Introduction

The HIV/AIDS epidemic in South Africa continues to grow at a rapid rate. UNAIDS estimates that in 2000, 19.9 % of adults were infected, up from 12.9 % two years previously[1]. According to UN figures with an estimated total of 4.2 million infected (and some put the figure higher than this), South Africa is said to have more people living with HIV than any other country.

Reliable empirical data on the epidemic in South Africa are hard to come by. The main source of information is the series of annual antenatal seroprevalence surveys conducted by the Department of Health (DoH). These show that South Africa has experienced a very rapid spread of HIV during the last decade. In 1990, the first year of the survey, prevalence was less than 1% and by 2000 its level was nearly 25%[2]. This yearly survey, covering all the regions of the country, is conducted on a sample of the routine bloods taken from pregnant women who attend the public health sector for antenatal care. The majority of pregnant women (over 80%) make use of public antenatal care. This group of women makes an ideal sentinel group for monitoring the epidemic as they have recently had unprotected sex. In 1998 the protocol for this survey was revised to standardise procedures and sampling methodology across all the provinces. It was also changed to allow women to choose whether or not to be tested[3], however, it is thought that very few refuse. Not only does this change make it difficult to compare the figures of more recent years with earlier years, it also makes the recent data more difficult to interpret. Despite the observed anomalies in the provincial level results, this survey provides reasonably consistent data that form a foundation for surveillance of the epidemic.

Various projections of the demographic impact of HIV, based on the antenatal survey results, suggest that the disease will have a considerable impact on mortality in South Africa[4,5,6,7]. While the projections differ somewhat, they suggest that between 2000 and 2010, somewhere between four and seven million South Africans will die from AIDS[8]. This number of AIDS deaths will be considerably larger than that from any other single cause of death and will be almost double the number of deaths from all other causes combined over that period[8]. Model projections of the impact of HIV/AIDS have an important role to play in providing planning information. However, their accuracy depends on the many assumptions that are made in the model. Considering the magnitude of the epidemic, it is extremely important for South Africa to monitor AIDS mortality so as to provide reliable information for planning and to be able to assess the impact of interventions.

Routine mortality statistics are compiled by Statistics South Africa (Stats SA) from the vital registration system. The statistics are based on the medical certification of the cause of death, required by law, at the time of registration of the death with the Department of Home Affairs (DHA). However, the statistics are problematic, as death registration is known to have been incomplete and to suffer from misclassification of cause of death[9]. After 1994, the Government initiated extensive efforts to improve death registration and statistics[10]. These involved significant interdepartmental collaboration, the introduction of a new death certificate, dissemination of manuals on how to complete the death certificate and classify the cause of death, and the establishment of a task teams in each province to improve registration. Comparison with projections from the ASSA600 model (of the Actuarial Society of South Africa) suggest that the percentage of all deaths registered improved from a low of slightly more than 50% in 1990 to 78% in 1995 and over 80% in 1996.

Despite improved registration, delays continue to occur in the production of full cause of death statistics. The most recent detailed statistics are for 1996. Furthermore, cause of death statistics significantly underestimate the number of AIDS deaths. Due to the stigma associated with HIV and AIDS, details completed on the certificate tend to

focus on opportunistic infections or the mechanism of death rather than providing the underlying cause. Thus, the routine official death statistics fail to provide timely or accurate information on the extent of AIDS deaths and, at best, give under-estimated numbers some time later.

The Department of Home Affairs maintains the national population register on computer. It comprises administrative details of all persons who have been issued with a South African identity document. A unique identity (ID) number is allocated to each individual on the register. Death details are also included on the population register. This database provides information on the age and sex of dead individuals who were on the Population Register. Since many children are not registered, this data source does not provide adequate statistics on children.

This study investigates the trends in reported deaths up until 1996 based on the statistics from Stats SA and compares the results for adults with more recent data obtained from the population register. After adjusting for the under-reporting of deaths, the trend in the age pattern and the broad cause of death profiles are considered to assess the impact of HIV/AIDS on mortality in South Africa. The empirical data are compared with model estimates based on the ASSA600 AIDS and demographic model to assess the consistency of the empirical data with the model projections.

Data on Deaths

Data sources

Two reporting systems that provide data on deaths are considered here:

- **Firstly**, the routine cause of death data compiled and reported by Stats SA (formerly the Central Statistical Services) which have been published as official reports for many years[11] formed the main source of data. During the period covered in this technical report there have been two series of annual official mortality reports published: (03-09-01) which covered whites, colureds and Asians from 1985 onwards, and a separate series (03-10-01) which covered deaths of Africans. Beginning with the report covering 1991, the series (03-10-01) was discontinued and series (03-09-01) continued under the new title of "Recorded Deaths". The new series no longer reported the population group of the deceased. These reports are published approximately 4 to 5 years after the year covered. The most recent year for which full cause of death statistics have been released is 1996[12]. In an endeavour to speed up the publication of mortality data Stats SA now releases a series (P0309.1), the advance release of recorded deaths. These advance reports do not contain cause of death data. The source of data for the official published statistics is based on the detailed cause of death information recorded on the medical certificate required for death registration. Once the forms are fully processed and archived by the Department of Home Affairs, Stats SA codes the underlying cause of death information according to international standards. The official published statistics for a given year contain data for that year which are received *up to a particular cut-off date*. (This date varied from year to year). Thus the official report for a given year not only omits some late registrations for that year,

but also contains late registrations for previous years. In this technical report we describe the tabulation of deaths processed in this manner as by "year reported". At the same time that the official printed reports were released, an anonymised micro data computer file of the individual records used to produce the report was released to researchers. Unfortunately this data was available in computerised form only for a limited time before the government agency destroyed the tape. (This practice ceased after 1994). Nonetheless the MRC has collected and preserved a complete set of these tapes dating from 1968 onwards. The most recent one is for 1996. By extracting the deaths for a particular year from the tape for that year, and for succeeding years, it is possible to obtain the numbers of deaths which actually occurred in that particular year (given, of course, that the death was registered). The final year in any such series will however still be subject to under-reporting. The mortality data are analysed in this technical report on the basis of **deaths by year in which they occurred.** This differs from the year in which the deaths were reported, which is the method of reporting used in the official published statistics. The details of the total number of deaths reported in each year in the official reports and number that actually occurred in each year are shown in Appendix A, Table A1. The deaths for the years 1985-1996 are also analysed and tabulated in Table A2 by age and sex; as well as in Table A3 by age, sex and broad category of cause of death (including, external, non-communicable, infectious/maternal and ill-defined natural causes). This is the first time that data for this period has been published by "year of occurrence".

- **Secondly**, permission has been obtained from the Department of Home Affairs to analyse the data on deaths that are included on the Population Register. These data were extracted electronically from the monthly log of the transactions on the register†. The register does not include all the deaths registered in a particular year but only those of people who are on the population register (i.e. those that have an ID number). Data from this source have been obtained for the period June 1999 through to the end of September 2000 and have been supplemented by data from the same source that were previously analysed by Stats SA for the Department of Health (covering the period mid-1997 to mid-1998) and data collected by the Department of Health on a monthly basis (from mid-1998 to mid-1999). The data had to be cleaned to remove duplicates that arose when administrative alterations were made to a death record on the Population Register and to remove a few cases which were missing information. The data set includes the cause of death information captured by the Department of Home Affairs. This is generally the cause specified in the top line of the medical section of the certificate, the immediate cause, or else simply "natural" and "unnatural". The cause of death information in this data set is not standardised but it is possible to categorise most of the data into natural causes and the external causes. These data for the period 1997/98 to 1999/2000 are tabulated in Appendix A, Table A4. Full details of the data cleaning exercise are reported in Appendix B. The consolidated data have been divided into three sets of annual data, by period of occurrence, for analysis by age, sex and natural/external classification. Stats SA is about to issue a report (in series P0309.1) on the advanced release of mortality covering the years 1997 - 2000 based upon data derived from the population register of home affairs. However, these figures will differ from those given in Table A4 not least because they will not be adjusted for undercount but also because of a slightly different method of extraction and a different calendar year of reporting.

†. The data include a personal identifier and are treated as confidential. They are stored under secure conditions, behind a firewall and with protected access keys.

Data limitations

All the death data suffer from under-reporting. In particular, there has been considerable under-registration in the rural areas of the Republic of South Africa and the former so-called independent homelands of Transkei, Boputhatswana, Venda and Ciskei (TBVC) were not included in the reporting system until 1994. However, registration has improved since 1994, particularly since the introduction of the new death certificate in 1998. It is not clear what effect the efforts to improve registration of deaths and the centralisation of the processing of death records since 1994 has had on the patterns of under-reporting by age.

Mortality patterns

The results for the period 1988-1996 (which are derived from Stats SA cause-specific data sets) are shown in Figures 1.1 to 1.3. The distribution of the number of registered deaths by age has a distinct pattern which is a function of both the age-specific death rates and the age structure of the population. Infants (age 0) account for the highest number of deaths and the number per age group then drops to a very low level for children aged 5-14. In the case of women, the number of deaths in each age group increases in a concave pattern to a peak in the 65-79 age groups. In the case of men, the number of deaths among young adults increases rapidly with age, giving the increase over the age range a convex shape. The relative number of deaths of young men varies from year to year. In all years, adult deaths reach a peak at ages 65-69 but from 1995 the peak in young adults is almost as high.

The cause of death profile for the women is fairly consistent over the years. In the case of men, fluctuations appear that are related to the number of deaths from external causes. The number of young adult male deaths in 1992 is low in comparison to 1991 and 1993. When the data were examined by place of death, the number of external deaths registered in Durban in 1992 was substantially lower than that registered in 1991 and 1993. However, data from the Gale Street Mortuary show that the number of external deaths in Durban was stable during this period, if not higher in 1992[13]. Thus it would appear that a batch of death certificates originating in the Gale Street Mortuary was omitted from the vital statistics for 1992.

The deaths reported for 1996 are shown in Figure 1.3. Compared with 1995, there were more deaths reported for both men and women, but they are distributed similarly by age although the proportion of infant deaths was slightly lower. The men's deaths have a broader, flatter peak in adulthood while for women a slight peak is emerging at ages 25-34 in addition to the peak in old age.

The age distributions of adult deaths from the population register of the Department of Home Affairs (DHA) are shown in Figures 2.1 to 2.3. For the 12 month period, mid-August 1997 to mid-July 1998, the number of deaths of adults over 15 years of age is almost equal to the total number of deaths in 1996. The adult deaths display a very similar age pattern to that in 1996. The numbers of adult deaths in 1998/99 and 1999/2000 show annual increases in the numbers and a shifting age pattern. By 1999/2000, the peak in the young adults is higher than that in old age for men while the female distribution has a distinct bi-modal pattern, with equally high peaks in early adulthood and old age.

Figure 1.1: Cause of death by age and sex by year of occurrence 1988 , 1989 and 1990 (Stats SA data)

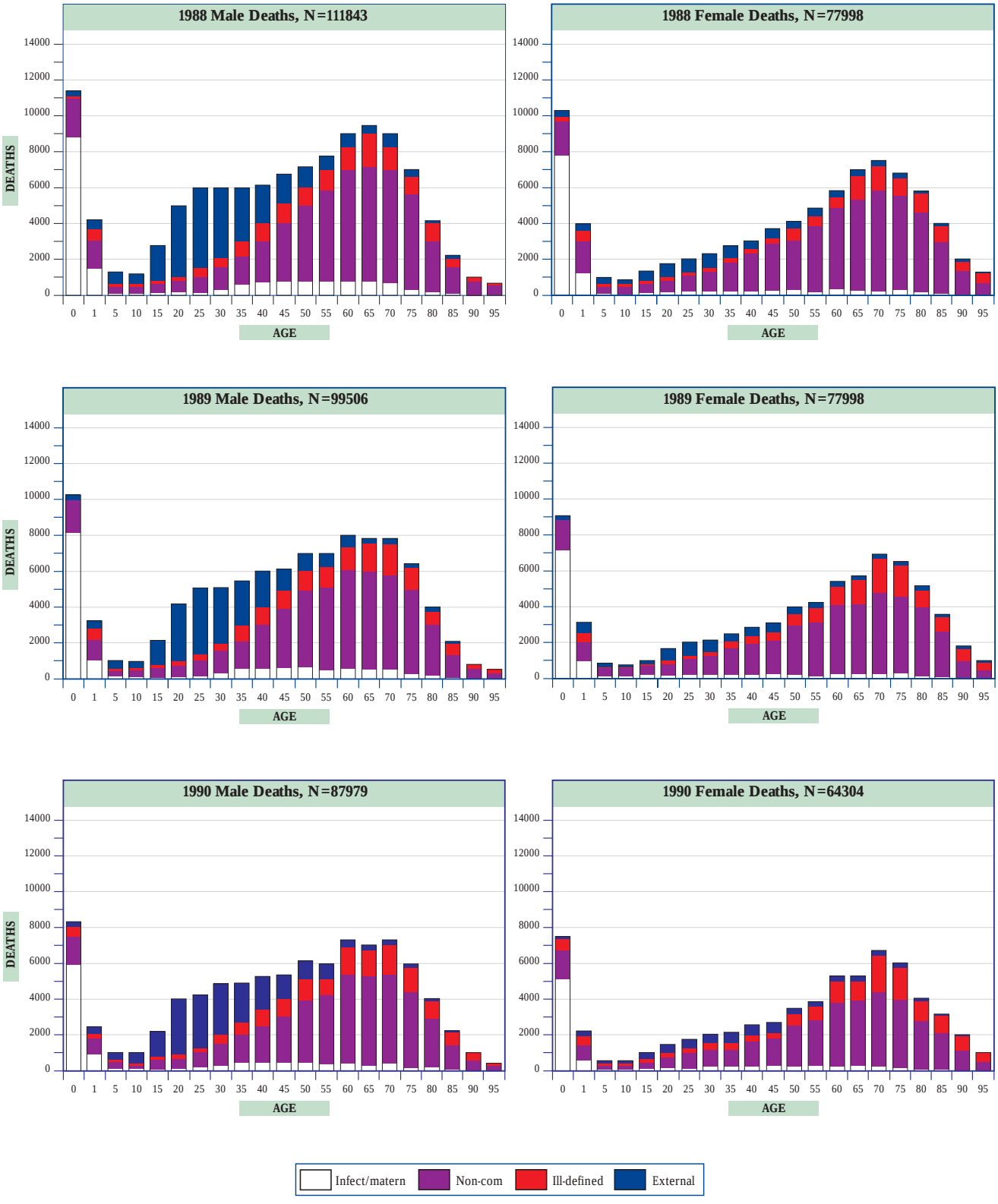


Figure 1.2: Cause of death by age and sex by year of occurrence 1991, 1992 and 1993 (Stats SA data)

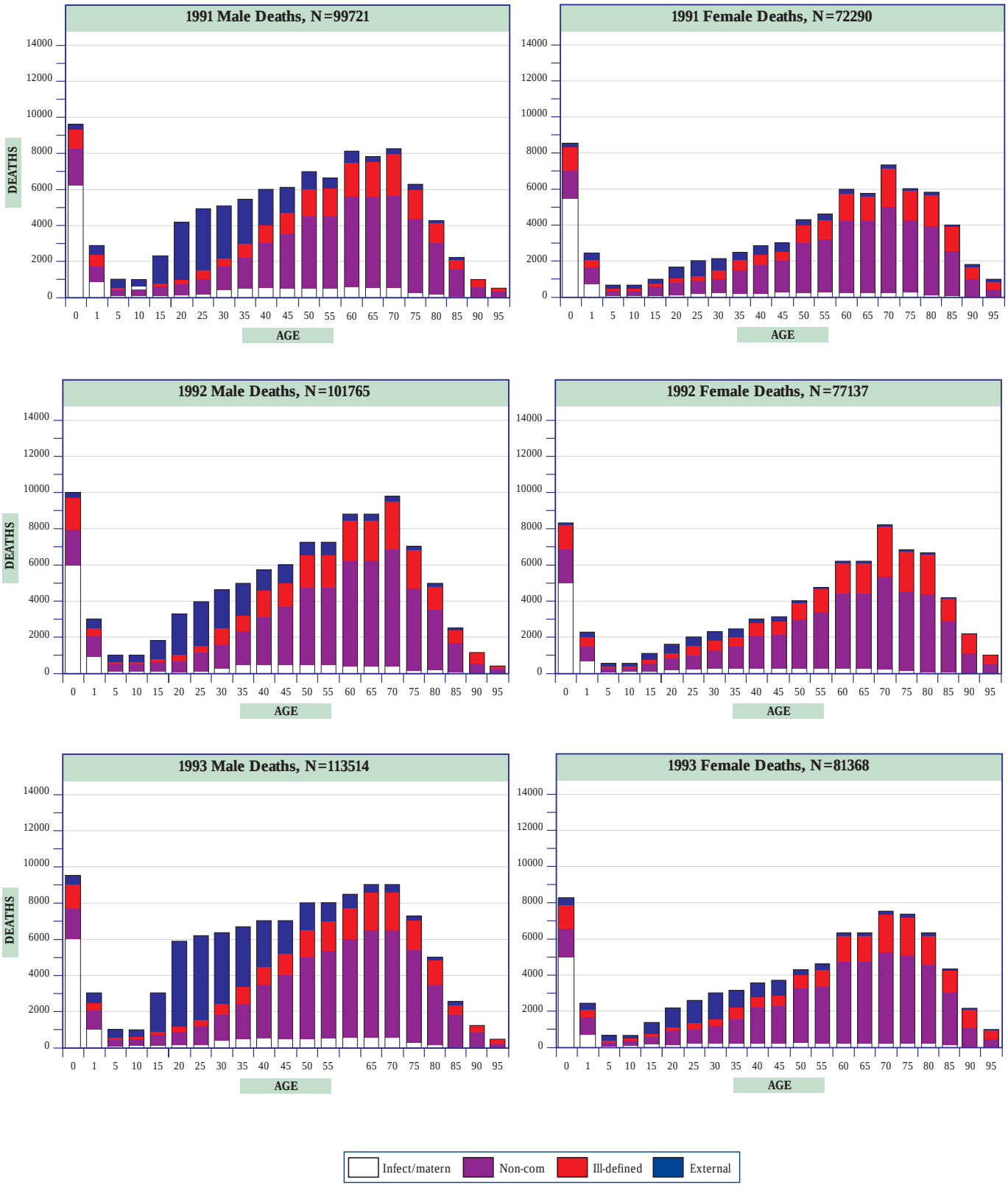


Figure 1.3: Cause of death by age and sex by year of occurrence 1994, 1995 and 1996 (Stats SA data)

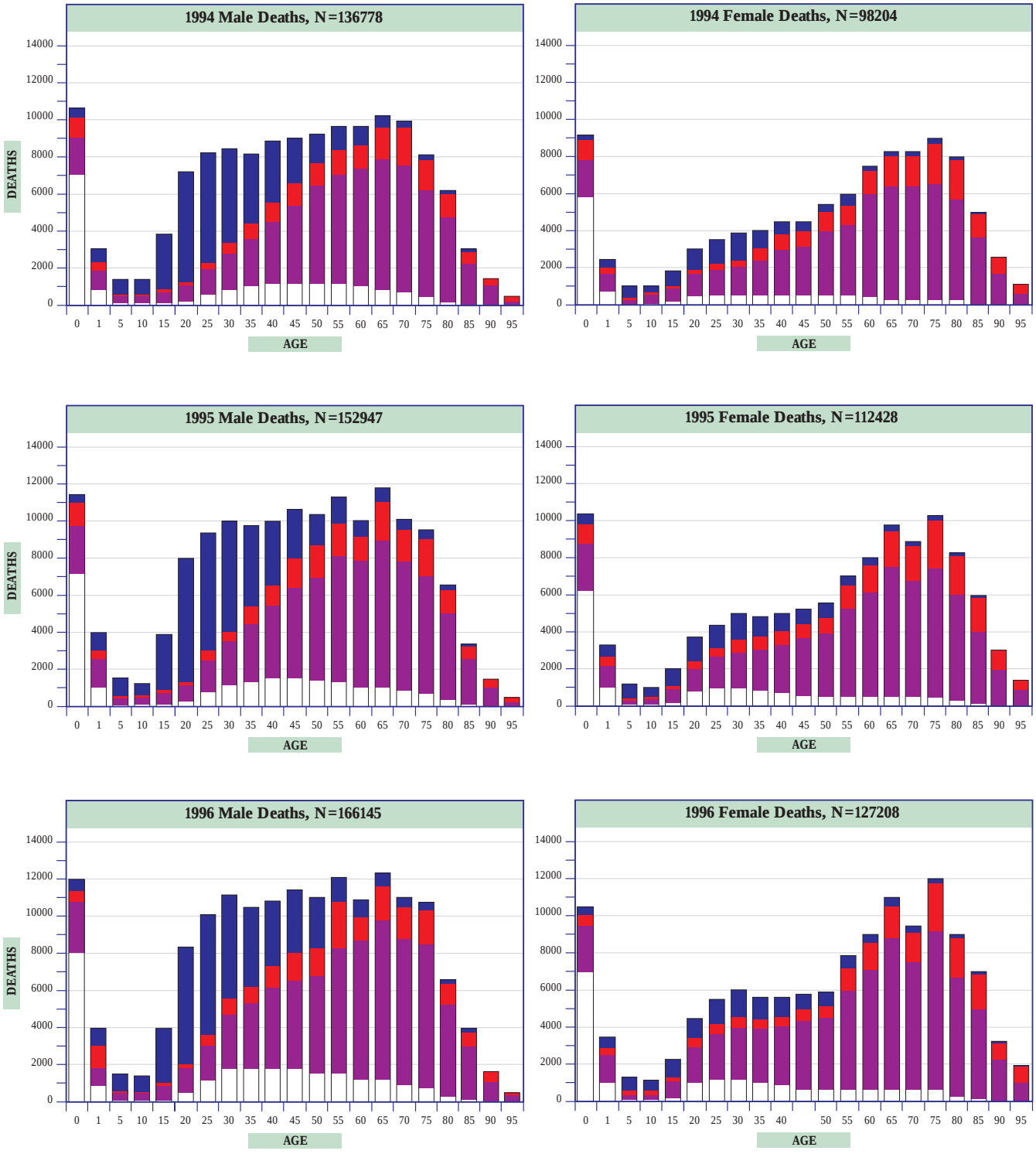


Figure 2.1: Adult deaths by age and sex by year of occurrence
August 1997 - July 1998 (DHA data)

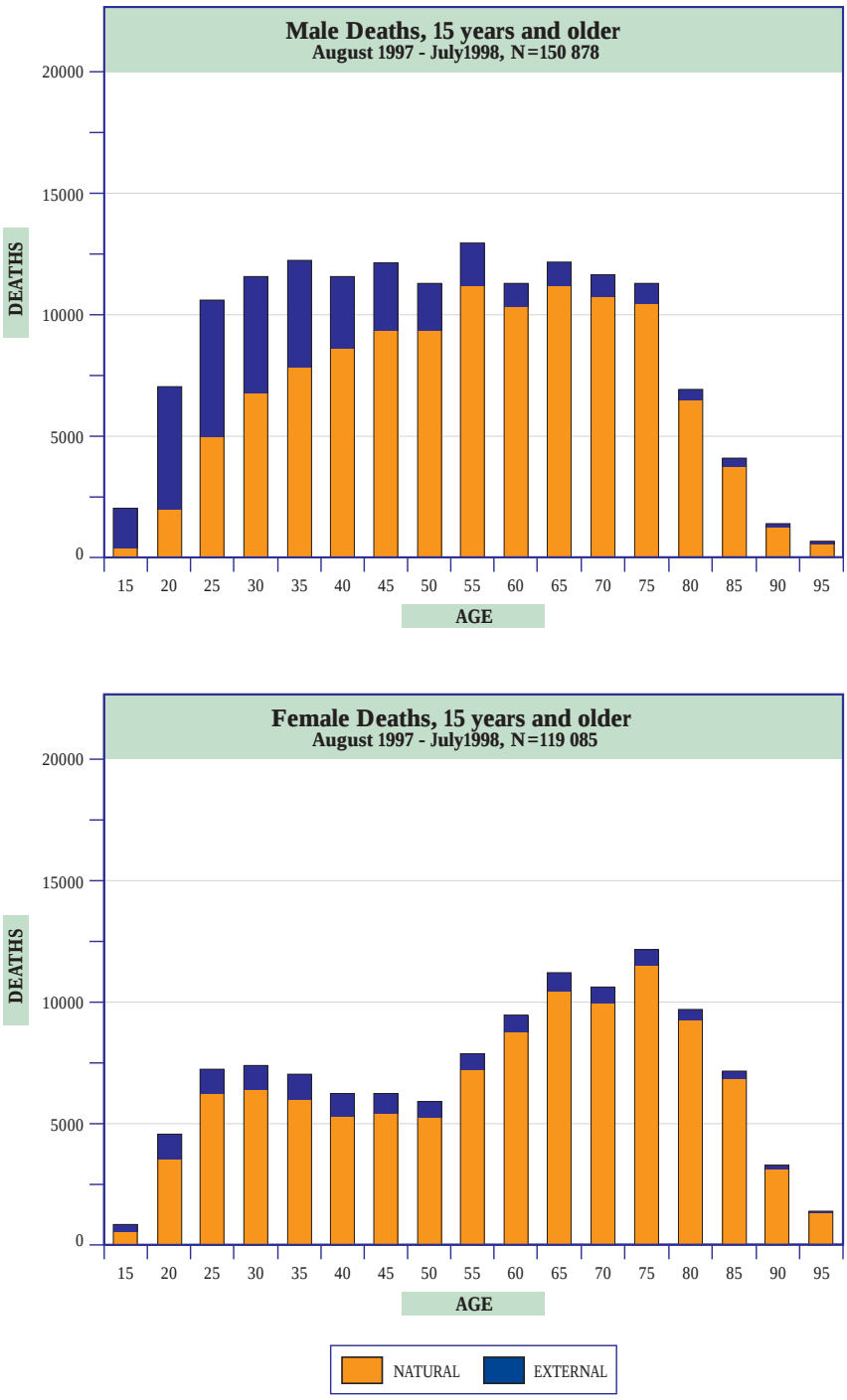


Figure 2.2: Adult deaths by age and sex by year of occurrence
July 1998 - June 1999 (DHA data)

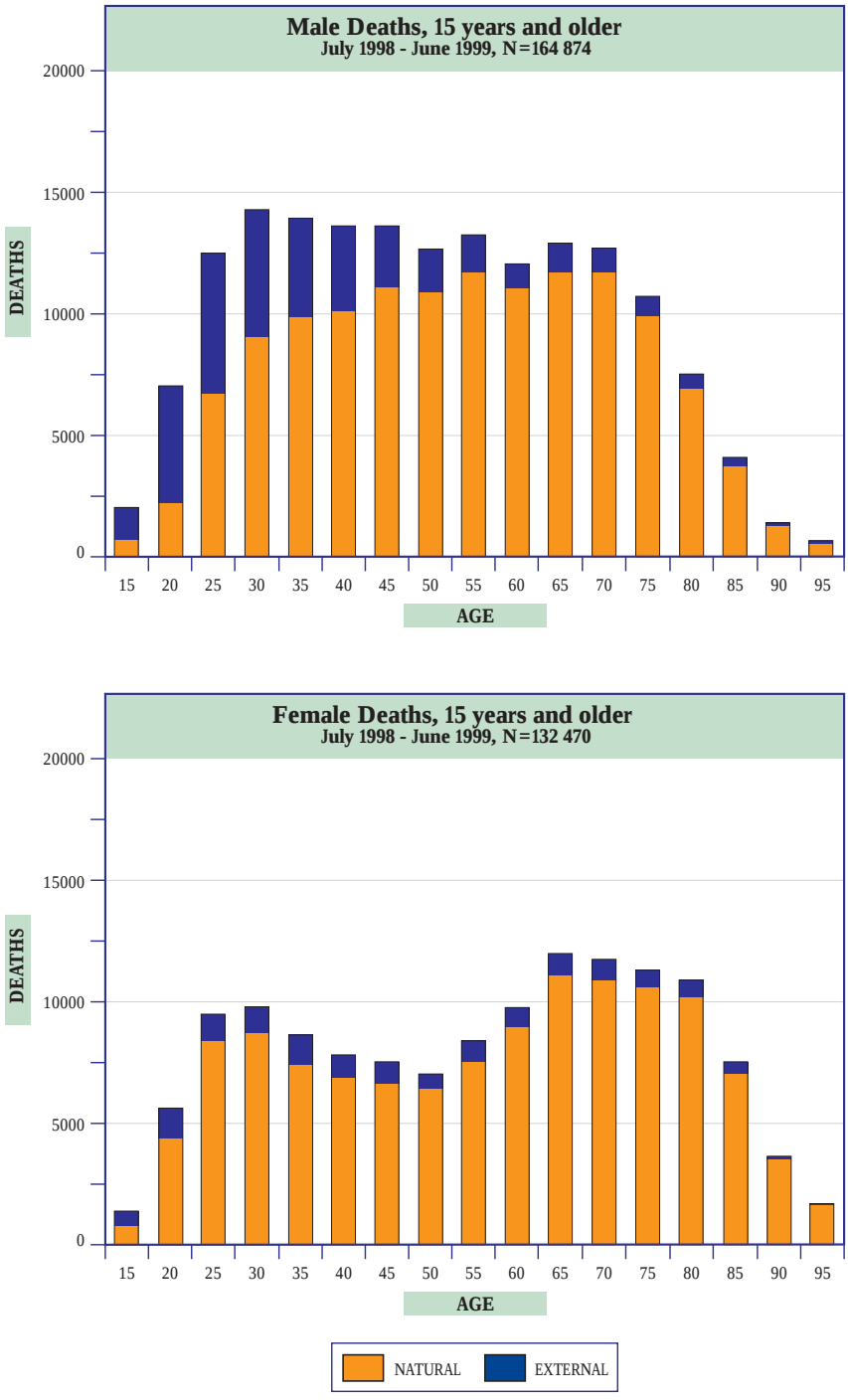
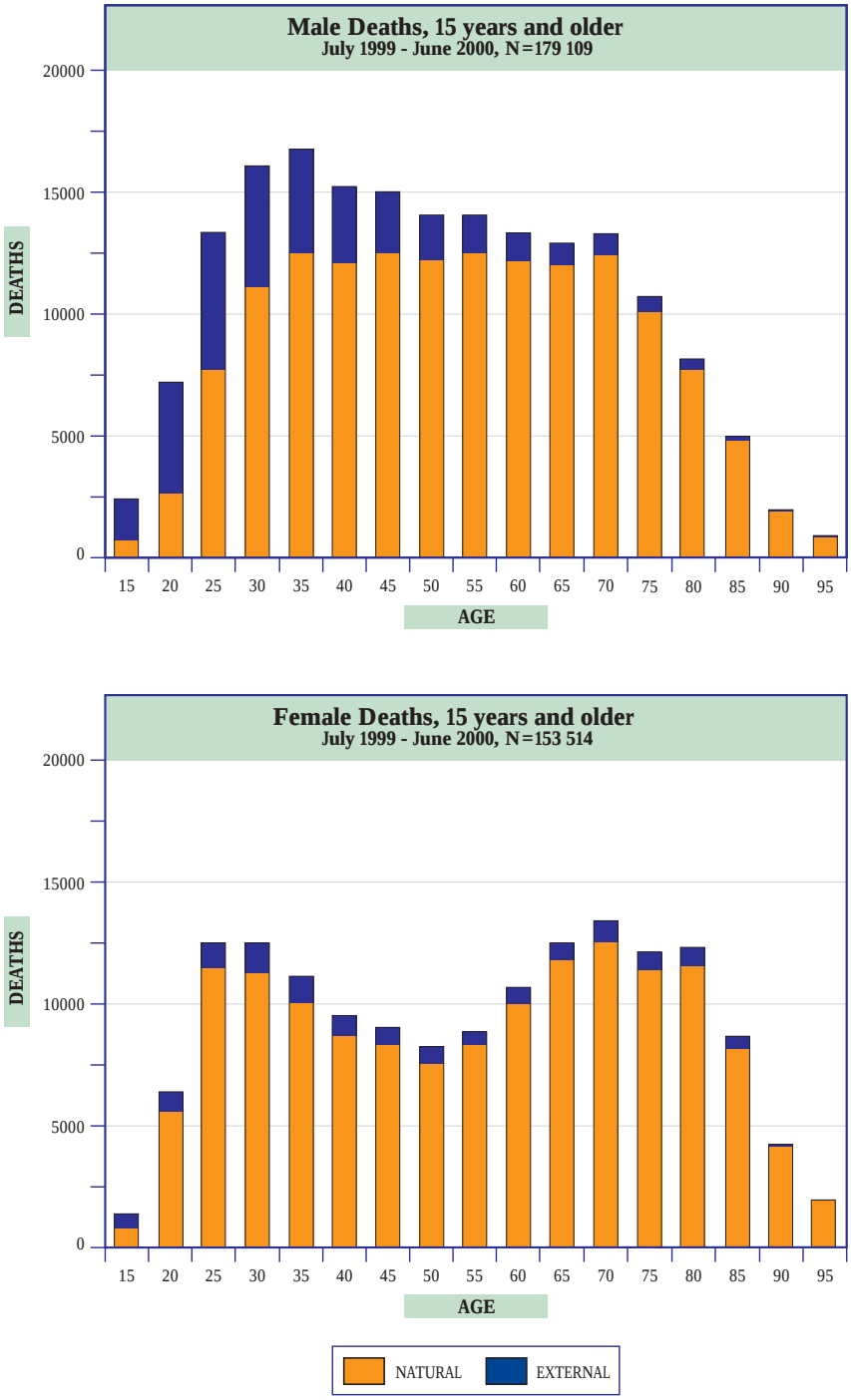


Figure 2.3: Adult deaths by age and sex by year of occurrence July 1999 - June 2000 (DHA data)



A simple summary index of the shift in mortality is the ratio of the sum of deaths aged 15-49 years to the sum of deaths aged 50 and over. The larger this ratio the more the deaths are skewed towards the young ages. This ratio was fairly level prior to 1990 but as can be seen from Table 1 it has been increasing since then and particularly rapidly in the most recent three years.

Table 1: Ratio of deaths aged 15 - 49 to deaths aged 50+ for reported deaths by year of occurrence and sex

Year	Ratio	
	Female	Male
1990	0.31	0.66
1993	0.37	0.73
1996	0.47	0.82
1997/98	0.57	0.88
1998/99	0.67	0.97
1999/00	0.78	1.00

Completeness of registration of deaths

Under-registration of deaths has long been known to be a problem in South Africa[9,16] and it is important to estimate the extent of under-reporting. Standard demographic techniques such as the Brass's Growth Balance method[14] or that developed by Bennett and Horiuchi[15] can be applied to the data for the years prior to 1990 because the deaths can be analysed separately for each population group. In particular, under-reporting can be assumed to be negligible in the non-black African groups and, importantly, to be constant over all adult ages for Africans. However, the fact that the age structures of the population groups differ and as a consequence the level of completeness of registration differs by age invalidates the assumption of constant under-reporting for all adult ages for the total population. An innovative approach[16] was developed for the analysis of the data for the period 1989-91 whereby the extent of distortion introduced by this heterogeneity could be estimated from the proportion of the total deaths that were in Africans in 1985. This was then used to estimate the extent of under-reporting by age for the black population group in this period. However, for the more recent years, the problem is complicated further by the fact that extrapolations from 1985 become less reliable and further distortions are introduced by AIDS deaths. For these years the completeness of death reporting and proportion of deaths that were in Africans in each age group were estimated iteratively for a range of assumptions about the completeness of reporting of deaths in adult Africans. We then determined which of these adjustments yielded complete reporting using the method proposed by Bennett and Horiuchi[17].

An additional complication is that the DHA do not computerise all deaths for which there is a death certificate. They only capture deaths of individuals on the Population Register, i.e., those for which an ID number or birth certificate exists. In order to allow for the deaths in persons with a certificate but no ID, the DHA data were scaled up by dividing by the proportion estimated to have IDs, estimated from an inspection of a sample of certificates. This correction has been incorporated in the data contained in Table A4 in Appendix A. Of course both of these adjustments assume that there is no bias in the under-registration.

In other words those not captured on the Population Register experience the same level of mortality as those registered. The impact of any selection bias on estimates of overall mortality is likely to be small as more than 90% of deaths registered at ages 15+ are of individuals on the register, suggesting that, even before their adjustment, the registration data cover more than 80% of all adult deaths

The estimated completeness of registration of adult deaths over the age of 15 for each year (relative to the population estimate from the ASSA model after first correcting the DHA data to allow for South Africans not on the Population Register) is shown in Table 2*. It can be seen that there has been a major improvement in coverage of death registration in the last few years, as a result of the national efforts of Government. It can also be seen that having adjusted for the improved registration, there has been a steady rise in the number of adult deaths during this last decade. Over this period while the population grew by about 37% the deaths have grown by some 73%!

Table 2: Number of deaths, completeness of registration and estimated number of deaths 15 years and older by year of occurrence

Year	Number of adult deaths registered	Estimated Completeness[17]	Estimated number of adult deaths
1989	141 876	60%	237 000
1990	129 256	54%	241 000
1991	145 587	59%	247 000
1992	152 485	61%	250 000
1993	168 489	57%	270 000
1994	205 266	73%	280 000
1995	231 932	79%	292 000
1996	258 220	85%	304 000
1997/98+	295 483	87%	339 000
1998/99+	326 761	87%	375 000
1999/2000+	366 790	89%	412 000

+ deaths from the Population Register, scaled up to allow for deaths reported but not on the Population Register

* These figures are approximations at this stage as the method is still being fine-tuned.