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Deadly Cities? A Note on Spatial Inequalities in Mortality in Sub-Saharan Africa

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Deadly Cities?
A Note on Spatial Inequalities in Mortality in Sub-Saharan Africa

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Abstract

In this paper we analyze if an 'urban mortality penalty' exists for today's developing countries, repeating the history of industrialized nations during the 19th century. We analyze the Demographic and Health Survey (DHS) of 19 Sub-Saharan African countries for differences in child and adult mortality between rural and urban areas. Our findings indicate that child mortality is higher in rural areas for almost all countries. On average child mortality rates are 13.6 percent in rural areas and 'only' 10.8 percent in urban areas. In contrast, average urban adult mortality rates (on average 14.5 percent) have indeed exceeded rural adult mortality rates (on average 12.8 percent) in many of our sample countries in the 2000s. For many countries high child mortality pockets do, however, exist in slum areas within cities. Child mortality rates in slum areas are on average 1.65 times higher than in the formal settlements of cities, but still lower than in rural areas.

Key words: mortality, urban, slum, inequality.

JEL: I10, I30, J10, R00.

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1 Introduction

Living a long life is at the core of human wellbeing (Sen, 1999). This is also reflected in international measures of wellbeing such as the Human Development Index (HDI) and the Millennium Development Goals (MDGs), both of which incorporate mortality or life expectancy as an important indicator of wellbeing. These policy measures focus on population averages, with little concern about the distribution of mortality within countries. In recent years, considerable research on mortality inequalities in developing countries has therefore emerged. This branch of research has, however, ignored two important aspects of inequality in mortality, which we aim to address in this paper.

First, research on mortality inequality has very much focused on inequalities across socio-economic groups and has typically not focused on spatial or geographic inequalities, e.g. between rural and urban areas. Previous empirical studies often find a negative correlation between child mortality and socio-economic status (e.g. Wagstaff, 2002). However, economic stratification usually predicts only a small portion of the variation in child mortality (Pradhan et al., 2003) and environmental and community characteristics could be very important too. For example, the availability and quality of health care as well as public investments in water and sanitation infrastructure should all have an equally important impact on mortality as income.

Moreover, high urbanization rates together, with little economic progress in many developing countries, have led to a growing literature concerned with deteriorating health conditions and increasing mortality rates in urban areas: a pattern which repeats the history of today's industrialized nations (Konteh, 2009; Moore et al., 2003; Sclar et al., 2005). Rapid and unplanned urban growth with high population densities and insufficient environmental and health services, in combination with large wealth inequalities, led to a 'urban mortality penalty' during the 19th century in Europe and the Americas (e.g. Cain and Hong, 2009; Konteh, 2009; Szreter, 1997; Williamson, 1990). To our knowledge, little empirical literature exists which tries to analyze this possible 'urban mortality penalty' for today's developing countries. Most studies have instead focused on child nutrition as an indicator of health inequalities between rural and urban and within urban areas (Montgomery and Hewett, 2005; Fotso, 2006).

Second, whereas there is a long tradition of measuring inequalities in adult mortality (the probability of dying between ages 15 and 60) in Europe and the US (e.g. Singh and Siahpush, 2006), to the best of our knowledge no study on inequalities in adult mortality within developing countries has been conducted. This is largely related to the paucity of comparable data on mortality in developing countries.

Across countries, adult mortality is usually closely related to child mortality and one might therefore argue that inequalities in child mortality are a good, or at least, sufficient proxy to understand inequalities in adult mortality. First, what is true for between country correlations might not necessarily be true for within country correlations. Second, even if, in general, we could make conclusions about inequalities in adult mortality from measures of child mortality inequality, it is still useful to identify outliers of this relationship. Third, it is already well-known that during the last decade, child mortality rates have declined in almost all developing countries whereas adult mortality has increased tremendously in Sub-Saharan Africa and especially in East African countries, where the rise of the HIV/AIDS epidemic was most severe (Bradshaw and Timaeus, 2006). Hence, even at the country level, the correlation between child and adult mortality has become less clear in recent years.

The objective of this paper is to study the differences between the 1990s and the 2000s in urban and rural child and adult mortality for several countries in Sub-Saharan Africa , with a special focus on slum settlements within urban areas. Although African countries still show the lowest share of people living in urban areas (Table 1), they have experienced tremendous urbanization rates within the last decade (Table 1) with the urban population having doubled within the last 10 years (UN-Habitat, 2006). Moreover, further high growth rates of urbanization in Africa both in relative terms as well as in absolute numbers is estimated (UN-Habitat, 2006). Moreover, Sub-Saharan African cities show the largest share of slum dwellers in the world (UN-Habitat, 2003).

From a methodological perspective, and to our knowledge, we are the first to study inequalities in adult mortality for a development country setting, where data on adult mortality is scarce. To do so, we apply a recently proposed indirect sibling methodology (see e.g. Timaeus et al., 2001). Furthermore we propose new measures to define slum inhabitants in urban areas of developing countries.

Our results indicate that, on average, urban households experience lower child mortality rates than rural households. Across all countries and years in our sample, the average child mortality rate in urban areas is 10.8 percent whereas it is still 13.6 percent in rural areas. The reverse pattern seems to be prevalent for adult mortality, and this is especially true for recent years: higher adult mortality in cities in comparison to rural areas. On average, we find adult mortality rates of 14.3 percent in urban areas and of 13.1 percent in rural areas. This means that for adults in developing countries the negative health impact of a higher population density (as it is found in cities) seems to dominate the positive impact of the usually higher material wellbeing and better health infrastructure in urban areas. Second, in almost all cities we can find high child mortality in slum areas with 1.65 times higher mortality rates than formal settlements. In some rare cases, slum areas even show higher mortality rates than the rural population, but for almost all countries the differences in child mortality rates between urban formal settlements and urban slum areas is larger than the difference between slum areas and the rural population. These comparative results are quite robust to various definitions of slum settlements, even though absolute measures of child mortality largely depend on the definition of slums.

The paper is structured as follows: In section 2 we describe the theoretical background as well as the methodology used, followed by a presentation of the results in section 3. In section 4 we finally discuss the results and conclude.

2 Methodology

2.1 Theoretical Background

In this paper we do not intend to analyze the specific determinants of child or adult mortality but rather analyze the combined impact of spatial specific variations in health determinants. The theoretical framework we have in mind follows a simplified version of the set-up proposed by Rosenzweig and Schultz (1983). We assume that a household has a utility function that is positively influenced by the health of its members H and other n goods X, subject to the usual properties of a utility function:

$$U = U(X_i, H), \qquad i = 1, ..., I. \tag{1}$$

We furthermore assume that the health status of household members H is negatively correlated with the death probabilities, i.e. mortality rates, of household members. The health of the individuals of a household can be described by a health production function, where M represents a health input that can be acquired by a household, and that is not part of X and hence cannot increase the utility of a household except through improved health H. μ represents the disease environment that has an effect on the health (and hence utility) of a household, but which cannot be influenced by the household:

$$H = H(M_j, \mu), \qquad j = 1, ..., J. \tag{2}$$

We assume that M enters the health production function positively and μ negatively. The budget constraint of the household can furthermore be represented by:

$$Y = \sum_{i=1}^{I} X_i p_i + \sum_{j=1}^{J} M_j q_j, \tag{3}$$

where Y represents the exogenous money income of a household and p_i and q_j are exogenous prices for general goods and health inputs, respectively. A household's reduced health demand function derived from a maximization of equation (1) subject to (2) and (3) can therefore be written as:

$$H = \phi(p, q, Y, \mu). \tag{4}$$

The health of the members of a household hence depends (i) on the relative prices of health inputs (such as medical expenditure or transport to the closest health facility) to other goods, (ii) on the income of the household and (iii) on the external disease environment. If we denote the rural population with r and the urban population with u, we would, in general, assume that

$$Y_r < Y_u; \qquad \frac{p_r}{q_r} > \frac{p_r}{q_r}. \tag{5}$$

This means that we would expect that the income of rural households is lower but that the relative costs of health inputs in rural areas are higher. Both assumptions would lead - if we assume utility maximization under the given conditions - to a higher demand for health and hence to a better health status of the urban population. However, and as described in the introduction, several authors have argued that the disease environment (mainly because of higher population density) is higher in urban areas, $\mu_r < \mu_u$. As all three factors enter the reduced form health demand function, it is - at least from a theoretical point of view - unclear which factors will dominate, a question which we will try to analyze in Section 3.

2.2 Data set

To analyze differences in child mortality and adult mortality between rural and urban areas and between urban slums and urban formal settlements, we use the nationally representative Demographic and Health Survey (DHS) data sets. All DHS surveys provide detailed information about the birth and death histories of all children of the interviewed women (who are between the age of 15 and 49). We use these child histories for the estimation of child mortality rates. In addition, some selected DHS surveys also contain information about the birth and mortality history of the siblings of the interviewed women, which we use to calculate adult mortality rates. Other DHS surveys contain detailed information on housing conditions including the number of rooms of a household, which can be used to identify urban slum households.

Our sample therefore consists of two overlapping sub-samples. The first sub-sample consists of countries for which number of rooms (and by calculation, number of rooms per person) is available for each household: Cameroon, Chad, Egypt, Ethiopia, Kenya, Morocco, Mozambique, Niger, Tanzania, and Uganda. For those countries we can calculate differences in child mortality between slum and urban non-slum dwellers. The second sub-sample consists of countries for which information on siblings is available: Burkina Faso, Cote d'Iviore, Chad, Ethiopia, Guinea, Kenya, Madagascar, Malawi, Mali, Morocco, Mozambique, Senegal, Tanzania, and Zimbabwe. For those countries we can calculate both inequalities in child- and in adult mortality.

We furthermore only included countries, for which at least two DHS surveys were conducted within the last 20 years. This allows us to also analyze changes in spatial inequality within countries over time. The exclusion restrictions of a) two surveys available within the last 20 years and b) information on sibling mortality and/or number of rooms per household available, leave us with a final sample of 36 surveys from 18 Sub-Saharan African countries, which are shown in Table 1.

[Please insert Table 1 about here.]

2.3 Defining urban slums

The term 'slum' has many different connotations in both developed and/or developing countries. In some countries slum simply refers to the urban poor in general, while in other countries only informal settlements are considered as slum areas. An overview of the various country-specific definitions of slums is given in UN-Habitat (2003a). The problem of defining and quantitatively measuring the extent of slums in urban areas is threefold:

First, a slum is a multidimensional phenomenon: Slum dwellers are poor in many social and economic characteristics simultaneously. Whereas the access to basic infrastructure, income levels, and the population density can easily be measured, the social deprivation of slums dwellers, such as insecurity or social exclusion, is difficult to capture. It is even more difficult to decide on the aggregation and weighting of the different dimensions of living deprivation. Second, 'slums' are, at least to some extent, a relative concept in comparison to the standard of living of the rest of the city: an area that is defined as a slum in one city or country is not necessarily considered a slum in another city or country. This inconsistency makes it difficult to set globally applicable and agreed on indicators of slum dwellers on the one hand, and to compare the number of slum dwellers across countries, on the other hand. Third, most people would agree that the concept of a slum has a spatial dimension, or in other words, describes an area within a city. UN-Habitat (2003) defines slums as '...a *contiguous settlement where the inhabitants are characterized as...'*. However, most housing conditions have to be measured at the household and not the community level.

In this paper we closely follow the quantitative approach as proposed and applied by UN-Habitat (2003) to define urban slum dwellers.[1] According to the UN-Habitat definition, slums are characterized by: inadequate access to safe water; inadequate access to basic sanitation; poor structural quality of housing, and overcrowding.[2] We will therefore rely on a categorization that is based on physical housing characteristics and the public provision of basic infrastructure. It does not take into account any social exclusion or security concerns of slum dwellers. As an extension of the UN-Habitat definition, we do, however, apply three different methods to combine the four identified characteristics of slum households to analyze if and how estimates of mortality inequalities are dependent on the underlying definition of slums.

In a first step, and applying the original UN-Habitat (2003) definition, we define a person as a slum dweller if he/she lives in a household that is characterized by *at least one* of the previously mentioned attributes. We consider a household as being deprived of access to safe water if the household does not have access to a private or public pipe, bore hole, or a protected well or spring.[3] We define a household as being deprived of basic sanitation if it lacks a flush toilet or an improved latrine (ventilated improved pit latrine or pour flush latrine). A dwelling is considered as overcrowded if more than three persons per habitable room live in the dwelling. We define a household as being deprived of structural housing if the floor material is earth, dung, sand, or wood.

This commonly applied definition of a slum dweller has obviously two main shortcomings. First, a household is already considered as a slum household if it only lacks one deprivation leading to very high shares of slum dwellers in urban areas. In many Sub-Saharan African countries, the share of the population lacking access to basic sanitation is often high (see Table A.1 in the Appendix), which leads to a high number of slum dwellers only because of this particular indicator. To capture differences between 'slum dwellers' and ‘poor sanitation households’, in a second step we therefore apply a more strict definition of slum dwellers: A household is considered as a slum dweller only if it is characterized by *at least two* of the four slum indicators, which prevents the problem of one dominating slum indicator.

Furthermore, qualitative descriptions of slums usually have some notion of spatial clustering and mention ‘slum areas’ and/or ‘settlements’. We would therefore argue, that any definition of slum dwellers should go beyond the identification of single ‘slum’ households and contain some notion of area or community characteristics. The quantitative definition of slum dwellers of UN-Habitat (2003) ignores this spatial dimension of slums. It is therefore possible that people living in the same neighborhood are considered as slum and non-slum dwellers. To illustrate this point Figure 1 shows the households characterized as slum households according to the household centered UN-Habitat definition for the case of Addis Ababa, Ethiopia. Red dots mark slum households and black dots mark non-slum households. The figure nicely shoes that according to this particular slum definition one could not really identify any slum areas, but only slum households[4] To explicitly take into account the geographical dimension of slums, we hence apply a third alternative definition. We define a person as a slum dweller if he or she lives in a household that is situated in an *urban cluster where the share of slum dwellers, according to the first slum definition, is higher than 50 percent.* With this approach we try to combine information at the household level with a higher geographical level.

[Please insert Figure 1 about here.]

2.4 Measuring adult mortality

To get an estimate of adult mortality we use the recently proposed indirect measure of sibling mortality (Gakidou et al., 2004; Hill and Trussel, 1977; Timaeus et al., 2001; Timaeus and Jasseh, 2004). This method allows us to estimate adult mortality for countries with neither vital registration systems nor good census data, which is the case for almost all countries in Sub-Saharan Africa.

While birth histories collected in DHS surveys are widely used to calculate child morality rates, sibling survival data - also collected in several DHS data sets - has not often been analyzed. In recent years, several demographic studies have, however, started to use this indirect measure of adult mortality, but it has - at least to our knowledge - not been applied for inequality studies.

The method is straightforward: Each woman in the DHS surveys is asked about the number of times her mother gave birth, and how many of these siblings are alive today. This information, combined with the age of the interviewed woman gives an estimate of the probability to survive until the age range of the interviewed women (Hill and Trussel, 1977). The assumption is that siblings are (or would be, if already dead) likely to be in the same age segment as the interviewed women. For women above the age of 40 the assumption is that siblings are on average 2 years younger. We test and validate this hypothesis in Table 2 in the 1st and 2nd columns. To do so we subtracted the age of the interviewed women from the average age of her living siblings.

The relationship between the share of surviving siblings until a certain age range and life table probabilities of surviving from age 5 to the end of this age range have been calculated by Timaeus and co-authors (UN, 2002). These relationships are the same for males and females. The relationship to survive until the age of 45 and the share of surviving siblings of women between the age of 40 and 44 can be expressed as:

$$l_{45}/l_{15} = -0.1140 + (1.1168 \cdot (l_{40-44}/l_{15})), \tag{6}$$

where $l_{45}/l_{15}$is the probability within a country and/or region to survive between the age of 15 and 45, and where l_{40-44}/l_{15} is the proportion of brothers (or sisters) of interviewed women in a country and/or region who - having survived to the age of 15 - are still alive as of today (UN, 2002).

[Please insert Table 2 about here.]

The major concern of this approach is underreporting, due to a recall bias of sibling deaths and a selection bias of interviewed women. Siblings may have been born and have died before the surveyed women or they might have died a long time ago and simply been forgotten (Stanton et al., 2000).[5] In addition, families with high mortality rates might be underrepresented in the DHS samples given that it is less likely to interview women from high mortality families (Gakidou et al., 2006). In the extreme case, women from families with no survivors until the age of 40 to 44 have a zero probability of being interviewed.[6]

Trussell and Rodriguez (1990) have, however, provided proof that if survival rates are not correlated with sibship size selection bias does not occur when we exclude the interviewed women from the denominator and nominator for the calculation of sibling mortality rates. We empirically test this necessary mathematical condition - sibling group size uncorrelated with adult mortality rates - in Table 2. At least for our sample, it can be observed that whereas there is a positive correlation between sibship size and child mortality rates (in this case until the age of 15), no clear correlation can be detected between sibship size and adult mortality rates (age 15-45). Note that both adult and child mortality rates are calculated with sibling information in this particular table. Analyzing adult mortality rates from the age of 15 furthermore limits underreporting due to recall bias, as it largely excludes cases where siblings died before the respondent was born.

To separate between rural and urban adult mortality rates, we assume that the siblings of a woman, who has been living in urban (or rural) areas her entire life, also live in urban (or rural) areas. We therefore only kept observations where the interviewed woman is living today in the same setting as during her childhood. We use the variables 'current place of residence' and 'childhood place of residence' of the DHS data for the matching of childhood and adulthood place of residence. Obviously this will still lead to some misclassifications as some of the siblings might have migrated, especially from rural to urban areas. In other words, rural mortality estimates might be biased: even if the woman interviewed has been living in a rural environment her entire life, not all her siblings necessarily have, but we would still count those siblings as rural inhabitants. The difference between rural and urban mortality might therefore, due to misclassification, be underestimated.

The DHS surveys provide information on living conditions within urban areas, and hence allow for a classification of slum households and/or slum areas (see previous section). The DHS surveys do not, however, provide any information as to whether or not the interviewed women have always lived under those settlement conditions (in contrast to the available information on whether the women have always lived in urban areas). We were therefore not able to calculate adult mortality rates separately for slum areas.

3 Results

3.1 Spatial distribution of population

Table 3 shows the population shares of our sample by urban and rural areas and also by urban slums and formal settlements.[7] For all countries in our sample and almost all periods, the rural population share is higher than the urban population share (column 1 and 2). Ethiopia, Niger, and Uganda show the lowest urban population shares with a ratio of urban to rural population of less than 0.30 (column 5). The urban population only exceeds the rural population in Cameroon and Morocco in the 2000s. Over time, most countries show an increasing urbanization (column 5).

[Please insert Table 3 about here.]

Column 3 and 4 of Table 3 indicate the shares of urban slum dwellers and urban non-slum dwellers at the national level.[8] Most countries show a share of 15 to 20 percent urban slum dwellers of the total population. The ratio of the share of slums dwellers to the total urban population reveals that, in almost all countries (except Egypt), more urban habitants are living in slums than in formal settlements (column 6). Except for Kenya, the slum dweller share of the total population has either increased or remained relatively constant (column 4), whereas the ratio of slum dwellers to the urban population has decreased or stayed constant (column 6) - with the exception of Niger and Cameroon. This means that in most Sub-Saharan African cities the absolute number of slum dwellers has often increased, whereas the relative magnitude of slum inhabitants has decreased.

Of all the previously described slum indicators, which ones most influence the chance of being labelled a slum-dweller? Table A.1 in the Appendix shows that at least in our sample, overcrowded living areas and lack of access to improved sanitation are the two dominant parameters that determine the status of most slum dwellers. Table A.1 also shows that there is no clear trend of overall improvement in housing conditions over time.

Table A.2 in the Appendix shows the population shares living in urban slums and formal settlements by the described alternative definitions of slum dwellers. Slum-1 refers to the definition of an urban household which lacks at least one basic service and/or housing condition (UN-Habitat definition), slum-2 refers to the definition of an urban household which lacks at least two dimensions, and slum-3 refers to the definition of an urban household which is defined as a slum dweller if it is located in an urban cluster where more than 50 percent of the households are defined as slum households according to the first definition (slum-1).

Comparing the first and the second slum definition reveals that the share of slum dwellers is considerably lower using the more strict definition of slum dwellers. Whereas (on average) 70 percent of the urban population in our sample countries live in slum areas according the first definition, 'only' 30 percent live in slums according to the second definition. This means that the lack of one adequate housing dimension does not necessarily mean that a household suffers from further deprivation.

Taking into account the spatial dimension of the slums (slum-3), it is interesting to see that for almost all countries, the share of slum dwellers slightly increases in relation to the first definition (except Egypt, Mozambique and Morocco). On average, 70 percent of urban inhabitants are defined as slum dwellers according to the household centered definition, whereas 76 percent are considered as slum dwellers according to the community based definition. Note that a spatial definition of slum dwellers does not necessarily lead to a higher measured share of slum dwellers.[9] But, obviously if the level of slum dwellers is already high according to the first (household based) definition we cannot obtain large differences when applying a spatial definition, which is different for smaller shares of slum dwellers.

3.2 Inequality in child mortality

Table 4 shows our estimates for spatial inequalities in child mortality. The estimates are based on our first slum definition. Table 4 shows five distinct patterns. First, we find sizable heterogeneity in child mortality across countries. The lowest level of child mortality is found in Egypt for 2008 (26.9 deaths under the age of five per 1000 children born), the highest level is found in Niger for 1998 (245.8 deaths per 1000 children born). Second, we find a small overall reduction in child mortality in almost all countries in our sample over time. Third, child mortality rates are, on average, considerably higher in rural than in urban areas. This clear bias against rural areas could either indicate worse health conditions for children (because of generally much lower income in rural areas) or a worse access to basic health infrastructure, or a combination of both.

[Please insert Table 4 about here.]

Fourth, we also find a clear mortality bias against the slum population in comparison to the rest of the urban population. In all countries, the ratio of slum to non-slum child mortality is greater than one. To give only one example: In Ethiopia we find child mortality rates of 'only' 54.0 children out of 1000 in non-slum areas, whereas in slum settlements 88.6 children out of 1000 died in the same reference year, resulting in a ratio of slum to non-slum mortality of 1.64. Considering the urban population as a homogenous group in the analysis of child mortality can therefore cover large urban inequalities.

The fifth distinct pattern that we observe in Table 4 is that child mortality rates in rural areas are not only higher than in urban areas as a whole but in most cases also higher than in urban slum settlements. This contradicts papers that have analyzed child nutrition rates, where data often shows higher undernutrition in slum than in rural areas (see, e.g. Ghosh and Shah., 2004; Kapur et al., 2005; Abidoya and Ihebuzor, 2001; Waihenya et al., 1996). The higher mortality rates in rural areas indicates that although slums areas show a higher health risk for children than rural areas (according to previous studies), the access to basic health infrastructure still seems to be better than in rural areas, thus off-setting the 'morbidity penalty' of slum areas. Table 4 does, however, also indicate that the differences in child mortality *within* cities is larger than the difference between child mortality *between* rural and slum areas. The child mortality ratio slum/non-slum is larger (1.65) than the child mortality ratio rural/slum (1.24) for almost all countries (see column 6 and 7).

[Please insert Table 5 about here.]

Table 5 shows estimated child mortality rates for the three different definitions of slums described in Section 2.2. As expected, we find an overall higher mortality level for the more strict definition of slums (households lacking access to at least two basic services) and hence even higher urban inequality in child mortality. This alternative definition does, however, not alter the ranking of rural, slum and formal child mortality. Even with this strict (or more severe) definition of slum dwellers, rural mortality is higher than slum mortality for almost all countries. Interestingly, we observe very similar findings comparing child mortality in slum settlements according to the first and the third definition, which takes into account the spatial dimension of urban slums. The spatial definition of slums shows child mortality rates that are almost equal to the first definition, even though slums now contain several households that, based on their specific characteristics, would not be considered as slum dwellers (i.e. they have access to improved water and sanitation and show appropriate structural housing with enough space per person).

In the last two columns of Table 5 we compare the child mortality rate of households that are not only counted as slum households according to definition 1 but that are also locted in slum areas (where more than 50 percent of households are considered as slum households), with households that are deprived of at least one basic urban service (definition 1) but are located in urban environments that cannot be considered as an agglomeration of slum households and hence slum areas. The former group shows much higher child mortality rates, which indicates that the 'slum mortality penalty' is indeed not only caused by poor household conditions but also by unhealthy environments.

3.3 Inequality in adult mortality

Table 6 shows adult mortality rates for the 14 Sub-Saharan African countries for which sibling information was available for at least two points in time. The first observation is that adult mortality rates are very high in all our sample countries. In 2000, the probability of dying between the age of 15 and 45 was between 7.9 percent percent (Madagascar) and 21.1 percent (Zimbabwe). For comparison, the rate was not even 0.5 percent in most European countries in 2000.[10] Second, there is a wide variability in levels of adult mortality mainly (but not only) correlated with HIV prevalence rates. The highest levels in the 2000s can be found for Zimbabwe, Mozambique, Malawi and Ethiopia; three countries of which are highly affected by the HIV/AIDS epidemic. The lowest levels are found in Senegal, Madagascar, Cote d'Ivoire and Kenya; only one of which is highly affected by the HIV/AIDS disease. Except for Mozambique, all countries affected by the HIV/AIDS epidemic have seen a high increase in adult mortality rates between the 1990s and the 2000s, and especially Zimbabwe where adult mortality rates doubled to reach 21.1 percent in the 2000s.

[Please insert Table 6 about here.]

Whereas child mortality rates are lower in urban than in rural areas for all countries in both periods (see Table 4), urban adult mortality rates are, for several countries, already higher than rural adult mortality rates in the 1990s, and for almost all countries, higher in urban areas in the 2000s (see Table 6). Thus, in Sub-Saharan African countries in recent years, the negative health impact of higher population densities in cities on adult survival rates - for example through faster spread of communicable diseases - seems to dominate the positive impact of usually higher material wellbeing and better health infrastructure. This phenomenon cannot be observed for child mortality. Spatial inequality in child mortality is therefore not a good predictor for spatial inequality in adult mortality. What is even more concerning, and already well-known from previous demographic literature, is that adult mortality has risen over the last decade; and according to our estimates especially in urban areas. To the contrary, child mortality has decreased considerably both in rural and urban areas. One should note, however, that due to our estimation procedure which differs for child and adult mortality rates, child mortality rates are estimated for the last 5 years whereas adult mortality rates go back 11.5 years (UN, 2002). Hence, child mortality rates reflect somewhat more recent estimates than adult mortality rates.

4 Conclusion

In this paper we have analyzed spatial inequalities in child and adult mortality over a large sample of developing countries: this has not been done before in the literature. Our results indicate that an 'urban mortality penalty' exists for adult mortality (similar to that which existed in the 19th century cities in Europe), but not for child mortality. Hence, the urban environment seems to pose a higher health burden on adults than on children.

We furthermore find very high differences in child mortality rates between formal and informal settlements in cities. We do not, however, find that child mortality rates are higher in slum areas than in rural areas, which contradicts previous literature on child morbidity. Our interpretation of this latter result is that the higher health risks of urban slums, as shown by previous studies, is off-set by the better access to health services in urban slums, compared to rural areas. We also find that the higher child mortality rates in slum areas are not only caused by worse housing conditions, but also by the worse environment in which a child is living.

In line with our objective to analyze spatial inequalities in child mortality, we also discussed the problem of defining slum households in this paper and think that the ideas presented can feed into further research on this topic. Our comparative results are, however, not very sensitive to the three used definitions of slums in this paper.

Last, we have shown that child mortality rates are a bad predictor for adult mortality, not only for trends but also for inequalities. Given these results, the international community should, in our opinion, put more efforts into measuring, analyzing, and addressing adult mortality rates, which have often been neglected in the past, owing to a much larger focus on child mortality.

Notes

[1]We use the word slum dweller and slum household interchangeably in this paper. Any statistics are weighted at the household level.

[2]UN-Habitat (2003) also includes security of tenure as a fifth component, but this information is not available for most countries in general, and not available in the DHS surveys in particular.

[3]UN-Habitat (2003) considers a household as having an improved access to safe water if it shows one of the following characteristics: piped connection to house or plot; public standpipe serving no more than five households; bore hole; protected well; protected spring; rain water collection.

[4]Some DHS data sets also contain information about the latitude and longitude of households which allows for a geographical mapping of slum households.

[5]The failure to report siblings that moved away and the woman had lost contact with only biases the estimates if moving is correlated with mortality rates which is unlikely.

[6]The correlation coefficient between UN estimates of adult mortality and DHS mortality estimates is 0.74 and in general DHS adult mortality estimates seem to be lower than the UN estimates (Gakidou et al., 2004). The problem is, however, that UN mortality estimates for Sub-Saharan African countries are also not based on complete vital registration systems. They are often based on the Princeton North model life tables fitted to the more accurate and available estimates of child mortality and adjusted for HIV rates calculated with epidemiological models based on HIV seroprevalence data from antenatal clinics (Timaeus and Jasseh, 2004). In other cases adult mortality estimates are based on a selected coverage of vital registration or demographic surveillance systems of a small and non-random part of the population.

[7]All calculations are population weighted.

[8]According to our first slum definition, defining households as slum dwellers if they are characterized by at least one of the four slum indicators.

[9]For example, let's assume we analyzed a city with 10 clusters where 70 percent of households were defined as slum households according to an household centered definition. If all of these households were located in exactly 7 clusters, our result of 70 percent of slum dwellers would not change with a spatial definition. Now assume we identified 70 percent of slum dwellers because we had 6 clusters with 100 percent of slum dwellers and 2 clusters with a share of 50 percent of slum dwellers each. According to our spatial definition we would now obtain a share of 60 percent of slum dwellers, only. To the contrary, if we obtained 70 percent of slum dwellers based on the individual definition because we observed 5 cluster with 100 percent of slum dwellers each, 2 clusters with 60 percent and 1 cluster with 80 percent of slum dwellers, our spatial definition would lead to 80 percent of slum dwellers.

[10]See life tables for WHO member states on: www.who.int/healthinfo/statistics.

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Tables and Figures

Table 1: DHS data by country and year

	Year 1	Year 2	HIV Prevalence (perc. points)	Urban Population 2005 (perc. points)	Urbanization Rate 1995-2005 (perc. points)	Data on Rooms per Household	Data on Siblings
Burkina Faso	1998	2003	1.6	18.3	4.8	no	yes
Cameroon	1998	2004	5.1	54.3	4.3	yes	no
Chad	1996	2004	3.5	25.3	4.7	yes	yes
Cote d'Ivoire	1994	2005	3.9	46.8	3.6	no	yes
Egypt	2004	2008	1.1	42.6	1.8	yes	no
Ethiopia	2000	2005	2.1	16.1	4.2	yes	yes
Guinea	1999	2005	1.6	33.0	3.3	no	yes
Kenya	1998	2003	8.5	20.7	3.4	yes	yes
Madagascar	1992	2004	0.1	28.5	4.0	no	yes
Malawi	1992	2004	11.9	17.3	5.5	no	yes
Mali	1995	2001	1.5	30.5	4.5	no	yes
Morocco	1992	2003	0.1	55.0	2.0	yes	yes
Mozambique	1997	2003	12.5	34.5	5.8	yes	yes
Niger	1998	2006	0.8	16.3	4.1	yes	no
Senegal	1992	2005	1.0	41.6	3.1	no	yes
Tanzania	1996	2004	6.2	24.2	4.1	yes	yes
Uganda	1995	2006	5.4	12.5	3.7	yes	no
Zimbabwe	1994	2006	15.3	35.9	2.7	no	yes
Average	1995	2003	5.4	31.0	3.9		

Source: DHS, United Nations Population Division, UNAIDS.

Table 2: Test Statistics for Adult Mortality Estimates

Country	Age Difference Siblings-Respondent 1990s	Age Difference Siblings-Respondent 2000s	Corr. Sibship Size and Adult Mortality 15/45 1990s	Corr. Sibship Size and Adult Mortality 15/45 2000s	Corr. Sibship Size and Child Mortality 0/15 1990s	Corr. Sibship Size and Child Mortality 0/15 2000s
	(1)	(2)	(3)	(4)	(5)	(6)
Burkina Faso	-2.16	-2.05	0.03	0.03	0.37	0.32
Chad	-0.76	-1.29	-0.03	-0.02	0.34	0.36
Cote d'Ivoire	-1.97	-3.73	-0.01	-0.06	0.36	0.25
Ethiopia	-0.76	-1.86	-0.07	-0.02	0.29	0.29
Guinea	-2.02	-1.67	0.04	-0.02	0.33	0.34
Kenya	-2.32	-2.18	0.03	-0.03	0.3	0.22
Madagascar	-2.44	-1.84	-0.09	-0.01	0.21	0.2
Malawi	-1.3	-0.75	0.01	-0.02	0.4	0.34
Mali	-1.39	-1.8	-0.02	0.1	0.38	0.3
Mozambique	-1.57	-1.92	0.19	0.01	0.3	0.3
Senegal	-1.78	-1.4	-0.08	0.05	0.25	0.11
Tanzania	-2.68	-2.35	-0.05	-0.07	0.34	0.26
Zimbabwe	-1.83	-1.77	0.01	-0.1	0.32	0.19
Average	-1.76	-1.92	-0.01	-0.01	0.32	0.27

Source: Demographic and Health Surveys (DHS); calculations by the authors.

Table 3: Population shares by urban slums and non-slums, and rural areas

country	year	Rural	Urban	Urban Non-slum	Urban Slum	Ratio urban/rural	Ratio slum/urban
		(1)	(2)	(3)	(4)	(5)	(6)
Cameroon	1998	0.65	0.35	0.13	0.22	0.55	0.62
	2004	0.45	0.55	0.18	0.37	1.21	0.67
Chad	1996	0.77	0.23	0.02	0.21	0.30	0.92
	2004	0.79	0.21	0.03	0.19	0.27	0.88
Egypt	2004	0.59	0.41	0.24	0.18	0.70	0.43
	2008	0.59	0.41	0.25	0.16	0.70	0.40
Ethiopia	2000	0.82	0.18	0.03	0.15	0.22	0.84
	2005	0.82	0.18	0.03	0.15	0.22	0.82
Kenya	1998	0.77	0.23	0.06	0.17	0.30	0.73
	2003	0.75	0.25	0.16	0.09	0.33	0.35
Morocco	1992	0.51	0.49	0.21	0.28	0.97	0.57
	2003	0.40	0.60	0.35	0.26	1.53	0.43
Mozambique	1997	0.76	0.24	0.06	0.17	0.31	0.73
	2003	0.63	0.37	0.13	0.23	0.58	0.64
Niger	1998	0.80	0.20	0.02	0.19	0.26	0.91
	2006	0.80	0.20	0.05	0.15	0.25	0.75
Tanzania	1996	0.77	0.23	0.02	0.22	0.31	0.93
	2004	0.72	0.28	0.04	0.24	0.40	0.85
Uganda	1995	0.85	0.15	0.01	0.14	0.18	0.94
	2006	0.83	0.17	0.03	0.14	0.20	0.80
Average	2001	0.70	0.30	0.10	0.19	0.49	0.71

Source: Demographic and Health Surveys (DHS); calculations by the authors.

Table 4: Child mortality by slum, non-slum, urban and rural areas

Country	Period	Total	Urban	Rural	Slum	Non-Slum	Ratio rural/ urban	Ratio slum/ non-slum	Ratio rural/ slum
Cameroon	1998	151.1	122.8	161.3	125.8	117.1	1.31	1.07	1.28
	2004	138.2	108.6	161.2	109.0	107.4	1.48	1.01	1.48
Chad	1996	187.4	201.3	183.5	185.3	174.6	0.91	1.06	0.99
	2004	183.0	162.3	187.8	153.4	137.6	1.16	1.11	1.22
Egypt	2005	38.4	37.1	39.2	41.6	33.3	1.06	1.25	0.94
	2008	26.9	28.1	26.2	36.6	22.0	0.93	1.67	0.72
Ethiopia	2000	157.0	118.0	162.0	125.9	51.5	1.37	2.44	1.29
	2005	121.4	86.1	124.1	88.6	54.0	1.44	1.64	1.40
Kenya	1998	113.2	96.5	116.8	82.1	48.6	1.21	1.69	1.42
	2003	115.4	83.2	122.5	85.9	81.3	1.47	1.06	1.43
Morocco	1992	73.7	48.4	87.2	51.2	43.2	1.80	1.19	1.70
	2003	45.3	32.7	58.2	39.1	26.3	1.78	1.49	1.49
Mozambique	1997	190.6	183.3	192.8	204.7	104.9	1.05	1.95	0.94
	2003	141.9	124.5	149.0	134.2	104.3	1.20	1.29	1.11
Niger	1998	245.8	158.3	262.3	154.4	118.1	1.66	1.31	1.70
	2006	168.1	118.7	177.0	129.8	76.7	1.49	1.69	1.36
Tanzania	1996	149.4	132.6	151.7	136.6	35.8	1.14	3.82	1.11
	2004	110.5	109.7	110.6	109.4	111.9	1.01	0.98	1.01
Uganda	1995	128.8	107.4	133.5	109.9	30.7	1.24	3.58	1.22
	2006	107.6	103.2	108.7	107.2	66.4	1.05	1.62	1.01
Average	2001	129.68	108.14	135.77	110.53	77.29	1.29	1.65	1.24

Source: Demographic and Health Surveys (DHS); calculations by the authors.

Table 5: Child mortality by alternative slum definitions

country	year	Slum 1	Slum 2	Slum 3	Slum1 and Slum 3	Slum1 and NOT Slum 3
Cameroon	1998	125.8	143.7	128.6	147.6	116.16
	2004	109.0	113.8	111.7	115.1	109.82
Chad	1996	185.3	186.8	199.9	198.1	208.78
	2004	153.4	122.8	161.2	122.8	178.06
Egypt	2004	41.6	33.3	42.8	38.5	43.32
	2008	36.6	37.3	38.6	39.6	38.53
Ethiopia	2000	125.9	137.3	117.9	137.6	105.59
	2005	88.6	97.3	88.6	97.3	82.75
Kenya	1998	82.1	102.7	91.0	109.5	80.84
	2003	85.9	73.1	104.8	81.9	98.41
Morocco	1992	51.2	85.1	58.5	101.0	51.47
	2003	39.1	50.1	44.0	49.6	35.54
Mozambique	1997	204.7	245.0	193.2	247.6	170.29
	2003	134.2	145.6	137.9	147.1	128.99
Niger	1998	154.4	176.6	160.3	176.9	139.06
	2006	129.8	150.2	122.9	147.0	88.29
Tanzania	1996	136.6	163.9	132.6	163.9	105.31
	2004	109.4	145.1	108.0	145.1	91.83
Uganda	1995	109.9	113.6	108.2	113.6	105.72
	2006	107.2	130.2	104.7	131.0	94.16
Average	2001	110.53	122.68	112.77	125.54	103.65

Note: Slum 1 follows the UN-Habitat (2003) definition of slums. An urban household is considered as being a slum dweller if the household is deprived at least of one of the four indicators: lack of access to drinking water, to sanitation, poor houseling quality, overcrowding. Slum 2 refers to the definition where the household lacks at least of two of the four indicators. Slum 3 defines an urban household as a slum dweller if the household lives in a area where more than 50 percent of the households are slum dweller according to the slum 1 definition. Missing values indicate a very low number of observations of that particular group.
Source: Demographic and Health Surveys (DHS); calculations by the authors.

Table 6: Adult Mortality Rates

	1990s				2000s			
Country	urban	rural	total	Ratio urban/ rural	urban	rural	total	Ratio urban/ rural
Burkina Faso	164.77	154.84	156.21	1.06	157.42	119.36	124.71	1.32
Chad	113.84	140.22	135.1	0.81	133.51	112.92	116.66	1.18
Cote dIvoire	101.77	115.01	110.03	0.88	110.9	84.69	92.58	1.31
Ethiopia	161.49	186.16	185.19	0.87	188.91	164.55	166.8	1.15
Guinea	133.79	127.52	129.56	1.05	114.79	135.66	131.49	0.85
Kenya	145.36	81.33	84.74	1.79	144.58	102.74	105.54	1.41
Madagascar	115.36	157.5	148.79	0.73	79.14	79.46	79.4	1.00
Malawi	165.47	116.61	118.79	1.42	223.28	183.55	187.29	1.22
Mali	61.34	116.97	105.88	0.52	116.21	130.13	127.93	0.89
Morocco	52.67	63.38	59.73	0.83	38.96	49.04	43.54	0.79
Mozambique	251.79	222.89	227.25	1.13	160.76	143.47	148.38	1.12
Senegal	57.74	104.74	90.78	0.55	91.05	82.89	90.49	1.10
Tanzania	148.85	100.77	105.52	1.48	137.05	130.48	131.27	1.05
Zimbabwe	68.96	104.68	101.2	0.66	242.02	196.17	211.2	1.23
Average	131.56	132.91	131.04	1.00	145.95	128.35	133.37	1.12

Source: Demographic and Health Surveys (DHS); calculations by the authors.

Figure 1: Slum Households in Addis Ababa, Ethiopia, 2005, UN-Habitat Definition

Source: Demographic and Health Surveys (DHS); calculations by the authors.

Appendix

Table A.1: Shares of slum indicators by country and year

Country	Year	Lack of access to drinking water	Lack of access to sanitation	Poor quality of dwelling	Overcrowded living area
Cameroon	1998	0.23	0.36	0.16	0.29
	2004	0.20	0.41	0.20	0.36
Chad	1996	0.26	0.70	0.83	0.45
	2004	0.19	0.29	0.79	0.43
Egypt	2004	0.03	0.30	0.02	0.23
	2008	0.02	0.24	0.02	0.24
Ethiopia	2000	0.18	0.25	0.60	0.65
	2005	0.08	0.47	0.29	0.65
Kenya	1998	0.18	0.42	0.17	0.53
	2003	0.15	0.44	0.16	0.68
Morocco	1992	0.05	0.19	0.03	0.47
	2003	0.06	0.06	0.02	0.39
Mozambique	1997	0.26	0.33	0.33	0.35
	2003	0.17	0.23	0.33	0.36
Niger	1998	0.27	0.75	0.29	0.42
	2006	0.08	0.59	0.38	0.25
Tanzania	1996	0.20	0.90	0.32	0.49
	2004	0.17	0.75	0.25	0.47
Uganda	1995	0.24	0.80	0.29	0.68
	2006	0.24	0.34	0.24	0.62
Average	2001	0.16	0.44	0.29	0.45

Source: Demographic and Health Surveys (DHS); calculations by the authors.

Table A.2: Population shares by slum definitions

			Slum 1			Slum 2			Slum 3		
country	year	rural	slum share	non-slum share	Ratio slum/ urban	slum share	non-slum share	Ratio slum/ urban	slum share	non-slum share	Ratio slum/ urban
Cameroon	1998	0.65	0.22	0.13	0.62	0.10	0.26	0.27	0.24	0.11	0.69
	2004	0.45	0.37	0.18	0.67	0.12	0.42	0.23	0.42	0.13	0.77
Chad	1996	0.77	0.21	0.02	0.93	0.16	0.07	0.74	0.23	0.00	0.99
	2004	0.79	0.19	0.03	0.88	0.07	0.14	0.36	0.21	0.00	0.98
Egypt	2004	0.59	0.18	0.24	0.43	0.01	0.40	0.04	0.14	0.28	0.33
	2008	0.59	0.16	0.25	0.40	0.01	0.40	0.03	0.12	0.29	0.30
Ethiopia	2000	0.82	0.15	0.03	0.84	0.06	0.13	0.31	0.18	0.00	0.98
	2005	0.82	0.15	0.03	0.82	0.04	0.14	0.24	0.17	0.01	0.95
Kenya	1998	0.77	0.17	0.06	0.73	0.06	0.18	0.24	0.19	0.05	0.80
	2003	0.75	0.09	0.16	0.35	0.05	0.20	0.22	0.08	0.17	0.32
Morocco	1992	0.51	0.28	0.21	0.60	0.02	0.47	0.15	0.31	0.18	0.63
	2003	0.40	0.26	0.35	0.48	0.02	0.58	0.08	0.20	0.40	0.33
Mozambique	1997	0.76	0.17	0.06	0.79	0.06	0.17	0.40	0.18	0.05	0.77
	2003	0.63	0.23	0.13	0.76	0.07	0.29	0.40	0.22	0.14	0.61
Niger	1998	0.80	0.19	0.02	0.73	0.08	0.12	0.36	0.20	0.01	0.97
	2006	0.80	0.15	0.05	0.83	0.06	0.14	0.53	0.18	0.02	0.91
Tanzania	1996	0.77	0.22	0.02	0.68	0.09	0.14	0.16	0.23	0.01	0.97
	2004	0.72	0.24	0.04	0.65	0.09	0.19	0.11	0.27	0.02	0.93
Uganda	1995	0.85	0.14	0.01	0.94	0.06	0.09	0.50	0.14	0.15	0.94
	2006	0.83	0.14	0.03	0.80	0.05	0.12	0.28	0.16	0.01	0.95
Average	2001	0.70	0.19	0.10	0.70	0.06	0.23	0.28	0.20	0.10	0.76

Note: Slum 1 follows the UN-Habitat (2003) definition of slums. An urban household is considered as being a slum dweller if the household is deprived at least of one of the four indicators: lack of access to drinking water, to sanitation, poor houseling quality, overcrowding. Slum 2 refers to the definition where the household lacks at least of two of the four indicators. Slum 3 defines an urban household as a slum dweller if the household lives in a area where more than 50 percent of the households are slum dweller according to the slum 1 definition.

Source: Demographic and Health Surveys (DHS); calculations by the authors.