Urban-Rural Disparities in Adult Mortality in Sub-Saharan Africa

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ABSTRACT

Empirical evidence showing higher levels of survivorship in urban areas of Sub-Saharan Africa (SSA) supports a general theory of rural disadvantage. Yet, evidence on the residential gradient in mortality in SSA builds almost exclusively on children. This study uses a broad set of nationally representative data sources and explores adult mortality differences by residence across SSA. The indirect orphanhood method is applied to 90 Demographic and Health Survey datasets from 30 SSA countries from 1991 to 2014. Estimated survivorship ratios are converted to probabilities of dying between ages 15 and 60 ($_{45}q_{15}$) for rural and urban populations separately. We find urban levels to exceed rural for many individual countries and for SSA as a whole. Amongst adult women the mean $_{45}q_{15}$ is 0·2809 and 0·2741 and amongst adult men 0·3065 and 0·2922 in urban and rural populations, respectively. Multivariate models suggest that as countries develop they move from higher urban to higher rural adult mortality. The slow (and slowing) of the demographic transition in SSA may explain why urban mortality often remains higher than rural. Failure to reduce adult mortality in cities may harm the ability of countries in SSA to harness demographic dividend.

INTRODUCTION

Empirical evidence from Sub-Saharan Africa (SSA) consistently shows an urban mortality advantage: mortality levels appear substantially lower in cities in comparison to those found in rural areas (Akoto and Tambashe 2002; Bocquier et al. 2011; Cai and Chongsuvivatwong 2006; Fink et al. 2013; Gould 1998). This suggests SSA is consistent with patterns in other regions, where mortality has consistently been shown to be lower in urban areas (Buckley 1998; Snyder 2016). It also fits the general pattern predicted by the epidemiological transition where mortality rates in urban areas fall below those in rural once public health and sanitation expand and pandemics recede (Dye 2008; Omran 1971). Yet, it turns out that the empirical foundations of the well-established rural disadvantage in mortality for SSA are built on evidence from infant or child survivorship, and more occasionally maternal mortality. In fact, despite recognition of the value of lowering mortality in SSA as a whole (UN 2015), there is surprisingly little empirical evidence showing how adult mortality levels compare across urban and rural sectors (see Günther and Harttgen (2012) as an exception).

The lack of evidence on adult mortality across SSA is surprising. Adults in cities should be expected to also enjoy lower mortality, particularly given longstanding urban bias (Lipton 1977), expanded health service provision in cities (The Lancet 2015) and better educational and economic opportunities in urban areas (Lipton 1977; Sahn and Stifel 2003). In this article we assess the extent of rural/urban adult mortality differences for men and women, and whether existing differences vary as countries develop. We also consider the role of HIV prevalence in shifting the burden of disease to urban areas over the last three decades.

We build both on the wide expansion of survey data across Sub-Saharan Africa and expanded methodological tools to estimate adult mortality. In recent decades indirect methods of estimating mortality have advanced enabling estimates of adult mortality in low income settings where vital registration is often incomplete or inaccurate (Gakidou et al. 2004; Timaeus 1991). The spread of household surveys in poorer countries has expanded access to data necessary for application of indirect methods for estimation of adult mortality. Moreover, the data combined with these powerful methods makes it possible to estimate within-country spatial variation in mortality for adults, while addressing particular challenges raised by internal migration patterns. Before presenting our results, we explain why the orphanhood method is the most appropriate approach for estimating separate urban and rural adult mortality levels.

Empirical evidence of national adult mortality levels so far paints a clear picture: adult mortality is higher in developing countries where insufficient resources are focused on avoiding premature deaths (Murray and Feachem 1990; Rajaratnam et al. 2010). At the sub-national level, both under-five mortality and adult mortality are higher in many less developed countries rural areas compared to urban (Akoto and Tambashe 2002; Bocquier et al. 2011; Buckley 1998; Cai and Chongsuvivatwong 2006). There is widespread evidence of the urban advantage for under-five mortality in SSA. However, there is yet little empirical evidence on rural/urban gaps in adult mortality in SSA despite extensive implications for understanding the spatial distribution of deaths. To reduce premature deaths, policy makers need to identify where populations require more resources and address inequalities between rural and urban populations (The Lancet 2015). Moreover, they need to recognise that adult mortality is concentrated amongst the socially and economically most active population, with adult losses often imposing heavy burdens on families, communities, and states in developing countries (Beegle et al. 2008; Dixon et al. 2002).

More generally, demographic transition theory suggests that urban mortality will remain higher than rural mortality until the final stage of transition (Dyson 2011). Whether this holds true in SSA is less clear. On the one hand, both mortality and fertility rates provide evidence of a transition already set in motion. On the other hand, despite rapid urbanization trends across SSA in the 1960s, this urban growth is mostly “urbanization without growth” (Fay and Opal 2000). The relatively weak state of industrialization common to many SSA states and the continued economic stagnation across much of the continent offer little or no basis for predicting trends in adult mortality and their differences across the urban and rural sectors. In fact, the strong emphasis of development and health projects on under-five mortality may have unintentionally contributed to a relative neglect of adults. Thus, SSA offers a compelling opportunity to explore whether the urban disadvantage in adult mortality persists under these conditions.

METHODOLOGY & DATA

Most countries in SSA lack sufficient population registration and mortality records that are necessary for direct estimation of adult mortality (Timaeus 1991). Surveys that incorporate questions on recent adult deaths also fail to provide adequate information to estimate adult mortality as they are typically limited by sample size (Timaeus 1991), which become even more problematic if regional or sectoral estimates are needed. The most important response has been the development of indirect methods to estimate mortality including the sibling and orphanhood methods (Brass et al. 1981; Brass 1975). Both these methods use a very limited set of questions collected from surviving relatives – surviving children in the case of orphanhood and siblings in the case the sibling method – to estimate mortality at one or two points back in time. Both methods have been shown to be effective at capturing broad trends and levels of adult mortality used for population forecasting and resource allocation (Timaeus and Jasseh 2004; Timaeus 1991).

Despite their similarities, there are important differences between the sibling and orphanhood methods. The sibling method uses the proportion of brothers or sisters surviving by age of respondent as an indicator of survivorship. It allows for occurrence-exposure mortality rates to be calculated for defined periods and age groups. The orphanhood method uses responses to questions on the age of respondents and parental survival to enable calculation of lifetable measures of conditional survivorship in adulthood (Brass et al. 1981; Timaeus 1986; Timaeus 1992). The orphanhood method produces relatively recent estimates for past adult mortality when data are obtained from children ages five to fourteen.

Estimates of general adult mortality produced by both the sibling and orphanhood methods may also suffer from biases. Underreporting is common in sibling history data collection when siblings may die before the respondent's birth, or where there is no contact between siblings. Selection bias using the sibling method leads to lower estimates of mortality when groups of siblings with high mortality are underrepresented (Gakidou and King 2006; Masquelier 2013). The orphanhood method can be biased due to coverage error – childless adults are not included. Further bias may arise if the parental probability of survival is related to the number of surviving children, although such biases appear small (Palloni et al. 1984).

While the above biases are well recognized, there are typically few alternatives and estimates of adult mortality produced using both methods are considered "adequate for many practical purposes" (Timaeus 1991). However, when estimating separate urban and rural adult mortality within countries, the biases in each of these methods are potentially magnified. For example, nulliparous adults will likely be more common in urban settings. However, one critical advantage of the orphanhood method over the sibling survivorship method is that mortality of parents of young children will have *typically* occurred while children and parents were co-resident and shared their rural/urban status. (Of course, it is possible that parental mortality leads to orphan migration and we explore this concern below.) The assumption of shared rural/urban status is more difficult to make for adult siblings, reducing the value of the sibling approach for estimating separate rural/urban adult mortality levels. Robustness tests following our main analyses provide additional support for our findings.

Our analyses are based on data from the Demographic and Health Surveys (DHS), which include questions on parental survivorship from household members aged zero to 17. We apply the orphanhood method to estimate separate urban and rural adult mortality levels from 90 surveys conducted between 1991 and 2014 that cover a total of 30 SSA countries. Since respondents' mothers were alive when respondents were born (and fathers alive at time of conception) their exposure to risk of dying is the age of the respondents. Using information on the mean age at which mothers give birth in the rural and urban sectors, it is possible to predict life table survivorship from age 25 to 35, or l_{25+n}/l_{25} in standard demographic notation where l_x represents survival to age x. The mean age at which men have children is estimated by adding an index (calculated from the sex difference in median ages of those currently married) to women's mean age of childbearing. Life table survivorship for men is from age 35 to 45 as they are typically older than their partners. Survivorship ratios are then converted to a common index of mortality, the probability of dying between exact ages 15 and 60 conditional on survival to age 15, ${}_{45}q_{15}$, by fitting a one-parameter relational logit model life table.

The survivorship ratio from the orphanhood method represents the average mortality during the years that parents were exposed to the risk of dying. A "time location" for the mortality estimate is calculated by matching the survivorship ratio to period survivorship. The point in time the estimates refer to are dated further back into the past as the age of the respondent increases.

Mortality estimates for SSA based on the orphanhood method may be biased downward in countries with widespread HIV/AIDS and limited access to treatment (Timaeus and Nunn 1997). There are two main sources for the bias. Firstly, HIV positive women can transmit the virus to their children, who are then less likely to survive to report on parental deaths. Secondly, HIV positive women typically have lower fertility than uninfected women. This leaves fewer children in the population to report on parental death, which exaggerates the proportion of mothers alive. A correction for this bias has been developed for countries with moderately severe HIV epidemics (Timaeus and Nunn 1997).

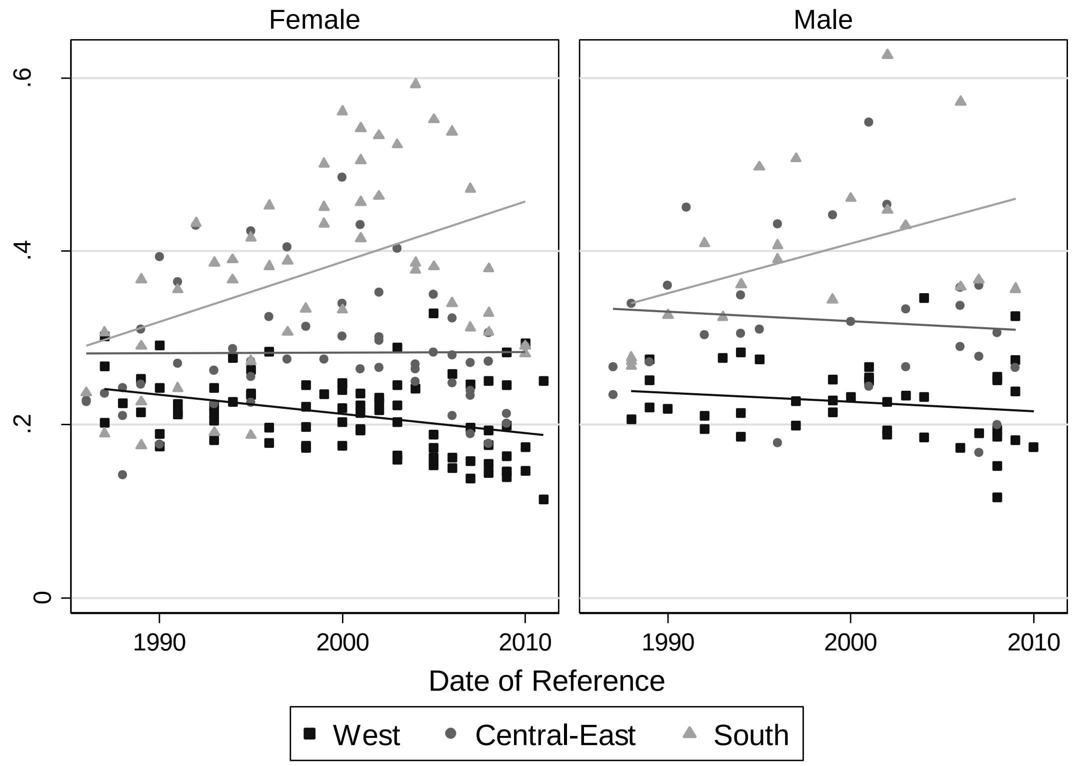
Despite the advantages of correction, several considerations lead us to withhold the correction in our main analyses. Firstly, the necessary data for application of the corrections including HIV infection prevalence, mother-to-child transmission rate, relative level of fertility of HIV positive to HIV negative women and the proportion of men with infected partners are not typically available by rural/urban sector for most countries in SSA. Where these data do exist, evidence on HIV prevalence across countries in SSA show higher urban prevalence rates (Barongo et al. 1992; Dyson 2003; Killewo et al. 1990), indicating that the impact on survivorship would be particularly strong in urban populations. This suggests that urban relative to rural adult mortality is likely biased upwards, at least where HIV prevalence is high. A second reason not to correct for HIV bias is the increased spread of HIV anti-retroviral treatments in recent years, changing the relationship between HIV and mortality and rendering a correction possibly obsolete for estimates from the latest surveys. A third justification lies in maintaining uniformity in estimating mortality across countries and time. Finally, and perhaps most importantly, we verified the robustness of our findings by applying the correction for East African countries with HIV prevalence of between five and ten percent and our results on rural/urban adult mortality differentials remained consistent.

We examine rural/urban adult mortality over time, as countries urbanise and develop and over the course of the demographic transition. Our multivariate analyses explore the relationship between adult mortality and a series of predictors including urban setting, sex, time period, proportion of country urban, national development, and HIV prevalence. In order to understand why some countries appear to transition more quickly to higher relative rural mortality while others more slowly, we develop a model that incorporates various additional rural/urban characteristics, including maternal education, total fertility and housing characteristics, which may hinder the crossover to an urban mortality advantage. Our analyses are based on a series of fixed effects models that account for between-country sources of heterogeneity that are both observed as well as differences that are fixed but unobserved.

RESULTS

National level estimates of adult mortality from 1986 till 2011, seen in Figure 1, highlight disparities in adult mortality across regions along with important similarities by sex. Among all three regions, countries in Western Africa have lower levels of mortality. There, the female probability of dying between ages 15 and 60 (${}_{45}q_{15}$) drops below 20% in later years while male ${}_{45}q_{15}$ remains fairly stable. Higher levels of mortality are seen in Southern Africa amongst both sexes, increasing sharply over this time period, and most likely driven by high HIV prevalence (Timaeus and Jasseh 2004). Yet, amongst females, there seems to be a start of decline in mortality levels in the late 2000s in SSA, as noted by others (Rajaratnam et al. 2010). Overall, while the orphanhood method generates twice as many data points for women as compared to men, there is an impressive degree of consistency in trends for men and women across all three regions.

Fig. 1 National level adult mortality estimates (${}_{45}q_{15}$) for Sub-Saharan Africa using orphanhood method, by sex and region



Note: Our analysis includes 90 surveys from 30 SSA countries. Regional divisions as presented in Table 1.

Table 1 presents the estimated probabilities of dying between ages 15 and 60 for 30 SSA countries by rural/urban residence and the urban/rural mortality ratio, by sex. These results show variation between countries and region. Women on average have higher urban mortality for all regions; men have lower urban mortality in Southern Africa, almost equal rural/urban adult mortality in Central-East Africa, and much higher urban mortality in West Africa. When weighted by country population size, urban mortality is higher for both women and men in all regions except Central-East Africa, where *male* rural mortality is higher than urban.

Table 1 Adult mortality in Sub-Saharan Africa between ages 15 and 60 by rural and urban residence and ratio of urban/rural mortality, by sex

Country	Survey	Female				Male			
		Reference Date	Urban 45q15	Rural 45q15	Urban/Rural Ratio	Reference Date	Urban 45q15	Rural 45q15	Urban/Rural Ratio
Western Africa									
Benin	1996	1991	0.167	0.240	0.70	1992	0.231	0.198	1.17
		1993	0.237	0.245	0.97				
	2001	1996	0.180	0.178	1.01	1997	0.223	0.229	0.97
		1998	0.163	0.177	0.92				
	2006	2001	0.202	0.188	1.07	2002	0.226	0.226	1.00
		2003	0.188	0.238	0.79				
	2011	2009	0.150	0.143	1.05	2008	0.187	0.186	1.01
		2006	0.156	0.146	1.07				
Burkina Faso	1993	1987	0.293	0.262	1.12	1989	0.311	0.267	1.16
		1990	0.278	0.294	0.95				
	2003	1998	0.271	0.211	1.29	1999	0.361	0.234	1.54
		2000	0.338	0.232	1.45				
	2010	2005	0.241	0.130	1.85	2006	0.257	0.155	1.66
		2007	0.157	0.133	1.17				
Chad	1997	1991	0.215	0.214	1.00	1993	0.328	0.262	1.25
		1994	0.263	0.281	0.94				
	2004	1999	0.375	0.192	1.96	2000	0.366	0.200	1.83
		2001	0.352	0.207	1.70				
Côte d'Ivoire	1994	1989	0.210	0.174	1.21	1990	0.227	0.215	1.06
		1991	0.167	0.217	0.77				
	2005	2000	0.234	0.181	1.29	2001	0.291	0.252	1.15
		2002	0.205	0.238	0.86				
	2011	2006	0.273	0.246	1.11	2008	0.308	0.217	1.42
		2009	0.304	0.207	1.47				
Ghana	1993	1988	0.213	0.232	0.92	1989	0.264	0.245	1.08
		1990	0.193	0.261	0.74				
	1998	1993	0.153	0.196	0.78	1994	0.187	0.222	0.84
		1995	0.161	0.260	0.62				
	2003	1998	0.157	0.189	0.83	1999	0.254	0.212	1.20
		2000	0.205	0.158	1.29				
	2008	2003	0.169	0.160	1.05	2004	0.249	0.222	1.12
		2005	0.198	0.182	1.09				

Guinea	1999	1994	0.226	0.226	1.00	1995	0.313	0.260	1.20
		1996	0.268	0.290	0.93				
	2005	2000	0.280	0.222	1.26	2001	0.322	0.222	1.45
		2002	0.237	0.229	1.04				
	2012	2007	0.291	0.223	1.31	2008	0.322	0.227	1.41
		2009	0.228	0.303	0.75				
Liberia	2007	2001	0.197	0.229	0.86	2003	0.189	0.257	0.74
		2004	0.175	0.273	0.64				
	2013	2008	0.149	0.166	0.90	2009	0.230	0.247	0.93
		2010	0.162	0.189	0.85				
Mali	1996	1990	0.216	0.178	1.21	1992	0.270	0.166	1.62
		1993	0.191	0.209	0.91				
	2001	1996	0.248	0.176	1.41	1997	0.245	0.186	1.32
		1998	0.166	0.205	0.81				
	2006	2001	0.273	0.161	1.70	2002	0.216	0.185	1.17
		2003	0.220	0.196	1.12				
	2012	2007	0.186	0.149	1.25	2008	0.155	0.108	1.44
		2009	0.118	0.144	0.82				
Niger	1992	1987	0.209	0.320	0.65	1988	0.255	0.196	1.30
		1989	0.157	0.269	0.58				
	1998	1993	0.152	0.230	0.66	1994	0.219	0.179	1.22
		1995	0.196	0.242	0.81				
	2006	2001	0.204	0.226	0.90	2002	0.235	0.180	1.30
		2003	0.240	0.246	0.97				
	2012	2007	0.214	0.193	1.11	2008	0.191	0.146	1.31
		2009	0.229	0.194	1.18				
Nigeria	2003	1998	0.244	0.245	1.00	1999	0.257	0.192	1.34
		2000	0.240	0.251	0.96				
	2008	2003	0.161	0.159	1.01	2004	0.208	0.175	1.19
		2005	0.137	0.172	0.80				
	2013	2008	0.149	0.140	1.07	2009	0.217	0.159	1.37
		2010	0.142	0.148	0.96				
Senegal	1992	1987	0.167	0.222	0.75	1989	0.190	0.234	0.81
		1990	0.149	0.187	0.80				
	2005	2000	0.234	0.208	1.12	2001	0.275	0.241	1.14
		2002	0.182	0.235	0.78				
	2010	2005	0.180	0.168	1.07	2007	0.204	0.181	1.13
		2008	0.162	0.184	0.88				
	2012	2006	0.167	0.159	1.05	2008	0.201	0.190	1.06
		2009	0.122	0.158	0.78				
	2014	2009	0.137	0.183	0.75	2010	0.122	0.210	0.58
		2011	0.105	0.120	0.88				
Sierra Leone	2008	2003	0.326	0.268	1.22	2004	0.394	0.325	1.21
		2005	0.361	0.315	1.15				
	2013	2008	0.305	0.224	1.36	2009	0.405	0.293	1.38
		2010	0.313	0.287	1.09				
Togo	1998	1993	0.255	0.207	1.23	1994	0.303	0.276	1.10
		1995	0.305	0.248	1.23				
	2013	2008	0.195	0.192	1.01	2009	0.277	0.274	1.01
		2011	0.262	0.244	1.07				
Average			**0.213**	**0.210**	**1.032**		**0.256**	**0.216**	**1.199**
Weighted Average			**0.200**	**0.199**	**1.013**		**0.246**	**0.196**	**1.262**
					Central-East Africa				
Burundi	2010	2005	0.355	0.350	1.01	2006	0.306	0.363	0.84
		2007	0.278	0.271	1.03				
Cameroon	1991	1986	0.167	0.254	0.66	1987	0.214	0.247	0.87
		1988	0.184	0.219	0.84				
	1998	1993	0.181	0.299	0.61	1994	0.317	0.301	1.05
		1995	0.208	0.298	0.70				
	2004	1999	0.284	0.268	1.06	2000	0.326	0.315	1.04
		2001	0.269	0.260	1.03				
	2011	2006	0.294	0.269	1.09	2007	0.302	0.264	1.15
		2008	0.280	0.268	1.04				
CAR	1995	1989	0.320	0.302	1.06	1990	0.353	0.367	0.96
		1991	0.354	0.371	0.95				
Congo	2005	2000	0.295	0.309	0.96	2001	0.236	0.253	0.93
		2002	0.258	0.274	0.94				
	2011	2006	0.204	0.220	0.93	2007	0.149	0.195	0.77
		2008	0.173	0.185	0.93				
DRC	2007	2002	0.308	0.296	1.04	2003	0.239	0.285	0.84

		2004	0.266	0.263	1.01				
	2013	2008	0.234	0.291	0.81	2009	0.267	0.266	1.00
		2010	0.270	0.300	0.90				
Gabon	2001	1995	0.234	0.199	1.17	1996	0.175	0.187	0.94
		1997	0.292	0.231	1.26				
	2012	2007	0.190	0.184	1.03	2008	0.196	0.218	0.90
		2009	0.211	0.150	1.41				
Kenya	1993	1988	0.158	0.140	1.13	1989	0.252	0.274	0.92
		1990	0.182	0.177	1.03				
	1998	1993	0.229	0.222	1.03	1994	0.230	0.368	0.63
		1995	0.292	0.248	1.18				
	2003	1998	0.423	0.293	1.44	1999	0.417	0.447	0.93
		2000	0.378	0.332	1.14				
Rwanda	1992	1987	0.323	0.231	1.40	1988	0.458	0.333	1.37
		1989	0.332	0.242	1.37				
	2005	2000	0.534	0.477	1.12	2001	0.611	0.538	1.14
		2002	0.365	0.350	1.04				
	2010	2005	0.331	0.276	1.20	2006	0.330	0.337	0.98
		2007	0.257	0.236	1.09				
Tanzania	1991	1986	0.281	0.214	1.32	1987	0.283	0.262	1.08
		1988	0.299	0.227	1.32				
	1996	1991	0.288	0.267	1.08	1992	0.292	0.306	0.96
		1993	0.278	0.259	1.07				
	1999	1994	0.352	0.271	1.30	1995	0.286	0.317	0.90
		1996	0.352	0.318	1.11				
	2007	2002	0.352	0.282	1.25	2003	0.329	0.334	0.99
		2004	0.349	0.225	1.55				
	2010	2004	0.307	0.259	1.18	2006	0.317	0.284	1.11
		2007	0.335	0.208	1.61				
	2012	2009	0.205	0.214	0.96	2008	0.349	0.296	1.18
		2006	0.237	0.251	0.94				
Uganda	1995	1990	0.482	0.382	1.26	1991	0.528	0.441	1.20
		1992	0.535	0.415	1.29				
	2001	1995	0.559	0.402	1.39	1996	0.447	0.429	1.04
		1997	0.420	0.403	1.04				
	2006	2001	0.443	0.429	1.03	2002	0.533	0.443	1.20
		2003	0.390	0.404	0.97				
	2011	2006	0.368	0.317	1.16	2007	0.314	0.366	0.86
		2008	0.233	0.314	0.74				
Average			**0.303**	**0.279**	**1.093**		**0.323**	**0.323**	**0.991**
Weighted Average			**0.302**	**0.284**	**1.069**		**0.315**	**0.326**	**0.964**
				Southern Africa					
Malawi	1992	1987	0.231	0.317	0.73	1988	0.243	0.283	0.86
		1989	0.401	0.363	1.11				
	2000	1995	0.487	0.404	1.21	1996	0.438	0.384	1.14
		1997	0.392	0.389	1.01				
	2005	1999	0.504	0.418	1.21	2000	0.521	0.452	1.15
		2001	0.473	0.405	1.17				
	2010	2005	0.450	0.371	1.21	2006	0.319	0.366	0.87
		2007	0.308	0.313	0.99				
Mozambique	1997	1992	0.395	0.444	0.89	1993	0.314	0.327	0.96
		1994	0.366	0.397	0.92				
	2003	1998	0.333	0.334	1.00	1999	0.408	0.316	1.29
		2000	0.334	0.332	1.01				
	2011	2006	0.356	0.333	1.07	2007	0.399	0.355	1.13
		2008	0.331	0.328	1.01				
Namibia	1992	1987	0.220	0.178	1.24	1988	0.222	0.280	0.79
		1989	0.109	0.193	0.57				
	2000	1995	0.208	0.293	0.71	1996	0.257	0.451	0.57
		1997	0.287	0.313	0.92				
	2007	2001	0.382	0.491	0.78	2002	0.330	0.505	0.65
		2004	0.327	0.417	0.78				
	2013	2008	0.345	0.400	0.86	2009	0.334	0.371	0.90
		2010	0.319	0.272	1.17				
South Africa	1998	1993	0.207	0.177	1.17	1994	0.358	0.365	0.98
		1995	0.216	0.163	1.32				
Swaziland	2007	2001	0.461	0.554	0.83	2002	0.558	0.637	0.88
		2003	0.467	0.533	0.88				
Zambia	1992	1986	0.241	0.232	1.04	1988	0.242	0.300	0.81
		1989	0.295	0.287	1.03				

	1996	1991	0.401	0.325	1.23	1992	0.464	0.374	1.24
		1993	0.435	0.354	1.23				
	2002	1996	0.476	0.440	1.08	1997	0.548	0.483	1.13
		1999	0.436	0.460	0.95				
	2007	2002	0.536	0.418	1.28	2003	0.555	0.370	1.50
		2004	0.472	0.332	1.42				
	2014	2008	0.354	0.279	1.27	2009	0.405	0.329	1.23
		2010	0.328	0.256	1.28				
Zimbabwe	1994	1989	0.170	0.238	0.71	1990	0.302	0.331	0.91
		1991	0.248	0.240	1.03				
	1999	1994	0.336	0.374	0.90	1995	0.379	0.530	0.71
		1996	0.386	0.381	1.01				
	2011	2005	0.491	0.568	0.87	2006	0.451	0.608	0.74
		2007	0.380	0.498	0.76				
Average			**0.355**	**0.353**	**1.020**		**0.383**	**0.401**	**0.974**
Weighted Average			**0.300**	**0.281**	**1.115**		**0.376**	**0.378**	**1.006**
SSA Average			**0.274**	**0.265**	**1.048**		**0.307**	**0.292**	**1.082**
SSA Weighted Average			**0.254**	**0.244**	**1.051**		**0.294**	**0.275**	**1.111**

Note: Adult mortality (the conditional probability of dying between ages 15 and 60- 45q15) calculated from DHS samples using the orphanhood method. From each survey two mortality estimates are calculated for females (two time locations/ reference dates) and one estimate for males. Regional and population weighted averages are included.

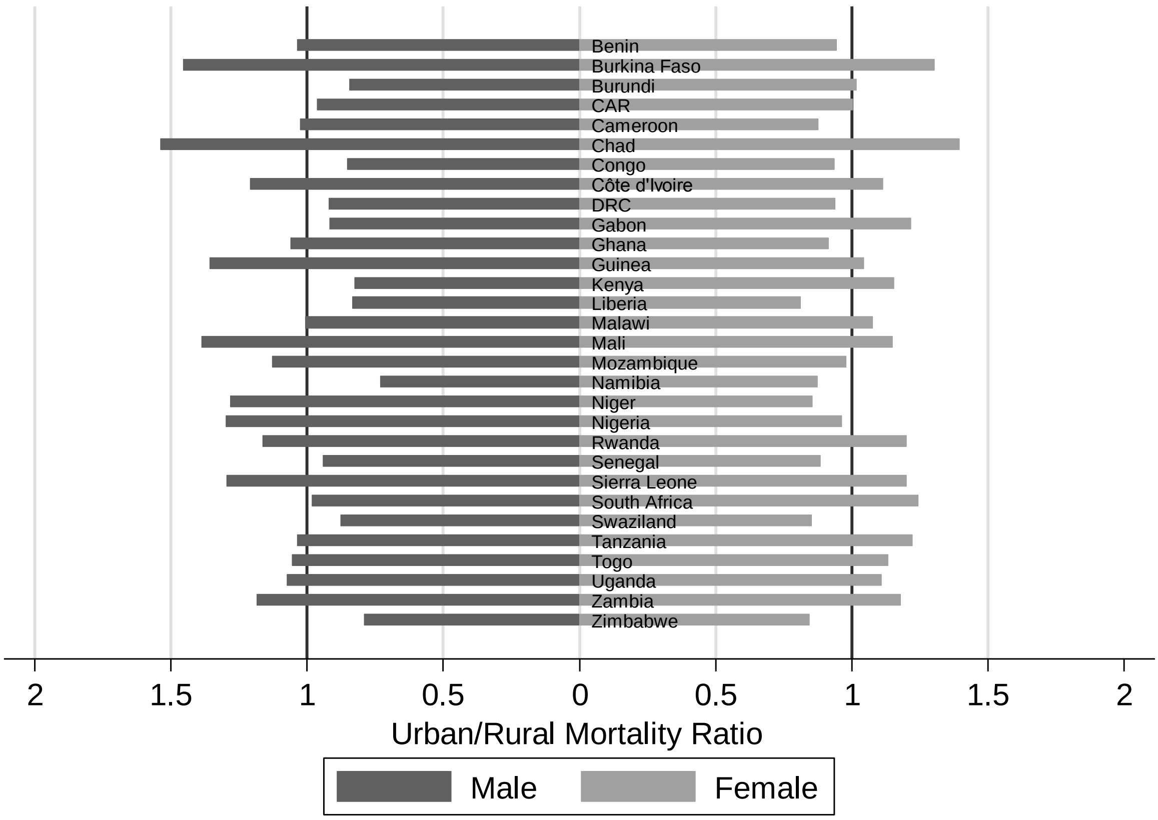
Estimated adult mortality by residence indicates that the mean probability of dying for adult women is 0.274 in urban settings compared to 0.265 in rural. The mean urban/rural mortality ratio[1] is 1.05 for women. For adult men, the urban probability of dying is 0.307 compared to the 0.292 rural probability of dying and the mean urban/rural ratio is 1.08 for men. Thus, we find that average SSA estimates for adult mortality indicate higher ${}_{45}q_{15}$ in urban areas for both sexes.

Unsurprisingly, the overall SSA average conceals considerable heterogeneity across countries. Figure 2 shows average, national urban/rural ${}_{45}q_{15}$ ratios over time by sex and indicate an urban adult mortality disadvantage (urban/rural mortality ratios in excess of one) in 55-60% of countries. Moreover, while some countries show an urban mortality advantage (urban/rural mortality ratios below unity), it is far more common to see estimates well above “1” than well below. In our data, there are 11 (12) countries where urban mortality is 10% greater than rural but only 7 (8) where rural is 10% greater than

[1] An urban/rural ratio above unity indicates an *urban disadvantage*- mortality is higher in urban areas.

urban amongst men (women). Countries with higher rural mortality average 13% greater mortality and countries with higher urban mortality average 15.5% greater mortality.

Fig. 2 Mean urban/rural adult mortality ratio by country and sex in Sub-Saharan Africa



Note: Our analysis is based on the country mean of all surveys presented in Table 1. A ratio above one means higher urban mortality.

ROBUSTNESS TESTS

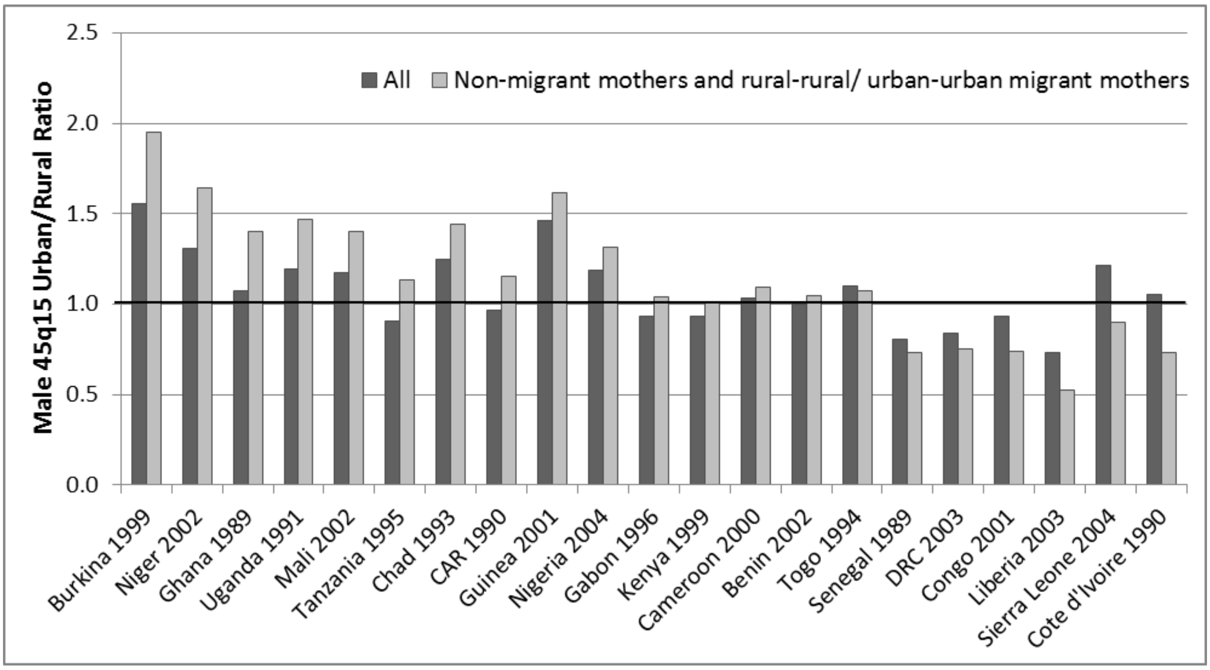
The above results offer little or no reason to argue that rural adult mortality in SSA exceeds those levels found in cities. As mentioned earlier, an upwards bias in urban mortality estimates might be driven by rural-to-urban migration of orphans, leading to artificially inflated urban estimates and deflated rural estimates. Here, we offer several arguments for why the direction of any bias is unlikely to reverse a conclusion that urban adult mortality levels exceed those in rural areas.

1. Existing empirical evidence on orphan migration. Existing evidence shows that children in the urban sector are more likely to migrate to rural sectors after being orphaned (Isiugo-Abanihe 1985; Monasch and Boerma 2004; Sahn and Catalina 2013; van Blerk and Ansell 2006). This suggests that the actual bias goes in the opposite direction and that the urban-rural adult mortality ratio is underestimated[2].
2. Testing an association between child migration and maternal mortality in rural areas. DHS data do not enable us to connect child migration and adult mortality. Thus, data from six InDepth[3] surveillance sites in Kenya, Senegal, Tanzania and Côte d'Ivoire help clarify this association. These data include event sequences that allow us to evaluate the relationship between child migration and parental mortality in mostly rural sites. Overall, 30.7% of children had migrated during the surveillance periods. Separate migration rates are calculated over this period for those children with mothers that died and for those with mothers still alive. Migration rates are found to be higher for those living mothers (0.42 versus 0.28). While these data do not enable us to distinguish migration destinations - whether to rural or urban areas - the results suggest little difference in migration levels among maternal orphans and non-orphans.
3. Testing paternal orphan differences. We tested the impact of orphan migration on paternal mortality estimates using DHS data for 21 West and Central-East African countries that include questions on maternal residence. Adult male mortality is estimated from single orphans whose mothers have not migrated, or only migrated from

[2] Double orphans are most likely to migrate (Thomas 2012; Ueyama 2007) but comprise only 11% of orphans in our sample.
[3] INDEPTH Health and Demographic Surveillance System http://www.indepth-ishare.org/

rural-to-rural areas or urban-to-urban areas. We assume orphans remain with their mothers after paternal deaths. Results shown in Figure 3 reinforce our claim that urban mortality tends to exceed rural and that these findings are not dependent on whether children migrated. Evidence to weaken our findings would show urban mortality exceeding rural *until* migration status is controlled. In terms of Figure 3, this would mean dark grey bars above one and light grey bars below. While we have two such cases (Sierra Leone and Côte d'Ivoire), at least four show the opposite and help to further raise confidence in our conclusions.

Fig. 3 Male urban/rural mortality ratios excluding rural-to-urban and urban-to-rural migrants for 21 countries



Note: Our analysis includes one survey from West and Central-East African countries where data on maternal residence is available. A ratio above one means higher urban mortality. Countries are sorted from largest negative gap to largest positive gap.

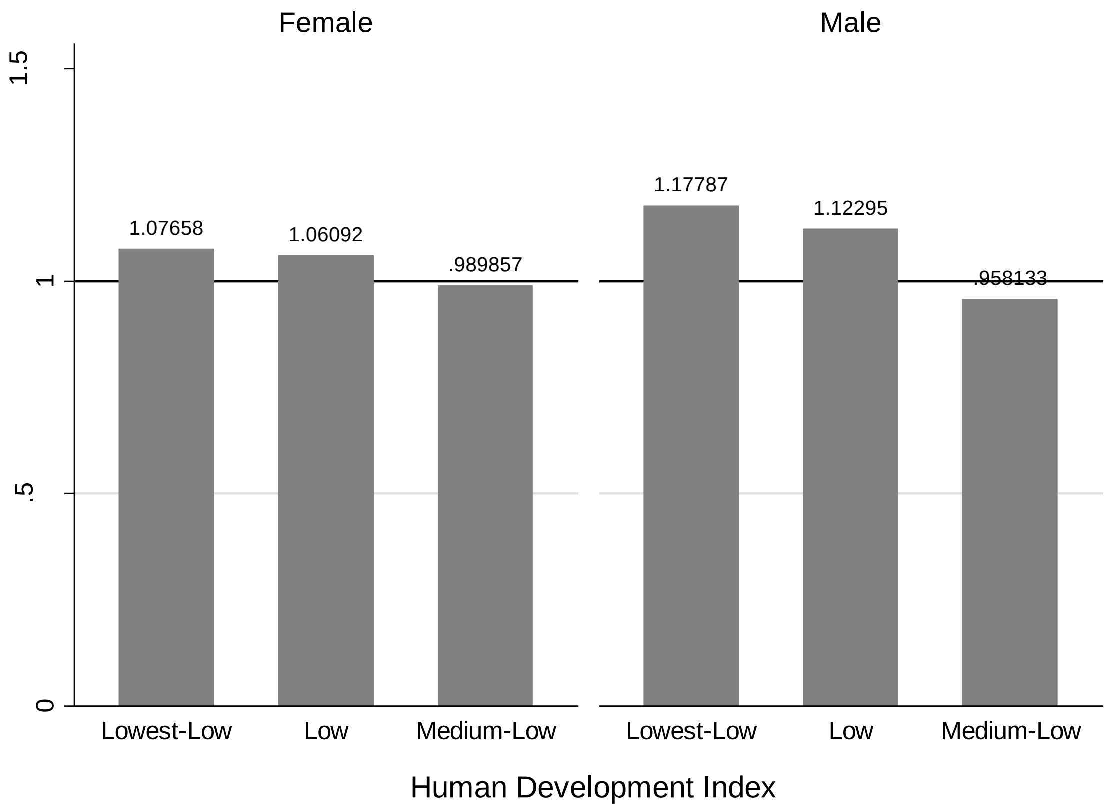
4. Testing duration of exposure and migration. An alternative evaluation is based on the fact that older children will have longer exposure to the possibility of migration following parental death. Thus, if an association between orphanhood and child migration is driving adult urban mortality to be relatively over-estimated, the urban/rural mortality ratio estimated from older children (aged 10 to 14) should be higher than the urban/rural mortality ratio estimated from younger children (aged five to nine). A separate analysis where young and older children are compared was conducted on 11 West African countries – chosen to reduce the potential influence of HIV. The results offer further support with the urban/rural female adult mortality ratio for younger children higher in 26 of the 34 time locations examined.
5. Calculating urban/rural adult mortality from non-migrant orphans in Benin. While we find that rural-to-urban migration is unlikely to be driving our estimates of relatively high urban adult mortality, analysis from the Benin 2006 DHS survey offers some additional and conflicting evidence. The Benin 2006 DHS asks all household residents whether they have lived in the same community since birth – a feature not available in other countries in our data. This enables estimation of parental survival amongst a sub-sample of *non-migrant* children. In comparison to the adult mortality estimates for Benin shown in Table 1, estimates from non-migrants indicate that our urban adult mortality estimates may be inflated while rural estimates are basically stable. Yet, while the overall urban/rural mortality ratios from the sub-sample of non-migrant children are on average 7% lower, the female urban/rural ratio for 2011 still exceeds unity. Thus, despite the possibility of some upwards bias in estimated adult mortality in urban areas resulting from orphan migration, the overall impact appears relatively muted.

A PROLONGED URBAN DISADVANTAGE?

Our findings offer compelling evidence that for the 30 countries in Sub-Saharan Africa that we explore, rural mortality for adults is mostly comparable and often lower than levels found in the urban sector. This is surprising though consistent with Günther and Harttgen (2012), who focus primarily on a different question, while applying the sibling method of mortality estimation in the 2000s on a more limited sample of SSA countries. Underlying our quest to uncover past patterns of adult mortality across urban and rural settings is a broader aim of learning whether SSA is heading in the direction of an urban mortality advantage that has been delayed or whether urbanization in SSA simply has little relationship with adult mortality. An “urban penalty” (especially visible amongst adult males) has been shown to change over the course of the demographic transition in Europe with mortality decline being much faster in urban areas (Reher, 2001). Our analysis in this section considers whether this is true for SSA countries through the relationship between adult mortality and national level indicators of development status.

One perspective is gained by considering the shift over the course of development. The Human Development Index (HDI) is a powerful indictor of national development, based on life expectancy at birth, mean years of schooling and gross national income per capita (UNDP 2015). We examine whether rural/urban adult mortality differentials vary systematically with levels of HDI. Our findings, shown in Figure 4, offer strong indications that urban/rural mortality ratios decline as countries develop. With very low HDI of below 0.37, urban mortality is higher than rural. In SSA countries with higher HDIs of above 0.454 the urban/rural ratio falls to below one (though close to equity amongst females), indicating a greater rural disadvantage in adult mortality.

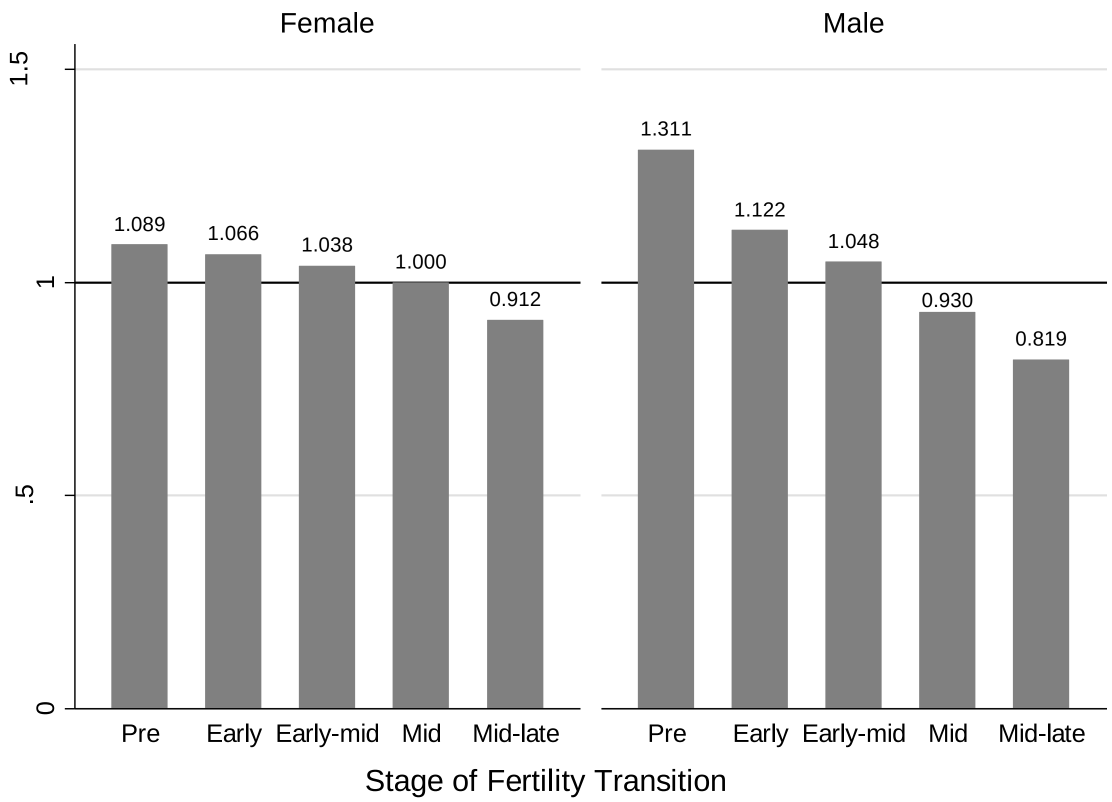
Fig. 4 Mean urban/rural adult mortality ratio in Sub-Saharan Africa by HDI level and sex



Note: Our analysis includes all 45q15 estimates presented in Table 1, by HDI terciles. A ratio above one means higher urban mortality.

A further indicator of national development is progress through the demographic transition. Countries in SSA have started to see fertility decline from total fertility rates (TFR) of over seven in pre-transition, to TFR levels of between three and four in mid-late transition (as defined by Bongaarts (2003). As shown in Figure 5, lower levels of national fertility are associated with adult mortality shifting from urban to rural disadvantage.

Fig. 5 Mean urban/rural adult mortality ratio in Sub-Saharan Africa by stage of fertility transition



Note: Our analysis is based on the mean urban/rural ratios of adult mortality estimated using the orphanhood method (presented in Table 1) for 30 SSA countries, by stage of fertility transition. Pre-transition countries have a TFR of over seven; mid-late transition countries have a TFR of between three and four. A ratio above one means higher urban mortality.

These bivariate impressions are powerful. The next step is to consider what factors – both within and across countries in SSA – are associated with change in the rural/urban adult mortality difference in a multivariate context. Table 2 presents a series of models to estimate how rural/urban residence is associated with adult mortality, ${}_{45}q_{15}$. In these models, each case is an estimate of adult mortality at a given time for a given country for either the urban or rural sector. The models are estimated using linear country-level fixed effects (FE).

Our models evaluating the effect of urban versus rural *within* countries over time, generally offer support for our main finding - an urban mortality disadvantage. The urban coefficient in Model 1, 0.06, reflects an urban disadvantage of some 20% relative to the average of ${}_{45}q_{15}$ across all periods and countries. Our models control for sex, temporal patterns in mortality, national levels of urbanisation, HIV prevalence, HDI, and TFR and rural/urban measures of median number of years of female education, the percent of the population living in households with an improved water source and the percent of households with electricity[4].

Interesting effects to emerge from the models include that adult women's mortality is lower, in keeping with other findings (Nathanson 1984; Rajaratnam et al. 2010). Adult women still show a lower value of adult mortality, with being female associated with an average decline in ${}_{45}q_{15}$ by .033 or by about 10% of average ${}_{45}q_{15}$. Also, in comparison to mortality between 1986 and 1990 (the reference category) mortality levels have actually been rising over time. Adult mortality peaks between 1996 and 2000, then starts to decline, though remaining higher than in the late 1980s. These findings are consistent with studies on mortality trends worldwide which indicate increases in mortality since the 1970s in SSA, followed by recent declines (McMichael et al. 2004; Rajaratnam et al. 2010; Wang et al. 2012).

The role of HIV is found to be positive but insignificant in Model 1, showing that within country variation in HIV has little relation to overall adult mortality patterns. Note, when simple OLS is estimated on the same variables the percent of adults infected with HIV is positively associated with mortality – consistent with other findings (Blacker 2004;

[4] Some of the data for these independent variables are not available on a yearly basis and are used to represent a wider range of years.

Hosegood et al. 2004). Countries with higher HDI experience substantial declines in mortality. For example, moving from a low HDI of 0.3 to a medium HDI of 0.6 is associated with a decline of 0.2 in ${}_{45}q_{15}$. Interestingly, higher female education does not translate into lower mortality; wider provision of structural improvements for households – water and electricity - reduces adult mortality. Household characteristics such as these have also been found to account for part of the gap in rural/urban infant mortality (Van de Poel et al. 2009). It is worthwhile noting that when the variables in Model 1 are estimated without the infrastructure variables – water and electricity (not shown) - the estimated "total" effect of urban residence on mortality disappears. Thus, these structural factors likely account for (or proxy) some of the beneficial dimensions of urban residence while their omission from the model likewise conceal the negative impact of cities on survivorship (Galea and Vlahov 2005).

We explore further two specific interactions between urban residence in Models 2 and 3. In Model 2, we introduce an interaction of urban with HIV prevalence to test whether HIV increases adult mortality more in the urban sector. While the main effect of HIV is not significant (Model 1), the interaction indicates that higher levels of HIV *reduce* the urban disadvantage. Thus, an increase in HIV prevalence from 5% to 10% among 15 to 49 year olds brings the urban effect down from 0.056 to 0.046. The last test includes an interaction between urban and HDI, as seen in Model 3, which indicates that while the main effect of HDI is already strongly negative, the effect is further strengthened when HDI is higher. This finding provides further support for our earlier analyses on the relationship between HDI and the urban mortality advantage. Here we see that as country HDI rises, the urban disadvantage transforms into an advantage.

Table 2 Predicting Adult Mortality ${}_{45}q_{15}$ in Sub-Saharan Africa

	Model 1 b/se	**Model 2** b/se	**Model 3** b/se
Urban	0.057**	0.066**	0.105**
	-0.02	-0.02	-0.027
Female	-0.033**	-0.033**	-0.033**
	-0.005	-0.005	-0.005
1991-1995	0.056**	0.056**	0.053**
	-0.011	-0.011	-0.011
1996-2000	0.111**	0.110**	0.106**
	-0.012	-0.012	-0.012
2001-2005	0.108**	0.106**	0.101**
	-0.014	-0.014	-0.014
2006-2011	0.122**	0.117**	0.111**
	-0.019	-0.019	-0.02
Proportion Urban	-0.002	-0.002	-0.002
	-0.001	-0.001	-0.001
HIV Prevalence	0.001	0.002	0.000
	-0.004	-0.004	-0.004
HDI	-0.684**	-0.677**	-0.600**
	-0.103	-0.102	-0.107
TFR	-0.014*	-0.011	-0.014*
	-0.007	-0.007	-0.007
Female Yrs Edu	0.002	0.005	0.006†
	-0.003	-0.003	-0.003
Improved Water	-0.001*	-0.001†	-0.001*
	0.000	0.000	0.000
Electricity	-0.001**	-0.001**	-0.001**
	0.000	0.000	0.000
HIV*Urban		-0.002**	
		-0.001	
HDI*Urban			-0.174**
			-0.064
Constant	0.678**	0.644**	0.647**
	-0.08	-0.08	-0.08
R-squared	0.746	0.751	0.75
No. of cases	510	510	510

Note: The models predict the probability of dying between ages 15 and 60, estimated using the orphanhood method from 90 DHS surveys, covering 30 SSA countries for rural and urban populations separately. All models are linear country-level fixed effects. Standard errors (se) are presented below coefficients (b). The omitted category of time is 1986-1990. † p<.10, * p<.05, ** p<.01 [two-tailed tests]

DISCUSSION

In contrast to higher infant mortality in rural areas, adult mortality is shown here to be higher in urban areas in many SSA countries. Historically, before the onset of the demographic transition, Europe experienced higher mortality in urban settings (Reher 2001; Woods 2003). Our results suggest that contemporary SSA may be facing similar challenges, though possibly for different reasons (Dye 2008). We found that better access to an improved water source and electricity in urban areas does not sufficiently account for lower urban mortality. Urban populations may be facing higher mortality in part due to factors related to natural resistance to disease (Johansson and Mosk 1987) - including the increasing proportion of poverty in urban areas (Gould 1998; Ravallion et al. 2007) and growing urban slums (Fink et al. 2014).

As most countries in SSA are still transiting to low fertility and mortality rates, urban mortality is expected to remain higher than rural. Indeed, we found that countries with low HDI have higher urban adult mortality amongst both sexes. Only in the final stage of the demographic transition when mortality stabilises at low rates is rural mortality expected to be higher than urban (Dyson 2011), as suggested by our findings. Thus, higher levels of development do appear to eventually create conditions of higher rural relative to urban ${}_{45}q_{15}$.

The recent declines in life expectancy seen in SSA depicted by McMichael et al. (2004) as reversals of trends, highlight the importance of understanding mortality dynamics within countries in the region, particularly between rural/urban populations. Our findings identify a delayed adult mortality decline in urban populations in SSA. What is equally worrisome is if and how the urban adult mortality disadvantage may affect the course of progress of African states. Unfortunately, the implications may be exacerbated by the economic costs associated with a prolonged urban mortality disadvantage occurring in the midst of a demographic transition.

While cities play a key role in development (Dyson 2001), the impact of slower decline in urban adult mortality may be especially salient in SSA where countries are soon to reach a phase where their economic growth may be accelerated through the demographic dividend (Bloom et al. 2007; Eastwood and Lipton 2011). For example, Nigeria’s potential demographic dividend could raise per capita incomes by 30% or more by 2030 (Bloom et al. 2010). Yet, Nigeria's estimated male urban disadvantage in mortality is particularly great (1.37 urban/rural ratio in 2009), potentially reducing their potential dividend.

The demographic dividend depends on harnessing the output of a relatively large work force at a stage where dependency ratios are declining. Excess adult mortality in the ages 15-60 could reduce productivity in these peak labour productivity ages. The dividend will be reduced when adult mortality is high, during ages of parenthood and work productivity. Related concerns have been raised in gauging the cost of the HIV/AIDS epidemic on many developing states (Beegle et al. 2008; Dixon et al. 2002). A relatively slow decline in adult mortality in cities can produce unexpected costs, posing a challenge to SSA states. Thus, more effective policies are needed to address excess adult mortality in urban areas where education and employment opportunities are greater and the productivity of young adults is relatively high.

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