

**Recent Age Patterns of Mortality in Tanzania:
An Examination of the Impact of HIV/AIDS on Mortality.**

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INTRODUCTION

Understanding mortality in sub-Saharan Africa has been hampered by the lack of data and by the use of methods that do not consider changes in the burden of disease and environment in which new diseases are emerging (Zuberi et al. 2003). The lack of data for African countries is because vital registration systems are essentially non-existent, or if they do exist, they are mostly incomplete or inaccurate. Demographers working in this region depend mostly on model life tables to make estimates and predictions. The basic assumption is that mortality in the population under study closely resembles the mortality shown by one of the model life tables. Africa has experienced varying demographic changes over the course of the past several decades, most notably being the decline in mortality. However, recent studies on mortality in sub-Saharan Africa have found stagnation or reversals of what was once assumed to be generally declining mortality trend in sub-Saharan Africa (Blacker 2004; Feeney 2001; Heuveline 2003; Timaeus 1999; Timaeus and Jasseh 2004; Tollman et al 1999; United Nations 1998). These studies have attributed the increase in mortality, particularly among adults, to the rise in infectious and parasitic diseases, especially as a result of the HIV/AIDS epidemic.

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In this study, we set out to investigate the cause structure of mortality and the age patterns of mortality in Tanzania, and whether they reflect a significant impact of HIV/AIDS. Age patterns of mortality may differ systematically from the existing model life tables. We empirically test the applicability of the existing model life tables to Tanzanian mortality. We do not refine the existing model life table systems. However, we suggest which model life tables may be applicable to contemporary sub-Saharan African countries suffering from the HIV/AIDS pandemic. Additionally, using the life table techniques, we investigate the demographic effects of the HIV/AIDS mortality on the Tanzanian populations by estimating the potential gains in life expectancy if deaths from the HIV/AIDS were eliminated from these populations.

SIGNIFICANCE

The significance of our paper is two-fold. First, it contributes to the literature on HIV/AIDS mortality in sub-Saharan Africa by providing empirical analysis of longitudinal mortality data. The general objective is to understand what effect HIV/AIDS is having on mortality patterns in sub-Saharan Africa, and in Tanzania in particular. With the current estimate of HIV prevalence among adults at 8.8%, Tanzania is considered among the worst affected countries by the disease in sub-Saharan Africa. Because vital registration system, which typically provides cause of death data are essentially non-existent in Tanzania, use of verbal autopsy data from three demographic surveillance sites of differing socio-demographic and geographic characteristics provide a rare opportunity to examine the mortality situation in the era of HIV/AIDS.

Secondly, mortality is not only a major population dynamic; it is also a major determinant of public health policy focus. Moreover, HIV/AIDS epidemic is high on the population and public health agenda of many countries in the developing world, particularly in the eastern and southern Africa where the level of HIV/AIDS prevalence among adults is significantly high. Beyond the demographic significance of this study, the analyses of causes of death are important in informing policy, in guiding the implementation of effective intervention programs and in the monitoring and evaluation of health programs. Such analyses provide knowledge about the distribution of causes of death and identification of age groups of populations that are affected most by HIV/AIDS.

PATTERNS OF MORTALITY AND HIV/AIDS

The Life table presents the implications for longevity of a set of age-specific death rates, and provides a description of the varying chances of dying as a function of age. The age-specific death rates of a population are linked to the health and well-being of the population. The pattern of the age-specific death rates is a basic measure of the quality of life of a population. Age-specific death rates are highest in the period immediately after birth, remaining high at a lower level through infancy, and drops until about age 15 years, after about age 15 mortality increases with increasing age. This general pattern occurs in all known human populations; however the structure of the age-specific death rates depends on the level of mortality and the importance of different age-specific causes of death (Clark et al. 2003; INDEPTH³ 2002, 2004; McDaniel and Preston 1994; Preston

³ INDEPTH stands for International Network for the continuous Demographic Evaluation of Population and Their Health in developing countries. The vision of the network is to set up a platform of sentinel

1970, 1976; Preston, McDaniel and Grushka 1993, Preston and Nelson 1974). In sub-Saharan Africa, these age patterns are generally characterized by high infant and early childhood mortality, followed by a rapid decline to a minimum in late childhood and early adolescent, and then a gradual increase with age (Bawah 2002; Horiuchi and Wilmoth 1998). While a number of countries in sub-Saharan Africa may conform to this characteristic pattern, the emergence and severity of the HIV/AIDS pandemic particular in the southern African countries is believed to have distorted the African 'classical' pattern. Existing life table information for which demographers use to estimate mortality levels and to make extrapolations and future predictions for mortality patterns have some limitations. Among others, they do not represent the impact of the HIV/AIDS pattern. This limits their ability to capture mortality patterns in Africa, especially in countries where HIV/AIDS is a significant cause of death, or where it is anticipated to be in the near future (Heuveline 2003; INDEPTH 2004, Stanecki 2000). Lack of accurate empirical data on AIDS deaths and HIV infection among the general population have contributed to slowing down of revisions to the existing model age patterns to include the impact of the AIDS epidemic.

In sub-Saharan Africa, the emergence of HIV/AIDS is believed to have contributed to a major rise in death rates, especially among adult men and women in their most reproductive years. It is estimated that about four fifths of the world's AIDS deaths come from this region. There is also some indication that under-five mortality is stagnant or is rising in several African countries, possibly because of mother to child-transmission of HIV/AIDS (Ng'weshemi et al 2003; Nicoll et al 1994; Timaeus 1998; Walker,

demographic sites that provides health and demographic data and research to enable developing countries to set health priorities and policies based on longitudinal evidence.

Schwartlander and Bryce 2002; Zaba, Marston and Floyd 2003). The UNAIDS (2004) report on the global burden of HIV/AIDS indicate that the disease is reversing the gains of economic development and shortening life expectancies in many HIV affected African countries. The report estimates the current life expectancy at birth in sub-Saharan Africa at 47 years. According to the report, without HIV/AIDS, it would have been 62 years.

Tanzania is considered to be among the hardest hit countries by HIV/AIDS in sub-Saharan Africa. Being among the world's poorest countries, the HIV/AIDS epidemic presents an enormous challenge to Tanzania. The AIDS fatality was first reported in the country in 1983 in Kagera Region. Since then the situation and the impact on the health and well being of the population is considered to have worsened. It is now the leading cause of adult mortality in many parts of the country (United Republic of Tanzania 1997). Early in the epidemic, urban populations and communities located along highways were most affected. According to annual report by the Tanzanian National AIDS Control Program (1996), the epidemic has rapidly spread to rural communities in Tanzania. By the end of year 2002 number reported to the National AIDS Control Programme (NACP) were about 157,000 (National AIDS Control Programme 2002). However, it is very likely that this is an underestimate of the true burden. NACP obtain HIV prevalence data from women attending ante-natal clinics and blood donors in the health facilities across the country. Monitoring the epidemic and its impact on population is challenging. Researchers, program managers and policy makers in the country have been dependent on mortality data mostly from health facilities as their major source of information. In Tanzania, health facility data alone do not reflect the true picture of the disease burden.

The establishment of demographic surveillance system in some selected areas in Tanzania (the very first sites were established in 1992 in three communities) has been in response to the need for reliable, community-based data that is routinely collected for various uses particularly in the health sector. By the year 2002, there were six fully functioning demographic surveillance sites in Tanzania (Dar es Salaam, Hai, Morogoro, Ifakara, Rufiji and Magu) owned by the Ministry of Health in partnership with donor agencies. The demographic surveillance sites generate empirical population and health data up to the household level. Data generated through DSS are generally of high quality and can contribute to our knowledge of mortality in sub-Saharan Africa and in particular to the contribution of important causes of morbidity and mortality.

DATA AND METHODS

In this article, we use data from three DSS sites - one urban and two rural areas – operated by the Adult Morbidity and Mortality Project (AMMP)⁴ of the Tanzanian Ministry of Health to investigate the current mortality situation of the country. Demographic Surveillance System data are able to produce measures of fertility, mortality and migration with reference to the population. Socio-demographic data are collected via periodic census rounds while mortality data are prospectively collected through a continuous mortality monitoring, and using Verbal Autopsy⁵ (VA) for ascertaining causes of death.

⁴ AMMP is a project of the Tanzanian Ministry of Health, funded by the UK Department of International Development (DFID) and implemented with technical assistance and management of the University of Newcastle upon Tyne (UK). The project operates in partnership with rural districts of Hai and Morogoro, and the municipalities of Ilala and Temeke in Dar es Salaam

⁵ Verbal autopsy (VA) is a simple indirect technique for ascertaining probable cause of death. The technique relies on the clinical assessment of signs and symptoms during the terminal illness, based on the

EXAMINE THE IMPACT OF THE HIV/AIDS

Tuberculosis is the most common opportunistic infection in AIDS patients, and accounts for about one-third of HIV/AIDS deaths in sub-Saharan. This makes it a challenge to disentangle the effect of HIV/AIDS on the overall mortality, especially where co-morbidity of HIV/AIDS and tuberculosis is very high. It is perhaps necessary to say how the impact of HIV/AIDS was examined in this study. The physicians who did the coding of the probable cause of death from information on verbal autopsies could assign any of the 5 possible cause of death to HIV/AIDS related causes: 1) unspecified TB/AIDS, 2) pulmonary tuberculosis, 3) AIDS, 4) AIDS + pulmonary tuberculosis, or 5) all other forms of tuberculosis. Since discriminating between tuberculosis and HIV/AIDS may not be precise from the VAs because they often occur in the same individual and have many symptoms in common (Quigley et al, 1999), we combine all forms of possible HIV/AIDS related deaths into a single category TB/AIDS. We use the combined category, TB/AIDS, to measure the impact of HIV/AIDS on mortality in the populations.

In order to explain the divergence of age-specific patterns of mortality from the expected pattern for Tanzania, we employ VA data to examine the cause structure of mortality underlying these age patterns. We produce mortality rates and plots of age-specific patterns of mortality for the three DSS sites. The validity of the cause-of death assignments in the DSS sites is tested by comparing the age patterns of mortality from all causes and from specific cause produced using DSS data with the age pattern recorded in populations in which cause-of-death structure is more precise. Preston (1976) has

assumption that most causes of death can be distinguished by their signs and symptoms, and that these can be accurately recognized, recalled, and reported by lay respondents.

compiled cause specific mortality rates for national populations at different ranges of mortality levels. Among others, he has produced mean death rate estimates by age for males and females for 21 national populations with life expectancy at birth between 45 and 54.99 years. We use this model as the standard for comparisons of age-specific death rates by cause in the three DSS sites and age-specific death rates from census data because of similarity in the level of mortality. The method employs plotting on the same graph, sex-specific death rates from all causes combined and then plotting separately for each specific causes of death in these populations.

We then apply ordinary least squares (OLS) regression to explicit examine the age patterns of mortality in the DSS sites and to test the fit of the models for males and females using model life table systems and other standards. We use Ansley Coale and Paul Demeny (1966, 1983), the United Nations (1982) and the World Health Organization (2002) model life-table families as our standard models. The age pattern of mortality within a model life table system can be efficiently estimated as a two-parameter transformation of a standard age pattern of mortality appropriate for that model. This modeling method is referred to as two-parameter model (McDaniel and Preston, 1994). The regression parameters capture deviations from the standard. Brass (1968) proposed a simple relational two-parameter regression model for capturing the complexity of age pattern of mortality of any population in relation to the standard pattern based upon logit transformation of l_x , the probability of surviving to age x :

$$\lambda_x = \alpha + \beta \lambda_x^s \quad (1)$$

But,

$$\lambda_x = \log it[l_x] = \frac{1}{2} \ln \left[\frac{1 - l_x}{l_x} \right] \quad (2)$$

Substituting (2) in (1) we get

$$0.5 \ln \left(\frac{1.0 - l_x}{l_x} \right) = \alpha + 0.5 \beta \ln \left(\frac{1.0 - l_x^s}{l_x^s} \right) \quad (3)$$

The parameter α indicates the level of the mortality in the population relative to the standard: a higher value of α implies a higher mortality in the study population (that is a lower probability of surviving to any age x as well as lower probability of surviving between any two ages x and y). The parameter β represents the ‘slope’ of mortality: when β increases, mortality increases at older ages (ages above that at which $l_x = 0.5$) and decreases at younger ages. The values of α and β in equation (3) are estimated using OLS regression. For modeling purpose, we use different values of l_x^s from various model life tables and other selected standards pertaining to a life expectancy of between 45 and 55 years. Various sources of data have reported an estimate of life expectancy for the Tanzanian falling in this age range.

The presence of high burden of infectious diseases and its dominant influence on the age-patterns of mortality in Tanzania more likely suggests the impact on HIV/AIDS on mortality patterns in Tanzania. We apply a three parameter model technique suggested by McDaniel and Preston (1994) to investigate this. For comparative reasons, we collapse disease categories into three broad causes: (1) infectious and parasitic; (2) non-communicable conditions; and (3) all other causes combined. Implied levels of mortality from the three causes can be estimated since age-specific death rates (${}_n m_x$) and age-specific survival probabilities (l_x) are related through the relationship:

$$l_x = e^{-\int_0^x m_a da} = e^{-\int_0^x m_{a1} da} \times e^{-\int_0^x m_{a2} da} \times e^{-\int_0^x m_{a3} da} \quad (4)$$

where m_a is the overall death rate at exact age a , and m_{ai} is a death rates from cause i at age a .

If we assume that the age-specific death rates from a particular cause of death in Tanzania are scalar multiple of death rates from that cause in the standard model, then it follows that:

$$\ln l_x^T = -k_1 \int_0^x m_{a1}^s da - k_2 \int_0^x m_{a2}^s da - k_3 \int_0^x m_{a3}^s da \quad (5)$$

where l_x^T is the probability of surviving from birth to age x in Tanzania and m_{ai}^s ($i=1,2,3$) are respective death rates at age a in the standard from infectious and parasitic (1), non-communicable conditions (2) and all other causes combined (3); and the k_i 's are multipliers for a particular cause of death that is appropriate for Tanzania. The factors k_i 's are then estimated by linear regression which relates l_x^T to m_{a1}^s , m_{a2}^s and m_{a3}^s . The regression is forced through the origin to eliminate an intercept. If k for a specific cause is equal to one, then the level of cause-specific mortality in Tanzania is the same as that in the standard population.

Furthermore, we apply life table techniques to investigate the impact of HIV/AIDS on life expectancies. We first produce current life tables for the three DSS areas. We then consider a hypothetical situation where deaths from TB/AIDS are eliminated from the DSS populations. Using cause-deleted life table methods (Preston, Heuveline and Guillot 2001), we estimate the potential gains in life expectancies in the Tanzanian populations.

SUMMARY OF FINDINGS

Our findings indicate that, consistent with other findings in sub-Saharan Africa, adult mortality for males and females is very high in Tanzania as a result HIV/AIDS pandemic. The infectious and non-infectious diseases account for large proportions in the overall mortality burden. The paper also highlights some of the limitations of existing model life tables for use in examining the contemporary African mortality situation. Perhaps the most widely used model life table systems is the Coale-Demeny regional model life tables. However, findings from this study suggest that the Coale-Demeny set of regional model life tables may not be the best choice for estimating the contemporary African mortality especially in HIV endemic sub-Saharan African countries. The general conclusion is that for populations with high prevalence of HIV/AIDS, the Coale-Demeny, Preston's national populations, and the United Nations life table systems are no longer appropriate for modeling, estimating and projecting African mortality. For African populations with high prevalence of HIV/AIDS and no vital registration data, we recommend the use of newly produced INDEPTH models patterns as an alternative for examine and estimating mortality these populations.

Estimates of the impact of HIV/AIDS on mortality are sensitive to the type of data, the assumptions one make about the quality of data and the estimation methods employed. Although the HIV/AIDS epidemic clearly reduces the life expectancies at birth in affected populations, there is much more uncertainty about levels of mortality, particularly among adults in countries impacted by HIV/AIDS, than implied in the current available demographic estimates. In Tanzania for example, various research and sources of information, both local and international, provide current estimates of levels

and patterns of mortality for Tanzania reflecting higher or lower impact of HIV/AIDS in Tanzania than what may actually be, with the majority reflecting much higher impact of HIV/AIDS resulting into lower estimates of life expectancies at birth of about 47 years or lower. In our study, we have estimated life expectancies at birth of 51 years and above for both males and females in the rural and urban populations.

Our paper also underscores the important relationship between causes of death and age patterns of mortality. With clearer understanding of the similarity or lack of uniformity in the changes in the age patterns over time, and the use of appropriate model life tables, we can improve our ability to study the impact of new emergent diseases and predict the future patterns of mortality change.

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