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RESEARCH ARTICLE

Monitoring adult mortality by type of residence in the absence of death registration: a perspective from Burkina Faso

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Abstract: In the context of the post 2015 agenda, disaggregation of mortality indicators is needed to assess health inequalities within populations. However, producing sub-national estimates of adult mortality is notably difficult in the absence of death registration. Using Burkina Faso as a case study, this paper revisits the main avenues to quantify differences in adult mortality between the ages of 15 and 60 according to urban/rural residence. Estimates are based on reports on the survival of parents and siblings collected in surveys and in the 2006 census, and compared to levels inferred from recent household deaths or inferences based on child mortality. Results indicate that in Burkina Faso, adults living in urban areas still benefit from a health advantage compared to their rural counterparts. Thus, efforts made in reducing adult mortality in rural settings should be intensified. In terms of methods, this analysis shows the value of asking additional questions about the place of residence of close relatives to avoid misclassification errors. The approach adopted here could be implemented in other countries to facilitate the measurement of spatial inequalities in health indicators for all ages when monitoring Sustainable Development Goals (SDGs).

Keywords: adult mortality, Burkina Faso, indirect techniques, urban, rural, SDGs

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1 Introduction

Historically, European cities were long characterized by higher mortality rates, a phenomena referred to as the "urban penalty", while cities in Sub-Saharan Africa have long benefited from a comparative advantage, due to colonial health policies that were very favorable to large urban centers (Leon, 2008). As many health determinants (such as education, sanitation, access to health services, and wealth) are better on average in urban areas, it is generally assumed that urban residents in Sub-Saharan Africa benefit from better health conditions compared to their rural counterparts (Leon, 2008; Montgomery, 2009). Hence, mortality rates by urban/rural location are regularly monitored to track progress made in reducing the gap in mortality, initially with a focus on rural health, but with a particular attention on urban health in recent years (Fink, Günther, and Hill, 2014; Bocquier, Madise, and Zulu, 2011). Yet, most of these studies were limited on child survival and findings, mainly based on the Demographic and Health Surveys (DHS), show that the urban advantage is weakening overtime. This is partly due to the development of slums associated with rapid and poorly managed urbanization in Sub-Saharan Africa (Kimani-Murage, Fotso, Egondi *et al.*, 2014). This particular focus on child survival fit well within the context of the Millennium Development Goals (MDGs), but adult health is now as important on the global health agenda. Coupled with the strong desire to place equity in a central role in the Sustainable Development Goal (SDG) framework ("no one should be left behind"), disaggregation of adult mortality indicators by urban/rural location is now imperative to track progress in a world that is becoming both older and more urban (United Nations, 2015).

A better monitoring of adult mortality by place of residence is more important than ever in Sub-Saharan Africa; available evidence shows that rapid urbanization could be a threat to adult health. In contrast to most rural areas where infectious and parasitic diseases remain the leading causes of deaths, urban settings of Sub-Saharan Africa are often characterized by a "double burden of diseases," particularly among urban poor (Ramroth, Lorenz, Rankin *et al.*, 2012; Awini, Sarpong, Adjei *et al.*, 2014; Agyei-Mensah and de-Graft Aikins, 2010). While wealthy adults are at higher risk of non-communicable diseases due to lifestyle (smoking, alcohol consumption, physical inactivity), and inadequate diet habits (diets too rich in sugar, salt, fat), the urban poor bear simultaneously the burden of infectious and non-communicable diseases (Soura, Lankoande, Millogo *et al.*, 2014; Mberu, Wamukoya, Oti *et al*., 2015). For instance, slums are a favorable ground for some infectious diseases such as malaria and tuberculosis, and at the same time their inhabitants tend to consume cheaper energy dense food that promote obesity, a risk factor for non-communicable diseases (Neiderud, 2015; Zeba, 2012). Furthermore, mental disorders and injuries seem to be more prevalent in urban settings of Sub-Saharan Africa (Dyson, 2003; Kobusingye, Guwatudde, and Lett, 2001). In summary, it is simplistic to always consider the urban environment as a "safer place" for adults, compared to rural areas. Poor sanitary and living conditions experienced by rural dwellers may be offset by health problems related specifically to urban residence.

Despite its relevance for the global health agenda, research on urban/rural differentials in adult mortality in Sub-Saharan Africa is still largely limited by the scarcity of data. While much is known about child mortality, the measurement of adult mortality is hampered by the lack of reliable data and the absence of very robust estimation methods. In the absence of civil registration data, estimates derived from surveys and censuses are prone to recall errors and selection biases (Reniers, Masquelier, and Gerland, 2011). These problems are magnified when looking at differentials.

Census reports on the number of household members who died in the last 12 months are a common source of data on adult mortality by place of residence. However, these data are subject to many errors, including omissions of deaths due to recall errors and household dissolutions after a death of an adult, but also fieldworkers' related errors, coverage errors, and errors on the reference period (Timæus, 1991). Adult mortality rates published in census reports are sometimes also inferred from child mortality rates combined with model life tables, but this practice is not recommended because mortality in children and adult do not always evolve in the same direction (Masquelier, Reniers, and Pison, 2014). This approach is even more problematic when deriving estimates of adult mortality by place of residence, because nothing guarantees that urban/rural differentials are invariant by age. Child mortality rates are dominated by infectious diseases which are more prevalent in rural areas, while chronic conditions that disproportionately affect adults are typical of urban areas.

Apart from census estimates, it is possible to derive mortality rates from survey reports on the survival of close relatives, such as parents or siblings. Nevertheless, estimates based on these methods are also not exempt of problems (Helleringer, Pison, Kanté *et al.*, 2014; Reniers, Masquelier, and Gerland, 2011). Mortality rates obtained from the survival of parents are related to the past and dating estimates is only possible under some assumptions. Data on survival of siblings provide the opportunity to directly estimate adult mortality but estimates may be altered by underreporting of deaths. Nevertheless, beyond these general issues related to the estimation, deriving estimates of adult mortality by place of residence is even more challenging since information on the place of residence of close relatives is not collected in surveys such as DHS. To the best of my knowledge, no attempt was made in the literature to estimate adult mortality by place of residence based on orphanhood data. However, few studies have used sibling survival data collected in the “maternal mortality module” of the Demographic and Health Surveys (DHS) to explore urban/rural differences in adult mortality in Sub-Saharan Africa. Their findings are not consistent, and this is likely due to the different approaches adopted to circumvent the issue raised by the lack of information on the place of residence or death of the siblings. De Walque and Filmer (2013) assumed that women and their siblings share the same place of residence and concluded to a slightly higher mortality in rural areas of Sub-Saharan Africa. It was an analysis of pooled data on sibling survival collected in 84 DHS surveys from 46 countries (33 of which were in Sub-Saharan Africa). The datasets covered the period of 1975–2004 and adult mortality was measured as the risk of dying between the ages of 15 and 55. In addition to the issue of the sibling’s place of residence, the aggregated analysis conducted by the authors will hide cross-country variations in the urban/rural disparities in adult mortality. Also based on sibling survival data of the DHS datasets, Günther and Harttgen (2012) documented urban/rural mortality differences at the country level in 14 Sub-Saharan countries. The risk of dying between the ages of 15 and 45 was used as a measure of adult mortality. In complement to the approximation made by De Walque and Filmer (2013), their analysis was restricted to siblings reported by women who spent their entire life in an urban (rural) area. They found that in the 2000s, out of 14 countries, urban adult mortality rates were *higher* than rural mortality rates for 11 countries. For example, in Burkina Faso, urban/rural adult mortality ratio rose from 1.09 during the 10 years before the 1998 DHS to 1.33 also ten years before the 2003 DHS. These results were totally inconsistent with estimates published in Burkina Faso’s census reports where an excess mortality in rural areas was documented in 1984, 1995, and 2006 (INSD, 1989; 2000a; 2009a).

Faced with these inconsistent results and limitations inherent in the different methods, this paper uses Burkina Faso as a case study to explore new strategies for providing better disaggregated mortality indicators in countries lacking vital registration. Existing research on differentials in adult mortality by urban/rural location are extended in two directions. First, I revisit together, the main estimation methods that were used in isolation in previous studies despite their limitations. This includes the application of the orphanhood method that has never been used to look at mortality differentials by urban/rural location. Second, the impact of limitations related to the different techniques on mortality differentials is assessed by further analysis and thanks to the use of a specific survey conducted in 2000 which included questions on the place of residence and deaths of parents. The study covers approximately the 1989–2006 period and starts with the presentation of the study setting. Adult mortality by urban/rural location is then computed using indirect methods and multiple data sources. The estimates are discussed and reconciled to offer a coherent picture of urban/rural adult mortality differences in Burkina Faso. Lastly, I discuss technical issues related to adult mortality estimation by place of residence in Sub-Saharan Africa in general, and draw conclusions for the measurement of differentials.

2 Data and Methods

2.1 Study Setting

Burkina Faso is one of the poorest countries in the world, with a population estimated at 14 million inhabitants in 2006 (INSD, 2009b). The population size has grown at an annual rate of 3.1% between the two last censuses (1996–2006), but the annual growth rate in the urban areas is as high as 7.1%, more than twice the national average (INSD, 2009b). In recent years, the country has experienced a rapid and poorly managed urbanization. As a result, a growing number of urban dwellers live in slum-like conditions. For example, the share of slum dwellers was estimated at 30% in Ouagadougou, the capital city (Boyer and Delaunay, 2009). The urbanization process is mainly driven by rural exodus, emergence of new cities, and spatial extension of large urban centers such as Ouagadougou

(INSD, 2009c). The capital is among the fastest-growing cities in the world. Even though the population is essentially rural (77% in 2006), it is expected that urban population will take over in 2050 (United Nations, 2014). However, the health indicators in Burkina Faso are not very encouraging. The under-five mortality rate is still high, reaching a level of 10.4% in urban areas and 15.6% in rural areas (INSD, 2012). Data on adult mortality are scarce, but the probability ${}_{45}q_{15}$, estimated at 30.4% in men and 26.8% in women in 2005, was higher than that observed in countries such as Senegal and Niger (IHME, 2014). According to IHME (2015), in 2013, communicable diseases were the leading causes of death in adults aged 15–49 while non-communicable diseases represented the major causes of death in adults aged 50–69.

2.2 Data

Adult mortality is measured as the probability of dying between 15 and 60 years of age (${}_{45}q_{15}$). Three types of data sources are used in this paper to estimate mortality levels. The corresponding sample sizes by urban/rural location are presented in the Appendix (Table A3). It is important to mention that the definition of urban and rural residence changes over time, from one census to another. An economic criteria was used in the 1996 census, but an economic and population size criteria was retained in 2006 (INSD, 2009c). The definition used in DHS is based on the definition adopted in the most recent census (INSD, 2004; INSD, 2012).

2.2.1 Census Reports on Recent Household Deaths

To date, four censuses have been conducted in Burkina Faso to monitor demographic trends (1975, 1985, 1996, and 2006). However, it is unclear whether data from the 1975 census have been properly archived. Samples of individual-level data from censuses conducted in 1985 and 1996 are freely available online through the Integrated Public Use Microdata Series (IPUMS), but the urban/rural status is missing. Thus, only the census of 2006 is used here to estimate adult mortality, based on data collected on the number of deaths in each household in the twelve months preceding the census.

2.2.2 Data on Sibling and Parental Survival from Demographic and Health Surveys (DHS)

Data from DHS conducted in Burkina Faso in 1993, 1998/1999, 2003, and 2010 are used in this study. Funded by the U.S. Agency for International Development (USAID), these surveys are a key data source to assess population dynamics and their health in countries lacking vital registration systems. The data are freely available online and are representative at the urban/rural level. In the 1993, 2003, and 2010 surveys, children aged less than 15 years were asked about the survival status of their parents (mothers and fathers). In surveys conducted in 1998/1999, 2003, and 2010, each woman interviewed was also asked to list all her siblings born to the same mother. For each sibling, information was collected on their date of birth, sex, survival status, current age for those who were alive, age at death, and number of years since death for those who had died prior to the survey.

2.2.3 Orphanhood Data from the Migration Dynamics, Urban Integration and Environment Survey (EMUIB)

Census and DHS data are complemented with a survey (EMUIB) conducted in Burkina Faso in 2000 by the Demography department of the University of Ouagadougou and has never been used so far to estimate mortality. This survey was representative at the national and urban/rural levels. In total, 9188 individuals aged between 15 and 64 years old were interviewed. The overall objective was to provide reliable and relevant information on urban planning in Burkina Faso and topics such as migration and employment were covered (for a full description of the survey design, see Poirier, Piché, Le Jeune *et al*. (2001)). The questionnaire included a set of questions on parental survival and, unlike in other surveys, the place of residence at the time of survey or at the time of death of parents was also collected. This is an added value compared with DHS data where information on parents' place of residence at the time of the survey or at the time of death is usually not collected.

2.3 Methods

The different techniques used to estimate differences in urban/rural mortality levels in Burkina Faso are presented in this section. The choice of these methods was mainly guided by the availability of data. For each method, adult mortality rates, and confidence intervals around estimates (if relevant) were computed according to urban/rural residence for each sex. The datasets used in each estimation technique, the reference period for the estimates, the sample description, and the approximations of the place of residence are reported in Table 1.

Table 1. Datasets used, reference period, sample description and approximation of the place of residence for each estimation method

Estimation method	Datasets	Sample description	Approximation of the place of residence	Reference period for male mortality	Reference period for female mortality
Growth balance	Census 2006	Household heads reporting on deaths among adults aged 15–60 years old	Household's place of residence	2006	2006
Direct estimation from sibling survival data	DHS 1999	Women aged 15–49 years old reporting on the survival of their siblings	Women's place of residence	1992–1997	1992–1997
	DHS 2003			1998–2003	1998–2003
	DHS 2010			2004–2009	2004–2009
Orphanhood	DHS 1993	Children aged 5–9 years old and 10–14 years old, reporting on the survival of their parents	Children's place of residence	1988	1987,2; 1989,4
	DHS 2003			1998,5	1997,8;2000,0
	DHS 2010			2005,6	2004,8; 2007,0
	EMUIB 2000	Young adults aged 15–19 years old; 20–24 years old and 25–29 years old, reporting on the survival of their parents	Parent's place of residence	1989,8; 1991,4	1989,4; 1990,9;1992,6

2.3.1 Estimating Adult Mortality from the Growth Balance Method

Data collected on the number of deaths in each household were discarded by the National Institute of Statistics (INSD) when deriving mortality estimates from the 2006 census. The published estimates of adult mortality were obtained from child mortality rates combined with model life tables. Even though the estimation method is not entirely clear in the official report, it seems that child mortality rates were estimated indirectly from reports on the number of children ever born and still alive (INSD, 2009). This approach is inadequate because trends in child and adult mortality do not always evolve in the context of Sub-Saharan Africa. In Burkina Faso, DHS estimates indicate that child mortality rates have declined substantially in recent decades, while adult mortality rates have mostly stagnated, although the reason for these divergent trends is undetermined (Masquelier, Reniers, and Pison, 2014).

To move away from the child-mortality matching approach used by the INSD, I estimated for each place of residence, adult mortality using the Growth Balance Method (GBM) developed by Brass (1975). Its principle is to estimate the completeness of the reporting of deaths relative to an estimate of the population under the assumptions that the population is stable, is closed to migration and that the completeness of underreporting of deaths is constant above a certain age limit. This estimate which is an indicator of data quality, is then used to adjust mortality rates upward to account for incompleteness of death reporting (Moultrie, Dorrington, Hill *et al*., 2013). To reduce the sensitivity of the method to internal migration, which can be a great concern in a country such as Burkina Faso, the completeness estimates were obtained solely from reported deaths among adults aged 35 and above, because they are less likely to migrate (Beauchemin, 2011). With this method, there was no need to compute confidence intervals because estimates were derived from the census data.

2.3.2 Estimating Adult Mortality from Orphanhood Data

The rationale behind the orphanhood method is to convert proportions of respondents classified by five-year age groups whose mother (father) is still alive into survivorship ratios using a set of coefficients (obtained from simulations). The mean age at childbearing of women (men) is used to control for variations in the fertility schedule, which affects the exposure time. Survivorship ratios are then converted into summary indices of adult mortality using one parameter of a relational logit model table (Moultrie, Dorrington, Hill *et al*., 2013). Finally, estimates are located in time under the assumption that mortality trends have been linear. Coefficients used in this paper to convert proportions into survivorship ratios are those proposed by Timæus (1992), and the time location procedure is the method developed by Brass and Bamgboye (1981). In addition, since DHS and EMUIB data are samples of the entire population, confidence intervals are required to statistically compare levels of adult mortality between urban and rural areas. Orphanhood estimates are seldom presented with confidence intervals, and there is no standard way to obtain them. Here, I computed 95% bootstrap-based confidence intervals of estimates in each place of residence (2000 replicates). The bootstrap technique has proven useful over the years to estimate robust confidence interval without making strong assumptions about the distribution of estimates (Efron and Tibshirani, 1993). To the best of my knowledge, this method has never been used to compute confidence intervals based on orphanhood data.

The estimates derived from the DHS and EMUIB data were obtained from the survival of parents of young children (5–9, 10–14 years old), and young adults (15–19, 20–24, 25–29 years old) respectively. I also applied the orphanhood method on data collected during the 2006 census and the multiple indicator cluster survey (MICS) conducted in 2006. The corresponding results are not commented in the main text because there are in line with estimations derived from EMUIB and DHS data (Appendix, Table A1 and Figure A1).

The orphanhood method does not assume that the population is closed to migration, but a major issue in applying the method with data disaggregated by place of residence is the lack of information on the urban/rural status of parents. In DHS surveys, only the place of residence of children at the time of the survey is known. I used this information as a proxy for the parents' place of residence at the time of the survey or at the time of death. By contrast, in the EMUIB survey, it is possible to correct for this and assess the impact of misclassification of parent's place of residence on differences in urban/rural adult mortality. For this survey particularly, to investigate the variation in the quality of data by place of residence that may affect the estimates, I compared by urban/rural location and for each age group, the proportion of surviving parents, reported by men and women (Appendix, Table A2).

2.3.3 Estimating Adult Mortality from Sibling Survival Data

Unlike the two methods presented above, sibling survival data provide an opportunity to "directly" estimate adult mortality rates. With the information provided by each interviewed woman (15 to 49 years) on her siblings, it is possible to compute mortality rates by dividing the number of deaths by the population at risk for a given period and age group. However, because adult mortality is a relatively rare event, and sample sizes in DHS are too small to derive age- and period-specific estimates without introducing some smoothing, mortality rates were derived from a quasi-Poisson model for this analysis. The data file was reshaped in person-periods and the dependent variable was the number of deaths. The age group, sex, and place of residence (urban/rural) were used as explanatory variables. This approach, introduced by Timæus and Jassey (2004), also generates confidence intervals. As suggested by Masquelier (2013), no attempt was made to weigh the data to account for selection biases, and I assume that mortality does not vary with the number of adult siblings.

Although the sibling survival method does not rely on many assumptions, the quality of data is an issue, particularly the underreporting of deaths due to recall biases. Evidence abounds of decay in the completeness of death reporting among siblings when the time interval between the death and the survey increases (Masquelier, Reniers, and Pison, 2014; Obermeyer, Rajaratnam, Park *et al.*, 2010). To account for this, mortality estimates were restricted to the 6 years prior to each survey. The choice of this cutoff point also helped to keep the sampling errors at an acceptable level for the analysis and to attenuate the effect of heaping for five years prior to the survey (Bicego, 1997).

A major drawback also related to the estimation of adult mortality by place of residence using sibling survival data is the difficulty to apprehend siblings' place of residence. The DHS surveys do not collect information on the place of residence of siblings at the time of survey or at the time of death. To address this issue, the place of residence of interviewed women was tested as proxy for the place of residence of their siblings. Misclassification of siblings' place of residence may thus lead to misinterpretation of differences in urban/rural mortality levels, particularly when migrations flows are important (Bicego, 1997).

3 Results

3.1 Growth Balance Method (GBM)

Estimates of adult mortality obtained by place of residence and by sex in 2006 from the GBM, and from the census official report are presented in Table 2. The completeness of death reporting was higher in urban areas compared to rural areas (80.5% and 73.5% respectively), suggesting that data quality issues are more prevalent in rural areas. The estimates were also higher than those published in the census report (except for women in rural areas). Disregarding these methodological differences, the value of the probability ${}_{45}q_{15}$ was higher in rural areas than urban areas according to both sources. In the estimates presented here, the urban-rural differentials in mortality were lower among men with a ratio of urban to rural mortality of 0.7. This ratio rose to 0.9 in women. As expected, the levels of male mortality were higher than those of female mortality.

Table 2. Estimates of ${}_{45}q_{15}$ (per 1000) from the GBM and results published in the census' official report by sex and according to urban/rural residence in Burkina Faso in 2006

	Men			Women		
	Urban	Rural	Urban/rural Ratio	Urban	Rural	Urban/rural Ratio
GBM	270.2	366.1	0.7	215.2	248.6	0.9
Census report	220.0	321.5	0.7	183.6	280.3	0.7

3.2 Orphanhood Method

Figure 1 presents trends in adult mortality obtained from orphanhood data collected in the 1993, 2003, and 2010 DHS according to place of residence and sex of parents. For men, only one estimate was obtained from each dataset (because the estimation of male mortality requires that reports from two adjacent age groups be combined). For women, two estimates were derived from each dataset (based on 5–9 and 10–14 year-olds).

Overall, in urban as well in rural areas, adult mortality rates seem to have fallen since 1988 to 2005 for men, and since 1987 to 2007 for women. Quite surprisingly, urban residents seem to have experienced a slight mortality increase in the late 1990s and the early 2000s. This counterintuitive result is likely due to the issue raised by the approximation of parents' place of residence (those who are at risk of dying) by their children's place of residence. Over the whole period considered, values of ${}_{45}q_{15}$ were on average higher in urban areas compared to rural areas. In men, these inequalities in mortality seem to have widened over time in favor of the rural settings. In women, the gap of urban/rural mortality was most pronounced in the first half of the 2000s.

By using parents' place of residence in the estimation, thanks to data collected in the EMUIB survey (Figure 2), the mortality differentials were reversed in favor of urban areas in men, and the gap widened in favor of urban areas in women. In men, when children's place of residence is used as proxy for their parent's place of residence, values of ${}_{45}q_{15}$ were far higher in urban areas than in rural areas. However, a lower mortality in urban areas was obtained when parents' place of residence at

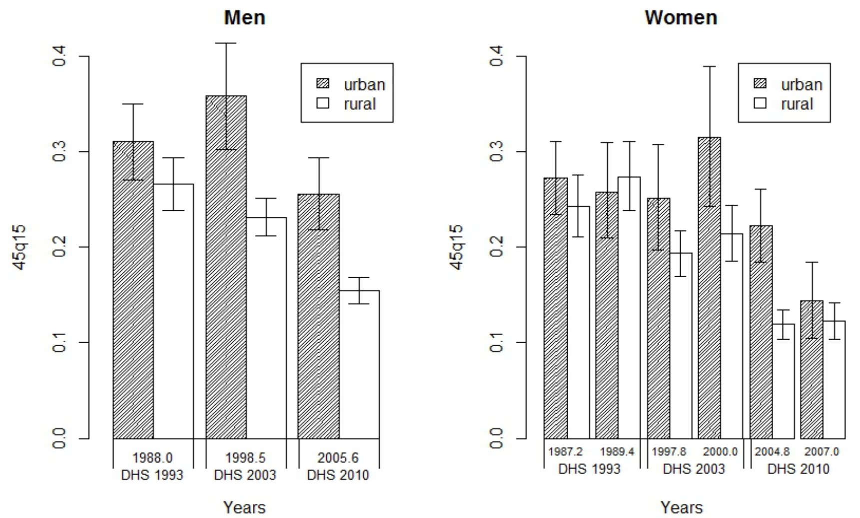

Figure 1. Estimates of adult mortality with bootstrap confidence intervals (95%), by sex and according to place of residence (DHS orphanhood data).

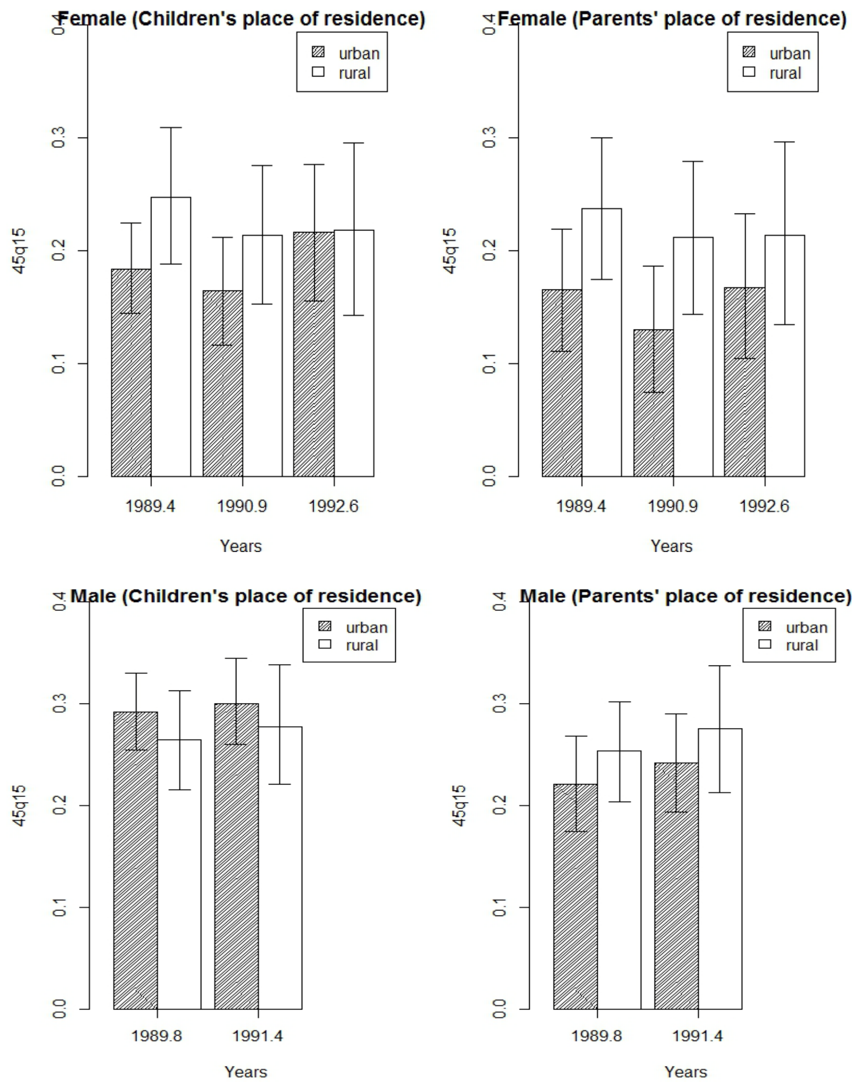

Figure 2. Estimates of adult mortality with bootstrap confidence intervals (95%), by sex and according to place of residence (EMUIB orphanhood data).

the time of the survey or at the time of death is used to assess the gap in mortality. In women, estimates obtained by using children's place of residence yielded an urban advantage. This advantage was reinforced when parent's place of residence were taken into account.

These results suggest that information on children's place of residence is not a good proxy for their parents' place of residence. In addition, misclassification errors seem to operate differentially according to the sex. Nevertheless, even if urban areas benefit from a slight advantage, this difference is not significant at the 0.05 level, because confidence intervals considerably overlap in each period.

3.3 Sibling Survival Histories

Estimates of adult mortality based on sibling histories are presented in Figure 3 for both types of residence. The dating procedure is more precise here (compared to orphanhood estimates) and the availability of three surveys provides a rough idea on the trend in mortality. On the one hand, adult mortality rates have decreased since 1990s to 2000s in urban areas. This mortality decline was more marked among men. On the other hand, rural areas experience stalls, sometimes reversals, in adult mortality. Rural areas tend to have an advantage in terms of adult mortality that fades over time. In the period of 1992–1997, for men as well as women, the value of ${}_{45}q_{15}$ in urban areas was around 0.4 while this value was less than 0.3 in rural areas. An inverse situation was observed in the period of 2004–2009, with higher mortality in rural areas. However, for each period, confidence intervals largely overlap, indicating that DHS sample sizes are too small to detect any significant difference. Again, I should reiterate that the place of residence of interviewed women was used as a proxy for their sibling's place of residence.

To assess the quality of sibling survival histories in the different DHS, Figure 4 shows the mean number of siblings reported by the five-year age group of respondents. This number is the average parity of the respondents' mother; it should be closed to the completed fertility in Burkina Faso, and should increase with the respondents' age since fertility has declined in recent decades. Two major observations stand out from these plots. First, the average parity is globally higher in urban

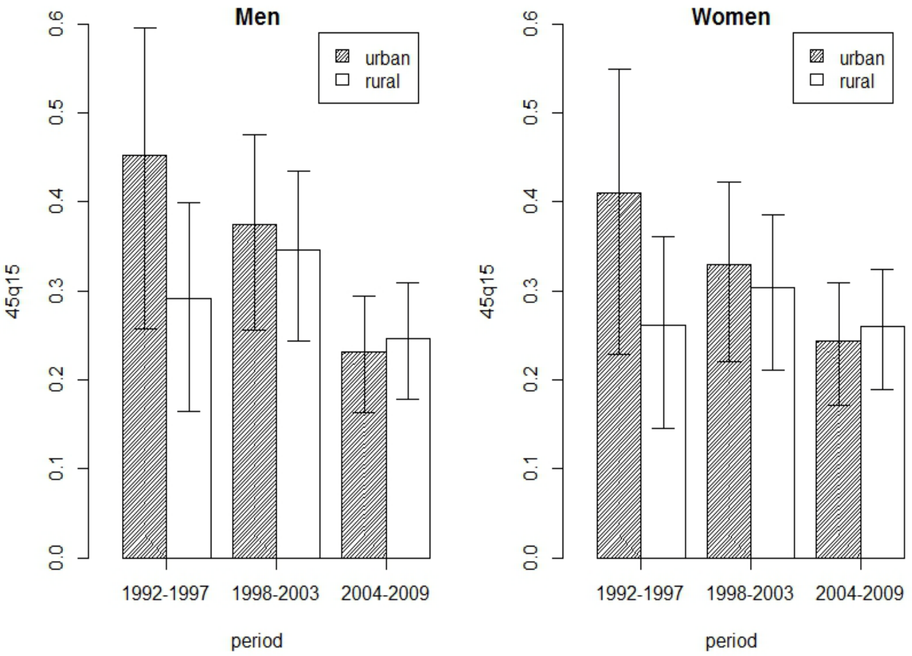

Figure 3. Estimates of adult mortality with 95% confidence interval, by sex and according to place of residence based on siblings survival data from 1992 to 2009 (DHS data).

areas compared to rural areas in 1999 and 2003. The same pattern is observed in the 2010 DHS among older respondents (30–49 year-olds). Second, the average number of siblings declines with the respondent's age in rural areas, and it remains stable in urban areas. These results are surprising, because fertility is higher in rural areas in Burkina Faso, and over the years, it has declined both in urban and rural areas (Shapiro and Gebreselassie, 2009). The patterns observed here are likely caused by rural exodus of women or a pronounced omission of women's siblings in rural areas. As reported by Stanton *et al*. (2000), as well as Masquelier and Dutreuilh (2014), it is likely that older respondents disproportionately omit to report all of their siblings. These omissions seem to be more marked in rural areas, and if related to adult death, it is likely that adult mortality will be underestimated, particularly in these settings. This could be explained by the low level of education among interviewed women and misunderstanding of local language by fieldworkers in rural areas (Johnson, Grant, and Khan, 2009).

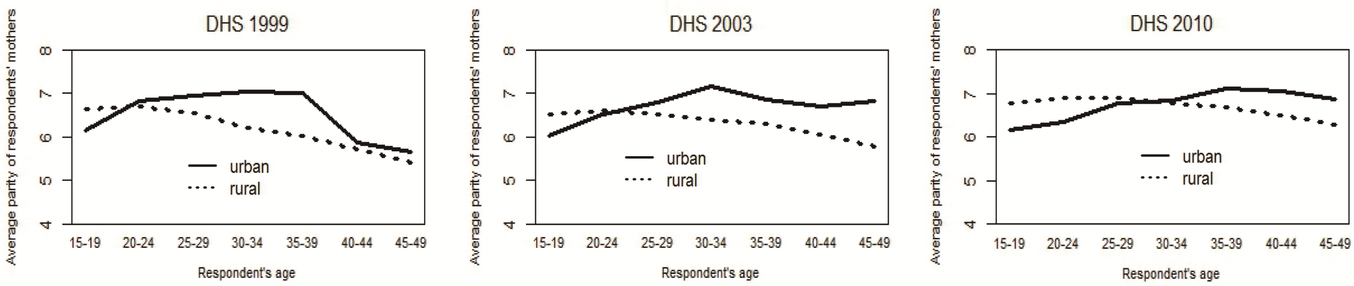

Figure 4. Average parity of respondents' mothers by respondents' age and place of residence according to each round of survey (DHS data).

3.4 Summary

Figure 5 presents estimates of differentials in urban/rural mortality derived from the different sources and methods. Estimates derived from the orphanhood method applied on DHS are discarded from this plot, since those obtained from the EMIUB survey are to be preferred.

Among men as well as women, an urban penalty is unlikely from 1989 to 2006, if one remembers that sibling survival data overestimate adult mortality in urban areas and underestimate adult mortality in rural areas. It is only since around 1994 that adult mortality appears to be particularly lower in rural areas. These estimates were derived from sibling survival data of the DHS conducted in 1998/1999. A cursory evaluation of data quality indicates that this survey is not as reliable as the others. For example, the percentage of deaths which were reported without any information on "age at death" and "years since death" was respectively 2.7% and 0.2% in 2003 and 2010 respectively, while it was as high as 8.5% in 1998/1999 (INSD, 2000b; 2004; 2012).

4 Discussion

At first glance, the picture of differentials in urban/rural mortality derived from the different methods is inconsistent. While the orphanhood method produced mixed results, the growth balance method tends to conclude to an urban advantage in the recent period, and sibling histories data suggest that urban areas suffer from a penalty that is vanishing overtime. This highlights the crucial need to restrain from drawing any firm conclusion on differentials based on a particular technique of estimation in isolation. The different estimates have to be screened in order to come up with a better measurement of urban/rural differentials in adult mortality. Despite technical issues related to the estimation (issues of assumptions, data quality, and selection effects), and the administrative problem in defining urban areas, a systematic analysis shows that an urban disadvantage in terms of mortality is unlikely in Burkina Faso.

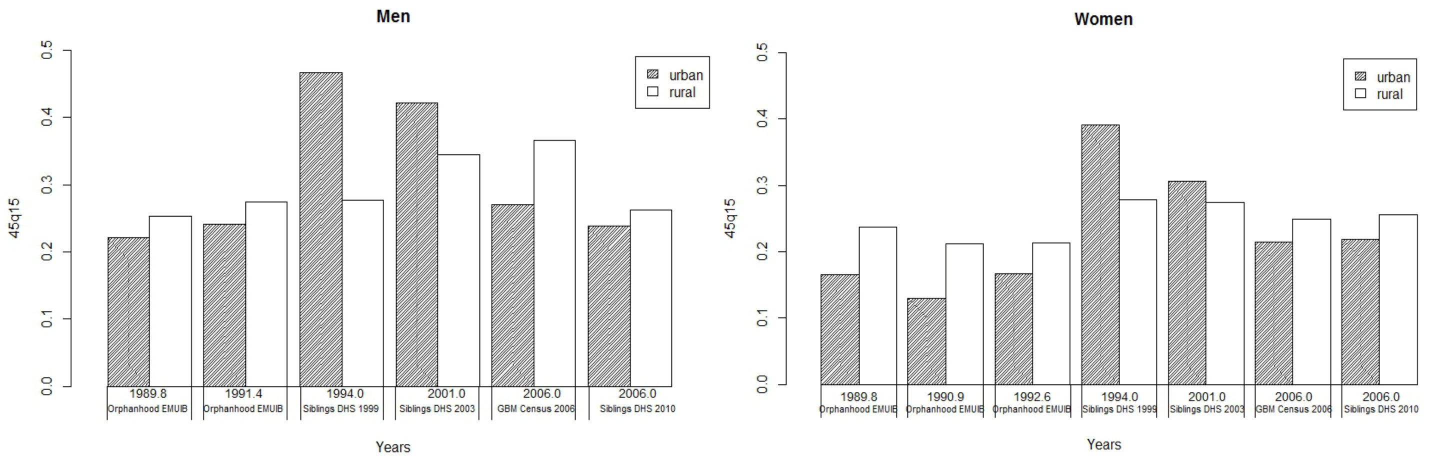

Figure 5. Estimates of adult mortality in Burkina Faso by place of residence and sex according to different sources and methods, from 1989 to 2006.

A common limitation of the application of the growth balance method to measure adult mortality in sub-geographical units is the issue of migration. The method could be adjusted to take into account internal migration flows between urban and rural areas, but such data are rarely available (Bhat, 2002; Hill and Queiroz, 2010). In the case of urban/rural differentials in mortality in Burkina Faso where migration flows are mainly from rural to urban areas, discarding migration effects will result in an underestimation of mortality in urban areas and an overestimation in rural areas (Moultrie, Dorrington, Hill *et al*., 2013). The approach adopted here by limiting the estimation of the completeness of the reporting of deaths on people aged 35 years and more, seems to yield consistent results. Estimates do not seem to be affected by migration since it is possible to get a straight line in each case by plotting the partial births against the partial deaths (Figures A2 and A3 in the Appendix). In addition, the completeness of death registration was high enough, both in urban (80.5%) and rural areas (73.5%). This limits the effect of adjusting for completeness on the final mortality estimates in the two settings (Moultrie, Dorrington, Hill *et al*., 2013). In summary, estimates derived from the growth balance method for each place of residence are acceptable.

The EMUIB survey allows bypassing a major problem encountered when applying the basic orphanhood method in sub-national geographic units using DHS data, as respondents and parents do not always share the same place of residence (Moultrie, Dorrington, Hill *et al*., 2013). Indeed, the urban disadvantage observed in orphanhood estimates in DHS data (based on reports from children), is likely due to the effect of the practice of child fostering in Burkina Faso. A common practice in the country is to move children from one family to another for schooling or housework (Dabiré, 2001; Serra, 2009). Based on the definition adopted by Grant and Yeatman (2012), the DHS data indicate that the prevalence of child fostering varies greatly with place of residence in Burkina Faso. For example, in 2010, only 7.6% of children under 15 were fostered in rural areas whereas this figure rose to 17.2% in urban settings. In addition, orphanhood prevalence was higher in fostered children compared to non-fostered ones in both urban and rural areas. By using children's place of residence as a proxy for their parent's place of residence, a fraction of deaths occurring in rural areas was therefore transferred to urban areas, and those of the urban areas were allocated to rural areas. The problem raised by the misclassification of parent's place of residence is likely to play against urban areas because flows from rural to urban areas are more important. A great share of urban growth in Burkina Faso is still explained by internal migration (Guengant, 2009). I can conclude that mortality levels based on DHS data are overestimated in urban areas, and underestimated in rural areas, yielding a spurious "urban penalty." When data on the survival of young adult's parents were used to estimate the difference in mortality between urban and rural areas, the urban disadvantages vanishes, as shown in Figure 2, even though the difference in favor of the urban advantage is not significant. In addition, these estimates are not impacted by variation in the quality of data according to urban/rural location (Appendix, Table A2). Except, for the 20–24 year-old age groups in rural areas, proportions of surviving parents reported by men and women are not statistically different at the threshold of 5%. The urban/rural mortality differentials derived from data on young adults collected during the EMUIB survey are probably the most reliable, but they are only available for the late 80s and early 90s.

Estimates based on sibling histories present the advantage of depicting the trend in adult mortality by place of residence in a relatively long period. However, the major issue related to these estimates is the approximation of the place of residence of the siblings of interviewed women. In the absence of migration data, I made the assumption that siblings and interviewed women share the same place of residence. This approach has been adopted in previous studies (Bicego, 1997; De Walque and Filmer, 2013); however, it is problematic when migration flows are important. Another possibility was to limit the analysis to siblings of interviewed women who had never migrated before the survey as experimented by Günther and Harttgen (2012). This may lead to a selection bias if siblings of migrant women are affected by lower or higher mortality compared with siblings of non-migrant women. In contrast with previous research which ignored or did not quantify the impact of these approximations of sibling's place of residence on mortality differentials, further analysis shows that adult mortality is likely overestimated in urban areas and underestimated in rural areas. First, from the experience I have drawn from the orphanhood method applied on data collected during the EMUIB survey, it is clear that a large amount of deaths occurring in rural areas are transferred to urban areas and the opposite is done with deaths occurring in rural areas, but with a lesser magnitude. This suspicion is strengthened by the higher sibships reported in urban areas compared to rural areas on average. Second, from the analysis of the mean number of reported siblings, I saw that there is a more pronounced underreporting of siblings in rural areas and if related to adult deaths, it is likely that mortality is underestimated in rural areas. In summary, an urban disadvantage is not likely, what appeared in early periods is probably spurious and generated by the misclassification of sibling's place of residence, and by the poor data quality mainly in rural areas.

By carefully analyzing the case of Burkina Faso, the results presented in this paper showed that the urban disadvantage in adult mortality put forward by Günther and Harttgen (2012) is improbable, even though the differences in favor of the urban areas found here are not significant. Such a conclusion is reinforced by estimates derived from the different Health Demographic Surveillance Systems (HDSS) located in Burkina Faso. By taking the HDSS of Ouagadougou as a proxy for the urban areas and the other HDSS located in the country (Nouna, Nanoro, Kaya) as proxies for rural areas, one can again observe that adult mortality (45q15) is lower in urban areas (for the period of 2009–2011) (Sié, Soura, Derra *et al.*, 2015). Taken together, these results support the argument that urban adults in Burkina Faso still benefit from better health conditions. Although the dynamic of differentials in urban/rural mortality is still somewhat erratic and difficult to depict based on the available evidence, the urban environment continues to be negatively associated with adult mortality in Burkina Faso. Despite the global concern about the rising burden of non-communicable diseases in least developed countries associated with urbanization, urban dwellers still live longer than their rural counterparts in Burkina Faso. Efforts made in reducing adult mortality in rural settings should therefore not be abandoned.

Beyond the case of Burkina Faso, this paper highlighted the need for additional information on the type of residence of close relatives to obtain a better picture of adult mortality differences by urban/rural location in countries without death registration. Given that expansion of data collection in large programs such as DHS will not happen in a near future, the comparative approach taken here could be implemented in other countries when measuring spatial inequalities in health indicators for all ages in the context of the SDGs. The availability of untapped sources of data particularly on migration (e.g., EMUIB in Burkina Faso, the 2009 migration and remittances household surveys in Senegal), may help to correct data on the survival of siblings and parents for a better measurement of the levels and trends in spatial inequalities in mortality.

Conflict of Interest and Funding

No conflict of interest has been reported by the author

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Appendix

Table A1. Estimates of adult mortality (per 1000) by sex and according to place of residence (MICS orphanhood data)

Men			Women		
Date	Urban	Date	Urban	Date	Urban
2001.3	243.2	231.1	2002.7	206.4	133.1
			2000.6	149.0	141.7

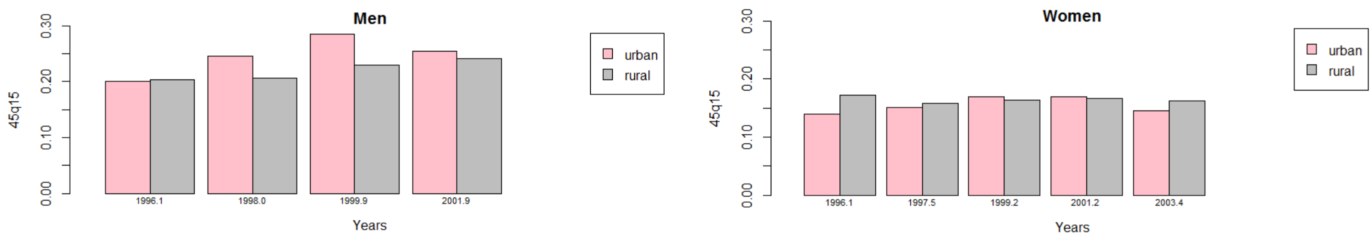

Figure A1. Estimates of adult mortality by sex and according to place of residence (Census Orphanhood data)

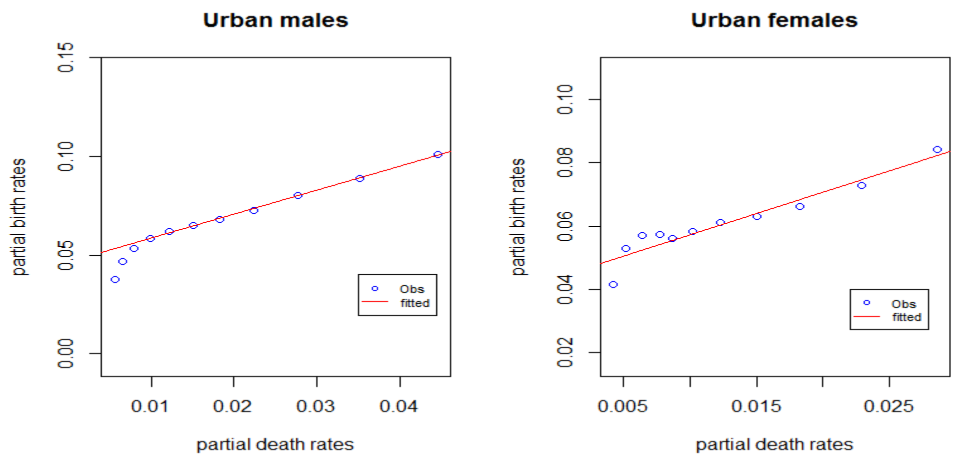

Figure A2. Diagnostic plots from GBM, by sex in urban areas, census 2006.

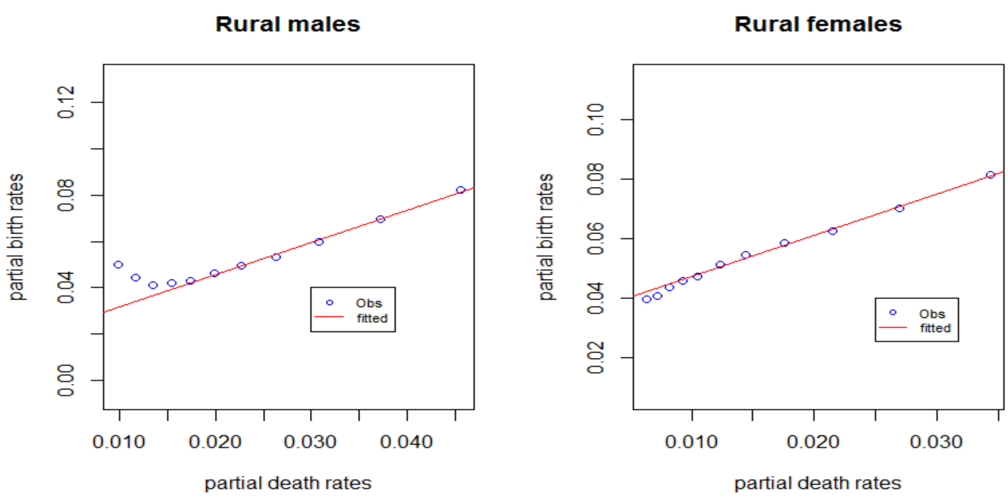

Figure A3. Diagnostic plots from GBM, by sex in rural areas, census 2006.

Table A2. Comparison of the proportion of surviving parents reported by men and women, according to urban/rural location

		Urban			Rural		
Sex (parents)	Age group	Male	Female	Proportion-test (P. values)	Male	Female	Proportion-test (P.values)
Male	15–19	0,8775	0,8475	0,5728	0,7957	0,8493	0,6095
	20–24	0,7384	0,813	0,3232	0,8082	0,742	0,0177
	25–29	0,7224	0,7347	0,7111	0,6632	0,6876	0,4166
Female	15–19	0,9567	0,9311	0,1371	0,9505	0,8948	0,2875
	20–24	0,9505	0,9257	0,1249	0,9056	0,8786	0,5382
	25–29	0,9202	0,843	0,1725	0,8717	0,7936	0,9615

Table A3. Sample size by sex and place of residence for each data set

Estimation method	Datasets	Sample description	Individuals reported in sample size	Number of individuals				Number of deaths			
				Men		Women		Men		Women	
				Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural
Growth balance method	Census 2006	Household heads reporting on deaths among adults aged 15–60	Individuals aged 15–60	936320	2173654	920183	2736823	3522	13595	2663	11039
Direct estimation from sibling survival data	DHS 1999	Women aged 15–49 reporting on the survival of their siblings	Siblings aged 15–60 (6 years prior the survey, persons years are reported)	9537	46146	9626	43430	74	221	58	189
	DHS 2003			24386	84901	23740	81228	114	485	143	336
	DHS 2010			47305	132551	46624	126872	169	511	173	509
Orphanhood method	DHS 1993	Children aged 5–9 and 10–14, reporting on the survival of their parents	Parents of the interviewed children	3683	6513	3683	6513	338	455	171	293
	DHS 2003			3249	14987	3249	14987	357	951	155	525
	DHS 2010			5840	19412	5840	19412	424	847	193	413
	EMUIB 2000	Young adults aged 15–19; 20–24 and 25–29, reporting on the survival of their parents	Parents of the interviewed adults	1261	2272	1261	2272	277	637	120	280