Estimating the Contribution of HIV/AIDS and Related Causes to Mortality in Botswana

K. Setlhare
Department of Statistics, the University of Botswana
Private Bag UB00705, Gaborone
E-mail: setlhark@mopipi.ub.bw
Tel:+267-355-5014; Fax: +267-318-5099

N. Forcheh
Department of Statistics, the University of Botswana
Private Bag UB00705, Gaborone
E-mail: forchehn@mopipi.ub.bw
Tel:+267-355-5014; Fax: +267-318-5099

L. Gabaitiri
Department of Statistics, the University of Botswana
Private Bag UB00705, Gaborone

Abstract

Overall mortality in Botswana has continued rising since the 1990s despite continued growth in the health sector and most other sectors of the economy. Researchers and policy makers have generally blamed the reversal of the remarkable health gains during the 1970s and 1980s on HIV/AIDS, which was first discovered in Botswana in 1985. Understandably, the health gains continued throughout the 1980s, and started to decline only after AIDS emerged as a significant contributor to mortality, and then to a major cause by 1993. It is however, not clear as to whether the rising mortality can be blamed solely on HIV/AIDS or whether the concentration of resources on the fight against HIV/AIDS might have led to a neglect of other serious causes of mortality. The purpose of this paper is to study the contribution of AIDS and related causes of death to the total mortality in Botswana from 1990 - 2003. Using Preston models, the analysis found that AIDS contribute to about 4.3% of all deaths (4.29% for males and 4.37% for females) and about 5.8% and 5.9% for males and females respectively for institutional deaths. The analysis reveals that AIDS accounts for about 4% of the total deaths among both males and females from all causes and about 6% among the intuitional deaths between 1991 and 2003. When the infants are excluded, AIDS accounts for 7% and 9% among the males and females respectively in the institutional death.

Keywords: AIDS, Opportunistic Infections, Mortality, Related causes, Preston model

1. Introduction

Mortality analysis and projections form an integral part of national planning. The trends in mortality provide an indicator of the effectiveness or otherwise of any country's health policies. Since the onset of HIV/AIDS, overall mortality in many countries, especially in sub-Sahara Africa, has been severely negatively affected. In Botswana mortality has continued rising since the 1990s despite continued growth in the health sector and most other sectors of the economy. Although researchers and policy makers have blamed the reversal on HIV/AIDS, little formal studies focusing on causes of mortality have been conducted in the country. The main aim of this study is to investigate the impact of HIV/AIDs on mortality trends, using cause of death data from Botswana as a case study.

HIV/AIDS has become one of the leading causes of death since the beginning of this millennium (World Health Report, 2002). Some studies predict that AIDS may be the world's third leading cause of death by 2030 (Hitti, 2006). A substantial amount of research has been conducted on HIV/AIDS, but these have focused on prevalence, attitudes, behaviors, knowledge, education, intervention, transmission and transition (NACA, 2004; De Cock et al, 2000; Hope, 2001; Seloilwe et al, 2001; Shapiro et al, 2003; Thior et al, 2007; Kebaabetswe et al, 2003). Most developing countries lack resources to certify causes of deaths, especially when they occur outside health institutions. Many terminally ill patients, especially those in rural areas, do not die in health institutions. Cause-specific mortality data therefore, tend to be scanty. As a result, relatively very few studies have been conducted in developing countries focusing on the nature and causes of mortality.

2. Literature Review

Few literatures are available on mortality in Botswana. Majelantle (1991) utilized official aggregate statistics to give a general overview of gender differentials in morbidity and mortality in Botswana over the period 1986-1991 and found that females were more morbid and mortality was higher among males at infancy and early childhood than among females.

Later on, Owuor and Kobule (1993) studied the impact of the Botswana hierarchical referral health system as a determinant of maternal mortality, but did not address trends and levels of maternal mortality. Datta (1989) analyzed the differential mortality levels in districts, villages and urban areas using crude death rates (CDR) and age-sex standardized death rates (ASDR) obtained from census data in Botswana and Bangladesh. He also correlated mortality patterns in Botswana with factors such as education, occupation, type of water supply, sanitation facilities, medical facilities and urbanization, and concluded that factors that affect mortality included housing conditions, urbanization and education.

Elsewhere in Africa, Grassly et al (2004) compared household survey estimates of mortality with UNAIDS/WHO projections in the era of HIV/AIDS. They observe that vital registration in sub-Saharan African countries is rare, except in a handful of countries. They utilized survey data from national surveys such as Demographic and health surveys and multiple indicator surveys, and noted the limitations in most of these data sets. They found the mortality estimates from survey data to be significantly lower than those from UNAIDS/WHO models and concluded that the proportion of orphans attributable to AIDS may be greater than previously estimated.

Momodou (2004) attempted to reconcile mortality data from household surveys with those from epidemiological studies in sub-Saharan African countries between 1992 and 2002. Momodou noted that routine data on adult mortality in sub-Saharan Africa are rare except in a few countries and that the reporting of causes of death is poor because most of the deaths are not certified medically.

Conti, Farchi and Prati (1994) described the impact of AIDS on mortality of young adults in Italy using data from the Italian mortality database for 1990. They noted that mortality among young men in Italy started to rise in mid 1980's after a steady decrease over many years. As in most African countries, this rise coincided with the appearance and spread of AIDS in Italy which has particularly affected young men. The data used were classified using The International Classification of Diseases (ICD9) and direct methods were used to obtain standardized mortality rates. A comprehensive review of trends in the analysis of cause specific mortality data is found in Manton and Stallard (1984). They noted that studies on mortality tend to rely on data from official publications or on death certificates that have been certified by medical officers and caution that there are serious differences between cause specific mortality data from the three main sources: government publications, death certificates and from autopsy investigations. The differences could be attributed to the ICD which assigns each death to a single, underlying cause, even if the deceased suffered from multiple conditions at the time of death.

In determining as to whether the underling cause of a particular death was AIDS, an AIDS case definition is used (Sackoff et al, 2006). The AIDS case definition includes a positive test result for HIV and either a positive test for one or more of 26 opportunistic illnesses or a CD4+ lymphocyte count less than $0.200*10^9$ cells/L or less than 14 percent of total lymphocytes (Sackoff et al, 2006). It is therefore possible to misclassify deaths due to AIDS related causes when using the single cause of death approach that has been adopted by international classification of diseases. For example if a pneumonia patient dies without undergoing an AIDS tests (which is voluntary) then the individual's cause of death would be classified as pneumonia even if pneumonia was an opportunistic infection. On the other hand if a patient is diagnosed to have both AIDS with pneumonia as an opportunistic infection, then when he/she dies, the cause of death would be recorded as AIDS even if he had pneumonia before HIV, and might have died of pneumonia. Some opportunistic infections such as pulmonary tuberculosis and pneumonia have been among the leading causes of mortality in Botswana even before the onset of HIV/AIDS.

Dublin and Van Buren (1924) analysed material to show the incidence of secondary causes, the extent to which each disease is associated with other diseases, and the frequency of certain combinations. They pointed to the value of multiple cause analysis as well as the problems involved in interpreting the data. Weiner et al. (1955) found that if multiple-cause information were available, all but about 1% of death certificates could be classified into etiological and site-specific disease patterns, on the basis of clinical and biological insights (Manton and Stallard, 1984: 20). Nam (1990) points out that the complexity of mortality analysis is reflected in the fact that death is best viewed not just as a momentary vital event in time but also, and more meaningfully as "the end of a life-long process during which the individual has experienced some brief and prolonged episodes of illness and disability which have combined with the persons genetic and physiological stock to alter the risks of survival".

The main objective of this paper is to study the contribution of AIDS and related causes of death to the total mortality in Botswana from 1990 - 2003. The study investigates the extent to which trends in mortality attributed to AIDS are related to trends in mortality due to opportunistic infections, ill-defined conditions and other causes of mortality. Models are developed to estimate the net contribution of HIV/AIDS to annual mortality and that due to other causes.

3. Statistical Methods

Let n_{ij} be the number of deaths in the i-th cohort due to cause j and P_i be the annual mid year population of cohort i. Then the standardized mortality rate in cohort i due to cause j is $M_{ij} = \frac{n_{ij}}{P_i} \times 100,000$. Although mortality rates are usually expressed per 1000 (see e.g. Shryock et al., 1976), we express these rates per 100,000 since cause specific mortality numbers are much smaller than total mortality. A cohort is defined by year-age-sex combination. The total mortality rate in the i^{th} cohort due to all causes is given by $T_i = \frac{\sum_{j=1}^{p} n_{ij}}{P_i} \times 100,000 \quad \forall i = 1,2..$.

One of the aims of the research is to study trends in AIDS mortality in relation to trends in mortality due to related causes such as TB, pneumonia, other opportunistic infections and ill-defined conditions. Trends in mortality rates due to AIDS were obtained for the different age groups and by sex of deceased in order to appreciate how mortality has affected different male and female age cohorts. Scatter plots of AIDS mortality versus mortality due to TB, pneumonia, other opportunistic infections and ill defined conditions were obtained, and the strength of association determined using the rank correlation coefficient, since there was no basis in assuming that the relationship would be linear. Ternary diagrams were used to study how mortality due to AIDS, TB and other opportunistic infections including pneumonia changed over the years across age-groups and between male and females.

In order to determine the contribution of AIDS to total mortality relative to other causes of death, we fit a series of Preston models (Preston, 1976; Murray and Lopez, 1996 and Salmon and Murray, 2002):

(1) $M_{ij} = \beta_{0j} + \beta_{1j} T_i + \varepsilon_{ij}$ for $i = 1, 2, .., n$; $j = 1, 2, ..., p$;

where n is the number of year-age cohorts and p is the total number of causes or cause groups. M_{ij} is the cohort-specific mortality rate in cohort i due to cause j and T_i is the corresponding total mortality rate for cohort i as defined under data description. The regression coefficient β_{1j} is interpreted as the proportionate contribution of cause j to total mortality. In theory, $\sum_{j=1}^{p} \beta_{1j} = 1$, but in practice, this is not guaranteed since separate models are fitted for each cause of death (Salomon and Murray, 2002). The deviation of $\sum_{j=1}^{p} \beta_{1j} = 1$ is thus a measure of the goodness of fit of the model.

Preston (1976) and subsequent authors (Murray and Lopez, 1996 and Salmon and Murray, 2002) have used the Preston model and its derivatives. In epidemiological transition models, causes are grouped in terms of which diseases are prominent at the different stages of the transition (Preston, 1976) whereas in the global burden of disease models (GBD90 model), causes are divided into 3 groups. Group 1 comprises of communicable, maternal, prenatal and nutritional diseases; group 2-Non-communicable diseases and group 3 -Injuries, both intentional and accidental and log mortality rates are obtained (Murray and Lopez, 1996). Newer adaptations of the Preston Model have been suggested by Salmon and Murray (2002), but these require additional information such as GDP, hence those will not be used in this study. We fit two sets of models. In the first set only institutional deaths are considered and there are 6 cause groups namely M_1 - AIDS, M_2 - Pulmonary Tuberculosis (TB), M_3 - Pneumonia, M_4 - Other Opportunistic infections, excluding TB and Pneumonia, M_5 - Ill Defined Conditions, and M_6 - All Other institutionally certified causes. In the second set, the non-institutional deaths are included and hence there are 7 cause groups being M_1 - AIDS, M_2 - Pulmonary Tuberculosis (TB), M_3 - Pneumonia, M_4 - Other Opportunistic infections, excluding TB and Pneumonia, M_5 - Ill Defined Conditions, M_6 - All Other institutionally certified Causes and M_7 - Non-Institutional and Unknown Causes.

3.1. Data Description

This study uses annual mortality data that are routinely collected by the Health Statistics Unit of the Central Statistics Office (CSO) in Botswana from 1991 to 2003. This is the period in which the Health Statistics Unit standardized its data collection procedures in accordance with international recommendations and adopted the 9th revision of International Classification of Diseases (ICD9) for reporting morbidity and mortality. The ICD9 divides diseases into a total of 307 distinct causes of morbidity and mortality (CSO HSR, 2003). From 2004, The Health Statistics Unit started using ICD10 classification and hence data from 2004 have not been included in the study.

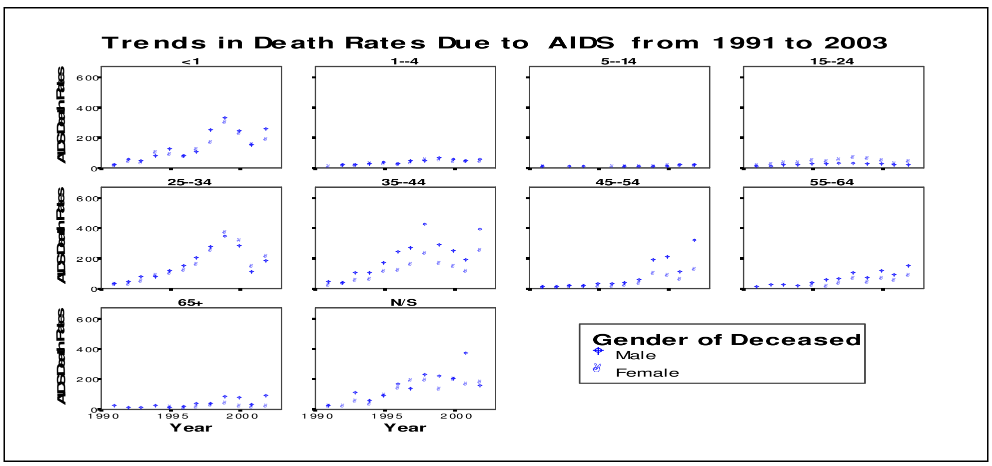
In epidemiology and demography, standardized mortality rates are preferred to raw mortality counts in the analysis of mortality data since standardized rates eliminate the effect of differences in the population composition with respect to key demographic variables (Shryock et al., 1976; Ahmad et al., 2000). Age has been described as the single most important demographic variable in the analysis of mortality (Shryock et al 1976). Causes of mortality also impact on males and females differently.

Hence age-sex specific standardized rates are used in place of crude death rates and counts. The quality of the birth and death data in Botswana is quite high, and hence that of the population projections. For example the projected population for 2001 and the eventual census population differed by just 13108 people (less than 1 percent of the actual population. We therefore, used the Botswana 1991 and 2001 census population data and the CSO inter-censual population projections as the reference population in the standardization.

4. Results and discussion

Figures 1-5 are scatter plots showing trends in age-sex-specific death rates from 1991 to 2003. Similar mortality patterns among the under 1, 25-34 and 34-44 groups are observed. In these three age groups, mortality due to AIDS increased steadily until around 2000 before dropping in 2001 and 2002 and increasing again in 2003. For age groups over 44, mortality due to AIDS was fairly low until 1999/2000. Among age group 1-4, 5-14 and 15-24 mortality due to AIDS has remained very low over the study period. Gender differences are evident in age-group 15-24 and 35-44. Relatively more males in the age 35-44 died from AIDS than females as compared to the 15-24 age group where slightly more females died of AIDS than males.

Figure 1: Age-Specific Death Rate due to AIDS



From Figure 2, it is evident that most pneumonia deaths occur among infants reaching up to 1000 deaths per 100,000 in 2003. This is much clearer in Figure 6 that the infant group was hardly hit by incidences of pneumonia deaths while hardly any deaths due to pneumonia occurred among the age groups 1-24. Pneumonia deaths are relatively low in the older age groups compared to AIDS deaths with maximums of 250 deaths per 100, 000. As a result there is generally a weak association relationship between AIDS deaths and pneumonia deaths. On the contrary, there appear to be a positive association between AIDS deaths and TB deaths from age groups 25-34 and 35-44 (Figure 3). These observations are confirmed in table 1 by correlation coefficient of 0.786 and 0.894 for males and females respectively for the 25-34 age group and 0.788 and 0.912 for males and females respectively for the age group 35-44 age group. Incidences of TB deaths are low among people under 25 years and are more evident among males than females over 25 years of age.

Figure 2: Age-Specific Death Rates due to AIDS vs Pneumonia, Pulmonary Tuberculosis, Other OI's and Ill-Defined Conditions.

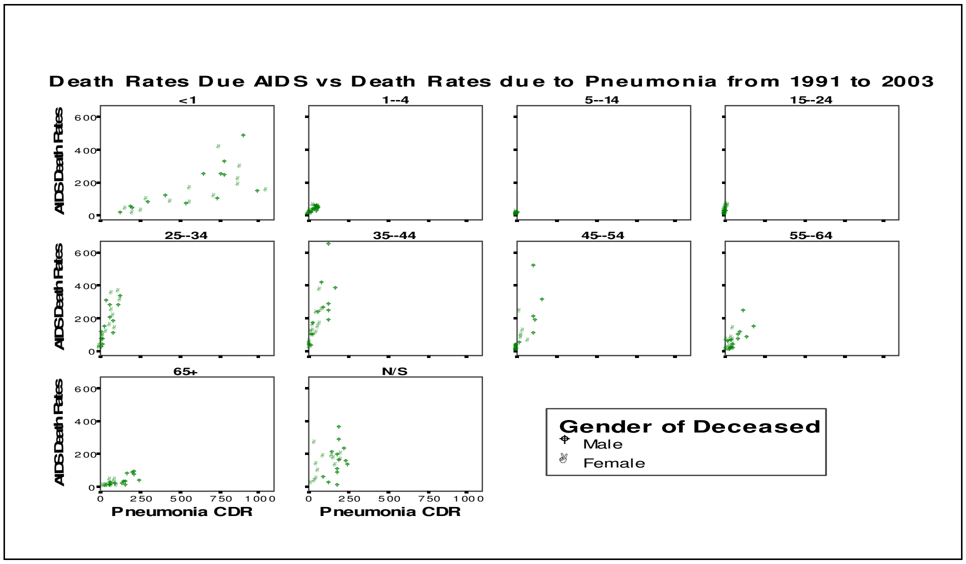


Figure 3: Age-Specific Death Rates due to AIDS vs Pneumonia, Pulmonary Tuberculosis, Other OI's and Ill-Defined Conditions.

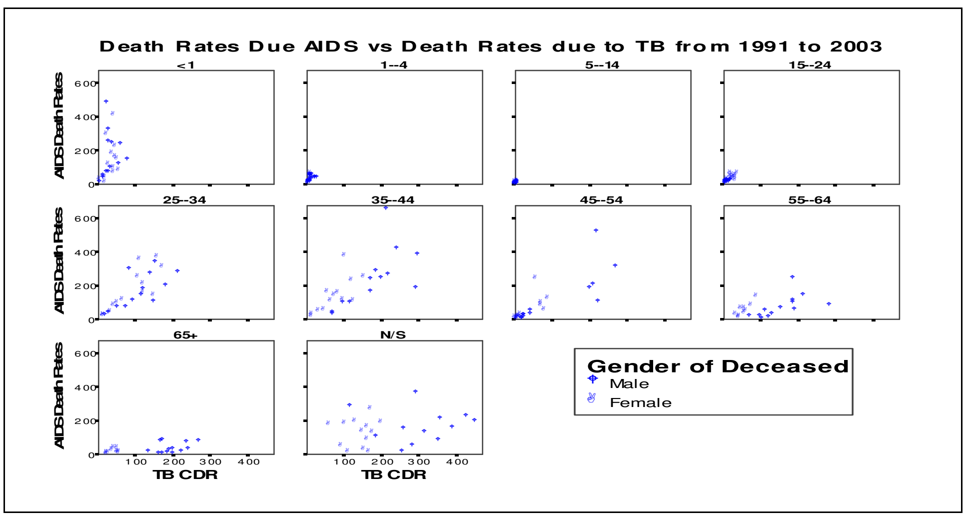


Figure 4: Age-Specific Death Rates due to AIDS vs Pneumonia, Pulmonary Tuberculosis, Other OI's and Ill-Defined Conditions.

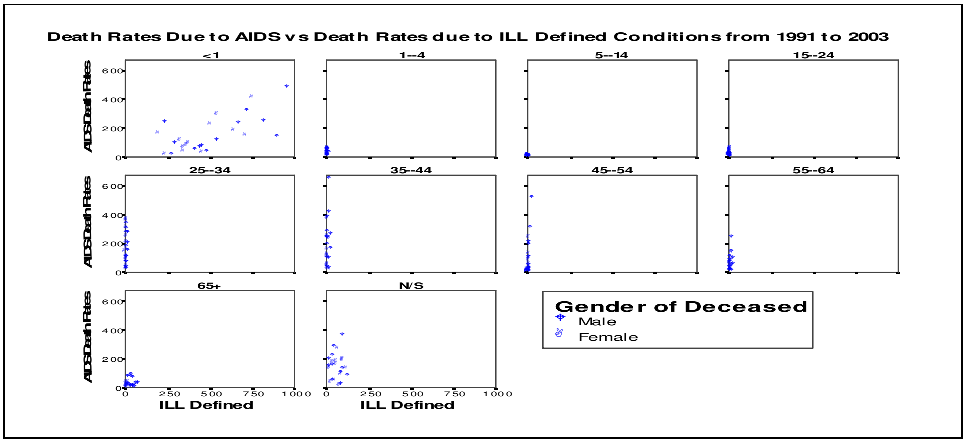
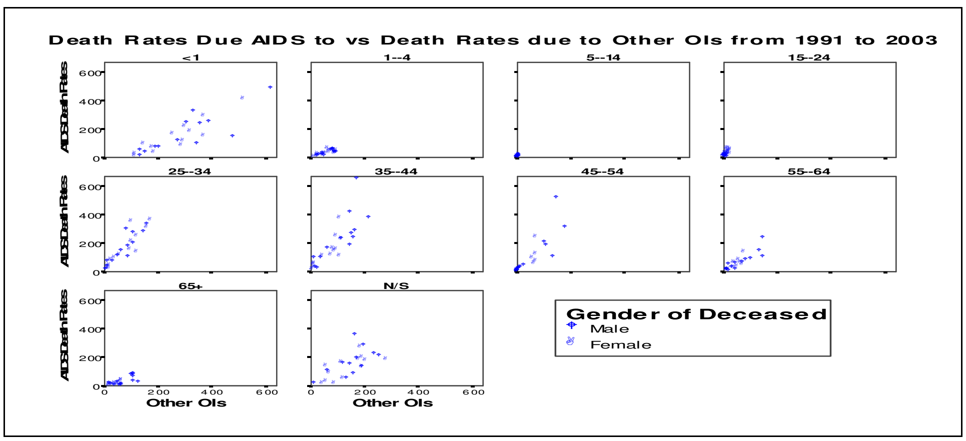


Figure 5: Age-Specific Death Rates due to AIDS vs Pneumonia, Pulmonary Tuberculosis, Other OI's and Ill-Defined Conditions.



Deaths due to ill defined conditions are prevalent mainly among infants and are hardly prevalent in any other age groups (Figure 4). There are very strong associations between AIDS deaths and deaths due to other opportunistic infections (Figure 5) among the infants and young adults (25-44) and those whose age was not stated.

Ternary diagrams were used to describe mortality patterns. It is observed that mortality among the under 15's are due to AIDS and has been increasing over the years as shown in figure 8. For the 15-44 age groups, it is not clear which of the three AIDS, TB and Opportunistic infections is more evident as a cause of death while opportunistic infections have been the major cause of death among the 45years old and over. The results of the Preston models given in table 2 show contribution of various causes of death to total mortality. The contribution of AIDS deaths towards total mortality was around 4.3% for males and 4.4% for females. This decreased slightly to 4.1% (males) and 4.3% (females) when the infants are excluded. The contribution of pulmonary tuberculosis to total mortality among males was higher (4.9%) than among females (2.4%). The contribution rose sharply to 8.8% and 4.9% respectively when excuding infants. When the infants are included, pneumonia is by far the leading cause of deaths among both males (11.0%) and females (13.6%). This is followed by ill-defined condition which contributes 8.4% among males and 9.7% among females. However, when the infants are excluded these contributions drop significantly among both males and females. The results show that the infant mortality has very little contribution towards TB deaths while it is pneumonia which experiences a large contribution from infant deaths.

Considering only institutional deaths pneumonia remains the leading contributor to total mortality followed by ill-defined conditions. However the contribution of AIDS to total mortality increased by about 1.5% while that due to TB is basically unaffected. When we exclude infants, TB becomes the leading contributor among males (12.9%) and the second leading contributor among females (8.6%). AIDS is the leading contributor among females (9.1%) and the third leading contributor among males (7.0%). Other opportunistic infections is the third leading contributor among females (8.5%) and fourth leading contributor among males (5.9%). Hence AIDS, TB, pneumonia and other opportunistic infections each contribute 6.0% or more to total institutional mortality among the population aged 1 year or more.

Table 1: Spearman Rank Correlation coefficients between death rates due to AIDS and corresponding rates due to various diseases groups from 1991 to 2003

Age group of	**Pulmonary Tuberculosis**		**Pneumonia**		**Other Opportunistic Infections**		**ILL Defined Conditions**		**All other Known Causes**	
Deceased	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**
<1	0.568*	0.434	0.802**	0.797**	0.847**	0.913**	0.593*	0.627*	0.828**	0.835**
1--4	0.610*	0.768**	0.762**	0.721**	0.814**	0.782**	0.302	0.484*	0.656**	0.608*
5--14	0.497*	0.574*	0.844**	0.836**	0.824**	0.879**	0.383	0.360	0.765**	0.736**
15--24	0.666**	0.731**	0.569*	0.719**	0.573*	0.725**	0.111	0.536*	0.630*	0.770**
25--34	0.786**	0.894**	0.841**	0.907**	0.891**	0.912**	0.152	0.264	0.802**	0.907**
35--44	0.878**	0.912**	0.862**	0.960**	0.916**	0.900**	0.530*	-0.147	0.913**	0.879**
45--54	0.817**	0.853**	0.857**	0.767**	0.867**	0.920**	0.285	0.218	0.887**	0.860**
55--64	0.790**	0.863**	0.825**	0.743**	0.944**	0.877**	0.152	-0.059	0.885**	0.895**
65+	0.589*	0.476	0.803**	0.796**	0.750**	0.916**	-0.300	-0.550*	0.801**	0.888**
N/S	0.264	0.199	0.441	.581*	.761**	.764**	-0.266	0.357	-0.047	-0.028

* Rank Correlation is significant at the 0.05 level .
** Rank Correlation is significant at the 0.01 level.

Pair wise rank correlation coefficients were used to explain the association between trends in death rates due to AIDS and trends in death rates due to other causes of death among different age cohorts (see table 1). There is strong positive association between death rates due to AIDS and the corresponding rates due to other opportunistic infection and Pneumonia in all age groups and among males and females. The rank correlation tends to be higher among females than among males. The association between death rates due to AIDS and the rates due to pulmonary tuberculosis are generally weak among the age groups under 15 years of age and over 65 years and above. Death rates due to ill-defined condition tend to have weak or no significant association with death rates due to AIDS. The positive association between death rates due to AIDS and death rates due to all other causes is an indication of the general increase in the overall mortality during the study period.

Table 2: Contribution of various diseases groups to Total Mortality from 1991-2003

	All Causes of Deaths				Institutional Deaths			
	M1: All Age groups		M2: excl <1yr		M3: All Age groups		M4: excl <1yr	
Cause of Death	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**
AIDS	4.3	4.4	4.1	4.3	5.8	5.9	7.0	9.1
Pulmonary Tuberculosis	4.9	2.4	8.8	4.9	5.1	2.2	12.9	8.6
Pneumonia	11.0	13.6	5.8	3.9	15.1	19.8	8.5	7.2
Other Opportunistic Infections	6.1	7.0	3.9	4.6	8.2	9.5	5.9	8.5
ILL Defined Conditions	8.4	9.7	1.5	2.0	12.2	14.2	2.0	3.1
All other Known Causes	44.1	39.7	44.8	38.9	53.7	48.4	63.6	63.5
Non-Institutional Deaths	21.2	23.2	31.1	41.3	n/a	n/a	n/a	n/a

4.1. Model diagnostics

The diagnostic statistics for each of the Preston models shows that for Model 1 Adjusted R^2 ranges from 25% for AIDS to 94.2% for all known causes. In Model 2, the range for adjusted R^2 is from 16.5% for AIDS to 93.3% for all other known causes. In Model 1 the Adjusted R^2 ranges from 15.8% for TB to 90.5% for all other known causes. For Model 2, the Adjusted R^2 ranged from 23.3% for AIDS to about 85.9% for TB. The values of adjusted R^2 indicated the goodness of fit of the models. All the coefficients of all the two models were highly significant (p-value<0.01). The coefficients (slopes) of all the models added to 1, i.e. $\sum_{j=1}^{p} \beta_{1j} = 1$. Hence the model fit was adjusted in all cases.

Figure 6: Distribution of Standardized Mortality due to Pneumonia within age-groups

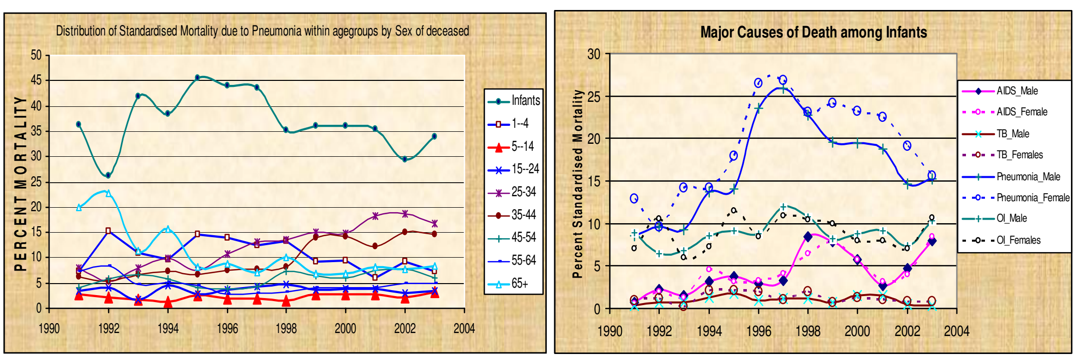


Figure 7: Contribution of AIDS to total and institutional mortality and contribution of institutional mortality to total mortality from 1991 to 2003.

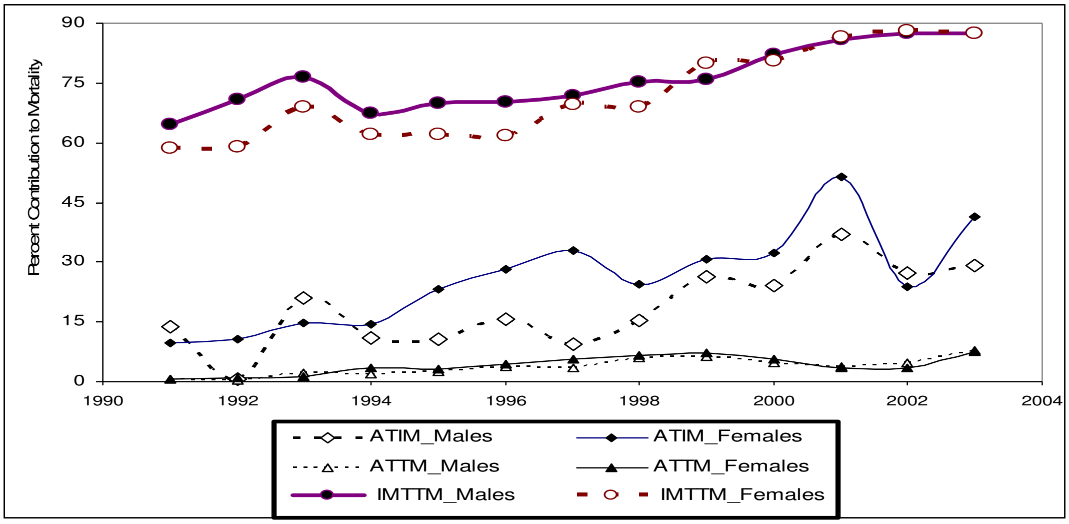


Figure 7 shows the trends in the contribution of AIDS to institutional mortality (ATIM), AIDS to total mortality (ATTM) and institutional mortality to total mortality (IMTTM) from 1991 to 2003. The contribution of institutional mortality to total mortality has been rising steadily from about 60% in 1991 to almost 90% by 2002. The contribution of AIDS to total mortality has remained fairly constant (under 10%). But the contribution of AIDS to institutional mortality has tended to increase as more deaths occur in the institutions. The relatively higher institutional deaths among males compared to females, is mainly due to the inclusion of neonatal and infant mortality, where many more males die than females. These finding are consistent with the Preston model results.

5. Conclusion

Most studies (NACA, 2005, 2006; BIAS II, NACA 2006) have identified population in the reproductive age group as the most afflicted cohort by HIV. This is confirmed by this study that most AIDS deaths are occurred not only in these groups but also among the infants (<1 year). The infant cohort accounts for most of the mortality due to pneumonia in all the years. This is surprising given that Botswana has adopted the Primary Health Care system that focuses primarily on infant and child health. The analysis reveals that AIDS accounts for about 4% of the total deaths among both males and females from all causes and about 6% among the intuitional deaths between 1991 and 2003. When the infants are excluded, AIDS accounts for 7% and 9% among the males and females respectively in the institutional death.

The analysis further suggests that Pneumonia was the leading cause of death among both males and females in both institutional and all causes of death. However, once the infants are excluded, pulmonary tuberculosis became the leading cause of death among males while AIDS became the leading cause among females in institutional deaths. Strong association between AIDS and Pneumonia and also between AIDS and TB were shown to exist. This implies that Pneumonia is more prevalent among infants under 1 year particularly females. This is consistent with results of other research studies on trends in causes of death due to AIDS and TB, Pneumonia and other OI's (ICD9). It has been observed that there is weak or no association between AIDS and Ill-Defined conditions. This is consistent with ICD9 a classification.

This work has some limitations and in particular of using secondary data. The data is available for the period 1991-2003. We believe one would observe a different trend in causes of death due to the introduction of ARV which was introduced in 2002. The second limitation concerns misclassification of the underlying causes of death. This is because the HIV test is not mandatory and someone who might have died from AIDS could be classified as having died from any of the opportunistic infections. And lastly the data has some category of persons whose age was not stated. Aa a result the distribution of deaths among the group is not known.

References

[1] Botswana Millennium Development Goals, Status Report, 2004.

[2] Busang, L., 2003. "Factor Affecting the control of AIDS in HIV-1C infected people in Botswana: A special study of those receiving national ART support", MA Dissertation, Department of Statistics, University of Botswana.

[3] Central Statistics Office, 1988. *Family Health Survey II*. Botswana

[4] Central Statistics Office, 1994-2000. *Health Statistics Report*. Botswana..

[5] Conti S., G. Farchi, and S. Prati, 1994), "AIDS as a leading cause of death among young adults in Italy", *European Journal of Epidemiology 10*. pp. 669-673.

[6] Datta, K., 1989. "Mortality Differentials in Botswana and factors accounting for these differences". *Unpublished report*

[7] De Cock, K. M., M.G. Fowler, E. Mercier, I. de Vincenzi, J. Saba, E. Hoff, D.J. Alnwick, M. Rogers, and N. Shaffer, 2000. "Prevention of mother-to-child HIV transmission in resource-poor countries: translating research into policy and practice", Journal *of American Medical Association*, 283, pp. 1175-82.

[8] Dublin, L.I., and G.H. Van Buren, 1924. "Contributory Causes of Death: Their Importance and Suggestions for Their Classification", *American Journal of Public Health, 14.*

[9] Hope, K. R., 2001. "Population Mobility and Multi-Partner Sex in Botswana: Implications for the Spread of HIV/AIDS". *African Journal of Reproductive Health / La Revue Africaine de la Santé Reproductive,* 5**,** pp. 73-83.

[10] Kebaabetswe, P., S. Lockman, S. Mogwe, R. Mandevu, I. Thior, M. Essex, R.L. Shapiro, 2003. "Male circumcision: an acceptable strategy for HIV prevention in Botswana". *Sexually Transmitted Infections*, 79, pp 214–219.

[11] Majelantle A. N. 1991. "Gender differentials in morbidity and Mortality in Botswana". *(C.S.O/Unpublished*).

[12] Manton K.G. and E. Stallard, 1984. "Recent Trends in Mortality Analysis", *Academy Press.*

[13] Ministry of Health, 1985. "The national Tuberculosis Programme". *Botswana Epidemiological Bulletin,* 6 (4).

[14] Momodou, J. 2004. "Adult mortality in Sub Saharan Africa: Evidence from Demographic and Health Surveys". *Demography 41 (4),* pp757-772.

[15] Murray, J. L., and A.J. Salomon, 2002. "The Epidemiologic Transition Revisited: Compositional Models for Causes of Death by Age and Sex". *Population and Development Review*, 28(2), pp 205-228

[16] NACA, 2004. "The Botswana AIDS Impact Survey II (BAIS I)", *Report* Gaborone.

[17] NACA, 2005. "Botswana Second Generation HIV/AIDS", *Surveillance Report*

[18] Nam C. B. 1990. "Mortality Differentials from a Multiple-Cause-of Death Perspective". *Clariton Press*, Oxford.

[19] Preston S.H. 1976. "Mortality Patterns in National Populations. With special reference to recorded causes of death". *Academic Press.*

[20] Seloilwe, E., A. Jack, K. Letshabo, K. Bainame, D. Veskov, M. Mokoto, M. Kobue, and R. Muzila, 2001. "HIVI AIDS at the University of Botswana: behavioral and prevention issues". *Botswana Journal of African Studies*, 15 (2), pp 204-210.

[21] Thior, I., L. Gabaitiri, J. Grimes, R. Shapiro, S. Lockman, P. Kebaabetswe, E. Garmey, S. Kim, M. Montano, T. Peter, S. Chang, R. Marlink, M. Essex, 2007. "Voluntary Counseling and

Testing Among Post-Partum Women in Botswana". *Patient Education and Counseling,* 65(3), pp 296-302.

[22] Weiner, L., M. Bellous, G. McAvoy, and E. Cohen, 1955. "Uses of multiple causes in the classification of deaths from cardiovascular and renal disease". *American Journal of Public Heath,* 45, pp 492-501.

Appendix

Figure 8: AIDS Related Mortality for the under 15's

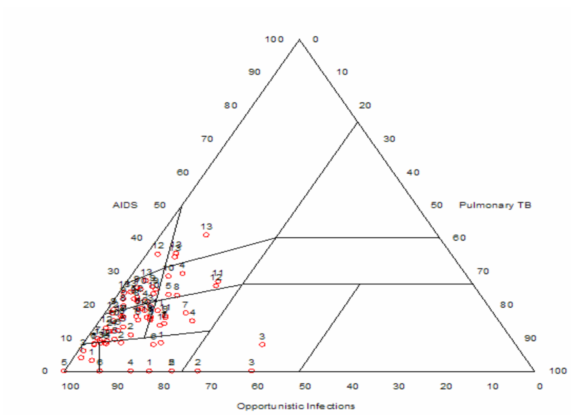


Figure 9: AIDS Related Mortality among 15-44 age groups

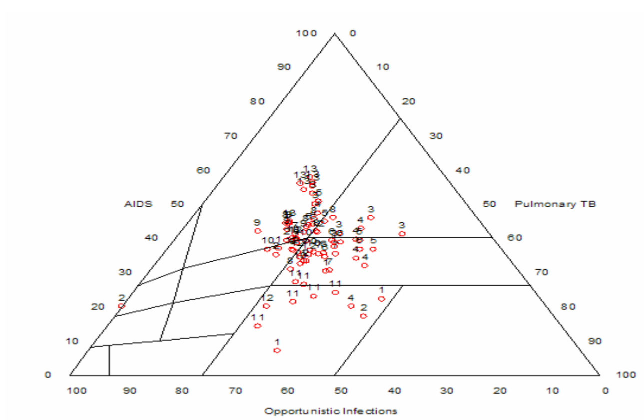


Figure 10: AIDS Related Mortality among 45 years and over