Recent Trends of Older Adult Mortality in Sub-Saharan Africa : an Analysis of the Modal age at Death from an Indirect Estimation Based Model

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Abstract

This study aims to highlight the trends of recent older adult mortality in sub-Saharan Africa looking at the patterns of modal age at death which is a more specific indicator related to longevity of older adults. Using surveys and censuses age specific tabulated data gather by the United Nations Population Division, the analysis will cover twenty-two countries with at least two national representative cross-sectional data sources over the period of 1959 to 2012. Specifically, two main research questions underlies this paper. The first is to know the ages at which older adult deaths are concentrated in sub-Saharan African countries. The second question seeks to know whether sub-Saharan African countries behave differently in terms of mortality at older ages.

Key words

Older adults, mortality, modal age at death, sub-Saharan Africa

Introduction

In mortality studies, the adult modal age at death appears to be a relevant indicator for studying longevity. Defined as the age at which the maximum number of adult deaths occured in a synthetic cohort of individuals experiencing similar mortality conditions, this indicator is less sensitive to any improvement on the health of children and young adults compared to life expectancy at birth or median age at death (Canudas-Romo, 2008, 2010; Horiuchi, Ouellette, Cheung, & Robine, 2013; Ouellette, Robine, Bourbeau, & Desjardins, 2012). In developed world characterized by aging populations, many studies are devoted to the analysis of this indicator and its evolution over time and space (Canudas-Romo, 2008, 2010; Diaconu, Ouellette, Camarda, & Bourbeau, 2016; Missov, Lenart, Nemeth, Canudas-Romo, & Vaupel, 2015; Ouellette & Bourbeau, 2011; Ouellette, Bourbeau, & Camarda, 2013). As for traditional analysis on older adult mortality, research on the modal age at death are also virtually non-existent in sub-Saharan Africa. The purpose of this work is to improve the state of knowledge about mortality of the elderly in this region of the world.

Infectious diseases are almost endemic in sub-Saharan countries and affect all segments of the population, including the elderly. (Hontelez et al., 2011; Negin & Cumming, 2010; Wallrauch, Bärnighausen, & Newell, 2010). In combination with age-related alterations and

the high risks of developing chronic diseases, these older people faced a double burden of diseases that could have an affect on their longevity. However, poor vital statistics registration and poor data quality, particularly at older ages, make it difficult to estimate mortality and related indicators. Since the 1950s, the emergence of indirect systems for generating life tables aimed to address this issue (Hu & Yu, 2014). However, these approaches had many limitations, including the non-representativity of the sample of life tables used to build them, their inability to take into account the effect of devastating epidemics such as HIV on the structure of age-specific mortality, together with their unique parametric nature and their little flexibility (Murray, Ahmad, Lopez, & Salomon, 2000). Recently, indirect systems for modeling life tables from at least two parameters have been developed (Murray et al., 2003; Sharrow, Clark, & Raftery, 2014; Wilmoth, Zureick, Canudas-Romo, Inoue, & Sawyer, 2012). These models offer a window to improve the quality of the estimated life tables and an opportunity to study the modal age at death in sub-Saharan african countries.

This study aims to highlight the trends of recent older adult mortality in sub-Saharan Africa looking at the patterns of modal age at death which is a more specific indicator related to longevity of older adults. Specifically, two main research questions underlies this paper. The first is to know the ages at which older adult deaths are concentrated in sub-Saharan African countries. The second question seeks to know whether sub-Saharan African countries behave differently in terms of mortality at older ages.

Data

We are using age-specific tabulations of data from surveys and censuses in which information about household deaths during the last preceding twelve months were collected. These tabulations were gathered by the United Nations Population Division that have made them available for my research (Table 1). For the purpose of this study, we needed three information to derive full abridged life tables. These information are the level of child mortality (5q0), the level of adult mortality (45q15) and the HIV prevalence for each period concerned. The child mortality is generally underestimated in censuses (Masquelier et al., 2016; Merdad, Hill, & Levin, 2016). Even in surveys, it the case, but the estimates from demographic and health surveys (DHS) seems to be more accurate than other surveys. To overcome this issue of underestimation and to be more confident in the inputs used, we will used the United Nations Inter-agency Group of child Mortality Estimation (UN-IGME). These estimates were generated using a bayesian B-splines bias adjusted model with all the available data sources starting with the most recent data first, eliminating data sources with important non-sampling errors or omissions and taking into account populations severely affected by HIV and AIDS (United Nations Inter-agency Group for Child Mortality (UN IGME), 2017).

Table 1 : Countries with at least two national representative cross-sectional data sources gathered by the United Nations Population Division for sub-Saharan African countries

Countries	Periods	Number
Eastern Africa		
Ethiopia	1983, 2006	2
Malawi	**1977**, [1983], **1987**, **1998**, **2007**, [2009], [2010]	7
Mozambique	**1997**, **2007**	2
Uganda	**2002**, [2006], [2010]	3
Tanzania	**1967**, [1973], 1988, 2002, [2007], 2008, 2010, **2012**	8
Zambia	[2007], 2010	2
Zimbabwe	1992, [1997], **2002**, [2005], **2012**	5
Southern Africa		
Botswana	1981, **1991**, [1998], **2001**, [**2006**], 2011	6
Lesotho	1971, [1977], [1980], 1985, 1995, [2000], **2005**	7
Namibia	**2001**, [2006], 2011	3
South Africa	2001, [2006], 2011	3
Swaziland	**1996**, [**2006**]	2
Middle Africa		
Cameroon	1975, **1986**	2
Central African Republic	[1959], **1988**, 2003	3
Western Africa		
Burkina Faso*	**1985**, **1996**, **2006**	3
Côte d'Ivoire	1978, 1998, [2005]	3
Ghana	[2005], 2010	2
Guinea	1982, 1996	2
Mali	**1976**, **1986**, 1997, **2008**	4
Mauritania	1976, 1987	2
Nigeria	1964, [2008], 2010, [2012]	4
Togo	[1961], [1970], 1981, 2010	4

Source : United Nations Population Division

Notes : Years in brackets are surveys and years in bold text can be disaggregated in rural-urban subgroups.

** The data from Burkina Faso are provided by their National institute of statistic and demography*

As such, the child mortality information from the UN Inter-agency group seems to be more reliable. However, the adult mortality information are derived directly from our censuses and surveys age-specific tabulations. Unlike the child mortality information very often underestimated, figures for adult mortality is more contrasted. For example, an evaluation of the data quality between three sites of observatories and the corresponding areas in Senegal Censuses reveal a higher concordance between both sources. This is not a proof that data on adult mortality reported on censuses are safe, but an indication that they may be often accurate. For our estimation, we used direct estimates to avoid any kind of completeness-adjusted based methods usually based on unrealistic assumptions. The HIV information are collected for each country and corresponding period in the UNAIDS online database.

Methods

As stated by Clark (2016), the log-quadratic model (Wilmoth et al., 2012) is the state of the art mortality model relating child and adult mortality to generate age-specific pattern of mortality. This model used a singular value decomposition (SVD) as components for the regression of residuals by exploiting the curvilinear relationship between child mortality and older age mortality. Rather than using SVD factorization like components to model residuals or building the model on a particular functional form, the Sharrow-Clark age-specific model used SVD to factorize observed log mortality. The model is the culmination of an ongoing work started with the PhD of Clark (2001). Its extension allows taking into account covariates such as the region (African or non-African countries), the sex, HIV prevalence and adult mortality in a way to be possible to combine either life expectancy at birth or child mortality to the previous covariates. More details can be found in the original paper of the authors (Sharrow et al., 2014). Even though they labelled their paper for countries with generalized HIV epidemics, it appears to be more general and applicable to non-generalized HIV countries since it is possible to specify a lower or higher HIV prevalence as a predictor in the model. For countries with very low or almost zero HIV prevalence, the model returns very similar estimates compare to the log-quadratic model. But as far is the departure of the HIV prevalence from zero, the model is able to outperform the log-quadratic model and the other model life tables (Sharrow et al., 2014). In overall, the mean absolute errors for the model were lower. Because of its simplicity, its flexibility and its generalizability to any country with partial and limited data, the Sharrow-Clark indirect age-specific model of mortality estimation have been preferred for the sub-Saharan Africa context. The authors expressed the model as follows:

$$\ln({}_nm_{x,j}) = c_j + \sum_{i=1}^{3} \omega_{i,j} k_{i,x} + \varepsilon_{x,j}$$

where ${}_nm_{x,j}$ is the period age-specific mortality rate from age x to age $x+n$ for life table j, c_j is a constant specific to life table j, $k_{i,x}$ and $\omega_{i,j}$ represent respectively the value of the i th component for age x and the weight of the i th component for life table j. The error term of the model is $\varepsilon_{x,j}$ such as $\varepsilon_{x,j} \overset{iid}{\rightarrow} \mathcal{N}(0, \sigma^2)$. Based on the fact that the estimated modal age at death $\widehat{M}$ is the maximum of life table deaths distribution at adult ages, and assuming that distribution to follow a poisson law, the function "Mort1Dsmooth" of the package *MortalitySmooth* (Camarda, 2012) is used to refine ages at death with decimal-point precision and smooth the mortality curve from P-splines approach. Insofar life tables are derived directly from raw data, we used the functions ${}_nd_x$ and ${}_nL_x$ of the estimated life tables as proxy of observed death counts and person-years lived to smooth forces of mortality and estimate M. Since information about adult mortality were estimated directly despite the suspicion of underestimation, a sensitivity analysis was done by increasing the 45q15 up to 20% of its original value and check how this affect the estimates of modal age at death. The

choice of 50% is arbitrary but we thought it was very high enough to appreciate the robustness of our estimates.

Expected findings

Before extending our analysis to the other countries, we use Burkina Faso as our starting point. For this country, information on child mortality were available for each year since the 1960s, but they were disaggregated by sex only for 1990, 2000, 2010, 2015 and 2017. We use the ratio between the total and sex-specific estimates to extrapolate estimation of 5q0 for the three years of our censuses. As said in the data section, the adult mortality information (45q15) are derived directly from raw data. The HIV prevalence from the online UNAIDS country-specific information (http://aidsinfo.unaids.org). According to the WHO 2005 summary country profile, the first case of HIV in Burkina Faso was reported in 1986 (www.who.int/hiv/HIVCP_BFA.pdf). Therefore, HIV was ignored for that period in our calculations. All the information are summarized in Table 2 below.

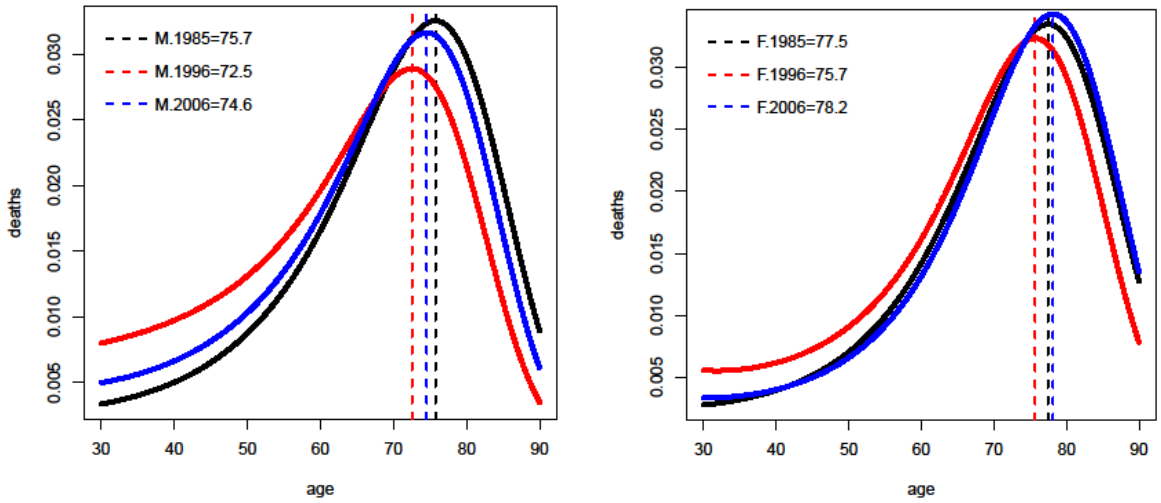
Table 2 : *Summary information used to build Burkina Faso life tables and estimate the modal age at death*

	Males			Females		
	1985	1996	2006	1985	1996	2006
5q0	0.223	0.200	0.153	0.206	0.185	0.141
45q15	0.237	0.381	0.284	0.190	0.267	0.185
HIV prevalence (%)	na*	3.6	1.2	na*	3.4	1.5

*Note : * According to the 2005 summary country profile of WHO, the first case of HIV in Burkina Faso was reported in 1986 (www.who.int/hiv/HIVCP_BFA.pdf)*

Looking at the three points over time (1985, 1996 and 2006), we observe an increase of mortality in 1996 which affected older adults (Figure 1). This overall increase of mortality was worse males. It may be due to many factors, mainly meningitis and measles epidemics with respectively about 43000 and 32000 cases recorded in health-care services (DGISS, 2011; Nicolas, 2012). In addition, there was a decreased use of health-care services from 32% in 1986 to 18% in 1996 (INSD, 2000). This widespread degradation of sanitary conditions has something to do with the increase of mortality in 1996. The distribution of deaths is slightly more peaked for females than males. After declining from almost 75.7 in 1985 to 72.5 in 1996, the estimated modal age at death for males stood at 74.6 in 2006. The pattern for females was quite similar with an estimated modal age at death declining from 77.5 in 1985 to 75.7 in 1996 before incresing and reaching 78.2 in 2006. What lessons can we drawn from this figure ? If these changes in modal age at death are real, not due to any deficiencies in our data, then the better longevity of females observed generally in humans population is confirmed in Burkina Faso. Even if we do not have enough point on time, it seems that the gap between males and females is increasing over time.

Figure 1 : Adult modal age at death for males and females, Burkina Faso 1985, 1996 and 2006 censuses



Future work

Following this first analysis, we need to test the robustness of the estimates. Furthermore, these analysis will be extended to the other countries mentionned above. Even if the observatories data from the Indepth network are from small areas, we are looking for the possibility to take advantage of their longitudinal data to make additional analysis in conjuction with these cross-sectional data.

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