Estimating the level and trends of child mortality in South Africa, 1996-2006.

By

Timotheus Brian Darikwa

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Plagiarism Declaration

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Abstract

The lack of reliable data for child mortality estimation since 1998 has meant that child mortality rates for South Africa have not been updated for almost ten years now. It is the overall aim of this research to explore the possibility of determining up-to-date estimates of South Africa's infant mortality and under-five mortality rates from the 2007 Community Survey data and to use these results to describe the trend in child mortality rates since 1996.

Ward and Zaba's (2009) variant to Brass's technique is used after adjustment for the fact that prevalence has only been stable for the last few years to estimate the levels and trends of infant and under -five mortality rates between 2000 and 2004 using children ever born/children surviving data from the Community Survey. Blacker and Brass's (2005) variant of the previous birth technique is used to estimate the infant mortality rate circa 2006 from the survival status data of last child born reported in the 2007 Community Survey. Direct estimates using data on deaths in the previous year reported by households are used to estimate both the infant and under-five mortality rates circa 2006.

The 1996 estimates of child mortality are determined from past research. Reported household child death data in the 2001 census are used to estimate child mortality rates a year before the 2001 census. These estimates and those obtained from the 2007 Community Survey are used to determine the trend in the completeness of death registration by age between 1996 and 2006 by assuming a logistic trend. The completeness of death registration for infants, 1-4 year olds and children under-five in 2006 are estimated by comparing the national estimates of mortality rates estimated from the Community Survey to those produced directly from the number of reported deaths from the vital registration and estimates of the mid-year population and births in that year. Knowledge of the completeness of registration of deaths by age is then used to adjust the number of deaths from vital registration in each year between 1996 and 2006 and to determine the child mortality trends in the 10-year period.

Infant mortality rates are found to have been almost constantly around 50 deaths per 1000 live births while under-five mortality rates are found to have increased from just below 70 deaths per 1000 live births in 1996 to around 75 deaths per 1000 live births 2006. The completeness of death registration of infants improved markedly over the period from a low of 44 per cent in 1996 to almost 90 per cent in 2006. The increase was more rapid after 2001. The increase in the registration of deaths of children aged 1-4 years has not been as dramatic, with an increase from 43 per cent in 1996 to just 63 per cent in 2006.

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1 Introduction

1.1 Background

The absence of complete vital registration in South Africa means that national child mortality estimates have to be estimated using census and survey data. Indirect and direct techniques have been used in determining estimates of child mortality from these data. Direct estimation has been mainly from birth history data obtained from the Demographic and Health Surveys and reported deaths by households obtained from the 2001 census data while census and survey questions about the total numbers of births and numbers surviving are used to produce indirect estimates.

Mortality trends and future estimates for the country have been developed by independent groups such as the Actuarial Society of South Africa (ASSA), Inter-agency Group for child mortality Estimation (IGME), Murray, Laakso, Shibuya *et al* (2007) (MLSHA2007), Department of Health [South Africa], Medical Research Council and OrcMacro (2003) (SADHS1998) and Dorrington, Moultrie, Timaeus *et al* (2004) (DMTN2004). They each use different methods to produce child mortality estimates from different data sources for the country. ASSA has developed a population projection model which allows for the demographic impact of HIV/AIDS and produces complete life tables for each year, while IGME and MLSHA2007 use either Loess or Spline regression analysis. Dorrington, Moultrie, Timaeus *et al* (2004) adjusted the death rates obtained from the vital registration for completeness of death registration to estimate mortality trends for the country and provinces for the period 1986 to 1996. SADHS1998 estimates were calculated directly from birth history data obtained during the Demographic and Health Survey of 1998. The mortality rates for South Africa from these independent groups and by individuals such as Sadie (1993) and Udjo (1998) are quite varied. Figure 1.1 below illustrates this point by presenting under-five mortality rates just before 1996 by Sadie (1993), Udjo (1998) and estimates from the 1998 Demographic and Health Survey.

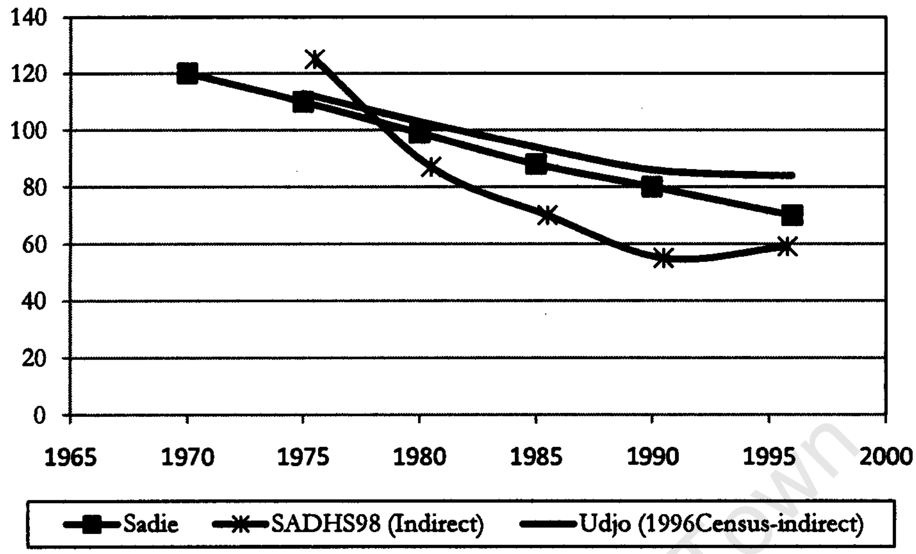

Figure 1.1 Various estimates of mortality rates from three sources for the period preceding 1996.

The purpose of this research is to estimate infant and under-five mortality rates from the 2007 Community Survey. It is the intention of this research to use these estimates, together with estimates of infant and child mortality from 1996 and the number of registered deaths by year to estimate the trend in infant and under-five mortality rates over the period 1996 to 2006. Adjustment of the number of deaths for underreporting can be used to estimate child mortality rates and child mortality trends over time in countries where there is incomplete vital registration (Hill and David, 1988) such as South Africa. It has been used in child mortality estimation in different countries with acceptable results. These countries include, among others, the Phillipines (Cabigon, 1996) and South Africa (Dorrington, Moultrie, Timaeus *et al.*, 2004).

1.2 Objectives of the research

This section lists the overall and specific objectives of this research.

1.2.1 Overall objective of the research

The overall objective of the research is to determine an up-to-date estimate of South Africa's infant mortality rate and under-five mortality rate from the 2007 Community Survey data. Subordinate to this primary objective is the underling aim to use these results to describe the trend in child mortality rates between 1996 and 2006.

1.2.2 Specific objectives of the research

1. To determine child mortality estimates for the year 2006 and as many estimates as possible between 1996 and 2006 using the Community Survey data of 2007.
2. To use past research to determine an estimate of child mortality for the year 1996.
3. To use the estimates obtained above to determine the extent of underregistration of child deaths by year from 1996 to 2006.
4. To use this knowledge of the extent of completeness of death registration to adjust the number of deaths for underreporting and hence determine mortality trends over the years spanning 1996 to 2006.

1.3 Structure of the thesis

The thesis is structured as follows. Chapter 2 reviews the literature relevant to this research. Recent estimates and trends in South Africa's child mortality are reviewed and so is the usefulness of reported household deaths in South Africa for estimating mortality rates of children. The chapter also reviews various other methods of estimating child mortality.

Chapter 3 covers the method applied to achieve the objectives of this research. It starts by examining the type and the quality of data available for use in child mortality estimation. Next, the steps taken to assess the quality of the data are also outlined. The steps followed in applying the indirect and direct methods of child mortality estimation are also outlined. Descriptions of how the mortality levels and trends are calculated over the 10-year period are also discussed in detail in this chapter. Chapter 4 presents the detailed results and some analysis of those results. Finally, Chapter 5 reflects on the results obtained and deliberates on the conclusions that can be inferred from the research, limitations of the research and the scope for future research.

2 Literature Review

This chapter reviews the various estimates of recent child mortality in South Africa and the computational methods that are applied in the research.

2.1 Review of recent estimates of child mortality in South Africa

The history of child mortality in South Africa can be looked at in two periods: the pre-1996 period when data for child mortality estimation was hard to come by and the period from 1996 onwards when more national data were available through national censuses and demographic health surveys. There are still problems that need to be addressed in as far as the validity of estimates in child mortality is concerned as there are many researchers who have each produced mortality estimates for the same period of time.

One of the contributors to child mortality estimation using Brass's technique in South Africa was Chimere-Dan (1993) who used data from 1982 from a questionnaire based on the World Fertility Survey (see Van Tonder, 1985) to estimate South Africa's national infant and child mortality between 1968 and 1977 using Trussell's variant to Brass's method. The data for both married and non-married women was used in order to make the sample more representative of the true population for the country (Chimere-Dan, 1993). The results so obtained, according to Chimere-Dan (1993), did not agree with estimates from three other national reviews who used other different data sources, namely those by Sadie (1978), Rossouw and Hofmeyr ((1990) and van Tonder (1985)The results did not show any consistent trend during the period under review and are not consistent with the view that mortality should have been on the decline due to improved health care and services. The infant and child mortality rates for females were higher than for males in some instances such as the years ranging from 1973 to 1975. The author acknowledges the problem but does not investigate further. The reasons he cited for the problematic data are misreporting of mothers' ages and failure to recall accurately the number of births and deaths in the family especially by women at older ages. There were problems with the 1982 World Fertility Survey itself and for more information on the critical analysis of this research refer to Dorrington, Bradshaw and Wegner (1999).

A review of work between 1985 and 1990 by Dorrington, Bradshaw and Wegner (1999) revealed how varied the estimates were for the period and in most cases not reliable due to the inadequate data that were available. For instance, the estimates of the infant mortality rate ranged from 62 per 1000 to as high as 94-124 per 1000 for the period. Nannan, Bradshaw, Mazur *et al.* (1998) reviewed infant mortality rates and birth registration after 1990. The estimates then were mostly obtained from household surveys: 1993 and 1994 October household surveys (OHS) and the 1993 Poverty Survey by the Southern African Labour and Development Research Unit (SALDRU). The Brass method was used to estimate child mortality from these data. The estimates they reviewed at the time from secondary data showed that infant mortality ranged from 40 to 71 deaths per 1000 births while the estimates they got from the data using Brass's technique gave infant mortality rates of 11 to 81 per 1000 births. Estimates were found to be unrealistically low in the case of OHS data while estimates from the SALDRU data were too high for the mortality level of the time. The problem with the data then was that some parts of South Africa, for example TBVC homelands, were not sampled (Nannan, Bradshaw, Mazur *et al.*, 1998).

The trends and estimates of infant (SAIMR) and under-five (SAU5MR) mortality rates before and around 1996 are illustrated in Figure 2.1. The number of child mortality estimates is as varied as the number of researchers. The infant mortality rates for 1996 vary from as low as 45 from the SADHS98 direct estimate to as high as 56 for the SADHS98 indirect estimate, while the under-five mortality rate varies from as low as 59 from the SADHS98 direct estimate to as high as 84 from Udjo's indirect estimate from the 1996 census data (Udjo, 2005). What is common among these sets of estimates is the undeniable reality that mortality was falling in South Africa until around 1992-1993.

The pregnancy history data from the 1998 Demographic and Health Survey was used to estimate child mortality rates. Although the data on children ever born/children surviving data was also available it was decided to use estimates calculated directly from the pregnancy history data as these data are considered to give "the most robust estimates of child mortality" (Department of Health [South Africa], Medical Research Council and OrcMacro., 2003, p 100) in the absence of a complete vital registration. The estimated infant and under-five mortality rates from the pregnancy history data were 45 and 59 deaths per 1000 live births, respectively, while that from children ever born/children surviving method were 56 for infant mortality rate and 75 for under-five mortality rate. The indirect estimates were found to be consistent with other estimates obtained from surveys done by the Human Sciences Research Council (HSRC) centred on 1990 (Department of Health [South Africa], Medical Research Council and OrcMacro., 2003). Combining estimates from these surveys the results from the SADHS managed to show a clear downward trend in child mortality until around 1991 and a reversal in fortunes in the mid-1990s. The under-five mortality rate fell from about 90 deaths per 1000 births in 1978 to 54.8 deaths per 1000 births in 1991 before rising to 59.4 per 1000 births in 1996. On the other hand, the infant mortality rate fell from 60 per 1000 births in 1978 to the lowest ever infant mortality rate for South Africa of 39.2 per 1000 births in 1991 before increasing to 45.4 per 1000 births in 1996. This reversal in health gains over the years have been attributed to HIV/AIDS. The SADHS1998 results noted that about 75 percent of under-five mortality in South Africa occurs in infancy.

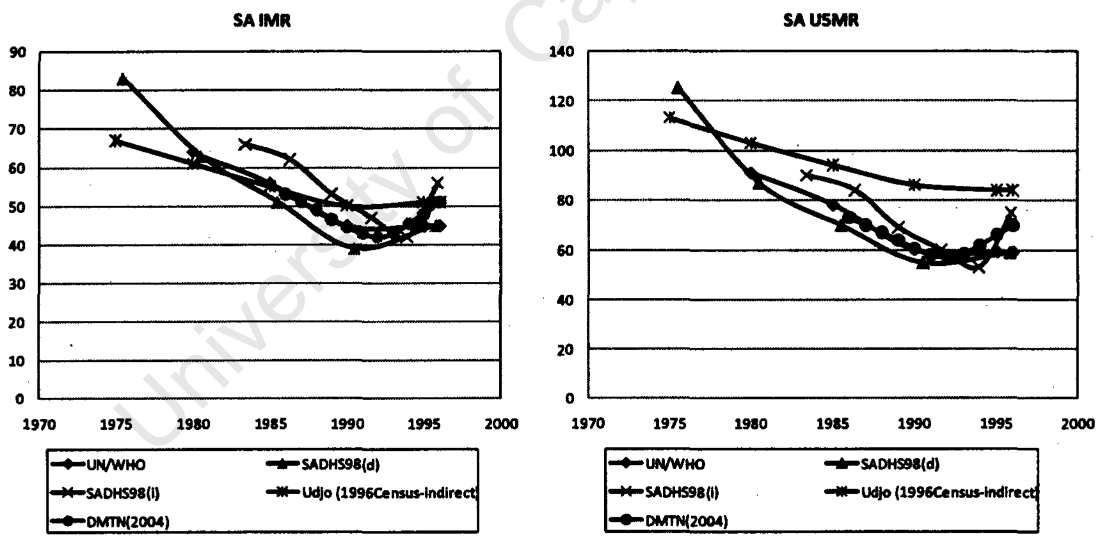

Figure 2.1 Child mortality estimates by author, organisation, or data source.

The other source of estimates for the period is the Inter-agency Group for child mortality Estimation (IGME) which was formed at the initiation of UNICEF, The World Health Organisation (WHO), The World Bank and The United Nations Population Division to try and harmonise the work by these organisations in formulating child mortality indicators. They compile country data which they deem to be as representative as possible of the prevailing child mortality levels at a given time and use these to derive mortality trends. They used the estimates from the Human Science Research Council centred on 1990, the 1998 South African Demographic and Health direct estimates from pregnancy history data and indirect estimates from children ever born/children surviving data. The infant mortality rates also made use of data from the vital registration system. They then fitted a weighted least squares (loess or spline, not specified) regression of the under-five and infant mortality rates over time. The weighting was done using prior knowledge of the quality of the data. The implied mortality trends for other child mortality indicators were derived using Coale and Demeny's West model life table as they found this to give the best fit to the direct estimate of the 1998 SADHS. Their final estimates, those for 1995-1996, are the same as those from the 1998 SADHS with an IMR of 45 and U5MR of 59 (UNICEF, WHO and UN, 2007). The trend in child mortality before 1996 is similar to that derived from the 1998 SADHS data.

Murray, Laakso, Shibuya *et al* (2007) applied Loess regression analysis to data from various databases. They then estimated past and future trends using their model. South African under-five mortality rate from their model is about 70 deaths per 1000 circa 2005. They estimated the mean annual decline in the under-five mortality rate for South Africa to be zero per cent. In other words they expect under-five mortality rate to remain constant around 70 between 1990 and 2015. They came to the conclusion that South Africa has a zero probability of achieving the millennium development goal number 4. This goal's aim is to reduce by two-thirds infant and under-five mortality rates of the level in 1990 by the year 2015.

The 1996 census collected children ever born/children surviving data that were used by Udjo (2005) in the estimation of infant and under-five mortality rates. Figure 2.1 shows that the implied mortality trends by Udjo's estimates were generally flatter than those by other authors. He used correction factors attributed to Fernandez (1985) to correct for the fact that the mortality rates of the children of women from the youngest age group tend to be higher than the general mortality level. The higher mortality rates of children of women in this group he attributed to, among other reasons, reporting of stillbirths as deaths of live births and possibly the impact of HIV/AIDS. His estimate of infant mortality rate was 50 per 1000 while the under-five mortality rate was 84 per 1000 for this age group and applies to the year 1996.

The ASSA2003 model, like the IGME, is based on a range of different estimates from various surveys. It projects the population on an annual basis from 1985 using an HIV/AIDS and demographic model. The model estimates infant mortality rate for 1996 as 52 per 1000 live births while the under-five mortality rate is 71 per 1000 (Dorrington, Johnson, Bradshaw *et al.*, 2006).

Dorrington, Moultrie, Timaeus *et al* (2004) estimated national and provincial child mortality rates from 1985 to 1996 using the 1996 census and the 1998 SADHS. The under-five mortality rate was shown to have decreased from 73 deaths per 1000 live births in 1986 to 57 per 1000 in 1992 and then increased to 70 per 1000 in 1996. According to Dorrington, Moultrie, Timaeus *et al* (2004), the Brass technique tends to overestimate under-five mortality rates because the South African population is characterized by unusually long birth intervals. The indirect estimates of child mortality were higher than estimates calculated directly from the 1998 DHS data. The difference between these was taken as a measure of the bias due to use of indirect techniques (Dorrington, Moultrie, Timaeus *et al.*, 2004).

The national and provincial completeness of registration of child deaths (C_C) was determined for 1996. The national completeness of registration of child deaths was also calculated for each year from 1986 to 1996. This was done by dividing the reported number of deaths by the expected number of deaths derived using the infant and under-five mortality rates generated by the Brass technique. The expected number of births was derived using age-specific fertility rates obtained by Feeney's variant to Brass's P/F ratio method and provincial forecasts done using the ASSA2000 model. The country's completeness of registration of child deaths, C_C , (as a percentage) for each year beginning with 1986 and ending with 1996 are 45, 43, 44, 39, 32, 38, 38, 34, 35, 37, and 39.

Estimates of child mortality rates from the 1996 census showed that mortality rates started to rise after 1992, after years of decline, for all population groups and in all provinces. The increase in mortality rates was more pronounced in low birth rate population groups. This was attributed to errors due to the use of the indirect method and selection bias. HIV may be the reason for the reversal in heath gains for the African population but not for other populations where the reversal could have been due to limited access to health care at the time of the demise of the apartheid regime. The official child mortality rates were deemed not to be credible as Statistics South Africa used level of completeness of adult death registration to produce their child mortality estimates (Dorrington, Moultrie, Timaeus *et al.*, 2004).

Nannan, Bradshaw, Timeaus *et al* (2000) used the Brass method to estimate child mortality from the 1996 census data and 1998 SADHS and compared the results. The mortality trends given by the two data sources are the same, both showing a reversal in the decline of child mortality around 1992. This is consistent with the trends obtained from the 1998 SADHS report. The level of child mortality from the census is higher than that from the SADHS. The difference is attributed to stillbirths, which were recorded in the census as dead live births which could be the source of this inflation in census.

Under-five mortality started increasing fast after 1995 due to a rapid increase in infant mortality rate at about the same time. Infant mortality has a bigger impact on the reversal in child mortality. This is not surprising given the observation in the DHS report that at least 75 per cent of under-five mortality occurs below age one year. The trend by population group from the census is such that there is an upturn in child mortality after 1992 which is more pronounced among Whites, Asians and Coloureds than Africans. While the same trend can be seen with the SADHS data, the trend for the Indian child mortality is not as smooth due to use of a small sample size from the DHS (Nannan, Bradshaw, Timeaus *et al.*, 2000). Nannan, Bradshaw, Timeaus *et al* (2000) also showed that there is a correlation between infant mortality and HIV prevalence and also with poverty as measured by households whose income is less than R600 per month. HIV is seen as accounting for 26 per cent of infant mortality, while both poverty and HIV account for 61 per cent of the infant mortality rates.

The ASSA2000 model, together with the SADHS data of 1998, the vital registration and the census data of 1996 was used to derive the burden of disease estimates for the country by Bradshaw, Grounewald, Laubscher *et al* (2003). A total of

106,000 of the total 556,585 deaths estimated using the ASSA2000 model were deaths of children (Bradshaw, Bourne and Nannan, 2003). The infant and under-five mortality rates obtained for the year 2000 were 59 and 95 deaths per 1000 births, respectively. They found out that about 40 per cent of the children were dying from HIV/AIDS.

The quality of the 2001 data was deemed not to be adequate enough to produce accurate estimates of child mortality by Dorrington, Moultrie and Timaeus (2004). Instead, the life tables they produced were "illustrative." The illustrative tables suggested that the infant mortality rate ranged from 47 to 53 per 1000 births while under-five mortality rates ranged from 67 to 75 deaths per 1000 births.

The SADHS of 1998 was followed by another demographic health survey in 2003. Child mortality estimates were calculated from the SADHS of 2003 for the three five-year periods prior to the survey as was done for the SADHS of 1998. The estimates from this survey were deemed too low and they were also inconsistent with data from the 1998 SADHS (Department of Health, Medical Research Council and OrcMacro, 2007).

Bourne et al (2009) used the vital registration data to analyse age-specific infant and child mortality in fine resolution in South Africa, for the purposes of examining the trend over the period 1997 to 2002 as well as distinguishing between non-HIV related mortality and HIV related mortality. The data on children under one month was not included in the analysis to avoid inclusion of stillbirths in the analysis. The total annual births for the country was assumed to be constant at 1.1 million between 1997 and 2002 as per the findings of Moultrie and Dorrington (2004).

Bourne et al (2009) used Poisson regression to model post-neonatal HIV related mortality counts for those below the age of one year. They plotted mortality counts by age at death in months over time. Their results showed that there was a peak in mortality centred between 2-3 months followed by a decline in mortality by age up to 11 months of age. Mortality counts per each age increases with time and so did the peak. This peak was found to be associated with HIV AIDS. It was not replicated in the non-HIV related data for the same period.

There has been health and demographic surveillance sites (DSS) in Mpumalanga and Kwazulu-Natal that has been used to make child mortality estimates for the rural areas. Garrib et al (2006) analysed data of a rural setting characterised by high HIV prevalence from Africa Centre Demographic Information System (ACDIS) in KwaZulu-Natal to determine child mortality for the period starting 1 January 2000 and ending 31 December 2002. Cause of death was determined using verbal autopsy. Poisson regression was used to identify significant variables associated with children's mortality. The infant mortality rate was found to be 59.6 deaths per 1000 live births while under-five mortality rate was found to be 97.1 for the mid-point of the period under study, which is mid-2001. Forty one per cent of the under-five mortality rate was attributed to HIV/AIDS. Sixty one per cent of under five mortality was found to be due to infant deaths. More boys (52 per cent) died than girls (48 per cent) did. The contribution of HIV to child mortality may have been understated since multi-cause analysis was not done. Abdool Karrim and Abdool Karim (2005) are cited by Garrib et al (2006) as estimating the HIV prevalence of women aged 20-24 attending the antenatal clinic in this area for the year 2001 as 50.8 per cent, which was an increase from 6.9 per cent in 1992.

There have been cases where the previous birth technique has been used to estimate infant mortality of a region. Buchmann, Croffon Briggs and McIntyre (1992) analysed a survey asking 2,388 women between 15 October 1988 and 31 October 1989 who visited Mosvold Hospital and its satellite clinics about the survival status of their last born child. The hospital is located in rural Kwazulu-Natal. Of the women asked, 1,795 of them had had a previous birth. The result was an infant mortality rate of 62 per 1000 births. Fifty one per cent of the children died at home and the study concluded that there was no significant difference in mortality between the children dying at home or those who were dying at the hospital/clinic. Comparisons showed that the rate was higher than the national estimate for blacks (54) and higher than estimates from other homelands with similar characteristics. Unfortunately, they did not give a reason as to why their rate was higher.

Rollins, Little, Mzolo (2007) also used the PBT to estimate child mortality in Kwazulu-Natal. Their work was part of an HIV/PMTCT surveillance programmes involving 3 peri-urban and 4 rural clinics that took place between August 2004 and July

2005. Mothers who brought 6 week-old children for immunisation were asked about the survival status of their previous birth within the last 20 years (excluding the current child who would obviously be alive at the time of the interview). The data for estimating child mortality was provided by 5,169 women out of the 9,334 women who visited the clinics for immunisation. The infant mortality rate was calculated as the proportion of children who die less than one year out of the total live births of children born at least a year before the survey while the under-five mortality rate would be the proportion of the children who die aged less than five years out of those born five years or more prior to the survey. They came to the conclusion that child mortality was on the rise in Kwazulu-Natal. Rollins, Little, Mzolo (2007) findings were that infant mortality rate fell from 52 before 1990 to 28 for the period 1990-1994 before rising to 49 for the period 1995-1999 culminating in an infant mortality rate of 92 for the period 2000-2005. A similar trend was observed with the under-five mortality rate. The upper limit of their confidence interval for the infant mortality for the 1995-1999 period had an estimate of 59.9 and that for their under-five was 80 which are close to the estimates by Dorrington, Johnson, Bradshaw *et al.*, (2006) for the year 2000 of 60 and 86, respectively. The problem with their estimates is the wide confidence intervals which may be due to the small sample size. Rollins, Little and Mzolo's estimates show the general pattern of mortality trends for the period which saw a decline in child mortality rates being reversed in the mid-1990.

2.2 The use of household death data in the estimation of child mortality in South Africa

Dorrington, Moultrie and Timaeus (2004) in their monograph in which they estimated mortality in South Africa from the 2001 census data also looked at the usefulness of reported household death in the estimation of mortality in South Africa. They noted that reported household death data have a poor record of accomplishment for estimating mortality and give as an example the Swaziland 1997 census where the data on household deaths were not reported on as the data were found not to be useful for estimating mortality. Researchers are cautioned by Dorrington, Moultrie and Timaeus (2004) against using these data to estimate directly current mortality levels since the methods have not been thoroughly tested in both the developing and developed countries. They advise researchers to use these data in combination with estimates from other data sources, especially the vital registration system, to identify consistencies. Should there be consistency the data can then be used in conjunction with the estimate from the other data source to come up with the level of mortality and the patterns of mortality.

The household child death data for the 2001 census had significant imputations for the variables 'month of death' (3.1 per cent edited), 'year of death' (6.0 per cent edited) and 'age at death' (7.8 per cent edited) while editing of the sex of the deceased was less than 2 per cent of the cases thus not significant (Dorrington, Moultrie and Timaeus, 2004). Dorrington, Moultrie and Timaeus (2004) looked at the distribution of editing procedures by, among others, population groups, provinces and age, to ascertain the effect of editing on the quality of the data. They found differences between the imputed data and the non-imputed data but these differences were not significant enough to affect the overall quality of the data. Dorrington, Moultrie and Timaeus (2004), while noting that the levels of editing of household deaths data depends on the province, made the assumption that the there was no difference in every respect between the edited data and the data with no imputation. This is because the edit rules were found to have little impact on the quality of the household death data. The child deaths reported by households were then used in combination with other data sources to produce illustrative life tables that gave estimates of both child and adult mortality for the period just before the 2001 census.

2.3 Methods of estimating child mortality

The incompleteness in the vital registrations of the countries of the developing world such as South Africa has meant that calculating vital rates directly will give unreliable estimates. Consequently alternative methods were developed to estimate the demographic rates (Coale, 1966 ; Brass, Coale, Demeny *et al.*, 1968 ; Coale, Kirk, Hauser *et al.*, 1971 ; Sullivan, 1972 ; Trussell, 1975 ; Palloni, 1979 ; Feeney, 1980). Two such methods, albeit modified, will be used to estimate child mortality in this research. These are the Brass children surviving/children ever born method and the previous birth method. This section reviews these indirect methods which make use of the data from the 2007 Community Survey to estimate infant and under five mortality rates as well as the method of making use of deaths reported by households to estimate mortality directly.

2.3.1 Review of the Previous Birth Technique (PBT)

The previous birth technique (PBT) was first suggested by Brass and Macrae in 1984 (Hill and Aguirre, 1990 ; Hill, 1991). The method was originally used to calculate the probability of dying between birth and age two (Hill and Aguirre, 1990 ; Hill, 1991), $q(2)$, using information obtained from women giving birth at maternity hospitals or clinics who had had a birth before. The women are asked if the baby from the previous birth was still alive or dead. While this method has the advantage of being cheap and easy with respect to data collection and analysis, it has the problem of selection bias because only women who have access to health facilities and are pregnant provide information. In developing countries like South Africa, these are likely to be urban and well-to-do women whose children are at a lower risk of dying than rural women who might not afford such facilities or live in areas remote and far removed from health institutes. In addition, the mortality of first time births is not recorded. Consequently, child mortality is likely to be underestimated. The method assumes a mean birth interval of 2.5 years (30 months) for a given population but it has been shown that this is not always the case and can vary from country to country, region to region within a country as was in Bangladesh where $q(3)$ had to be estimated instead of $q(2)$ (Bairagi, Shuaib and Hill, 1997) because of birth intervals of almost 40 months. However, $q(2)$ can be calculated from $q(3)$ as it is about 90 per cent of $q(3)$ (Hill and Aguirre, 1990). If we have many conversions in the approximation of child mortality we might be compounding errors in mortality estimates.

Generally if a country's median birth interval is less than 30 months $q(2)$ is underestimated and on the other hand, when a country's median birth interval is greater than 30 months $q(2)$ is overestimated (Hill and Aguirre, 1990). South Africa's population is characterised by long median birth intervals of about 59 months by 1998 (Moultrie and Timaeus, 2002) and thus this method will overestimate mortality for South Africa. In such instances the extent the magnitude of the bias due to deviation of birth intervals from 30 months is estimated by linear interpolation on the logits of a model life table (For more details see, Hill and Aguirre, 1990). According to the findings by Hill and Aguirre (1990) the extent of bias is negligibly small and only in some countries in Latin America and the Middle East where birth intervals are 24 months would an adjustment be worthwhile.

According to Hill (1991) David, Bisharat and Hill (1990) first suggested the use of this method in household surveys in 1990. The method only requires that the Community Survey or a census ask women aged 12 to 50 years the following simple questions: When was (the person's) the last child born, even if the child died soon after birth? Is (the person's) last born child still alive? The proportion dead among children born in the last 12 months was used to approximate the infant mortality rate. This has the advantage of minimising the bias due to selection and giving a current estimate of the infant mortality rate, but there are also problems inherent in this method. Blacker and Brass (2005) cite Blacker (1984) and Chackiel and Gough (1989) as pointing out that the application of this method has given unacceptable results more often than not. This is mainly because of age heaping at age 12 months and non-responses to the date of last birth questions.

Thus Blacker and Brass (2005) refined the method by determining the infant mortality rate from the proportion dead among children born in the last 24 months. They assumed that the life-table survivors $l(x)$ in infancy and childhood is given by $l(x) = (1 + \alpha x)^{-\beta}$ where x is the age in years or months , α is a constant representing the pattern of death rates and β is a constant representing the level of death rates. Using the fact that D,the proportion dead among children born in the last 24 months is given by $D = 1 - \frac{1}{2}\int_0^2 l(x)dx$ and that the infant mortality rate $q(1) = 1 - (1 + \alpha)^{-\beta}$, an adjustment factor (multiplier), $q(1)/D$, required to convert the proportion dead of births in the last 24 months, D, into infant mortality rate , $q(1)$, can be determined if α and β are known. Blacker and Brass (2005) determined this by way of simulation. The correction factors ranged from 1.04 to 1.1 and with an average value of 1.092, in general, and ranged from 1.087 to 1.097 with median value of 1.092 for Africa, in particular. They give selection guidelines on which factors to use. The adjustment factor for South Africa was found to be 1.0909 (Blacker and Brass, 2005). This adjustment factor for "South Africa" is actually that of the Agincourt Demographic Surveillance Site and thus for the women of Agincourt. The assumption by Blacker and Brass (2005), and also in this thesis, is that this adjustment factor is applicable to all women in South Africa.

Any errors due to an incorrect choice of the correction factor should not be any worse than the response errors and are "trivial" (Blacker and Brass, 2005, p.32). The estimates of infant mortality rates produced using this method were found to be robust to changes in the age pattern of mortality, α, and the level of mortality, β. This method has the advantage of being robust even for countries with high HIV prevalence since according to Blacker and Brass (2005) Artzrouni and Zaba (2003)showed that the selective bias due to HIV is small for the children born within one or two years of the survey while the problem increases with an increase in age. Thus, this method can be used in South Africa where HIV prevalence is high. Calculating IMR from the proportion dead among those born in the last 24 months not only deals with the problem of age heaping at age 12 months, but also reduces sampling errors because of a bigger sample size of children. Very few mothers would have had more than one birth in this period thus minimising the bias due to under-representation of such children.

2.3.2 Children ever born / Children surviving method with adjustment for HIV/AIDS

The children ever born/children surviving technique was developed by Brass and has evolved with each new refinement over the years (United Nations, 1983). This technique requires information on the number of women and the number of children ever born to women aged 15-49 years, by age of mother in five-year age groups (numbered 1 to 7), and the number of those children born to women in each age group who survived to the time of the survey and provide the information. If we denote the total number of women in age group i by $W(i)$, the number of children ever born to the women in age group i by $CEB(i)$ and those children who died by $CD(i)$ then the proportion of children dead, $D(i)$ is given by:

$$D(i) = \frac{CD(i)}{CEB(i)}$$

Brass (Brass, Coale, Demeny *et al.*, 1968) notes that the proportion dead of the children born to a women in a given age group is a good indicator of the level of child mortality in the population. In particular the proportion in the first age group approximates $q(1)$, in the second age group $q(2)$, the third $q(3)$, the forth $q(5)$, the fifth

$q(10)$, etc, quinquennially after that. The question was how to adjust for non-mortality factors in-order to convert the proportion dead into probabilities of dying between birth and before reaching certain ages. This is achieved by multiplying the proportion dead by correction factors, sometimes referred to as multipliers, so that the equation to calculate the probability proportion dead before a certain age, say z, is given by

$$q(z) = k(i) * D(i),$$

where $q(z)$ is the probability of dying before reaching age z and $k(i)$ is the correction factor corresponding to women in age group i. The correction factors or multipliers are a function of the fertility patterns of the population and are calculated from average parities of consecutive age groups, $\frac{P(i)}{P(i+1)}$, where $P(i)$ is the average parity of women in age group i. The correction factors have been refined over the years by demographers like Sullivan(1972) and Trussell (1975). The Trussell variant is described by Palloni as the "most successful model" (1979, p.456) and these correction factors have been found to be superior to both Sullivan's and Brass's correction factors (Adegbola, 1977). This is because Trussell's correction factors make use of parities for the women aged 15-19(P1), 20-24(P2) and 25-29(P3), which cover a wider segment of the fertility experiences of the population when compared to Brass's and Sullivan's methods. Trussell's fertility schedules also include early fertility experiences for women 12 to 18 years, which according to Adegbola (1977), was "underrepresented" in Sullivan's method. This is important for Africa since the majority of the continent's women experiences birth at an early age (Adegbola, 1977).

The correction factor for the Trussell variant of the Brass technique is given by:

$$k(i) = a(i) + b(i)\frac{P(1)}{P(2)} + c(i)\frac{P(2)}{P(3)}$$

where $a(i), b(i)$ and $c(i)$ are coefficients derived for each of Coale-Demeny model life tables by Trussell (1975) using simulation and regression on the average parities. This way of determining child mortality assumes that the population's fertility patterns have been constant over a period of 15 to 20 years before the survey and that the age pattern of mortality from the model life table chosen is the same as the age pattern mortality of the population. The risk of the child dying is assumed to be independent of the mother's age. It is also assumed that the children ever born to women by their age groups are equally reported at the time of the survey.

The child mortality rates as determined by the Brass method do not provide the mortality rates at the time of the survey, but estimates mortality rates in the recent past. Coale and Trussell in 1977 determined the reference time period to which the calculated mortality rates refer by assuming a linear change in mortality in the recent past (Hill, 1991). The time reference period to which $q(z)$ refers to is given by:

$$t(z) = a(i) + b(i)\frac{P(1)}{P(2)} + c(i)\frac{P(2)}{P(3)}$$

where $a(i), b(i)$ and $c(i)$ are given coefficients for each of Coale-Demeny model life tables as determined by simulation and regression on the average parities as was done for multipliers. Thus one can use this method together with model life tables to determine mortality levels and trends over time. Mortality rates and trends can be determined using the Brass technique for a period of about ten years prior to the census or survey relatively well (Hill, 1991).

The Brass technique has the advantage of not requiring women to recall exact date of death of their children and very little information is required to apply it. This method, which uses data of births and deaths of children over many years, is not as prone to sampling errors as with methods that make use of data over one year period. It is not possible to estimate accurately child mortality rates within three years of the survey date (Hill, 1991) because the young mothers (15-19 years), whose children's mortality rates would give close to current child mortality rates, are mostly first time mothers and tend to have the highest risk of losing a child resulting in overestimation of current mortality rates (Ewbank, 1982). Furthermore, the estimate of infant mortality determined from young women is prone to sampling errors because they still have few births. The method is also limited in that any deviations in fertility levels and patterns from the age patterns of fertility as implied by the data will result in biases in mortality estimation. South Africa's level of fertility has been on a slow but constant decline in the recent past and thus the assumption of constant fertility is violated. The impact of the change in fertility on child mortality estimates has been ignored in the estimation of child mortality in South Africa. This is, perhaps, because the effect is small relative to other errors.

An incorrect choice of the model life table will also result in unreliable estimates. The age patterns of child mortality in South Africa have changed over the past decade due to the effects of HIV and use of Coale and Demeny model life tables will introduce bias that will need correcting.

In addition, reliability of the estimates depends on the quality of the data. The period of the children's exposure to the risk of dying depends, on average, on the mother's age and thus any misreporting of a mother's age has results in biased mortality estimates being obtained. Generally, there has been no problem in reporting of mother's age in South Africa.

South Africa has one of the highest levels of HIV prevalence among women aged 15-49 years estimated at 21.22 per cent (Dorrington, Johnson, Bradshaw *et al.*, 2006) for the year starting 1 July 2006 and ending 1 July 2007. The HIV epidemic compromises the validity of some of the assumptions of the Brass technique. HIV prevalence levels and viral loads vary with the age of women. The higher the viral load the higher are the chances of vertical transmission of HIV from mother to child. Thus, the risk of children dying is now also dependent on the age of the mother.

The Brass technique uses data on living mothers only. The selective nature of HIV means that some mothers might not survive to be interviewed, with age groups above 25 years most likely to be affected more than those below 25 years (Blacker and Brass, 2005). The Children's deaths are now correlated to that of their mothers due to vertical transmission of the virus from mother to child and high levels of mortality due to the virus in both adults and children. The high mortality in HIV infected women might result in underreporting of births and deaths of children born to these women. Due to the fact that there is higher mortality in the children of the HIV infected women this results in underestimation of mortality rates for the given period (Blacker and Brass, 2005).

The assumption that the age pattern of mortality in the population can be represented by a standard model life table is also violated as HIV has caused changes in the age-specific mortality patterns for the young adults and the children. Thus the model life tables will not be appropriate for estimating the age specific mortality patterns of the HIV population and will result in the introduction of biases in the estimation of child mortality.

Ward and Zaba (2009) assessed the extent of biases introduced by the advent of HIV in the estimation of child mortality using the Brass technique by simulating a stable population model in an HIV population. They also derived correction factors for the bias introduced by HIV when using the Brass technique. They defined the true level of mortality in the population as:

$$q(z)^t = q(z)^e + n(z)$$

where $n(z)$ is the estimated correction factor dependent on prevalence levels in childbearing women, $q(z)^e$ is the mortality rate estimate calculated from the usual Brass technique and the corrected or true estimate of mortality will be given by $q(z)^t$.

Two regression models were developed to determine the correction factors, $n(z)$. These are the basic and extended regression models. The latter model generally improves on the estimates obtained using the former model in the youngest age groups. The basic regression model is defined by:

$$n(z) = aPREV + b(PREV)^2$$

where $PREV$ is the prevalence in women of childbearing age, expressed as a proportion. The extended regression model is given by:

$$n(z) = aPREV + b(PREV)^2 + cPREV15$$

where $PREV15$ is HIV prevalence in women aged 15-19 years, expressed as a proportion. The models were fitted for each five-year age group of the women of childbearing age. The coefficients were all significant except the *b* coefficient for the 15-19 age group in the basic equation which was not significant at the one (1) percent significant level. The $n(Z)$ values were used to determine the correction factors which were, in turn, used to determine the maximum level of prevalence at which the errors will be within a 5 per cent range for each of the seven five-year age groups for women of childbearing age. The highest prevalence simulated was 45 per cent. The authors conclude that using either the basic or the extended model, one can accurately estimate $q(5)$ from the reports of women aged 30-34 even if HIV prevalence is as high as 45 per cent within an error of 5 per cent. The 35-39 and the 40-44 age groups are acceptably accurate using the basic model up to a prevalence of about 30 per cent while they are acceptably accurate using the extended model at all prevalence levels for the former and up to about 30 per cent for the latter. The basic model is such that estimates for the first, second and sixth age groups become unreliable for prevalence exceeding 12 per cent and even lower for the seventh age group. The corrected estimates of the extended model for the first and second age groups are reliable for the prevalence rates of up to 44 per cent and 33 per cent, respectively, while those for the sixth and seventh age groups are reliable up to 12 per cent prevalence.

Ward and Zaba (2009) assumed a stable population with stable HIV prevalence in their model. This means that the levels of mortality and HIV incidence have been constant in the recent past (Mahy, 2003). However, there has been an upward trend in child mortality in South Africa after 1994, with under five mortality rate peaking in 2001 after which it declined as a result of PMTCT programmes (Dorrington, Johnson, Bradshaw *et al.*, 2006). Thus the assumption of stability is violated and need to be adjusted for in this research.

In addition, the model used by Ward and Zaba only concerned itself with mother to child transmission of infection and thus made no allowance for infection later in life. For this reason, the adjustments for the oldest and to some extent the second oldest age group of women are likely to over correct for the impact of HIV on mortality.

2.3.3 Direct Estimation of child mortality.

Ideally the estimation of child mortality rates by direct methods, according to Rutstein and Rojas (2003), require that we have data on the date of birth of every child, their survival status and the date of death or age at death for those children who are dead. These data can be obtained from surveys that include appropriate questions regarding to survival of children or from a vital registration system. The synthetic cohort life table approach is the method that will be used to directly estimate child mortality in this project.

The synthetic cohort life table approach determines the probability of dying between birth and certain age z, say, from the mortality experiences of a real cohort. This method gives current mortality estimates and specific time references and as such has found favour in the analysis of DHS data (Rutstein and Rojas, 2003). Misreporting of age at death affects the direct estimation of infant mortality rates. Age heaping at age one year is the most problematic resulting in underestimation of infant mortality rates because deaths that could have occurred to babies less than one year in age will have been transferred to a higher age category due to the misreporting. The under-five mortality rate is little affected by age misreporting. The misreporting of birth dates has little effect on the mortality rates, unless the misreporting is concentrated more on the dead children.

The infant mortality rate for a given period is found by simply dividing the number of deaths of infants by the number of births for that given period. The under-five mortality rate is determined by generating a complete life table. Let ${}_1q_x$ be the probability of dying between ages x and $x+1$. The ${}_1q_x$'s are calculated using the following formula:

$${}_1q_x = 1 - e^{-{}_1M_x}$$

where ${}_1M_x$ is the age specific central mortality rate given by ${}_1M_x = \frac{D_x}{P_x}$

D_x is the number of deaths of people aged x in that year and P_x is the mid-year population of people aged x. Setting ${}_1q_0$ equal to the infant mortality rate and calculating ${}_1q_x$ for $x = 1, 2, 3, 4$ the under-five mortality rate or the probability of dying before reaching age five, ${}_5q_0$, can be calculated using the following formula:

$${}_5q_0 = 1 - ((1 - {}_1q_0) \times (1 - {}_1q_1) \times (1 - {}_1q_2) \times (1 - {}_1q_3) \times (1 - {}_1q_4))$$

3 Data Sources and Methods

This chapter looks at the data available for estimating child mortality and the methods that can be used for the estimation from these data. Table 3.1 below summarises the type of data available and the corresponding method that can be used to estimate child mortality from these data. The recent Community Survey of 2007 sampled 947, 331 people from 250, 348 households and the registered deaths from the vital registration for the whole country are the main data sources. This chapter starts with a section that briefly looks at the data quality of the registered deaths and the 2007 Community Survey. The second and last section will outline how the methods listed in Table 3.1 were used to estimate child mortality and how the mortality trend between 1996 and 2006 can be determined.

Table 3.1 Summary of data sources and methods

Data Source	Sample	Data	Method
2007 Community Survey	Sample size: 947,331 individuals from 250,348 households	(1) Children ever born/Children surviving data.	(1) Trussel variant of Brass technique adjusted for HIV using Ward and Zaba method
		(2) Child deaths reported by households for the one year before the census date	(2)Direct child mortality calculation from reported household deaths data using synthetic cohort life tables.
		(3) Survival status of last child born	(3) Blacker and Brass variant of previous birth technique.
Vital Registration	Registered deaths and births, 1996-2006.	(1) Registered deaths.	(1) Direct child mortality calculation from registered household deaths data using synthetic cohort life tables. (2)Completeness of death registration and trend fitting

3.1 Data Sources and the quality of data available

The data that are available for use in this project are analysed for suitability of use in estimating child mortality. The data are described in this section and the methods used to assess the data quality are also outlined alongside some of the results.

3.1.1 Data from the vital registration (VR)

The death registration or notification data on children were obtained in STATA format from Statistics South Africa for the years 1996 to 2006. The registered death data are summarised in Appendix 1. Figure 3.1 shows the trend in the number of deaths recorded by age over the 10-year period under study for both sexes combined (See also Table A 1). The number of reported death of children less than 5 years of age has been increasing over the years since the introduction of the deaths notification form in 1998 (Brody 2007). This has been mainly due to the increase in the reporting of deaths of infants whose numbers took a sharp turn upwards since 2001. This has seen the number of reported infant deaths almost doubling from as little as 24, 606 recorded deaths in 1996 to as high as 47, 703 recorded deaths in 2006. The recorded deaths of the 1-4 year age group have also doubled over the 10-year period from 8, 058 in 1996 to 15, 893 in 2006. The death registration of children aged 1-4 continue to increase in the period but the increase is happening at a slow pace with number of death reported seemingly becoming constant around 5, 800 between 2004 and 2006.

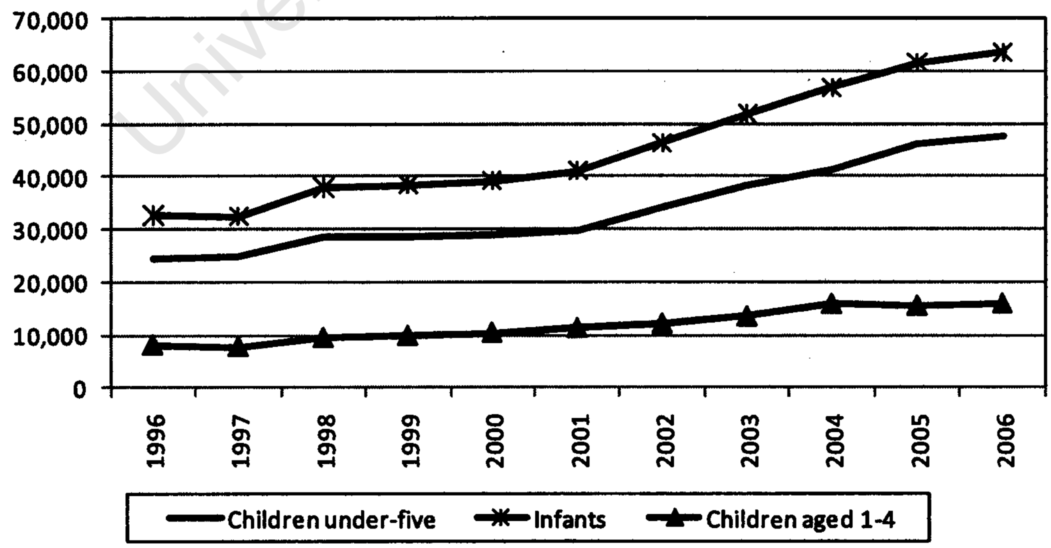

Figure 3.1 The number of recorded child deaths in South Africa by age, 1996-2006.

The child mortality rates are not expected to double over the 10-year period thus this increase should translate to an increase in completeness of death registration for the infants and children aged 1-4. Sex was missing on 0.16 per cent of the death notification forms in 1996 and 1.3 per cent of the forms in 2006. The deaths are allocated between male and female by assuming that the sex distribution of the not stated is the same as that specified on the other death notification form.

The recorded births obtained from Statistics South Africa's Statistical release P0305 (Statistics South Africa, 2008) are shown in Table A 2. The table includes projected births from the ASSA2003 model which will be used in calculating the extent of birth and death registration. Births from ASSA2003 have been used before in child mortality estimation by Bourne, Thompson, Brody *et al.* (2009) with reasonable results for the same period.

The completeness of births registrations were calculated by dividing the reported births by the births from ASSA2003 and are shown in Figure 3.2. The completeness of birth registration was almost constant around 82 to 84 per cent between 1996 and 2003 before increasing rapidly from 2004 and is estimated to be 92 per cent in 2006 which is close to the official estimate of 93 per cent for 2006 based on population estimates from the 2007 Community Survey (Statistics South Africa, 2008).

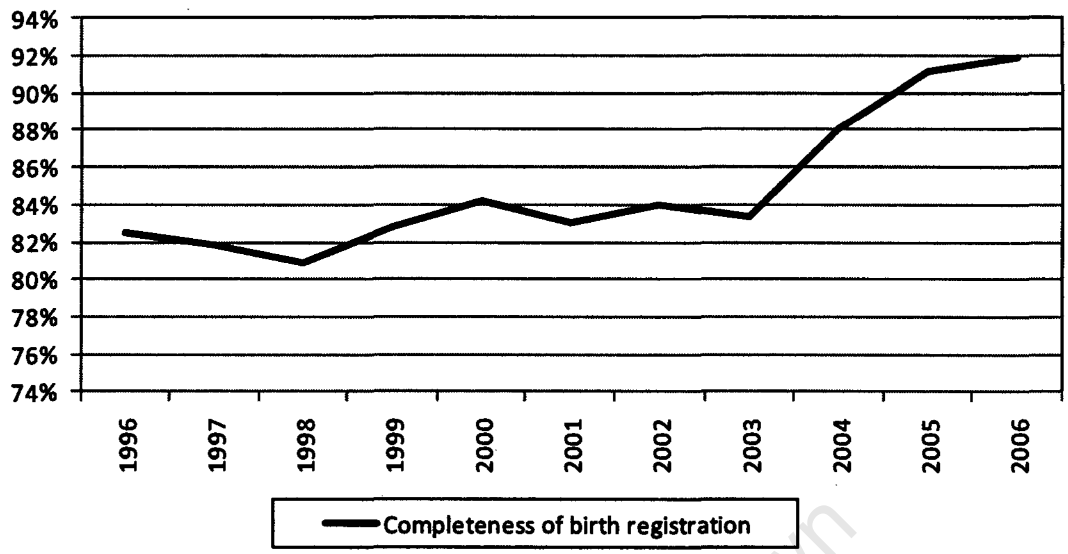

Figure 3.2 Completeness of birth registration between 1996 and 2006.

3.1.2 Children ever born/Children surviving data

The Community Survey of 2007 collected information on children ever born and children surviving to women aged 15 to 49 from 263, 595 women. The initial estimates of probability of dying by a specific age using Brass's method produced mortality rates that are higher for girls than boys. Furthermore, the probabilities of dying by a specific age do not increase monotonically with the age group of mother as would be expected (Preston and Haines, 1984). These are the same inconsistencies and anomalies observed by Udjo and van Aardt (2008) in the 2007 Community Survey data. These irregularities pointed to the fact that the data may be problematic. The 2007 Community Survey questionnaire included questions pertaining to the male and female children who are alive and still live at home and those living elsewhere. This enabled one to check the internal consistency by reconciling the responses to these questions with those on children ever born/children surviving data. The first check revealed that the sum of the reported female (FCEB) and male (MCEB) children ever born did not tally with the reported total children ever born (TCEB) and this is shown in the Table 3.2. These checks revealed that the total children ever born might have been underreported across all age groups. Further checks of consistency between the total children ever born, total children reported surviving (TCS), living at home and away from home, and the total children dead (TCD) were undertaken (see Table 3.3).

Table 3.2 Comparison of total CEB data to data on FCEB and MCEB

AGE GROUP	Total CEB	FCEB	MCEB	FCEB+MCEB	Variance
1	357,249	181,304	178,711	360,015	-2,766
2	1,521,565	756,749	781,471	1,538,220	-16,654
3	2,400,463	1,201,932	1,217,115	2,419,047	-18,584
4	3,411,793	1,704,904	1,724,330	3,429,234	-17,441
5	4,116,113	2,042,650	2,082,409	4,125,059	-8,946
6	4,573, 378	2,288,968	2,305,618	4,594,586	-21,209
7	4,155,444	2,076,174	2,094,823	4,170,997	-15,554
Total	20,536,004	10,252,680	10,384,478	20,637,158	-101,154

The data for women with inconsistencies were dropped from the analysis using the STATA code in Appendix B[1]. The original sample data had 263, 595 women (representing, when weighted, 13, 279, 570 women in the population), 22, 245 of whom, or 8 per cent, were found to have inconsistent data and were dropped from the analysis and 241, 350 women from the sample (representing 12, 060, 661 women in the population) were retained. The estimates of mortality from this new data set did not show the anomaly of females having higher mortality than males as before. These are the data that are used to estimate child mortality using Ward and Zaba variant to Brass's technique.

[1] The rules used here were to keep the data of reproductive women for whom:

a) total children ever born equaled the sum of the total male children ever born and total female children ever born;
b) total children ever born equaled the sum of the total surviving children ever born living at and away from home and total children dead;
c) total female children ever born equaled the sum of the total female surviving children ever born living at and away from home and total female children dead; and
d) total male children ever born equaled the sum of the total surviving male children ever born living at and away from home and total male children dead.

Table 3.3 Comparison of total children ever born, surviving and the dead children.

AGE GROUP	TCEB	TCS	TCD	TCS+TCD	Variance
1	357,249	351,515	25,103	376,618	-19,369
2	1,521,565	1,502,436	99,252	1,601,688	-80,123
3	2,400,463	2,354,785	152,886	2,507,671	-107,208
4	3,411,793	3,316,542	227,874	3,544,416	-132,623
5	4,116,113	4,014,014	270,931	4,284,945	-168,833
6	4,573,378	4,378,172	373,820	4,751,992	-178,614
7	4,155,444	3,893,293	426,744	4,320,038	-164,594
Total	20,536,004	19,810,758	1,576,609	21,387,367	-851,363

The age structure of the women aged 15-49 is virtually unchanged and is consistent with the age structure of the data from the 1996 and 2001 censuses. Whipple's index and Myer's blended method showed that there is no age misreporting for the mothers. The average parities for women aged 15 to 49 were also compared with data from the 1996 and 2001 censuses and the 1998 SADHS is illustrated in Figure 3.3 . The average parities increase with age group of mother which is consistent throughout for the four data sets. The Community Survey of 2007 has average parities which are generally less than the average parities from data sets of previous years. This is consistent with the fact that the fertility rate in South Africa has been declining (Dorrington, Moultrie, Timaeus *et al.*, 2004). This consistency suggests that the quality of the 2007 Community Survey is fairly good. One of the assumptions of Brass's method is that fertility has been constant in the recent past and the fact that fertility is changing may have an effect on the accuracy of the estimates of child mortality, but as highlighted earlier on the effect may be considered small relative to other errors.

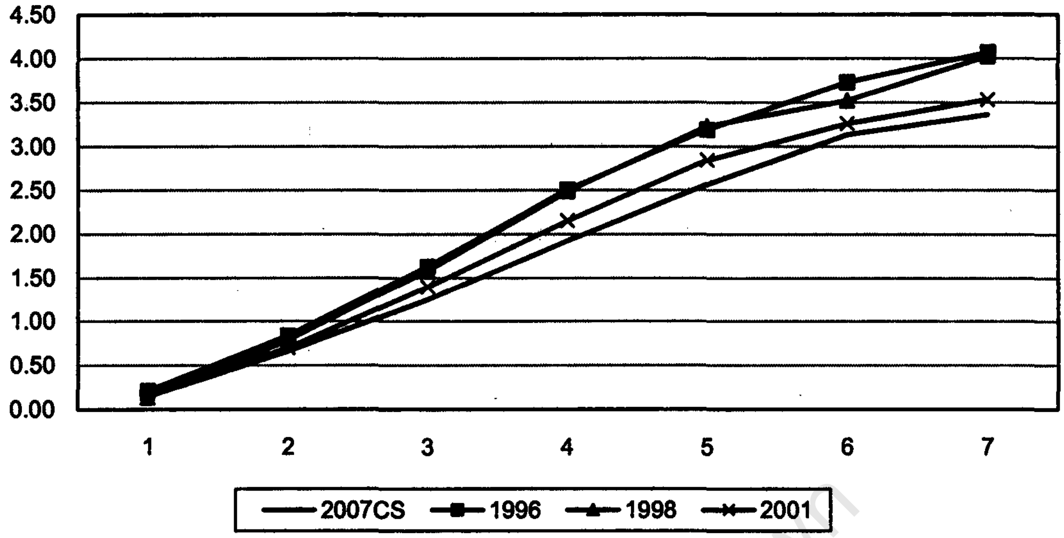

Figure 3.3 Comparison of average parities of women aged 15-49 from the CS and from the 1998SADHS and the two censuses of 1996 and 2001.

3.1.3 Reported household deaths data

The mortality data at household level is obtained using responses to section I of the questionnaire during the survey of 2007. The respondents were asked if there had been a death or deaths in the household in the past 12 months between February 2006 and March 2007. If their answer to the question was affirmative then they were to provide, among others, information on the month and year of death, the sex and age of the deceased at the time of death and the cause of death. The variables of interest: age at death, month of death, year of death and the sex of the dead child, had in some instances blank (missing) and implausible non-blank responses. These were edited by Statistics South Africa and there is a need to look at the significance of the impact of the editing procedures on the quality of the data.

The Community Survey reported 1, 932 deaths of children under the age of five years, which represent 92, 739 household deaths in the South African population as a whole after applying the given household weights to scale up the sample to the population as a whole. Table 3.3 gives the proportion of the data on household child deaths that were edited for responses on age at death, month of death, year of death and the sex of the deceased.

Table 3.4 Proportion of household death data that was edited by variable of interest, 2007 South African Community Survey.

Variable	Not edited	Edited
Month of death	98.0%	2.0%
Year of death	94.6%	5.7%
Age at death	99.7%	0.3%
Sex of deceased	100.0%	0.0%

The table shows that no data on sex of deceased was edited while 2 per cent or less of the data on month of death and age at death were edited, and the impact of the edits can be expected to be small. The proportion edited for year of deaths at 5.7 per cent is high and needed further investigations to see if there are any benefits to their imputation. Further analysis of the distribution of imputations showed that about 4.5 per cent of the edits were by logical imputation from non-blank and these are expected to be reasonable. Thus, the impact of any errors due to imputation on data quality can be expected to be small.

3.1.4 Data on survival of last child born

Women aged 12 to 50 years who had at least one live birth, excluding stillbirths, were asked about the survival of their previous birth. They gave responses to the following line items:

i. the date of birth of the last child born by day, month and year of birth;

ii. the sex of the last child born; and

iii. the survival status of the last child born, whether child is still alive or dead.

It is common in surveys of this nature to have unreported birth dates, survival status and gender for last live birth. The data on the day, month and year of birth two years prior to the survey were fully reported, while less than one per cent of both the data on the sex and the survival status used in the estimation of infant mortality were edited by logical rules from either a blank record or non-blank record. The extent of imputation is low enough that it can be ignored as inconsequential to the final estimates of infant mortality. Thus, it may be safe to infer that, with regards to item completion for the questionnaire section on survival status of last child, the 2007 Community Survey seems to be of good quality.

The sex ratios at birth were found to be on the high side at approximately 106 male births per 100 female births against the expected of 101 to 102. In addition, somewhat surprisingly, the proportion of dead for female was found to be higher than that for males. The proportion dead for the male last childbirths was found to be 0.036 while the proportion dead for the female last childbirths was 0.047. There is an anomaly here in that the proportion of male deaths should have been higher for males than females. Figure 3.4 shows the proportion dead by age of mother and sex of last child born. Clearly, the anomaly of having the highest proportion of the dead among females being higher than for males is repeated at all age groups of mothers. This abnormality was repeated by the data for all population groups and provinces. Any further efforts to improve the quality of the data were not successful.

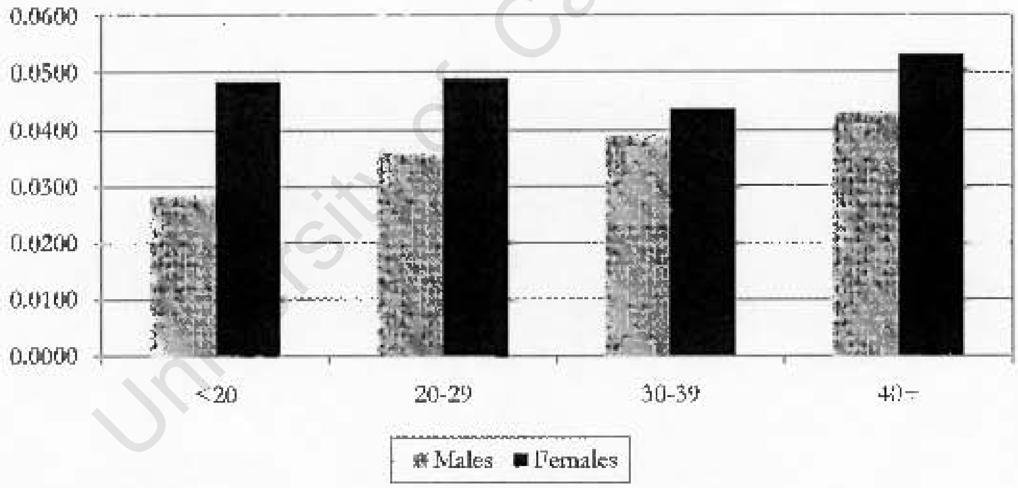

Figure 3.4 Proportion dead by age of mother

3.2 Methods of estimating child mortality

This section looks at the indirect and direct methods that are applied to the data from the 2007 Community Survey to estimate the infant and under five mortality rates.

3.2.1 Estimating infant mortality rates from proportion dead among births in the last 24 months (Previous Birth Technique)

This method is simple and straightforward in its application. The reference date of the survey can be assumed to be mid-February 2007 (2007.125) thus the PBT is used to analyse the sex-specific survival status of children born 24 months before 15 February 2007, that is those born between 15 February 2005 and 15 February 2007. The proportions of children surviving of those children born to women aged 15 to 49 years 2 years before the survey date were determined by sex. These were then multiplied by a factor of 1.09 to adjust anticipated biases in this sort of data.

3.2.2 Estimating child mortality using Ward and Zaba variant

The estimation of mortality using the Ward and Zaba equations require the knowledge of the number of reproductive women by their five-year age groups and the survival status of the total children ever born to them. This information was extracted from STATA file of the Community Survey data. There was no need to estimate the time location, $t_B(x)$, to which the $q(x)$ apply in the original Ward and Zaba method since they assumed a stable HIV population. However, changes in HIV prevalence over the years in the South African population has meant that child mortality must be estimated at the time of birth to women of reproductive age by their age groups. Thus, the knowledge of the prevalence of HIV/AIDS of women aged 15 to 49 at the time of the survey and at the time they give birth is required. These were derived from the ASSA2003 model. In estimating the time location to which the mortality rates apply it was assumed that HIV/AIDS do not impact on the time locations greatly. This research is not going to estimate child mortality rates corresponding to the two oldest age groups of reproductive women as Ward and Zaba adjustments are likely to over correct for the impact of HIV/AIDS on mortality as highlighted in the last paragraph of section 2.3.2.

The CEB/CS data are used to derive the average parities for women aged 15-49 by their five-year age groups and the proportion of children who are dead by age group of their mothers. Trussell's multipliers derived from the West model life tables were then used to convert the proportion of dead children into probabilities of death before specific age x, $q(x)$ and $t_B(x)$ the time to which the $q(x)$ apply. The data are then corrected for the impact of HIV using Ward and Zaba's basic equation and the HIV prevalence rate of

21.6 per cent among women aged 15-49 years. But this adjustment assumes that the HIV prevalence has been constant in the recent past which is not the case in South African. HIV prevalence has been increasing and so there is a need for correction factors that allow for the fact that HIV prevalence had not be stable over the past years.

Deriving such correction factors accurately will be a thesis on its own so it was decided to derive adjustments to the Ward and Zaba correction factors which allow approximately for the fact that prevalence has been rising steadily until shortly before the survey. The Ward and Zaba correction factor is an addition that corresponds to prevalence at the time of the survey. Had there been no HIV the adjustment would be zero. Thus, what is required are additions that lie between those calculated at current HIV prevalence rate and zero, which in some way reflects the lower average prevalence applicable to the group of women over time. This addition should range from nearly the full adjustment for the youngest age group to very little for the oldest age group. As a way of phasing out the adjustment from more or less full in the recent past to more or less none in the most distant past a first approximation is obtained by scaling the Ward and Zaba additions (correction factors) by the ratio of the prevalence at the time reference point, $t_B(x)$, to that at the time of the survey.

The required average prevalence, in the context of Ward and Zaba, is the prevalence at the time at which the respondents gave birth. This can be estimated as the weighted average of the prevalence at the time of birth of all births to women aged 45-49, 40-44, ..., 15-19. The weighting used is the number of births to women at these ages. Thus let C_y^{2006-x} be the number of babies per woman (age specific rates) x years before the survey for women aged y years at the time of the survey. The weighted average HIV prevalence at the time of the birth of their children for women aged y years is given by:

$$PREV(y) = \frac{\sum_{x=0}^{y-15} w_y^{2006-x} * PREV(2006-x)}{\sum_{x=0}^{y-15} w_y^{2006-x}}$$

where $w_y^{2006-x} = \frac{C_y^{2006-x}}{\sum_{x=0}^{y-15} C_y^{2006-x}}$ is the weight and where $PREV(2006-x)$ is the HIV prevalence for women aged 15-49 exactly x years before 2006. The C_y^{2006-x}'s (or ASFRs) have a curve which is skewed over time as shown in Figure 3.6 for the cohort aged 47 at the time of the survey. Because the curve is skewed it sufficed to calculate the average HIV prevalence at the time of birth for the median age to represent the age group of women. For instance, the average HIV prevalence at the time of birth to women in the age group 45-49 is calculated by finding the average prevalence at the time of birth for women aged 47 at the time of the survey. The annual ASFR were obtained from the ASSA2003 model and those for the years prior to 1985 are assumed to be at the same level as in 1985. These HIV prevalences are then used to adjust Ward and Zaba's correction factors.

The period mortality rates implied by the death rates obtained using the children ever born/children surviving method adjusted to allow for the impact of HIV/AIDS cannot be derived using Coale and Demeny's model life tables for a country with a high HIV prevalence rate such as South Africa. In the case of South Africa, the ASSA2003 model provides model life tables that incorporate the impact of HIV/AIDS on mortality.

Brass showed that the survivorship probabilities of two life tables can be linearly related by a two-parameter system of equations called relational logit system. Brass's relational logit system is given by:

$$\text{logit}(l_x) = \alpha + \beta\, \text{logit}(l_x^S)$$

where $\text{logit}(l_x) = \frac{1}{2} * \ln\left[\frac{1-l_x}{l_x}\right]$ and l_x^S are the survivorship probabilities of the standard life table. The period life table from ASSA2003 corresponding to the year of the time reference to which $q(x)$ applies are used as the standard life tables. Setting $\beta = 1$ so as to maintain the shape of mortality patterns at the reference period gave the life table with the implied survivorship for $q(x)$ from which the implied infant and under-five mortality rates and trends were determined.

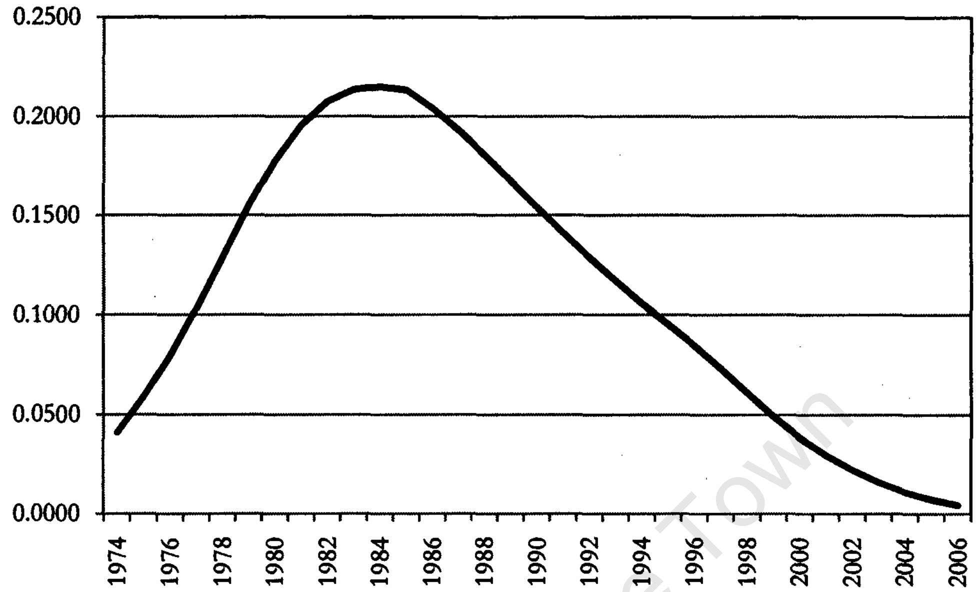

Figure 3.5 ASFR for cohort of women aged 47 at survey date for the 32 years before the survey.

3.2.3 Direct Estimation of child mortality.

Child mortality estimates were calculated directly from the reported deaths by households and the reported deaths from the vital registration. Complete life tables were calculated for the children aged 0 to 4. The infant mortality rate, assumed to approximate ${}_1q_0$, was calculated by dividing the number of deaths of infants by the number of births for the given year obtained from ASSA2003. The central mortality rate, ${}_1M_x$, for children between ages x and $x+1$ for $x=1,2,3,4$ were determined by dividing the deaths of children aged x by their mid-year population. This central mortality rate was then converted to the probability of dying between ages x and $x+1$, ${}_1q_x$, for $x=1,2,3,4$. The under-five mortality rate was then calculated using the following formula:

$$ {}_5q_0 = 1-((1-{}_1q_0)\times(1-{}_1q_1)\times(1-{}_1q_2)\times(1-{}_1q_3)\times(1-{}_1q_4)) $$

Note that in the calculation of population ${}_1q_x$, for $x=0,1,2,3,4$, it is assumed that those who die between ages x and $x+1$ do so halfway through the year.

3.3 Method of fitting a trend

The method for estimating the trend between 1996 and 2006 requires prior knowledge of the level of child mortality in 1996 and 2006 and as many years in between. The 1996 infant and under-five mortality rates are determined using estimates obtained by reviewing the work by others. The level of child mortality in 2006 and some of the years between 1996 and 2006 are determined from the estimates obtained from the 2007 Community Survey. The final estimates take into consideration the fact that the completeness of infant deaths cannot be greater than the completeness of births registered in the year in which they were born[2] (for similar use of assumption also see, Cabigon, 1996).

The next step after determining the level of infant and under-five mortality rates is to determine the changes in completeness over the period 1996-2006. The completeness of death registration are obtained by first calculating infant and child mortality rates directly using registered deaths between 1996 and 2006 and births and the mid-year populations from the ASSA2003 model. The implied completeness of infant registration in a given year is calculated by dividing the infant mortality rate calculated from the vital registration directly by the infant mortality rate calculated from the census or the survey. This is repeated with the under-five mortality rates to obtain the implied completeness of death registration for children below age five years.

The estimates of completeness of death registration implied by estimates of infant and under-five mortality rates obtained after adjusting the Ward and Zaba variant of children ever born/children surviving at their time locations, those from the 2001 census at a point exactly 6 months before the census, and the 1996 and 2006 (6 months before the survey) are plotted separately for the infants and under-five children. A logistic shape is considered the best fit to the estimates of completeness since completeness of registration appears to have been roughly level at the start of the period and can be expected to level off as it approaches 100 per cent. The best fit logistic curves are obtained and a smooth trend in completeness of reporting of infant, under-five and 1-4 year deaths determined separately. The logistic curve is fitted using LOGISTIC spreadsheet from the Population Analysis Spreadsheets (PASEX) developed by the US Bureau of Statistics

[2] Registration of births is assumed to be generally higher than deaths in South Africa because child grants encourage registration of births. It is also more likely that a death of a birth is not registered than an unregistered birth would have the death registered.

International programmes Centre (Arriaga, 1994). This spreadsheet fits a logistic function to at least 2 and up to a maximum of 17 data points and requires the setting of a maximum and a minimum asymptote.

In estimating of the trend in completeness of reporting over the period it is assumed that the trend in completeness is smooth (that is fluctuations in the data are not due to fluctuations in completeness) and that completeness in any age group did not fall over the period. The completeness of death registration of infant deaths must not exceed completeness of birth registration (including late birth registrations up to at least one year after the year of birth).

Having determined the completeness of death registration between 1996 and 2006 the next step is to determine the mortality level in each year. The infant mortality rates in each year are obtained by dividing the infant mortality rates obtained by the direct methods using the reported deaths from the vital register by the fitted completeness in that year. Likewise, the under-five mortality rate was obtained by multiplying the under-five mortality rate obtained from vital registration by the inverse of the corresponding extent of death registration in each year. It is assumed that the extent of male and female death registrations is the same.

4 Results

This chapter is divided into two sections. The first section shows the child mortality estimates as obtained from the three methods, namely the previous birth technique, Ward and Zaba's variant to the Brass technique and the direct estimates from reported household deaths. The second section looks at the extent of completeness of death reporting for children who die before their first birthday and those who die before reaching their fifth birthday using the death notification data between 1997 and 2006 obtained from Statistics South Africa (Stats SA) and the trend analysis results.

4.1 Child mortality estimates

The estimates of child mortality comprise estimates from indirect methods and direct methods. This section first looks at the results from the indirect methods of PBT and children ever born/children surviving and then the direct methods calculated from household deaths as reported in the 2007 Community Survey and the 2001 census.

4.1.1 Mortality Estimates from the Previous Birth Technique (PBT)

The Community Survey of 2007 asked women aged 12 to 49 years questions on the survival status of the last live birth they had. These data are used to derive the proportion dead of the children born in the two years prior to the survey, which is the two years spanning from 15 February 2005 to 15 February 2007. The Blacker and Brass's (2005) variant of the previous birth technique which makes use of the proportion of dead children of those born in the previous two years to estimate infant mortality rate is applied with an adjustment of 1.09 for both sexes combined which is applicable to South Africa. The male conversion factor is 1.0872 and the female one is 1.0909. The results are shown in Table 4.1.

There were 1.9 million previous births reported in the whole population of which 78, 500 children are estimated to have died representing a proportion of 0.042. The proportion of dead children was then adjusted to give an infant mortality rate of 46 infant deaths per 1000 live births for a period centred on 2006. The sex-specific infant mortality rates exposed the anomaly of the higher female mortality rate of 52 than the 39 for males. This irregularity could not be eliminated and suggests that the data used are problematic. The anomaly of infant female mortality being significantly higher than male mortality could be the result of underreporting of male deaths, although it is not clear why this would be the case. There was nothing much that could be done to remove this anomaly and this may have the effect of lowering the overall infant mortality rate for both sexes combined. This is not an uncommon anomaly as this was the case with infant mortality rates derived from the 1982 fertility survey data (Chimere-Dan, 1993 ; Dorrington, Bradshaw and Wegner, 1999) and also with child mortality rates derived for years 2003 and 2004 using data from a Demographic Surveillance Site in Kwazulu-Natal by Muhwava and Nyirenda (2008).

Table 4.1 Infant mortality estimated from dead children of those born in the last 24 months, Community Survey 2007

	Males	Females	Total
Births in the last 24 months	960,785	918, 358	1,879,143
Number of children dead	34,811	43,693	78504.35
Proportion dead	0.03623	0.04758	0.04178
Conversion Factor	1.0872	1.0909	1.09
Estimated Infant Mortality Rate (per 1000)	39.4	51.9	45.5

4.1.2 Mortality Estimates from Ward and Zaba's Variant to Brass's Technique

The corrected data of CEB/CS from the Community Survey is used to calculate the average parities and the proportion dead for each age group of women as shown in Table 4.2. The average parities and the proportion dead of children are increasing with the age group of mother, as expected. The Trussell multipliers are obtained using the West model life table and are used to convert the proportion dead of children into $q(x)$, the probabilities of dying before reaching age x and the reference dates to which $q(x)$ refers are derived in the usual way. The Ward and Zaba correction factors were then applied to give $q(x)$'s adjusted for the HIV prevalence among women age 15-49 which stood at approximately 22 per cent at the date of the survey (2007.125). The adjusted probabilities are shown in the last column of the Table 4.2.

Table 4.2 Application of Ward and Zaba basic regression method to the 2007 Community Survey.

Age group	No. of women	Average parities	Proportion dead	Multipliers, k(i)	Age x	q(0,x)	Reference date	W&Z additions with no adjustments	q(0,x) adjusted for HIV
15-19	2,433,363	0.125	0.042	0.973	1	0.0412	2005.9	0.0101	0.0513
20-24	2,244,794	0.601	0.046	1.008	2	0.0459	2004.5	0.0121	0.0580
25-29	1,832,812	1.163	0.047	0.982	3	0.0462	2002.5	0.0153	0.0615
30-34	1,656,268	1.825	0.051	1.000	5	0.0508	2000.2	0.0326	0.0834
35-39	1,469,172	2.443	0.050	1.021	10	0.0510	1997.7	0.0347	0.0856
40-44	1,318,812	2.949	0.065	1.009	15	0.0659	1995.1	0.0457	0.1117
45-49	1,105,439	3.131	0.087	1.001	20	0.0869	1992.2	0.1076	0.1945
Total	12,060,660								

The Ward and Zaba estimates in the last column above are a function of the current HIV prevalence, which are different from the average prevalence rates that existed in the age group of mothers at the time when they were giving birth. Table 4.3 below shows the first approximation of mortality rates when Ward and Zaba's correction factors are adjusted by multiplying them by the ratio of the HIV prevalence rate at the reference time and the rate at the date of survey. In the same table and on the second panel the mortality rates are obtained by adjusting the Ward and Zaba's correction factors by multiplying them by the ratio of the average HIV prevalence rate in the age group of mothers at the time of birth of their children and the rate at the date of survey

The estimates of the $q(0,x)$'s in (1) and (2) of Table 4.3 are similar with minor differences at the middle age groups of mothers. The estimates in (2) were used in conjunction with life tables from the ASSA2003 model to determine the implied infant mortality rate $q(1)$ and the under-five mortality rate $q(5)$ using Brass's logit relational model with one parameter. The selection of a model life table for use in translating the adjusted Ward and Zaba estimates into infant and under-five mortality rates trends was one of the most challenging tasks in this research. The ASSA2003 model was chosen as it provides probably the best and most consistent set of estimates for South Africa. The quality of the translation depends on how well ASSA2003 really incorporates the dynamic and impact of HIV/AIDS mortality for the period 1996 to 2006.

The implied mortality trends for males, females and both sexes combined are shown in Figure 4.1 (See also Table A 4). The male child mortality rates are higher than the female mortality rates as would be expected. One cannot say with certainty at this point whether mortality has been rising or has been decreasing.

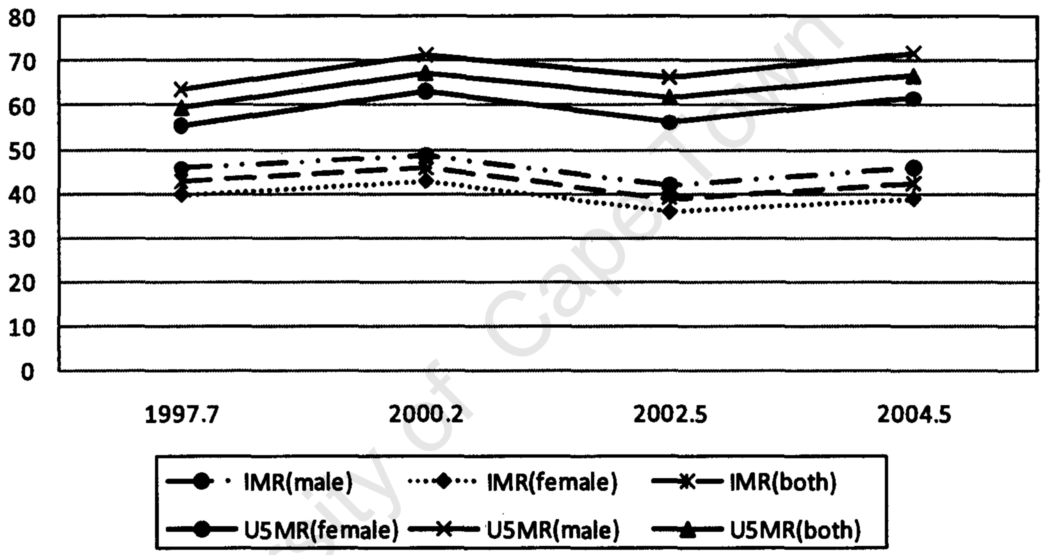

Figure 4.1 Implied Mortality trends from Ward and Zaba mortality estimates using ASSA life tables

The Ward and Zaba's method assumes that HIV prevalence is constant among women of childbearing age. This is a problem as we know that prevalence has changed over time. This results in the overestimation of mortality of children born to women especially at higher ages. The mean survival time for children was set in their model at 2.5 years from time of infection and for adults it is set at 8 years. They assumed that no infected child lives beyond the age of 5 years and they ignore the impact of later infection of children after they become sexually active. Thus the adjustment is quite wrong for the oldest and to some extent second oldest age groups. As an instance, consider the estimate of ${}_{20}q_0$ which is based on the survival of children aged between 0 and 35. The majority of them (15 years and above) will be sexually active and will have been exposed to HIV prevalence rates even higher than those of their mothers at the time of their birth, in an environment of increasing prevalence rates. This has the effect of inflating mortality rates for women in the older age groups. Thus the estimates at these ages are of no use and are disregarded in this analysis.

4.1.3 Mortality Estimates obtained directly from reported household deaths.

The sex specific life tables and also that for both males and females combined are constructed using the deaths reported by households in the 2007 Community Survey. The results are shown in Table A 4together with the derived under-five mortality rate. The infant mortality rates for males and females are close at 53 and 52 deaths per 1000 births respectively, while 53 is the national rate. The under five mortality, ${}_5q_0$, is estimated at 80 for the country while the male and female mortality are estimated at 82 and 78, respectively.

Table 4.3 q(x)'s adjusted for (1) HIV prevalence at the reference date and (2) average prevalence of mothers at the time of giving birth.

(1)					(2)	
Age group	Reference date	HIV prevalence at the date	W&Z additions with adjustments	q(x) adjusted for HIV	Prevalence at time of birth	q(x) adjusted for HIV
15-19	2005.9	20.9%	0.0097	0.0509	20.8%	0.0509
20-24	2004.5	20.0%	0.0112	0.0571	18.9%	0.0565
25-29	2002.5	18.1%	0.0128	0.0590	15.3%	0.0570
30-34	2000.2	14.7%	0.0221	0.0730	11.0%	0.0673
35-39	1997.7	9.4%	0.0151	0.0660	7.0%	0.0622
40-44	1995.1	3.8%	0.0080	0.0740	3.8%	0.0739
45-49	1992.2	0.8%	0.0040	0.0909	1.6%	0.0950

4.1.4 Final mortality estimates for the year 2006.625

To determine the child mortality estimates applying for the year before the survey the child mortality results obtained using the previous birth technique and those calculated directly from the deaths reported by the households were compared with those projected by ASSA2003 model (Dorrington, Johnson, Bradshaw et al., 2006) and the UN/WHO estimates (See, UNICEF, WHO and UN, 2007). These comparisons showed that the estimates by the previous birth technique and ASSA2003 model around 2006 are close (46 and 48, respectively) while the estimates from the direct method and those projected by the United Nations population division around 2006 are close to each other (53 and 56, respectively). The difference between the direct estimate of the infant mortality rate and the one by PBT is about 7 deaths per 1000 live births which are large.

Which to choose is not obvious but a look at the estimate from the PBT suggests that it underestimates child mortality. The PBT estimate of 46 deaths per 1000 live births means that deaths in that year would need to be 95.6 per cent complete. This is higher than the completeness of birth registration in the country (92 per cent) (see Table A 2 in Appendix 1 for estimates of the completeness of birth registration in South Africa between 1996 and 2006). Since the completeness of infant deaths cannot be greater than the completeness of births registered up to at least a year after the year of birth, it means that 46 deaths per 1000 live births is an underestimate of child mortality in 2006. The average of the estimates from the two methods was estimated to give a final infant mortality rate of 49.1 deaths per 1000 live births.

The under-five mortality rate of 80 around 2006 may be too high when compared with 2006 estimates from ASSA2003 (73) and UN/WHO (69). Thus this estimate is adjusted to the extent of the averaged infant mortality rate by multiplying it by a factor of 0.932835 (= 49.1/52.6) to bring it in line with the final estimate of infant mortality. This also has the effect of maintaining the infant to under-five mortality ratio of 0.66 from the original estimates (52.6/80.0=0.66) which corresponds to the ratio of deaths in these ages and the ratio of rates from other sources (e.g. ASSA2003). The final estimate of under-five mortality is 74.7. The second approach used was to estimate the implied under-five mortality rate from the PBT infant mortality rate of 46 using the Brass logit relational model with one parameter and ASSA2003 model life table for the year 2006 gave a similar answer. The implied under-five mortality rate was found to be 70.5. The average of 80 and 70.5 gave average under-five mortality rate of 75.25 which is close to what was found before. Thus the estimates that apply for the year prior to the survey date for infant and under-five mortality rate are 49 and 75 deaths per 1000 live births, respectively.

4.1.5 Final Estimates for the year 1996

There are various estimates of child mortality for 1996 as was shown in Chapter 2. The decision which is the best estimate for that year is not an easy one. The indirect methods estimates are generally regarded as too high while, on the other hand, Blacker and Brass noted that in HIV populations the child mortality rates obtained from birth history data "are more likely to be too low than too high" (2005, p 38). It was thus decided to take an average of the estimates from the indirect and direct estimates from the 1998 SADHS. Udjo's (2005) estimates from the 1996 census are disregarded as they included stillbirths and because he used the age group 15-19 for his estimates. Estimates from independent groups such as IGME and Dorrington, Moultrie, Timaeus *et al.* (2004) were excluded from the analysis as they already average estimates from various data sources. The final 1996 infant and under-five mortality rates obtained in this way were 50.5 and 67 deaths per 1000 live births, respectively.

4.1.6 Final Estimates for the year 2001.175

It has been mentioned in Chapter 2 that The 2001 census data was used by Dorrington, Moultrie and Timaeus (2004) to derive illustrative life tables that showed that under-five mortality at the time lay between 67 and 75 while infant mortality rate lay between 47 and 53. Verification with reported deaths by household data from the 2001 census data give an infant mortality rate of 48 per 1000 and under-five mortality rate of 72 per 1000 live births (see Table A 6). These estimates are within the range of the illustrative life tables estimates and are reasonable estimates for the level of mortality for the year prior to the 2001 census.

4.2 Estimated trend in completeness for the period 1996 to 2006

The decision on which is the best estimate of the trend in completeness of death registration is not an easy one. It could have been easier to smooth by hand as described by Hill and Amouzou (2005), a method they cite as having been used by the United Nations (1988, 1992). According to Hill and Amouzou (2005) the problem with this method is that of subjectivity, as one draws with a free hand and the fact that the projection model cannot be specified satisfactorily. A linear trend would have been a possibility but the points do not exactly follow a straight line. Besides, linear trends are sensitive to extreme values and extrapolation of the linear trend into the future will go beyond a completeness of 1. Thus the logistic function was chosen as it approaches 1 with time and was found to be the most appropriate for the data.

The method outlined in section 3.3 is followed in estimating the trend in completeness between 1996 and 2006. Under-five mortality rates for each year from 1996 to 2006 are calculated from vital registration and an estimate of births and mid-year population age 1-4 from the ASSA2003 model. The results are shown in the Table 4.4.

Table 4.4 Child Mortality rates from the vital registration (VR)

	Infant Mortality rate			Under-five Mortality rate		
Age	**Male**	**Female**	**Both**	**Male**	**Female**	**Both**
1996	0.022	0.020	0.021	0.031	0.028	0.029
1997	0.023	0.020	0.021	0.030	0.027	0.029
1998	0.026	0.024	0.025	0.035	0.032	0.034
1999	0.026	0.024	0.025	0.035	0.033	0.034
2000	0.027	0.024	0.026	0.037	0.034	0.035
2001	0.028	0.025	0.026	0.038	0.035	0.037
2002	0.032	0.029	0.031	0.044	0.040	0.042
2003	0.036	0.033	0.034	0.049	0.045	0.047
2004	0.039	0.035	0.037	0.054	0.049	0.052
2005	0.044	0.040	0.042	0.059	0.054	0.056
2006	0.047	0.041	0.044	0.062	0.055	0.058

Table 4.5 shows the estimates that are used to derive the completeness of death registration where IMR is the infant mortality rate and U5MR is the under-five mortality rate for a given year. It can be seen that completeness of death reporting for both the infants and the children below five years has been increasing over the years, but the increase is higher for infants than for children aged 1-4 since 2004. Logistic curves are

fitted to these data to give equations describing the extent of death reporting for infants, 1-4 year olds and children below five years over the years as described in section 3.3.

Table 4.5 Data points used in deriving trends in completeness of death registration.

Year	IMR	IMR(VR)	Completeness of death registration	U5MR	U5MR(VR)	Completeness of death registration
1996.0	49	21	44%	67	29	44%
1997.7	43	21	50%	60	29	49%
2000.2	46	25	55%	67	35	52%
2001.3	48	26	56%	72	37	51%
2002.5	39	31	79%	62	42	67%
2004.5	42	37	87%	67	52	77%
2006.6	49	44	89%	75	58	78%

The fitted completeness of death registration for infants, children below 5 years and the children aged 1-4 as well as the observed completeness are shown in panels 1,2 and 3 of Figure 4.2. Panels 1 and 2 show the observed and fitted values (See also Table A 7). Generally, the logistics curves give a good fit for the estimates of completeness of death registration. The completeness of death reporting has been increasing over the years and at all ages. Panel 3 shows that the completeness of reporting of infant death has improved faster than reporting of death for children aged 1-4. This has seen the completeness of death reporting for infants rising from 44 per cent to around 90 per cent in contrast to the rise from 43 per cent to about 57 per cent for the children aged 1-4 years

The child mortality rates from vital registration are then adjusted for the incompleteness of death registration. The reciprocal of the completeness of death registration is applied for a given year to the vital registration mortality rates of male, females and both sexes combined.

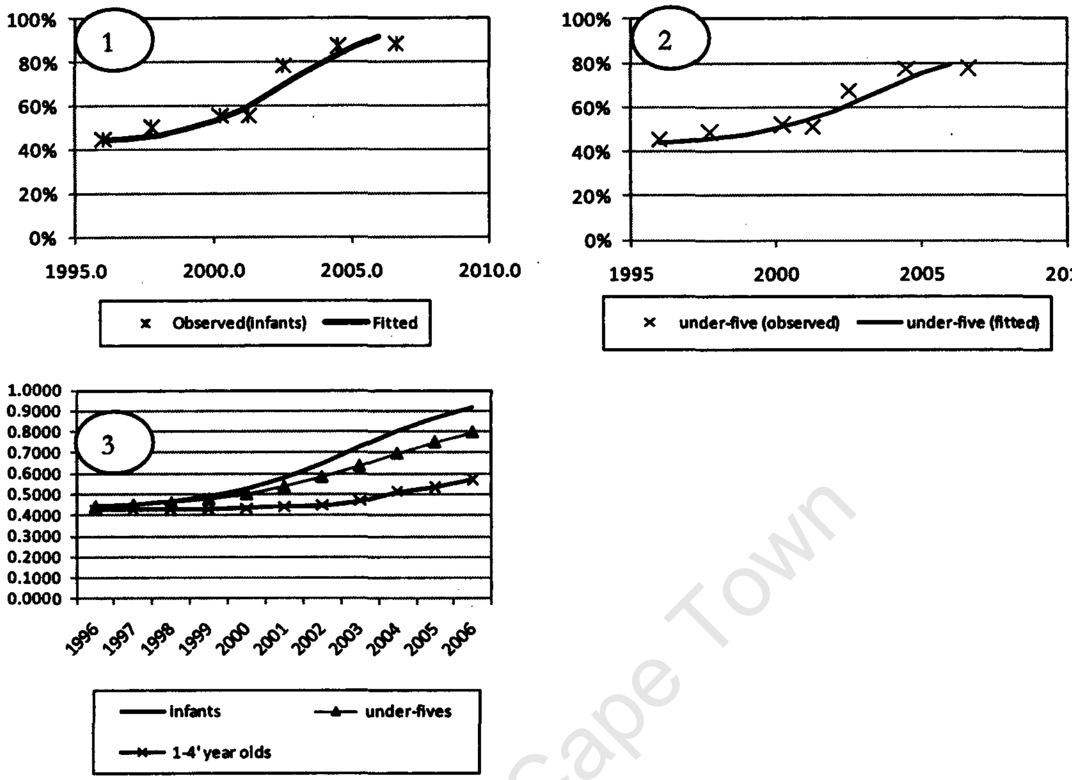

Figure 4.2 Completeness of death registration of infants, children below 5 and children aged 1-4.

The trends in mortality rates (adjusted for completeness of death registration) over the period are shown in Figure 4.3 (See also Table A 8). These trends show that IMR may have remained fairly level at around 50 deaths per 1000 live births over the decade while the under-five mortality rates have increased slightly from below 70 deaths per 1000 births in 1996 to around 75 deaths per 1000 live births by 2006.

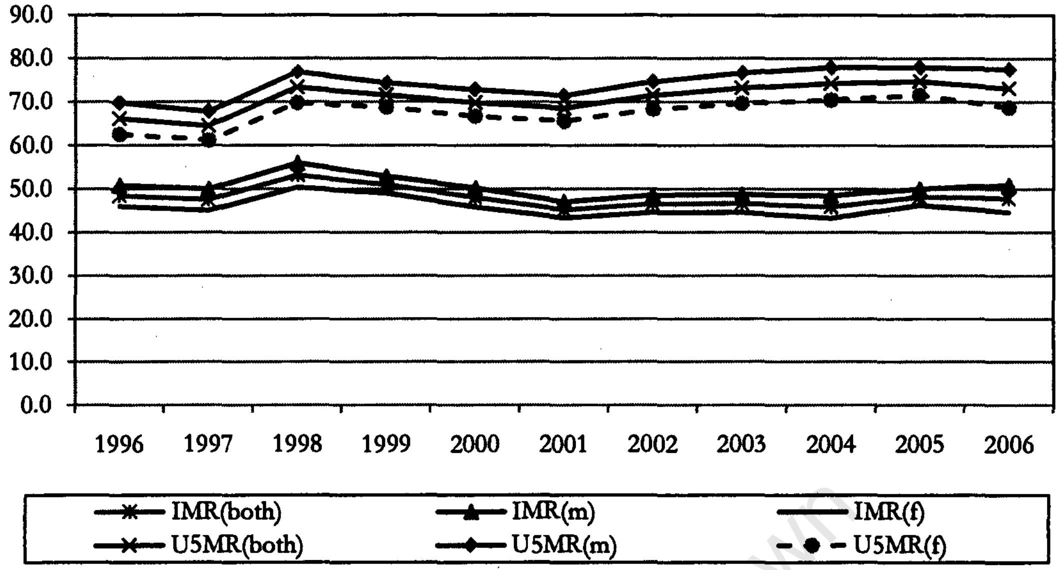

Figure 4.3 Trends in Infant and Under-five mortality rates (adjusted for completeness of death registration) in South Africa, 1996-2006.

5 Discussions and Conclusions

The overall objective of this project was to produce up-to-date infant and under-five mortality rates using data from the 2007 Community Survey. In addition, the aim was to use these estimates to derive the trend in child mortality from 1996 to 2006. This chapter explores the extent to which these objectives have been met. This involves discussing the quality of the data, the reasonableness of the estimates of child mortality for 2006 and the trends in these rates and the methodology used. The limitations of the study and the scope for future research are discussed before conclusions are reached based on the findings.

The 2007 Community Survey data had to be interrogated and edited before being used in child mortality estimation. The inclusion of children still alive, living at home and those living away from home, and the sex-specific children ever born/children surviving data made it possible to check for internal consistencies. The data from the Community Survey had some problems which were removed by excluding women whose data were inconsistent. In the process 8 per cent of the data on the women of reproductive age was lost. This is quite a bit of information to lose but this enabled the production of estimates which were more sensible in terms of the relationship between those for males and those for females and the trends over time.

The analysis has shown that an application of an adaptation of the new Ward and Zaba technique to the children ever born/children surviving data from the 2007 Community Survey can be used to produce rough estimates of levels and trends of infant mortality and under-five mortality rates for the whole of South Africa. These estimates were used, in conjunction with estimates from past research, previous birth technique, and estimates directly calculated from reported household death data from the 2007 Community Survey and 2001 Census, to produce trends of child mortality between 1996 and 2006 after adjusting for incompleteness of death registration. The evidence provided here by the estimates is such that infant mortality rates have been almost level for the decade under review at 50 deaths per 1000 births while under-five mortality rates have also been fairly constant around 70 deaths per 1000 births for a larger part of the period before slightly increasing to around 75 deaths per 1000 births. South Africa does not seem to have reduced child mortality over these years.

5.1 Data sources and data quality

Vital registration for South Africa is not complete. Births and deaths are continuously registered and updated on an annual basis as births and deaths are not recorded in the year in which they are registered. Late registrations mean that completeness of death registration continuously changes over time although by ever decreasing amounts as time passes. Thus the estimates of completeness of death and birth registration will depend on the date of the release of the vital registration information. These changes are becoming insignificant in the long run with vast improvements in the reporting of vital events. Generally the data from the 2007 Community Survey were of fairly good quality, in spite of the edits done to it, while the vital registration system has improved enormously over the years in terms of completeness of reporting.

The new adaptation of the Ward and Zaba (2009) technique provides a simple but potentially powerful tool for estimating child mortality in a changing HIV epidemic, not only in South Africa, but the whole sub-continent whose populations are being ravaged by HIV. The children ever born/children surviving data that has been available but could not be used due to unreliability of the estimates in an HIV environment can become useful again in estimating child mortality with the aid of this technique. This is very important given that the vital registration systems in the sub-continent are generally very incomplete and cannot be relied upon to provide accurate estimates of child mortality. The results obtained using this adaptation may be regarded as first approximations to the levels and trends in child mortality and should not be taken as substitutes for estimates from a high quality registration system.

5.2 Levels and trends of child mortality

The estimates from the two indirect methods, the direct methods and the estimate for 1996 obtained in section 4.1.4 are compared with the final estimates obtained after fitting the completeness of death registration to ascertain how well the methods worked. The results appear in Figure 5.1. IMR and U5MR stand for infant mortality and under-five mortality rate, respectively. The other abbreviations, W&Z is for the adjusted Ward and Zaba method, DR is for direct method, AV1996 is an average estimate obtained for 1996 while the solid line shows the mortality trend after adjusting for completeness of death registration.

The adjusted Ward and Zaba estimates suggest that the children of reproductive women aged 20-24 and 25-29 have a lower mortality than the general mortality. The reason for this discrepancy is not apparent. It is more likely that the data given by these women are suspect and that women interviewed during the Community Survey may have underreported the deaths of their children. Note that Brass's method is very sensitive to reporting errors (Palloni, 1981). However, it may also be due to the problems inherent in the Ward and Zaba (2009) method or the nature of the adjustments made to the Ward and Zaba (2009) method for non-stable HIV prevalence. The estimate for the women aged 30-34 is close to the final estimates. This is not surprising given that the estimates from this age group of women were found to be robust using the original Ward and Zaba technique (Ward and Zaba, 2009).

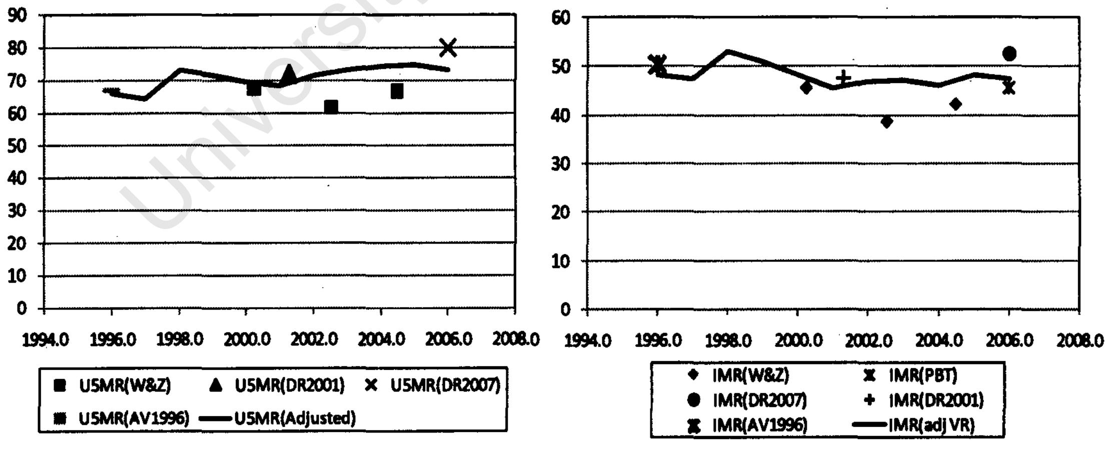

Figure 5.1 Comparison of child mortality estimates from different methods used.

Figure 5.1 shows that infant mortality and under-five mortality increased by about 12% between 1997 and 1998. An inspection of Figure 5.2 and Table A 1 suggest that that it could be the first two data points 1996 and 1997 that are problematic. The main issue here lies with the original vital registration data. Table A1 of Appendix 1 shows that the total registered deaths dipped in from 32,664 in 1996 to 32,464 in 1997. This decrease in child deaths is probably not the result of child health gains but more likely the result of a reduction in recorded deaths. Consequently, an adjustment for the incompleteness in death registration will lead to an underestimate of the true child mortality estimates for the year 1997. The trends shown here can be described in terms of what is known about the proximate determinants of child and infant mortality in South Africa. Nannan, Bradshaw, Timeaus *et al* (2000) showed that there is a correlation between infant mortality and HIV prevalence and also poverty as measured by households with income less than R600 per month and that HIV accounts for 26 per cent of infant mortality, while both poverty and HIV account for 61 per cent of the infant mortality rates (Nannan, Bradshaw, Timeaus *et al.*, 2000). StatsSA reports that apart from HIV and its aligned diseases two other leading causes of deaths among children (0-14 years) between 1996 and 2006 were intestinal infections and influenza/pneumonia (Statistics South Africa, 2002, 2005, 2006, 2008). These are diseases related to good sanitation facilities and availability of clean water. Availability of clean water and sanitation were also found to be significant determinants of child mortality in South Africa (Anderson, Romani, Phillips *et al.*, 2002 ; Argeseanu, 2005).

Researchers have shown that poverty levels worsened between 1995 and 2000 (May and Woolard, 2005) and that the number of people who are poor actually increase by about 2.7 million for the same period (Meth and Dias, 2004). After 2000 there were modest declines in poverty levels (van der Berg, Burger, Burger *et al.*, 2005 ; Meth, 2006). Aguero, Carter and May (2007) also came to the same conclusion of persistent poverty in the 1990s followed a slow decline in poverty levels after the turn of the new millennium as a result of government interventions. There has been a significant improvement on the availability of cleaner water to households but sanitation services have still not improved significantly (Busari and Jackson, 2006). The fact that there has been slow progress in addressing the proximate determinants of the major causes of deaths for children is a contributing factor to the virtually constant child mortality levels between 1996 and 2006.

The mortality levels should not deteriorate hereafter, but should start going down as the government efforts start taking effect.

The government of South Africa has been focusing on PMTCT, HAART, and service delivery and on the provision of a Child Support Grant to mitigate the effects of HIV and poverty on child heath over the 10-year period under study. Baseline (or non-HIV) mortality would have been expected to decline under these circumstances. The impact of these programmes on baseline mortality have been overwhelmed by HIV related mortality to the extent that the overall mortality rates have remained relatively constant and, in the case of under-five mortality rates, they have started going up. It would seem that PMTCT and HAART programmes are merely preventing an increase in overall infant mortality but the effects of the disease are beginning to show as the children whose lives may have been extended by HAART start succumbing to the virus just before their fifth birthday.

The trends obtained here are in line with the findings of Murray, Laakso, Shibuya *et al* (2007) that child mortality rates are likely to remain constant for the period 1990 to 2015. These results confirm the findings by the latter that South Africa is unlikely to meet its target with regards to the Millennium Development Goal number 4.

The estimates of infant and under-five mortality rates obtained by adjusting the vital registration system are contrasted with estimates from ASSA in Figure 5.2. The infant mortality trends suggest that there has been a reversal in child health in the early 1990's until 1996. This was followed by a 10-year period of relatively constant mortality rates, indicating any improvements in child health were probably being counteracted by the impact of HIV/AIDS. The estimated mortality trends are consistent with estimates by Dorrington,Moultrie,Timaeus *et al.* (2004) with the infant mortality rates coinciding. The fluctuations in the estimated child mortality trends are likely to be spurious patterns due to random fluctuations.

The reasons for the differences between the results produced here and those obtained by ASSA maybe that the assumptions in the ASSA2003 model on the impact of

HIV may have resulted in the overestimation of both infant and under-five mortality rates in the interval. The IGME estimates of infant and under-five mortality rates are persistently higher than the results produced here. This difference is likely to be due to the assumptions in their model. The South African average estimates for child mortality for the period 1995-2000, 2000-2005 and 2005-2010 from ASSA2003 and IGME are close. This suggests the two models have similar levels and trends of child mortality over the period under study (See Table A 9).

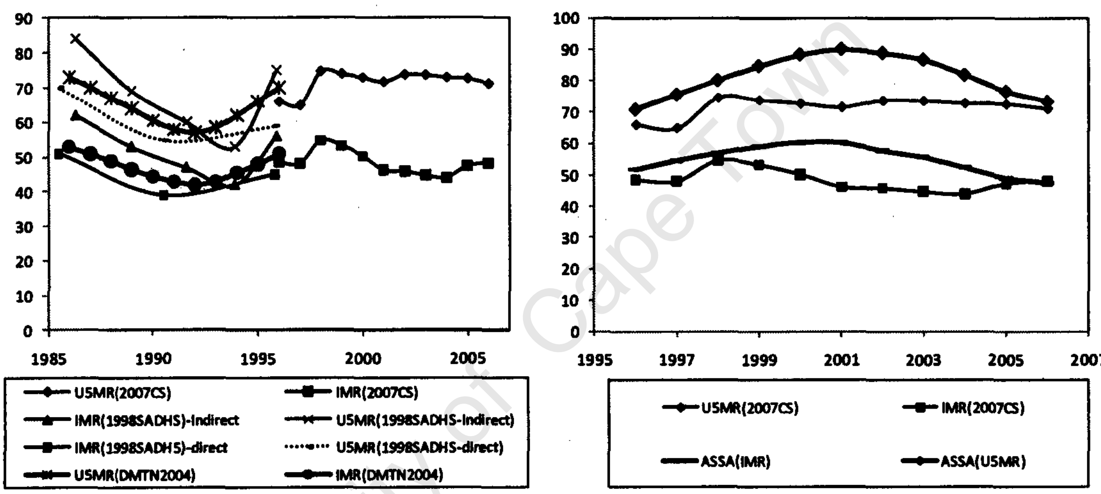

Figure 5.2 Child mortality trends in South Africa, 1985-2007.

5.3 Limitations of the study

The major limitations of this project are the quality of the Community Survey and vital registration data, the applicability of Ward and Zaba to South Africa and the decision on the best trend in completeness of death registration. These are discussed in detail below.

The Ward & Zaba method assumes that the HIV population of a country has been stable in the past 40 years. HIV/AIDS started surfacing in South Africa in the mid-1980's and only became a major area of concern in the mid-1990's as HIV prevalence rate increased. The prevalence of HIV has been on the increase and has started levelling off in the recent past. It becomes pertinent to consider the suitability of using Ward and Zaba adjustments in an environment of increasing incidence and prevalence of HIV. The violation of a constant mortality or/and fertility trend in the recent past when using variants to Brass's technique have been dealt with before by various authors (Kraly and Norris, 1978 ; Sullivan and Udofia, 1979 ; Palloni, 1980) but none of these methods can be used to correct for the instability of the HIV population when using Ward and Zaba. The research used the proportion of HIV prevalence at the time of birth to the prevalence at the time of the survey to adjust Ward and Zaba's correction factors. The accuracy of this adjustment depends on the accuracy of the time reference among other factors.

There is the problem of time referencing that is generally a problem with the Brass's technique. The advent of HIV has seen children dying young with 60 per cent of infant deaths being attributed to the impact of HIV/AIDS in South Africa (Bradshaw, Bourne and Nannan, 2003). The impact of HIV on the time reference is unknown at the moment and may affect the accuracy of the estimates. Non-HIV deaths may also be changing, but not necessarily due to the changes in HIV prevalence rates. Fertility rates have been shown to be on the decline. This may also affect our mortality estimates. This may cause a shift to the average time at which the children are dying. There is a possibility that the time references obtained may be wrong. This results in too many or too few reported deaths which lead to either the underestimation or overestimation of child mortality.

The decision on which is the best trend in completeness of death registration was done after considering various possible models as outlined in section 5.3 above. The logistic model fitted gives reasonable estimates and have the shape of the distribution of completeness of death registration over time. The accuracy of the trend will rely on the accuracy of the mortality estimates between and including the years 1996 and 2006. Accuracy is likely to be affected by the few estimates used and the uncertainty surrounding these estimates.

5.4 Scope for future research

This section looks at some of the opportunities for further research.

There is a need for research into the reasons for the higher female mortality than male mortality in the data for the previous birth technique in order to determine whether male deaths were misplaced or there was a problem in capturing the data.

The assumption of constant HIV prevalence among women of childbearing age by Ward and Zaba is not true and needs investigation to ascertain the extent of overestimation. Such research should also consider the impact on mortality of later infection through causes other than mother to child transmission of children born to women at older ages.

5.5 Conclusions

The overall conclusion drawn from this project is that it is possible to use indirect and direct methods to estimate the level and trends of infant mortality rates between 1997 and 2006 using the 2007 Community Survey and the knowledge of the completeness of death registration over the 10-year period. The results showed that infant mortality rate has remained constant around 50 deaths per 1000 live births for the period, while the under-five mortality rate has increased slightly from below 70 deaths per 1000 live births to about 75 deaths per 1000 live births over the period. The lack of improvement in child health could be a result of the intervention programmes against HIV/AIDS not being adequate enough to maintain the decline in mortality rates but these intervention programmes may have been good enough to stop the deterioration in child heath. The government, while focusing on PMTCT and HAART programmes, also need to focus more on preventative measures in the fight against HIV. There is also a need to focus on poverty alleviation, water and sanitation delivery programmes in order to reduce child mortality.

The method used to adjust the Ward and Zaba method to estimate child mortality in a non-stable HIV population appears to produce reasonable results. The estimates from the adjusted Ward and Zaba method suggested a similar trend in mortality over the period as was with the final trend obtained, only that the Ward and Zaba method gave slightly lower estimates than the adjusted vital registration mortality rates for some age groups. The mortality estimates obtained for 2006 are comparable with the estimates from other independent groups such as IGME and ASSA, although the past trends differ.

There is evidence that the completeness of death and birth registration is continuously improving though it is still affected by late registrations. In particular the death registration of infants has dramatically improved since 2001. This augurs well for the accuracy in future infant mortality rates. There is a strong possibility that future estimates of child mortality, starting with infant mortality rates, will be done directly from vital registration with minimum adjustment.

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Appendix A: Tables

Table A 1 Recorded deaths from death notification forms

Age	1996 Male	1997 Male	1998 Male	1999 Male	2000 Male	2001 Male	2002 Male	2003 Male	2004 Male	2005 Male	2006 Male
0	13,003	13,089	15,088	14,952	15,178	15,617	18,023	20,126	21,857	24,110	25,561
1	2,304	2,244	2,622	2,851	2,863	3,147	3,261	3,752	4,298	4,404	4,923
2	961	874	1,159	1,102	1,247	1,345	1,546	1,614	1,822	1,793	1,680
3	578	530	611	657	751	778	922	1,020	1,195	1,098	1,021
4	474	422	516	504	551	637	621	752	908	885	736
Total	**17,319**	**17,159**	**19,997**	**20,066**	**20,590**	**21,525**	**24,373**	**27,264**	**30,079**	**32,291**	**33,921**

Age	1996 Female	1997 Female	1998 Female	1999 Female	2000 Female	2001 Female	2002 Female	2003 Female	2004 Female	2005 Female	2006 Female
0	11,603	11,636	13,399	13,660	13,683	14,206	16,333	18,180	19,275	22,012	22,142
1	2,063	2,073	2,535	2,703	2,677	2,933	2,970	3,291	3,981	3,889	4,498
2	822	821	1,036	1,003	1,179	1,234	1,396	1,485	1,695	1,650	1,480
3	477	428	584	555	611	636	772	853	1,024	959	849
4	379	351	373	419	486	524	560	653	884	796	706
Total	**15,345**	**15,309**	**17,926**	**18,340**	**18,636**	**19,532**	**22,031**	**24,462**	**26,860**	**29,305**	**29,675**

Age	1996 Total	1997 Total	1998 Total	1999 Total	2000 Total	2001 Total	2002 Total	2003 Total	2004 Total	2005 Total	2006 Total
0	24,606	24,725	28,487	28,612	28,861	29,823	34,356	38,306	41,132	46,122	47,703
1	4,367	4,317	5,157	5,554	5,540	6,080	6,231	7,043	8,279	8,293	9,421
2	1,783	1,695	2,195	2,105	2,426	2,579	2,942	3,099	3,517	3,443	3,160
3	1,055	958	1,195	1,212	1,362	1,414	1,694	1,873	2,219	2,057	1,870
4	853	773	889	923	1,037	1,161	1,181	1,405	1,792	1,681	1,442
Total	**32,664**	**32,468**	**37,923**	**38,406**	**39,226**	**41,057**	**46,404**	**51,726**	**56,939**	**61,596**	**63,596**

Table A 2 Extent of Completion of Birth Registration

Age	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Births (ASSA2003)	1,154,122	1,149,581	1,143,140	1,134,620	1,128,469	1,124,624	1,118,771	1,111,539	1,103,623	1,095,651	1,087,930
Recorded births	952,322	940,690	924,791	940,066	949,572	933,171	939,421	926,592	971,142	998,257	999,874
Completeness of birth registration	83%	82%	81%	83%	84%	83%	84%	83%	88%	91%	92%

Table A 3 Average parities per age group of mother.

Age Group	1	2	3	4	5	6	7
MEAN CEB(CS2007)	0.1	0.7	1.2	1.9	2.6	3.1	3.4
MEAN CEB (1996Census)	0.2	0.8	1.6	2.5	3.2	3.7	4.1
MEAN CEB (2001Census)	0.2	0.7	1.4	2.2	2.8	3.3	3.5
MEAN CEB (1998DHS)	0.1	0.8	1.6	2.5	3.2	3.5	4.0

Table A 4 Implied Mortality trends from Ward and Zaba mortality estimates using ASSA life tables

Reference	IMR			U5MR		
Period	male	female	Both	male	female	Both
1997.7	46	40	43	64	55	60
2000.2	49	43	46	71	63	67
2002.5	42	36	39	66	56	62
2004.5	46	39	42	72	62	67

Table A 5 The life table for ages 0-4, South Africa 2007 Community Survey

Age,	Mid-Year Population, Px			Death, Dx			Central Mortality rate,Mx			Probability of dying, qx		
x	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total
0	554,697	537,052	1,091,749	30,306	28,674	58,980				0.0532	0.0520	0.0526
1	535,695	518,134	1,053,829	7,772	6,244	14,016	0.0145	0.0121	0.0133	0.0144	0.0120	0.0132
2	504,152	503,920	1,008,073	4,718	4,796	9,513	0.0094	0.0095	0.0094	0.0093	0.0095	0.0094
3	486,476	488,675	975,151	1,695	1,748	3,443	0.0035	0.0036	0.0035	0.0035	0.0036	0.0035
4	459,613	472,318	931,931	1,449	1,464	2,913	0.0032	0.0031	0.0031	0.0031	0.0031	0.0031
									5q0	**0.0816**	**0.0784**	**0.0800**

Table A 6 The life table for ages 0-4, South Africa 2001 Census

Age, x	Mid-Year Population, Px			Death, Dx			Central Mortality rate,Mx			Probability of dying, qx		
	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total
0	439,084	446,019	885,103	23,677	19,474	43,150				0.0525	0.0427	0.0476
1	434,173	427,109	861,283	6,946	5,892	12,837	0.0160	0.0138	0.0149	0.0159	0.0137	0.0148
2	438,652	435,890	874,542	2,676	2,425	5,101	0.0061	0.0056	0.0058	0.0061	0.0055	0.0058
3	431,363	436,231	867,595	1,472	1,360	2,832	0.0034	0.0031	0.0033	0.0034	0.0031	0.0033
4	453,438	455,118	908,556	949	896	1,846	0.0021	0.0020	0.0020	0.0021	0.0020	0.0020
									5q0	**0.0783**	**0.0658**	**0.0721**

Table A 7 Fitted Completeness of death registration.

Completeness of death registration			
Year	Infants	Under-five	1-4
1996.0	44.2%	44.1%	42.7%
1997.0	45.1%	44.8%	42.9%
1998.0	46.6%	45.9%	42.9%
1999.0	49.1%	47.6%	42.8%
2000.0	53.0%	50.1%	42.9%
2001.0	58.5%	53.7%	43.5%
2002.0	65.6%	58.3%	43.9%
2003.0	73.4%	63.8%	46.2%
2004.0	80.8%	69.6%	51.0%
2005.0	86.7%	75.0%	53.3%
2006.0	91.0%	79.5%	57.5%

Table A 8 Final Estimates of IMR and U5MR (adjusted for completeness of death registration) for the Period 1996 to 2006.

	Infant Mortality Rates			Under-five Mortality Rates		
	Both	Male	Female	Both	Male	Female
1996	**48.4**	50.8	45.9	**66.1**	69.8	62.5
1997	**47.5**	50.0	45.0	**64.5**	67.7	61.2
1998	**53.2**	56.0	50.3	**73.3**	76.9	69.8
1999	**51.0**	52.9	49.0	**71.6**	74.4	68.7
2000	**48.0**	50.2	45.8	**69.8**	72.8	66.7
2001	**45.2**	47.0	43.3	**68.5**	71.4	65.5
2002	**46.6**	48.6	44.6	**71.5**	74.6	68.2
2003	**46.6**	48.7	44.6	**73.2**	76.7	69.6
2004	**45.8**	48.4	43.2	**74.2**	77.9	70.4
2005	**48.2**	50.1	46.3	**74.8**	77.9	71.6
2006	**47.8**	50.9	44.7	**73.1**	77.5	68.7

Table A 9 Comparison of ASSA and UNPD (IMGE) Estimates

	1995-2000		2000-2005		2005-2010	
	ASSA	IGME	ASSA	IGME	ASSA	IGME
IMR	54	57	56	59	44	49
U5MR	75	77	86	86	69	72

Appendix B: Stata Code used to drop Inconsistent CEB/CS data

```
*Group ages of reproductive women

gen age_15to49=p03_age if  p03_age>12 &  p03_age<50 & p04_sex==2
recode age_15to49  (12/14=0)
(15/19=1)(20/24=2)(25/29=3)(30/34=4)(35/39=5)(40/44=6)(45/49=7)

tab age_15to49 if age_15to49>0 [iw= persg_wgt]

*KEEP WOMEN OF REPRODUCTIVE AGE ONLY

drop if p04_sex==1
drop if p03_age<12
drop if p03_age>50
drop if  age_15to49==.
drop if p06_lastnight_stay>1
keep if  typedwell==30
keep if p41tceb==p42tcs+p43tcs+p44tcd
keep if  p42fcs+p43fcs+p44fcd==p41fceb
keep if p42mcs+p43mcs+p44mcd==p41mceb
keep if p41tceb==p41mceb+p41fceb
keep if p41tceb==p41mceb+p41fceb
```