indicators of preventive health care, and measures of undernutrition, focusing on low birth weight and the share of underweight children. In a separate set of regressions focusing on the most recent period, I will also add a measure of HIV prevalence as an explanatory factor.[25]

4. Data and Methodology

In order to undertake this analysis, an international panel data set was put together. The core of this data set consists of the newly assembled and regularly updated WHO Global Database on Child Growth and Malnutrition (WHO, 1997; de Onis et al., 1993) which includes the most comprehensive collection of surveys of children's anthropometric indicators in developing countries. A particular advantage of the database is that all surveys included have been standardized and are based on the US-based reference standards described above. In addition, the database provides detailed information on sample sizes, age ranges, coverage, and sources. Based on these data, two data sets are created. The first is a panel data set consisting of all national surveys (and a few regional sets if the included regions contain large shares of the national population). Whenever there are several surveys from different years, there are all included. This panel data set includes some 270 observations. The smaller data set is a cross-section of one strictly national survey per country from the mid-1980s to 1997, and includes some 90 observations.[26]

To match the Global Database, data on PPP-adjusted GNP per capita, fertility, education, mortality, calorie availability, access to health, water and sanitation, breastfeeding practices, incidence of low birth weight, HIV prevalence, and immunization rates from the same years were assembled from World Bank, UNDP, and UNICEF sources.[27] While these data are the best available, some of the data may be subject to measurement error and/or not be compatible internationally. In particular, the indicators on health, water, and breast-feeding prevalence, low birth weight, and calorie availability appear to be particularly subject to some measurement error and, in some cases, known biases (Svedberg, 1991).[28]

[24] I am including it here as a potential proxy for access to services, including health care.
[25] As with the undernutrition regression, I will estimate full models with all underlying and basic determinants and reduced form regressions that include only variables that are proxies for basic determinants.
[26] In a later stage, other sub-sets of the data will be considered. In particular, a high quality sub-set only including identical age ranges will be created to reduce the impact of measurement error.
[27] The GNP figures are PPP-adjusted and drawn from the Penn World Tables. For the most recent years not yet covered by the PWT, World Bank data are used (after being adjusted to be compatible with the PWT data).
[28] For example, Svedberg (1991) argues that calorie availability data from FAO (which is the source of the data in UNDP's publication) seriously understate availability in African countries. It turns out that access to health, water, initial breast-feeding coverage, calorie availability, as well as the Gini coefficient have no significant impact on any of

I estimate fixed effect panel models of the various undernutrition indicators and a fixed effects panel model of mortality indicators, with undernutrition being one of the arguments.[29] The fixed effects included are regional fixed effects (not country-specific ones)[30] and the time fixed effects consider four periods (not individual year effects). Particular emphasis will be on the difference between the fixed effects coefficients on Sub-Saharan Africa and South Asia. If they differ greatly, then the models are unable to account for a share of the variation in undernutrition and mortality between the two regions which may be related to the measurement issues discussed above, or to the influence of omitted variables.

Since one of the theories to be considered is that undernutrition in South Asia is overstated, I will apply various measures that correct for this potential bias using econometric procedures developed to correct for measurement error.[31] If these corrected undernutrition indicators perform better than the uncorrected ones, this lends some support to the hypothesis that undernutrition is indeed not well measured in South Asia.

To test the potential potentiating effect of risk factors on mortality, I also estimate a mortality model where the risk factors do not add linearly, but exponentially, and one where there the elasticity of the covariates is presumed to be constant.[32]

In addition, I estimate a cross-section model of infant and under 5 mortality. This allows the inclusion of the HIV prevalence rate variable for which there is no information prior to the 1990s.

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the anthropometric or mortality indicators which is likely to be related to this measurement error. In the course of this project, this issue will be taken up in greater detail.

[29] There is a question as to whether there may be reverse causality between undernutrition and levels of income, as undernutrition may be a cause of lower productivity and thus lower incomes (a.g. Dasgupta, 1997). Pritchett and Summers (1996), using similar data, examine this issue in great detail and conclude that reverse causality is not a major issue. Smith and Haddad (1999) also test for the endogeneity of GDP and find it not to be the case.

[30] This allows the inclusion of observations from countries with only one data point. Moreover, since I believe that regional peculiarities are more important than peculiarities of countries within a region, the use of fixed effects should not pose a major problem. I also ran country-specific fixed effect panel models and found them to yield virtually identical results which indicates that indeed the regional differences are much relevant than the differences of countries within a region.

[31] They include replacing the undernutrition and low birth weight indicators with instrumental variables, or correcting specifically the South Asian values. See below.

[32] The first can be achieved by expressing the dependent variable in logs while reteining the other variables in their normal form and then estimating the model using OLS. The second is achieved by transforming both sides into logs and estimating them using OLS.

In all models, standard errors are corrected for heteroscedasticity, and various specification tests are performed to examine the explanatory power of the regressions.[33] As the main focus is on the differences between South Asia and Sub Saharan Africa, I will calculate point estimates to determine to what extent the models are able to explain the differences in undernutrition and mortality between the two regions.

5. Undernutrition Models

a. Low Birth Weight

Columns 1 to 3 in Table 3 show three regressions predicting the prevalence of low birth weight (defined as the share of births with less than 2500 grams birth weight). The results are generally as expected. Higher levels of income reduce the incidence of birth weight. Moreover, maternal conditions play a role. Higher fertility raises, and higher female literacy lowers the prevalence of low birth weight. The two are closely correlated as one would expect given the literature on the impact of female literacy on fertility. In the reduced form model estimated in regression 3, the fertility rate is omitted and consequently the impact of the female education variable increases and becomes more significant. In the second regression, long breast-feeding appears to increase the rate of low birth weight babies as one would expect, given the drain of prolonged breast-feeding on the health and nutritional status of the mother (see also Ramalingaswami et al., 1996). Population density raises the share of low birth weight babies. To the extent that densely populated countries are characterized by high real costs of calories and nutrients, this variable may pick up this effect.[34] Apart from the education variable, the coefficients on income and population density change little in the reduced form regression. Most importantly, in all three regressions the dummy variables for the South Asia and Sub-Saharan Africa are large, highly significant and of opposite signs, suggesting that the model is unable to explain a significant portion of the observed differences in low birth between the two regions (see also Osmani, 1997).[35]

c. Stunting

[33] In particular I use the Ramsey RESET test that examines whether the model suffers from omitted variable bias and consider the adjusted R-Squared criterion for inclusion of additional variables.

[34] Densely populated poor countries are characterized by a low-wage labor-intensive agriculture where the ratio of food prices to wages may be higher than in less densely populated countries. At this point, this should be treated as a hypothesis to be investigated further.

[35] The model does not pass the Ramsey RESET test for omitted variables. It turns out that this is due to the non-linear relationship of some of the variables. When I include squares of GNP, population density, and female literacy, the fit is improved and it passes the test. This suggests that all three variables have a declining impact on stunting. The size and significance of the South Asia dummy remained. The regression is not reported, but available on request.

Columns 4 and 5 show two specifications of the model predicting moderate and severe stunting rates.[36] The coefficients in columns 4 and 5 are as one would predict and the specification test suggests that there are no omitted variables that would improve the fit significantly. High fertility is associated with higher stunting rates as children in large families are likely to get less individual attention and fewer resources. Log GNP has a negative impact, and higher population density is associated with greater stunting rates. As with the low birth weight regression above, this could be related to the lower availability and higher relative costs of calories and other nutrients which may be higher in densely populated countries.[37] As expected, better sanitation access reduces stunting rates as it presumably reduces the incidence of illnesses that can prevent the absorption of nutrients.

The reduced form model in column 5 shows that the impact of female education on stunting is considerable and operates mainly via the fertility rate.[38] Also the coefficient on income is now larger suggesting that income not only has a direct impact on stunting but also has an indirect impact operating via access to sanitation. After controlling for these factors, South Asia has significantly higher stunting rates than all other regions (by about 10 percentage points), and the difference to Sub Saharan Africa amounts to over 15 percentage points. Clearly, this model is also not explaining all of the differences in undernutrition between the two regions. Similarly, East Asia and the Pacific also appears to suffer from unusually high stunting rates, although they are somewhat lower than in South Asia. In fact, this regression nicely that South Asia and East Asia have much higher than expected stunting rates, while the Caribbean, Africa, Eastern Europe and the Middle East and North Africa have lower than expected stunting rates, compared to Latin America (the left-out category).

d. Underweight

The reduced form model of the severe underweight regression (column 6) is similar to the stunting regressions. Female literacy and GNP have large negative effects, population density a positive effect on severe underweight (defined as less than 3 SD below the reference standard). The dummy variables for South Asia remains positive, significant and large. Columns 7 and 8 show two specifications of the moderate and severe underweight model. With education, fertility,

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[36] This refers to the share of children below 2 standard deviations, which also includes the share of children below 3 standard deviations of the reference standard.

[37] I also included per capita calorie availability as one regressor but found this to have not ver y large and often insignificant effects. This is probably due to the measurement problems associated with this variable (Svedberg, 1991).

[38] As shown in column 4, there is not a significant direct impact of female education on stunting, apart from the effect operating via fertility.

sanitation, and incomes having the expected impacts, low birth weight is also associated (insignificantly) with higher rates of underweight. But once again, South Asia has a huge and highly significant dummy, suggesting that, controlling for the effects of the other regressors, rates of underweight are 20 percentage points higher than elsewhere (see also Brinckmann, 1997; Osmani, 1997; Smith and Haddad, 1999).

While these models provide quite a good fit explaining anthropometric shortfall, as indicated by the very high R-squares, high significance of the coefficients, and good specification tests, they are not able to explain much of the observed differences in anthropometric indicators between Sub Saharan Africa and South Asia. In fact, many of the significant explanatory variables in the model would lead one to expect *higher* undernutrition rates in Africa. In particular, Sub Saharan Africa has lower GNP, lower immunization rates, and higher fertility, all associated with higher undernutrition (see Table 2). Only the lower population density, the lower rate of late breast-feeding, the slightly higher rates of female literacy, the better access to sanitation, and the lower incidence of low birth weight can account for some of the better performance in undernutrition in Sub Saharan Africa.

Table 4 uses predicted values based on the regressions to see what share of the actually observed differences in anthropometric indicators between the two regions are explained by differences in the regressors. Differences in population density have the largest impact in accounting for the differences in anthropometric shortfall, followed by sanitation access and late breast-feeding. Conversely, fertility and GNP often offset this impact so that the explanatory variables combined can only account for 15-30 of the observed differences in undernutrition between the two regions. Most of the actually observed differences are accounted for by the regional dummies, or left unexplained.[39]

Unless the inability of the models to explain the differences between Africa and South Asia is due to the influence of left out variables, this finding is consistent with the claim that the use of US-standards to measure anthropometric shortfall does not measure undernutrition accurately, or at least not in a way that lends itself to international comparisons. These (still preliminary) findings suggest that the US-standard overestimate undernutrition in South Asia, especially when compared to Sub Saharan Africa. In fact, the magnitude of the dummy for South Asia is entirely consistent with a small genetic difference in height and weight potential (or growth towards that potential) of children in that region. A 1-2 % difference in genetic potential could, in the South Asian situation

[39] The overriding importance of the dummy variable is very robust and does not depend on particular specifications. See also Smith and Haddad (1999) and Osmani (1997).

where a large share of the population clusters around the cut-off point, account for most of this unusually poor anthropometric performance.

6. Mortality Models

a. Under Five Mortality Panel Regressions

Table 5 shows the regressions predicting under five mortality rates.[40] The same factors that appear to influence undernutrition also influence under five mortality. Higher female literacy, higher GNP, and lower fertility are associated with lower under five mortality. The strength of the effects of fertility and female literacy is particularly striking. These findings are consistent with other findings in the literature (e.g. Guilkey and Riphahn, 1998; WHO, 1995; Pritchett and Summers, 1996). Surprisingly, population density now lowers under five mortality although this effect is only significant in one specification. To the extent that high population density facilitates access to health and other public services, this may be plausible.[41] Equation 2 includes low birth weight and immunization coverage.[42] Both also have the expected signs and the regression now has a very high R-squared and performs well on specification tests. A higher incidence of low birth weight raises child mortality rates, as does a lower immunization coverage.

After controlling for these factors, South Asia generally has a lower, and Sub Saharan Africa has a significantly higher under five mortality rate. This suggests that other factors, not included in the model, account for part of this fairly low under five mortality in South Asia, and exceptionally high under five mortality in Africa.

Including the share of moderately and severely underweight children has no impact on the regression and the effect is not significant. This could either be due to the actual absence of an impact of undernutrition, which would favor the adaptionist school of thought, or it may be due to measurement error. In particular, if it is the case that undernutrition is overestimated in South Asia and poorly measured in other ways, this may be the reason for the lack of impact of the variable.

One way to test this is to replace the actual underweight variable by predicted values based on instrumental value regressions and other methods to correct for possible measurement error in

[40] I also ran regressions on infant mortality rates which generated very similar results.
[41] Due to the poor quality of the service access variables, this could not be tested directly. It will be examined in greater detail later. The insignificance and relatively small size of the coefficient in most specifications can also be the result of off-setting effects. While high population density is an indicator of crowding which increases the spread of diseases and mortality, it may also be a proxy for better health access which reduces mortality.
[42] The indicator for immunization coverage refers to immunization rates against diphtery, pertussis, and tetanus.

South Asia.[43] Based on these instrumental variables regressions, Table 6 shows that the predicted values for underweight and low birth weight for South Asia are much lower than the actual.

Column 4 shows that the corrected underweight variable performs much better and has a significant and sizeable impact on child mortality. This gives considerable support to the claim that the underweight variable was poorly measured, particularly in South Asia, while it goes against the hypothesis that undernutrition has no impact on mortality.

Columns 5 and 6 illustrate the success of the corrected values for underweight and low birth weight on under five mortality. Column 5 is based on the uncorrected values and has a much lower explanatory power (as shown by the adjusted R-squared). Column 6 has a much better fit and more significant results suggesting that measurement error is indeed a problem and undernutrition is smaller than supposed in South Asia, compared with other regions.[44]

Thus it appears that part of the puzzle of the differing relationship between undernutrition and mortality in South Asia and Sub Saharan Africa is indeed simply due to measurement error. Compared to Sub Saharan Africa, undernutrition in South Asia is not much larger, but appears to be of similar orders of magnitude and thus we would not expect under five mortality in South Asia to be much higher than in Africa (see Table 6). But it cannot solve the puzzle entirely. After all, under five mortality in South Asia is not only not higher, but actually much lower than in Sub Saharan Africa.

Table 7 shows to what extent the regressions are able to account for the differences in under five mortality. The two most important factors leading to higher mortality in Africa appear to be higher fertility, lower income, lower population density, and poorer immunization coverage. This would suggest that many children, greater poverty, and poorer access to health are leading to the high observed child mortality in Africa. But the dummy variables remain significant and account

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[43] This is a standard econometric technique to deal with variables measured with error. It involves a first stage regression where the variable measured with error is regressed on the instruments and then the second stage regression is as before except that it uses the predicted values for the variable measured with error. The instruments used are calories per capita and the share of women still breast-feeding at 20-23 months. They both pass the relevance and overidentification restriction test, i.e. they have a significant impact on the underweight variable, but they are not correlated to under five mortality, other than through their impact on underweight. The instrumental variable regressions (where the actual underweight variable is regressed on the two instruments) are estimated for all data except those from South Asia where we suspect the measurement error. I also experimented with a variety of other methods to correct the undernutrition variables from South Asia. They included predictions for South Asia based on the regressions shown in Table 3, merely reducing the values in South Asia by the dummy variables for South Asia in Table 3, or simply multiplying the levels of anthropometric shortfall observed in South Asia by 0.7, among others. All procedures lead to very similar results (see Table 6). I also instrumented for the low birth weight variable using the ratio of male to female life expectancy and the share of populaton with access to water. These instruments also pass the tests.

[44] A word of caution here. Whenever I talk about undernutrition being overestimated in South Asia, this is meant in a comparative sense, i.e. undernutrition in South Asia is not much higher in South Asia than in Sub Saharan Africa. Whether undernutrition is overestimated in an absolute sense is difficult to say given that many children that are not below 2 standard deviations of the reference standard may still be undernourished (so called type 2 error or the sensitivity of the criterion).

for 55-95% of the differences so that we are not yet able to explain a significant portion of the differences in mortality.

Columns 1 to 3 in Table 8 uses the exponential specification proposed by Pelletier to see whether there are potentiating effects of undernutrition and other risk factors. The dependent variable is expressed in logs which effectively means that each independent variable, which enters linearly as before, has an exponential effect on mortality and the impact of each risk factor enters multiplicatively (rather than linearly, see Pelletier et al. 1993).[45] The results are similar to the linear specification regarding the importance of specific independent variables. But now, as shown in Table 9, the importance of high fertility, lower incomes, and lower immunization rates in explaining the differences in mortality between South Asia and Africa is much larger now. This is to be expected given the specification. Now high fertility not only raises mortality rates directly, but through the multiplicative relationship, it also raises the impact of all other risk factors. The dummy variables are now less important and less significant. It appears thus that this specification is better able to explain the regional differences in under five mortality rates. On the other hand and in contrast to the regressions in Table 5, all three regressions fail a specification test suggesting that there are still omitted variables to be considered. Thus it is difficult to conclude which specification is to be preferred. Both types fit the data very well.

Regressions 2 and 3 also show that the uncorrected underweight variable has no impact on mortality, while the corrected variable (using instrumental variables) has a large and significant impact on mortality. This confirms that undernutrition does have an impact on mortality, but that undernutrition is not measured well in South Asia.

Column 4 uses a double log specification which thus assumes constant elasticities of each independent variable.[46] The results are, again, similar to the linear and the exponential specification. Now the impact of fertility on mortality is even larger. A 1% increase in fertility is associated with a 1% increase in under five mortality.

The influence of fertility on under five mortality is also considered in column 5 where I interact, in a linear setting, the fertility rate with Sub Saharan Africa and South Asia to see whether the impact of fertility on under five mortality is different in these two regions. It turns out that indeed in both regions fertility has a larger impact on mortality. But this is particularly the case in

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[45] The regression equation is thus $\ln(u5m) = a + b_1 (TFR) + b_2 (Femlit) + \ldots$. If you take the antilog on both sides, the equation becomes: $u5m = a * e^{b_1(TFR)} * e^{b_2(Femlit)} * \ldots$ which illustrates the exponential and multiplicative impact of each coefficient.

[46] A linear specification implicitly assumes that at all values of the independent variable, the same absolute change has the same absolute effect. Constant elasticity assumes that at all values of the independent variable, the same percentage change of the independent variable leads to the same percentage change of the dependent variable.

Sub Saharan Africa. Each additional child is associated with a 15 point increase in the under five mortality rate, a very large impact. This suggests that high fertility is a particular problem in Sub Saharan Africa. This may be due to the lack of adequate preventive and curative health care, including access to adequate prenatal, obstetric, and postnatal care, and effective primary health care.

The panel regressions thus confirm that undernutrition appears to have a sizeable impact on mortality, but that it is measured poorly in South Asia. Moreover, they indicate that a large share of the differences in mortality between South Asia and Sub Saharan Africa is due to high fertility in Africa which appears to be particularly damaging in Sub Saharan Africa. Finally, there is some evidence of a potentiating effect of risk factors, but it is not clear that this specification fits the data better than the linear specification.

b. Cross-Section Regressions of Infant and Under Five Mortality

One of the factors that may also be responsible for the unusually high under five mortality rates may be the higher HIV-AIDS prevalence in Sub-Saharan Africa. The World Bank (1997) collected data on adult HIV prevalence in developing countries in December 1994. To be able to use this information, the sample for the estimation was restricted to a cross-section of national surveys from the 1987 to 1997.

I use infant mortality as the dependent variable. Since most HIV-infected babies (through mother to child transmission in the absence of effective treatment) die within the first year, we would expect HIV prevalence to have a larger impact on infant than on under five mortality. This is indeed the case. Columns 6 and 7 in Table 8 shows that the HIV prevalence increases infant mortality, and this effect is of about the right magnitude[47] and significant. Table 9 shows that HIV prevalence accounts from some 20-30% of the difference in infant mortality between the two regions. This is a sizeable impact, but not the overriding one. Higher fertility in Africa continues to have a much larger effect. As the difference in HIV prevalence widens, we can, however, expect a similar widening in the differential of infant mortality between the two regions.

7. Conclusion

This paper has investigated some of the potential causes of the large differences between South Asia and Sub Saharan Africa in the relationship between anthropometric shortfall and infant

[47] With a mother to child transmission rate of some 25% and the assumption that 2/3 of HIV infected babies die within the first year, we would expect that a 1 percentage point increase in the HIV prevalence rate would raise the infant

and child mortality. It constitutes a preliminary assessment of the evidence based on a panel of macro data from developing countries. It may be useful to summarize some of the findings.

First, while confirming many of the known correlates of undernutrition, including poverty, high fertility, low female education, a higher population density, and a higher incidence of low birth weight, the regressions cannot explain much of the difference in undernutrition between South Asia and Sub-Saharan Africa, which supports the claim that part of the difference is due to the inappropriate use of the US-based reference standards for international comparisons of undernutrition. This is supported by three further pieces of evidence. The first is that small genetic differences in growth believed to exist between populations would lead to precisely the type of differences observed between Africa and South Asia. Second, if one replaces the actual values with predictions from instrumental values, most of the difference in undernutrition disappears. And, lastly, these adjusted undernutrition variables have a much stronger and significant impact on under five mortality.

Second, the mortality regressions also confirm many of the findings in the literature on the determinants of infant and child mortality. Undernutrition appears to have a significant impact on child mortality, but only once the anomalously high undernutrition rates from South Asia are corrected. But again, they are not able to account for a large share of the different in infant and child mortality rates between Sub Saharan Africa and South Asia. To some degree, this may be due to the different impact of particular risk factors. For example, higher fertility appears to pose greater mortality risks in Africa than elsewhere. It is also, to a small part, related to higher HIV prevalence in Africa. Other factors, such as health access or environmental risk factors could also play a role, and these questions will be pursued in further stages of the project. There is some evidence of a potentiating effect of individual risk factors which could also explain the higher under five mortality in Africa.

These findings therefore suggest the following solution to the puzzle posed at the beginning of the paper: The unusually high rates of undernutrition in South Asia are, to an important degree, related to the inappropriate use of the reference standard for international comparisons. Once the figures are corrected, undernutrition and the incidence of low birth weight are similar in the two regions. The unusually high infant and child mortality in Africa, on the other hand, is related to high fertility, high prevalence of HIV, a more damaging impact of fertility on child mortality there, and possibly a potentiating effect of the risk factors on each other.

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mortality rate by about 0.16% or 1.6/1000. The observed coefficient is very close to that value if slightly smaller (1.1 to 1.4 /1000).

Finally, it is important to end on a cautionary note. Even if it turned out that undernutrition in South Asia is not as large compared to Sub Saharan Africa as the data suggest, this does in no way suggest that we can neglect the problem of undernutrition there. Similarly, despite being lower than Africa's, South Asia's infant and child mortality rates are unacceptably high, in fact the second highest in the world. Much remains to be done to remedy the massive suffering associated with undernutrition and premature loss of life in South Asia. Renewed efforts are needed to combat undernutrition and child mortality in both regions. It just appears from the findings here that the challenge is more daunting in Sub Saharan Africa than elsewhere.

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Table 1: Anthropometric and Mortality Indicators: South Asia versus Sub Saharan Africa

	Sub Saharan Africa	South Asia	East Asia and Pacific
Low Birth Weight	13.3	33.3	12.4
Moderate and Severe Wasting	8.7	15.5	7.7
Severe Stunting	13.9	25.7	12.6
Moderate and Severe Stunting	32.8	44.8	32.9
Severe Underweight	7.4	17.5	5.5
Mod. and Severe Underweight	25.7	46.5	26.3
Infant Mortality	91.7	69.8	43.4
Under Five Mortality	166.3	101.6	71.2

Note: These are based on a cross-section sample of 38 African and 5 South Asian, and 10 East Asian and Pacific countries from the late 1980s to mid 1990s. Low birth weight refers to the share of children with a birth weight below 2500g. Moderate and severe wasting, stunting and underweight refers to the share of children aged usually 0.5-5 years old (age ranges vary in the surveys) whose weight for height, height for age, and weight for age, respectively is below 2 standard deviations from the US-based international reference standard. Severe wasting, stunting and underweight refers to children being below 3 SD of the reference standard. Infant and Under Five Mortality Rates are per 1000 children in age group.
Source: WHO (1998), UNICEF (various years).

Table 2: Other Descriptive Statistics: South Asia, Sub-Saharan Africa, and East Asia

	Sub Saharan Africa	South Asia	East Asia and Pacific
LnGNP	6.95	7.11	7.64
Female Literacy	42.9	37.8	75.9
BF 20-23	47.7	73.4	46.0
Immunization	58.5	79.8	82.8
Population Density	68.9	342.3	95.4
HIV Prevalence	4.6	0.1	0.5
Total Fertility Rate	5.9	3.9	3.4
Sanitation Access	37.0	24.4	57.4
Calories per Capita	2158.7	2301.8	2504.3

Note: These are based on a cross-section sample of 38 African and 6 South Asian, and 10 East Asian and Pacific countries from the late 1980s to mid 1990s. The data each refer to the year for which an anthropometric survey was available. BF 20-23 refers to the share of children that are still breastfed at 20-23 months of age. Immunization refers to the children under six who have been immunized against DPT. Population density is inhabitants per square kilometer. LnGNP is the log of PPP-adjusted GNP per capita in 1985 prices. HIV prevalence refers to share of adults who have been found to be HIV positive in December 1994.
Source: WHO (1998), UNICEF (various years), UNDP (various years), World Bank (various years).

Table 3: Determinants of Anthropometric Indicators (heteroscedasticity-adjusted T-statistics in brackets)

Dependent Variable	(1) Low Birth Weight	(2) Low Birth Weight	(3) Low Birth Weight	(4) Mod.+Sev. Stunting	(5) Mod.+Sev. Stunting	(6) Severe Underweight	(7) Mod+Sev. Underw.	(8) Mod.+Sev. Underw.
(Constant)	35.42***	31.37***	39.23***	78.42***	128.60***	28.64	31.17***	76.56***
	(7.11)	(2.20)	(7.77)	(15.87)	(13.89)	(9.05)	(2.39)	(12.01)
East Asia + Pacific	2.50***	2.75*	2.33**	6.41**	6.03**	2.70***	15.65***	15.58***
	(2.39)	(1.63)	(2.20)	(2.01)	(1.89)	(3.42)	(8.79)	(7.70)
Eastern Europe + C. Asia	-3.82		-4.39*		-8.63***	0.32		-2.90*
	(-1.18)		(-1.41)		(-2.49)	(0.26)		(-1.36)
Middle East + N. Africa	-2.03**	1.21**	-2.16**	0.43	-3.53*	-1.41*	0.16	-3.08*
	(-2.00)	(0.97)	(-2.08)	(0.14)	(-1.42)	(-1.72)	(0.01)	(-1.58)
Caribbean	-2.02	0.87	-2.25*	-8.82***	-11.60***	-0.36	-1.29	-1.55
	(-1.33)	(0.34)	(-1.52)	(-3.23)	(-4.64)	(-0.45)	(-0.63)	(-0.76)
South Asia	15.30***	13.30***	15.00***	9.68***	10.62***	10.10***	20.64***	20.68***
	(7.18)	(7.05)	(7.32)	(2.21)	(2.49)	(5.80)	(5.63)	(5.28)
Sub Saharan Africa	-2.87***	-2.15*	-2.80***	-7.94***	-5.08**	-0.34	5.94***	2.96*
	(-2.52)	(-1.64)	(-2.48)	(-2.49)	(-1.93)	(-.0.46)	(2.42)	(1.64)
90-94	0.09	-0.41	0.15	-3.74**	-1.72	-0.35	0.56	-0.20
	(0.09)	(-0.37)	(0.15)	(-1.83)	(-0.96)	(-.54)	(0.42)	(-0.18)
85-89	1.62*	2.14**	1.84**	-3.85*	-2.20	-0.76	-1.14	-0.62
	(1.51)	(1.80)	(1.73)	(-1.58)	(-1.05)	(-1.05)	(-0.63)	(-0.42)
PRE1985	1.98	4.04***	2.15	-1.69	2.76	0.52	-0.19	0.38
	(1.40)	(2.62)	(1.55)*	(-0.62)	(1.19)	(0.53)	(-0.06)	(0.23)
POPDENS	0.019***	0.018***	0.018***	0.023***	0.017***	0.007***	0.022***	0.021***
	(5.09)	(3.14)	(5.09)	(3.73)	(3.03)	(2.76)	(3.33)	(4.23)
TFR	0.353	0.180		3.259***			1.70***	
	(0.92)	(0.31)		(3.81)			(2.87)	
FEMLIT	-0.045**	0.005	-0.055***	0.026	-0.121***	-0.066***	-0.030	-0.150***
	(-2.04)	(0.83)	(-2.89)	(0.46)	(-2.66)	(-3.79)	(-0.65)	(-3.73)
LNGNP	-3.14***	-3.30***	-3.34***	-7.60	-12.19***	-2.72***	-2.88**	-6.96***
	(-4.15)	(-2.19)	(-5.01)	(-4.41)	(-9.62)	(-6.29)	(-2.06)	(-7.46)
BF2023		0.068**						
		(1.89)						
SANITATION ACCESS				-0.140***			-0.090***	
				(-3.20)			(-2.37)	
LOW BIRTH WEIGHT							0.209	
							(1.15)	
Adjusted R-Squared	0.773	0.760	0.770	0.725	0.702	0.746	0.828	0.776
Omitted Variable Test	Failed	Failed	Failed	Passed	Passed	Failed	Passed	Passed
N	186	114	142	138	190	170	136	217

*denotes 10% significance, ** 5% significance, and *** 1% significance in a one-tailed test. Left out categories: Latin America and 1995+

Table 4: Share of Differences in Anthropometric Shortfall between Sub Saharan Africa and South Asia Accounted for by Regression

	(1) LBW	(2) LBW	(3) LBW	(4) Mod. Stunt.	(5) Mod. Stunt	(6) Sev. Underw.	(7) Mod. Underw.	(8) Mod. Underw.
Total Difference	23.0	23.0	23.0	18.3	18.3	12.7	23.6	23.6
TFR	-2.4%	-1.2%	0.0%	-27.4%	0.0%	0.0%	-11.1%	0.0%
Femlit	0.7%	-0.1%	0.9%	-0.5%	2.5%	2.0%	0.5%	2.4%
LNGNP	-4.4%	-4.6%	-4.7%	-13.3%	-21.4%	-6.9%	-3.9%	-9.5%
Popdensity	23.7%	22.5%	22.5%	36.1%	26.7%	15.9%	26.8%	25.6%
BF 20-23	0.0%	6.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Sanit	0.0%	0.0%	0.0%	9.1%	0.0%	0.0%	4.5%	0.0%
LBW	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	20.4%	0.0%
Dummies	79.0%	67.1%	77.4%	96.2%	85.7%	82.4%	62.4%	75.2%
Total	96.7%	90.1%	96.1%	100.1%	93.5%	93.3%	99.6%	93.7%

Note: These calculations are based on the respective regressions in Table 3. The first row, labeled total difference, shows the difference in anthropometric shortfall indicators between South Asia and Sub-Saharan Africa, based on all observations in the sample (and thus the figures differ from Table 1 which is only based on the cross-section). The following columns then show the share of the difference accounted for by each factor. A positive percentage means that this factor would predict higher anthropometric shortfalls in South Asia, a negative percentage would predict higher anthropometric shortfall in Sub Saharan Africa.

Table 5: Regressions predicting Under Five Mortality Rates (U5M)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Dependent Variable	U5M	U5M	U5M	U5M	U5M	U5M	U5M
(Constant)	374.99***	334.25***	314.67***	59.50	48.93***	-78.34***	475.83***
	(8.07)	(6.33)	(5.41)	(0.61)	(7.15)	(3.16)	(13.46)
East Asia and Pacific	-15.50**	-10.24	-15.66	9.52			-18.30***
	(-2.23)	(-1.36)	(-1.37)	(1.12)			(-2.50)
Eastern Europe+C. Asia	-0.62	4.40	6.47				-11.61*
	(.202)	(0.51)	(0.75)				(1.66)
Middle East+N. Africa	-24.42***	-13.81	-14.71	9.75			-25.91***
	(-2.46)	(-1.26)	(1.23)	(0.64)			(-2.71)
Caribbean	-23.05***	-20.07***	-17.40**	17.61			-26.77***
	(-2.68)	(-2.44)	(-2.11)	(1.03)			(-2.93)
South Asia	-18.68*	-17.81	-28.03*	-10.52			-25.11**
	(-1.54)	(-1.02)	(-1.42)	(-0.58)			(-2.02)
Sub Saharan Africa	4.61	19.75**	20.83**	15.25			7.75
	(0.48)	(1.95)	(1.89)	(1.02)			(0.81)
90-94	1.80	-0.92	-2.33	3.89			3.71
	(0.26)	(-0.13)	(-0.319)	(0.42)			(0.54)
85-89	12.26	1.45	2.08	7.55			15.38**
	(1.6)	(0.18)	(0.252)	(0.74)			(2.05)
PRE1985	16.01	36.49*	35.07*	87.40***			23.42**
	(1.18)	(1.62)	(1.64)	(5.02)			(1.80)
POPDENS	0.011	-0.030	-0.043*	-0.023			-0.001
	(0.54)	(-1.21)	(-1.60)	(-0.85)			(-0.05)
TFR	8.67***	6.55***	5.86**	14.25***			
	(2.89)	(2.42)	(2.03)	(3.89)			
FEMLIT	-0.923***	-0.733***	-0.767***	-0.459			-1.15***
	(-5.17)	(-3.66)	(-4.81)	(-1.46)			(-7.30)
LNGNP	-34.24***	-28.52***	-25.71***	-6.36			-40.62***
	(-4.823)	(-5.78)	(-4.81)	(-0.62)			(-9.15)
IMMUNIZATION		-0.30*	-0.30*	-0.36			
		(-1.55)	(-1.47)	(-1.38)			
LOW BIRTH WEIGHT		1.36**	1.37**	0.15	-0.25		
		(2.01)	(1.87)	(0.19)	(-0.31)		
ADJ. LBW						8.87***	
						(3.40)	
MOD. UNDERW.			0.341		2.67***		
			(0.609)		(6.46)		
ADJ. MOD. UNDERW.				3.22***		3.75***	
				(4.03)		(4.61)	
Adjusted R-Squared	0.786	0.811	0.811	0.750	0.306	0.406	0.779
Omitted Variable Test	Failed	Passed	Passed	Passed			Passed
N	198	167	156	106	176	105	199

Note: Left out categories are Latin America and 1995+. Heteroscedasticty-adjusted t-statistics in brackets.

Table 6: Adjusted Underweight and Low Birth Weight Indicators

	Sub Saharan Africa	South Asia	East Asia and Pacific
Mod.+Sev. Underweight			
Unadjusted	25.7	46.5	26.3
Adjusted (IV)	25.4	32.4	24.2
Adjusted (Pred.)	25.7	26.1	26.3
Low Birth Weight			
Unadjusted	13.3	33.3	12.4
Adjusted (IV)	13.2	12.5	12.8

Note: The unadjusted figures are from Table 1, the adjusted (IV) underweight figures are based on instrumental variable regressions using calories per capita and the share being breast-fed at 20-23 months as instruments. The adjusted (pred) figures are derived by using regression 8 in Table 3 to predict underweight rates for South Asia (without adding the dummy variable for South Asia). The adjusted LBW figures are based on instrumental variable regressions using the female-male ratio of life expectancy and the access to water as instruments.

Table 7: Share of Differences Under 5 Mortality between Sub Saharan Africa and South Asia accounted for by Regressions

	(1)	(2)	(3)	(4)	(7)
Total Difference	39.6	39.6	39.6	39.6	39.6
TFR	33.7%	25.4%	22.8%	55.3%	0.0%
Femlit	-8.8%	-7.0%	-7.3%	-4.4%	-11.0%
LNGNP	27.8%	23.2%	20.9%	5.2%	33.0%
Popdensity	-8.0%	21.8%	31.2%	16.7%	0.7%
Mod Under	0.0%	0.0%	-15.3%	0.0%	0.0%
Adj. Mod Und	0.0%	0.0%	0.0%	-47.0%	0.0%
HIV Prev.	0.0%	0.0%	0.0%	0.0%	0.0%
Immudpt	0.0%	10.6%	10.6%	12.7%	0.0%
LBW	0.0%	-79.0%	-79.6%	-8.7%	0.0%
Dummies	58.8%	94.8%	123.4%	65.1%	83.0%
Total	103.5%	89.8%	106.5%	94.8%	105.7%

Note: These calculations are based on the respective regressions in Table 5. The first row, labeled total difference, shows the difference in under 5 mortality between Sub-Saharan Africa and South Asia, based on all observations in the sample (and thus the figures differ from Table 1 which is only based on the cross-section). The following columns then show the share of the difference accounted for by each factor. A positive percentage means that this factor would predict lower under 5 mortality in South Asia, a negative percentage would predict lower under 5 mortality in Sub Saharan Africa.

Table 8: Regressions predicting Under Five Mortality Rates and Infant Mortality Rates

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Dependent Variable	LN (U5M)	LN (U5M)	LN (U5M)	LN(U5M)	U5M	IMR	IMR
(Constant)	8.64***	8.29***	4.47***	1.15	348.29***	132.4***	107.1**
	(13.0)	(12.9)	(5.0)	(0.9)	(7.0)	(2.6)	(2.2)
East Asia and Pacific	-0.01	-0.13	0.30***	0.35***	-9.14	7.18	12.98**
	(-0.1)	(-1.0)	(2.7)	(3.3)	(-1.3)	(1.0)	(2.0)
Eastern Europe + CA	-0.18	-0.20			-2.89	-1.25	
	(-1.1)	(-1.2)			(-0.4)	(-0.2)	
Middle East and N.	0.17	0.17	0.39**	0.52***	-11.41	-5.54	-9.26
Af.	(1.3)	(1.2)	(2.0)	(2.9)	(-1.2)	(-0.8)	(-1.1)
Caribbean	-0.49***	-0.47***	0.14	0.33	-22.06***	16.40	87.12***
	(-2.6)	(-2.6)	(0.7)	(1.3)	(2.7)	(0.7)	(12.2)
South Asia	0.06	-0.20	-0.08	0.09	-25.98*	0.26	-7.32
	(0.3)	(-0.8)	(-0.4)	(0.5)	(-1.6)	(0.0)	(-0.7)
Sub Saharan Africa	-0.01	-0.02	0.07	0.15	-29.89	7.17	-4.61
	(-0.1)	(-0.1)	(0.5)	(1.1)	(-1.1)	(0.9)	(-0.5)
90-94	-0.06	-0.08	-0.01	-0.03	1.59		
	(-0.7)	(-0.9)	(-0.1)	(-0.4)	(0.2)		
85-89	0.03	0.05	0.11	0.14*	4.74		
	(0.3)	(0.5)	(1.1)	(1.6)	(0.6)		
PRE1985	-0.06	-0.07	0.12	0.21	40.92		
	(-0.3)	(-0.3)	(0.9)	(1.3)	(2.0)		
POPDENS	0.0002	0.000	-0.0003*	-0.066***	0.016	-0.004	-0.005
	(0.8)	(0.0)	(-1.6)	(-1.6)	(0.7)	(-0.3)	(-0.5)
TFR	0.12***	0.09***	0.17***	1.07***	5.98**	5.21***	7.95***
	(3.3)	(2.5)	(4.3)	(5.6)	(2.1)	(2.6)	(3.3)
FEMLIT	-0.004**	-0.005**	-0.003	-0.03	-0.66***	-0.53***	-0.61***
	(-2.3)	(-2.4)	(0.4)	(-0.3)	(-3.4)	(-3.4)	(-2.4)
LNGNP	-0.55***	-0.50***	-0.17**	-0.09	-28.82***	-9.1**	-8.28**
	(-8.2)	(-7.5)	(-1.7)	(-0.9)	(-5.7)	(-1.7)	(-1.7)
IMMUNIZATION	-0.007***	-0.007***	-0.005***	-0.069	-0.39**	0.04	0.09
	(-3.5)	(-3.5)	(-2.5)	(-1.2)	(-2.1)	(0.3)	(0.5)
HIV Prevalence						1.11**	1.44***
						(1.7)	(2.3)
MOD. UNDERW.		0.007					
		(1.5)					
ADJ. MOD.			0.040***	0.938***			
UNDERW.			(5.2)	(5.7)			
SA*TFR					5.59**		
					(2.1)		
SSA*TFR					9.10**		
					(1.72)		
Adjusted R-Squared	0.821	0.820	0.770	0.795	0.811	0.773	0.794
Omitted Variable Test	Failed	Failed	Failed	Failed	Passed	Passed	Passed
N	180	168	112	112	180	74	48

Note: Left out categories are Latin America and 1995+. Heteroscedasticty-adjusted T-statistics in brackets. In regression 4, the independent variables are the logs of immunization rates, population density, total fertility rate, female literacy, and adjusted moderate underweight. Thus the coefficients in this regressions represent elasticities. Regressions 6 and 7 are based on a cross-section of observations from the late 1980 to the mid 1990s as information on HIV prevalence is only available for this time period.

Table 9: Accounting for the Difference in Mortality between Sub Saharan Africa and South Asia

	(1) Ln(U5M)	(2) Ln(U5M)	(3) Ln(U5M)	(4) Ln(U5M)	(5) U5M	(6) IMR	(7) IMR
Total Difference	0.304	0.304	0.304	0.304	39.61	21.9	21.9
TFR	60.8%	45.6%	86.1%	108.8%	23.2%	47.6%	72.6%
Femlit	-5.0%	-6.2%	-3.7%	-1.1%	-6.3%	-12.4%	-14.2%
LNGNP	58.3%	53.0%	18.4%	9.5%	23.4%	6.7%	6.0%
Popdensity	-18.9%	-3.2%	28.4%	49.2%	-11.6%	5.0%	6.2%
Mod. Under	0.0%	-41.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Adj. Mod Underw	0.0%	0.0%	-75.6%	-63.7%	0.0%	0.0%	0.0%
Immudpt	32.3%	32.3%	23.0%	3.8%	13.8%	-3.6%	-9.0%
SAFERT	0.0%	0.0%	0.0%	0.0%	-66.0%	0.0%	0.0%
SSAFERT	0.0%	0.0%	0.0%	0.0%	142.7%	0.0%	0.0%
HIV Prevalence		0.0%	0.0%	0.0%	0.0%	22.8%	29.6%
Dummies	-23.1%	60.9%	49.4%	19.8%	-9.9%	31.5%	12.4%
Total	104.4%	141.3%	126.0%	126.3%	109.3%	97.6%	103.6%

Note: These calculations are based on the respective regressions in Table 8.

Figure 1: Underweight and Under Five Mortality