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Urban Advantage or Urban Penalty?: Under-5 Mortality and Urbanization in Sub-Saharan Africa

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Abstract

Rapid urbanization rates in sub-Saharan Africa (SSA) have been accompanied by worsening urban child health outcomes and a narrowing of the region's historic under-5 urban survival advantage. I use DHS data from twelve SSA countries to investigate whether there is an aggregate change in this advantage between 1995-2000 and 2005-2010. I find that the urban advantage persists, but that it is weakening. I then examine whether the diminishing urban advantage is uniform across urban areas and find it is not. The overall decrease in the urban advantage is due to slower improvements in survival rates in smaller urban areas compared to large cities or rural areas. These findings support the growing literature which finds that rapid urbanization in SSA poses the greatest risk to improvements in child survival the smaller cities most likely to see the greatest proportional growth in the coming decades.

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Urban Advantage or Urban Penalty? Under-5 Mortality and Urbanization in Sub-Saharan Africa

Sub-Saharan Africa (SSA) is the world's fastest urbanizing region and is projected to become predominately urban in 2030 (UN-Habitat 2010). Research from the past 50 years shows that SSA's urban residents have enjoyed an advantage over rural areas in survival rates, particularly for infants and children. However, there is some evidence that rapid rates of urbanization in SSA have contributed to worsening health outcomes for urban children and a decline or reversal of the urban under-5 mortality advantage (Gould 1998; Fotso 2007; Antai et al. 2010; Bocquier *et al.* 2011).

This paper examines whether the under-5 survival advantage in SSA cities still holds. Recent research provides contradicting evidence, with aggregate or multi-country studies showing a clear urban child health advantage, but several single-country studies suggesting the urban advantage is declining. Nearly all recently published multi-country studies which find evidence of an urban child health advantage use cross-sectional data from one time point (van de Poel et al. 2007; Bocquier et al. 2011, Harttgen & Gunther 2011), revealing nothing about potential changes in this urban/rural under-5 survival differential. The two studies which have looked at changes over time at the regional level also found the urban advantage persists but these studies did not use data from the same time periods (Brockerhoff and Brennan 1998; NCR 2003). The few studies which have used time series data and showed a decline in the differential in Nigeria (Antai and Moradi 2010), Kenya (Gould 1998) and Mozambique (Macassa *et al.* 2003) are limited to single-country experiences at different times and it is not clear if they represent the overall trend throughout SSA.

I use DHS data from twelve SSA countries at two time points to investigate whether the urban under-5 survival advantage holds and whether there has been an aggregate change in this advantage between 1995-2000 and 2005-2010. I find that the urban advantage persists, but that there are indications that it is weakening. I then examine whether the diminishing urban advantage is most pronounced in the largest and fastest growing cities, or uniform across all urban areas. I find that the urban survival probabilities mirror the hierarchy of city size: with under-5 survival probabilities highest in the largest cities, second-highest in other urban areas and lowest in rural areas. However, when known socio-demographic and socio-economic correlates of under-5 mortality are controlled for, the under-5 survival advantage is attenuated and is statistically significant only between rural and urban areas in the 2005-2010 period.

The continued urbanization and population growth projected for SSA in coming decades, coupled with the continent's high fertility rates and young age structure, means that changes in urban child survival probabilities will impact two of the fastest-growing segments of the continent's population – children under five and urban residents. Given that SSA has the world's highest infant and child mortality rates, understanding patterns of under-5 mortality by residence in SSA is particularly important because they have substantial implications for informing decisions on how best to allocate limited resources for combating high child mortality rates in the region.

Background

Rural-urban mortality differentials

Rural-urban mortality differentials are not new. Historical evidence from Europe and North America shows that urban areas were characterized by an "urban penalty" (Kearns 1988) with mortality rates substantially higher in cities compared to rural areas, particularly for infants and children (Preston and Haines 1991; Gould 1998). These higher urban mortality rates were associated with the spread of communicable diseases due to high density, overcrowding and unsanitary conditions in cities, despite the greater availability of health facilities and higher overall incomes compared to rural areas[1] (Gould 1998). By the 20th century this urban mortality penalty had been transformed into an urban advantage, due largely to improvements in public health and sanitation (Preston and Haines 1991; Haines 1995).

Conversely, African cities in the 19th and 20th centuries generally experienced an *urban mortality advantage*. Most contemporary large African cities were designated as colonial centres in the 19th century, with health-related infrastructure and services for the colonial settlers (Gould 1998) with positive spill-over effects for local urban populations (NRC 2003). This concentration of sanitation and health services in urban SSA contributed to substantial lower mortality in urban areas relative to rural areas. The few studies on health differentials in SSA in the mid 20th century show that under-5 mortality rates were lower in urban areas than rural in Zambia from 1950-1955 (Moore 2009), urban infant mortality in Senegal was nearly half that in rural areas in 1960-1985 (Antoine and Mbodji 1991), and (the largest?) city in Sierra Leone, Freetown, had the lowest under-5 mortality in the country in 1971 (Kandeh 1989).

Extremely high rates of urbanization and urban growth in Sub-Saharan Africa (SSA) may be eroding the urban health advantage in the region. While still predominately rural, SSA is urbanizing faster than any other region in the world (UN-Habitat 2010) due to its urban natural increase, high fertility, and rural-to-urban migration. The United Nations forecasts that between 2005 and 2025, 87 percent of population growth in SSA will occur in urban areas (UN-Habitat 2003) and that the region's urban population will triple (UN-Habitat 2010). The rates of

[1] A lack of comparable data suggests it is not possible to say definitively whether the urban/rural mortality differentials of historic Europe applied everywhere, specifically questioning whether these differentials existed in East Asian cities (Woods 2003).

urbanization in SSA are not extraordinary from a historical perspective but the absolute number of growth of the urban population in SSA is unprecedented (NRC 2003). Cities throughout the region are increasingly struggling to provide adequate housing, water, sanitation and transportation for their growing populations given low economic growth and little funding for improvements and expansions to urban infrastructure (Montgomery et al. 2003; Leon 2007; Dyson 2010; Gould 1998; UN-Habitat 2010).

Emerging evidence from SSA in the past few decades indicates worsening health outcomes for urban children in SSA (Lalou and Legrand 1997; Brockerhoff & Brennan 1998; Antai et al. 2010) and some of the recent literature suggests there is a decline in the urban under-5 mortality advantage (Gould 1998). At the regional level, however, the urban child mortality advantage holds. Urban children in SSA have been shown to have a net under-5 survival advantage over children in rural areas in several multi-country studies (NCR 2003; Bocquier et al. 2011, Harttgen & Gunther 2011), with absolute inequality between urban and rural areas for under-5 mortality highest in SSA compared to other developing regions (van de Poel et al. 2007). However, all these studies used cross-sectional data and therefore cannot speak to whether there have been recent changes in this advantage.

Alternatively, a handful of time series country-level studies from SSA point to recent declines in the urban child health advantage. Senegal's urban infant mortality advantage began eroding in the 1970s, (Antoine and Mbodji 1991) and Mozambique's urban under-5 mortality advantage showed evidence of a decline starting in 1992[2] (Macassa *et al.* 2003). Gould (1989) has argued that recent increases in under-5 mortality rates in Nairobi are indicative of a potential

[2] The decrease in the urban under-5 mortality coincided with the end of Mozambique's civil war in 1992and may have been impacted by the post-conflict environment and higher than normal levels of rural-to-urban migration by those displaced by the conflict.

reversal in the urban mortality advantage in Kenya. Two multi-country studies have looked at trends in urban under-5 mortality in SSA since the 1980s and found evidence of a decline in the urban advantage (Montgomery et al 2004; Fotso 2007), but did not use data from comparable time periods across countries and could thus be comparing trends across different periods.

Why might SSA's urban health advantage be declining? Improvements in rural health narrowed the urban mortality gap in the second half of the 20th century in SSA, but recent declines in the urban advantage are attributed to worsening urban health (Gould 1998; UN-Habitat 2003; Fotso 2007; Bocquier et al. 2011). In Nigeria, Kenya, and Mozambique, increases in under-5 mortality rates in urban areas have been documented as part of the decline in the urban child mortality advantage (Gould 1998; Macassa et al. 2003; Fotso et al. 2007; Antai and Moradi 2010). These worsening urban child health outcomes in cities are thought to be due to growing urban populations and crowding, decreased access to safe water, lower vaccination rates and greater pollution (Faye *et al.* 2005; Fotso 2007).

Compositional Differences as a Potential Explanation for the Eroding Urban Health Advantage

The changing composition of urban dwellers might explain the declining urban health advantage in SSA. The growth of two groups – the urban poor and migrants – may contribute to aggregate declines in urban health and a narrowing of the urban child mortality advantage. The proportion of the urban poor is increasing at a rate faster than the overall global urban population (Gould 1998) and thus the health outcomes of this group will have an increasingly larger influence on average urban health outcomes. The urban poor tend to have worse child health outcomes than urban non-poor and in some cases, have worse child health outcomes and under-5 mortality than their rural counterparts (NRC 2003; Montgomery et al. 2004; van de Poel et al. 2007;

Montgomery 2009). The higher under-5 mortality rates of the urban poor, particularly where rates are higher than in rural areas, suggests that the aggregate under-5 mortality advantage could narrow as the proportion of urban poor increases among SSA's cities.

Migrants in SSA also have worse child health outcomes than urban natives (Brockerhoff and Yang 1994; Stephenson *et al*. 2003; Brockerhoff 1990; Brockerhoff 1995) and rural non-migrants (Antai *et al.* 2010), though Bocquier and colleagues (2011) did not find evidence of higher child mortality for urban migrants compared to non-migrants from rural or urban areas. Rural-urban health differentials could be affected by migrants because of substantial flows and because of the increase in young female migration (Brockerhoff 1998) if many move with their children. It is likely that higher under-5 mortality rates among in-migrants could result in declining aggregate under-5 survival rates in cities and narrow the urban-rural mortality differential, as has been argued to have been the case in Mozambique (Macassa *et al.* 2003). However, if urban in-migrants have lower under-5 mortality rates than rural non-migrants, even if higher than urban non-migrants, this could further increase the urban mortality advantage.

The fact that the urban poor and recent migrants have worse child health outcomes is thought to be due in part to the proliferation of slums in SSA cities and that this where the urban poor and migrants settle (Brockerhoff 1995). Slums lack basic infrastructure and services (Montgomery 2009; UN-Habitat 2010) exposing children to greater health risks (NRC 2003). SSA cities already have the largest proportion of slum dwellers globally (UN-Habitat 2003) and in many already over-burdened cities in SSA the influx of immigrants and the rapid pace of urban growth is leading to a further increases in the proportion of urban residents living in slums (Fotso *et al.* 2007; UN-Habitat 2010). The growth of slums will have had a negative impact on aggregate urban under-5 survival rates, and lead to a decline in the urban survival advantage, if child mortality rates in these marginalized areas are higher than in other urban and rural areas.

Individual and community characteristics have also been shown to play an important role in explaining child health outcomes and rural-urban differences in child mortality. In several studies which find a urban child mortality advantage, once known demographic and socio-economic correlates of under-5 mortality are included the advantage decreases or disappears, most notably among the urban poor (Bocquier et al. 2011; Van de Poel et al. 2009). This suggests that the urban advantage is due primarily to differences in population characteristics between urban are rural areas, namely greater levels of wealth and higher education in cities, not factors specific to living in an urban area. Yet other researchers have found that the urban child survival advantage is related to advantages offered by the urban environment, including greater immunization rates, improved infrastructure and better access to health services (NCR 2003; Faye *et al.* 2005). These findings imply that if access to basic health services and sanitation infrastructure remain superior in cities, despite stalls or declines, the urban under-5 mortality advantage will hold. Alternatively, this advantage would narrow if there is a deterioration of overall conditions in cities without comparable declines in rural areas.

Size of Urban Area and the Urban Health Advantage

The size of the urban area may be important for determining the degree of the urban health advantage. Child health survival differences have historically been largest in the largest urban areas. For example, infant mortality in 19^{th} century England and Wales was highest in the largest cities (Williamson 1982; Gould 1998). Even in SSA, where there is usually an urban advantage for child survival, in Nairobi Kenya, child mortality rates were nearly 20% higher than other urban areas during a period which coincided with rapid population growth in the city (Gould 1998). Moreover, Brockerhoff (1995) found that mortality rates for children of urban migrants in developing countries were higher in larger urban areas than in smaller cities, suggesting an association between the size of an urban area and decreased under-5 survival chances, at least for migrants.

However, in contemporary SSA it may be smaller cities are at greatest risks for declines in child health. The majority of African urbanites – nearly two-thirds – are estimated to live in cities of fewer than 500,000 (NRC 2003), and most urban growth in the coming decades in SSA is projected to occur in small- and medium-sized cities rather than in the largest cities (UN-Habitat 2010). Compared to the biggest cities, smaller urban areas are often relatively underserved by government services, particularly those related to health and hygiene (NRC 2003), and can have environmental and health conditions similar to those in rural villages (Montgomery and Ezeh 2005a). This small-city disadvantage appears to be particularly pronounced in SSA. A comparative study of living conditions between larger and smaller cities across the developing world found infant mortality rates in SSA, in contrast to other developing regions, were worse in smaller cities (50,000 to 1 million) than in larger urban areas (greater than 1 million) (Brockerhoff and Brennan 1998). Therefore, in this analysis I will also segment urban between the largest cities and all other urban areas to investigate whether it is the larger or smaller cities in SSA that show the greatest declines in under-5 mortality rates or in the urban child mortality advantage.

The Present Study

This paper assesses whether the urban health advantage in SSA has decreased during the past two decades of rapid urbanization. Using data from a group of countries at two comparable time points, this is the first study to measure changes in the rural-urban child mortality differential at the regional level over a standardized time period of time. Moreover, no previous research has examined variation in the differential across city size since the 1990s. In this paper, I analyze urban areas by size, to investigate whether any changes in the urban health advantage are experienced uniformly. Given that SSA has the world's highest infant and child mortality rates and highest rates of urbanization, understanding patterns of under-5 mortality by residence is critical to informing decisions on how best to allocate resources for addressing high child mortality rates in the region.

Data

This analysis uses data from twelve SSA countries that had a Standard Demographic and Health Survey (DHS) carried out between 1995-2000 and again between 2005-2010 (Table 1). The DHS collects nationally representative data in developing countries through household sample surveys that measure health, population and socioeconomic indicators, with a focus on maternal and child health (Rutstein and Rojas 2006). DHS surveys have standardized variables across surveys and are designed to be easily comparable across countries. In this analysis, the time between DHS surveys per country varies from 6-11 years, with an average of 9 years. The DHS are cross-sectional surveys, thus the time trend analysis in this study is at the aggregate as different areas can be linked between the two surveys but not individual respondents.

The study population consists of two groups: children born within the five years preceding the survey and their mothers. These two groups necessarily differ in sample size because many mothers have had more than one birth in the five years preceding the survey. The dependent variable here is survival of the child from birth to age five. All control variables refer to the mother, as the majority of children under the age of five live with their mothers (Bocquier et al. 2011).

The two key variables are child survival and urban/rural residence. Data on child health come from birth histories which are collected from all women surveyed, including parity, sex, month and year of birth, child survivorship status and age at death for children who died. These birth histories are used to determine whether a child survived to the age of five. For children who died the age of death is recorded in months for the first two years and then only in years. Number of children and survival rates are calculated from the birth histories.

I use under-5 mortality, combining infant and child mortality, for the following reasons. First, even in settings with limited data, data on young children is often available either through surveys (such as the DHS or the UNICEF Multiple Indicator Cluster Surveys) or health registration systems. Second, mortality is higher under-5 compared to older age groups, making it possible to estimate mortality with small samples. Third, there is evidence of different impacts of causes of death for infants (0-1 years) and children (1-4 years), with endogenous factors (including sex, multiple births, and maternal factors) having a greater effect on infant mortality, and exogenous factors (socioeconomic status, parents education and environmental factors) accounting for a greater proportion of child deaths (Balk *et al.* 2004). Combining infant and child mortality into a single under-5 age interval thus provides a longer exposure period to conditions that may be important determinants of rural-urban disparities in survivorship (van de Poel et al. 2007). Last, under-5 mortality is highly sensitive to population density (Woods 2003), which is important for large and growing cities where population density tends to be highest.

Urban and rural areas are defined in the DHS using each country's definition of what constitutes rural or urban residence[3]. In addition to the dichotomous variable for urban or rural residence type included in each survey, most surveys also include a variable for hierarchy of city type (countryside, town, small city, capital/large city) which was used to identify data from the largest cities (rapidly-growing large cities - RGLCs) within a province or area where more than one urban area was sampled.

To identify recent migrants, I use information on current and last place of residence from DHS surveys which includes the respondent's current place of residence and how long she has lived in this location. For women who do not respond "always" for the length of time lived in the location of the interview, they are asked to identify when they moved to their current location. This does not provide a comprehensive migration history but does account for those who have moved at least once prior to the survey. Women who have moved within the past five years are considered to be recent migrants in this analysis.

I include control variables referring to characteristics of the mother: children ever born (CEB), educational attainment, and household wealth. CEB is the number of children ever born at the time of the survey (not including current pregnancies). Educational attainment of mothers is coded with four categories: no education, primary, secondary, or higher. Respondents' household wealth is included as a covariate because of the strong association between higher wealth and higher child survival probabilities. The wealth index is a measure of the relative level of a household's wealth within a country based on a principal component analysis of household assets. The DHS divides households into five quintiles, calculated as the deviation of a household's wealth relative to that country's mean wealth (Rutstein and Johnson 2004).

[3]There is no international or standardized definition of urban and rural http://unstats.un.org/unsd/demographic/sconcerns/densurb/densurbmethods.htm

Methods

First, I show descriptive statistics for the pooled sample. Although there is some variation in distribution of characteristics of the covariates across countries, they are relatively similar across countries and well-represented by the pooled descriptive statistics. The pooled samples of all mothers are weighted at the country level to account for the multistage sampling design, but the subsequent pooled regressions are not weighted.

Next, I estimate Kaplan-Meier survival curves to test whether there are differences in survival to age by residence. This provides a nonparametric estimate of the survivor function *S(t)*, the probability of survival past time *t* (Cleves *et al.* 2010). All children born within the five years preceding the survey are included, with children considered at risk of death until age 5 and then left-censored. One advantage of using the Kaplan-Meier method is that it can produce survival estimates for the most recent time period (i.e. the past five years), rather than only for those children who were born five or more years before the survey. This permits calculating under-5 survival probabilities for the five years preceding each survey, without any overlap between each country's surveys. Under-5 mortality rates within urban areas (RGLCs and all other areas classified as urban) are then considered separately to investigate the association between the rate of urban size and growth and under-5 mortality risks.

Last, I use Cox proportional hazards models to examine the relationship between survival to age 5 by residence and a set of demographic and socio-economic variables known to impact under-5 mortality. The Cox regression calculates a hazard rate as a factor of a baseline hazard and included covariates. The outcome variable is the risk of death from birth to age five. A Cox model is fit separately the data from 1995-2000 and 2005-2010, to provide a basis for comparison of the pooled data at each time point to identify any changes between these two periods. I estimate three models. Model 1 is a Cox regression with residential status as the only covariate. Model 2 includes residential status and mother's migration status. Model 3 includes the addition of children ever born. Model 4 is the same as Model 3 but with the addition of two socio-economic variables: highest level of education attained and wealth quintile. All models were also run with country-level fixed effects but as this did not change the significance of any results they are not shown here.

The analysis is segmented at two levels: 1) stratified by urban and rural areas and 2) stratified within urban areas by: a) rapidly-growing large cities (RGLCs): those that have experienced an average annual growth rate of 2.5% or more for the period 1995-2010 among cities with estimated populations greater than 750,000 and b) all other areas designated as urban in the DHS (see Table 2). This division of urban areas is theoretical as well as practical. Theoretically, if rapid increases in population are more likely to lead to declining survival outcomes for children under five, then the effects would be most evident in the cities experiencing the fastest and/or greatest absolute growth. The practical reasons are factors of data reliability and comparability. Although the majority of urban residents in SSA live in small to mid-sized cities, there is no reliable information on the populations or growth of these cities, given the variability in quality of country-level data (Montgomery 2009; NRC 2003), rendering meaningful cross-country comparisons nearly impossible. Thus, I segment the largest cities using the United Nations Population Division population estimates and annual growth rates for cities with populations of 750,000 and compare them to all other areas classified in the DHS as "urban". Of those cities with populations over 750,000 with the exception of Harare, all of the cities grew by more than 2.5% per annum between 1995 and 2010, and are thus classified in this analysis as RGLCs.

This study compares averages of under-5 survival probabilities between urban and rural areas and does not seek to measure differences in sub-groups of these populations. These averages no doubt conceal substantial heterogeneity within populations, particularly intra-urban disparities of child morality between the poor and non-poor, but still provide a useful measurement of the combined effect of geographically specific variations in health outcomes on survival probabilities for children. The paper's main question is, on average, does living in a SSA city remain advantageous for survival chances of young children and has this advantage changed?

Results

Table 3 shows that just under a third of respondents live in urban areas, with only a slight increase in this proportion over the two time periods. Of those respondents who live in urban areas, only a minority live in the rapidly-growing large cities RGLCs (32.2 percent in 1995-2000 and 27.1 percent in 2005-2010). A substantial proportion of respondents have moved within the past five years, the most notable increase among women living in RGLCs where the proportion increased from 25% to 35% between the two periods. A higher proportion of women in urban areas, and particularly in RGLCs, have completed secondary or higher education than their rural counterparts. The average number of children ever born (CEB) also reflects the expected the residential hierarchy with lower fertility in large urban areas and higher fertility in rural areas.

The most salient difference between both urban and rural and intra-urban respondents is wealth, with wealth concentrated in the rapidly growing cities. [4] Over 70% of residents in the RGLCs in both time periods are in the highest wealth quintile, with only 1% or fewer in the

[4] Wealth index information is not available for the Nigeria 1999 DHS and thus the wealth quintile statistics for the 1995-2000 period do not include information on Nigeria.

lowest quintile. At the combined urban level, the majority of respondents are in the richest two quintiles. This is in sharp contrast to the rural areas, where the majority of respondents are in the poorest two quintiles and less that 5% in the richest. This suggests that differences in net under-5 survival rates could be due to differences in wealth.

Kaplan-Meier Survival Estimates

Table 4 shows probabilities of survival to age 5 by rural and urban residence for the 12 countries in the sample and two time periods. It shows that survival to age 5 is higher for urban residents than rural residents in all countries 1995-2000 and almost all countries for the later time period, 2005-2010. Survival changes for under-5s have increased at the aggregate level in both rural and urban areas between the two time periods. Moreover, most individual countries also show improvements in under-5 survival estimates, with the exception of Ghana, with a slight decrease for urban areas and Nigeria, with slight decreases for both urban and rural areas.

The urban advantage holds but has narrowed slightly between these two periods, with a decrease in the absolute difference in urban and rural under-5 survival chances by -.006. At the aggregate level there with slightly higher gains on average at the rural level have led to a slight decrease in the overall urban under-5 survival advantage. Again, there is variation among countries: the majority of countries showing a decline in the urban under-5 survival advantage over rural areas but three countries – Mali, Nigeria and Uganda – showing a widening of the urban survival advantage.

Table 5 also shows survival probabilities to age 5 by country and time period, but this time differentiates between rapidly growing urban areas and other urban areas. It shows that there has been an increase in the relative survival estimates in rapidly-growing large cities

(RGLCs) over other urban areas by .006 for this period. Most of the increase in the differential comes from larger gains in under-5 survival estimates in RGLCs than in other urban areas. Only Ghana and Tanzania show declines in the survival estimates for RGLCs, with Tanzania also having a substantial increase in survival estimates for other urban areas.[5]

Cox Proportional Hazards Models

Next, we turn to results from Cox proportional hazard models, to determine whether the urban child health advantage still holds when adjusting for factors such as compositional differences in the urban and rural populations. Table 6 and Table 7 show the results of the Cox model for the rural-urban comparison and the intra-urban comparison (between the rapidly-growing large cities and all other urban areas) for the periods 1995-2000 and 2005-2010, and test for whether compositional differences in the individual characteristics of these populations explain the differences in under-5 survival rates. When controlling for migration status, CEB, education and wealth I find that residence is only significantly associated with higher under-5 mortality in the rural/urban model in the 2005-2010 period; for the stratified urban areas, there is a survival advantage for children in RGLCs only in 2005-2010 when migration and CEB are included in the model, but this significance disappears in the full model with education and wealth status are added. This emergence of a child survival advantage independent of mother's characteristics in the 2005-2010 period for rural-urban comparison, suggests that geographic factors (including

[5] The log-rank test for equality of survivor functions for the rural/urban comparison of survival estimates is significant at the .05 level at the aggregate for both time periods. At the country level, in 1995-2000, the different survival estimates were significant for all countries except Kenya, Zambia and Zimbabwe, while in 2005-2010 they were significant for all countries except Ghana, Kenya, Uganda and Zimbabwe. For the urban/RGLC comparison at the aggregate level, the log-rank test for equality was not significant in the 1995-2000 period but became significant in the 2005-2010 analysis. At the country level, for the majority of countries the difference between the urban and the RGLC survival estimates were not significant at the .05 level; in the first time period the test of equality was significant only for Ghana and Mali, while in the later period it was significant for Benin, Guinea, Mali and Nigeria.

infrastructure, sanitation and other public health measures) are becoming increasingly influential on average under-5 survival differentials.

The positive association of the hazard of death before age five and mother's migration status is in line with the majority of research which finds that the children of migrants in SSA have higher mortality risks than those of non-migrants. However, this association shows particularly interesting changes between the two time periods. In the final model for the first period, the coefficient for mother's migration is significant only in the rural/urban regression. In the second period, mother's migration status is significantly associated with an increased risk of under-5 mortality for both the rural/urban and intra-urban regressions. Notably, the adjustment for demographic and socio-economic covariates strengthened the association between the migration and under-5 mortality risks, implying that migration poses a substantially greater risk for survival to age five in all geographic areas after population distribution factors are taken into account. The increase in the magnitude of the coefficient of the hazard for under-5 mortality between the two periods suggests that children of migrants in the later period experience greater risk of under-5 mortality than in the earlier period.

As expected, higher levels of education are associated with significantly lower hazards of under-5 mortality, with higher levels of mother's completed education associated with greater likelihood of surviving to age 5 and completion of higher education having the largest effect of any covariate in the full model on under-5 survival chances. However, the magnitude of the coefficients at every level decreases between 1995-2000 and 2005-2010. Surprisingly, completed primary education, compared to no education, is *not* significantly associated with under-5 survival in the intra-urban regression. It is not clear why having completed primary school offers no statistically significant advantage for under-5 survival in RGLCs compared to other urban areas, although Caldwell (1979) argued that only at the junior high school level did mother's education provide a protective effective for child health. Speculatively, this may also be a factor of the measure of education as *completed* education, if more women in RGLCs compared to other urban areas have at least a few years of primary education, but are still classified as having "no education".

The finding that household wealth is not significantly associated with under-5 survival rates in most cases is somewhat surprising, given the extensive literature linking household wealth to increased child survival chances [6]. This may largely be a reflection of the heavy concentration of wealth in cities and poverty in rural areas, but it unlikely accounts for all of the explanation. It may also be that the effect of household wealth is attenuated by the different geographically specific variations in rural and urban areas, namely the superior infrastructure and health services generally found in cities. As the overwhelming majority of women in RGLCs in both periods are in the richest wealth quintile and are more likely to have higher education levels, interactions were tested for residence and education or residence and wealth but were not found to be significant in either case.

Discussion

This study aims to determine if the long-held urban under-5 survival advantage in SSA has decreased and, if so, whether the diminishing urban advantage is most pronounced in the largest and fastest growing cities or if it is uniform across all urban areas. The urban advantage persists in SSA, with under-5 survival probabilities highest in the largest cities, then in other urban areas

[6] As wealth quintile information for Nigeria for the 1999 DHS is not available, it was not included in the Model 4 of the 1995-2000 regressions. While we cannot know if or how this might impact wealth quintile results for these models, when Models 1, 2 and 3 were run without Nigeria, there were no changes in the statistical significance of any coefficients, so it seems reasonable to assume that having Nigeria's wealth quintile data would not likely lead to changes in the results.

and lowest in rural areas. The absolute risk of under-5 mortality by residence is attenuated after controlling for a set of the mother's demographic and socio-economic characteristics: migration status, children ever born, education and wealth. After including these covariates, the under-5 survival advantage remains significant between rural and urban areas in the 2005-2010 period, but not 1995-2000. The emergence of this significant association between residence and under -5 mortality hazard in the final rural-urban model for the 2005-2010 time period implies that urban residence increasingly grants children a mortality advantage independent of their mother's demographic and socioeconomic characteristics not found in the earlier period. This contrasts findings from studies which attribute the SSA urban child health advantage not to place of residence but to household socio-economic factors (van de Poel et al. 2007; Bocquier et al. 2011).

Changes in the results from the Cox proportional hazards models show that the emergence of a significant urban advantage in under-5 survival chances over rural areas is accompanied by changes in the influence of other covariates. The coefficients for the socio-economic characteristics of the mother in the model (education and wealth) decrease while those for the demographic characteristics (migration status and CEB) increase. This suggests that a statistically significant urban advantage is due in part to decreasing influence of socio-economic factors and increasing importance of demographic characteristics.

Perhaps most importantly, this analysis indicates that the overall decrease in the urban advantage is due largely to slower improvements or declines in survival rates in small- or medium-sized urban areas, not in the largest cities. This finding lends supports other research which suggests that with continued urbanization in SSA the greatest threats to urban child health are likely to be found in smaller cities (Brockerhoff and Brennan 1998; Montgomery 2009). This also means that in contemporary SSA, unlike the early experiences of European and American cities, better under-5 survival chances in the largest cities play a key role in the persistence of this urban advantage. Despite substantial increases in absolute population numbers, the largest cities remain more favourable towards higher child survival rates in SSA, which may reflect in large part the tendency in poorer countries for infrastructure and public services to be concentrated in the largest cities (Brockerhoff and Brennan 1998) and the relatively larger strains of greater *rates* of population growth among smaller urban areas.

This research has several limitations that should be addressed in future work. First, this analysis attributes under-5 deaths to the place of residence of the mother at the time of the survey, which may not represent the true residence history of the child. Inaccurately accounting for migration status can introduce bias into estimates of mortality rates if residence at the time of survey is assumed to apply to the entire life span of the child in question, even when the mother and/or child changed location during the child's life. However, Bocquier, Madise and Zulu (2011) found that the impact of adjusting for migration status over the child's lifetime in Kaplan-Meier estimates on under-5 mortality was minimal. Furthermore, as the DHS only provides information on last move, attempting to divide period of risk of dying between current residence and last place of residence for migrants may miss circular and temporary migrations and still fail to adequately apply risk times for children. Secondly, this study does not account for causes of death, could account for some of the residential differentiation of under-5 mortality risk. Lastly, this analysis focuses on the combined effect of geographically specific variations in under-5 mortality beyond individual and household characteristics, but it does not account for variation in environmentally specific factors between and among urban and rural areas. Many of the determinants of child health are related to including infrastructure, sanitation services, access to and use of health services, and neighbourhood effects, and future contributions to the literature on the regional urban under-5 health advantage in SSA could take into account the effects of these factors.

The long-held urban child survival advantage over rural areas in SSA remains, but has decreased slightly. Despite unprecedented population growth and worsening health indicators among the urban poor and recent migrants, combined effect of urban living in SSA offers children better chances on average of surviving to age five. Controlling for socio-demographic indicators attenuates but does not erase this advantage. The narrowing in the urban advantage is due to lags in improvements in survival rates in small or medium-sized compared to both the largest cities and rural areas. These findings add to the growing literature which finds that rapid urbanization and population growth in SSA poses the greatest risk to improvements in child survival in the smaller cities which are likely to see the greatest proportional growth in the coming decades.

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Table 1: Description of DHS datasets

Country	Year of Survey 1 (1995-2000)	*Mothers*	*Children*	Year of Survey 2 (2005-2010)	*Mothers*	Children
Benin	1996	*3,322*	*5,228*	2006	*10,641*	*16,322*
Ghana	1998	*2,391*	*3,345*	2008	*2,158*	*3,032*
Guinea	1999	*4,073*	*6,012*	2005	*4,487*	*6,526*
Kenya	1998	*3,834*	*5,778*	2008	*4,103*	*6,148*
Mali	1996	*6,304*	*10,427*	2006	*9,067*	*14,468*
Niger	1998	*4,058*	*6,360*	2006	*18,090*	*29,058*
Nigeria	1999	*4,874*	*8,138*	2008	*5,909*	*9,317*
Senegal	1997	*4,808*	*7,490*	2005	*7,196*	*11,127*
Tanzania	1999	*2,137*	*3,268*	2010	*5,385*	*8,125*
Uganda	1995	*4,315*	*7,277*	2006	*5,024*	*8,478*
Zambia	1996	*4,628*	*7,339*	2007	*4,162*	*6,477*
Zimbabwe	1999	*5,686*	*7,394*	2006	*8,218*	*10,680*
N		**50,430**	**78,056**		**84,440**	**129,758**

Table 2: Average annual growth rate of rapidly-growing large cities by country

No.	Country	Major cities[a]	Average annual city growth rate (%)[b]			
			1995-2000	**2000-2005**	**2005-2010**	**Avg 1995-2010**
1	Benin	*Cotonu*	2.13	2.28	3.19	**2.53**
2	Ghana	*Accra*	3.35	3.41	3.30	**3.35**
		Kumasi	5.34	4.94	3.76	**4.68**
3	Guinea	*Conakry*	3.08	2.92	3.17	**3.06**
4	Kenya	*Nairobi*	3.67	3.79	3.78	**3.75**
		Mombasa	4.79	4.65	4.50	**4.65**
5	Mali	*Bamako*	3.97	4.19	4.32	**4.16**
6	Niger	*Niamey*	4.55	4.42	4.22	**4.40**
7	Nigeria	*Abuja*	9.16	9.16	8.33	**8.88**
		Benin City	2.85	2.85	2.95	**2.88**
		Lagos	3.85	3.85	3.76	**3.82**
		Ogbomosho	2.49	2.49	2.65	**2.54**
8	Senegal	*Dakar*	3.68	3.64	3.25	**3.52**
9	Tanzania	*Dar es Salaam*	4.75	4.73	4.46	**4.65**
10	Uganda	*Kampala*	3.68	3.68	3.85	**3.74**
11	Zambia	*Lusaka*	3.49	3.29	2.74	**3.17**
12	Zimbabwe	*Harare*	1.89	1.85	1.51	**1.75**

[a] Urban agglomerations with 750,000 inhabitants or more in 2009 (United Nations Population Division 2010)

[b] Average annual rate of change of urban agglomerations with 750,000 inhabitants or more in 2009 (United Nations Population Division 2009)

Table 3: Descriptive statistics by mothers' residence type from 12 DHS surveys

Mothers' characteristics by residence: rural and urban and intra-urban								
	1995-2000				2005-2010			
	Rural	**Urban**	**RGLCs[a]**	**Other cities**	**Rural**	**Urban**	**RGLCs[a]**	**Other cities**
Residence (%)	72.0	27.7	32.2	67.8	71.3	28.8	24.9	75.2
Highest education level (%)								
no education	59.4	37.9	32.2	40.5	59.5	38.9	28.4	42.3
primary	30.5	32.5	33.7	31.9	28.5	27.9	30.2	27.1
secondary	9.6	27.0	30.3	25.4	11.0	27.9	32.7	26.3
higher	0.5	2.7	3.8	2.2	0.9	5.4	8.7	4.3
Wealth quintile (%)[b]								
poorest	30.1	3.1	0.5	4.3	30.4	3.8	0.2	5.2
poorer	26.7	5.0	1.0	6.8	27.6	5.7	0.4	7.5
middle	23.1	9.0	2.6	11.9	22.9	13.2	2.5	16.8
richer	15.4	27.4	23.6	29.2	14.9	29.3	17.9	33.1
richest	4.7	55.5	72.4	47.8	4.2	48.0	79.1	37.7
Moved in past 5 years (%)	22.9	28.8	25.0	30.6	20.7	30.1	35.8	28.3
Age (mean years)	28.9	28.3	28.3	28.4	29.1	28.9	29.0	28.9
Children ever born	4.3	3.7	3.4	3.8	4.4	3.7	3.1	3.6
N (intra-urban)			*4,246*	*8,944*			*6,267*	*16,831*
N	34,397	13,190			57,223	23,098		

[a] Rapidly-growing large cities (RGLC)

[b] Excluding Nigeria DHS 1999

Source: DHS Surveys 1995-2010

Notes: Rural-urban statistics includes all respondents, while the intra-urban statistics are comprised a sub-group of all the respondents classified in the DHS as living in urban areas. Of those cities with populations over 750,000 with the exception of Harare, all of the cities grew by more than 2.5% per annum between 1995 and 2010, and are thus classified in this analysis as RGLCs.

Table 4: Kaplan-Meier under-5 survival estimate comparison: rural and urban

Kaplan-Meier survival estimates to age 5 by residence: Rural and urban											
	1995-2000					2005-2010					Change in difference: *diff 2005-2010 - diff 1995-2000*
Country	*Survey year*	Urban (u)	Rural (r)	Absolute difference *(u) - (r)*	Relative risk *(u) / (r)*	*Survey year*	Urban (u)	Rural (r)	Absolute difference *(u)-(r)*	Relative risk *(u) / (r)*	
All Countries	***1997.5***	**0.868**	**0.830**	**0.038**	**1.045**	**2006.5**	**0.900**	**0.869**	**0.032**	**1.037**	**-0.006**
Benin	*1996*	0.876	0.841	0.035	1.042	*2006*	0.906	0.876	0.030	1.034	-0.006
Ghana	*1998*	0.930	0.890	0.040	1.045	*2008*	0.919	0.923	-0.003	0.997	-0.043
Guinea	*1999*	0.873	0.812	0.062	1.076	*2005*	0.883	0.849	0.034	1.040	-0.028
Kenya	*1998*	0.904	0.890	0.014	1.016	*2008*	0.939	0.926	0.013	1.014	-0.002
Mali	*1996*	0.821	0.770	0.051	1.067	*2006*	0.881	0.812	0.069	1.085	0.018
Niger	*1998*	0.846	0.750	0.096	1.128	*2006*	0.893	0.844	0.050	1.059	-0.046
Nigeria	*1999*	0.883	0.840	0.043	1.051	*2008*	0.880	0.833	0.047	1.056	0.004
Senegal	*1997*	0.903	0.856	0.047	1.055	*2005*	0.926	0.891	0.035	1.039	-0.012
Tanzania	*1999*	0.891	0.821	0.069	1.084	*2010*	0.918	0.930	-0.012	0.987	-0.081
Uganda	*1995*	0.868	0.849	0.020	1.023	*2006*	0.905	0.877	0.028	1.032	0.009
Zambia	*1996*	0.824	0.813	0.011	1.014	*2007*	0.883	0.901	-0.018	0.980	-0.029
Zimbabwe	*1999*	0.918	0.899	0.020	1.022	*2006*	0.931	0.913	0.018	1.020	-0.001

Source: DHS Surveys 1995-2010. Time between surveys per country ranges from 6-11 years, with an average of 9 years.

Table 5: Kaplan-Meier under-5 survival estimate comparison: between urban areas

Kaplan-Meier survival estimates to age 5 by residence: Rapidly-growing large cities (RGLCs) and all other urban areas

Country	Rapidly-growing large cities	**1995-2000** *Survey year*	Rapid Cities (c)	Other Urban (o)	Absolute difference *(c) -(o)*	Relative risk *(c) / (o)*	**2005-2010** *Survey year*	Rapid Cities (c)	Other Urban (o)	Absolute difference *(c)-(o)*	Relative risk *(c) / (o)*	Change in difference: *diff 2005-2010 - diff 1995-2000*
All Countries		***1997.5***	**0.878**	**0.864**	**0.014**	**1.017**	***2006.5***	**0.916**	**0.896**	**0.020**	**1.022**	**0.006**
Benin	*Cotonou*	*1996*	0.855	0.882	-0.027	0.969	*2006*	0.935	0.899	0.036	1.040	0.063
Ghana	*Accra, Kumasi*	*1998*	0.976	0.910	0.066	1.073	*2008*	0.946	0.906	0.040	1.044	-0.027
Guinea	*Conakry*	*1999*	0.881	0.865	0.016	1.019	*2005*	0.908	0.868	0.040	1.045	0.023
Kenya	*Mombasa, Nairobi*	*1998*	0.905	0.904	0.001	1.001	*2008*	0.954	0.930	0.024	1.025	0.023
Mali	*Bamako*	*1996*	0.871	0.797	0.073	1.092	*2006*	0.907	0.868	0.038	1.044	-0.035
Niger	*Niamey*	*1998*	0.874	0.830	0.044	1.052	*2006*	0.890	0.895	-0.005	0.994	-0.049
Nigeria	*Abuja, Edo, Lagos, Oyo*	*1999*	0.919	0.874	0.045	1.051	*2008*	0.924	0.869	0.055	1.063	0.010
Senegal	*Dakar*	*1997*	0.888	0.910	-0.022	0.976	*2005*	0.920	0.927	-0.007	0.992	0.015
Tanzania	*Dar es Salaam*	*1999*	0.910	0.886	0.023	1.026	*2010*	0.888	0.923	-0.035	0.963	-0.058
Uganda	*Kampala*	*1995*	0.877	0.867	0.011	1.012	*2006*	0.920	0.890	0.030	1.034	0.019
Zambia	*Lusaka*	*1996*	0.816	0.827	-0.010	0.987	*2007*	0.863	0.888	-0.025	0.972	-0.014
Zimbabwe	*n/a*	*1999*					*2006*					

Source: DHS Surveys 1995-2010. Time between surveys per country ranges from 6-11 years, with an average of 9 years.

Table 6: Cox proportional hazards model for 5nder-5 mortality risk: 1995-2000 [a]

	Rural and Urban				Urban and RGLCs			
	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
Urban areas (ref: rural)	0.772***	0.771***	0.792***	0.974				
RGLCs (ref: other urban)					0.936	0.936	0.948	0.998
Mother's migration status (ref: non-migrant)		1.006	1.098***	1.164***		0.998	1.058	1.105
Children ever born			1.051***	1.028***			1.049***	1.015
Highest education level (ref: no educ.)								
Primary				0.786***				0.967
Secondary				0.542***				0.572***
Higher				0.412***				0.416***
Wealth quintile (ref: poorest)[b]								
Poorer				1.043				1.364*
Middle				1.013				1.089
Richer				0.98				0.985
Richest				0.801***				0.847
N	78,056	78,056	78,056	71,694	20,552	20,552	20,552	18,735

Exponentiated coefficients; * p<.05, ** p<.01, *** p<.001

[a]Source: DHS Surveys 1995-2000 (Benin 1996, Ghana 1998, Guinea 1999, Kenya 1998, Mali 1996, Niger 1998, Nigeria 1999, Senegal 1997, Tanzania 1999, Uganda 1995, Zambia 1996, Zimbabwe 1999)

[b] Wealth quintile information does not include Nigeria 1999

Table 7: Cox proportional hazards model for under-5 mortality risk: 2005-2010 [a]

	Rural and Urban				Urban and RGLCs			
	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
Urban areas (ref: rural)	0.765***	0.758***	0.796***	0.910***				
RGLCs (ref: urban)					0.842***	0.838***	0.872**	0.989
Mother's migration status (ref: non-migrant)		1.107***	1.251***	1.313***		1.072	1.179***	1.222***
Children ever born			1.082***	1.071***			1.084***	1.062***
Highest education level (ref: no educ.)								
Primary				0.802***				0.961
Secondary				0.763***				0.789***
Higher				0.501***				0.541***
Wealth quintile (ref: poorest)								
Poorer				1.018				1.053
Middle				0.991				0.858
Richer				0.968				0.847
Richest				0.816***				0.708***
N	129,755	129,755	129,755	129,755	35,273	35,273	35,273	35,273

Exponentiated coefficients; * p<.05, ** p<.01, *** p<.001

[a]Source: DHS Surveys 2005-2010 (Benin 2006, Ghana 2008, Guinea 2005, Kenya 2008, Mali 2006, Niger 2006, Nigeria 2008, Senegal 2005, Tanzania 2010, Uganda 2006, Zambia 2007, Zimbabwe 2006