The shifting rural–urban gap in mortality over the life course in low- and middle-income countries

Ashira Menashe-Oren and Bruno Masquelier

https://doi.org/10.1080/00324728.2021.2020326

Abstract

Studies have shown that children in rural areas face excess risks of dying, but the little research on spatial inequalities in adult mortality has reached mixed conclusions. We examine rural–urban differences in mortality in 53 low- and middle-income countries. We consider how the rural–urban mortality gap evolves from birth to age 60 by estimating mortality based on birth and sibling histories from 138 Demographic and Health Surveys run between 1992 and 2018. We observe excess rural mortality until age 15, finding the largest differences between urban and rural sectors among 1–59-month-olds. While we cannot claim higher mortality among urban adults than those in rural areas, we find a reduced gap between the sectors over the life course and a diminishing urban advantage in adult mortality with age. This shift over the life course reflects a divergence in the epidemiologic transition between the rural and urban sectors.

Keywords: mortality; sibling histories; birth histories; rural; urban; epidemiologic transition

Introduction

Ensuring that no one is left behind is core to the 2030 Sustainable Development Goals (SDGs) (United Nations 2015). To achieve this objective, monitoring of development indicators needs to be disaggregated, specifically by sex, age, income, ethnicity, migratory status, disability, and geographic location (SDG target 17.18). A large body of research has been devoted to disaggregating indicators of the health targets in SDG Goal 3 (Good health and well-being), in particular the indicators related to neonatal and under-five mortality (Wang 2003; Minujin and Delamonica 2004; Huicho et al. 2009; Alberto and Wood 2011; Bocquier et al. 2011; Golding et al. 2017; Li et al. 2019; Victora et al. 2020).

Estimating mortality subnationally by rural and urban sector is particularly relevant, since these two populations have different age and sex structures, divergent socio-economic profiles (e.g. employment rates and educational attainment), and unequal access to healthcare and basic facilities (e.g. safe drinking water and sanitation) (Lipton 1977; Sahn and Stifel 2003; Menashe-Oren and Stecklov 2018a). In addition, urbanization plays a key role in development, which in turn shapes mortality decline (Davis 1965; Dyson 2001). Sub-Saharan Africa has been the focus of this research due to the disproportionate burden of mortality in the region and its lower levels of urbanization (McMichael et al. 2004; United Nations 2018). However, the different relationship between urbanization and development in other regions of the world suggests that rural–urban mortality inequalities may be different outside sub-Saharan Africa.

Survey estimates suggest that under-five mortality in low- and middle-income countries (LMICs) is higher in rural areas than in urban areas (Akoto and Tambashe 2002; Bocquier et al. 2011; Fink, et al. 2014; Garcia 2020). This urban advantage can be attributed in part to better access to health services, superior infrastructure, and greater economic opportunities (Lipton 1977; Sahn and Stifel 2003; Dussault and Franceschini 2006). It is also driven in part by more proximate determinants, including lower fertility and wider birth spacing in the urban sector (Casterline and Odden 2016; Shapiro and Tenikue 2017). When considering rural–urban differences in mortality at adult ages, the available evidence is mixed. Based on indirect mortality estimates derived from reports on the survival of parents, Menashe-Oren and Stecklov (2018b) pointed to a degree of urban penalty in sub-Saharan Africa and argued that the excess urban mortality in adulthood is likely to shift to rural areas as countries develop. Focusing on 18 countries also in sub-Saharan Africa, Günther and Harttgen (2012) contrasted rural–urban differences in mortality among children and adults, concluding that urban households experienced higher adult mortality (among people aged 15–45 years) than rural households, whereas the reverse pattern was observed for under-five mortality. In contrast, De Walque and Filmer (2013) analysed survey data on the survival of adult siblings and highlighted a slight urban advantage among adults, although their analysis did not reveal large gaps by urban/rural residence.

Other researchers contend that the urban penalty observed for adults in some studies could be spurious, because existing adult mortality estimates in sub-Saharan Africa are largely based on retrospective reports on survival of close relatives, such as parents and siblings. These reports are regularly collected in Demographic and Health Surveys (DHSs). Recall biases in such reports have been found to differ between countries (Obermeyer et al. 2010) and could be larger in rural areas due to lower levels of educational attainment. Or there could be misclassification errors introduced by migration between the rural and urban sectors (Lankoande 2016). Rural-to-urban (and sometimes urban-to-rural) migrants are often positively selected for health (Lu 2008; Nauman et al. 2015; Ginsburg et al. 2016), directly lowering mortality estimates in the urban sector. Additionally, return migration to the rural sector among unhealthy or older people raises rural mortality estimates (Clark et al. 2007;

Ginsburg et al. 2016; Lankoandé et al. 2018). Moreover, respondents do not necessarily share the same type of residence (urban/rural) as those they report on.

Another limitation of studies that have documented a degree of urban penalty in adulthood is that they are generally based on comparisons of mean or median estimates of mortality, without considering the confidence intervals (CIs) around the estimates. These intervals can be quite wide in the case of adult mortality, since the number of mortality events is low in typical DHSs. It is therefore unclear whether the sample sizes in these studies were sufficiently large to distinguish the urban penalty observed in some countries from sampling errors.

The possible coexistence of an urban advantage in child mortality with an urban penalty in adult mortality thus calls for further investigation. In this paper, we analyse disparities in survival between sectors within the framework of the theoretical model of the epidemiologic transition. This model details the shift from a mortality regime dominated by infectious diseases, which tend to affect children, to a mortality regime dominated by non-communicable diseases, which tend to affect adults (Omran 1971). We propose a sector-specific theoretical framework detailing how the epidemiologic transition is likely to alter the mortality differences between rural and urban sectors, in order to better understand the age-specific variations in rural–urban mortality gaps. Empirically, we consider the variations between rural and urban areas over six smaller age intervals, covering all age groups from birth to 60 years of age. In this way, we seek to measure at what age a possible shift towards urban excess mortality could occur. To our knowledge, the age pattern of the rural–urban difference in mortality has not been documented systematically, and the disparities among children and adolescents aged 5–14 have been ignored. We further extend the scope of countries examined to evaluate whether an urban disadvantage exists in other LMICs aside from those in sub-Saharan Africa, by analysing 53 LMICs in total. Since living standards are higher outside sub-Saharan Africa and cause-of-death patterns vary by region (Roth et al. 2018), we expect rural–urban inequalities to differ in other regions of the world. Regional differences may also reflect various stages of the epidemiologic transition.

In the next subsection, we propose a stylized sector-specific model of the epidemiologic transition as experienced in LMICs. We then explain our methods for estimating mortality by sector over the life course and present these results. We further consider whether our estimates may be biased and present several robustness checks. Before concluding, we turn to exploratory analysis of the mortality trends in relation to disease and risk-factor prevalence, to test the validity of our model.

Rural–urban divergence in the epidemiologic transition

The epidemiologic transition theory broadly describes a decline in mortality rates and a shift in disease patterns from a high burden of infectious diseases and nutritional deficiencies to the emergence of non-communicable diseases as major causes of death (Omran 1971; Vallin and Meslé 2004). Building on this theory, we illustrate in Figure 1 plausible trends in cause-specific mortality by urban/rural sector over the transition. The schema depicts a shift from high mortality at the beginning of transition to low mortality, as originally formulated by Omran (1971), and further accounts for criticisms of the epidemiologic transition that have been raised in relation to low- and middle-income settings. This critique has addressed, first, the re-emergence of old infectious diseases (e.g. malaria) and emergence of new ones (e.g. HIV/AIDS), and second, socio-economic inequalities in mortality (Frenk et al. 1989; Smallman-Raynor and Phillips 1999; McKeown 2009). Populations in LMICs continue to be affected by communicable diseases, undernutrition, and maternal mortality as the transition progresses, while non-communicable diseases become more common, leading them to suffer from a double or triple burden of disease (Boutayeb 2006; Frenk and Gómez-Dantés 2011;

Bygbjerg 2012). Therefore Figure 1 does not assume convergence between sectors at low levels of mortality.

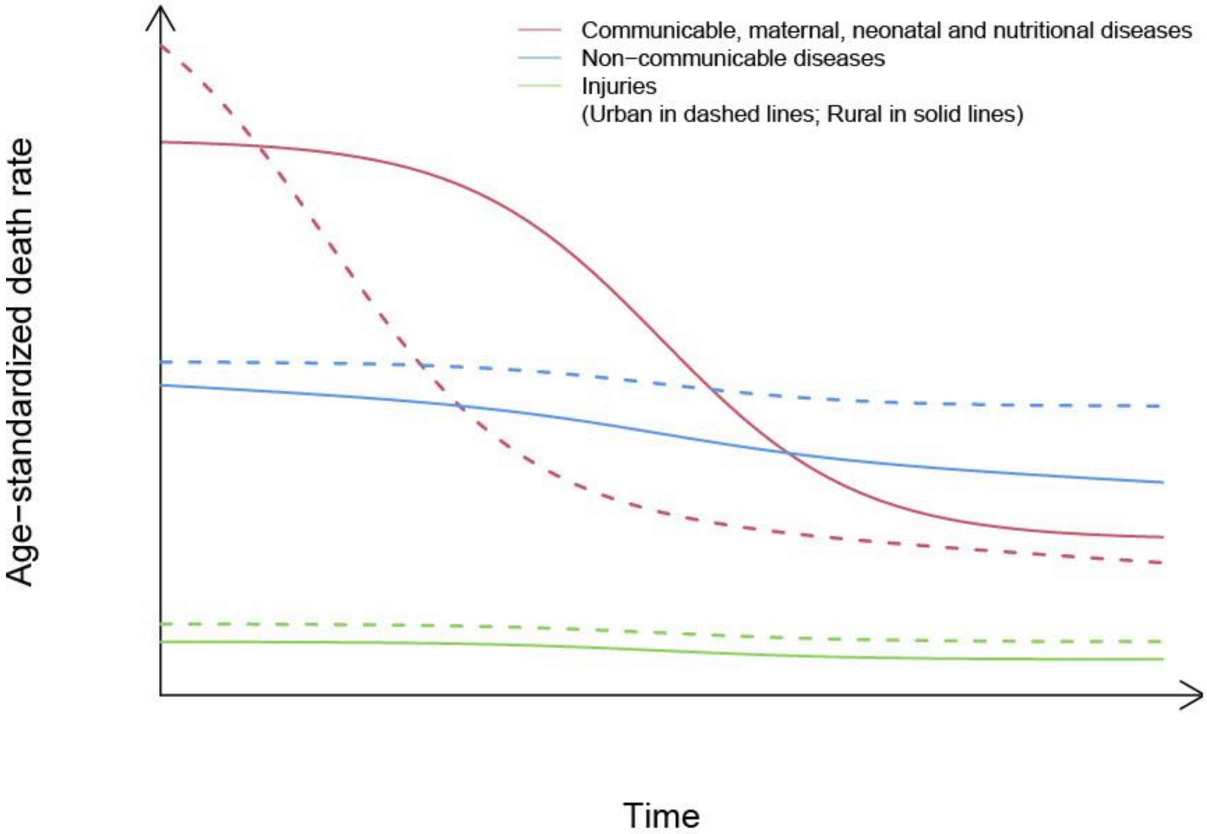


Figure 1 Schematic depiction of the shift in cause-specific mortality (age-standardized death rate) over the epidemiologic transition in LMICs, by urban/rural sector

Source: Authors' own depiction, based on Global Burden of Disease national-level data available from Institute for Health Metrics and Evaluation (www.healthdata.org/gbd/data).

The historical experience of Western Europe suggests that an urban penalty can be expected at the very beginning of the transition, due to greater interaction between individuals, rudimentary healthcare, and poor living conditions in towns, all factors conducive to the spread of infectious diseases (Reher 2001; Woods 2003; Dye 2008; Fox 2012). In the nineteenth century, higher mortality was associated with larger cities (Cain and Hong 2009).

For example, higher population density has been linked to measles infections in England before vaccinations were introduced (Keeling and Grenfell 1997). However, mortality from communicable diseases is expected to fall more rapidly in urban populations as public health systems and sanitation improve. For example, populations in the urban sector benefit from easier access to vaccinations (Singh 2013).

In later stages of the epidemiologic transition, when deaths from communicable diseases have declined, any urban advantage may decrease again under two conditions: (1) rapid and unplanned urban expansion, when the share of the population living in slums rises, creating an environment for infectious diseases to spread with ease (Gould 1998; Reher 2001; Dye 2008); and (2) re-emergence of old infectious diseases or emergence of new ones mostly affecting the urban population, for example tuberculosis or HIV/AIDS (Barongo et al. 1992; Dyson, 2003; Magadi 2013; ICF International 2020). Persistently high death rates from communicable diseases, whether new or not, may delay mortality declines or cause them to diverge across populations (Moore et al. 2003; McMichael et al. 2004; Sclar et al. 2007). This is portrayed in Figure 1 by a stall in mortality decline from communicable diseases in the urban sector. Inadequate sanitation, poor access to clean water, and overcrowding have been linked to higher proportions of deaths from communicable diseases, despite gains in overall life expectancy (Bilal et al. 2021). The urban population, particularly within poorly planned neighbourhoods, faces higher poverty and child malnutrition (Haddad et al. 1999). Evidence on child mortality suggests that although slum dwellers fare better than their rural counterparts, they fare worse than other urbanites (Fink et al. 2014). The urbanization of poverty has been noted particularly in Latin America (Ravallion et al. 2007), where within-city social inequalities are reflected in health outcomes (Bilal et al. 2019).

While mortality rates from communicable diseases not only fall dramatically but also diverge considerably between the rural and urban sectors, mortality rates from non-communicable diseases are deemed relatively stable over the course of the epidemiologic transition. At early stages of the transition, the gap between sectors is small to negligible. In Figure 1 we depict urban deaths from non-communicable diseases as higher than rural deaths, but they could equally be lower. Health conditions related to mortality from non-communicable diseases (e.g. hypertension) do not always differ between rural and urban sectors in countries with low levels of urbanization (Van der Sande et al. 1997; De Ramirez et al. 2010; Ratovoson et al. 2015). However, with urbanization and changing diets (especially towards higher salt intake with processed foods), chronic diseases become more common (Popkin 1999). Cardiovascular risk factors, including hypertension, obesity, and diabetes have increased in the urban sector, including in LMICs (Levitt et al. 1993; Mufunda et al. 2006; Addo et al. 2007; Hernández et al. 2012; Eckert and Kohler 2014). Thus, towards later stages of the epidemiologic transition, deaths from non-communicable diseases are expected to decline faster in the rural sector than in the urban. Moreover, there is some evidence that urban adults who live in poverty face a greater burden of communicable diseases, due to their holding specific occupations, living in neighbourhoods with worse air pollution, or not being able to afford treatment (Sverdlik 2011). Finally, in Figure 1 we do not presume specific differences between the urban and rural sectors in deaths from injury. On the one hand, road accidents or work-related injuries may be more urban phenomena (Sverdlik 2011), but on the other hand, urban populations benefit from easier access to health facilities to treat injuries.

Due to differences in leading causes of death and differential risk factors, rural–urban disparities in mortality will likely vary across age groups. Across all countries, causes of death change systematically with age, shifting from primarily neonatal disorders among babies under one month old to diarrhoeal diseases, lower respiratory infections, and other infectious diseases at postneonatal ages. In the 5–14 age group, injuries and malaria account for a larger proportion of deaths. Then, among males aged 15–49, dominant causes of death are cardiovascular diseases (CVD), HIV/AIDS, tuberculosis, and injuries, while for females aged 15–49, maternal causes additionally figure among the leading causes of death (Vos et al. 2020). At older ages (from age 50), there is an increasing contribution of non-communicable diseases, especially CVD, neoplasms, and chronic respiratory diseases (Roth et al. 2018). Moreover, as overall mortality declines, evidence from high-income countries suggests that the cause-specific composition of mortality also changes by age (Salomon and Murray 2002). For example, among children aged 1–14, cause of death shifts from predominantly infectious diseases early in the epidemiologic transition to a mixture of non-communicable diseases and injuries, while for adults aged 50+ the cause-specific composition of mortality does not change. Because of shifts in disease patterns across age groups and variations in causes of death and risk factors by urban/rural sector, it is difficult to predict how rural–urban mortality differences will play out. However, considering the sector-specific epidemiologic transition (Figure 1), we expect that at an early stage of transition when mortality from communicable diseases is high, there will be a rural advantage in child mortality. However, at later stages of transition, we anticipate a diminishing urban advantage in adult mortality, and possibly in child mortality too.

Data and methods

Our analysis is based on 138 nationally representative DHSs in which women eligible for an individual interview reported on both the survival of their children and the survival of their maternal siblings (Table A1, supplementary material). The surveys were conducted between 1994 and 2018, and they cover 53 LMICs, consisting of seven countries in Latin America and the Caribbean, one country in North Africa, one in Oceania, and eight countries in Asia, as well as 36 in sub-Saharan Africa. In full birth histories, women of reproductive age provide an exhaustive list of all their children, with information on their sex, date of birth, and survival status. Current age is recorded for surviving children, while age at death is collected for the deceased. Sibling survival histories are based on a similar structure, but the information provided refers to all brothers and sisters born to the same mother as the respondent.

We used event history analysis to estimate risks of dying in childhood in the 10-year period before data collection, for three age segments: neonatal mortality (<1 month), postneonatal mortality (1–59 months), and mortality in middle childhood and early adolescence (5–14 years). Birth histories were reformatted to calculate for each child the time spent in a 10-year window before the survey, broken down by months of age between birth and the first birthday, and then by years of age up to the 15th birthday. Mortality rates were estimated over these intervals by dividing the observed deaths by the total exposure time, converting these to survival probabilities, and chaining them together to obtain risks of dying over the desired age segments. We obtained 95 per cent CIs with a stratified jackknife approach.

Similarly, we used sibling survival histories to estimate mortality rates in three age segments: 15–29, 30–44, and 45–59. We made no attempt to estimate mortality at ages 60+, because DHS respondents are aged 15–49 and they report on siblings of a similar age on average. As a result, the numbers of deaths and person-years referring to the population aged 60+ are too low to provide accurate estimates. The mortality estimates based on the sibling survival method also refer to a 10-year period before the survey. For all estimates we used the *demogsurv* package in R (Eaton and Masquelier 2020).

A note on the rural–urban dichotomy

Our analysis is based on the DHS definitions of urban and rural sectors, which are country specific, arguably making comparisons across countries impossible. While a consistent definition of urban would be useful, it is important to note that the definitions capture the country contexts (Potts 2017). Essentially, what is considered urban in Nigeria, where population density is high, is not the same as in its neighbouring country Niger, whose population size is around one-tenth of Nigeria's. This is reflected by the definition of urban in each country: in Nigeria, urban refers to a 'town with 20,000 inhabitants or more', whereas in Niger, urban is defined as 'localities serving as administrative headquarters for departments and arrondissements, and those with an administrative headquarter with 2,500 inhabitants or more' (United Nations 2015). Although these are important differences in definition, it would also be nonsensical to consider a uniform definition for both countries.

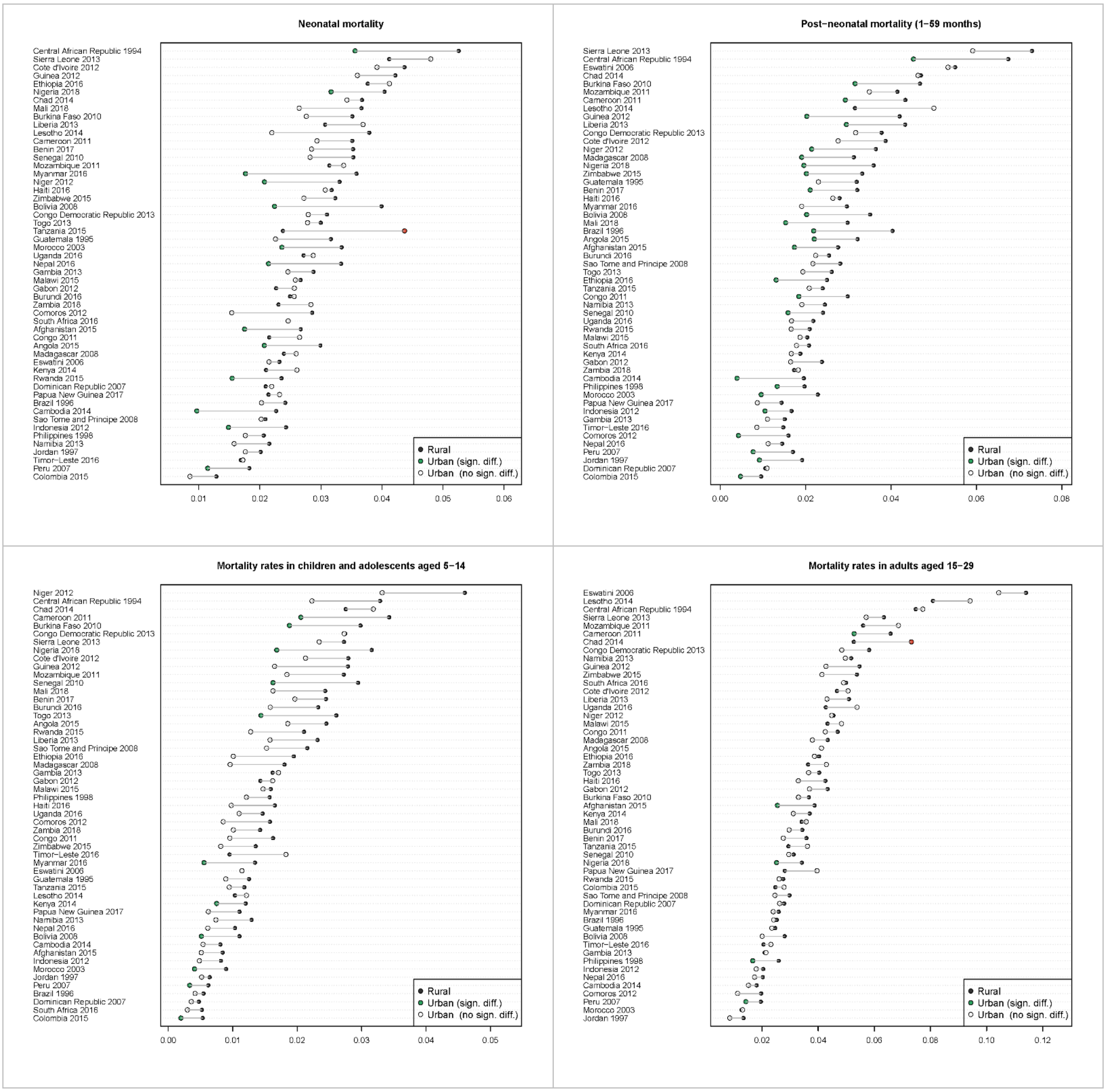
In addition to the cross-national differences in defining urban, there are changes in what is considered urban over time because countries in LMICs are generally still undergoing an urbanization process. Settlements grow and shift from being rural to urban. Across the surveys in our analysis, the proportion of the population living in urban areas is 36 per cent, mostly reflecting sub-Saharan African countries (see Table A1, supplementary material). Over the urban transition, the term urban may initially refer to a handful of relatively small settlements where the population still works primarily in agriculture, but as countries urbanize it may refer to a large capital city and some smaller cities, or at later stages of urban transition it may refer to multiple megacities. Notwithstanding the few surveys in Latin America, where countries are at advanced stages of urbanization, the low levels of urbanization in the majority of countries we investigate suggest similar meanings of what is considered urban when we examine the mortality differences we find between the rural and urban sectors. Of course, it is also possible that countries change their definition of what they consider urban over time, but this is generally an infrequent occurrence.

Moreover, the urban category can be quite diverse within countries; for example, in Kenya the meaning of living in a large capital city, such as Nairobi, would be very different to the meaning of living in a city with a population of around 120,000 people or a town of 30,000. A gradient of urbanicity is a more realistic reflection of settlement types than a simple dichotomy of rural and urban. The DHS allows for going beyond the dichotomy, with four categories: countryside; town; small city with over 50,000 people; and capital or large city with over 1 million residents. Dividing the urban category into three provides a more nuanced understanding of the inequalities in mortality within countries, and we explore this gradient in our analysis. However, for the most part we stick to the rural–urban dichotomy because of the smaller sample sizes per sector, because migration between the various sectors would further complicate the estimates, and because this categorization is not available in all surveys considered here (only in 85 out of 138).

Finally, although we consider rural and urban populations as separate entities, interdependence between the sectors exists. For example, rural residents may use heath facilities in cities, and urban residents may spend part of their year in the rural sector, maintaining two households. Movement between the sectors also leads to spread of disease and affects exposure to risk factors, which further complicates a clear divide between the sectors.

Evidence of rural–urban mortality inequalities

Based on the most recent surveys, in each of the 53 countries we consider, the median urban/rural ratio in the risk of dying before age 60 ($_{60}q_{0}$) is 0.92 (interquartile range (IQR): 0.86–1.05), indicating higher rural mortality overall. The five countries with the highest urban/rural ratios in mortality up to age 60 are Tanzania, Zambia, Timor-Leste, Papua New Guinea, and São Tomé and Príncipe (all ratios >1.25), and the five countries with the lowest ratios are Guinea, Bolivia, Afghanistan, Peru, and Comoros (all ratios <0.75). These divergent and extreme spatial gaps in mortality suggest that governments and other stakeholders in the former set of countries should invest in improving survival in the urban sector, whereas the latter should invest in the rural sector. Yet, these aggregated inequalities in mortality between rural and urban sectors conceal substantial heterogeneity in mortality by age. The rural–urban inequalities in child and adolescent mortality compared with those in adulthood are especially notable (Figure 2).



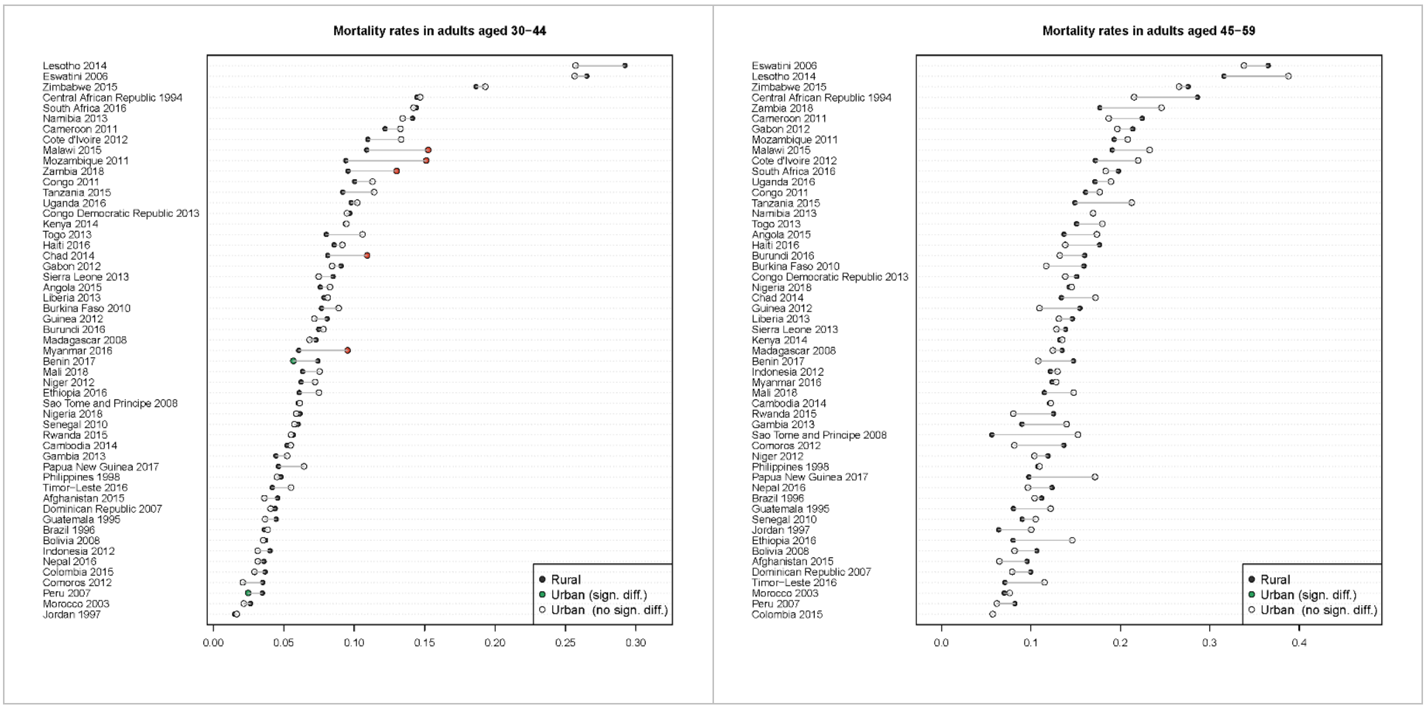


Figure 2 Equiplots of rural and urban mortality rates by age: neonatal, postneonatal, 5–14, 15–29, 30–44, and 45–59 years

Note: Countries in each panel are arranged from highest to lowest national-level mortality rates within each age group.

Source: Most recent Demographic and Health Surveys (1994–2018) in 53 countries.

Looking at the most recent survey available for each country in Figure 2, rural neonatal mortality rates (NMRs; Figure 2(a)) are higher than urban rates in 38 countries out of 53, although the difference between sectors is only significant in 13 of these cases (25 per cent). In Tanzania, unlike the rest of the countries, urban neonatal mortality is significantly higher than in rural areas, and the gap between sectors is exceptionally large. Across all countries the median urban/rural NMR ratio is estimated at 0.85 (IQR: 0.69–1.03), and it is higher in surveys conducted in sub-Saharan Africa than in other regions (Table 1).

With regard to mortality after the first month of life, the postneonatal mortality estimates (Figure 2(b)) suggest that larger gaps exist between the rural and urban sectors. The median urban/rural mortality ratio declines to 0.68 (IQR: 0.59–0.83) in this age group. The urban advantage in postneonatal mortality is significant in 26 countries out of 53, and there is no evidence of significantly higher urban mortality in any country. The survival advantage for children aged under five living in urban areas is substantial when expressed as an absolute difference. The SDG target for the national under-five mortality rate for 2030 is 25 deaths per 1,000 live births, but from the most recent surveys in 19 countries the absolute differences in under-five mortality exceed this value, meaning that the difference between urban and rural sectors is larger than the SDG target.

Table 1 Median urban/rural ratios of mortality rates (and IQRs), by age group and world region

Age	Sub-Saharan Africa ($n = 36$)		Other LMICs ($n = 17$)		All countries ($n = 53$)	
	Median	(IQR)	Median	(IQR)	Median	(IQR)
NMR (< 1 month)	0.91	(0.79–1.08)	0.71	(0.63–0.88)	0.85	(0.69–1.03)
Postneonatal (1–59 months)	0.72	(0.65–0.85)	0.61	(0.49–0.68)	0.68	(0.59–0.83)
5–14 years	0.68	(0.59–0.80)	0.59	(0.53–0.75)	0.67	(0.57–0.76)
15–29 years	0.93	(0.85–1.04)	0.88	(0.73–0.96)	0.91	(0.83–1.03)
30–44 years	1.03	(0.96–1.18)	0.94	(0.82–1.07)	1.02	(0.93–1.16)
45–59 years	1.01	(0.89–1.24)	1.01	(0.78–1.09)	1.01	(0.83–1.23)

Note: The urban/rural ratio is the risk of dying within the age group in urban areas divided by the risk of dying within the age group in rural areas. A ratio below 1.0 indicates that mortality is higher in rural areas, whereas a ratio above 1.0 indicates higher mortality in urban areas.

Source: Most recent Demographic and Health Surveys (1994–2018) in 53 countries.

Similarly, the probability of dying among older children and adolescents (${}_{10}q_5$) is larger in rural areas in 48 countries, although there are fewer significant differences (11), in part because of wider CIs around the mortality estimates (Figure 2(c)). There is not a single survey showing significantly higher risks of dying in urban areas in this age group. The median urban/rural mortality ratio among 5–14-year-olds is 0.68 (IQR: 0.59–0.80) in sub-Saharan Africa, once again higher than in the 17 surveys conducted in other regions (0.59; IQR: 0.53–0.75).

After age 15, we observe a drastic reduction in the relative differences between urban and rural mortality levels. In youth and young adults (aged 15–29), the majority of countries maintain higher rural mortality, although in only five countries is this gap significant (Figure 2(d)). In one country (Chad), there is a switchover in this age group to significantly higher urban mortality. Overall, the urban/rural ratios increase among 15–29-year-olds and the median ratio reaches 0.91 (IQR: 0.83–1.03). It is clear that the urban advantage is substantially reduced relative to younger age groups, but there is still no evidence of an urban penalty in young adults aged 15–29.

When looking at adults aged 30–44 (Figure 2(e)), the rural–urban mortality inequalities are very different from those among children and adolescents. The gap between the sectors is small to negligible in most countries, and the median urban/rural ratio reaches 1.02 (IQR: 0.93–1.16). In sub-Saharan Africa, the median is 1.03 (IQR: 0.96–1.18), still higher than in other regions covered by our sample, where the median remains below 1.0, at 0.94 (IQR: 0.82–1.07). It becomes clearer that in high-mortality countries, ${}_{15}q_{30}$ is higher in the urban sector, whereas in countries where mortality levels are lowest, rural ${}_{15}q_{30}$ is very close to or higher than urban ${}_{15}q_{30}$. In five countries, urban mortality is significantly higher than rural at this age (Chad, Malawi, Mozambique, Myanmar, Zambia), while two countries show the opposite pattern (Benin, Peru).

Finally, in the oldest age group we examine (45–59-year-olds), the median urban/rural ratio remains close to 1.0 (1.01; IQR: 0.83–1.23), and differences between areas are not significant in any country (Figure 2(f)). In this age group, the DHS sample sizes are too small to capture significant mortality disparities.

Overall, our results confirm the urban advantage in children and its disappearance in adults in the most recent surveys. The results also suggest that the urban penalty in adult mortality might not be as large as previously estimated and is concentrated among adults aged 30–45 and in countries with relatively high mortality. In any case, because of the progressive reversal of urban advantage with age, our study confirms that inferring inequalities in adult mortality based on differences observed in child mortality can be very misleading. The relationship between excess rural mortality in childhood and differences observed at adult ages is very weak. The correlation between ratios of urban/rural mortality for children aged under five and for adults aged 15–59 is only 0.38 (95 per cent CI: 0.12–0.59).

We further consider the synthetic probability of dying for children aged <15 (${}_{15}q_0$) and the equivalent probability for adults aged 15–59 (${}_{45}q_{15}$), to examine the trends in mortality over time in countries with at least three DHS rounds. We note that in some countries with a decline in under-15 mortality over time (e.g. Mozambique and Malawi), the rural–urban gap in ${}_{15}q_0$ decreased (Figure 3). Elsewhere, as in Indonesia and Niger, rural mortality among <15-year-olds remained higher than urban mortality. Trends in adult mortality were less consistent, with the rural–urban gap growing or contracting over time. In Chad, Ethiopia, Guinea, Haiti, Kenya, Mozambique, and Tanzania, urban adult mortality sometimes increased rather than decreasing between one survey and the next, while rural adult mortality was more stable. In countries hard hit by HIV/AIDS in southern and eastern Africa, the probability ${}_{45}q_{15}$ was clearly high. Yet, in many of these countries, such as Zambia, the effects of HIV/AIDS on mortality were not accompanied by shifts in the rural–urban gap.

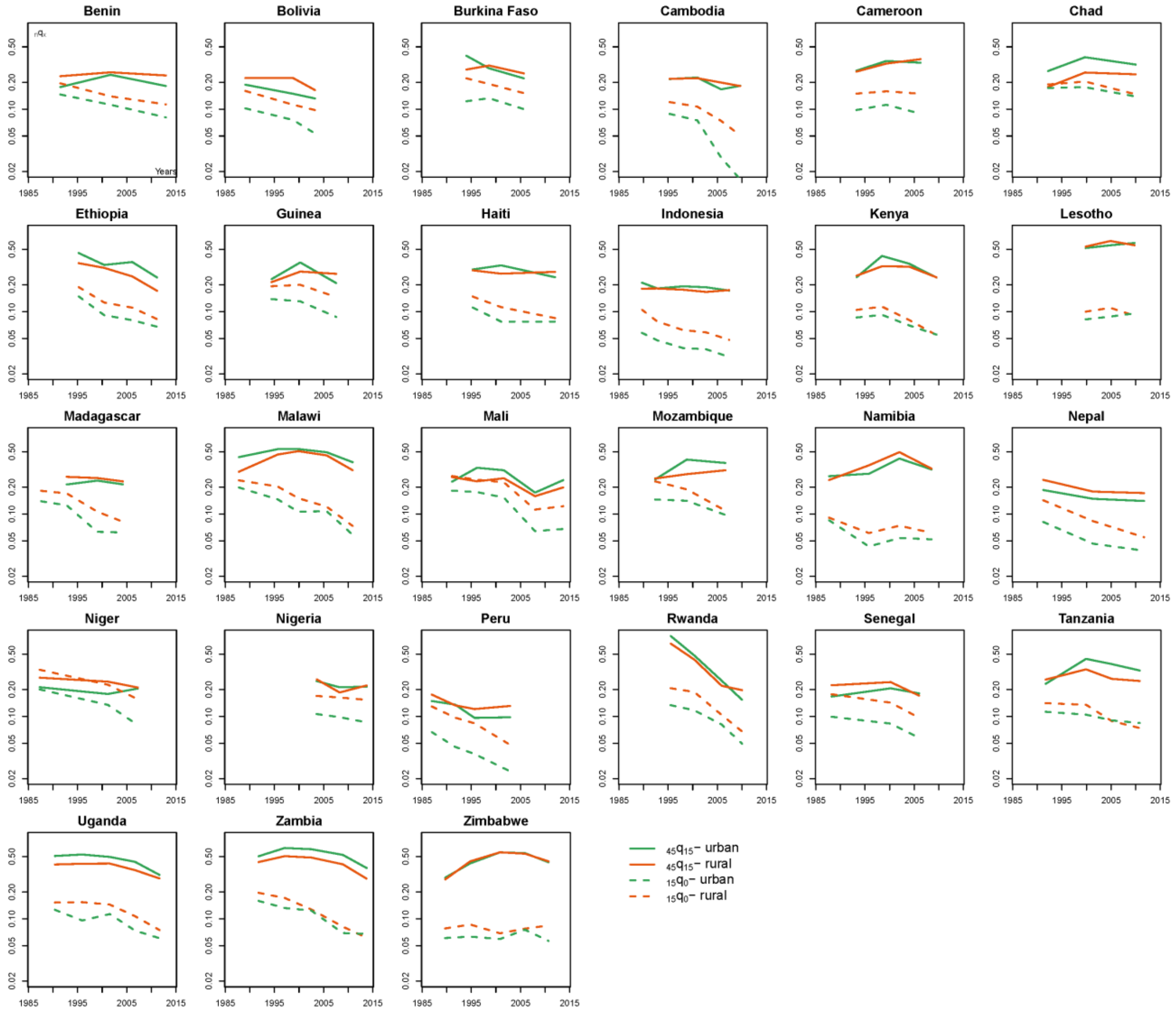


Figure 3 Trends in rural–urban differences in mortality for children (aged 0–14) and adults (aged 15–59)

Note: The y axis in on logarithmic scale.

Source: Demographic and Health Surveys in 27 countries with at least three survey rounds available.

Overall, Figure 3 suggests that the gap in rural and urban mortality is more dynamic among adults than among <15-year-olds. This can be explained by the stage of epidemiologic transition these countries are at, whereby mortality from communicable diseases has already declined dramatically in both rural and urban sectors. Since child mortality is mostly from infectious diseases, and among infants also from neonatal and maternal disorders (Roth et al. 2018), rural death rates are higher than urban rates. In contrast, among adults we observe a mixture of mortality trends by sector as the balance of deaths between communicable and non-communicable diseases changes, evolving in particular with the magnitude of the HIV epidemic.

In light of our aforementioned discussion on the rural–urban dichotomy, we further examine mortality (${}_{15}q_0$ and ${}_{45}q_{15}$) inequalities over a gradient of urbanicity (Figure 4). When comparing the mortality of <15-year-olds (upper three panels), mortality estimates are higher the less urban the settlement, with the greatest difference in mortality between countryside (rural) and towns (although these differences are not significant). The differences in adult mortality between towns, small cities, and large cities are variable and do not suggest clear differences between these sectors (see lower three panels). However, comparing towns with the rural sector, when the level of mortality is low, we note higher rural mortality. When mortality is high, the urban population suffers a greater burden. We interpret these results with caution due to smaller sample sizes but, overall, we note that the clearest mortality gap is between rural areas and towns (the smallest level of urban).

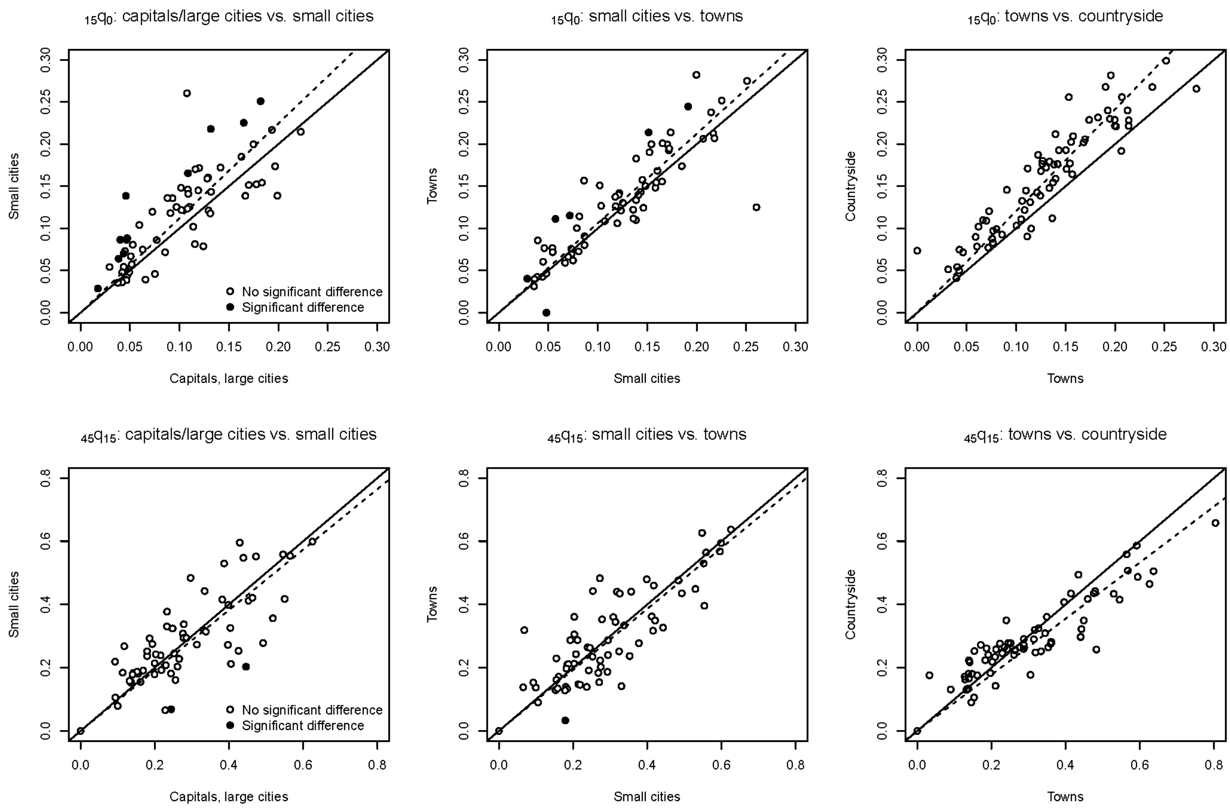


Figure 4 Inequalities in child mortality (ages 0–14) and adult mortality (ages 15–59) over a gradient of urbanicity

Note: The solid diagonal line represents equal mortality rates between the sectors, and the dotted diagonal line represents the linear fit.

Source: Demographic and Health Surveys in 41 countries (85 surveys) where four categories of urbanicity are available.

Are these estimates of reduced rural–urban inequalities in adult mortality reliable?

The observation of a relatively limited urban penalty among adults in our study, compared with previous work by Menashe-Oren and Stecklov (2018b) or Günther and Harttgen (2012), could point to bias in our estimates. We address three potential sources of bias and how they may differ by urban/rural sector. The sources of bias are: (1) reports of deaths only being possible when there is someone alive to report them; (2) misclassification of deaths and person-years at risk as rural or urban because of migration; and (3) inaccuracies in reporting. In Table 2 we lay out these biases, identifying where we expect them to affect our results. We accordingly suggest a range of checks to examine the extent of these biases and whether they challenge our conclusion of a smaller rural–urban gap in adult mortality than in child mortality.

Table 2 Potential sources of bias in urban/rural mortality ratios arising from birth and sibling histories

Source of bias	*Expected effect on differences between rural and urban estimates in birth and sibling histories*	*Checks*	*Results of checks*	*Conclusions*
Only survivors report on deaths of children/siblings. Adult siblings can be reported multiple times.	Assuming higher mortality in one sector, that sector will have fewer reporting mothers and therefore lower child mortality estimates. Assuming that adult mortality is not associated with sibship size,[1] mortality estimates should be unbiased in both rural and urban sectors. Shared contexts (e.g. socio-economic status) generate mortality clustering, which could introduce a downward bias in sibling-based estimates, particularly in rural regions.[2]	Comparison with estimates based on recent deaths in household (assuming few households dissolve after the death of a member)	Higher estimates of ${}_{45}q_{15}$ from recent deaths in both sectors (inconclusive with ${}_{5}q_{0}$). The urban/rural ratio of ${}_{45}q_{15}$ is higher based on sibling histories (compared with household deaths) in four out of five countries.	Confirms rural excess in under-five mortality and a reduction of the urban advantage among adults.
Misclassification due to respondent migration or child/sibling migration	Since most migration among respondents aged 15–49 is from rural to urban area,[3] reported child/sibling deaths and person-years attributed to the urban sector may have occurred in the rural sector before the respondent migrated. Similarly, in the case of rural-to-urban migration of children and siblings, if a child/sibling dies in the urban sector, the deaths and person-years are wrongly attributed to the rural sector if the respondent stays in a rural area. In both cases, misclassification should reduce the urban advantage in child mortality and adult mortality estimates will get closer to equity. Migration biases will likely be larger in adult mortality rates (longer exposure period and less likely to have migrated with the respondent).	1. Select sample of respondents living in same sector as at birth 2. Comparison with estimates based on recent deaths in household 3. Comparison with estimates based on parental deaths (for adults only)	1. Limited to non-migrant respondents, estimates of urban/rural under-five mortality ratios are quite similar. Lower ratios of postneonatal mortality rates suggest even higher rural mortality in this age group. Significant differences in mortality of 15–44-year-olds in sensitivity analysis suggest that when urban/rural ratios are very low, misclassification increases the ratio. When ratio is very high and above 1.0, misclassification reduces the ratio. 2. In four out of five DHSs, ratios on household deaths also point to smaller gaps among adults. 3. Comparison among adults with urban/rural ratios based on reports of parental death among orphans, where there is reduced bias from migration, does not contradict findings of excess urban mortality in some countries.	In children, rural-to-urban migration reduces the excess rural mortality, but we still reach a conclusion of lower urban mortality. In adults, misclassification bias reduces the urban penalty (when urban mortality is higher than rural), reinforcing the conclusion of higher urban mortality in some countries. Comparison with other methods of mortality estimation does not contradict conclusion of smaller mortality advantage among urban adults.

(In)accuracy in reports of surviving and dead	We expect that reports on children and siblings will be less accurate in rural areas because of lower rates of literacy,[4] resulting in underestimates of rural mortality (more than of urban mortality).	1. Age heaping of siblings alive and dead 2. Month heaping in date of birth among children alive and dead 3. Consistency of mortality rates over surveys that overlap	1. Rural respondents tend to be less accurate in reporting on ages of siblings, particularly ages at death. 2. Accuracy in reports of child death among rural and urban respondents is similar, but in both sectors there seems to be greater inaccuracy for dead children. 3. Mortality in earlier periods is more systematically underestimated compared with period immediately before the previous survey (particularly in sibling histories), but the extent of this under-reporting of deaths appears comparable across sectors.	Possible downward bias in rural adult mortality (the urban disadvantage could be spurious), but no evidence of sectoral bias in child mortality. Under-reporting of adult deaths is not more pervasive in rural sector and therefore cannot explain the narrowing of the rural–urban survival gap.
Overall differences in bias across methods	Estimating mortality based on sibling survival is more challenging than estimating mortality based on birth histories,[5] and these challenges should not differ by sector.	Comparing estimates of ${}_5q_{10}$ from birth and sibling histories	Both birth and sibling histories provide comparable levels of mortality among 10–14-year-olds once birth order is controlled for. Excess rural mortality in this age group is consistent.	Neither method seems more biased than the other, so higher urban estimates based on sibling histories is not artefact of bias in method.

[1]Masquelier 2013.
[2]McMurray 1997; van Dijk 2018.
[3]Menashe-Oren and Stecklov 2018a.
[4]ICF International 2020.
[5]Timæus 1991.

A first means of testing for the robustness of our results is by comparing mortality estimates from two different methods that also use the DHS data. We compare our results first with those based on the orphanhood method for 90 surveys from sub-Saharan Africa, available from Menashe-Oren and Stecklov (2018b) (see supplementary material, section A2). The urban/rural mortality ratios among adults aged 15–59 are not strictly comparable in both methods. The mortality estimates based on orphanhood are by sex, cover slightly different periods, and come with their own assumptions and biases. All the same, as seen in Figure 5, a comparison of urban/rural ${}_{45}q_{15}$ ratios suggests that we cannot conclude that higher urban mortality is more probable based on one method rather than the other. A paired t-test between the urban/rural mortality ratios leads us to the same conclusion (*p*-value = 0.27).

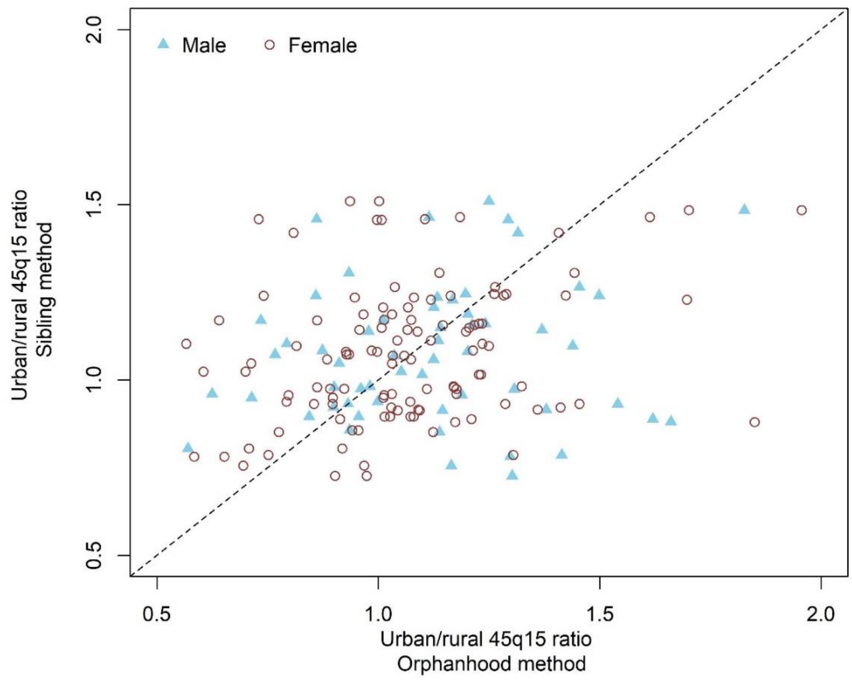


Figure 5 Comparison between rural–urban adult mortality gaps calculated using the sibling method and the orphanhood method

Notes: The urban/rural ratio is the risk of dying at age 15–59 in urban areas divided by the risk of dying at that age in rural areas. The urban/rural ${}_{45}q_{15}$ ratios based on the orphanhood method are sex specific because the estimation relies on the age of parents at childbirth, which is higher among men. The diagonal line represents equal ${}_{45}q_{15}$ ratios based on both methods.

Source: Demographic and Health Surveys: 90 surveys from sub-Saharan Africa.

We next compare our estimates with those based on recent household deaths from five DHS surveys where a question on household deaths in the last 12 months was included. This comparison is particularly beneficial for two reasons, despite the question featuring in only five surveys (see supplementary material, section A3). First, if there are any issues related to sampling or the interviewing process, they will be consistent in both methods since the questions are from the same interview. Second, data on recent household deaths allow estimation of both child and adult mortality, and most biases in these data should affect both age groups. Importantly, misclassification from migration is also drastically reduced. In Figure 6 we find evidence of higher urban/rural mortality ratios among adults when using mortality estimates based on sibling histories than when using estimates based on recent household deaths. An urban disadvantage in adult mortality is thus less apparent with estimates based on recent household deaths, so this method essentially reduces misclassification bias.

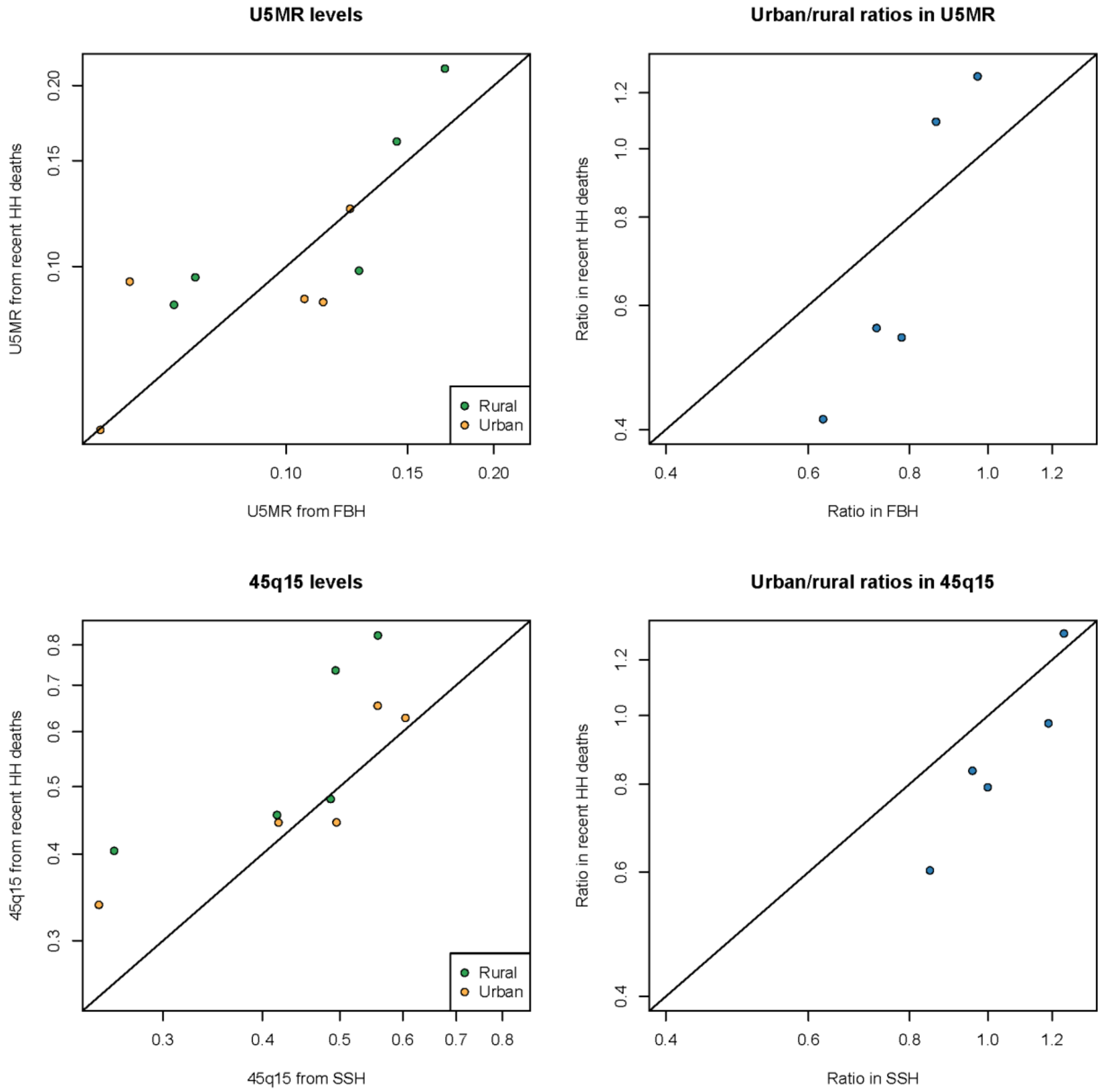


Figure 6 Comparison between rural and urban adult mortality (ages 15–59) levels and ratios based on sibling histories with those based on recent household deaths: five countries in sub-Saharan Africa

Notes: The diagonal line represents identical mortality estimates based on recent household deaths and either sibling survival histories (for adults) or full birth histories (for children). The dashed lines in the left-hand plots connect the rural and urban estimates within each of the five surveys. The scales of the x and y axes are logarithmic.

Source: Demographic and Health Surveys in Namibia (2006), Nigeria (2008), Uganda (2006), Zambia (2007), and Zimbabwe (2005).

Another way of checking the extent of misclassification due to migration is through estimating mortality from a subsample of non-migrant respondents. Our main estimates are based on the assumption that the children and siblings reported by the women interviewed in rural areas also live in rural areas (and vice versa). If the type of residence of the respondent is a poor proxy of that of her children or siblings, inequalities between areas will be underestimated, and this could mask a possible urban penalty. The assumption of co-residence is more reasonable for children than for siblings, although there is evidence of relatively high levels of child fostering in some parts of Africa (Isiugo-Abanihe 1985; Madhavan 2004). We adopt the same procedure as Günther and Harttgen (2012), by selecting only respondents who lived in the same place of residence at survey as in childhood to account for this bias, using 63 surveys where respondents were asked about childhood residence. On average, 73 per cent of women aged 15–49 were born in the same sector (rural or urban) as they lived in at time of interview (IQR: 70–82 per cent). In Figure 7, we compare the urban/rural mortality ratios in the full samples with those obtained in the restricted samples that exclude migrants.

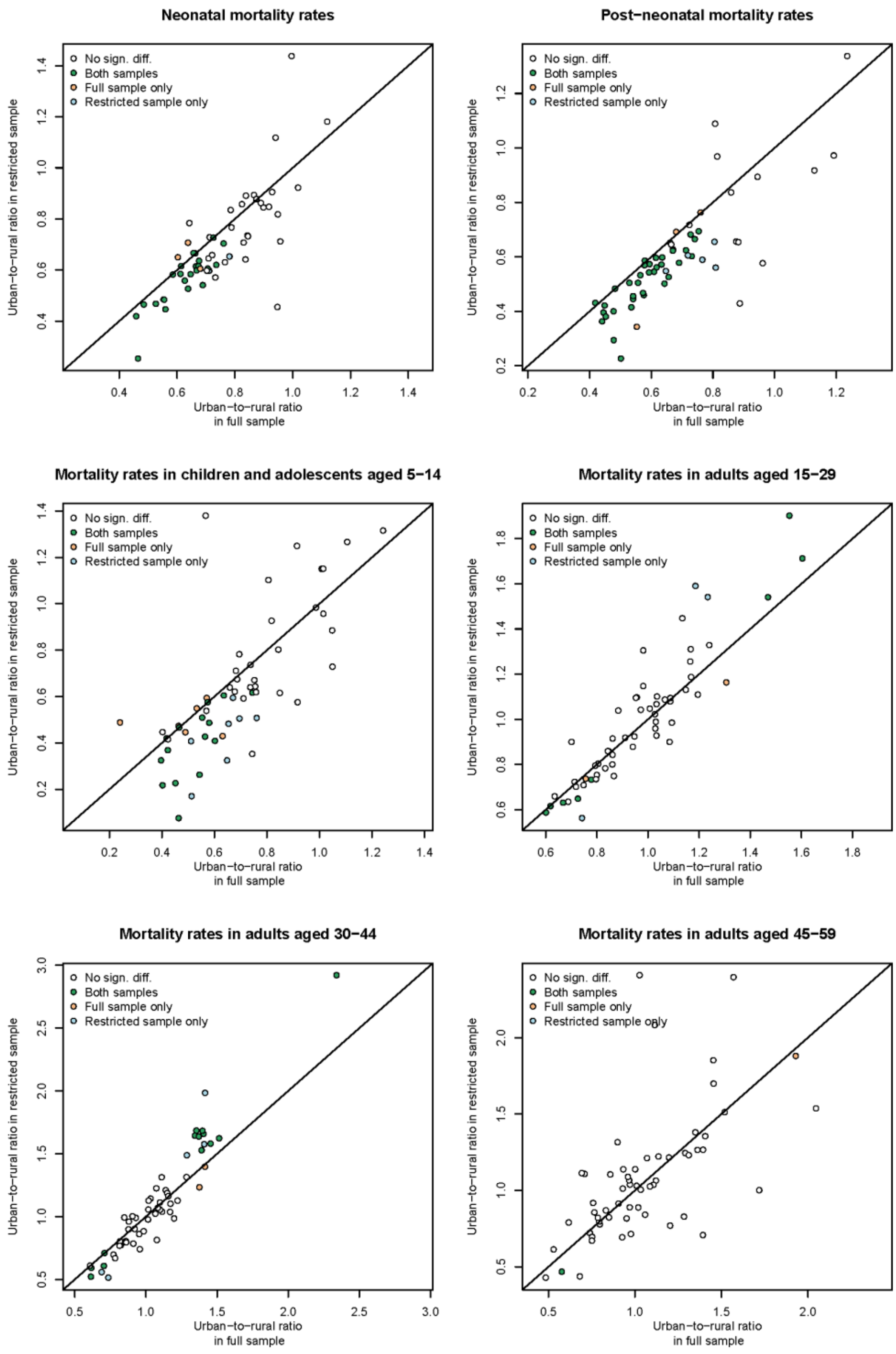


Figure 7 Sensitivity of urban/rural mortality ratios to misclassification bias due to migration, by age group

Notes: Restricted sample refers to mortality estimates based only on respondents whose childhood residence was the same as their current place of residence, while the full sample includes all eligible respondents. The diagonal line represents equal urban/rural mortality ratios in full and restricted samples. The colours and symbols used to identify the points refer to the existence of a statistical difference between urban and rural areas, based on a test within each sample. The difference in ratios across samples are evaluated with Wilcoxon signed-rank tests but these are not displayed.

Source: 63 Demographic and Health Surveys in 38 countries.

Urban/rural mortality ratios estimated in the restricted samples are considerably lower than in full samples among children under 15 years of age. Wilcoxon signed-rank tests confirm that this difference is significant in each age group below age 15 ($p < 0.005$). In other words, migration does introduce a bias by reducing the urban advantage in childhood. This may be explained by the higher risk of death among children of migrant mothers in comparison with the (often-urban) population at destination, due to disruption effects, and by the lower mortality of migrants' children in comparison with the (mostly rural) population at origin, due to selection effects (Brockerhoff 1990, 1994; van de Poel et al. 2009; Bocquier et al. 2011). By contrast, among adults, the ratios from the restricted samples are not statistically different from those from the full samples. Thus, our results on adult mortality appear robust to this migration bias.

A third source of bias is that of accuracy in reporting (i.e. recall bias), which could be affecting our rural–urban mortality differences. We check the extent of this bias using two indicators of recall error: in sibling histories by examining age heaping using Myers' Index and in birth histories by examining month preference. Respondents in the rural sector tend to be less accurate when reporting on siblings than respondents in the urban sector, especially when reporting on age of sibling at death (supplementary material, section A4, Figure A2). If age misreporting errors introduce downward bias in mortality estimates and/or they are associated with under-reporting of deaths, then rural mortality rates may actually be higher than estimated here. Respondents reporting on child's month of birth seem to be equally accurate in the rural and urban sectors (supplementary material, section A4, Figure A3). However, there is greater recall bias for birth months of children who have died.

Additionally, we use the consistency of estimates across successive surveys to assess the extent of under-reporting, assuming that under-reporting is more pronounced in the distant past relative to years directly preceding surveys (Timæus and Jasseh 2004; Masquelier et al.

2014) (see supplementary material, section A5). We find that child mortality estimates are more consistent than adult mortality estimates (Figure 8). The linear fitted line for urban child mortality lies on the diagonal line of equity and the fitted line for rural child mortality is also close. Mortality referring to an earlier period (as estimated from the most recent survey) is more systematically underestimated than mortality in the period immediately before the data collection (as estimated from the previous survey). However, there is no obvious difference between the rural and urban sectors. The linear fitted lines of adult mortality estimates over successive surveys are more distant from the diagonal, suggesting a more frequent under-reporting of deaths that occurred in the distant past, although they are almost identical in both sectors. This indicates that under-reporting of deaths is not more pervasive in the rural areas, and recall bias cannot explain the narrowing of the rural–urban survival gaps.

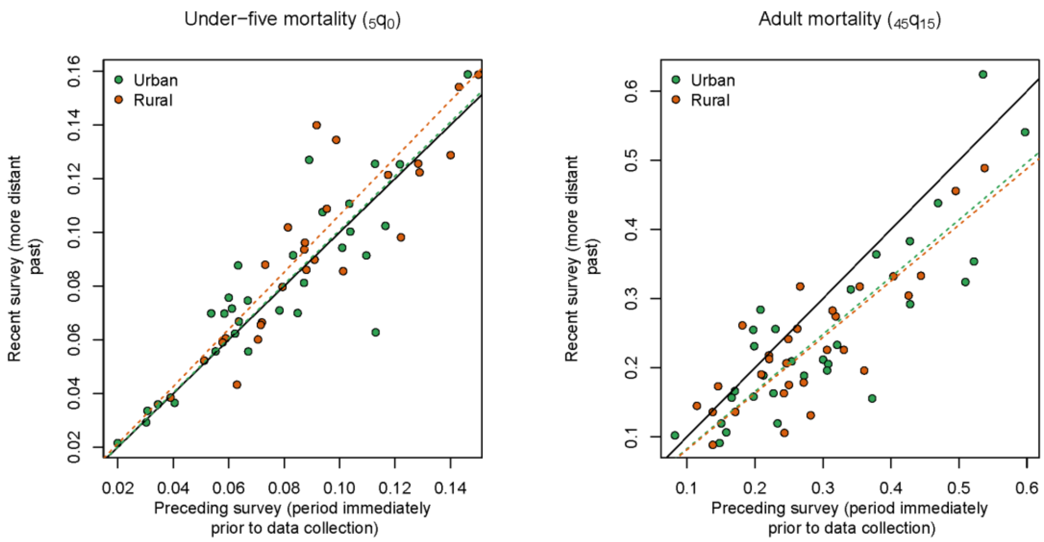


Figure 8 Comparison of mortality rates ($_5q_0$ and $_{45}q_{15}$) calculated on the basis of two successive surveys for the same period, according to urban/rural sector

Notes: The solid diagonal line represents equal mortality rates between the sectors and the two dotted diagonal lines represent the linear fit for the rural and urban sectors separately. Mortality referring to an earlier period is estimated from the most recent survey, and mortality in the period closest to the data collection is estimated from the previous survey.

Source: Demographic and Health Surveys in 39 countries with successive surveys less than ten years apart.

Finally, to determine whether sibling histories may be worse affected by these aforementioned biases, we turn to a comparison of mortality estimates among 10–14-year-olds (${}_{5}q_{10}$) from sibling and birth histories (see supplementary material, section A6). We estimate mortality only in children and siblings of birth orders three to five, reducing selection bias in birth histories related to birth order when examining mortality at higher ages (Hill et al. 2015). In sibling histories, the median ratio of urban/rural mortality in the 10–14 age group is 0.76 (IQR: 0.60–1.08), while in birth histories the median ratio is 0.82 (IQR: 0.43–1.23). A Wilcoxon signed-rank test indicates that the difference between these medians is not significant. Both sources provide comparable levels of mortality, and rural excess mortality appears consistently in both (see Figure A6, supplementary material, section A6).

In light of these robustness checks, and because we take into account the structure of the DHS sample when estimating CIs around mortality rates, we can definitely conclude that there is a reduction in the urban mortality advantage over the life course. Age heaping is the only indicator suggesting that rural respondents tend to be less accurate than urban respondents in reporting deaths of siblings, pointing to a possible downward bias in rural mortality (Table 2), although we postulate that this does not substantially affect the rural–urban mortality gap.

A further source of bias that we cannot check derives from the definition of urban, as discussed earlier. Considering that settlements may grow and become urban over time, our sensitivity analysis accounting for migration could be misleading. More importantly, neither childhood residence nor current residence of the respondent at survey necessarily captures the residence of the siblings on whom the adult mortality estimates are built. It is not possible to examine the extent of bias from this potential misclassification.

The epidemiologic transition and rural–urban mortality gap

Having established the rural–urban differences in mortality across age groups, we explore whether the smaller gap in rural–urban mortality among adults can be explained by the epidemiologic transition as depicted in Figure 1. As data on cause of death by urban/rural sector across LMICs do not exist, we use data on disease and risk-factor prevalence available from the DHS (ICF International 2020). In Figure 9(a)–(c) we probe the relationships between the probability of dying before age 15 and, first, the prevalence of malaria according to rapid diagnostic tests and, then, the prevalence of fever and diarrhoea in the last two weeks among children. Rural malaria prevalence is higher, as is rural mortality from birth to age 15 years, as presented by the positive slopes (Figure 9(a)). Although only 18 DHS surveys are represented (data on malaria are unavailable elsewhere), this relationship seems near universal. The proportion of children who have experienced fever or diarrhoea in the past two weeks offers a useful indication of infectious disease prevalence. According to Figure 9(b)–(c), these indicators do not seem to differ greatly between rural and urban sectors (evident from the numerous near-vertical lines), although proportionately more children seem to be ill in the rural sector. At higher levels of prevalence (over 20 per cent), positive slopes suggest that infectious diseases are related to higher rural ${}_{15}q_0$. Based on this exploratory analysis, sectoral mortality trends among children partly reflect the trends in mortality from communicable diseases, as expressed in the epidemiologic transition depicted in Figure 1.

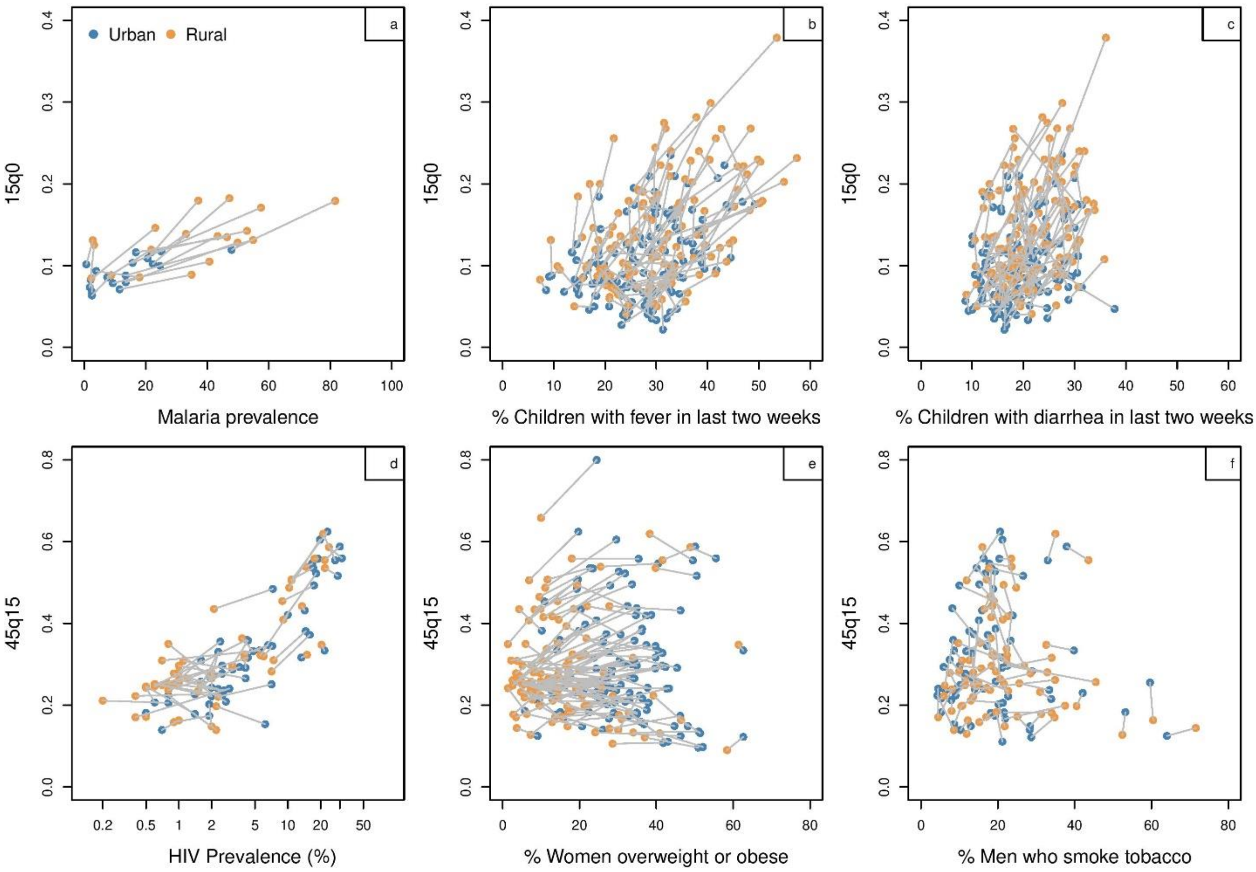


Figure 9 Probabilities of dying for children (aged 0–14) and adults (aged 15–59) and their association with six mortality risk factors in LMICs, by urban/rural sector

Note: Lines link urban and rural probabilities for the same country.

Source: Number of Demographic and Health Surveys varies across panels: 19 countries (19 surveys) for malaria prevalence, 53 countries (135 surveys) for fever, 52 countries (138 surveys) for diarrhoea, 30 countries (56 surveys) for HIV prevalence, 46 countries (123 surveys) for overweight women, and 41 countries (77 surveys) for men who smoke.

We further explore in Figure 9(d)–(f) the relationships between adult mortality and HIV/AIDS prevalence, proportion of women who are overweight or obese, and proportion of men who smoke, across rural and urban sectors. At low levels of HIV prevalence (below 7 per cent), there seems to be little correspondence between sectoral HIV prevalence and adult mortality (Figure 9(d)). However, with higher HIV prevalence, urban adult mortality tends to be higher, evident by the positive slopes with higher, lighter grey dots. This reflects the possible reduction of the urban advantage due to stalls in the decline of communicable diseases because of the emergence of new infectious diseases, as depicted in Figure 1. A general trend of positive slopes is also observed in relation to the percentage of women overweight or obese when the ${}_{45}q_{15}$ is higher than 0.3 (Figure 9(e)). The percentages of overweight and obese women are considerably higher in the urban sector than in the rural (horizontal lines), but only seems to be related to higher urban mortality when adult mortality levels are high. This suggests that urban populations are at higher risk of dying from non-communicable diseases, in line with the model in Figure 1. In contrast, there seems to be little relationship between adult mortality and the proportion of men who smoke tobacco by urban/rural sector (Figure 9(f)). Smoking patterns may be more diverse across countries and the sectoral relationship with adult mortality compounded by greater air pollution in the urban sector. In effect, this finding does not support higher urban mortality from non-communicable diseases in the schema of the epidemiologic transition (Figure 1). However, this analysis is limited, considering we do not examine mortality at ages 60+, where the proportion of deaths from non-communicable diseases is higher.

Overall, this exploratory analysis of disease and risk-factor prevalence supports our understanding of a shift to a reduced urban advantage in adult mortality, while child mortality remains higher in the rural sector: the epidemiologic transition stagnates in the urban sector, primarily due to the (re-)emergence of infectious diseases that affect adults more than children but also due to the socio-economic inequalities characteristic of many cities in LMICs.

Conclusion

To examine whether there really is an urban advantage in child mortality and an urban penalty in adult mortality, we explored the rural–urban mortality gap in six age groups across the less developed regions of the world. While our results showing higher urban than rural adult mortality in some countries were consistent with previous research (Günther and Harttgen

2012; Menashe-Oren and Stecklov 2018b), we were able to establish that these higher urban adult mortality estimates were not significantly different from rural estimates except in a few countries: Chad, Malawi, Mozambique, Myanmar, and Zambia. Significantly higher mortality in the urban sector was found, particularly among 30–44-year-olds, but in only five of the 53 countries' latest available surveys. Among older adults aged 45–59, although there were wider gaps between the rural and urban mortality estimates, this apparent urban penalty was not significant. This could be due to the small sample size for this age group.

Our most conclusive evidence of a sectoral gap was among 1–59-month-olds, where urban mortality was significantly lower in 49 per cent of the countries examined. An urban advantage was also found to be maintained up to age 15. To our knowledge, this has been the first study to examine child and adolescent mortality by urban/rural residence. Overall, rural ${}_{10}q_5$ was higher than urban ${}_{10}q_5$, although compared with under-five mortality, the sectoral differences were less often significant, even when estimates suggested a wide rural–urban gap. Considering the relatively low mortality levels in this age group, it is not surprising that differences were insignificant. This rural disadvantage was further reinforced by similar estimates of mortality for rural and urban 10–14-year-olds based on sibling histories.

Although we cannot conclude that there is evidence of higher urban mortality among adults, there is clear evidence of a smaller rural–urban gap in adult mortality and a diminishing of the distinct rural disadvantage seen among children up to age 15. The multiple checks that we used indicated that despite a range of biases in both birth and sibling histories, these biases do not systematically differ by sector.

We have demonstrated that in only a handful of countries is urban mortality significantly higher than rural. Considering the limitations in the method of estimation, further contribution to the understanding of rural and urban mortality differentials is needed based on direct estimation; this could identify deaths subregionally without migration bias or recall errors. Surveys with larger samples, pooled surveys, or direct estimates of mortality from censuses or death registration could also be useful when considering further disaggregation of the rural–urban dichotomy. Additionally, other factors such as education and wealth may compound any rural–urban differentials. Yet such rich subnational data are lacking across LMICs, and indirect mortality estimation among adults is currently the next best alternative.

We contend that the shifting rural–urban mortality gap over the life course is related to the sector-specific epidemiologic transition. Preliminary exploration of the association of disease and risk-factor prevalence by urban/rural sector indicated that the shift to higher urban mortality among adults reflects a diverging epidemiologic transition between the sectors. The transition in LMICs differs between the urban and rural sectors because of the urban adult population's greater exposure to non-communicable diseases and, in some contexts, also to communicable diseases (as in countries with high HIV prevalence), leaving urban adults particularly vulnerable once mortality from infectious diseases declines. Further analysis on differences in causes of death among adults between the sectors may provide better insight into the extent of the rural–urban mortality gap over the life course and how it reflects sectoral divergence throughout the epidemiologic transition.

Notes and acknowledgements

1 Ashira Menashe-Oren and Bruno Masquelier are both based at the Centre for Demographic Research, UCLouvain. Please direct all correspondence to Ashira Menashe-Oren, Centre for Demographic Research, UCLouvain, Place Montesquieu 1/ L2.08.03, 1348 Louvain-la-Neuve, Belgium; or by Email: ashira.menashe-oren@uclouvain.be

2 Ashira Menashe-Oren holds a postdoctoral research fellowship funded by the Fonds de la Recherche Scientifique (F.R.S.-FNRS).

References

Addo, Juliet, Liam Smeeth, and David A. Leon. 2007. Hypertension in Sub-Saharan Africa: A Systematic Review, *Hypertension* 50 (6): 1012–18. doi:10.1161/HYPERTENSIONAHA.107.093336.

Akoto, Eliwo, and Basile O. Tambashe. 2002. Socioeconomic Inequalities in Infant and Child Mortality among Urban and Rural Areas in Sub-Saharan Africa, Paper presented at *First Seminar of the IUSSP Committee on Emerging Health Threats,* Rostock, Germany. Available: http://www.demogr.mpg.de/Papers/workshops/020619_paper01.pdf.

Alberto, Jose, and Charles H. Wood. 2011. Mortality, Income Distribution, and Rural-Urban Residence in Brazil, *Population (English Edition)* 4 (3): 405–20.

Barongo, Longin R., Martien W. Borgdorff, Frank F. Mosha, Angus Nicoll, Heiner Grosskurth, Kesheni P. Senkoro, James N. Newell, et al. 1992. The Epidemiology of HIV-1 Infection in Urban Areas, Roadside Settlements and Rural Villages in Mwanza Region, Tanzania, *AIDS* 6 (12).

Bilal, Usama, Marcio Alazraqui, Waleska T. Caiaffa, Nancy Lopez-Olmedo, Kevin Martinez-Folgar, J. Jaime Miranda, Daniel A. Rodriguez, et al. 2019. Inequalities in Life Expectancy in Six Large Latin American Cities from the SALURBAL Study: An Ecological Analysis, *The Lancet Planetary Health* 3 (12): e503–10. doi.org/10.1016/S2542-5196(19)30235-9.

Bilal, Usama, Philipp Hessel, Carolina Perez-Ferrer, Yvonne Michael, Tania Alfaro, Janeth Tenorio-Mucha, Amelia de Friche, et al. 2021. Life Expectancy and Mortality Profiles Are Highly Heterogeneous in 363 Cities of Latin America: The SALURBAL Project, *Nature Medicine*. doi.org/10.1038/s41591-020-01214-4 Life.

Bocquier, Philippe, Nyovani Janet Madise, and Eliya Msiyaphazi Zulu. 2011. Is There an Urban Advantage in Child Survival in Sub-Saharan Africa? Evidence From 18 Countries in the 1990s, *Demography* 48: 531–58. doi.org/10.1007/s13524-011-0019-2.

Boutayeb, Abdesslam. 2006. The Double Burden of Communicable and Non-Communicable Diseases in Developing Countries, *Transactions of the Royal Society of Tropical Medicine and Hygiene* 100 (3): 191–99. doi.org/10.1016/j.trstmh.2005.07.021.

Brockerhoff, Martin. 1990. Rural-to-Urban Migration and Child Survival in Senegal, *Demography* 27 (4): 601–15. doi.org/10.2307/2061573.

Brockerhoff, Martin. 1994. The Impact of Rural-Urban Migration on Child Survival, *Health Transition Review* 4 (2): 127–49.

Bygbjerg, Ib Christian. 2012. Double Burden of Noncommunicable and Infectious Diseases in Developing Countries, *Science* 337 (September): 3. doi.org/10.1126/science.1223466.

Cain, Louis, and Sok Chul Hong. 2009. Survival in 19th Century Cities: The Larger the City, the Smaller Your Chances, *Explorations in Economic History* 46 (4): 450–63. doi.org/10.1021/nl061786n.Core-Shell.

Casterline, John B., and Colin Odden. 2016. Trends in Inter-Birth Intervals in Developing Countries 1965–2014, *Population and Development Review* 42 (2): 173–94. doi.org/10.1111/j.1728-4457.2016.00134.x.

Clark, Samuel J, Mark A. Collinson, Kathleen Kahn, Kyle Drullinger, and Stephen M. Tollman. 2007. Returning Home to Die: Circular Labour Migration and Mortality in South Africa, *Scandinavian Journal of Public Health* 35 (September 2007): 35–44. doi.org/10.1080/14034950701359512.

Davis, Kingsley. 1965. The Urbanization of the Human Population, *Scientific American* 213 (3): 40–53. doi.org/10.1038/scientificamerican0965-40.

de Walque, Damien, and Deon Filmer. 2013. Trends and socioeconomic gradients in adult mortality around the developing world, Population and Development Review 39(1): 1–29. https://doi.org/10.1111/j.1728-4457. 2013.00571.x

van Dijk, Ingrid K. 2018. Early-Life Mortality Clustering in Families: A Literature Review, *Population Studies* 73 (1): 79–99. doi.org/10.1080/00324728.2018.1448434.

Dussault, Gilles, and Maria Cristina Franceschini. 2006. Not Enough There , Too Many Here: Understanding Geographical Imbalances in the Distribution of the Health Workforce, *Human Resources for Health* 4 (12). doi.org/10.1186/1478-4491-4-12.

Dye, Christopher. 2008. Health and Urban Living, *Science (New York, N.Y.)* 319 (5864): 766–69. doi.org/10.1126/science.1150198.

Dyson, Tim. 2001. A Partial Theory of World Development: The Neglected Role of the Demographic Transition in the Shaping of Modern Society, *International Journal of Population Geography* 7 (2): 67–90. doi.org/10.1002/ijpg.215.

Dyson, Tim. 2003. HIV/AIDS and Urbanization, *Population and Development Review* 29 (September): 427–42.

Eaton, Jeff, and Bruno Masquelier. 2020. Demogsurv, Demographic Analysis of DHS and Other Household Surveys (package under Development), Available: https://github.com/mrc-ide/demogsurv.

Eckert, Sophie, and Stefan Kohler. 2014. Urbanization and Health in Developing Countries — A Systematic Review, *World Health & Population* 15 (1): 7–20. doi.org/10.4324/9781315070698-1.

Fink, Günther, Isabel Günther, and Kenneth Hill. 2014. Slum Residence and Child Health in Developing Countries, *Demography* 51 (4): 1175–97. doi.org/10.1007/s13524-014-0302-0.

Fox, Sean. 2012. Urbanization as a Global Historical Process : Theory and Evidence from Sub-Saharan Africa, *Population and Development Review* 38 (2): 285–310.

Frenk, Julio, José L. Bobadilla, Jaime Sepulveda, and Malaquias Lopez-Cervantes. 1989. Health Transition in Middle-Income Countries: New Challenges for Health Care, *Health Policy and Planning* 4 (1): 29–39.

Frenk, Julio, and Octavio Gómez-Dantés. 2011. The Triple Burden, *Harvard International Review*, 36–48. doi.org/10.4324/9780429474491.

Garcia, Jenny. 2020. Urban–Rural Differentials in Latin American Infant Mortality, *Demographic Research* 42 (8): 203–44. doi.org/10.4054/DemRes.2020.42.8.

Ginsburg, Carren, Philippe Bocquier, Donatien Béguy, Sulaimon Afolabi, Orvalho Augusto, Karim Derra, Kobus Herbst, et al. 2016. Healthy or Unhealthy Migrants? Identifying Internal Migration Effects on Mortality in Africa Using Health and Demographic Surveillance Systems of the INDEPTH Network, *Social Science and Medicine* 164: 59–73. doi.org/10.1016/j.socscimed.2016.06.035.

Golding, Nick, Roy Burstein, Joshua Longbottom, Annie J. Browne, Nancy Fullman, Aaron Osgood-Zimmerman, Lucas Earl, et al. 2017. Mapping under-5 and Neonatal Mortality in Africa, 2000–15: A Baseline Analysis for the Sustainable Development Goals, *The Lancet* 390 (10108): 2171–82. doi.org/10.1016/S0140-6736(17)31758-0.

Gould, William T. S. 1998. African Mortality and the New 'Urban Penalty', *Health and Place* 4 (2): 171–81. doi.org/10.1016/S1353-8292(98)00009-4.

Günther, Isabel, and Kenneth Harttgen. 2012. Deadly Cities? Spatial Inequalities in Mortality in Sub-Saharan Africa, *Population and Development Review* 38 (3): 469–86. doi.org/10.1111/j.1728-4457.2012.00512.x.

Haddad, Lawrence, Marie T. Ruel, and James L. Garrett. 1999. Are Urban Poverty and Undernutrition Growing? Some Newly Assembled Evidence, *World Development* 27 (11): 1891–1904. doi.org/10.1016/S0305-750X(99)00093-5.

Hernández, Adrián V., Vinay Pasupuleti, Abhishek Deshpande, Antonio Bernabé-Ortiz, and Jaime Miranda. 2012. Effect of Rural-to-Urban within-Country Migration on Cardiovascular Risk Factors in Low- and Middle-Income Countries: A Systematic Review, *Heart* 98 (3): 185–94. doi.org/10.1136/heartjnl-2011-300599.

Hill, Kenneth, Linnea Zimmerman, and Dean T. Jamison. 2015. Mortality Risks in Children Aged 5-14 Years in Low-Income and Middle-Income Countries: A Systematic Empirical Analysis, *The*

Lancet Global Health 3 (10): e609–16. doi.org/10.1016/S2214-109X(15)00044-3.

Huicho, Luis, Miguel Trelles, Fernando Gonzales, Walter Mendoza, and Jaime Miranda. 2009. Mortality Profiles in a Country Facing Epidemiological Transition: An Analysis of Registered Data, *BMC Public Health* 9. doi.org/10.1186/1471-2458-9-47.

ICF International. 2020. Measure DHS Statcompiler, 2020. http://www.statcompiler.com/.

Isiugo-Abanihe, Uche C. 1985. Child Fosterage in West Africa, *Population and Development Review* 11 (1): 53–73.

Keeling, Matthew J., and Bryan T. Grenfell. 1997. Disease Extinction and Community Size: Modeling the Persistence of Measles, *Science* 275 (5296): 65–67. doi.org/10.1126/science.275.5296.65.

Lankoandé, Bruno, Géraldine Duthé, Abdramane Soura, and Gilles Pison. 2018. Returning Home to Die or Leaving Home to Seek Health Care? Location of Death of Urban and Rural Residents in Burkina Faso and Senegal, *Global Health Action* 11 (1): 1475040. doi.org/10.1080/16549716.2018.1475040.

Lankoande, Bruno Yempabou. 2016. Monitoring Adult Mortality by Type of Residence in the Absence of Death Registration : A Perspective from Burkina Faso, *International Journal of Population Studies* 2 (1): 21–37.

Levitt, Naomi S., Judith M. Katzenellenbogen, Deborah Brabshaw, Margaret N. Hoffman, and Francois Bonnici. 1993. The Prevalence and Identification of Risk Factors for NIDDM in Urban Africans in Cape Town, South Africa, *Diabetes Care* 16 (4): 601–7. doi.org/10.2337/diacare.16.4.601.

Li, Zehang, Yuan Hsiao, Jessica Godwin, Bryan D. Martin, Jon Wakefield, and Samuel J. Clark. 2019. Changes in the Spatial Distribution of the under-Five Mortality Rate: Small-Area Analysis of 122 DHS Surveys in 262 Subregions of 35 Countries in Africa, *Plos One*, no. i: 1–17. doi.org/10.1371/journal.pone.0210645.

Lipton, Michael. 1977. *Why Poor People Stay Poor*. London: Temple Smith.

Lu, Yao. 2008. Test of the ‘Healthy Migrant Hypothesis’: A Longitudinal Analysis of Health Selectivity of Internal Migration in Indonesia, *Social Science & Medicine* 67: 1331–39.

Madhavan, Sangeetha. 2004. Fosterage Patterns in the Age of AIDS: Continuity and Change, *Social Science and Medicine* 58 (7): 1443–54. doi.org/10.1016/S0277-9536(03)00341-1.

Magadi, Monica. 2013. The Disproportionate High Risk of HIV Infection among the Urban Poor in Sub-Saharan Africa, *AIDS and Behavior* 17 (5): 1645–54. doi.org/10.1007/s10461-012-0217-y.

Masquelier, Bruno. 2013. Adult Mortality From Sibling Survival Data: A Reappraisal of Selection Biases, *Demography* 50: 207–28. doi.org/10.1007/s13524-012-0149-1.

Masquelier, Bruno, Georges Reniers, Gilles Pison. 2014. Divergences in Trends in Child and Adult Mortality in Sub-Saharan Africa : Survey Evidence on the Survival of Children and Siblings, *Population Studies* 68 (2): 161–77. doi.org/10.1080/00324728.2013.856458.

McKeown, Robert E. 2009. The Epidemiologic Transition: Changing Patterns of Mortality and Population Dynamics, *American Journal of Lifestyle Medicine* 3 (1_suppl): 19S–26S. doi.org/10.1177/1559827609335350.

McMichael, Anthony J., Martin McKee, Vladimir Shkolnikov, and Tapani Valkonen. 2004. Mortality Trends and Setbacks: Global Convergence or Divergence?, *Lancet* 363 (9415): 1155–59. doi.org/10.1016/S0140-6736(04)15902-3.

McMurray, Christine. 1997. Measuring Excess Risk of Child Mortality: An Exploration of DHS I for Burundi, Uganda and Zimbabwe, *Journal of Biosocial Science* 29 (1): 73–91. doi.org/10.1017/S0021932097000734.

Menashe-Oren, Ashira, and Guy Stecklov. 2018a. Rural-Urban Population Age and Sex Composition in Sub-Saharan Africa, *Population and Development Review* 44 (1): 7–35. doi.org/10.1111/padr.12122.

Menashe-Oren, Ashira, and Guy Stecklov. 2018b. Urban–rural Disparities in Adult Mortality in Sub-Saharan Africa, *Demographic Research* 39 (July): 136–76. doi.org/10.4054/DemRes.2018.39.5.

Minujin, Alberto, and Enrique Delamonica. 2004. Socio-Economic Inequalities in Mortality and Health in the Developing World, *Demographic Research Special Collections* 2 (13): 331–54. doi.org/10.4054/DemRes.2004.S2.13.

Moore, Melinda, Philip Gould, and Barbara S. Keary. 2003. Global Urbanization and Impact on Health, *International Journal of Hygiene and Environmental Health* 206 (4-5): 269–78. doi.org/10.1078/1438-4639-00223.

Mufunda, Jacob, Rufaro Chatora, Yustina Ndambakuwa, Peter Nyarango, Jephat Chifamba, Andrew Kosia, and Harvey V. Sparks. 2006. Prevalence of Noncommunicable Diseases in Zimbabwe: Results from Analysis of Data from the National Central Registry and Urban Survey, *Ethnicity and Disease* 16 (3): 718–22.

Nauman, Elizabeth, Mark Van Landingham, Philip Anglewicz, Umaporn Patthavanit, and Sureeporn Punpuing. 2015. Rural-to-Urban Migration and Changes in Health Among Young Adults in Thailand, *Demography* 52 (1): 233–57.

Obermeyer, Ziad, Julie Knoll Rajaratnam, Chang H. Park, Emmanuela Gakidou, Margaret C. Hogan, Alan D. Lopez, and Christopher J. L. Murray. 2010. Measuring Adult Mortality Using Sibling Survival: A New Analytical Method and New Results for 44 Countries, 1974-2006, *PLoS Medicine* 7 (4). doi.org/10.1371/journal.pmed.1000260.

Omran, Abdel. 1971. The Epidemiologic Transition: A Theory of the Epidemiology of Population Change, *The Milbank Memorial Fund Quarterly* 49 (1): 509–38. doi.org/10.1007/s13398-014-0173-7.2.

Poel, Ellen van de, Owen O’Donnell, and Eddy van Doorslaer. 2009. What Explains the Rural-Urban Gap in Infant Mortality: Household or Community Characteristics?, *Demography* 46 (4): 827–50.

Popkin, Barry M. 1999. Urbanization, Lifestyle Changes and the Nutrition Transition, *World Development* 27 (11): 1905–16. doi.org/10.1016/S0305-750X(99)00094-7.

Potts, Deborah. 2017. Conflict and Collisions in Sub-Saharan African Urban Definitions: Interpreting Recent Urbanization Data From Kenya, *World Development* 97: 67–78. doi.org/10.1016/j.worlddev.2017.03.036.

de Ramirez, S. Stewart, D. A. Enquobahrie, G. Nyadzi, D. Mjungu, F. Magombo, M. Ramirez, S. Ehrlich Sachs, et al. 2010. Prevalence and Correlates of Hypertension: A Cross-Sectional Study among Rural Populations in Sub-Saharan Africa, *Journal of Human Hypertension* 24 (12): 786–95. doi.org/10.1038/jhh.2010.14.

Ratovoson, Rila, Ony Rabarisoa Rasetarinera, Ionimalala Andrianantenaina, Christophe Rogier, Patrice Piola, and Pierre Pacaud. 2015. Hypertension, a Neglected Disease in Rural and Urban Areas in Moramanga, Madagascar, *PLoS ONE* 10 (9): 1–14. doi.org/10.1371/journal.pone.0137408.

Ravallion, Martin, Shaohua Chen, and Prem Sangraula. 2007. New Evidence on the Urbanization of Global Poverty, *Population and Development Review* 33 (4): 667–701.

Reher, David S. 2001. In Search of the 'Urban Penalty': Exploring Urban and Rural Mortality Patterns in Spain during the Demographic Transition, *International Journal of Population Geography* 7 (2): 105–27. doi.org/10.1002/ijpg.212.

Roth, Gregory A., Degu Abate, Kalkidan Hassen Abate, Solomon M. Abay, Cristiana Abbafati, Nooshin Abbasi, Hedayat Abbastabar, et al. 2018. Global, Regional, and National Age-Sex-Specific Mortality for 282 Causes of Death in 195 Countries and Territories, 1980–2017: A Systematic Analysis for the Global Burden of Disease Study 2017, *The Lancet* 392 (10159): 1736–88. doi.org/10.1016/S0140-6736(18)32203-7.

Sahn, David E, and David C. Stifel. 2003. Urban-Rural Inequality in Living Standards in Africa, *Journal of African Economies* 12: 564–97. doi.org/10.1093/jae/12.4.564.

Salomon, Joshua A., and Christopher J. L. Murray. 2002. The Epidemiologic Transition Revisited: Compositional Models for Causes of Death by Age and Sex, *Population and Development*

Review 28 (2): 205–28. doi.org/10.1111/j.1728-4457.2002.00205.x.

van der Sande, Marianne A.B., Robin Bailey, Hannah Faal, Winston A.S. Banya, Paul Dolin, Ousman A. Nyan, Sana M. Ceesay, et al. 1997. Nationwide Prevalence Study of Hypertension and Related Non-Communicable Diseases in The Gambia, *Tropical Medicine and International Health* 2 (11): 1039–48. doi.org/10.1046/j.1365-3156.1997.d01-184.x.

Sclar, Elliott D., Pietro Garau, and Gabriella Carolini. 2007. 21st Health Challenge of Slums and Cities, *The Lancet* 365: 901–3.

Shapiro, David, and Michel Tenikue. 2017. Women's Education, Infant and Child Mortality, and Fertility Decline in Rural and Urban Sub-Saharan Africa, *Demographic Research* 37 (September): 669–708. doi.org/10.4054/DemRes.2017.37.21.

Singh, Prashant Kumar. 2013. Trends in Child Immunization across Geographical Regions in India: Focus on Urban-Rural and Gender Differentials, *PLoS ONE* 8 (9). doi.org/10.1371/journal.pone.0073102.

Smallman-Raynor, Matthew, and David Phillips. 1999. Late Stages of Epidemiological Transition: Health Status in the Developed World, *Health and Place* 5 (3): 209–22. doi.org/10.1016/S1353-8292(99)00010-6.

Sverdlik, Alice. 2011. Ill-Health and Poverty: A Literature Review on Health in Informal Settlements, *Environment and Urbanization* 23 (1): 123–55. doi.org/10.1177/0956247811398604.

Timæus, Ian M. 1991. Measurement of Adult Mortality in Less Developed Countries: A Comparative Review, *Population Index* 57 (4): 552–68.

Timæus, Ian M., and Momodou Jasseh. 2004. Adult Mortality in Sub-Saharan Africa: Evidence from Demographic and Health Surveys, *Demography* 41: 757–72.

United Nations. 2015. Demographic Year Book, Available: https://unstats.un.org/unsd/demographic-social/products/dyb/documents/dyb2015/Notes06.pdf.

United Nations. 2015. Transforming Our World: The 2030 Agenda for Sustainable Development, Available: *https://sdgs.un.org/publications/transforming-our-world-2030-agenda-sustainable-development-17981*.

United Nations. 2018. World Urbanisation Prospects: The 2018 Revision, Department of Economic and Social Affairs, Population Division.

Vallin, Jacques, and France Meslé. 2004. Convergences and Divergences in Mortality. A New Approach to Health Transition, *Demographic Research* Special 2: 11–44. doi.org/10.4054/demres.2004.s2.2.

Victora, Cesar G., Aluisio J.D. Barros, Cauane Blumenberg, Janaina Calu Costa, Luis Paulo Vidaletti, Fernando C. Wehrmeister, Bruno Masquelier, et al. 2020. Association between Ethnicity and under-5 Mortality: Analysis of Data from Demographic Surveys from 36 Low-Income and Middle-Income Countries, *The Lancet Global Health* 8 (3): e352–61. doi.org/10.1016/S2214-109X(20)30025-5.

Vos, Theo, Stephen S. Lim, Cristiana Abbafati, Kaja M. Abbas, Mohammad Abbasi, Mitra Abbasifard, Mohsen Abbasi-Kangevari, et al. 2020. Global Burden of 369 Diseases and Injuries in 204 Countries and Territories, 1990–2019: A Systematic Analysis for the Global Burden of Disease Study 2019, *The Lancet* 396 (10258): 1204–22. doi.org/10.1016/S0140-6736(20)30925-9.

Wang, Limin. 2003. Determinants of Child Mortality in LDCs: Empirical Findings from Demographic and Health Surveys, *Health Policy* 65 (3): 277–99. doi.org/10.1016/S0168-8510(03)00039-3.

Woods, Robert. 2003. Urban-Rural Mortality Differentials: An Unresolved Debate, *Population and Development Review* 29 (1): 29–46. doi.org/10.1111/j.1728-4457.2003.00029.x.

World Bank. 2020. World Development Indicators, Available: http://data.worldbank.org/data-catalog/world-development-indicators.

Appendices

A1 Surveys Included in Analysis and Estimates of Rural and Urban ${}_{15}q_0$ and ${}_{45}q_{15}$

Table A1 DHS surveys included in the analysis, sample sizes, estimates of mortality in the age groups 0-14 and 15-59 by sector for the period 0-9 years before the survey, and percentage of the total population living in urban areas at the time of the survey

Country	Year	Sample size (women)	${}_{15}q_0$ (rural)	${}_{15}q_0$ (urban)	${}_{45}q_{15}$ (rural)	${}_{45}q_{15}$ (urban)	% urban
Afghanistan	2015	29,461	74 (67-81)	47 (40-54)	170 (143-196)	121 (63-176)	25
Angola	2015-16	14,379	120 (107-132)	86 (74-98)	235 (184-283)	273 (221-321)	63
Burkina Faso	1998-99	6,445	256 (241-270)	157 (138-176)	278 (213-338)	397 (290-488)	17
Burkina Faso	2003	12,477	221 (211-232)	164 (138-189)	308 (256-357)	287 (237-334)	20
Burkina Faso	2010	17,087	179 (170-188)	119 (107-132)	252 (216-286)	222 (181-261)	25
Benin	1996	5,491	232 (217-246)	178 (156-200)	234 (185-280)	177 (104-244)	37
Benin	2006	17,794	171 (162-179)	136 (126-145)	259 (222-294)	243 (202-281)	41
Benin	2017-18	15,928	136 (128-144)	100 (91-109)	239 (204-272)	182 (156-207)	47
Bolivia	1994	8,603	177 (161-192)	112 (101-122)	223 (169-274)	188 (142-232)	59
Bolivia	2003	17,654	123 (113-133)	82 (74-90)	223 (181-263)	149 (127-170)	63
Bolivia	2008	16,939	108 (98-118)	58 (51-65)	164 (132-194)	132 (112-151)	66
Brazil	1996	12,612	79 (65-92)	50 (44-56)	165 (121-207)	159 (141-178)	78
Burundi	2010	9,389	165 (155-176)	95 (73-116)	296 (251-339)	265 (195-330)	11
Burundi	2016-17	17,269	105 (98-112)	79 (58-98)	249 (226-272)	224 (182-263)	12
Congo Democratic Republic	2007	9,995	202 (174-229)	143 (125-161)	350 (269-422)	270 (228-309)	38
Congo Democratic Republic	2013-14	18,827	139 (128-149)	117 (106-129)	278 (240-313)	258 (230-284)	42
Central African Republic	1994-95	5,884	206 (191-220)	147 (131-163)	435 (325-526)	382 (305-450)	37
Congo	2005	7,051	159 (142-175)	126 (113-140)	435 (358-504)	373 (299-439)	61
Congo	2011-12	10,819	102 (94-110)	84 (72-96)	280 (245-314)	301 (241-356)	64
Côte d'Ivoire	1994	8,099	193 (179-207)	138 (126-149)	291 (247-332)	290 (224-350)	41
Côte d'Ivoire	2011-12	10,060	143 (128-157)	116 (104-129)	297 (248-343)	358 (278-429)	48
Cameroon	1998	5,501	187 (168-206)	115 (98-131)	264 (223-302)	270 (160-366)	44
Cameroon	2004	10,656	193 (179-207)	135 (120-149)	325 (283-363)	347 (293-397)	48
Cameroon	2011	15,426	180 (169-191)	109 (99-119)	364 (325-400)	332 (298-364)	52
Colombia	2015	38,718	32 (26-38)	17 (14-20)	114 (99-128)	110 (97-123)	80
Dominican Republic	2002	23,384	50 (44-56)	45 (39-51)	130 (107-153)	149 (128-169)	63
Dominican Republic	2007	27,195	41 (35-46)	40 (35-45)	163 (134-191)	139 (125-154)	70
Ethiopia	2000	15,367	240 (227-252)	175 (149-201)	349 (317-380)	454 (374-523)	15
Ethiopia	2005	14,070	164 (154-174)	119 (92-146)	309 (277-341)	334 (282-382)	16
Ethiopia	2011	16,515	138 (127-149)	95 (77-111)	248 (222-273)	360 (214-478)	18
Ethiopia	2016	15,683	101 (92-110)	77 (58-97)	170 (146-194)	240 (168-307)	20
Gabon	2000	6,183	113 (97-129)	101 (89-113)	393 (291-481)	300 (227-367)	79
Gabon	2012	8,422	86 (75-98)	72 (62-82)	316 (257-370)	291 (226-351)	87

Gambia	2013	10,233	85 (74-95)	68 (56-79)	148 (108-186)	202 (158-244)	58
Guinea	1999	6,753	227 (214-240)	171 (157-185)	214 (170-255)	231 (173-286)	31
Guinea	2005	7,954	229 (218-241)	157 (138-176)	281 (246-315)	356 (275-427)	32
Guinea	2012	9,142	171 (156-186)	103 (85-121)	265 (226-303)	209 (169-246)	34
Guatemala	1995	12,403	99 (93-106)	68 (56-80)	143 (116-168)	174 (121-224)	44
Haiti	2000	10,159	176 (158-193)	131 (114-148)	290 (246-332)	297 (236-353)	36
Haiti	2005-06	10,757	131 (115-146)	91 (78-104)	266 (212-317)	330 (258-395)	44
Haiti	2016-17	14,371	100 (90-110)	86 (73-100)	279 (230-325)	243 (207-277)	53
Indonesia	1994	28,168	120 (111-129)	68 (58-77)	181 (157-203)	211 (168-252)	35
Indonesia	1997	28,810	90 (83-96)	57 (49-65)	181 (153-209)	182 (145-217)	38
Indonesia	2002-03	29,483	74 (65-82)	49 (42-55)	176 (144-207)	192 (153-230)	44
Indonesia	2007	32,895	67 (61-73)	43 (37-49)	166 (144-188)	187 (162-212)	48
Indonesia	2012	45,607	56 (51-61)	36 (31-40)	174 (154-194)	172 (155-188)	51
Jordan	1997	5,548	51 (40-63)	36 (31-41)	90 (43-135)	123 (97-147)	78
Kenya	1998	7,881	122 (109-135)	94 (75-113)	253 (215-289)	243 (178-302)	19
Kenya	2003	8,195	131 (117-145)	110 (92-127)	322 (279-363)	421 (318-508)	21
Kenya	2008-09	8,444	93 (80-105)	75 (57-93)	319 (266-369)	345 (267-414)	23
Kenya	2014	31,079	66 (61-71)	63 (56-70)	242 (220-263)	241 (203-277)	25
Cambodia	2000	15,351	145 (136-154)	103 (83-123)	219 (193-244)	218 (161-270)	19
Cambodia	2005	16,823	125 (117-134)	85 (71-99)	222 (202-242)	226 (187-263)	19
Cambodia	2010	18,754	85 (79-92)	35 (26-43)	199 (179-219)	167 (131-201)	20
Cambodia	2014	17,578	59 (52-65)	22 (17-27)	182 (161-202)	183 (155-209)	22
Comoros	2012	5,329	70 (57-84)	33 (21-46)	183 (101-258)	111 (16-196)	28
Liberia	2007	7,092	148 (133-163)	129 (116-143)	237 (182-288)	277 (197-350)	47
Liberia	2013	9,239	134 (124-145)	118 (99-136)	253 (213-292)	236 (182-287)	49
Lesotho	2004	7,095	111 (100-123)	89 (71-107)	535 (503-566)	516 (432-588)	22
Lesotho	2009	7,624	121 (110-131)	104 (82-125)	619 (580-655)	554 (472-624)	24
Lesotho	2014	6,621	100 (89-110)	107 (80-132)	555 (521-586)	588 (517-648)	27
Morocco	1992	9,256	109 (96-122)	64 (54-74)	134 (100-166)	124 (91-156)	50
Morocco	2003-04	16,798	75 (67-83)	41 (34-47)	106 (78-132)	108 (87-128)	54
Madagascar	1997	7,060	209 (191-227)	146 (128-164)	261 (214-305)	214 (173-254)	26
Madagascar	2003-04	7,949	135 (116-153)	80 (71-90)	253 (203-301)	237 (187-284)	28
Madagascar	2008-09	17,375	99 (92-107)	71 (62-80)	232 (209-255)	215 (183-246)	31
Mali	1995-96	9,704	299 (286-312)	210 (191-228)	260 (208-307)	231 (130-320)	26
Mali	2001	12,849	275 (260-289)	209 (189-229)	233 (195-268)	330 (258-395)	29
Mali	2006	14,583	256 (243-268)	184 (161-207)	252 (199-301)	310 (235-376)	33
Mali	2012-13	10,424	131 (120-143)	88 (76-100)	158 (122-193)	174 (103-239)	38
Mali	2018	10,519	146 (135-157)	83 (67-98)	199 (160-236)	240 (168-306)	42
Myanmar	2015-16	12,885	91 (81-102)	46 (34-58)	198 (175-220)	230 (195-263)	30
Malawi	1992	4,849	268 (253-282)	223 (195-250)	298 (235-355)	435 (328-525)	12
Malawi	2000	13,220	230 (221-239)	168 (138-198)	465 (430-498)	534 (431-619)	15
Malawi	2004	11,698	172 (165-180)	117 (94-139)	507 (465-546)	536 (469-594)	15
Malawi	2010	23,020	138 (133-144)	130 (114-145)	455 (426-482)	493 (429-549)	16
Malawi	2015-16	24,562	89 (84-94)	74 (62-85)	310 (286-333)	381 (310-445)	16
Mozambique	1997	8,779	267 (242-292)	175 (141-207)	250 (138-347)	244 (192-293)	29
Mozambique	2003	12,418	221 (207-234)	163 (148-178)	280 (235-322)	408 (336-471)	30
Mozambique	2011	13,745	135 (123-146)	116 (104-129)	310 (246-368)	374 (326-418)	32
Nigeria	2008	33,385	200 (191-209)	126 (115-138)	261 (238-283)	249 (213-284)	42

Nigeria	2013	38,948	185 (174-195)	116 (106-126)	186 (168-203)	212 (188-236)	46
Nigeria	2018	41,821	182 (173-192)	102 (94-110)	223 (200-245)	216 (191-240)	50
Niger	1992	6,503	379 (357-399)	235 (215-255)	272 (224-318)	213 (158-263)	16
Niger	2006	9,223	268 (253-282)	174 (159-189)	246 (178-308)	179 (145-211)	16
Niger	2012	11,160	200 (190-210)	113 (96-129)	211 (176-245)	206 (156-252)	16
Namibia	1992	5,421	111 (98-124)	94 (78-110)	241 (197-282)	265 (192-332)	28
Namibia	2000	6,755	73 (64-83)	53 (38-67)	352 (307-394)	283 (227-335)	32
Namibia	2006-07	9,804	88 (80-96)	63 (54-72)	494 (461-525)	419 (365-469)	38
Namibia	2013	9,176	74 (65-83)	59 (49-69)	323 (290-355)	317 (271-359)	45
Nepal	1996	8,429	167 (157-177)	96 (78-114)	242 (202-280)	186 (119-248)	11
Nepal	2006	10,793	96 (87-106)	56 (43-68)	178 (138-217)	148 (83-208)	15
Nepal	2016	12,862	65 (56-73)	45 (38-51)	172 (133-209)	140 (115-164)	19
Peru	1991-92	15,882	146 (134-157)	73 (67-80)	176 (139-211)	149 (127-171)	70
Peru	1996	28,951	110 (102-117)	51 (47-56)	133 (115-151)	136 (117-154)	71
Peru	2000	27,843	96 (89-102)	44 (39-48)	121 (104-138)	96 (82-110)	73
Peru	2007-08	22,558	54 (50-59)	27 (24-31)	131 (116-146)	98 (84-112)	76
Papua New Guinea	2016-18	15,198	60 (51-68)	48 (36-60)	163 (138-188)	255 (173-329)	13
Philippines	1998	13,983	77 (69-85)	57 (50-64)	172 (150-193)	164 (141-186)	46
Rwanda	2000	10,421	282 (268-295)	195 (166-223)	658 (631-683)	800 (750-839)	15
Rwanda	2005	11,321	244 (232-257)	170 (150-190)	435 (401-467)	484 (422-540)	17
Rwanda	2010	13,671	131 (124-138)	102 (86-117)	220 (199-241)	251 (196-302)	17
Rwanda	2014-15	13,497	88 (81-95)	64 (52-75)	197 (174-220)	153 (125-181)	17
Sierra Leone	2008	7,374	192 (174-209)	191 (169-212)	256 (205-304)	297 (196-385)	38
Sierra Leone	2013	16,658	190 (179-201)	171 (154-188)	262 (229-293)	240 (200-277)	40
Senegal	1992-93	6,310	212 (197-226)	124 (109-138)	224 (175-270)	167 (109-221)	39
Senegal	2005	14,602	177 (165-188)	105 (93-117)	243 (206-278)	207 (151-259)	42
Senegal	2010-11	15,688	125 (116-134)	74 (64-83)	171 (138-203)	181 (139-222)	44
Sao Tome and Principe	2008-09	2,615	87 (72-102)	82 (62-102)	139 (97-179)	224 (147-293)	63
Eswatini	2006-07	4,987	112 (100-124)	115 (97-133)	587 (555-615)	559 (489-620)	22
Chad	1996-97	7,454	228 (212-244)	200 (185-216)	177 (138-215)	268 (196-334)	22
Chad	2004	6,085	240 (219-260)	207 (191-223)	257 (184-324)	382 (274-474)	22
Chad	2014-15	17,719	173 (161-184)	168 (154-182)	246 (206-284)	316 (246-380)	22
Togo	1998	8,569	180 (169-191)	127 (111-142)	258 (199-312)	262 (213-308)	32
Togo	2013-14	9,480	128 (118-139)	80 (68-91)	250 (217-283)	293 (246-337)	39
Timor-Leste	2009-10	13,137	97 (90-104)	67 (56-78)	144 (119-169)	125 (73-173)	27
Timor-Leste	2016	12,607	50 (44-57)	50 (39-61)	128 (99-155)	183 (118-243)	30
Tanzania	1996	8,120	170 (159-182)	131 (115-146)	259 (218-297)	232 (193-268)	21
Tanzania	2004-05	10,329	156 (146-165)	127 (110-142)	337 (290-382)	443 (312-549)	24
Tanzania	2010	10,139	103 (95-111)	103 (86-119)	264 (230-296)	387 (295-467)	28
Tanzania	2015-16	13,266	86 (80-92)	93 (82-105)	250 (225-274)	327 (285-367)	32
Uganda	1995	7,070	177 (164-190)	144 (123-165)	407 (360-452)	507 (411-588)	13
Uganda	2000-01	7,246	179 (167-192)	114 (99-130)	415 (369-458)	527 (462-584)	15
Uganda	2006	8,531	168 (159-177)	126 (103-148)	417 (382-450)	496 (427-556)	17
Uganda	2011	8,674	127 (118-136)	89 (72-105)	352 (299-401)	437 (326-530)	20
Uganda	2016	18,506	89 (84-94)	71 (61-81)	284 (260-307)	311 (266-353)	23
South Africa	1998	11,735	72 (61-82)	44 (37-51)	255 (211-297)	251 (217-283)	56
South Africa	2016	8,514	62 (52-72)	50 (38-62)	348 (297-394)	334 (291-374)	65
Zambia	1996	8,021	222 (209-234)	174 (159-189)	434 (388-476)	504 (439-561)	37

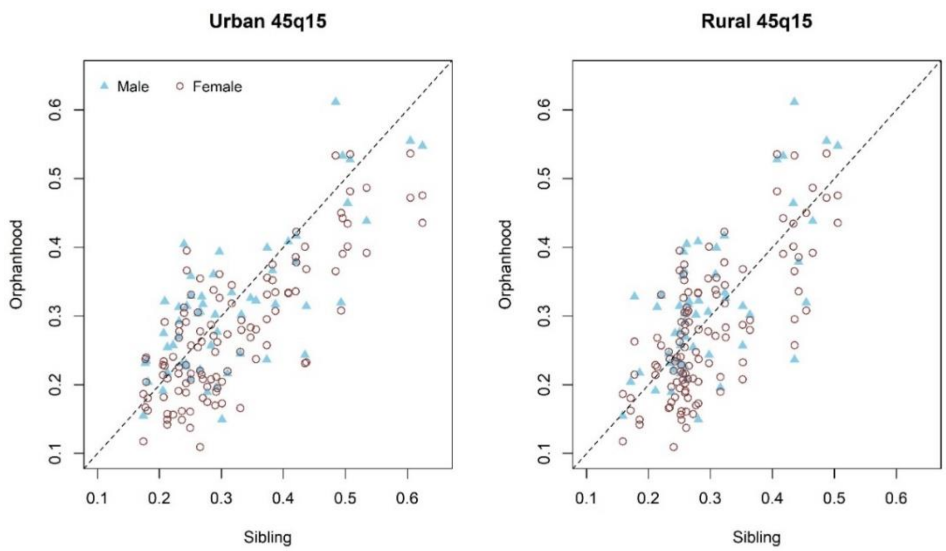
Zambia	2001-02	7,658	202 (191-214)	156 (139-173)	505 (472-536)	624 (570-672)	35
Zambia	2007	7,146	148 (136-159)	145 (127-162)	487 (436-534)	605 (533-665)	38
Zambia	2013-14	16,411	96 (89-103)	81 (72-90)	409 (372-444)	522 (479-561)	41
Zambia	2018	13,683	76 (68-83)	77 (61-94)	282 (244-319)	372 (292-443)	44
Zimbabwe	1994	6,128	90 (81-99)	66 (53-78)	276 (225-325)	290 (214-358)	31
Zimbabwe	1999	5,907	102 (89-115)	67 (53-81)	442 (397-484)	420 (342-489)	33
Zimbabwe	2005-06	8,907	83 (72-94)	70 (58-82)	558 (527-588)	558 (518-595)	34
Zimbabwe	2010-11	9,171	95 (85-104)	87 (71-102)	539 (507-568)	546 (495-593)	33
Zimbabwe	2015	9,955	97 (85-110)	65 (54-76)	442 (394-487)	432 (354-500)	32

Source: DHS program (www.dhsprogram.com). 15q0 refers to the risk of a newborn dying before age 15 under the mortality conditions prevailing in the period 0-9 completed years before the survey, while 45q15 is the risk for an adolescent aged 15 of dying before reaching age 60. Percent urban as reported in World Development Indicators for the year of the survey(World Bank 2020).

A2 Adult Mortality Estimates Based on Orphanhood Method

The orphanhood method is an indirect method of mortality estimation based on questions of parental survival. It is applied here to children aged 5-14 since the DHS surveys ask about parental survival only among children. Respondent's mothers were necessarily alive when respondents were born (and fathers were alive at time of conception), so that the age of respondents provides the exposure time to risk of dying. Based on the mean age at childbirth, survival probabilities for women are obtained between ages 25 to 35. For men survivorship is estimated from age 35 to 45. These survivorship ratios can be converted to conditional probabilities of dying between ages 15-60 (${}_{45}q_{15}$) and we use these ${}_{45}q_{15}$ estimates by rural-urban sector from Menashe-Oren and Stecklov from 90 sub-Saharan African surveys (2018b) to compare to our estimates based on the sibling method (Figure A1). This comparison is not exactly of the same measures, since the time periods they represent are different, and the orphanhood method is estimated for each sex separately while our sibling-based estimates are for both sexes combined. It does, however, provide a broad picture of whether one method over- or under-estimates mortality in either rural or urban sector. We do not note a bias in mortality estimates in one method over the other (Figure A1) in both rural and urban sectors. However, when mortality is high (over 0.35), estimates of urban ${}_{45}q_{15}$ are lower when derived from the orphanhood method than in the sibling method. This may be because the orphanhood estimates are affected by a downward bias due to vertical transmission of HIV, which was not accounted for. Since HIV prevalence is higher in the urban sector (Barongo et al. 1992; Dyson 2003; Magadi 2013; ICF International 2020), this bias will be more pronounced in the urban sector.

Figure A1 Comparison of rural and urban adult mortality estimates based on the sibling and orphanhood methods in sub-Saharan Africa



A3 Estimation of Mortality Based On Recent Household Deaths

In the midst of high HIV prevalence in sub-Saharan Africa, DHS surveys included a module between 2005 and 2008 aimed to gather information to assist households who are burdened by a death (Bendavid et al. 2011). Thus, the number of surveys with this information is limited. This module included a question on recent household deaths – in the last twelve months, with the age at death also recorded. This data can be used to calculate complete life tables, and we use them to estimate the probabilities of dying (q-rates) for 0-15 year olds and 15-59 year olds. We first estimate age-specific mortality rates (${}_nm_x$) for five-year age groups (and one-year age group for the first year of life) based on the reported household deaths, out of the population within each age. Estimates of population, that is, those exposed to risk of death, are obtained from the household roster. This method of estimating mortality is less sensitive to misclassification due to migration (household members most likely lived in the same place), and to recall bias (these are recent deaths). However there might be some omissions or double counting due to difficulties in defining who the household members are, and the number of deaths captured in the survey, particularly when mortality levels are low as among adults, can be small. This led us to exclude Eswatini from our analysis.

A4 Testing for Recall Errors Using Month Preference in Birth Histories, and Age at Survey or at Death of Siblings in Sibling Histories

Figure A2 Misreporting of ages in sibling histories by rural-urban sector

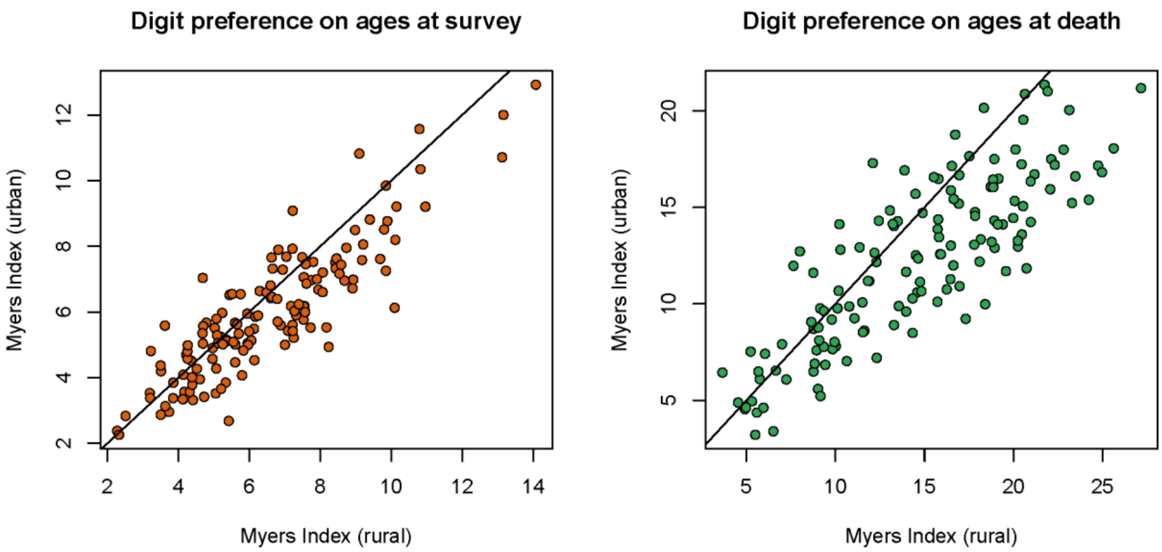
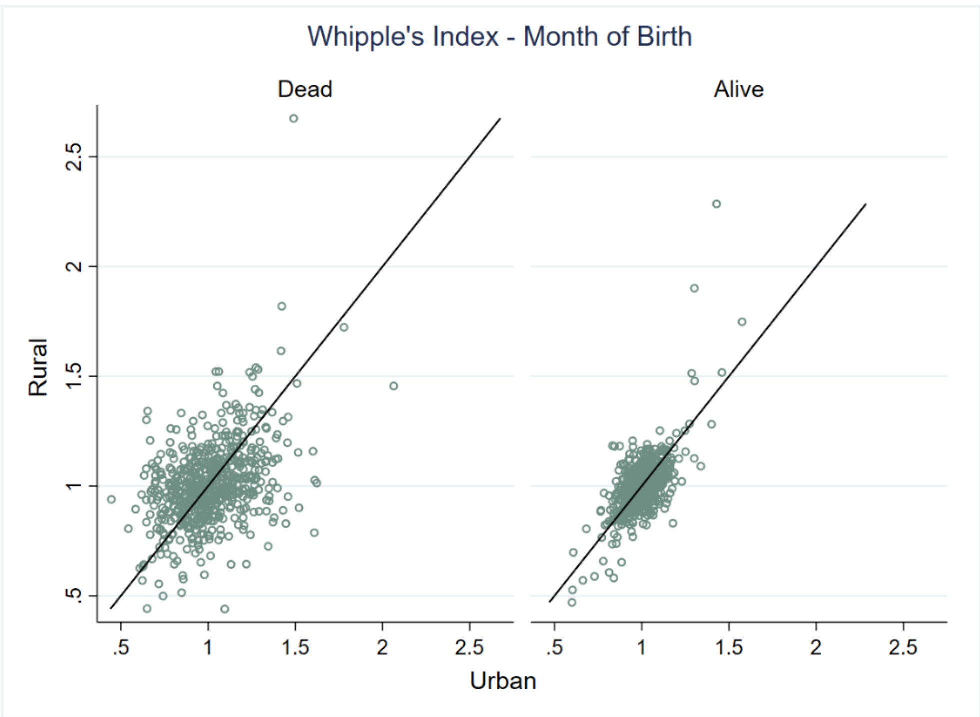


Figure A3 Misreporting of birth dates in birth histories by rural-urban sector



A5 Consistency between Successive Surveys

Quality of reporting on deaths may differ according to rural-urban sector. In particular, underreporting of deaths may be more common in the rural sector. To test this, we analyzed the consistenty of estimates across successive surveys. This was originally done for three countries by modelling mortality by age and over time using Poisson regression and adding a variable to the model that specifies whether the data came from the first or second survey considered (Timæus and Jasseh 2004). By doing this it was possible to detect that the under-reporting of deaths is more pronounced in the distant past, as compared to the years directly preceding the survey. A comparable approach of introducing the time elapsed since the survey as dummy variables in models based on 95 DHS for children and 58 DHS for adults indicated differences in under-reporting for children and adults (Masquelier et al. 2014). A slight underestimation of infant mortality was noted as the time since death increases, but no significant effect on child deaths (1-4), except for the years immediately preceding the survey (probably due to birth transference). Among adults, however, under-reporting was more widespread; more than 20% were under-reported when the time since death extended beyond six years. Here we take a similar approach to determine whether under-reporting of deaths is more pronounced among respondents living in rural areas compared to those interviewed in urban areas. We use the 30 countries in our sample where two successive surveys were conducted less than 10 years apart. For each country, we then calculate the probabilities ${}_{5}q_{0}$ and ${}_{45}q_{15}$ for the period when the two surveys provide an estimate.

Figure A4 illustrates a hypothetical situation of decay in the quality of death reporting as the time elapsed between deaths and the survey increases. Survey 1 (conducted in 2013) therefore provides higher estimates than Survey 2 (conducted in 2018) over the period where there is an overlap.

In order to compare successive surveys, the uncertainty around the estimates must be considered. In Table A2, we detail the number of countries for which the estimate from the earlier survey (Survey 1 in Figure A4) is *significantly* lower than that from the later survey (Survey 2 in Figure A4), the number of cases where the estimate from the later survey is *significantly* lower than that from the earlier survey, for each sector and for two synthetic mortality indices: ${}_{5}q_{0}$ and ${}_{45}q_{15}$. We also present the median of the ratio between earlier ${}_{n}q_{x}$ (1) and later ${}_{n}q_{x}$ (2) and the level of significance of a Wilcoxon signed rank test to establish whether the two distributions of these estimates differ.

Figure A4 Illustration of mortality trends estimated in two successive surveys, compared to actual level of morality – where underestimation of mortality is evident from an earlier past

Table A2. Comparing child and adult mortality estimates by sector, estimated from successive surveys in 30 countries where surveys are less than ten years apart

	${}_nq_x$ (1) < ${}_nq_x$ (2)	${}_nq_x$ (2) < ${}_nq_x$ (1)	${}_nq_x$ (1) ≠ ${}_nq_x$ (2)	Median ${}_nq_x$ (1)/${}_nq_x$ (2) [IQR]	Sign.
${}_5q_0$ (rural)	3	2	25	0.96 [0.90-1.07]	> 0.1
${}_5q_0$ (urban)	0	1	29	0.98 [0.91-1.05]	> 0.1
${}_{45}q_{15}$ (rural)	0	4	26	1.18 [1.03-1.42]	< 0.01
${}_{45}q_{15}$ (urban)	1	5	25	1.23 [1.04-1.47]	< 0.01

Child mortality estimates from two successive surveys are more consistent than adult mortality estimates. In children, the two distributions of ${}_nq_x$ (1) and ${}_nq_x$ (2) do not differ significantly and the median ${}_nq_x$ (1)-to-${}_nq_x$ (2) ratio is close to unity in each sector. The difference between ${}_nq_x$ (1) and ${}_nq_x$ (2) at the rural level is significant in five countries, but in three cases the more recent estimate from the previous survey is lower, and in two cases the opposite pattern is observed. In urban areas, a significant difference is observed in only one country. In contrast, among adults, the median of the ratio ${}_nq_x$ (1)/${}_nq_x$ (2) is significantly greater than one, and the two distributions of ${}_nq_x$(1) and ${}_nq_x$ (2) are distinct in both areas. Mortality referring to an older period is more systematically underestimated, compared to the period immediately before the previous survey. This is consistent with the existing literature. However, there is no obvious difference between the sectors. The extent of underreporting of deaths appears to be comparable. A Wilcoxon signed rank test on the ${}_nq_x$ (1)/nqx (2) ratios between sectors confirms this.

A6 Full Birth Histories and Sibling Histories for Estimating 10-14 Year Old Mortality

In assessing whether sibling histories lead to biased rural-urban mortality differentials, we estimate mortality between 10 and 15 year olds using both sources. Figure A5 presents a comparison of the $_5q_{10}$ probability as obtained from sibling histories (on the x-axis) and as obtained from birth histories (on the y-axis) for rural and urban sectors. Surveys for which the two sources provide significantly different estimates are identified in colour. In both sectors, mortality is higher when derived from sibling histories. The two data sources also provide a different representation of sectoral differences: in the sibling histories, the median ratio between urban and rural mortality in the 10-14 age group is 0.82 (IQR: 0.64-0.98), while this median ratio is 0.66 (IQR: 0.48-0.94) in the birth histories. A Wilcoxon signed rank test confirms that rural excess mortality is significantly larger when apprehended from birth histories at these ages.

Figure A5 Mortality between 10 and 14 years of age according to birth and sibling histories, in rural and urban sectors, calculated on children/siblings

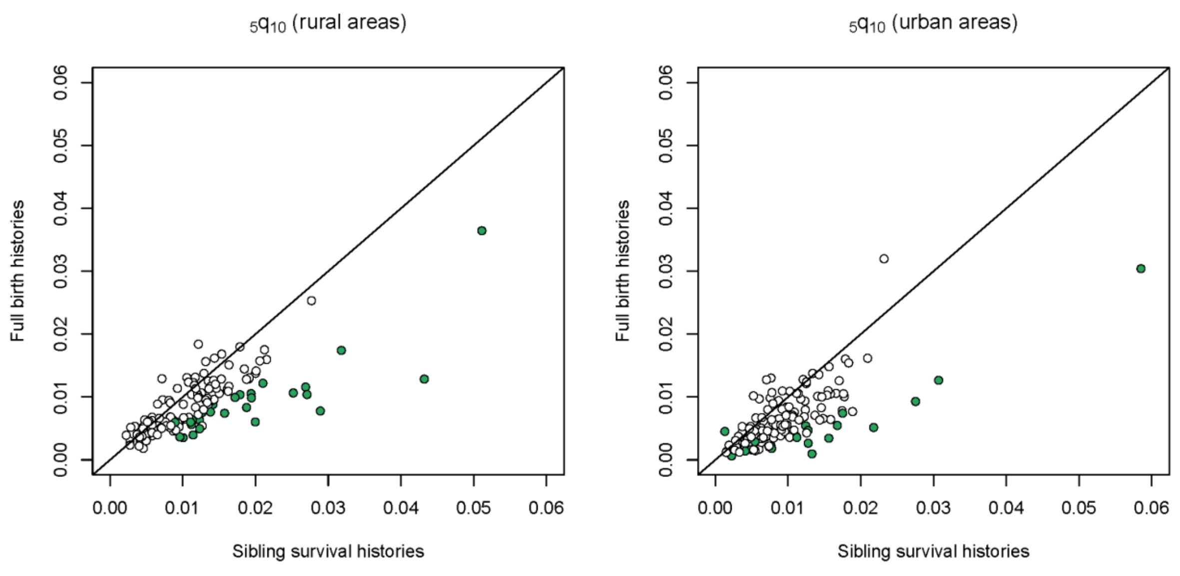
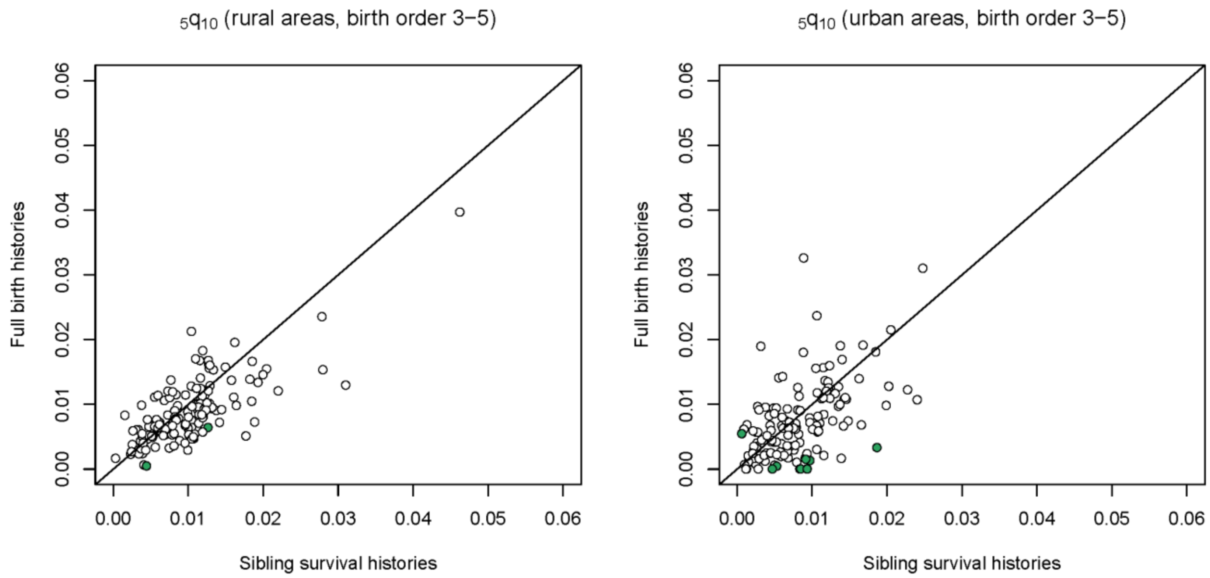


Figure A5 indicates higher mortality in sibling histories, even though sibling histories seem to be affected by more pronounced data quality problems. We postulate that this is a reflection of varying composition by birth rank in these two samples. Mortality rates estimated at higher ages from birth histories are more likely to be biased by selection associated with birth order of the children or the age of the mothers at the birth of these children (Hill et al. 2015). The experience of first-born children and those born to young mothers will be over-represented in deaths and exposure referring to mortality beyond five years, especially for periods farther away from the date of the survey. Similarly, calculating child mortality in a recent period from sibling histories is problematic because few respondents aged 15-49 at the time of the survey have siblings who were still under five years of age in the years prior to the survey. In the information provided by sibling histories, higher-ranked children and those born to older mothers will be over-represented. Assuming that mortality is positively correlated with birth order, birth histories will provide an underestimate of mortality beyond age five, while sibling histories are expected to provide an upward biased estimate of child mortality. This is likely what is observed here between the ages of 10 and 14. These biases may also affect differences in mortality between sectors. Because fertility is lower in urban areas, children with higher birth ranks will be a more selective group with a higher risk of mortality. The mortality advantage in urban areas will therefore appear lower in sibling histories than in birth histories, as we see here.

Ideally, therefore, the comparison between sources should control for the age of mothers at the birth or the birth order. Since the former is not known for sibling histories, we chose here to control for birth order by estimating mortality only in children and siblings of rank three to five. As shown in Figure A6, in this case the two data sources provide much closer estimates.

Figure A6 Mortality between 10 and 14 years of age according to birth and sibling histories, in rural and urban sectors, calculated on children/siblings of rank 3-5 only



Appendix References

Barongo, Longin R., Martien W. Borgdorff, Frank F. Mosha, Angus Nicoll, Heiner Grosskurth, Kesheni P. Senkoro, James N. Newell, et al. 1992. The Epidemiology of HIV-1 Infection in Urban Areas, Roadside Settlements and Rural Villages in Mwanza Region, Tanzania, *AIDS* 6 (12).

Bendavid, Eran, Benjamin Seligman, and Jessica Kubo. 2011. Comparative Analysis of Old-Age Mortality Estimations in Africa, *PLoS ONE* 6 (10): 1–7. doi.org/10.1371/journal.pone.0026607.

Dyson, Tim. 2003. HIV/AIDS and Urbanization, *Population and Development Review* 29 (September): 427–42.

Hill, Kenneth, Linnea Zimmerman, and Dean T. Jamison. 2015. Mortality Risks in Children Aged 5-14 Years in Low-Income and Middle-Income Countries: A Systematic Empirical Analysis, *The Lancet Global Health* 3 (10): e609–16. doi.org/10.1016/S2214-109X(15)00044-3.

ICF International. 2020. Measure DHS Statcompiler, 2020. http://www.statcompiler.com/.

Magadi, Monica. 2013. The Disproportionate High Risk of HIV Infection among the Urban Poor in Sub-Saharan Africa, *AIDS and Behavior* 17 (5): 1645–54. doi.org/10.1007/s10461-012-0217-y.

Masquelier, Bruno, Georges Reniers, Gilles Pison. 2014. Divergences in Trends in Child and Adult Mortality in Sub-Saharan Africa : Survey Evidence on the Survival of Children and Siblings, *Population Studies* 68 (2): 161–77. doi.org/10.1080/00324728.2013.856458.

Menashe-Oren, Ashira, and Guy Stecklov. 2018b. Urban–rural Disparities in Adult Mortality in Sub-Saharan Africa, *Demographic Research* 39 (July): 136–76. doi.org/10.4054/DemRes.2018.39.5.

Timæus, Ian M., and Momodou Jasseh. 2004. Adult Mortality in Sub-Saharan Africa: Evidence from Demographic and Health Surveys, *Demography* 41: 757–72.

World Bank. 2020. World Development Indicators, Available: http://data.worldbank.org/data-catalog/world-development-indicators.