The level and trends of child mortality in South Africa, 1996-2006.[1]

Timotheus B. Darikwa[2]
University of the Western Cape, Department of Statistics, Private Bag X17, Bellville, 7535, South Africa.
darikwatb@gmail.com

Rob Dorrington[3]
Centre for Actuarial Research, University of Cape Town, Private Bag X1, Rondebosch, 7701, South Africa

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. This study makes use of the Community Survey data of 2007 and adaptation of the correction to the children ever born/children surviving method suggested by Ward and Zaba (2009) to estimate current rates of infant and child mortality and establishes trends in childhood mortality between 1996 and 2006. The study found that infant mortality rates have been almost constant at 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 in 2006.

Keywords: Infant mortality, under-five mortality, HIV/AIDS prevalence, Brass Technique, Trussel variant, South Africa.

Resume

L'absence de données fiables sur l'estimation de la mortalité infantile en Afrique du Sud n'ont pas été mise à jour depuis presque dix ans à partir de 1998. Notre étude a établit les estimations sur les taux de mortalité infantile ainsi que la mortalité des enfants de moins de cinq ans. Notre analyse a utilisé les données de l'Enquête communautaire de 2007, recensement de 2001 et les résultats sur les recherches antérieurs depuis 1996.Les résultats montrent que le taux de mortalité infantile sont restés presque constant, environ 50 décès pour 1000 naissances vivantes tandis que pour moins de cinq le taux de mortalité ont augmenté, passant de 70 décès pour 1000 naissances vivants en 1996 à 75 décès pour 1000 naissances vivants en 2006.

1. This paper is based on the Masters of Philosophy in Demography thesis submitted at the University of Cape Town in December of 2009.
2. Corresponding author: Timotheus Brian Darikwa, University of the Western Cape, Department of Statistics, Private Bag X17, Bellville, 7535, South Africa. Email: darikwatb@gmail.com
3. Rob Dorrington, Centre for Actuarial Research, University of Cape Town, Private Bag X1, Rondebosch, 7701, South Africa

Mots clés: Mortalité infantile, Mortalité des moins de Cinq ans, Prevalence du VIH/SIDA, Technique de Brass, Variance de Trussel, Afrique du Sud.

Introduction

South Africa's past mortality trends and future estimates for the country have been developed by individual researchers and 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), the Department of Health [South Africa], Medical Research Council and Orc-Macro (2003) and Dorrington, Moultrie, Timaeus *et al.,* (2004). What is common among these sets of estimates is the undeniable reality that infant and under-five mortality rates were falling in South Africa until around 1992-1993 after which they probably increased, although there is much uncertainty about the estimates.

Unfortunately after 1996/7 the data on infant and childhood mortality have been too poor to allow accurate estimation of childhood mortality (Dorrington, Moultrie and Timaeus 2004), until the recent 2007 Community Survey. In addition the main method of estimating infant and under-five mortality indirectly, the children ever born/children surviving method (Brass 1975; Trussell 1975; United Nations 1983) produces biased estimates in an HIV/AIDS epidemic (Ward and Zaba 2009). Thus an adaptation of the correction factors to the children ever born/children surviving method suggested by Ward and Zaba (2009) is applied to estimate the levels and trend in childhood mortality between 1996 and 2006 on the assumption that the increase in completeness of the vital registration implied by estimates of past mortality rates was monotonic between 1996 and 2006.

Literature review and theoretical Framework

The South African vital registration is incomplete. Thus indirect techniques have to be used to estimate childhood mortality. Brass's children ever born/children surviving method (Brass 1975; Trussell 1975; United Nations 1983) has been used in the past to estimate childhood mortality trends in South Africa (Dorrington, Moultrie, Timaeus *et al.,* 2004; Udjo 2005) but the advent of HIV/AIDS resulted in the violation of the assumptions inherent in this method (Ward and Zaba 2009). However, Ward and Zaba (2008) suggest a correction to Brass's children ever born/children surviving method to deal with this problem on the assumption that the population and the epidemic have been stable for some time.

Ward and Zaba (2009) assessed the extent of the bias introduced by the HIV epidemic to the estimation of childhood mortality using the Brass method by simulating a stable population with constant prevalence over time and from this derived factors for correcting for the bias. Thus the true probability of dying before reaching age Z

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

where $n(Z)$ is the estimated correction factor dependent on the level of prevalence of women of child-bearing age and age Z, and $q(Z)^e$ is the mortality rate estimated by applying the Brass method without correction.

Two regression models were developed for determining the correction factors, $n(Z)$. The basic regression

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

where *PREV* is the prevalence of women aged 15-49, and the extended regression

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

where *PREV*15 is HIV prevalence of women aged 15-19 years.

Unfortunately stable populations with stable HIV prevalence are not very likely, and South Africa is no exception. There has been an upward trend in HIV prevalence in South Africa after 1986, (Dorrington, Johnson, Bradshaw *et al.*, 2006). Thus the assumption of stability is violated and we need to allow for this somehow in this study.

A new approach to estimating infant mortality, which is not particularly biased by HIV/AIDS is that proposed by Blacker and Brass (2005). They derived factors for converting the proportion dead of births in the last 24 months into infant mortality rate using simulation. The derived correction factors for this previous birth technique (PBT) ranged from 1.04 to 1.1 with a median value of 1.092. They give selection guidelines on which factors to use. The adjustment factor for South Africa is given as 1.0909 (Blacker and Brass 2005) and although it is based on data from the Agincourt Demographic Surveillance Site which appears to experience child mortality lighter than the country as a whole, we assume, since this factor is not very different from the average of the simulations, it can be used to estimate infant mortality for the country as a whole.

Data and methodology

The recent Community Survey of 2007 and the registered deaths from the vital registration for the whole country are the main data sources. The former had children ever born/children surviving data that was used to estimate infant mortality rates (IMR) and under five mortality rates (U5MR) (adjusted for HIV) at particular reference periods. It also had reported household deaths which were used to estimate childhood mortality levels directly and data on the survival of the last child born to women aged 12-49 which was used to estimate childhood mortality using PBT. The reported household deaths from the 2001 Census were used to directly estimate the level of child mortality around 2001, while past research was used to ascertain the level of child mortality in 1996. This section outlines how these data and methods were used to estimate child mortality and how the mortality trend between 1996 and 2006 were determined.

Initial infant and child mortality estimates were derived using three methods. First estimates are derived using the Brass's method without correction for bias due to AIDS deaths. The initial age specific estimates of mortality rates applying Brass's method to all the data produced rates that were higher for girls than boys. These inconsistencies have been noted by others (Udjo and van Aardt 2008) and they suggest that the data may be problematic. The 2007 Community Survey questionnaire included questions pertaining to both male and female children who are alive, dead and whether they still lived at home or lived elsewhere. These data were used to check the internal consistency of the answers by reconciling the responses to these questions with those to questions about the total number of children ever born/children surviving . These checks revealed a number of inconsistencies.

We decided to exclude the data for women with inconsistencies from the analysis resulting in a loss of eight per cent of the responses. The estimates of mortality from this new data set no longer produced estimates of mortality of girls higher than that of boys. These data were then used to produce the estimates of child mortality presented below.

These estimates had to be adjusted for the impact of HIV/AIDS on the method. The use of the Ward and Zaba (2009) correction factors assumes that HIV prevalence has remained constant over time. This is not the case with South Africa and hence there is a need for correction factors that allow for the fact that HIV prevalence has not been stable over the past years.

Deriving accurate correction factors for a changing epidemic is a major research project on its own so it was decided to adjust the Ward and Zaba correction factors to allow approximately for the fact that prevalence has been rising steadily until shortly before the survey using the following rationale. Had there been no HIV the adjustment would be zero. Thus, what is required are correction factors that lie between those calculated using the prevalence at the time of the survey and zero, which in some way reflects the lower average prevalence applicable to the women at the time they gave birth. In addition these correction factors should range from nearly the full adjustment for births to women at the youngest age group to very little for those of women in the oldest age group.

There are several ways of meeting these requirements, all of which give similar answers. The approach we adopted was to scale the Ward and Zaba adjustment by the ratio of the prevalence at the time of the birth of the child, to the prevalence at the time of the survey. The average prevalence at the time at which the child was born was 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 was the number of births to women at these ages. These HIV prevalence rates were then used to adjust Ward and Zaba's correction factors.

The period infant and under-five 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 mortality rates underlying either the ASSA2003 or the United Nations Population Division (UNPD) projection models provide model life tables that incorporate the impact of HIV/AIDS on mortality, varying over time. For our purposes we used life tables produced by the ASSA2003 model. We allowed for the changing "shape" of the life table over time using different life tables for each age group, namely, the life table applicable to the particular time reference point. A one parameter Brass logit relational equation was then used to calculate the implied IMR and U5MR for each given period.

The mean survival time for children was set in their model at 2.5 years from time of infection and for adults it was set at 8 years, and they assumed that no infected child lives beyond the age of 5 years, and ignored the impact of later infection of children after they become sexually active. Thus their adjustment is quite wrong for the oldest and to some extent second oldest age groups. For example, 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 increasing the estimated mortality rates based on the reports of women in the older age groups. Thus the estimates at these ages are of no use and are disregarded in this analysis.

Next we used the Blacker and Brass's (2005) variant of the previous birth technique to estimate the infant mortality rate circa 2006 from the survival status data of last child born reported in the 2007 Community Survey. The reference date of the survey can be assumed to be mid-February 2007, thus the PBT is used to analyse the sex-specific survival status of children born 24 months before 15 February 2007. The mortality estimates for girls were higher than for boys for the PBT and this anomaly remained even after discarding the cases with contradictory summary births history data which suggest that the data remain problematic. Finally, we estimated infant and child mortality directly from the deaths in the previous year as reported by households using synthetic cohort life tables.

The estimates of mortality rates for 1996 were determined from past research. The 1998 South Africa Demographic and Health Survey and the 1996 Census are the two most reliable sources of data that have been used to estimate national child mortality rates in South Africa around 1996. There are various estimates of child mortality for 1996 (Department of Health [South Africa], Medical Research Council and OrcMacro. 2003; Dorrington, Moultrie, Timaeus *et al.,* 2004; Nannan, Bradshaw, Timeaus *et al.,* 2000; Udjo 2005). The decision to choose the best estimate for that year is not an easy one. It was thus decided to take an average of the estimates from the 1996 Census data and the indirect and direct estimates from the 1998 SADHS as described in more detail in Darikwa (2009).

Child deaths in the past year as reported by households in the 2001 Census and 2007 Community Survey were used to estimate child mortality rates a year before the date of the 2001 Census and 2007 Community Survey, respectively. The age specific synthetic cohort life tables are constructed using the deaths reported by households in the 2001 Census and the 2007 Community Survey.

These mortality estimates were then used to determine the trend in the completeness of death registration by age between 1996 and 2006 by assuming that the completeness of death registration follows a logistic trend over time. In estimating of the trend in completeness of reporting over the period it was 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 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[4] (for similar use of assumption also see, Cabigon 1996). The logistic curve was then fitted using the LOGISTIC spreadsheet (Arriaga 1994). Knowledge of the completeness of registration of deaths by age was then used to adjust the number of deaths from vital registration (VR) in each year between 1996 and 2006 and to determine the child mortality trends in the 10-year period.

Results

The Blacker and Brass (2005) variant of the previous birth technique gave an infant mortality rate of 46 infant deaths per 1,000 live births for the year before the 2007 Community Survey. The sex-specific infant mortality rates exposed the anomaly of the higher female mortality rate of 52 than the 39 for males. Although this could be the result of underreporting of male deaths, it is not clear why this would be the case. The anomaly could not be eliminated by removing data with obvious anomalies. This discrepancy has been noted before, for example, it was found with infant mortality rates derived from the 1982 Fertility Survey based data (Chimere-Dan 1993; Dorrington, Bradshaw and Wegner 1999) and also with child mortality rates derived for the years 2003 and 2004 using data from a Health and Demographic Surveillance Site in Kwazulu-Natal (Muhwava and Nyirenda 2008).

Using the deaths reported by households in the 2007 Community Survey gave an infant mortality rate of 53 deaths per 1,000 births and an under-five mortality rate was estimated at 80 per 1,000 births.

To estimate the child mortality in the year before the 2007 Community Survey the child mortality results obtained using the PBT and those calculated directly from the deaths reported by the households were compared with those projected by the ASSA2003 model (Dorrington, Johnson, Bradshaw *et al*., 2006) and the United Nations Population Division/World Health Organisation estimates (UNICEF, WHO, The World Bank *et al.*, 2007). These comparisons showed that the estimates from the PBT and the ASSA2003 model around 2006 were close (46 versus 48, respectively) while the estimates calculated directly from

4. 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 that is registered is not registered than that an unregistered birth would be registered in order to register the death.

deaths reported by household and those projected by the United Nations population division around 2006 are close to each other (53 versus 56, respectively). The difference between the direct estimate of the infant mortality rate and that estimated using the PBT is about 7 deaths per 1,000 live births, which is quite large.

Which estimate to choose is not obvious but the estimate using the PBT probably underestimates infant mortality, since it would imply that registration of infant deaths in that year was 95.6 per cent complete. This is higher than the completeness of birth registration in the country of 92 per cent (Darikwa, 2009). Since the completeness of infant deaths is unlikely to 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 1,000 live births is an underestimate of child mortality in 2006. Since 46 is too low and 53 is too high the average of the estimates from the two methods was used to give a final infant mortality rate of 49 deaths per 1,000 live births for the year centred on 2006.6.

The under-five mortality rate of 80 around 2006 estimated from the Community Survey data may be too high when compared with the estimates for 2006 from ASSA2003 (73) and United Nations Population Division/World Health Organisation (69) (UNICEF, WHO, The World Bank *et al.*, 2007), and an infant mortality rate of 49 deaths per 1000 births. Thus this estimate was adjusted to the extent of the averaged infant mortality rate by multiplying it by a factor of 0.932835 (= 49.1/52.6, being the ratio of IMR to U5MR obtained using the direct method from reported household deaths in the 2007 Community Survey) 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) which corresponds to the ratio of registered deaths in these ages and the ratio of rates from other sources (e.g. ASSA2003). Thus the final estimate of under-five mortality is 75. Thus the estimates that apply for the year prior to the survey date for the infant and under-five mortality rates are 49 and 75 deaths per 1,000 live births, respectively.

The corrected data on children ever born/children surviving from the Community Survey was used to calculate the original Brass estimates of child mortality using the West model life table to convert the proportion dead of children into the probabilities of dying before reaching age x, $q(0,x)$, and the reference dates to which $q(0,x)$ refers are derived in the usual way. The Ward and Zaba (W&Z) correction factors were then applied to give $q(0,x)$s adjusted for the HIV prevalence among women age 15-49, which stood at approximately 22 per cent at the date of the survey. The results are shown in Table 1. The unadjusted $q(0,x)$ are implausibly low, particularly in recent years, while the W&Z adjusted $q(0,x)$s are too high, particularly at the higher ages.

Table 1 Application of Ward and Zaba (W&Z) basic regression method to the 2007 Community Survey.

Age x	Reference date	Original Brass's q(0, x)	W&Z's q(0, x)	HIV prevalence at reference date	Adjusted W&Z (1) q(0, x)	Prevalence at time of birth	Adjusted W&Z (2) q(0, x)
1	2005.9	0.0412	0.0513	20.9%	0.0509	20.8%	0.0509
2	2004.5	0.0459	0.0580	20.0%	0.0571	18.9%	0.0565
3	2002.5	0.0462	0.0615	18.1%	0.0590	15.3%	0.0570
5	2000.2	0.0508	0.0834	14.7%	0.0730	11.0%	0.0673
10	1997.7	0.0510	0.0856	9.4%	0.0660	7.0%	0.0622
15	1995.1	0.0659	0.1117	3.8%	0.0740	3.8%	0.0739
20	1992.2	0.0869	0.1945	0.8%	0.0909	1.6%	0.0950

The Ward and Zaba estimates in the forth column of Table 1 are determined by the HIV prevalence at the time of the survey, which is higher than the average prevalence rates that existed in the age group of mothers at the time when they were giving birth. Thus the W&Z mortality estimates were thus adjusted by multiplying the Ward and Zaba's correction factors with 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 results are shown in column 8 of Table 1(W&Z (2)). Interestingly it was found that approximately similar results could be obtained when W&Z correction factors are adjusted using the ratio of the HIV prevalence rate at the reference date and the rate at the date of survey. Results are presented in column 6 of Table 1 (W&Z (1)).

The adjusted W&Z (2) estimates were used in conjunction with life tables from the ASSA2003 model to determine the implied infant mortality rate *q(0,1)* and the under-five mortality rate *q(0,5)* using Brass's logit relational model with one parameter. 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. As a check on the dependence of the results on the choice of model life tables (incorporating the impact of AIDS) the exercise was repeated using the latest United Nations Population Division life tables that also incorporates HIV/AIDS - this gave similar results to the above (For more details see Darikwa 2009). Thus it can be deduced that the results are not reliant on the model used to estimate the impact of AIDS on the mortality of children over time.

The 1996 infant and under-five mortality rates obtained by taking averages of the estimates from the 1996 Census data and the indirect and direct estimates from the 1998 SADHS were 50.5 and 67 deaths per 1,000 live births, respectively (Darikwa 2009). The deaths reported by household data from the 2001 Census gave an infant mortality rate of 48 per 1,000 and an under-five mortality rate of 72 per 1,000 live births. These estimates are within the range of the "illustrative life table" estimates produced by Dorrington, Moultrie and Timaeus (2004) and are thus considered to be reasonable estimates for the level of childhood mortality for the year prior to the 2001 census.

The decision on which is the best estimate of the trend in completeness of death registration is not an easy one. The logistic function was chosen as it approaches a limit with time and was found to fit the data well. Empirical estimates of completeness were derived by first calculating under-five and infant mortality rates for each year from 1996 to 2006 directly using the registered deaths and estimates of the number of births and of mid-year population for ages 1-4 from the ASSA2003 model.

Table 2 shows the estimates 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 registration 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 registration for infants, 1-4 year olds and children under age five, over the years.

The curve fitted to the completeness of death registration for infants, children below age five and the children aged 1-4 as well as the observed completeness are shown in Figure 1. The first two panels of Figure 1 show the observed and fitted values. Generally, the logistic curves give a good fit to the estimates of completeness of death registration. The completeness of death reporting has been increasing over the years and at all ages. The third panel shows that the completeness of registration of infant death has improved faster than reporting of death for children aged 1-4. This has seen the completeness of death registration of infant deaths rising from 43 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.

Table 2 Data points used in deriving trends in completeness of death registration.

IMR			U5MR		
Empirical estimate	Direct estimate (VR)	Implied Completeness of death	Empirical estimate	Direct estimat e	Implied Completeness of death
50	21	43%	67	29	44%
43	21	50%	60	29	49%
46	25	55%	67	35	52%
48	26	56%	72	37	51%
39	31	79%	62	42	67%
42	37	87%	67	52	77%
49	44	89%	75	58	78%

The infant and under five mortality rates derived directly from the vital registration data are then adjusted for the incompleteness of death registration from this curve. 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.

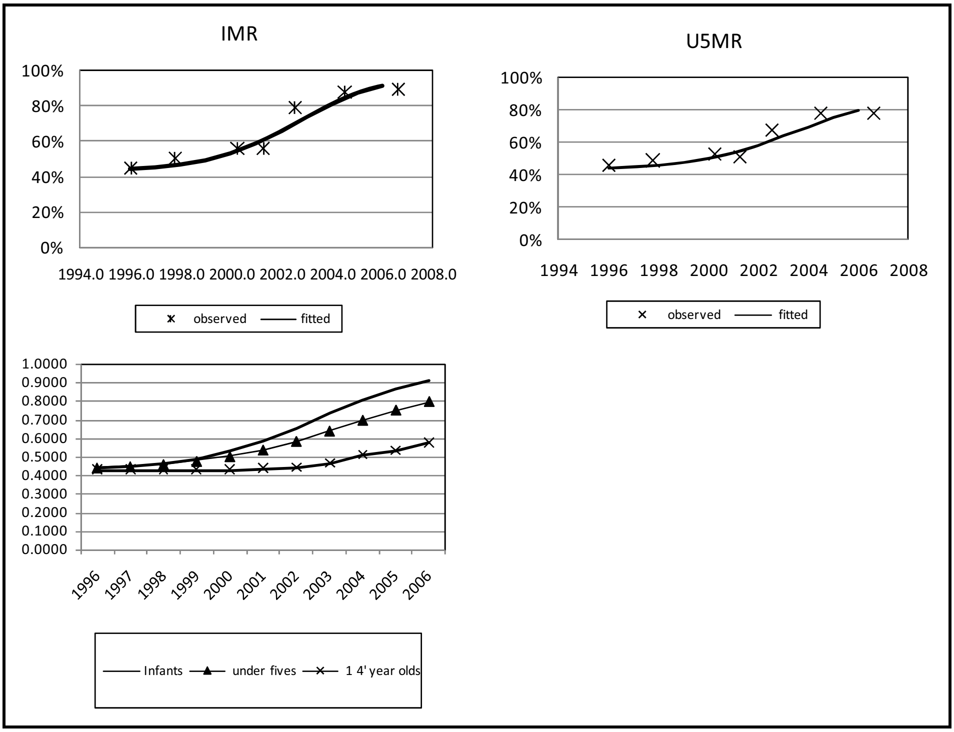
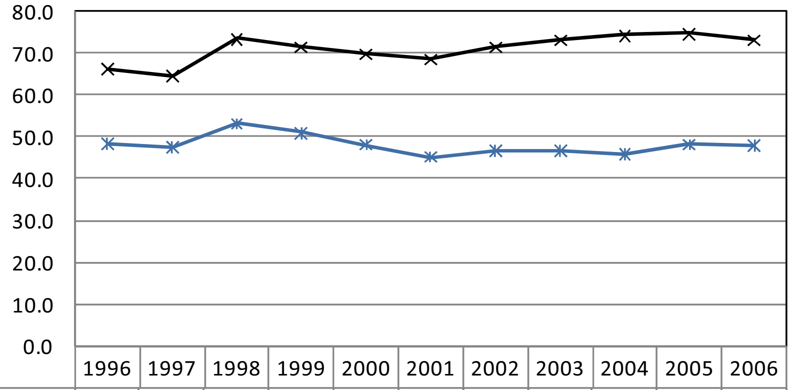


Figure 1 Completeness of death registration of infants, children below 5 and children aged 1-4.

The trends in mortality rates (adjusted for completeness of death registration) over the period are shown in Figure 2. These trends show that IMR may have remained fairly level at around 50 deaths per 1,000 live births over the decade while the under-five mortality rates have increased slightly from 70 deaths per 1,000 births in 1996 to around 75 deaths per 1,000 live births by 2006. Male rates are approximately 5% higher and female rates approximately 5% lower than these rates for both sexes combined.



	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
IMR(both)	48.4	47.5	53.2	51.0	48.0	45.2	46.6	46.6	45.8	48.2	47.8
U5MR(both)	66.1	64.5	73.3	71.6	69.8	68.5	71.5	73.2	74.2	74.8	73.1

Figure 2 Trends in Infant and Under-five mortality rates (adjusted for completeness of death registration) in South Africa, 1996-2006.

Discussion and conclusion

The objective of this study was to estimate the level of and trend in child mortality rates using deficient data biased due to HIV/AIDS, inter alia, in particular those from the 2007 Community Survey. The analysis has shown that the application of an adaptation of the Ward and Zaba adjustment to the estimates from the children ever born/ children surviving data from the 2007 Community Survey can be used to produce approximate estimates of levels and trends of IMRs and U5MRs for the whole of South Africa.

There is evidence that the completeness of death and birth registration has improved. 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, could be derived directly from vital registration with minimum adjustment.

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

The trends obtained are consistent with 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).

Research has shown that poverty levels worsened between 1995 and 2000 (May and Woolard 2005) and that the number of people who are poor actually increased by about 2.7 million for the same period (Dorrington, Moultrie, Timaeus *et al.,* 2004; Meth and Dias 2004). After 2000 there was a modest decline in poverty (Meth 2006; van der Berg, Burger, Burger *et al.,* 2005). 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 government of South Africa has been focusing on prevention of mother to child transmission (PMTCT), anteretroviral treatment (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 impacts of these programmes on baseline mortality have probably been overwhelmed by HIV related mortality to the extent that the overall mortality rates have remained relatively constant. The uncertainty around the estimates allows for the possibility that mortality rates peaked during the period under review. It would seem that PMTCT and HAART programmes are merely preventing an increase in overall infant mortality. The mortality levels might be expected to start going down as the government efforts start taking effect. There is a need to increase efforts to reduce poverty. These programmes have to be complemented by a robust multi-sectored approach that will increase access to the interventions for HIV positive women and their offspring to ensure a downward trend in child mortality.

The estimates of infant and under-five mortality rates obtained by adjusting the vital registration system are contrasted with estimates from the ASSA2003 model in Figure 3. The infant mortality trends suggest that there has been a reversal in child mortality in the early 1990s until 1996. This was followed by a 10-year period of relatively constant mortality rates, indicating that 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 *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 soon to be released ASSA2008 model has lower infant and under-five mortality rates with a less pronounced peak than the ASSA2003 model for the period under review. .

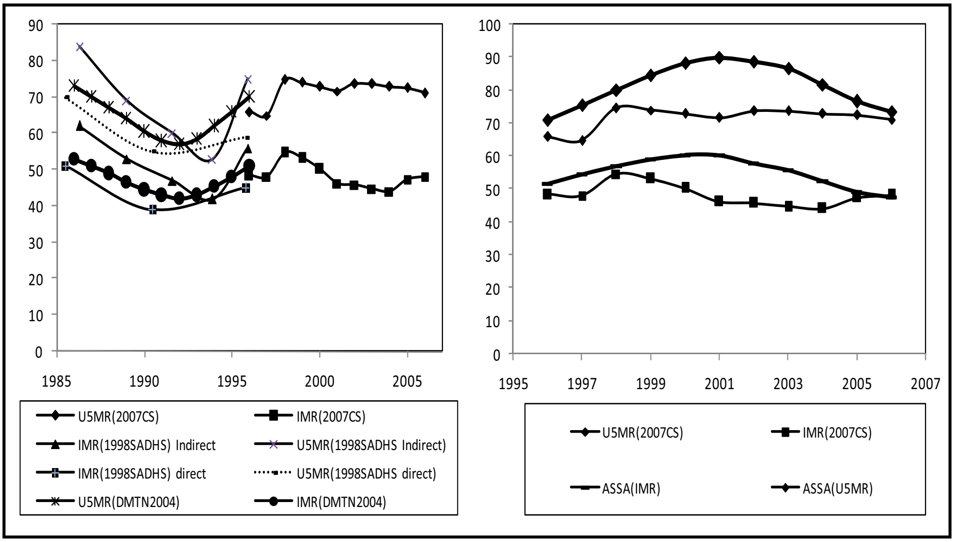


Figure 3 Child mortality trends in South Africa, 1985-2007.

Reference

Arriaga, E E 1994. Population Analysis with Microcomputers. Volume 1: Presentation of Techniques: US Census Bureau.

Blackr, John and William Brass. 2005. "The Estimation of Infant Mortality From Proportions Dying among Births in the Last 24 Months." SAJDem 10(1&2):25-42.

Brass, William. 1975. "Methods for Estimating Fertility and Mortality from Limited and Defective Data." Chapel Hill N.C: Laboratories for Population Statistics, Carolina Population Centre.

Cabigon, Josefina V. 1996. "Indirect Estimation of Maternal Mortality Ratios for 1990-1995 at the National, Regional, Provincial and City Levels, Philippines." In Seminar on Innovative Approaches to the Assessment of Reproductive Health. Manila, The Philippines: International Union for the Scientific Study of Population.

Chimere-Dan, O. 1993. "New estimates of infant and child mortality for blacks in South Africa, 1968-1979." S AfrMed J 83:199.

Darikwa, Timotheus Brian. 2009. "Estimating the level and Trends of Child Mortality in South Africa, 1996-2006." In Centre for Actuarial Research. Cape Town: University of Cape Town.

Department of Health [South Africa],Medical Research Council and OrcMacro. 2003. "South Africa Demographic and Health Survey Report, 1998." Pretoria: Department of Health.

Dorrington, R.,L. Johnson,D. Bradshaw and T. Daniel. 2006. "The Demographic Impact of HIV/AIDS in South Africa. National and Provincial Indicators for 2006." Cape Town: Centre for Actuarial

Research, South African Medical Research Council, Actuarial Society of South Africa.

Dorrington, Rob, Debbie Bradshaw and Trevor Wegner. 1999. "Estimates of the Level and Shape of Mortality Rates in South Africa Around 1985 and 1990, Derived by Applying Indirect Demographic Techniques to Reported Deaths." Cape Town: Medical Research Council Technical Report

Dorrington, Rob,Tom A. Moultrie and Ian M. Timaeus. 2004. "Estimation of Mortality using the South African Census 2001 Data. CARe Monography 11." Cape Town: Centre for Actuarial Research University

Dorrington, Rob,Tom A. Moultrie, Ian M. Timaeus and Nadine Nannan. 2004. "Estimates of Provincial Fertility and Mortality in South Africa, 1985-1996." SAJDem 9(2):25-57.

May, J. and I Woolard. 2005. "The State of Underdevelopment in South Africa, 1995-2005." In The Development Bank of Southern Africa: School of Development Studies, University of KwaZulu-Natal.

Meth, Charles. 2006. "What was the Poverty Headcount in 2004? A critique of the Latest Offering from van der Berg *et al*." School of Development Studies, University of KwaZulu-Natal.

Meth, Charles and Rosa Dias. 2004. "Increases in poverty in South Africa, 1999-2002." Development Southern Africa 21(1): 59 - 85.

Muhwava, William and Makandwe Nyirenda. 2008. "Demographic and Socio-Economic Trends in the ACDIS, Monograph No 2." Mtubatuba, South Africa: Africa Centre for Health and Population Studies.

Murray, Christopher J.L., Thomas Laakso,Kenji Shibuya,Kenneth Hill and Alan D Lopez. 2007. "Can we achieve Millennium Development Goal 4? New analysis of country trends and forecasts of under-5 mortality to 2015." Lancet 370(9592):1040-1054.

Nannan, N.,D. Bradshaw,I. Timeaus and R. Dorrington. 2000. "The impact of HIV/ AIDS on infant and child mortality in South Africa." Poster exhibited at the 13th International AIDS Conference in Durban:1-9.

Trussell, T. James. 1975. "A Re-estimation of the Multiplying Factors for the Brass Technique for Determining Childhood Survivorship Rates." Population Studies 29(1):97-107.

Udjo, E. O. and C.J. van Aardt. 2008. "Evaluating the population, economic and demographic aspects of the 2007 Community survey." Pretoria: Bureau of Market Research.

Udjo, Eric O. 2005. "An Examination of Recent Census and Survey data on Mortality Within the Context of HIV/ AIDS." In The Demography of South Africa, eds. Tukufu Zuberi, Amson Sibanda and Eric O. Udjo. New York, London.: M.E.Sharpe.

UNICEF, WHO, The World Bank and United Nations Population Division. 2007. "Levels and Trends of Child Mortality in 2006: Estimates developed by the Inter-agency Group for Child Mortality Estimation." New York: United Nations Population Division:1-54.

United Nations. 1983. "Manual X, Indirect Techniques for Demographic Estimation." New York: United Nations

Van der Berg, Servaas, Ronelle Burger,Rulof Burger,Megan Louw and Derek Yu. 2005. "Trends in poverty and inequality since the political transition." Stellenbosch University, Department of Economics.

Ward, Patrick and Basia Zaba. 2009. "The Effect of HIV on the Estimation of Child Mortality Using the Children Surviving/ Children Ever Born Technique." SAJ Dem 11(1):65-99.