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The effect of socio-demographic, socio-economic and environmental factors on under-five mortality in South Africa: analysis of the 1998 South African Demographic Health Survey dataset

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UNDER-5 MORTALITY STATISTICS IN SOUTH AFRICA:

Shedding some light on the trend and causes 1997-2007

AUTHORS:

Nadine Nannan, Rob Dorrington, Ria Laubscher, Nesbert Zinyakatira, Megan Prinsloo, Timotheus Darikwa, Richard Matzopoulos, Debbie Bradshaw

April 2012

Burden of Disease Research Unit

SOUTH AFRICAN MEDICAL RESEARCH COUNCIL



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A copy of this report is available on the Internet at: www.mrc.ac.za/bod/bod.htm

Dedication

We dedicate this report to the memory of the late David Bourne (1947–2009). He was a member of the team who set up this investigation and is remembered for his collegial spirit, his endless sense of enquiry and his public health concern about child mortality.

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Acronyms and abbreviations

ACME	-	Automated Classification of Medical Entities
AIDS	-	Acquired immune deficiency syndrome
ACDIS	-	Africa Centre Demographic Information System
ART	-	Antiretroviral treatment
ASSA	-	Actuarial Society of South Africa
HIV	-	Human Immunodeficiency Virus
Child PIP	-	Child Healthcare Problem Identification Programme
CEB/CS	-	Children ever borne/children surviving
DHIS	-	District Health Information System
DNF	-	Death notification form
HDSS	-	Health and Demographic Surveillance Site
HSRC	-	Human Sciences Research Council
ICD	-	International Statistical Classification of Diseases and Related Health Problems
IGME	-	Interagency Group for Child Mortality Estimation
IHME	-	Institute for Health Metrics Evaluation
IMR	-	Infant mortality rate
KIDS	-	KwaZulu-Natal Income Dynamics Survey
MDG	-	Millennium Development Goals
MRC	-	Medical Research Council
NBD	-	National burden of disease
NIDS	-	National Income Dynamics Survey
NIMSS	-	National Injury Mortality Surveillance System
NMR	-	Neonatal mortality rate
PCP	-	Pneumocystis carinii pneumonia
PEM	-	Protein energy malnutrition
PNMR	-	Perinatal mortality rate
PPIP	-	Perinatal Problem Identification Programme
PMTCT	-	Prevention-of-mother-to-child-transmission
SADHS	-	South African Demographic and Health Survey
U5MR	-	Under-5 mortality rate
UN	-	United Nations

UNAIDS	-	Joint United Nations Programme on HIV/AIDS
UNDP	-	United Nations Development Programme
UNICEF	-	United Nations Children's Economic Fund
USCB	-	United States Census Bureau
WHO	-	World Health Organization

Glossary

Cause of death

The cause of death statistics reported in this review focus on the underlying cause of death, which is considered to be important from a public health point of view in terms of the conditions that need to be addressed to reduce mortality. According to the ICD-10, the **Underlying Cause of Death** is the disease or injury that started the sequence of events leading directly to death or the circumstances of the accident or violence that produced the fatal injury. In the case of a violent death, the form of external violence or accident is antecedent to the injury entered, although the two events may be almost simultaneous. The **Immediate Cause of Death** is the final disease, injury or complication directly causing the death.

Broad causes of death

This review adopts the Global Burden of Disease Study (Murray and Lopez, 1996) approach and classifies causes of death into categories that fall into three broad groups:

Type I: communicable diseases, perinatal conditions and nutritional deficiencies

Type II: non-communicable causes of death

Type III: injury deaths

Child mortality age groups

The age groups considered in this report are neonatal (0–27 days), comprising early neonatal (0–6 days) and late neonatal (7–27 days); post-neonatal (1–11 months); and children (1–4 years). In terms of health programmes, a key distinction would be between newborns (<1 month) in the neonatal period, and babies and children aged 1–59 months. Demographically, the key age groups would be infants (0–11 months) measured by the infant mortality rate (IMR) and children (1–4 years) measured by the child mortality rate (CMR). Both age groups are measured by the Under-5 Mortality Rate (U5MR).

Executive summary

The global target set for Millennium Development Goal 4 is to reduce the child mortality in 2015 by two-thirds of the rate that it was in 1990. There is, however, considerable uncertainty around the estimates of child mortality in South Africa. This is because vital registration is incomplete, and there has not been a reliable household survey collecting detailed birth history information since 1998. Furthermore, the methods for estimating mortality from household surveys and censuses are biased in high HIV prevalence settings. Such methods now underestimate child mortality due to the correlation between the mortality of mothers and the mortality of her children due to HIV.

This report reviews available empirical data on levels and causes of child mortality, and consolidates information about the changes that have occurred between 1990 and 2007. The consistency between data sources is considered and efforts are made to estimate child mortality trends. The data include 11 years of vital registration data (1997–2007) from Statistics South Africa, national household surveys and censuses, five years of injury data collected by the National Injury Mortality Surveillance System (2001–005), as well as provincial and demographic surveillance and health service data. Model estimates of child mortality are also considered and assessed against the empirical data.

Vital registration shows that in 2007, the majority of registered child deaths were infants (76%), with 22% of these deaths occurring in the first month of life, i.e. the neonatal period. The majority of the deaths (54%) occurred in the post-neonatal age group (1–11 months). Of the 61 335 under-5 deaths registered in 2007, diarrhoeal disease accounted for 21% of deaths, lower respiratory infections for 16% and ill-defined natural causes for 13%. Only 1.2% of the deaths were certified as being due to HIV/AIDS. The number of registered child deaths increased steadily since 1997, peaking in 2006. The greatest rate of increase was observed in the post-neonatal period, with a particularly marked rise in infection-related deaths including diarrhoea and pneumonia. Interestingly, HIV/AIDS mortality is not particularly apparent in the neonatal period, but there is a definite ‘AIDS signature’ (a peak between months 2 and 4), which develops over the course of the epidemic. These deaths are concentrated in the pneumonia and ill-defined categories and to a lesser extent in the diarrhoea category. This peak starts to decline approximately two years earlier in the Western Cape (2003) than in the other provinces (2005) due to the earlier roll-out of PMTCT in that province.

Despite several efforts to measure child mortality rates since the 1998 SADHS, the summary birth history data from the 2007 Community Survey are the only data that allow the estimation of recent levels of infant and under-5 mortality (Darikwa, 2009). By excluding data that were internally inconsistent, and accounting for bias due to the impact of AIDS on maternal mortality using a method proposed by Ward and Zaba (2008) adapted to allow for the increasing prevalence of HIV over time, Darikwa and Dorrington (2011) estimated that infant and under-5 mortality rates remained largely unchanged at between 50 and 75 per 1 000 live births. The expected numbers of deaths on the basis of these estimates imply that the completeness of vital registration for children has increased considerably between 1997 and 2006, particularly since 2001. Scaling up the vital registration data for incompleteness of registration on the assumption that this increased monotonically over the period 1997-2007 provides the trend in the mortality rates shown in Figure 1. The adjusted data suggest a possible decline in the neonatal mortality rate of approximately 18–14 deaths per 1 000 live-births between 1997 and 2001. However, the rate remained roughly level thereafter.

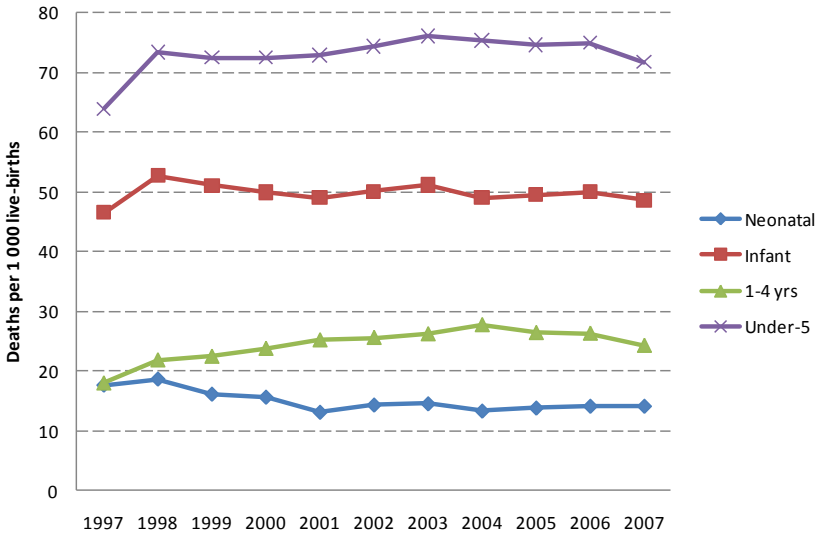


Figure 1: Estimated South African childhood mortality rates per 1 000 live-births, 1997–2007

Model projections of the U5MR follow different trajectories during this period. The ASSA2003 AIDS and Demographic Projection Model of the Actuarial Society of South Africa projects higher levels of child mortality for this period than we estimate. The ASSA2008 model, released in 2010, has taken the more recent estimates into account, and has revised downward the estimates of child mortality compared with ASSA2003. However,

this possibly declines too quickly in recent years. On the other hand, the latest model estimates from the Institute of Health Metrics and Evaluation (IHME) appear to ignore the improvement in completeness of vital registration entirely and consequently produce a completely unrealistic trend in child mortality. The estimates from the Interagency Group on Mortality Estimation (IGME) appear to be more or less at the correct level. The child mortality estimates in the MDG Country Report indicated a considerable increase in the U5MR but little change in the IMR over the period under consideration. The MDG Country Report estimate of U5MR cannot be considered plausible.

While Darikwa and Dorrington's estimates show a more level trend than the projection models that mostly indicate a more pronounced peak with a turning point around 2003, the cause of death trends, after correction using their estimate of completeness of registration, seem plausible. These estimates (Figures 2 and 3) indicate that there was a drop in neonatal mortality rates between 1997 and 2001 (possibly as a result of more births at facilities), with little change thereafter; a peak in HIV-related mortality in about 2003; an increase in childhood diarrhoeal death rates over the period; and a slight decline in childhood injury death rates over the period. Death rates from lower respiratory infections and TB follow the same pattern as HIV, and peak in 2003 for infants and in 2003/4 for children (1–4 years). The diarrhoea mortality rates, however, are different and showed an increase in 1998/9, followed by a dip and then a continued increase until 2006 before declining. These trends appear to compensate one another, so that the overall under-5 mortality rate and the infant mortality rate were roughly stable between 1998 and 2007, albeit at levels higher than those in the early 1990s.

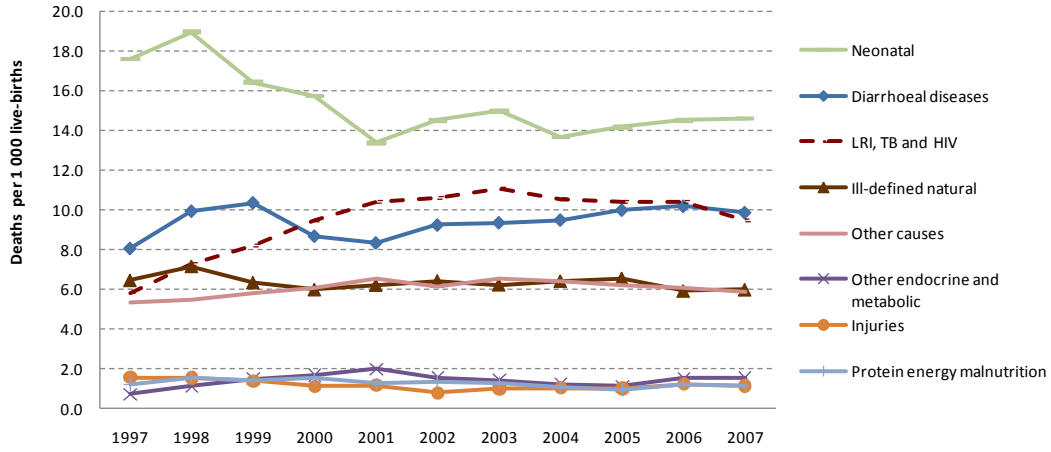


Figure 2: Causes of infant deaths after recoding P-codes and adjusting for under-registration, 1997–2007

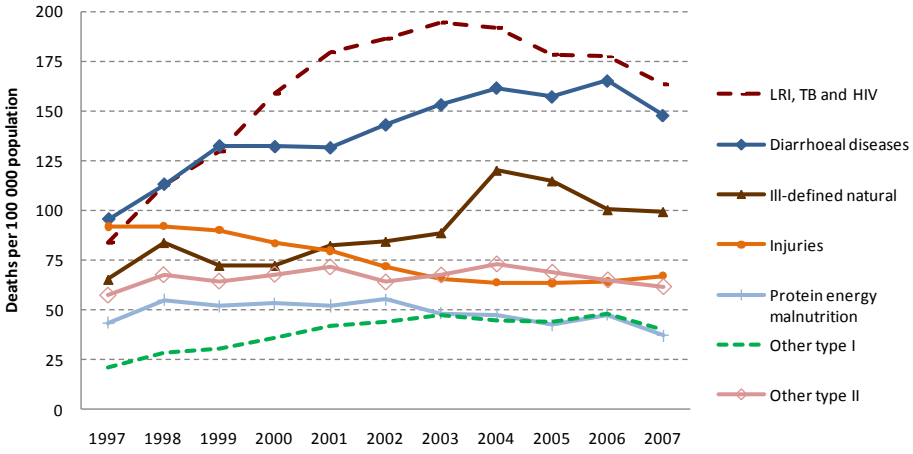


Figure 3: Estimated death rates of children 1-4 years per 100 000 by cause, 1997–2007

From this review, we conclude that there have been substantial improvements in the registration of child deaths during 1997–2007, reaching levels of 90% completeness for infants and 60% for children aged 1–4 years. Despite these improvements, South Africa cannot use vital statistics to measure child mortality without adjusting for completeness. In addition, the cause of death information needs to be interpreted carefully. Efforts to ensure that all deaths are registered and improve the quality of the cause of death information must continue.

The variation in the model projections reflects a degree of uncertainty in the trajectory of the U5MR in recent years. The general trend is quite apparent, with most projections reflecting a reversal of the downward trend of U5MR during the 1990s. However, there is no agreement about the lowest level reached before the reversal (although most estimates range from 50–60 per 1 000 in the early to mid-1990s from approximately 80 per 1 000 in 1984/5), nor the exact course that the rate followed over the change of the millennium (although most estimate a peak at 70–80 per 1 000 from 2003–2005, after which the rates fall), making it important that a good quality household survey, including a full pregnancy history, be undertaken to provide further information about the historical trend in the U5MR.

In the meantime, the cause of death pattern indicates that by 2007, the 'Big Five' health challenges (HIV/AIDS, pregnancy and childbirth complications, newborn illness, childhood infections, and malnutrition) previously identified by the South African Every Death Counts Working Group (2008), remain the priority challenges in order to meet MDG 4.

Chapter 1. Introduction

Reducing child mortality has been identified as one of the eight Millennium Development Goals (MDGs) (United Nations, 2000). The target for Goal 4 is to reduce child mortality (as measured by the infant and under-5 mortality rates) by 2015 by at least two-thirds of the rate that it was in 1990. These indicators are not only an index of the health status of children, they are an important component of life expectancy, and provide an indication of the overall health and development of the community.

The importance of measuring trends in child mortality over time is clear. Monitoring child mortality rates, however, poses a challenge for low- and middle-income countries. The *Lancet* 'Who Counts?' series highlights the fact that vital registration is often incomplete, with many deaths, particularly amongst the poorest families, not being recorded (Setel et al., 2007). Surveys and demographic surveillance data have become important sources of child mortality data in many countries. However, these are costly and do not provide up-to-date measures of child mortality, often making it necessary to track child mortality using models extrapolated from earlier empirical data (Child Mortality Co-ordination Group, 2006).

South Africa currently falls into the category of countries in which the vital statistics are not yet of a high enough quality to produce reliable estimates of child mortality directly. However, in contrast to many other countries, in which there have generally been little or no improvements in vital registration (Setel et al., 2007), great strides have been made in improving population health statistics in South Africa. In terms of vital registration, a new death notification form was introduced in 1998, which complied with WHO standards for the certification of cause of death, and was accompanied by efforts to extend death registration to all areas of the country.

Good progress has been made in improving the completeness of death registration, with about 90% of adult deaths estimated to be registered in recent years (Dorrington *et al*., 2001; Statistics South Africa, 2010a; Dorrington and Bradshaw, 2011). The extent of completeness of child deaths registration, however, is less certain, given the lack of recent estimates of child mortality, but it is apparent that this too has risen significantly in recent years. In addition to better registration, Statistics South Africa (Stats SA) has also markedly improved the production of cause of death statistics. Automated selection of the underlying cause of

death was introduced and the 5–6-year backlog in reporting statistics has been reduced to a 2-year lag (Statistics South Africa, 2009).

This improved availability of cause of death statistics in South Africa has occurred during a period of profound change in mortality due to the unfolding AIDS epidemic. In a review of maternal and child mortality in South Africa, Bradshaw and Nannan (2006) note that while it is estimated that AIDS has resulted in increased U5MRs, reliable data are lacking, as there has been no way to assess the extent to which improved death registration has contributed to the apparent increase in the number of child deaths.

Bradshaw and Dorrington (2007) urged government to improve the situation and collect better quality data that could provide accurate statistics on this critical indicator – a key indicator to monitor the Millennium Development Goals. They highlighted the unacceptable situation of trying to monitor progress using modelled estimates and the urgent need to conduct a follow-up Demographic and Health Survey to collect detailed information about the vital status of the children of a representative sample of South African women. Unfortunately, such a survey has yet to be conducted.

This report aims to review all available empirical data on the level and causes of child mortality, and consolidate information about the changes that have occurred between 1990 and 2007. The consistency between data sources, between the trend in the level of overall rates of mortality and the trend in the mortality rates from specific causes are assessed. This will inform efforts to estimate child mortality trends in the 2nd National Burden of Disease Study. In addition, model estimates of child mortality rates and causes of death are assessed against the empirical data. The estimates from the Actuarial Society of South Africa (ASSA) Projection Model are examined carefully in order to inform the development of the next version of this model.

Chapter 2. Data sources to measure child mortality

Ideally, child mortality rates should be estimated directly from the vital registration of births and deaths. However, in most low- and middle- income countries, vital registration systems are not of sufficient quality to provide reliable child mortality rates, making it necessary to use alternative methods and sources of data. Detailed birth or pregnancy histories collected from a sample of women in national surveys, such as the Demographic and Health Surveys (http://www.measuredhs.com/aboutdhs/), are often used to produce direct estimates of child mortality rates. In other household surveys and censuses, summary birth histories provide information on the proportion of the total number of children ever born to women aged 15–49 who have survived (CEB/CS), which can be used to produce indirect estimates of child mortality by making some assumptions about the underlying pattern of fertility and mortality. In addition, although of unknown reliability, deaths reported to have occurred in the past year (or two) by households in censuses and surveys might be used to produce direct estimates of child mortality. Health and demographic surveillance sites (HDSS), which collect data for defined populations, can also be useful in providing information about sentinel populations (http://www.indepth-network.org/).

In addition to population-based child mortality data, there are several health-facility data systems. These include the Perinatal Problem Identification Programme (PPIP) (http://www.ppip.co.za/) and the Child Healthcare Problem Identification Programme (CHIP) (http://www.childpip.org.za/) mortality audit systems that were set up in selected public health facilities to record and review child deaths that occur, identify modifiable factors associated with these deaths and implement changes to improve quality of care. In addition, the National Injury Mortality Surveillance System (NIMSS) (http://www.mrc.ac.za/crime/nimms.htm#national) collects statistical information about injury-related deaths from selected mortuaries and the District Health Information System (DHIS) collects aggregate statistics about perinatal mortality (stillbirths and early neonatal deaths (0–6 days)) at public hospitals and clinics.

This chapter provides some information about each of these data sources and describes acknowledged limitations of each. The age groups considered in the report are neonatal (0–27 days), comprising early neonatal (0–6 days) and late neonatal (7–27 days); post-neonatal (1–

11 months); and children (1–4 years). The neonatal and post-neonatal age groups make the infant age group, and the under-5s comprise all the age groups.

Vital registration – Statistics South Africa

The Birth and Death Act of 1992 requires that all deaths are registered with the Department of Home Affairs using a death notification form (BI-1663) including the medical certification of the cause of death. This is often referred to as the DNF. The Act was amended in 2010, but the changes were largely related to strengthening birth registration and reducing fraud. In situations where there is no doctor and the death was due to natural causes, the death report form (BI-1680) may be completed by a traditional leader (headman), in addition to the BI-1663.

Once processed by the Department of Home Affairs, the forms are sent to Stats SA, where the information is coded and the cause of death statistics compiled. The serious backlog in the production of the cause of death reports has been overcome in recent years and coincides with the introduction of Automated Classification of Medical Entities (ACME) for automated selection of underlying cause of death. The latest report is for the year 2008 (Statistics South Africa, 2010a), although this review only examines the data up until 2007.

A new DNF (BI-1663) was introduced in 1998 as part of a broader strategy to improve vital registration (Bradshaw et al., 1998; Cassim, S.A.). A large element of success was achieved, with adult death registration improving to nearly 90% in 2000 (Dorrington et al., 2001; Dorrington et al., 2004). The coverage of child death registration is less clear, because reliable estimates of mortality are needed in order to assess completeness of reporting as there are no indirect methods for doing this (Bradshaw and Dorrington, 2007). When compared with model-based estimates, the completeness of death registration appears to have risen sharply in recent years, but appears to continue to be lower for children than for adults. Also, registration of deaths is considered to be poorer in rural parts of the country than in urban areas.

The provinces are the lowest level of geographic information available for analysis in publicly released data, which precludes district level analysis. Population group information is available for about 75% of the records. However, there are very high levels of under-

recording of socio-demographic details, such as education level and occupation (Statistics South Africa, 2007).

Figure 2.1 shows the number of under-5 deaths recorded by Stats SA from 1997–2007 by province. Most provinces showed a general increase in the number of deaths over the period. However, an unusual decrease/levelling off is seen in deaths in KwaZulu-Natal and the Eastern Cape beginning in 1998 and 1999, with numbers increasing again by 2002. This pattern is not seen in other provinces, and although the reason for it is not clear, it may be due to administrative deficiencies in those provinces. Apart from this, provincial boundary changes in 2005/6 may have affected some of the provincial trends over this period.

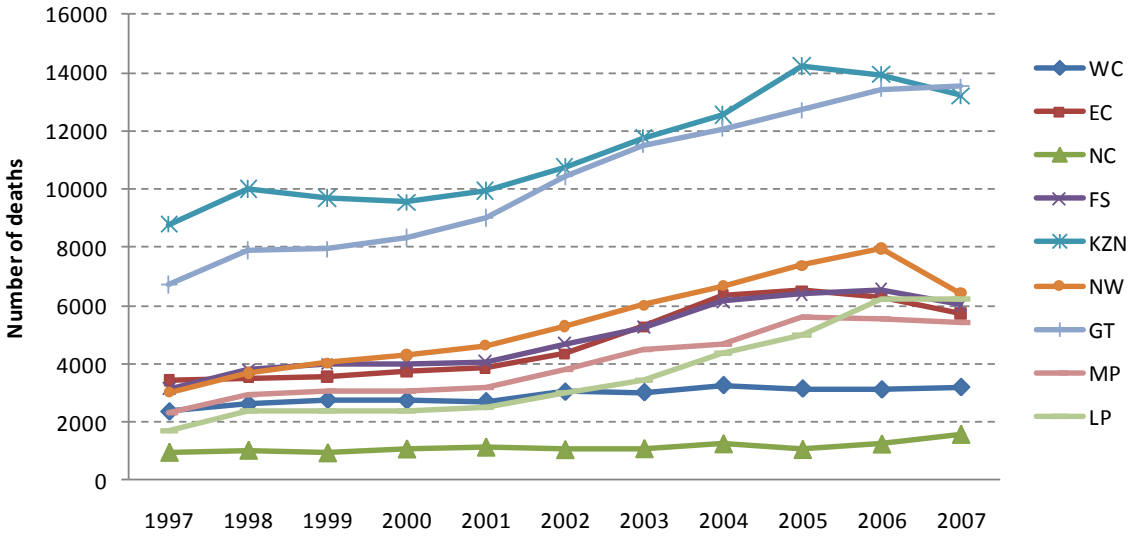


Figure 2.1: Number of registered under-5 deaths by province, Stats SA, 1997–2007

Other than the issues around the completeness of registration, the misclassification of causes also remains a challenge in South Africa. Several studies have highlighted misattribution of HIV/AIDS deaths (Groenewald et al., 2005; Nojilana et al., 2009; Yudkin et al., 2011). HIV has often not been disclosed on DNFs and the immediate cause of death (an opportunistic infection) has typically been reported as the underlying cause of death.

Between 1997 and 2005, there was a systematic miscoding of the cause of death for infants (children under-1 year of age). For most children dying before their first birthday, the cause of death was coded to a perinatal code (P-code), i.e. the causes '*originating in the first week of life*'. For example, the death of an 8-month old infant from pneumonia would have been

coded to the code for congenital pneumonia. Data for 2005 are shown in Figure 2.2, which indicates that the majority of infant deaths were attributed to conditions originating in the perinatal period even in the post-neonatal period. This coding practice was corrected after 2005, but for the period 1997–2005 it has resulted in a substantial inflation in the numbers of perinatal conditions, and a corresponding under-recording of true underlying causes of death for infants.

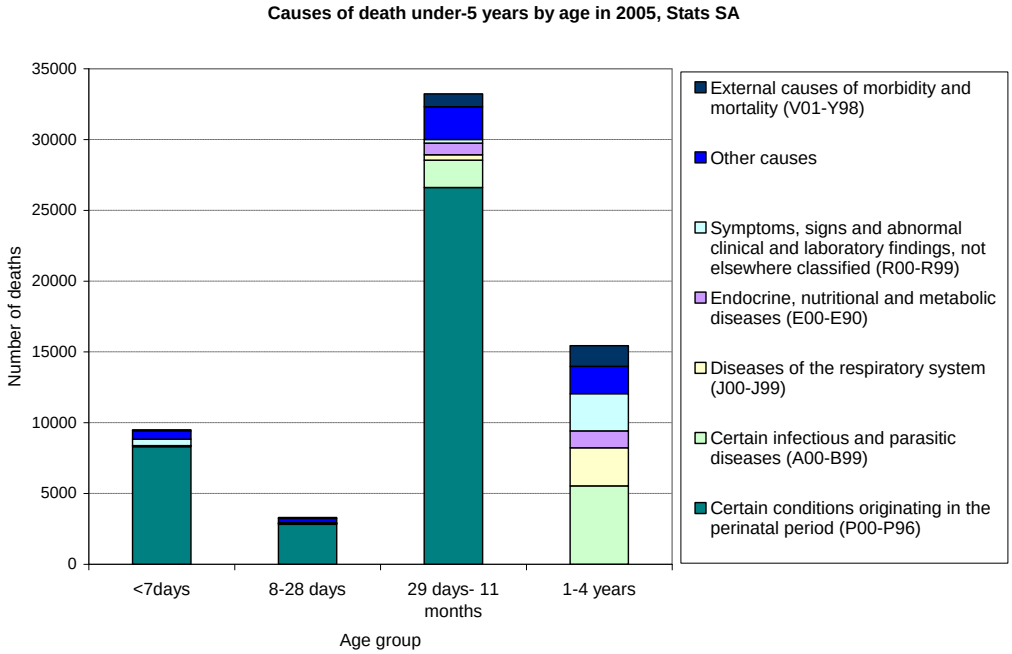


Figure 2.2: Number of under-5 deaths by cause and age group, 2005
Source: Bradshaw and Nannan, 2006

Based on unpublished data provided by Stats SA, Brody (2007) examined the data in finer age groups. Figure 2.3 shows the number of deaths for the category of the '*diseases of the respiratory system*' (J00–J99) by month of age between 1997 and 2002. The clear disjuncture in the numbers from 12 months to 13 months illustrates the under-representation of the '*diseases of the respiratory system*' for the 12 months and younger ages, that have been mis-coded to a P-code.

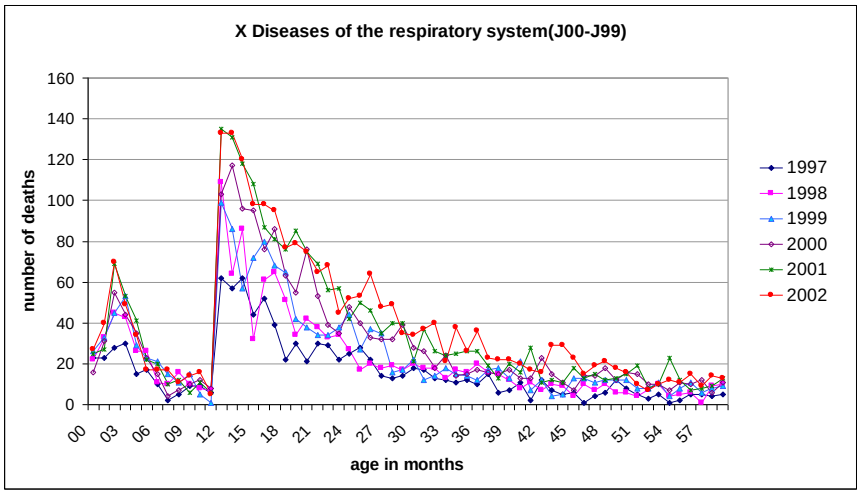


Figure 2.3: Annual number of deaths of diseases of the respiratory system by month of age, 1997–2002
Source: Brody, 2007

Vital registration – population register

The Department of Home Affairs has maintained a computerised population register since 1972 (Khalfani, 2005). Deaths of people with South African identity numbers[1] (IDs) are immediately recorded on this national database. Each month, the basic demographic details of these deaths are provided to the Medical Research Council (MRC) to enable the rapid monitoring and analysis of the age and sex pattern of registered deaths in South Africa as part of the Rapid Mortality Surveillance project (Bradshaw et al., 2004).

Figure 2.4 shows child deaths on the population register as a percentage of the number of all registered child deaths as reported by Stats SA (which includes those for which the death was registered but where the birth was not registered). Thus, this ratio gives an indication of the completeness of birth registration by age at death, since deaths that are registered for children who do not have a birth certificate are not entered on the population register, although they are captured by Stats SA. Figure 2.4 shows that birth registration increased rapidly over this period for all age groups. For deaths that occur under the age of 1, the proportion of registered deaths that appear on the population register increased from less than 10% to 42% between 1998 and 2007. This understates the extent of birth registration in this age group since it reflects only non-registration of babies who died before their birth was registered: those who do not die in the first year of life have longer to register the birth than those who

[1] Births in South Africa that have been registered and non-South Africans with South African citizenship or permanent residency.

die before their first birthday. For the older age groups, it appears that birth registration is now well over 80% (although the bias of higher registration (of both deaths and births) in urban areas may mean that the extent of birth registration is exaggerated a little). This increase in birth registration has also been reported by Statistics South Africa (2010b) and is likely to be related to the greater uptake of child maintenance grants, receipt of which requires that the child's birth be registered.

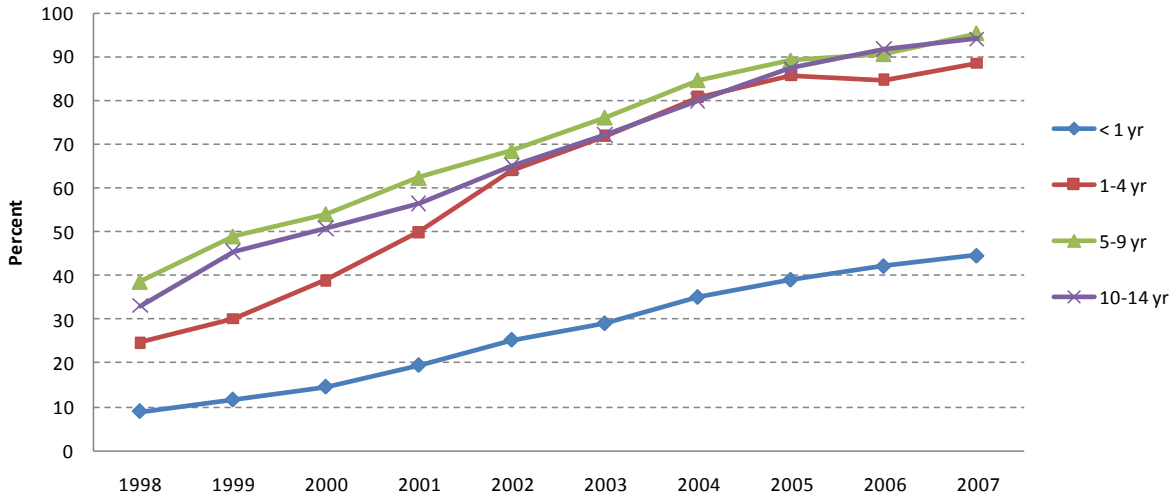


Figure 2.4: Proportion of registered child deaths that are captured on the population register, delineated by age group, 1998–2007

The death data from the population register does not contain detailed cause of death information. Only a single line, either the immediate cause of death or the broad category of either natural or unnatural death, is captured from the DNF by Home Affairs officials who have no training in assigning causes of death. Once the data are received by the MRC, the causes are categorised into natural or unnatural causes using a table of key words. The Home Affairs office where the death was registered makes it possible to monitor trends by province from 2000 onwards, based on the province in which the death was registered.

Full birth history data

In its basic form, a full birth history comprises the answers given by women of reproductive age to a survey questionnaire designed to obtain the details about all their births, including the date of birth, the sex of the child and whether the child has died. If dead, the questionnaire

asks about the age of the child at death. This information enables the measurement of the fertility and child death rates.

Demographic and Health Surveys

The South Africa Demographic and Health Survey (SADHS) is a national survey, modelled on the international series of demographic and health surveys designed by MEASURE DHS, ICF International. In general, if carried out properly, such surveys yield good quality data on child mortality, as they collect detailed birth histories from a nationally representative sample of women. Two SADHSs have been conducted in South Africa: one in 1998 and another in 2003.

There is consensus that the data from the 1998 survey were of high quality. Unfortunately however, the indications are that the 2003 SADHS under-estimated the level of child mortality quite significantly (Department of Heath, 2007). Birth history data from KwaZulu-Natal, the province with the highest mortality rates, in particular, were clearly incorrect as reflected by an impossibly low total fertility rate of 0.2 children per woman, and an under-5 mortality rate of 33.2 per 1 000 live-births – the lowest of all provinces.

Prior to 1994, the Human Sciences Research Council (HSRC) also conducted a series of DHS-type surveys for the RSA and each of the homelands between 1988 and 1992. The data from these surveys were pooled to develop national estimates for child mortality for this earlier period (Roussouw and Jordaan, 1997).

National Income Dynamics Survey (NIDS) 2008

The National Income Dynamics Study (NIDS) is a national household panel study. The first round was conducted in 2008 by the Southern African Labour and Development Research Unit (SALDRU) at the University of Cape Town. Although the main objective of the NIDS was to examine poverty through household income, consumption and expenditure, the study also collected demographic data such as fertility, mortality and migration. A total of 9 355 women in the sampled households were asked for their full birth histories. Unfortunately, analysis of these data identified several problems, including the incorrect recording of the year of birth and age at death (Moultrie and Dorrington, 2009). The conclusion of this

analysis is that no sensible estimate of the trend or the level of child mortality for the country as a whole can be derived from the NIDS data.

Summary birth history data

Censuses conducted in recent years and the Community Survey have included questions about the total number of children ever born to women and the number of those children that have died (also known as summary birth history data). These questions make it possible to use an indirect demographic technique (Brass's children ever born/children surviving (CEB/CS) method) to estimate child mortality rates. This method involves calculating life table indices using model life tables based on several assumptions. Careful checks are essential to detect any violation of the assumptions. This requires that the methods are not applied simply mechanically, but that the researcher questions the plausibility of the results. In the presence of HIV, such estimates of child mortality are biased downward as a result of the correlation between maternal death and child mortality. (The survey obviously does not record the mortality of children of mothers who were not alive at the time of the survey. Many of these mothers will have been infected with HIV and their children will, on average, experience higher mortality rates than those of mothers who are alive at the time of the survey.)

Censuses

The censuses conducted in 1996 and 2001 both incorporated summary birth history questions. The 1996 census was the first attempt since 1970 to enumerate all South Africans. The question related to child mortality did not distinguish between boys and girls, and although the estimates of the level of mortality, without adjustment, was thought to be on the high side, after appropriate adjustments the estimates were found to be in line with estimates from the 1998 SADHS (Nannan et al., 2007).

In contrast, analysis of the 2001 census found that the indirect question on children ever born and children surviving did not give plausible estimates of under-5 mortality (Dorrington et al., 2004). The main problem with the under-5 mortality data was that the number of children born to women of reproductive age was found to be under-reported to a significant extent. This was thought to be the result of incorrect or inaccurate training of the enumerators and

material imputation of data on the reported number of births occurring in the year preceding the census. Despite this, these data were used to map the spatial distribution of under-5 mortality for South Africa's magisterial districts (Bangha, 2008) showing, as might be expected, that there are disparities in the relative and absolute levels of under-5 mortality by magisterial district. However, it is unclear to what extent one can rely on these results given the concerns about the data.

Community Survey 2007

In 2007, Stats SA conducted a large census replacement survey – the Community Survey – which included nearly 2.5% of all South African households in order to provide profiles at municipal district level. The survey included the summary birth history questions. Initial attempts to produce infant and child mortality rates from these data produced implausible results (showing an upward trend when other data had indicated that mortality was falling, and higher rates for girls than boys). However, after removing the responses of women from whom the data on numbers of births and deaths were inconsistent (i.e. the total not equalling the sum of the parts), it was possible to produce more sensible results at provincial and national level (Darikwa and Dorrington, 2011).

KwaZulu-Natal Income Dynamics Survey (KIDS)

A panel study based on a representative sample of households in the province of KwaZulu-Natal was initiated in 1998. There have been three waves of data collection: 1998, 2004 and most recently in 2008. Child mortality rates can be calculated using both the full birth history information as well as using an indirect approach based on questions from the summary birth history data using standard questions posed to women aged 15-49 years.

Deaths reported by households

Census 2001

The 2001 census asked respondents to report the deaths of any members of the household in the 12 months prior to the census night. Respondents were also asked to report the sex and age of the deceased, and whether the death was the result of violence, or during or within six weeks after pregnancy, in the case of women of child-bearing age. These data have been

found to produce reasonable estimates of adult mortality, but it is unclear how useful they are for estimating child mortality (Dorrington, Moultrie and Timæus, 2004). Darikwa and Dorrington (2011) suggest that the estimate from the 2001 census may exaggerate infant and child mortality.

Community Survey 2007

The Community Survey asked the same questions regarding deaths in the household as the 2001 census. Although these data appear to be of some use in estimating adult mortality, their usefulness for estimating child mortality rates is also uncertain and the suggestion is that they may exaggerate infant and child mortality (Darikwa and Dorrington, 2011).

National Income Dynamics Survey 2008

Similar questions about deaths in households were included in the NIDS 2008 survey. Unfortunately, the age of almost 20% of deaths was not recorded or was recorded as unknown. This means that there is even greater uncertainty about the accuracy of the estimates of infant and child mortality from this source than there would usually be when estimating these numbers from deaths reported by households (Moultrie and Dorrington, 2009).

Facility-based data

District Health Information System

The District Health Information System is based on routine reports from public sector primary care facilities and district hospitals to the district health office. The monthly reports include the number of births, stillbirths and early neonatal deaths that occurred in the facilities. The District Health Barometer (http://www.hst.org.za/generic/77) has identified the perinatal mortality rate as one of its outcome indicators (Day et al., 2009). The perinatal period starts at the beginning of foetal viability (28 weeks gestation or 1 000 g) and ends at the end of the seventh day after delivery (reported as day 6). The perinatal mortality rate (PNMR) is the number of stillbirths together with the number of deaths in the first 7 days of life per 1 000 live-births. The PNMR gives an indication of maternal health, and the responsiveness and effectiveness of the health system with respect to maternal and newborn health. It is a very sensitive indicator of the quality of obstetric care.

The PNMR as recorded by the DHIS has gradually decreased from 37.0 per 1 000 live-births in 2003 to 34.5 per 1 000 in 2005, 33.2 in 2006/7 and 31.1 per 1 000 live-births in 2007/8. However, it should be noted that the District Health Information System cannot be considered to be the national rate, as it excludes the private sector, home deliveries and academic hospitals.

Perinatal Problem Identification Programme

The Perinatal Problem Identification Programme (PPIP), established by the MRC Unit for Maternal and Infant Health Care Strategies, supports a clinical audit system that was set up to identify avoidable causes of death, and improve the clinical and hospital management of pregnant women and neonates (http://www.ppip.co.za/). In addition, the PPIP compiles statistics from participating health facilities on stillbirths and neonatal deaths, and has produced six 'Saving Babies' reports providing a review of perinatal care (Saving Babies, 2007). Participation is voluntary, and thus far 164 hospitals participate nationally, capturing an estimated 52% of national births. The PPIP contributed information about avoidable causes of deaths of newborns and stillbirths to the Every Death Counts report (2008). Common modifiable factors in the first period included inadequate staffing and facilities, poor care in labour, poor neonatal resuscitation and difficulties for patients in accessing health care. Modifiable factors considered in the second period included poor intrapartum foetal monitoring, insufficient nurses or doctors, patient delay in seeking care, prolonged second stage of labour without intervention, inadequate facilities, lack of institution/transport, inadequate monitoring of newborn, never initiated antenatal care, delay in referring and no response to post-term pregnancy.

Child Healthcare Problem Identification Programme

Since 2004, the PPIP has been adapted to support the audit of child deaths through the Child Healthcare Problem Identification Programme (Chip PPIP). Reports focusing on modifiable factors associated with infant and child deaths in facilities have been compiled using data from the children's wards of participating facilities up until 2009 (Stephen et al., 2009) and reports are available for selected sites for 2008 (http://www.childpip.org.za/). In 2004, data were collected in 15 hospitals in six provinces, representing urban, peri-urban and rural settings, and different levels of paediatric health care. During the course of 2005, the CHIP was extended to seven new sites and involved all nine provinces. By 2007, the CHIP covered

9% of level 1 facilities, 33% of level 2 and 27% of level 3 (Stephen and Patrick, 2009). In total, there were 8 060 deaths audited between 2005 and 2007. The review of these data identified HIV, malnutrition and poverty as the main contributing factors to child mortality, and acute respiratory tract infection (including Pneumocystis pneumonia (PCP)), diarrhoeal disease, sepsis and tuberculosis as the main causes of death. Over these three years, the majority of deaths (63%) were under 1 year of age. A high proportion (64%) of the children who died were malnourished and 47% of the children who died were eligible for antiretroviral therapy (ART). The audit revealed that modifiable factors occurred in the home, clinics, and emergency and paediatric wards, with the majority attributable to factors that could be addressed by clinical personnel. In 2006 and 2007, 35% of the children who died with suspected or confirmed PCP had never received cotrimoxazole prophylaxis.

The age distribution of the deaths from the CHIP shows 87% were under 5 years of age. The proportion of deaths in the neonatal period increased while the proportion in the post-neonatal period remained stable (Table 2.1). However, as the participating sites have not been constant through this period, it is difficult to interpret trend data. Overall, the sex ratio of the child deaths was 1.12 boys per girl (data not shown).

Table 2.1: Age distribution of deaths reported by CHIP, 2005–2007

	2005		2006		2007	
Number of sites	**19**		**30**		**49**	
Age of deaths	**Number**	**%**	**Number**	**%**	**Number**	**%**
<1 month	31	2.0	122	4.2	204	5.4
1–11 months	911	59.3	1 637	57.0	2 231	59.0
1–4 years	399	26.0	716	24.9	905	23.9
5–17 years	172	11.2	297	10.3	413	10.9
Unknown	24	1.6	101	3.5	29	0.8
Total	**1 537**	**100**	**2 873**	**100**	**3 782**	**100**

Source: Stephen and Patrick, 2009 as amended by Cindy Stephen, personal communication

National Injury Mortality Surveillance System (NIMSS)

The National Injury Mortality Surveillance System (NIMSS) was established as a sentinel surveillance system to collect data on injury deaths. It provides information on the causes of injury deaths and is currently the only source of regular and detailed information on the causes of non-natural deaths nationally. In 2005, the NIMSS data were drawn from more than

30 State mortuaries in seven provinces, representing approximately 40% of the estimated national caseload. The NIMSS covers five of the country's six metropolitan centres along with several other major towns and cities, but is more reflective of the urban rather than the rural injury profile (Prinsloo, 2007). The NIMSS collates data from standard medico-forensic investigative procedures, including post-mortem reports, police dockets and chemical pathology laboratory results. For this review, NIMSS data and rates were available for analysis from four cities: Cape Town, Durban, Johannesburg and Pretoria.

The external cause of death and apparent manner of death codes have been partially recoded to the SA National Burden of Disease (NBD) list (Bradshaw et al., 2003). These can be summarised as follows:

Intentional injury deaths: Includes homicides perpetrated with firearms, sharp and blunt objects, strangulations, abandoned babies, etc.

Unintentional injury deaths: Includes those deaths that were unintentionally caused by burns/fires, drowning, falls, poisoning, suffocation and all road traffic injury deaths.

Other unintentional injury deaths: Includes all unspecified unintentional injury deaths, blunt objects, crushing, choking, firearms, lightning, aviation, railway, hanging, explosive blasts, electrocution and medical procedure deaths.

Exclusions: All natural deaths, sudden infant deaths (SIDS) and stillbirths/abortions were excluded from the analysis.

Local area surveillance data

Cape Town and Boland/Overberg

The Medical Officer of Health for the City of Cape Town has compiled cause of death statistics for more than 100 years. These are based on information collected from the death notification forms submitted to the Department of Home Affairs. In more recent years, an evaluation of the data-processing system identified the need for standardising the coding and a more public-health oriented analysis of the statistics. Subsequently, training and a short list for coding the cause of death were introduced. Age-standardised mortality rates are reported for the health sub-districts, identifying the major causes of death as well as considerable health inequities in the city. The system for collecting cause of death statistics developed in

Cape Town was implemented in the neighbouring health region of Boland/Overberg, it and has played an important role in monitoring and planning for that health region. Roll-out of the system across all districts in the Western Cape is currently underway.

In Cape Town, there were 1 704 child deaths under 5 years of age in 2004 (Table 2.2). The majority of the deaths occurred in the postnatal period (49.9%) and a sizable proportion in the early neonatal period (22.7%). The age distribution of the deaths in the Boland/Overberg is shown in Table 2.3 and it is very similar to that observed in Cape Town.

Table 2.2: Age distribution of deaths under 5 years, Cape Town, 2004

Age of deaths	Number	%
0–6 days	386	22.7
7–27 days	154	9.0
1–11 months	851	49.9
1–4 years	313	18.4
Total	**1 704**	**100.0**

Source: Unpublished data from City of Cape Town

Table 2.3: Age distribution of deaths under 5 years, Boland/Overberg, 2005

Age group	Number	%
0–6 days	167	21.9
7–27 days	69	9.0
1–11 months	368	48.2
1–4 years	159	20.8
Total	**763**	**100.0**

Source: Unpublished data from Boland/Overberg

Health and Demographic Surveillance Sites

South Africa has three Health and Demographic Surveillance Sites (HDSSs) where continuous recording of all demographic events, including cause of death by verbal autopsy, for a defined population is undertaken. These are the Agincourt site situated in Mpumalanga, the Africa Centre situated in KwaZulu-Natal and Dikgale in Limpopo.

Agincourt

The Health and Demographic Surveillance Site in the Agincourt sub-district is the oldest site. It is situated in the north-east Mpumalanga province, close to the Mozambique boarder. It spans 21 villages and is typical of a poor rural setting. The area has been under demographic surveillance since 1992, and in 2008, included approximately 11 500 households, with a total population of approximately 70 000 (Tollman et al., 2008). By 2010, there have been 16 census rounds over 20 years, mainly collecting data regarding annual births, deaths, migration episodes, and antenatal and perinatal health-seeking behaviour. Cause of death information is ascertained using a verbal autopsy instrument, which has been validated (Kahn et al., 2000).

The Africa Centre for Health and Population Studies

The Africa Centre Demographic and Information System (ACDIS) surveillance area is situated in rural northern KwaZulu-Natal near Matubatuba. A population of approximately 80 000 individuals in the Hlabisa district have been under surveillance since 2000. The entire area consists of about 11 000 households designated by area-type into urban and non-urban, and are further divided into rural (areas of less than 400 residents per square kilometre) and peri-urban (areas with more than 400 residents per square kilometre) (Tanser et al., 2008). Several rounds of data collection have served to describe the demography and socio-economics of the community and households (Hosegood et al., 2005; Hosegood and Timaeus, 2005; Case and Ardington, 2004), highlighting poor socio-economic conditions, extensive migration and high AIDS mortality. Subsequent to an initial baseline census of the population conducted in 2000, there have been routine household visits, which have collected individual and household socio-economic and event data (capturing births, deaths and migration episodes).

Dikgale

Started in 1996, the Dikgale health and demographic surveillance site is a small site located in rural Limpopo. It was set up mainly to measure non-communicable diseases. It comprises eight villages and at the end of 2007, it had an overall stable population of about 8 000 people. Although no trend data are available, the infant mortality rate was estimated at 38.9 per 1 000 live-births in 1998 (INDEPTH, 2002).

Chapter 3. Levels and trends in mortality rates

National trends from DHS

This chapter reviews the available sources of information on the levels and trends in child mortality rates. As shown in Figure 3.1 the 1988–1992 HSRC survey and the 1998 SADHS indicate a strong downward trend in child mortality until the early 1990s, after which it appears to have levelled off (at least until the early 2000s). However, the results of the 2003 SADHS are not consistent with the earlier surveys. This has been attributed to problematic fieldwork, as well as the bias introduced by the AIDS epidemic, which results from the correlation of child mortality with the mother's death due to AIDS, and the consequent under-reporting of child deaths. Given the levels of HIV in South Africa, and assuming an overall transmission rate of HIV from mothers to their babies of 35% in the absence of effective PMTCT, we estimate that 11% of the under-5 mortality in the five years prior to the 2003 SADHS was not recorded by the survey, while 17% was not recorded for the 5–10 years prior to the survey. Allowing for these increases, the estimates shown below are 65 per 1 000 live-births for the period 1994–1998 and 59 per 1 000 live-births for the period 1999–2003 (not shown in the figure) – values that are quite consistent with the previous survey. Future surveys based on a full birth history will obviously need to take this bias into account in order to produce more accurate mortality rates.

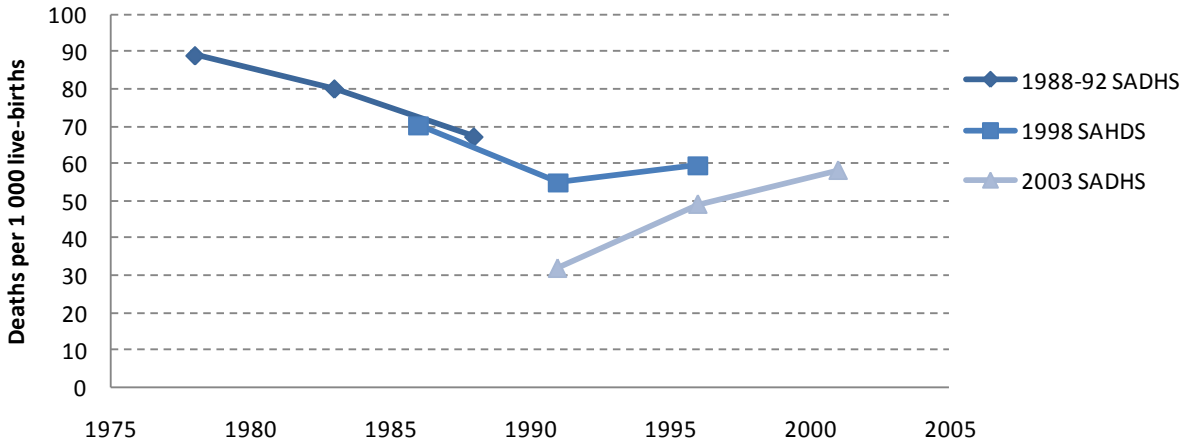


Figure 3.1: Time series of under-5 mortality from three Demographic and Health Surveys

Garenne and Gakusi (2005) made use of reports from women about earlier births to extend the mortality trend back in time. Since data pertaining to births in the earlier period are confined to births of the women when they were young mothers, it is possible, despite the possibility that women may be more likely to forget the birth of a child who has died, that it produces exaggerated estimates of past mortality. For example, Garenne and Gakusi found that since the mid-1960s, South Africa experienced one of the most rapid declines in child mortality reported for Africa from 188 per 1 000 in 1968 to 48 per 1 000 in 1992, which is considerably higher for the earlier period and lower at the point of reversal due to AIDS compared the estimates of others.

National trends from census data

As can be seen from Figure 3.2 the under-5 mortality rate calculated from the 1996 census data demonstrates a similar trend to that observed in the 1998 SADHS. However, the census estimates of childhood mortality are higher than those from the 1998 SADHS for the same period. Analysis by Nannan et al. (2007) suggests that while the 1998 SADHS was probably slightly too low, the census over-estimated mortality. The authors argued that the biggest factor associated with the over-estimation was the misreporting of stillbirths as live-births in the census data as demonstrated by Moultrie and Timæus (2002) based on their fertility analysis of the pregnancy history of the 1998 SADHS. Adjustments to the census estimates were conducted using the El-Badry (1961) correction to correct for the tendency of census enumerators to leave blank the parity for childless women rather than state zero parity (Nannan et al., 2007). A second adjustment was made to correct the data for the excess mortality risk of children born to teenage mothers (Collumbien and Sloggett, 2001). A third adjustment was made to correct for the mis-classification of stillbirths reported as child deaths, which was found to account for a 22% over-estimation of mortality. The level and trend of the census estimates after adjusting, closely match those of the estimates from the DHS, lending confidence to the estimates of childhood mortality up to 1996.

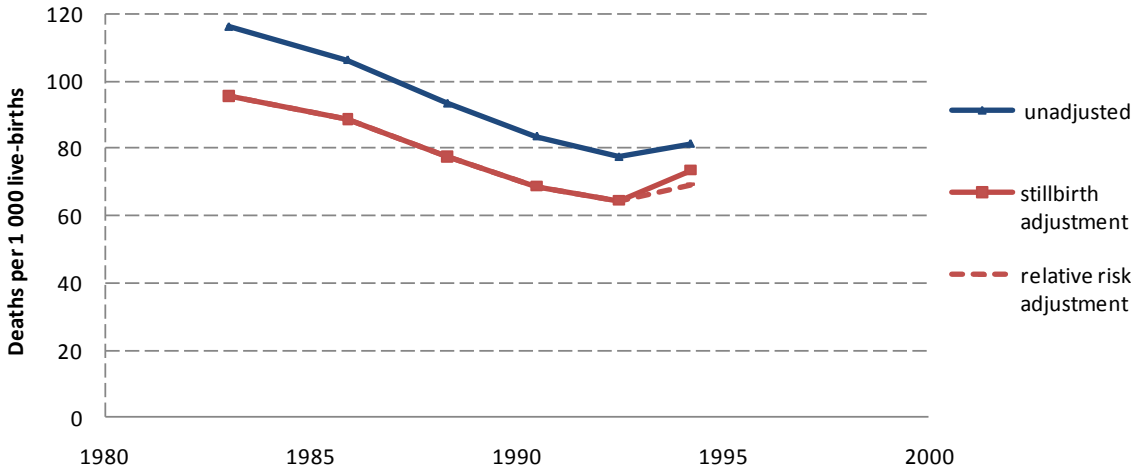


Figure 3.2: Comparison of adjusted levels of under-5 mortality, Census 1996

The analysis of the summary birth history data from the 2001 census undertaken by different researchers has produced inconsistent results. The investigation by Dorrington, Moultrie and Timæus (2004) found that the data quality compromised the estimation process to such an extent that it was not possible to derive reliable or even sensible estimates. Nonetheless, Udjo (2008) produced estimates of the mortality from the 2001 census, albeit with a bizarre boy/girl pattern. He concluded that infant mortality was 69 per 1 000 live boys and 65 per 1 000 live girls in 2001, falling to 56 and 53, respectively, by 2006, based on the 2007 Community Survey data. However, serious concerns about this work were raised by Dorrington and Moultrie (2008), who argued that the analysis by Udjo is 'logically, methodologically and operationally' flawed. First, the issues of poor fertility data quality were extensively detailed in two publications commissioned by Stats SA (Dorrington, et al., 2004; Moultrie and Dorrington, 2004), which argue that the 2001 census data were subject to editing and imputation rules, which generated significant proportions of data, and hence no sensible estimates of child mortality could be derived from this census. In addition, Dorrington and Moutlrie (2008) found that the data used by Udjo (2008) were inconsistent with data they derived from the 10% sample of the 2001 census data. However, the primary analytical error made by Udjo pertains to the application of the indirect method without correction for the bias due to the correlation of the mortality of mothers with that of their children in an HIV environment. South Africa's generalised epidemic began in the first half of the 1990s, necessitating an adjustment to correct for bias due to the fact that the data does not capture information on the survival of children of mothers who not alive at the time of the

survey. Failure to apply such an adjustment results in an underestimate of the child mortality rates. Dorrington and Moultrie (2008) point out that Udjo's estimates of IMR are inconsistent over time, and, in particular, that his estimates of IMR in 2001 are higher than estimates produced previously by Udjo (1999a, 1999b) and others (Dorrington et al., 2004 and Stats SA, 2000).

National trends from other surveys

A detailed analysis of the Community Survey undertaken by Darikwa and Dorrington (2011) provided three sets of estimates, based on the summary birth history data, applying the preceding birth technique and directly calculated mortality from the question about deaths in the household in the past 12 months. This work endeavoured to overcome the challenges resulting from data quality and the bias resulting from the impact of HIV/AIDS. Analysis of the summary birth histories revealed some basic data inconsistencies between the totals and the numbers by sex, survival status, and whether the child was living in the same house as the mother. About 8% of the data were excluded on the grounds that it was internally inconsistent. The data were then adjusted for the impact of HIV/AIDS using correction factors developed by Ward and Zaba (2009). However, as these correction factors assume a constant HIV prevalence over time, a further adjustment was required to allow for changing HIV prevalence. This was achieved by scaling the Ward and Zaba adjustment using the ratio of the prevalence at the time of birth of the child to the prevalence at the time of the survey (Darikwa and Dorrington, 2011). Another problem with the application of the CEB/CS approach in an HIV environment is that the life tables available for converting the rates to infant or under-5 mortality rates do not incorporate the impact of HIV on the mortality schedule. Even where a life table reflects the impact of HIV, such as the life table derived from some INDEPTH sites, it is unable to reflect the fact that children born during the past 15 years or so will have been born at different points in the epidemic. In order to overcome this problem, the underlying mortality in the demographic projection model ASSA2003 and the UN Population Division model life tables were used, as both incorporate the changing impact of HIV on each age group. However, work by Chitiyo (2011) and Mutemaringa (2011) show that the bias due to using a life table that does not reflect AIDS deaths is not very significant.

The Blacker and Brass (2005) variant of the previous birth technique was used to estimate the infant mortality in 2006 from the survival status of the children reported born in the previous

24 months, before 15 February 2007 (the assumed survey reference date). However, although this method produced an apparently sensible estimate of IMR for both sexes combined, the estimate for girls was higher than for boys, which is unlikely to be the case. As this anomaly did not rectify itself after omitting cases with inconsistent CEB/CS data, the authors were led to report irreconcilable data quality problems. Finally, infant and child mortality were calculated directly from the deaths reported in the previous 12 months by households using synthetic cohort life tables. These estimates suggest that the under-5 mortality rate remained stable between 2000 and 2006, and assuming that the CEB/CS estimates were slightly low and the household deaths estimate was slightly high, the U5MR rate was found to be approximately 75 per 1 000 live-births and the IMR approximately 50 per 1 000 live-births.

In contrast, the South Africa Millennium Development Goals (MDG) country report (Statistics South Africa, 2011) reported that the under-5 mortality rate, as calculated from the 2007 Community Survey summary birth history data, was 104 per 1 000 live-births. There are considerable concerns about the child mortality estimates in this report. It is conventional to use demographic indicators from the same data collection process to ensure consistency, and particularly in the case of children, to ensure internal consistency of deaths before the age of 1 and those between the ages of 1 and 4 years. This was not the case with the country report. In this case, the MDG baseline was taken from the 1998 SADHS for the U5MR, while that for the IMR was taken from the 2001 census. Furthermore, it should have been noted that although the DHS survey was conducted in 1998, the estimated mortality rates actually reflect an average of the five-year period preceding the survey, i.e. 1994–1998, and not the rate in 1998 as is claimed in the country report. The U5MR is reported as 104 per 1 000 live-births and the IMR as 53 per 1 000 live births. These results imply an increase in infant deaths of 1 per 1 000 and an increase of 45 deaths per 1 000 for children aged 1–4 years, when in fact all the evidence demonstrates that the increases affecting infants have been the driving force escalating under-5 death rates. Disappointingly, the MDG report does not discuss the implausibility of these results, particularly the relationship between the IMR and the U5MR, and as such, lacks credibility for monitoring South Africa's progress towards the child mortality target.

The 2008 National Income Dynamics Survey (NIDS) included both full and summary birth history questions. However, this survey also failed to yield good quality data for estimating child mortality. According to Moultrie and Dorrington (2009), the information about year of

birth and age at death of children who have died were often missing. Only half of all the deaths had a valid date of birth and significant proportions of ages at death could not be derived, leaving only 39% of the original sample with valid dates of birth and dates of death. In addition, the years of birth were concentrated in the 1970s and 1980s, while the deaths were reported to have occurred in the recent past. Hence, no child mortality estimates were possible from the full birth histories. The summary birth history data for black African children were analysed, and for this group, the under-5 mortality was 100 per 1 000 live births in 2006. If correct, this would imply that the rate of child mortality had remained relatively stable over the last 10 years.

National trends from vital statistics

Vital registration is the final source of data to be assessed for trends. The registered number deaths under 5 years of age reached a peak in 2006. The recorded infant deaths increased rapidly from 24 734 in 1997 to 48 239 in 2006, and then declined to 46 553 in 2007, as shown in Figure 3.3. The same pattern can be seen for deaths of children from 1–4 years of age, increasing from 7 751 in 1997 to 16 058 in 2006, and falling to 14 782 in 2007. Thus, from 1997 until 2006, this constitutes a 95% and 107% increase in recorded deaths for infants and 1–4 year olds, respectively. In all likelihood, much of this increase is due to an increase in the registration of deaths. This is partly confirmed by results from the Agincourt HDSS, which suggest that there was an increase in death registration of children less than 5 years of age from less than 10% to over 30% during the late 1990s (Kahn, 2006).

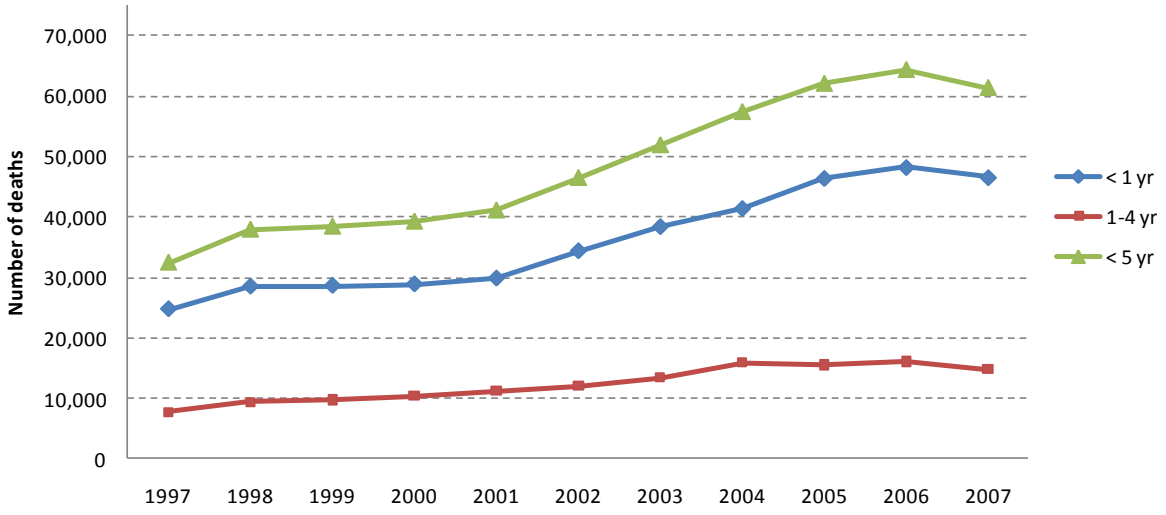


Figure 3.3: Number of registered child deaths under 5 years by age group, Stats SA

Registered deaths in the early neonatal, late neonatal and post-neonatal age groups all increased between 1997 and 2006, before dropping off slightly (Figure 3.4). Striking is the 114% increase in the number of post-neonatal deaths during this period. Early neonatal deaths increased by 39%, while late neonatal deaths increased by 64%, and overall infant death registrations increased by 88%. Most of these increases occurred after 2000/1. The increase in the post-neonatal component was responsible for much of the increase in the overall infant age group. The patterns for girls and boys were similar, therefore the data were combined.

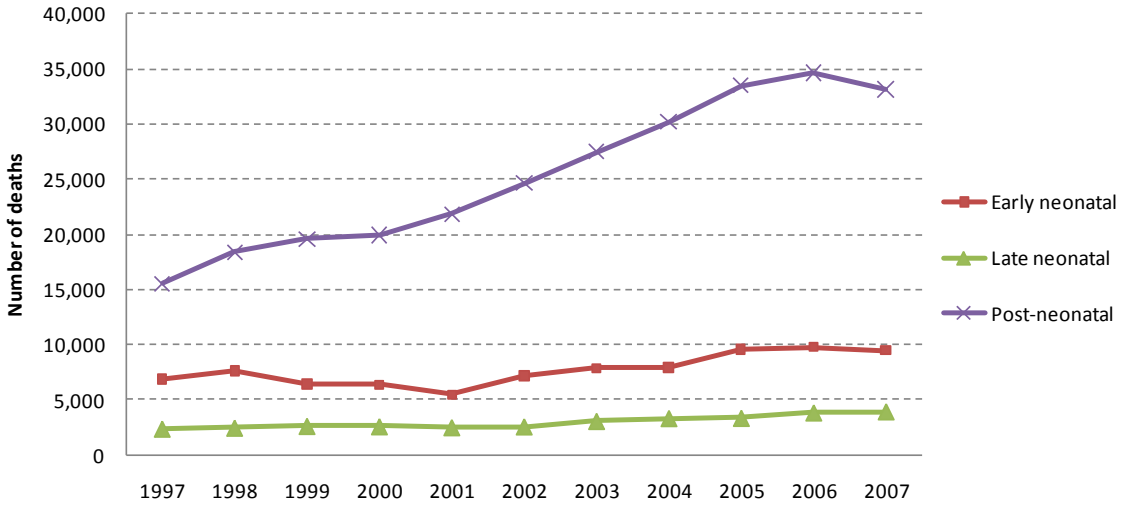


Figure 3.4: Numbers of early neonatal, late neonatal and post-neonatal registered deaths, Stats SA, 1997–2007

Infant mortality indices (early neonatal, late neonatal and post-neonatal), calculated from the registered deaths divided by the estimate of births in the year from the ASSA2003 model, are shown in Figure 3.5. The early neonatal and late neonatal rates were relatively flat throughout the period, whereas the post-neonatal and overall rates for infants increased considerably to a peak in 2006. The 1998 SADHS estimate of the infant mortality rate is plotted at the mid-point of the period that it represented (1996), indicating the considerable under-registration of

infant deaths in the early period. The provincial trends are shown in Appendix A.

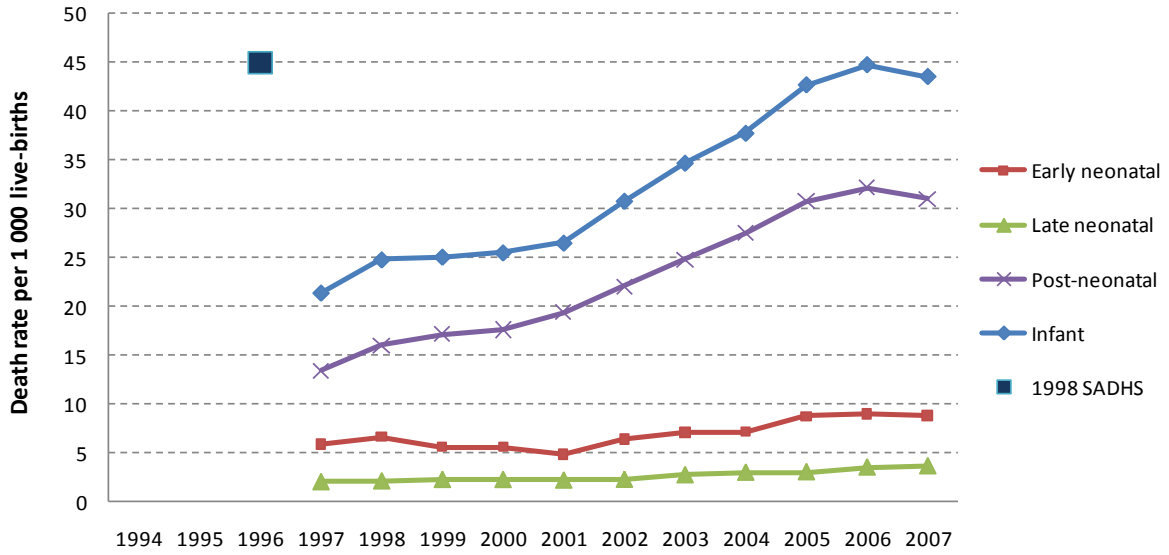


Figure 3.5: Infant mortality age pattern of infant deaths rates compared with the 1998 SADHS

Box 3.1: District Health Information System (DHIS)

The Neonatal Mortality Rate (NMR) has been collected through the DHIS since 2006 and shows a decrease from 14.4 per 1 000 in 2006 to 10.6 per 1 000 in 2008. However, this cannot be considered to be a national rate as it excludes deaths that occur in the private sector as well as home deaths. It is likely to be an under-estimate of the NMR, as late neonatal deaths (between 7 and 28 days of life) may occur outside of health facilities after the baby has been discharged.

Box 3.2: Perinatal Problem Identification Programme (PPIP)

Results from the PPIP for the period of October 1999 to September 2003 showed that the rate of death in the first week of life for infants weighing 1 000 g or more was 8.7 per 1 000 live births, and higher in rural areas at 10.4 per 1 000 live births. Results from the PPIP for the period October 2003 to March 2006 found the overall early neonatal death rate was 13.6 per 1 000 live births. For infants weighing more than 1 000 g, the early neonatal mortality rate was 8.5 per 1 000 live births. It is difficult to assess the trend in these data as the participating facilities increased.

Exploring the data using a finer age resolution, Bourne et al. (2009) noted an emerging mortality peak centred around 2–4 months of age, over and above a rise in infant mortality during the time period (Figure 3.6). The increasing excess deaths that contributed to a peak at 2–3 months has been shown to be strongly correlated with an increasing HIV prevalence in the population and could be considered to be an AIDS signature in the context of limited access to antiretroviral treatment or prevention of mother-to-child transmission (Bourne et al., 2009). This change in age pattern would not have been observed using the traditional indicators of child mortality such as neonatal and post-neonatal mortality, or if observing mortality by age of death.

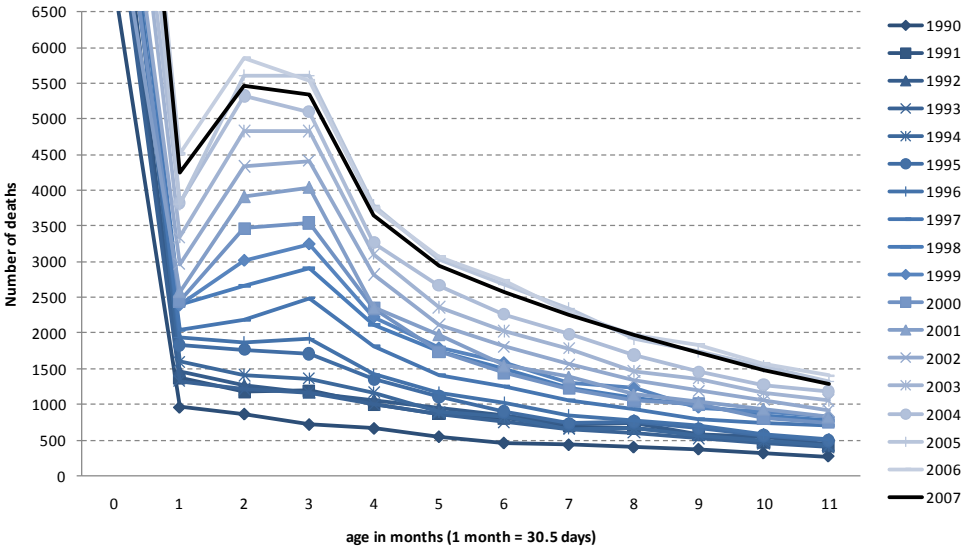
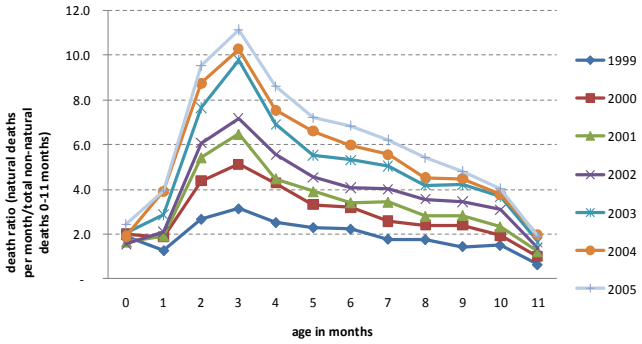


Figure 3.6: Historical trend in the monthly age pattern of deaths for infants, 1990–2007, Stats SA

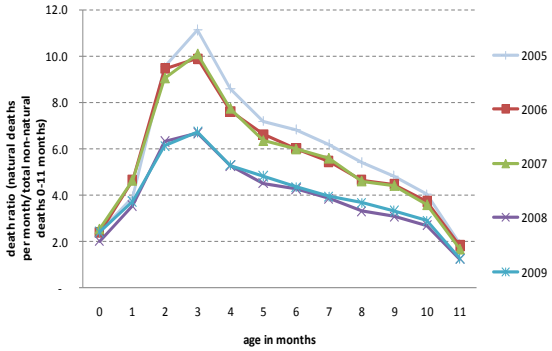
The Population Register database has the advantage of being a population data source that is available, by arrangement, to the MRC within a few weeks of the registration of deaths (as opposed to the two-year delay required to produce the official reports on VR deaths). The data for child deaths, however, need to be interpreted with care. The database is not representative of the population of infants who die, particularly under the age of 1 month. If a death notification is received before the birth is registered, the Department of Home Affairs does not add that individual to the population register. The number of infant deaths registered on the Population Register is therefore affected by improvements in birth registration. In recent years, South Africa has been successful in its efforts to improve both birth and death registration (Bradshaw et al., 1998; Bradshaw et al., 2004; Stats SA, 2010b), making it difficult to assess the trends in infant deaths in this data source. In order to correct for the

improvement in completeness in registration of births and deaths, the trend has been explored by considering the ratio of natural to non-natural deaths. On the assumption that the relative completeness has remained constant and the non-natural mortality rate has not changed, the ratio indicates whether natural deaths are increasing relative to non-natural deaths. Independent information from the NIMSS indicates that since 2001, the injury death rate for infants has not varied significantly from year to year.

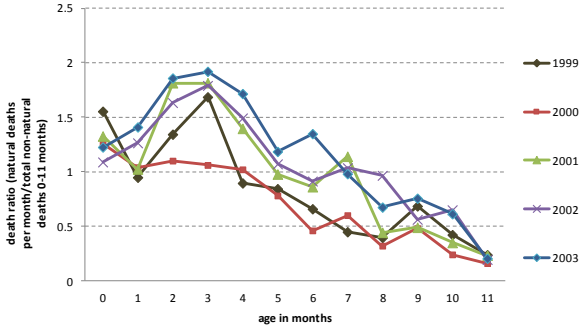
Figure 3.7 shows that for each year between 1999 and 2009, the ratio of natural to non-natural deaths by age for infants, separately for the Western Cape Province (panels c and d) and the remainder of South Africa excluding the Western Cape (panels a and b), separated in panels to show the year in which the ratio peaked, after which it started to fall. These data show the emergence of a peak between 2 and 3 months of age. In the Western Cape Province, the peak occurred over a wider age range (2–4 months) in 2003, coinciding with the earlier introduction of PMTC. The ratio for South Africa excluding the Western Cape Province peaked later, in 2005, around the age of 2 months.



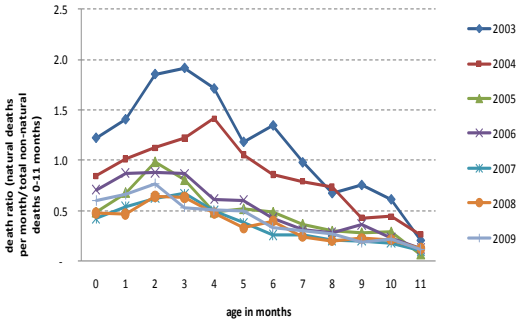
a) SA excluding WC showing increase for period 1999–2005



b) SA excluding WC showing decrease for period 2005–2009



c) WC showing increase for period 1999–2003



d) WC showing decrease for period 2003–2009

Figure 3.7: Infant ratio of natural to unnatural deaths in South Africa excluding the Western Cape and the Western Cape, 1999–2009

Observed trends in child mortality of local areas are shown in Boxes 3.2–3.4. These vary depending on location and the period. The reversal in under-5 mortality in the 1990s is seen clearly in the Africa Centre and Agincourt, followed by a period of decline from 2004 in the Africa Centre. The infant mortality rate in the Western Cape has declined since 1998 (Box 3.2).

Conclusion

In conclusion, the wealth of empirical data shows that there was an increase in under-5 mortality rates from 1996 to 2001, but there is less certainty about the trends thereafter. There are surprisingly few national surveys that can provide good quality information based on full birth histories.

The registered deaths increased over the period to 2006, particularly in the post-neonatal age group, and appear to have peaked in 2006, but it is not obvious how much of the increase is due to improved registration. There is an AIDS signature of the increase in deaths in the age range of 2–3 months, which peaked in 2003 in the Western Cape and 2005 in the other provinces.

Analysis of the 2007 Community Survey provides the most recent estimates of the U5MR and the IMR, which indicate, in contrast to the rising numbers of deaths, that there has been little change in child mortality rates in the past 10 years with the under-5 mortality rate remaining stagnant at approximately 75 per 1 000 live-births and the infant mortality at approximately 50 per 1 000 live-births. These estimates are based on indirect estimates derived from the summary birth history data adjusted for the impact of HIV, the previous birth technique and deaths reported by households. However, data from selected areas (Cape Town, Boland/Overberg and the Africa Centre) show that under-5 mortality has been declining in selected areas, while data from Agincourt shows that other areas have experienced an increase over the period.

Box 3.3: Demographic surveillance site: Africa Centre

The Africa Centre Demographic and Information Surveillance (ACDIS), based in rural KwaZulu-Natal, began longitudinal follow-up at the end 2000. In addition, information on births and deaths of children were collected from pregnancy histories of all women living in the area. These retrospective data were analysed to give a 20-year trend of child mortality indices (Figure B3.2.1). Neonatal rates remained stable over the period, whereas a reversal in the under-5 mortality rate was driven by increased deaths in the post-neonatal age groups. In 2000, the infant mortality rate was 89 per 1 000 live births, the neonatal mortality rate was 15 per 1 000 live births and the under-5 mortality rate was 116 per 1 000.

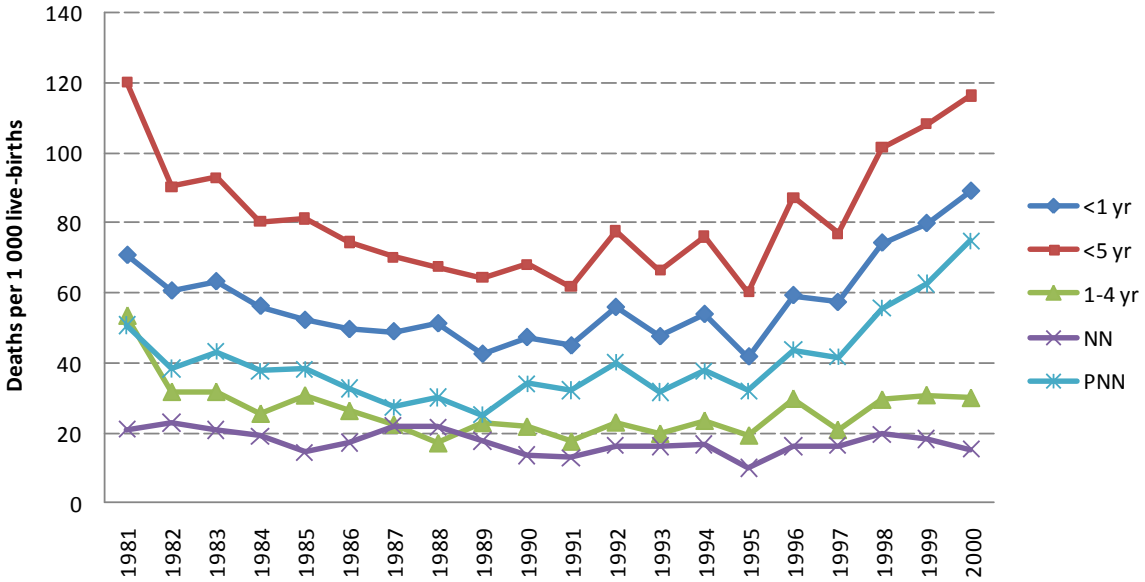


Figure B3.3.1: Africa Centre Demographic and Information Surveillance, 20-year trend in childhood mortality
Source: Own calculations

Ndirangu et al. (2010) reported trends in under-2 mortality by year of birth cohort from prospective data. Death rates declined in all age groups with the greatest declines experienced by neonates (62%), followed by those in the post-neonatal period (41%). Figure 3.3.2 shows that between 2003 and 2004 there was a sharp decline in the rates for the neonates and those in the post-neonatal period, after which the rates per 1 000 live-births was 4.3 for neonates, 32.6 for those in the post-neonatal period and 41.6 for infants. Given that the field procedures changed in 2004 and a neonatal mortality rate of 4.3 is extremely unlikely, and given that nationally it is estimated to be three time this during this period, it must be concluded that some of the decline might be attributed to a change in data collection procedures.

Box 3.3 cont.

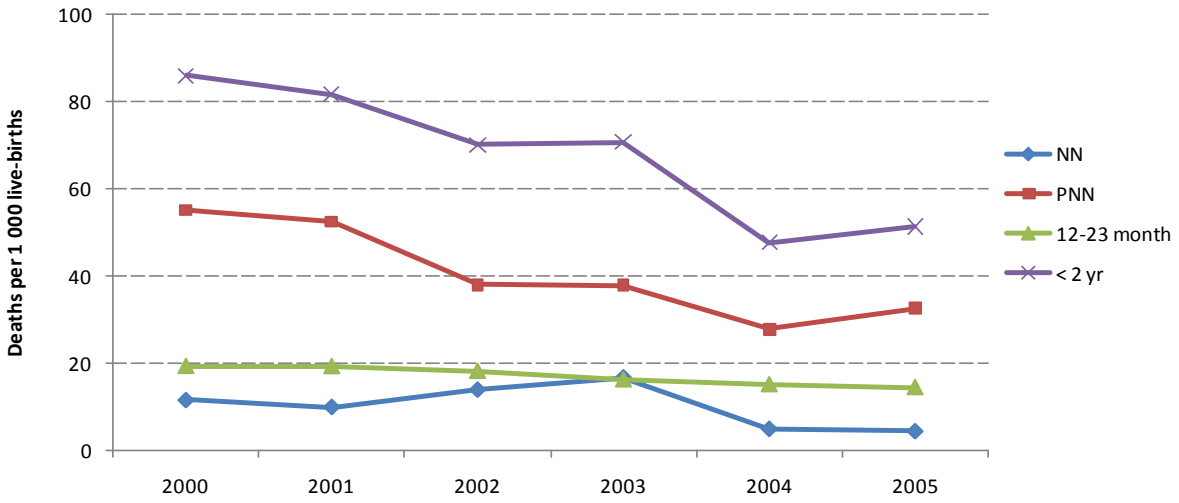


Figure B3.3.2: Age-specific under-2 mortality by year of birth cohort, ACDIS 2000-2005
Source: Adapted from Ndirangu et al., 2010

A more conventional description of mortality trends, calculated from the total under-5 deaths for each calendar year (January to December) divided by the person years of exposure (PYE), is shown in Figure B3.3.3. The overall rate shows the age group breakdown. Clearly an overall decline in mortality in all age groups occurred. However, the decline in the post-neonatal period from 10.6 to4.5 deaths per 1 000 PYE is the most substantial. Herbst et al. (2011) report HIV-related and other communicable diseases accounted for most of the decline. Although the death rate in the 1–4 year olds fluctuated over time, there was a small decrease from 6.2 to 5.2 deaths per 1 000 PYE.

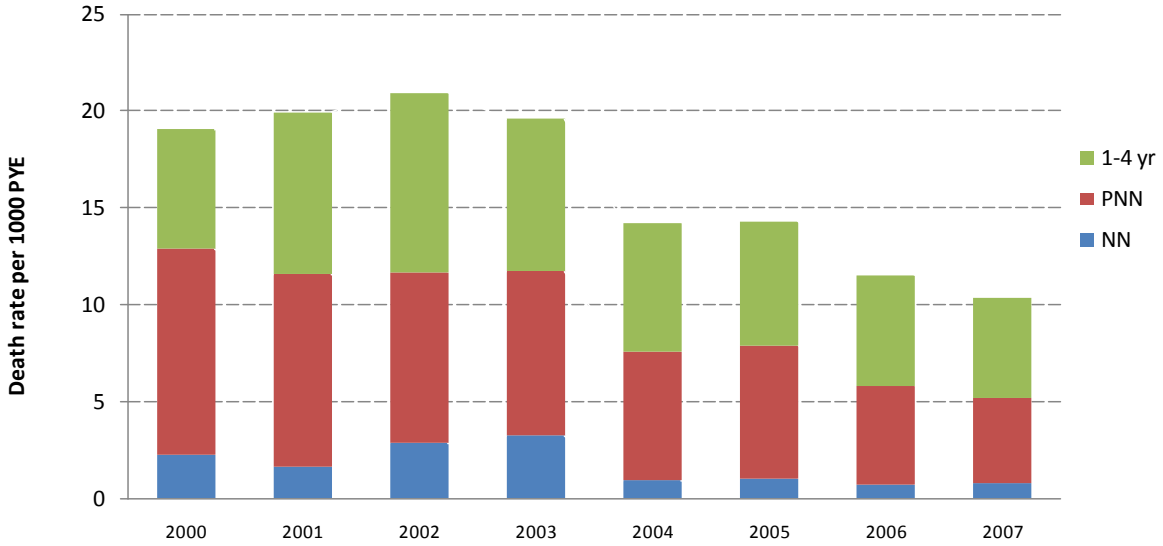


Figure B3.3.3: Trend in central death rates by age group per 1 000 PYE, Africa Centre Demographic and Information Surveillance 2000–2007
Source: Own calculations

Box 3.4: Demographic surveillance site: Agincourt

The Agincourt Health and Demographic Surveillance Site is situated in the rural north-east of the country, close to the Mozambique border. It is representative of a poor rural community. The trend in Figure 3.4.1 indicates that the mortality among the under-5 year age group declined until 1996/7, then increased sharply from 29 to 84 per 1 000 for boys and 26 to 71 per 1 000 for girls in 2002/3.

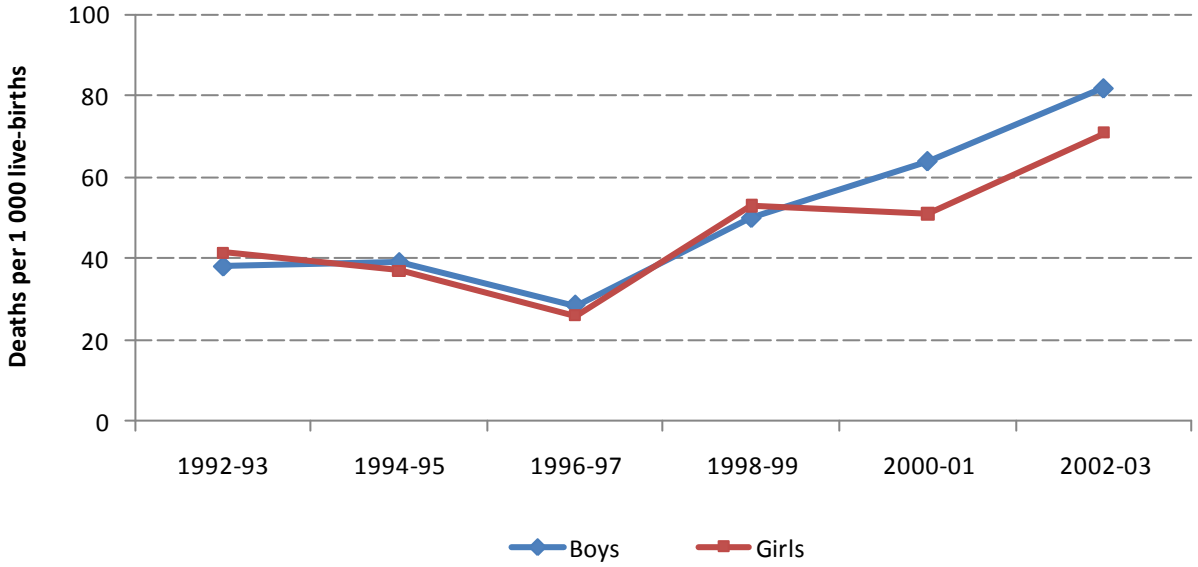


Figure B3.4.1: Under-5 mortality rate for boys and girls, Agincourt HDSS
Source: Kahn, 2006

The trend in U5MR shown in Figure B3.4.2 includes earlier retrospective data, as well as data from the 2010 census round. This indicates a reversal in the decline in under-5 mortality in the early 1990s as well as a possible decline in more recent years.

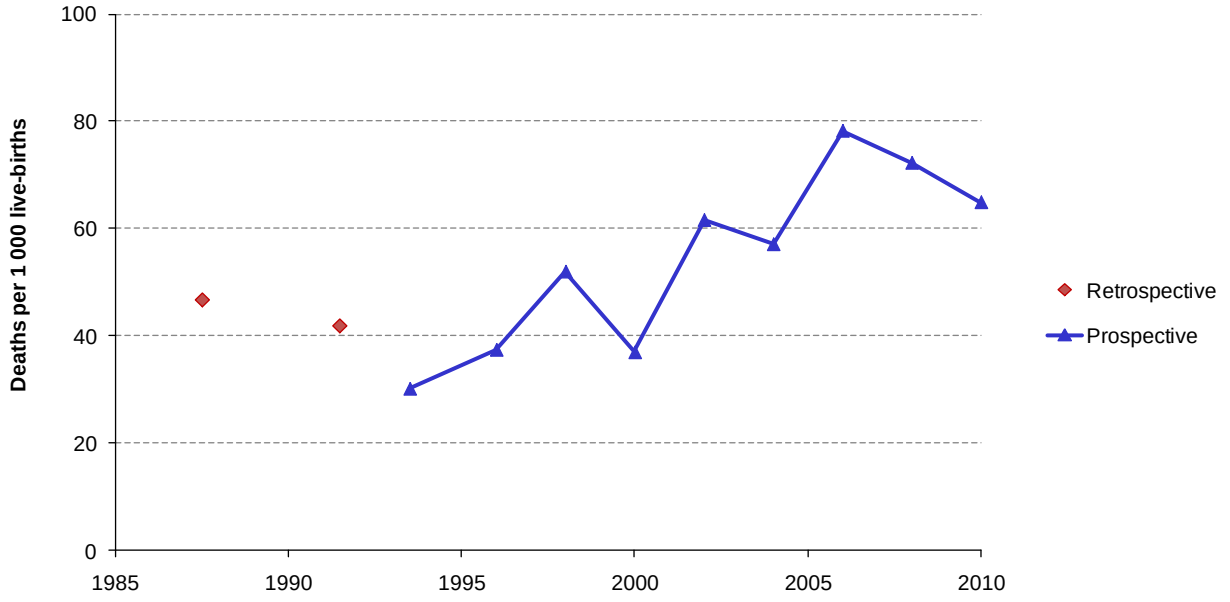


Figure B3.4.2: Under-5 mortality rate for 1985–2010, Agincourt HDSS
Source: Personal communication Michel Garenne

Box 3.5: Local mortality surveillance – Western Cape

There was a steady increase in the number of births in Cape Town since 2001, with a relatively large increase in the number of births between 2003 and 2004 reported in the Cape Town Metropole (53 000 to 58 000). Data quality from 2005 to 2008 makes it difficult to discern the trend over time. However, infant mortality rates in Cape Town over the period 2001–2009 appear to have remained fairly constant until 2004, before becoming more erratic, at a possibly lower level (Figure B3.5.1).

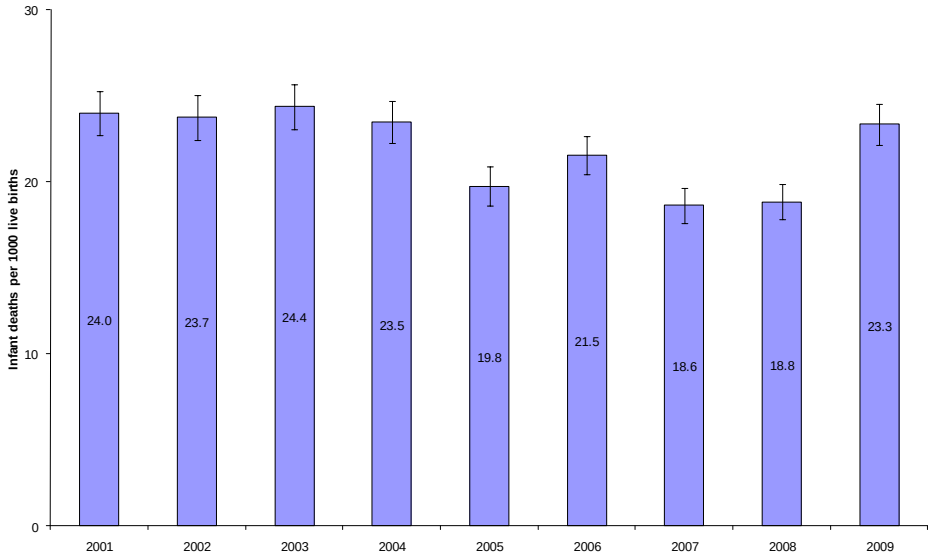


Figure B3.5.1: Trends in infant mortality rate per 1 000 births in Cape Town, 2001–2009
Source: City of Cape Town

Infant mortality in the Boland/Overberg region has remained fairly constant at around 30 infant deaths per 1 000 live births since 1997, with the possibility of a slight downward trend, as shown in Figure B3.5.2.

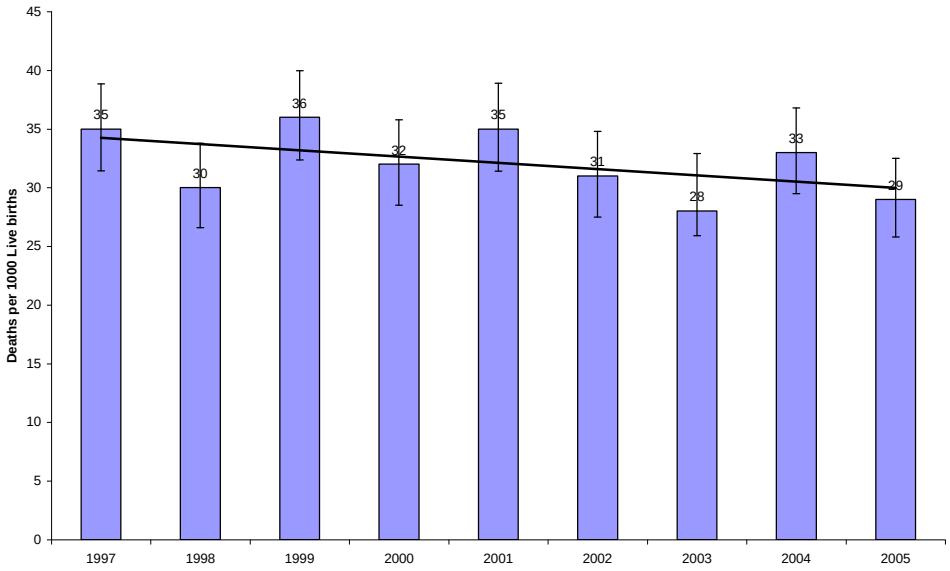


Figure B3.5.2: Infant mortality rate per 1 000 live births in Boland Overberg, 1997–2005
Source: Boland/Overberg

Chapter 4. Cause of death data

The cause of death data for 2007, and the trend from 11 years of vital registration (1997–2007) and 5 years of injury data collected by the National Injury Mortality Surveillance System (2001–2005) are presented in this chapter by age group. Rates are calculated using the number of births and the population of 0–4 years of age projected by the ASSA2003 model (Appendix B). Given the potential change in completeness of registration over this period and the misclassification of HIV as a cause of death, these trends need be interpreted with care. In addition, prior to 2006, deaths of infants older than 7 days were generally inappropriately coded to P-codes, making it impossible to assess trends in the cause of death data for infants without taking this into account. Data from the Western Cape provincial mortality surveillance system, health and demographic surveillance sites and the facility audits are examined to assess the coherence of the national data with those of select populations.

Cause of death in 2007

In 2007, there were 61 335 death notifications of children under the age of 5 years reported by Stats SA. From Figure 4.1, it can be seen that the majority of these deaths were infants (76%) with 54% in the post-neonatal age range. Just under one-quarter (24%) were children aged from 1–4 years. Programmatically, it is important to note that 22% of the deaths occurred in the neonatal period while 78% occurred in children of 1–59 months of age.

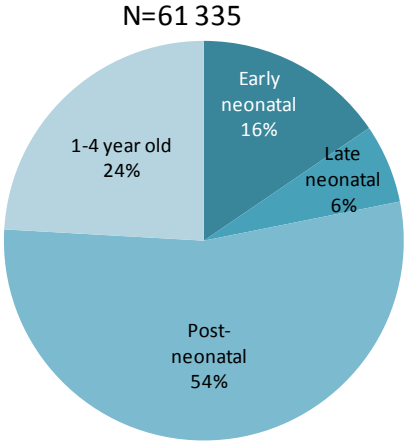


Figure 4.1: Age distribution of total deaths under 5 years of age, Stats SA 2007

The overall cause of death pattern in 2007 is shown in Figure 4.2, where causes of death have been grouped into burden of disease type categories detailed in Appendix C. Perinatal

conditions accounted for 24% of the under-5 deaths, largely from conditions related to prematurity, birth asphyxia and infections – primarily pneumonia and sepsis. This proportion is higher than the proportion of deaths in the neonatal period, as some of the deaths occur at a later stage. Diarrhoea in children mostly from 1–59 months of age accounted for 21% of all under-5 deaths, lower respiratory infections for 18% and ill-defined conditions for 13% of the deaths. Injuries accounted for 5% of the deaths, and TB and HIV/AIDS for only 4% of the deaths (2.5% and 1.2% respectively).

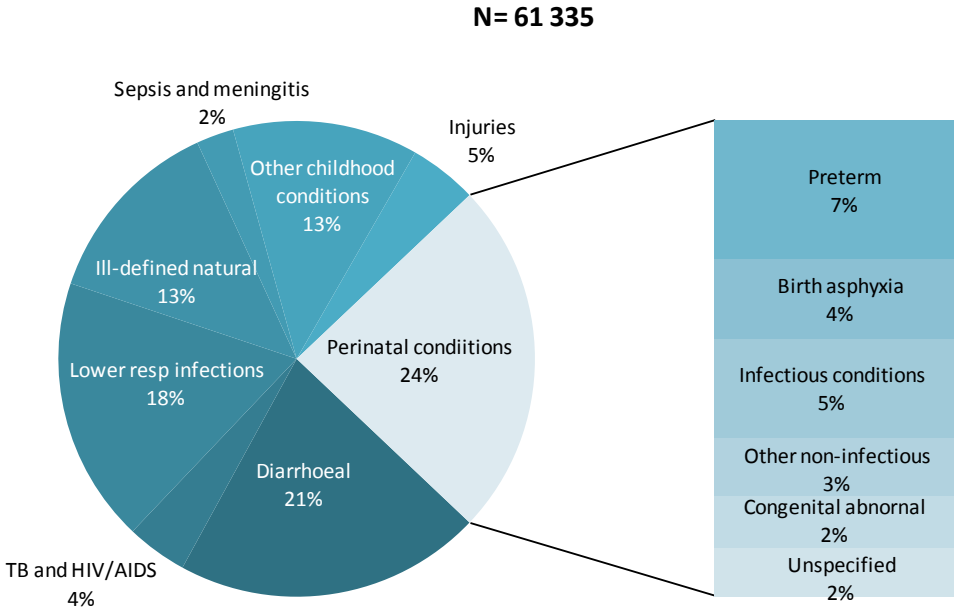


Figure 4.2: Proportion of under-5 deaths by cause, Stats SA 2007

Single causes of death of children under-5 years of age in 2007 are ranked in Figure 4.3. Infectious diseases, in particular, diarrhoeal diseases (21.4%) and lower respiratory infections (16.2%), stand out as the leading causes of death. When combined, these two conditions account for more than one-third of all the deaths. Conditions affecting newborns, including low birth weight (5.4%), other perinatal conditions (5.7%) and other perinatal respiratory conditions (4.1%) also feature in the leading causes. These are ranked 4th, 5th and 7th respectively. Ill-defined natural conditions ranked third and accounted for 13.0%. Only 1.2% of deaths were certified with HIV/AIDS as the underlying cause of death, which is much lower than one would expect, emphasising that the causes of death cannot be taken at face value. All causes of injuries were combined because a large proportion of the injury deaths have an undetermined external cause (42%). In total, injuries accounted for 4.6% of all deaths

under the age of 5 and poisonings (including herbal poisonings) was the most common external cause specified.

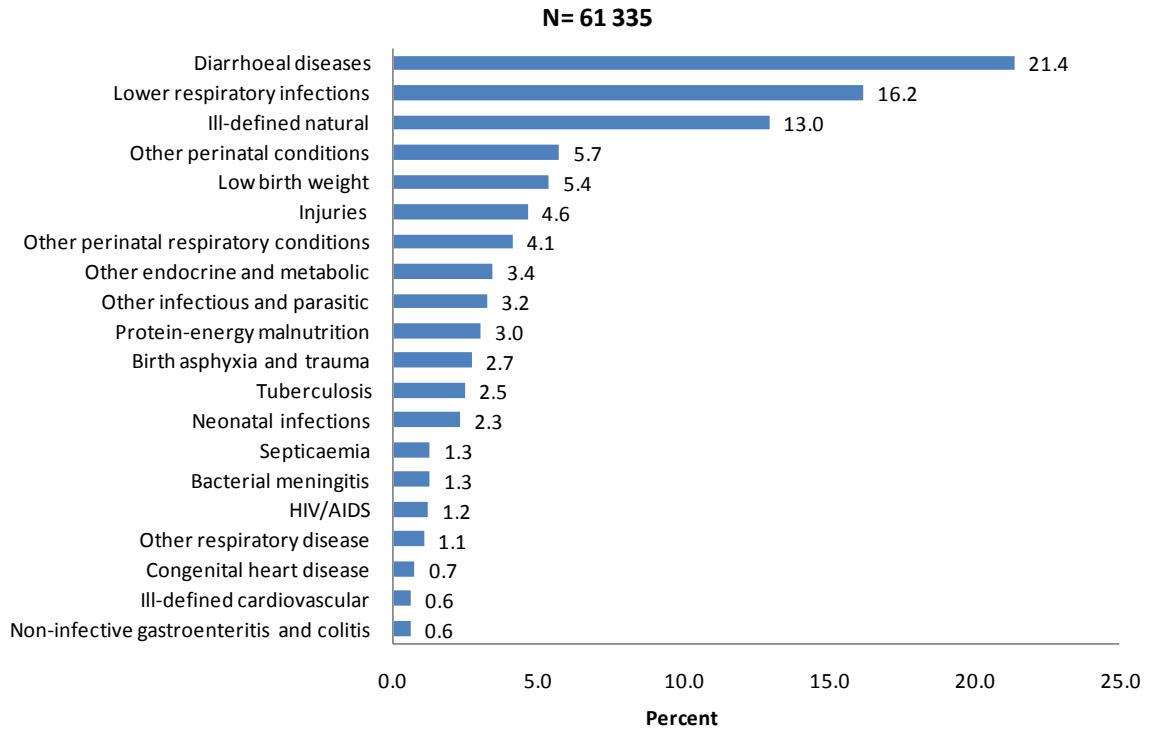


Figure 4.3: Proportion of deaths under 5 years of age by single cause, Stats SA 2007

The National Injury Mortality Surveillance System (NIMSS) recorded 2 297 non-natural deaths among children younger than 5 years of age in the four cities from 2001–2005. The specific cause of death was unknown for 16.7% of these deaths. The leading identifiable causes of injury death are shown in Figure 4.3. The remaining causes were grouped as 'other unintentional', which together account for 10.3% of the injury deaths. As a percentage of all deaths, including those with unknown causes, road traffic injury (23%) was the leading cause of injury death, followed by fires (14.4%), homicide (13%) and drowning (12.5%).

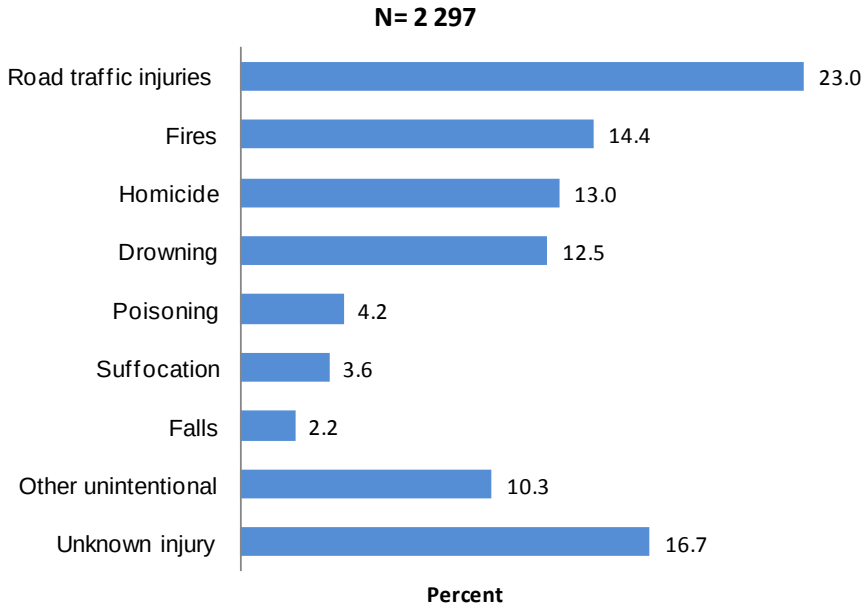


Figure 4.4: NIMSS injury profile for children under 5, 2001–2005

Infants (0–11 months)

In 2007, there were 46 553 deaths of children under 1 year of age. The cause of death profile (Figure 4.5) shows that 31% of infant deaths occurred in the neonatal age range. The most common of these was pre-term death (9%), followed by infections in the perinatal period, which accounted for 7%. Other large proportions of deaths were due to diarrhoeal diseases (20%) and lower respiratory infections (18%) occurring in children from 1–11 months. The ill-defined natural group is also a substantial proportion (12%). However, it is noteworthy that HIV/AIDS accounted for only 4%, signifying considerable under-reporting of HIV/AIDS as an underlying (primary) cause of death.

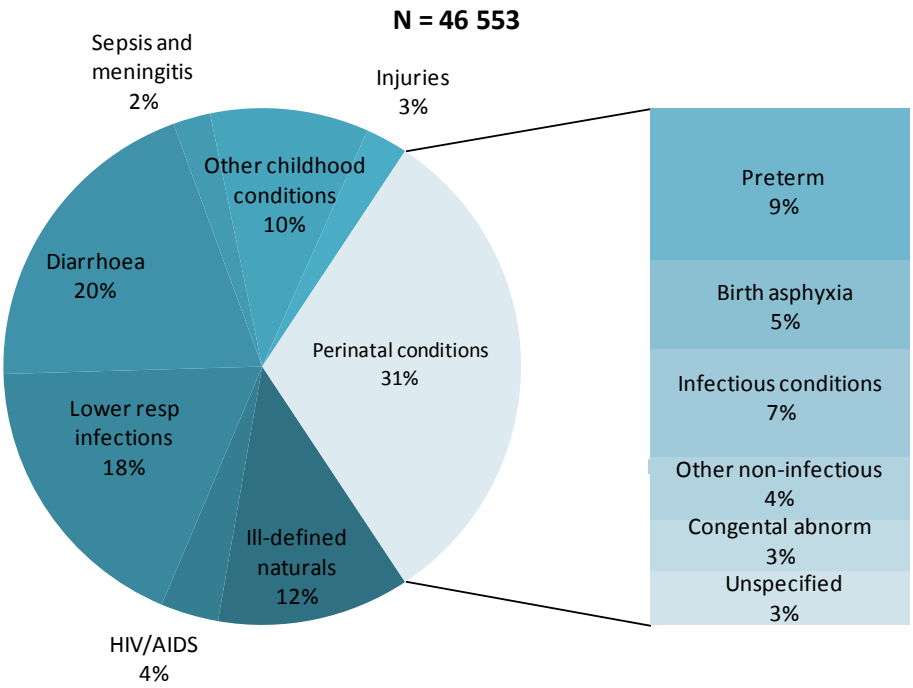


Figure 4.5: Proportion of infant deaths by cause, Stats SA 2007

Since 1997, the number of registered infant deaths increased by 95% to a peak of 48 239 deaths in 2006. The numbers of infant deaths by broad cause group are shown in Figure 4.6. It can be seen that the increase is caused by an increase in Type I conditions, which remained fairly constant until 2001 and then increased until peaking in 2005, followed by a steady decline. In 2006, Type II and the ill-defined natural causes of death increased as Type I causes decreased, corresponding to the correction in coding infant deaths to P-codes. Prior to 2006, Type I conditions were over-represented through the misclassification to perinatal conditions.

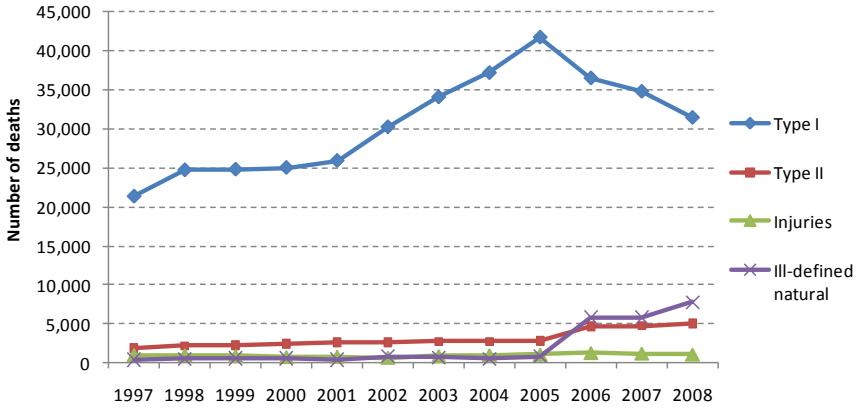


Figure 4.6: Number of infant deaths by broad cause group, Stats SA, 1997–2007

Table 4.1 shows the ranking of the top 10 causes of deaths for selected years throughout the period. The ranking of the causes of infant deaths remained relatively constant from 1997–2005, during the period of misclassified infant deaths to P-codes. Correct coding resumed in 2006 and is reflected in the change in ranking of infant deaths in 2007: other perinatal conditions decreased from 40.3% in 2005 to 7.5% in 2007. Noteworthy is the high proportion (12%) of the ill-defined natural causes of death in the most recent period, which shows up once the P-codes are properly applied. HIV/AIDS was the cause of 1.3% of the deaths in 1997 and 1.6% in 2001, but does not feature for later years and is implausibly low. In contrast, the Cape Town mortality surveillance shows that in 2006, 8% of infant deaths in that city were due to HIV/AIDS, despite this city having a lower HIV prevalence than the country as a whole (see Box 4.1). Furthermore, verbal autopsy data from the Africa Centre Demographic and Information System (see Box 4.2) shows that 29% of infant deaths during 2000–2002 were due to HIV/AIDS.

	1997 N=24 734		**2001 N=29 842**		**2005 N=46 427**		**2007 N=46 553**	
1	Other perinatal conditions	43.8%	Other perinatal conditions	37.2%	Other perinatal conditions	40.3%	Diarrhoeal diseases	20.6%
2	Other perinatal respiratory conditions	16.5%	Other perinatal respiratory conditions	24.0%	Other perinatal respiratory conditions	24.0%	Lower respiratory infections	16.5%
3	Low birth weight	10.8%	Low birth weight	8.3%	Low birth weight	7.8%	Ill-defined natural	12.0%
4	Neonatal infections	5.3%	Neonatal infections	5.4%	Neonatal infections	5.4%	Other perinatal conditions	7.5%
5	Birth asphyxia and trauma	3.8%	Other endocrine and metabolic	4.2%	Birth asphyxia and trauma	3.9%	Low birth weight	7.1%
6	Undetermined injury	2.7%	Other infectious and parasitic	3.2%	Other infectious and parasitic	3.3%	Other perinatal respiratory conditions	5.4%
7	Protein-energy malnutrition	1.7%	Birth asphyxia and trauma	3.2%	Other endocrine and metabolic	2.4%	Birth asphyxia and trauma	3.6%
8	Other endocrine and metabolic	1.6%	Protein-energy malnutrition	1.7%	Protein-energy malnutrition	1.8%	Other infectious and parasitic	3.4%
9	HIV/AIDS	1.4%	HIV/AIDS	1.6%	Ill-defined natural	1.4%	Other endocrine and metabolic	3.2%
10	Congenital heart disease	1.3%	Undetermined injury	1.1%	Surgical/medical misadventure	1.1%	Neonatal infections	3.0%
	Total top 10	89.0%	Total top 10	89.9%	Total top 10	91.4%	Total top 10	82.3%

Table 4.1: Ranked causes of infant deaths in 1997, 2001, 2005 and 2007, Stats SA

Injuries were an infrequent cause of death in this age group, accounting for 3% of all deaths. Stats SA data do not provide reliable details about the causes of injury deaths and have a high proportion due to injuries of undetermined intent and so the NIMSS data are presented. The number of injury deaths was relatively small and should be interpreted with caution. The NIMSS data indicate that homicide was the leading cause of injury deaths among babies aged from 0–11 months from 2001–2005 (Table 4.2). This category accounted for more than two-thirds of injury deaths for this age group between 2001 and 2004, and was mainly the result of babies being abandoned. The decrease in the proportion of deaths due to homicide in 2005 was accompanied by an increase in those with unknown cause in that year. Fire-related and passenger deaths were the second and third leading causes of death. These were followed by other unspecified unintentional injury deaths, suffocation and drowning mortality. Box 3.1 shows that in the City of Cape Town, 12% of infant deaths were due to injuries – considerably higher than the proportion in the national data (3%) or that from the Africa Centre Demographic and Information System (2%). (It should be noted that higher proportions do not necessarily indicate higher rates).

Table 4.2: Ranked causes of infant injury deaths*, NIMSS 2001-2005

	2001 N=125	2002 N=157	2003 N=135	2004 N=153	2005 N=211
1	Homicide 23.2%	Homicide 25.5%	Homicide 28.9%	Homicide 24.2%	Other unint. 15.2%
2	Other unint. 16.0%	Other unint. 9.6%	Other unint. 11.1%	Other unint. 15.0%	Fires 9.5%
3	Road traffic injury* 10.4%	Road traffic injury* 9.6%	Fires 11.1%	Drowning 7.8%	Road traffic injury* 9.0%
4	Fires 9.6%	Fires 9.6%	Suffocation 7.4%	Road traffic injury* 7.2%	Homicide 7.1%
5	Suffocation 4.0%	Suffocation 6.4%	Road traffic injury* 6.7%	Fires 5.9%	Drowning 4.3%
6	Drowning 2.4%	Drowning 1.9%	Drowning 4.4%	Suffocation 5.2%	Suffocation 3.8%
7	Poisoning 2.4%	Poisoning 1.9%	Poisoning 3.7%	Falls 2.0%	Poisoning 2.4%
8	Falls 2.4%	Falls 0.6%	Falls 1.5%	Poisoning 1.3%	Falls 0.5%
	Unknown 29.6%	Unknown 35.0%	Unknown 25.2%	Unknown 31.4%	Unknown 48.3%

* All passenger, pedestrian, cyclist and unspecified road traffic deaths were grouped as 'Road traffic injuries'

Box 4.1: Local area surveillance: City of Cape Town

The City of Cape Town participates in an on-going system that collects cause of death statistics. Figure B4.1.1 shows that in 2006, the highest proportion of infant deaths was due to perinatal conditions (26%), followed by the ill-defined (17%), injuries (12%) and respiratory infections (10%).

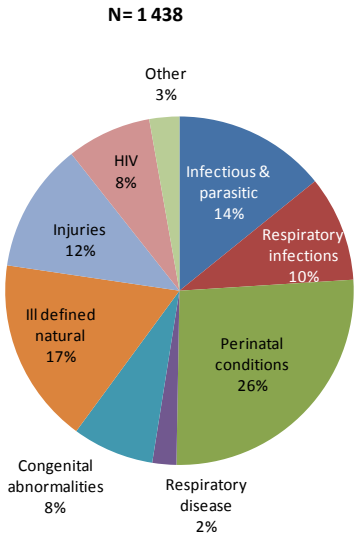


Figure B4.1.1: Cause of infant deaths, City of Cape Town, 2006

Box 4.2: Demographic surveillance site: Africa Centre

On-going demographic surveillance in a rural site in KwaZulu-Natal provides cause of death information. These causes of death have been ascertained using a verbal autopsy questionnaire modelled on the WHO verbal autopsy tool. Deaths due to HIV/AIDS, and infectious and parasitic conditions account for 77% of the total.

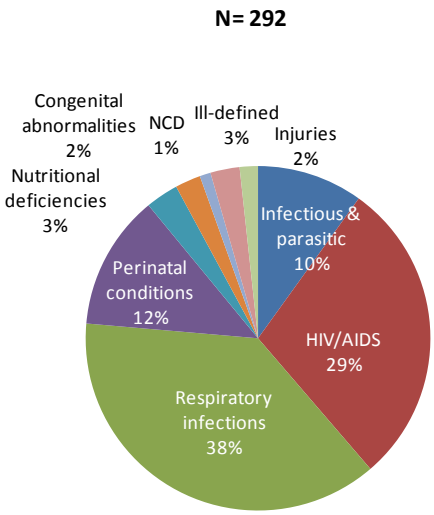


Figure B4.2.1: Cause of infant deaths, ACDIS, 2000–2002

Leading causes of early neonatal death, babies 0–6 days old

The coding in this age group has been in accordance with the ICD definition that restricts the P-codes to causes that *originate in the first week of life*, making it possible to examine the trends for early neonatal deaths across the whole period. Figure 4.7 shows the numbers of deaths due to the leading single ICD codes. (See Appendix D for provincial data). Although there was an increase in all causes of early neonatal deaths from 2002 onwards, birth asphyxia showed a marked increase, reaching a peak in 2006. It is difficult to interpret this trend, which could signify a deterioration of health care, a change in definition of what is considered to be a stillbirth or an increase in death registration.

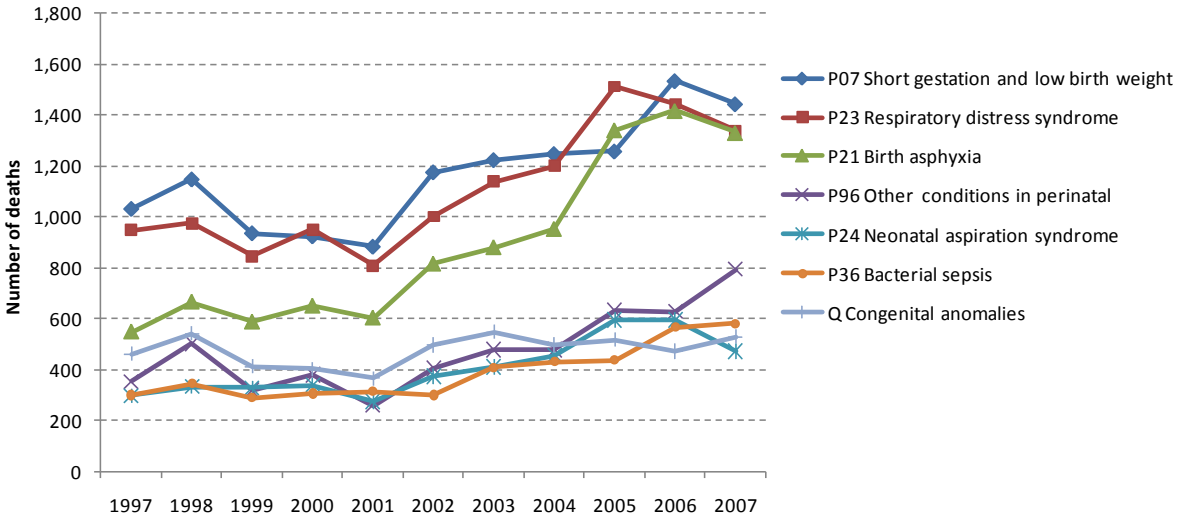


Figure 4.7: Leading causes of early neonatal death, Stats SA, 1997–2007

Box 4.3: Perinatal Problem Identification Programme (PPIP)

Figure B4.3.1 shows the primary causes of neonatal death for the cases captured by PPIP in the period from 2003–2006. The effects of prematurity and asphyxia accounted for 74% of the deaths. These proportions can be contrasted with the cause profile for the registered deaths of newborns (0-6 days old) in Figure B4.3.2. The registered deaths have a higher proportion of sepsis, and other infections and unspecified causes than the PPIP. It is interesting to note that 77% of the registered deaths in this age group occurred in hospital.

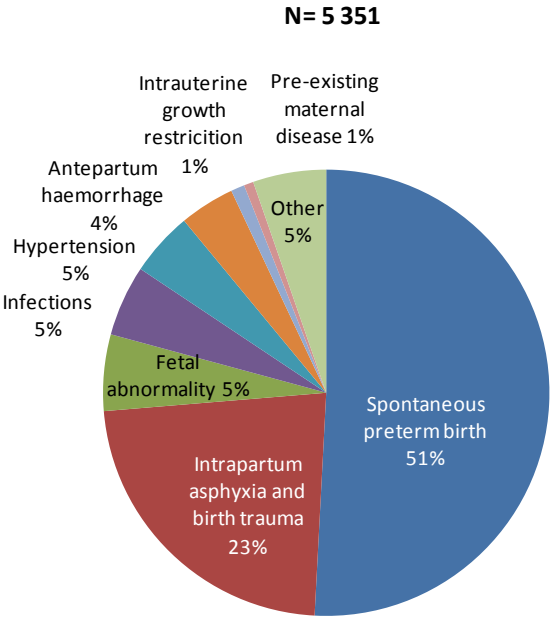


Figure B4.3.1: Proportion of neonatal deaths by cause, PPIP, 2003–2006

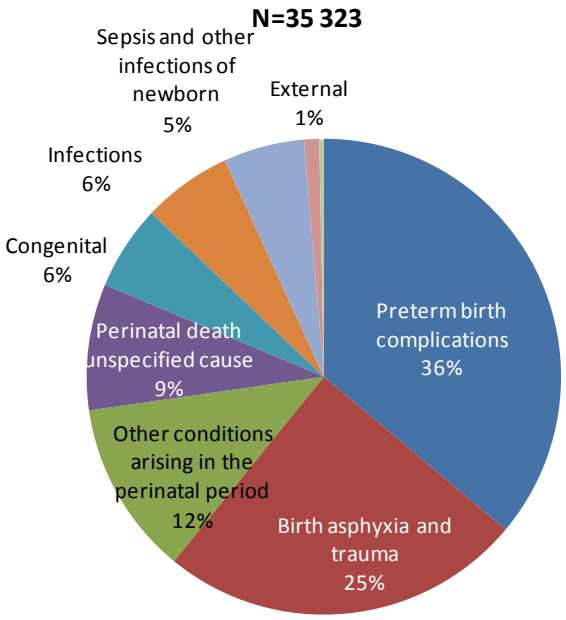


Figure B4.3.2: Proportion of early neonatal deaths by cause, Stats SA, 2003–2006

Leading causes of death in babies, 7–28 days old

The six leading causes of late neonatal death (7–28 days) are shown in Figure 4.8, highlighting the emergence of infectious diseases over time. (See Appendix E for provincial data). While short gestation, and low birth weight and respiratory distress syndrome remained fairly constant over the period, congenital pneumonia and bacterial sepsis more than doubled. Congenital pneumonia and bacterial sepsis may be related to HIV infection.

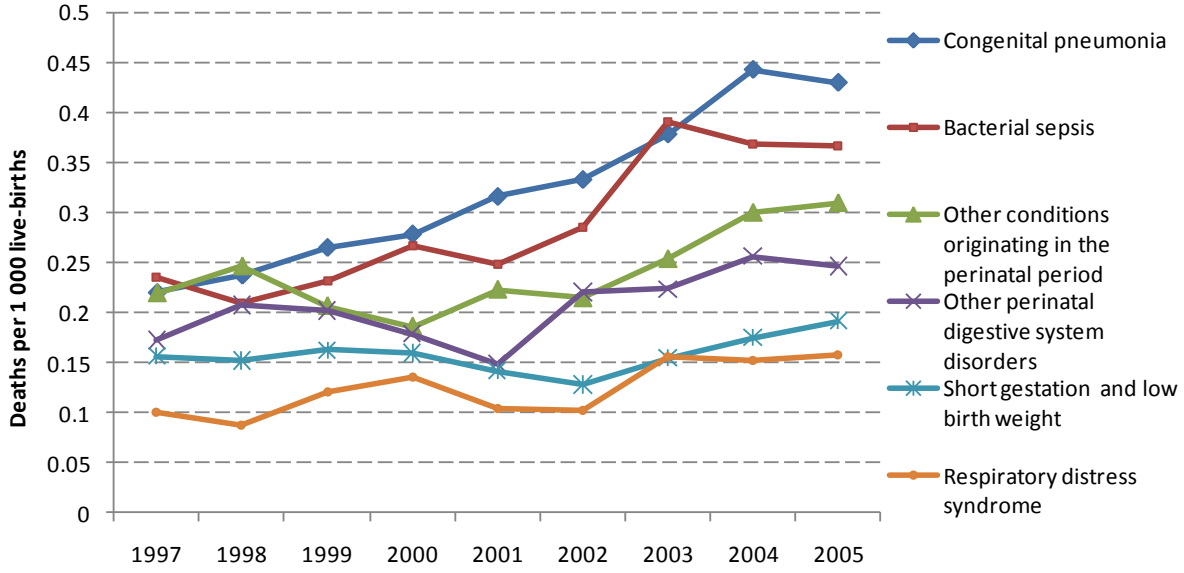


Figure 4.8: Leading causes of death in babies (7–28 days old), Stats SA, 1997–2005

Leading causes of death in children aged from 1–11 months old

In the post-neonatal age group, which showed the greatest rate of increase in deaths per 1 000 live births, there was a substantial increase in the HIV opportunistic infections as shown by other perinatal digestive system disorders and congenital pneumonia (Figure 4.9). Diarrhoeal disease deaths peaked in 1998/9, which could be associated with the cholera outbreak that occurred, with its epicentre in KwaZulu-Natal (See Appendix F for provincial data). The trends in the other causes of death were fairly unchanged.

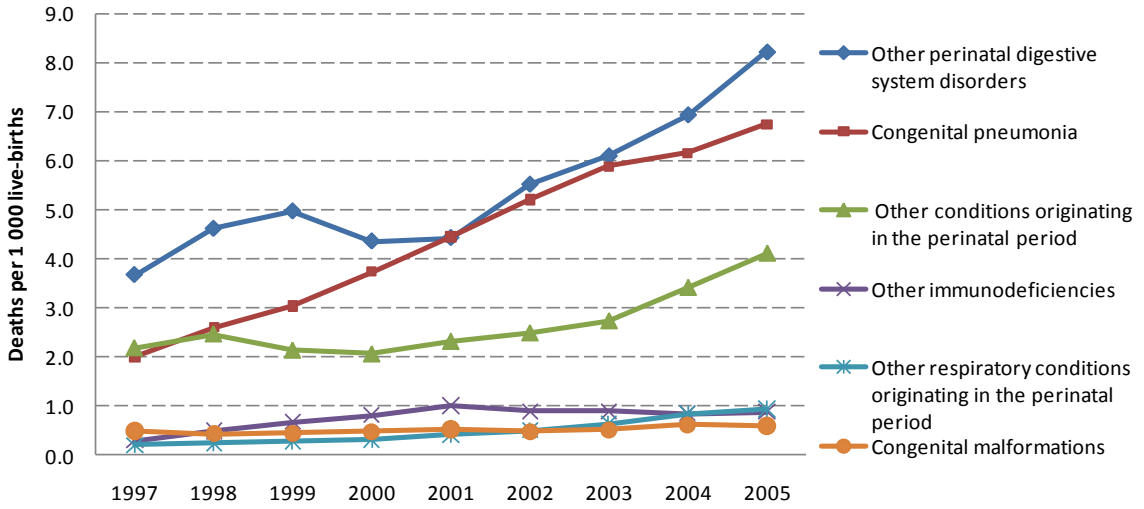


Figure 4.9: Leading causes of post-neonatal deaths (1–11 months old) Stats SA, 1997–2005

Table 4.3 shows the top causes of death that account for the decrease between age groups 2–3 months and 4–5 months for 2006 and 2007 combined, once appropriate ICD-10 coding was applied. Pneumonia, ill-defined causes, pneumocystosis and diarrhoea account for a large part of the increased numbers in the 2–3 month age group compared with the 4–5 month age group, and may be relevant in identifying the causes of death that are actually associated with HIV.

Table 4.3: Leading 20 causes of death that account for the difference between the 2–3 month and the 4–5 month age groups in 2006 and 2007 combined, Stats SA

	Cause of death	Number in 2–3 month age group	Difference compared to 4–5 month age group	% of total difference
J18	Pneumonia, organism unspecified	6 058	4 059	37.3
R99	Other ill-defined and unspecified causes of mortality	3 414	1 606	14.8
B59	*Pneumocystosis carinii*	1 175	981	9.0
A09	Diarrhoea and gastroenteritis of presumed infectious origin	4 734	915	8.4
D84	Other immunodeficiencies	596	340	3.1
J22	Unspecified acute lower respiratory infection	463	337	3.1
A41	Other septicaemia	398	237	2.2
B33	Other viral diseases, NEC	386	200	1.8
J98	Other respiratory disorders	223	140	1.3
Y67	Herbal poisoning	282	134	1.2
J20	Acute bronchitis	158	113	1.0
E86	Volume depletion	276	103	0.9
R95	Sudden infant death syndrome	127	95	0.9
B20	Human immunodeficiency virus disease resulting in infectious or parasitic disease	160	93	0.9
B22	Human immunodeficiency virus disease resulting in malignant neoplasm	184	89	0.8
J69	Pneumonitis due to solids and liquids	137	86	0.8
J21	Acute bronchiolitis	125	83	0.8
G03	Meningitis due to other and unspecified causes	205	74	0.7
E44	Protein-energy malnutrition of mother	102	69	0.6
I50	Heart failure	100	64	0.6
	Top 20 causes	19 303	9 818	90.3
	Overall difference	22 199	10 876	100.0

Children aged 1–4 years

Figure 4.10 shows the cause-specific breakdown of all deaths of children aged from 1–4 years in 2007. Infectious diseases accounted for 52% of deaths in this age group, diarrhoeal disease, 24% and lower respiratory infections, 15%. TB and HIV/AIDS apparently only accounted for 7% of the deaths. Other Type I and Type II causes are responsible for 17% of deaths, the ill-defined natural accounting for 16% and the injuries for 11%.

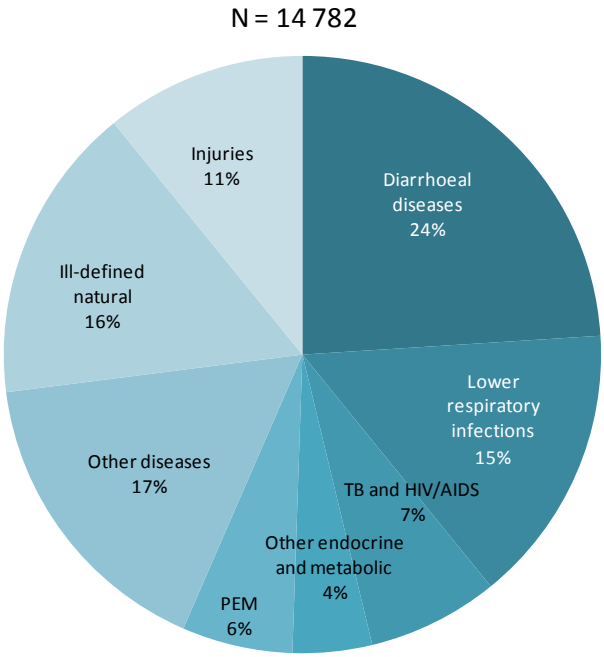


Figure 4.10: Proportion of child deaths aged from 1–4 years by cause, Stats SA, 2007

The total number of registered deaths of children between the ages of 1 and 4 increased by 91% over the 11-year period from 1996–2007. The trend in the number of registered child deaths (1–4 years) is shown in Figure 4.11 by broad cause group and it can be seen that infectious diseases increased while injuries and non-communicable diseases remained fairly constant. Deaths due to ill-defined causes were stable, but increased from 2003.

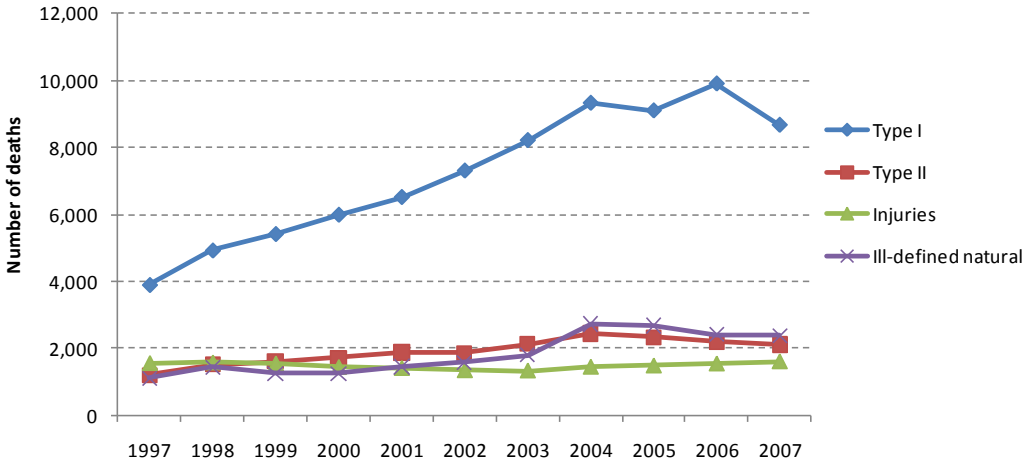


Figure 4.11: Number of child deaths (1–4 years) by broad cause, Stats SA, 1997–2007

Turning to the leading causes of death, Figure 4.12 shows that diarrhoea, which is mostly infectious in South Africa, is a major reported cause of death in children aged from 1–4 years. In this age group, diarrhoeal fatalities increased by 120% in the 11-year period. Other Type I causes, such as lower respiratory infections and TB/HIV, increased considerably, as well as other endocrine and metabolic disorders, which includes deaths certified with the 'immune suppression', a euphemism for AIDS. Ill-defined natural deaths increased substantially in 2004 and then declined slowly. This appears to have occurred only in the Eastern Cape and KwaZulu-Natal.

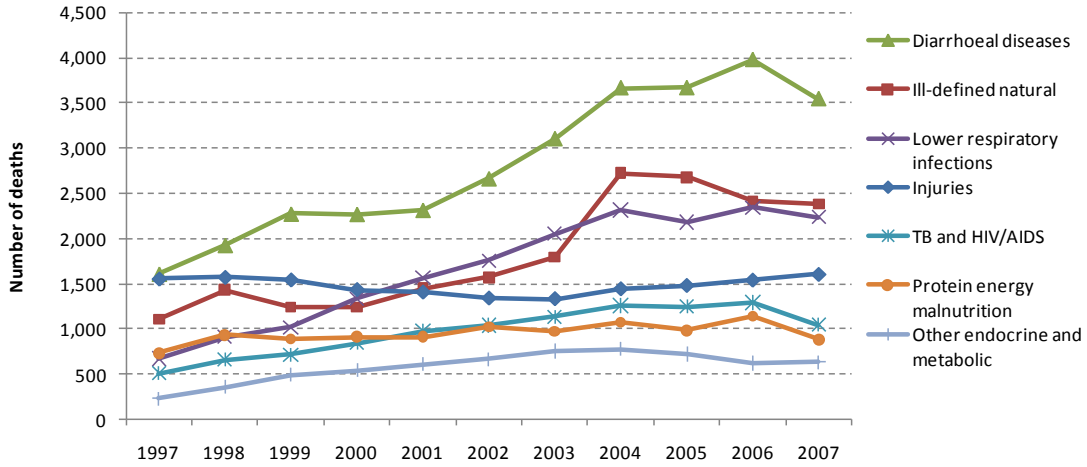


Figure 4.12: Leading causes of child deaths (1–4 years old) Stats SA, 1997–2007

The ranking of causes for specific years in Table 4.4 show that diarrhoeal diseases, lower respiratory infections and the ill-defined natural causes are quite constant in their ranking over time. Noteworthy, is the high proportion of undetermined injuries in this age group compared with infants, and the decreasing proportion over time (16.6% to 4.0%). The ranking and relative proportions of TB and HIV are also fairly consistent over this period.

Table 4.4: Ranked causes of death (1–4 years) in 1997, 2001, 2005 and 2007, Stats SA

	1997 N=7 751	2001 N=11 252	2005 N=15 596	2007 N=14 782
1	Diarrhoeal diseases 20.8%	Diarrhoeal diseases 20.6%	Diarrhoeal diseases 23.5%	Diarrhoeal diseases 24.0%
2	Undetermined injuries 16.6%	Lower respiratory infections 13.9%	Ill-defined natural 17.1%	Ill-defined natural 16.1%
3	Ill-defined natural 14.2%	Ill-defined natural 12.8%	Lower respiratory infections 14.0%	Lower respiratory infections 15.1%
4	Protein-energy malnutrition 9.5%	Undetermined injuries 8.1%	Protein-energy malnutrition 6.3%	Protein-energy malnutrition 6.0%
5	Lower respiratory infections 8.7%	Protein-energy malnutrition 8.1%	Undetermined injuries 5.7%	Tuberculosis 5.4%
6	Tuberculosis 3.8%	Tuberculosis 5.8%	Tuberculosis 5.6%	Other endocrine and metabolic 4.3%
7	Other endocrine and metabolic 3.0%	Other endocrine and metabolic 5.4%	Other endocrine and metabolic 4.6%	Undetermined injuries 4.0%
8	HIV/AIDS 2.9%	Other infectious and parasitic 3.1%	Other infectious and parasitic 3.0%	Other infectious and parasitic 2.6%
9	Ill-defined cardiovascular 1.8%	HIV/AIDS 3.0%	HIV/AIDS 2.4%	Bacterial meningitis 2.0%
10	Bacterial meningitis 1.5%	Bacterial meningitis 1.5%	Other respiratory diseases 1.7%	HIV/AIDS 1.7%
	Total top 10 82.6%	Total top 10 82.3%	Total top 10 84.0%	Total top 10 81.2%

The NIMSS four-city data for children aged from 1–4 years are shown in Table 4.5. Road traffic injuries were the leading cause of unnatural death from 2001–2005. These deaths accounted for nearly one-third of injury deaths and were mainly pedestrian fatalities. This was followed by fires and drowning, while homicide was the fourth leading cause of death for children aged from 1–4 years. Other unintentional injury deaths were mainly as a result of medical procedures, blunt objects, electrocution and crushing.

Table 4.5: Ranked causes of injury death* (1–4 years) NIMSS, 2001–2005

	2001 N=307	2002 N=291	2003 N=272	2004 N=326	2005 N=320
1	Road traffic injury 24.8%	Road traffic injury 28.9%	Road traffic injury 33.5%	Road traffic injury 34.4%	Road traffic injury 30.6%
2	Fires 17.9%	Fires 21.0%	Drowning 15.4%	Fires 17.2%	Drowning 15.6%
3	Drowning 16.3%	Drowning 20.3%	Fires 15.1%	Drowning 16.6%	Fires 14.7%
4	Homicide 12.1%	Other unint. 6.9%	Other unint. 9.6%	Homicide 9.5%	Other unint. 12.2%
5	Other unint. 8.5%	Homicide 6.5%	Homicide 9.2%	Other unint. 6.1%	Homicide 8.4%
6	Poisoning 8.5%	Poisoning 3.8%	Suffocation 5.1%	Poisoning 3.7%	Poisoning 5.6%
7	Falls 2.6%	Suffocation 2.7%	Poisoning 4.4%	Suffocation 2.5%	Falls 3.8%
8	Suffocation 2.9%	Falls 2.4%	Falls 2.2%	Falls 2.5%	Suffocation 0.9%
	Unknown 6.5%	Unknown 7.6%	Unknown 5.5%	Unknown 7.7%	Unknown 8.1%

* All passenger, pedestrian, cyclist and unspecified road traffic deaths were grouped as 'road traffic injuries'

Box 4.5: ***Local mortality surveillance – City of Cape Town***

The local mortality surveillance data from the City of Cape Town used a short code list, based on the ICD-10, to classify causes of death. Striking in the cause of death profile for children between the ages of 1 and 4 years is the very high proportion of deaths due to unintentional injuries (27%). In 2006, infectious and parasitic conditions accounted for 19% of deaths, HIV/AIDS for 12% and respiratory infections for 7%.

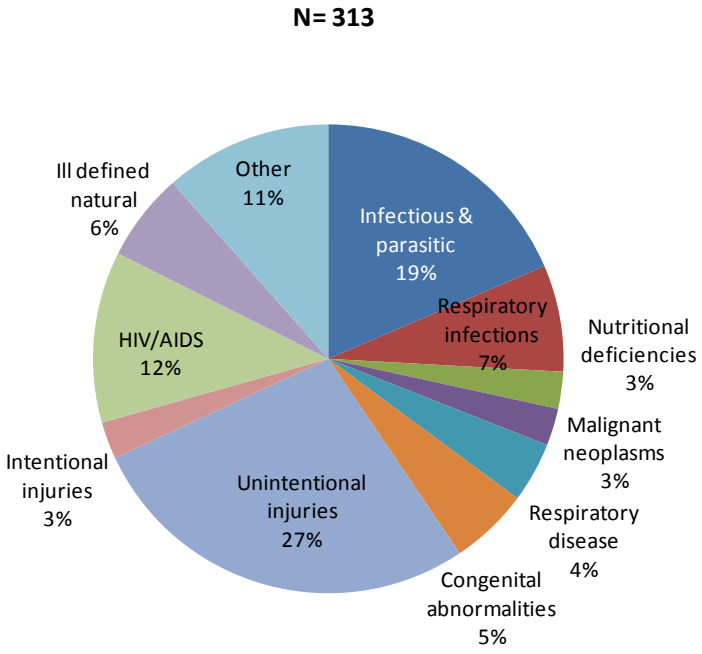


Figure B4.5.1: Deaths in children aged 1-4 years old, City of Cape Town, 2006

Box 4.6: Health and Demographic Surveillance Sites

Africa Centre deaths (1–4 years) 2000–2002

Three years of pooled surveillance data from a rural part of KwaZulu-Natal province show that HIV/AIDS was the leading cause of death (63%) in children aged from 1–4 years. Deaths due to infectious and parasitic conditions accounted for 13%, nutritional deficiencies for 7% and respiratory infections for 6%.

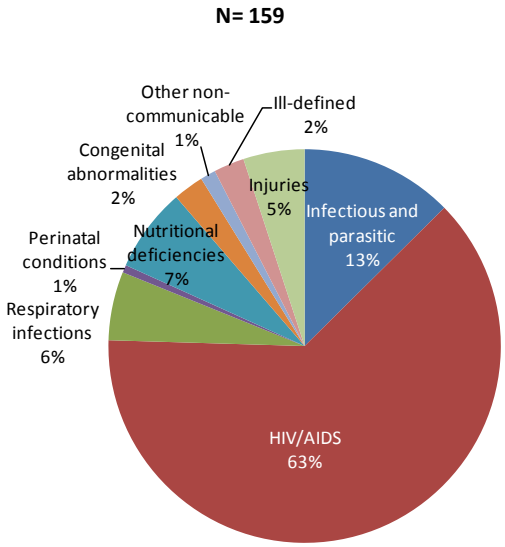


Figure B4.6.1: Child deaths (1-4 years) ACDIS, 2000–2002

Source: Own analysis of ACDIS data

Agincourt deaths (age 1–4) 2002–2005

Causes of death for children under 5 years living in the Agincourt surveillance area in rural Limpopo province (Figure B3.6.2) show that HIV accounted for 34% of deaths (which is consistent with the lower prevalence of HIV than in the Africa Centre), while other infectious diseases: diarrhoea accounted for 10% and acute respiratory infection for 8%, and malnutrition for 8%.

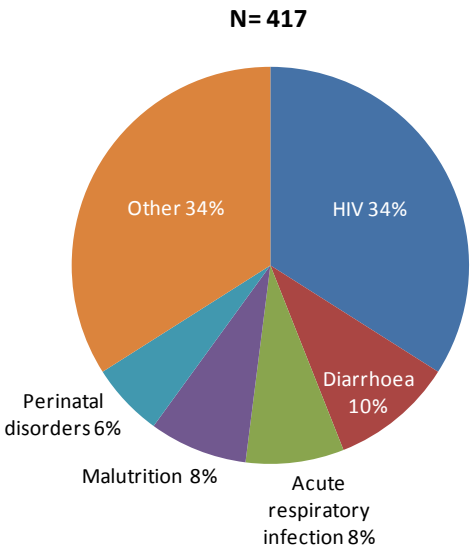


Figure B4.6.2: Child deaths (1–4 years) Agincourt, 2002–2005

Source: Tollman et al., *2008.*

Box 4.7: Facility-based data

Child Healthcare Problem Identification Programme

HIV status and malnutrition are collected as risk factors in Child PIP, and not the immediate causes of death. Analysis of the 2005 data to identify the HIV-related deaths and classify the causes of death according to the National Burden of Disease list shows that HIV/AIDS was the leading cause of death followed by lower respiratory disease, diarrhoea and septicaemia (Figure B4.7.1).

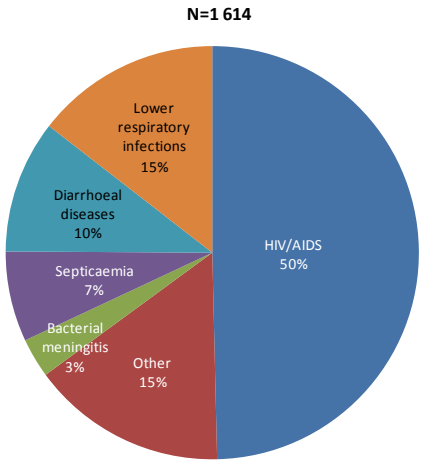


Figure B4.7.1: Child deaths under 5 years of age, Child PIP, 2005

Source: Own analysis of Child PIP data

Conclusion

It is difficult to distinguish an increase in death rates from an increase in registration of deaths from this analysis. However, congenital causes, which might be expected to remain stable over time, increased by 20% in 2002, suggesting that there has been a real increase in the number of deaths, which suggests that the increase in numbers of child deaths has resulted from a mixture of improved registration as well as an increase in death rates.

In terms of the impact of HIV, all sources of data show consistent increases in mortality due to infectious diseases, but the Stats SA data under-represent AIDS deaths. There are indications that HIV- related deaths are misclassified as pneumonia, pneumocystis, diarrhoea and ill-defined causes, among others. The facility-based data, as well as the verbal autopsy data, appear to provide a more realistic picture regarding the cause of death profile across age groups.

Chapter 5. Adjusted estimates of child mortality from vital registration

Introduction

Ideally one should be able to estimate infant and child mortality directly using the vital registration data. Unfortunately, these data are not complete, and to complicate matters, the level of incompleteness has not remained constant over time. However, if one had estimates of completeness of the vital registration over time, one could use these to correct the registered deaths and thus produce estimates of the mortality rates.

Without a survey of a representative sample of deaths of children to find out what proportion was registered, the only way to estimate the extent of incompleteness of the vital registration is to compare the estimates of IMR and U5MR derived directly from the registered deaths without correction, with (reliable) estimates produced from other data. This is what Darikwa and Dorrington (2011) did, with the additional assumption that the change in completeness over time was monotonic and smooth.

As pointed out by Darikwa and Dorrington (2011), if their estimates of the under-5 mortality rate derived from the 2007 Community Survey (and the previous censuses) are correct, then this implies that the completeness of vital registration for children increased considerably over the period from 1997–2006 (Figure 5.1). They fitted a logistic curve to the implied completeness factors, which suggested that in 1997, less than 50% of child deaths were registered. By 2006, the completeness reached 88% for infants and 60% for children aged from 1–4 years. A higher level of completeness for infants compared to children aged from 1–4 years may seem counter-intuitive, as completeness is generally assumed to increase with age, but it is also implied by the estimates of infant and child mortality rates produced by others (e.g. IGME, UN Population Division, ASSA, etc.). One possible explanation might be that given the high percentage of deliveries in health services (89% according to the 2003 SADHS and 95% observed in the 2008 SABSSM survey (Shisana et al., 2010) it is possible that infants who did not thrive, continued to access health services to the time of death, leading to a greater likelihood of the death being registered in the event of death, while older children did not. The 2003 SADHS indicates that this might have been the case, with, for example, a higher proportion of infants with diarrhoea in the two weeks preceding the survey being taken to health services (61%) compared with children over the age of 2 years (50%).

In addition, it is possible that those receiving a child support grant may be reluctant to record the death of this source of the income.

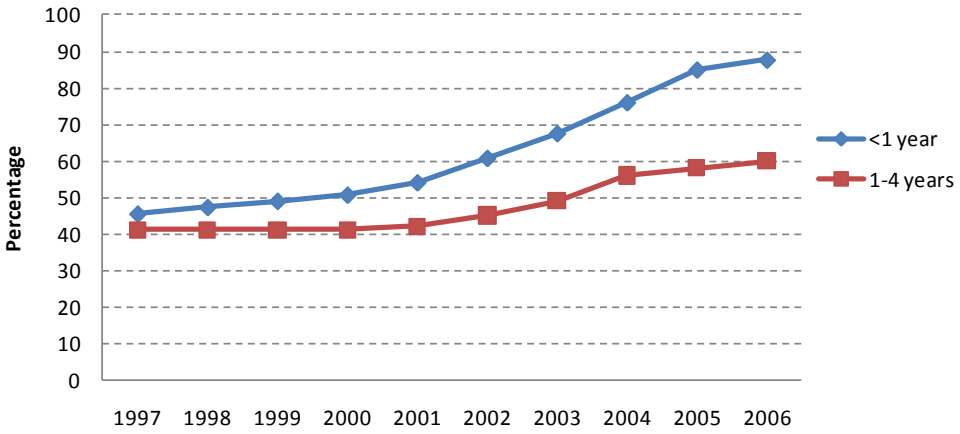


Figure 5.1: Completeness of vital registration for child deaths under 5 years

Figure 5.2 shows the estimates of the U5MR derived from CEB/CS and the household deaths data from the 2007 Community Survey, compared to the estimated rate from vital registration data after adjustment for incompleteness of registration. This suggests that there was little change in the U5MR between 1998 and 2006.[2] However, it is possible that the indirect method used to produce the estimates averaged rates so that any evidence of a peaking in rates over this period was removed.

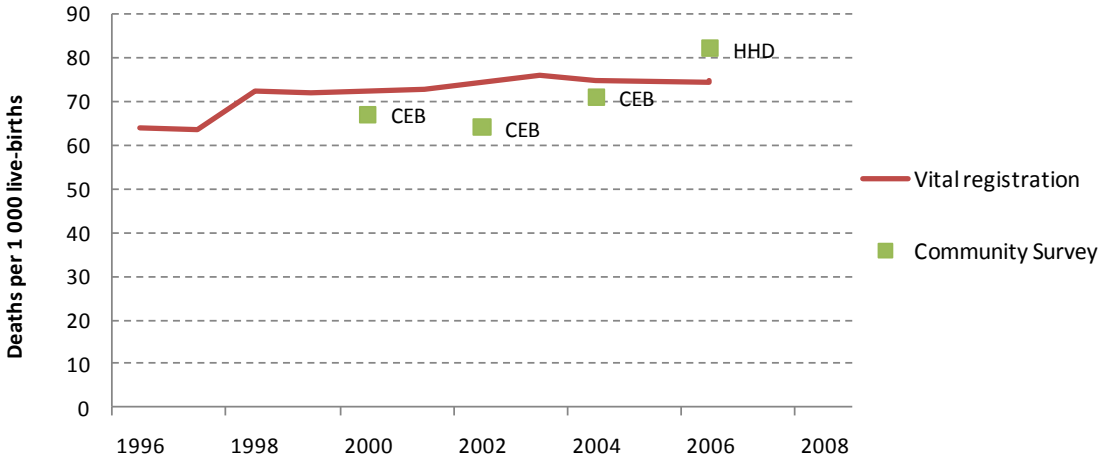


Figure 5.2: Comparison of under-5 mortality estimates derived from the data on CEB/CS and deaths reported by household from the 2007 Community Survey with estimates from vital registration (corrected for incomplete registration)

[2] It is assumed that deaths reported by households tend to lead to an overestimate of under-5 mortality, based on both the estimates from the 2001 census and the Community Survey.

Adjusted mortality rates

The trend in the under-5, infant and neonatal mortality rates, after applying the completeness adjustment to the vital registration data, are shown in Table 5.1 and Figure 5.3. If correct, these would indicate that despite the increase in registered infant deaths during the period, there relatively no change in mortality rates of children under the age of 1 year since 1998. There was, however, improvement in the neonatal rate from 17.6 in 1997 to 13.3 in 2004, after which the rates remained level. The increase in infant and under-5 mortality between 1997 and 1998 is fairly large, and may indicate that the deaths were less completely reported in 2007 than assumed. The under-5 mortality rate in 2007 was slightly lower than the rates in the earlier years, which was associated with a drop in mortality in all the age groups excepting the neonates, possibly due to PMTCT affecting HIV acquisition and reducing HIV/AIDS deaths. The adjustment made to the neonatal rate implies that neonatal mortality has remained unchanged, which is consistent with the SADHS 1998 estimate of 19.2 for the period 1994–1998.

Table 5.1: Estimated childhood mortality rates per 1 000 live-births, 1997-–2007

Year	Neonatal mortality rate	Infant mortality rate	Child mortality ${}_4q_1$	Under-5 mortality rate
1997	17.6	46.6	18.1	63.9
1998	18.6	52.7	21.9	73.4
1999	16.1	51.1	22.5	72.5
2000	15.6	49.9	23.8	72.5
2001	13.1	49.0	25.2	72.9
2002	14.3	50.1	25.6	74.4
2003	14.5	51.2	26.2	76.1
2004	13.3	49.0	27.7	75.4
2005	13.8	49.5	26.4	74.6
2006	14.1	50.0	26.3	75.0
2007	14.1	48.6	24.3	71.8

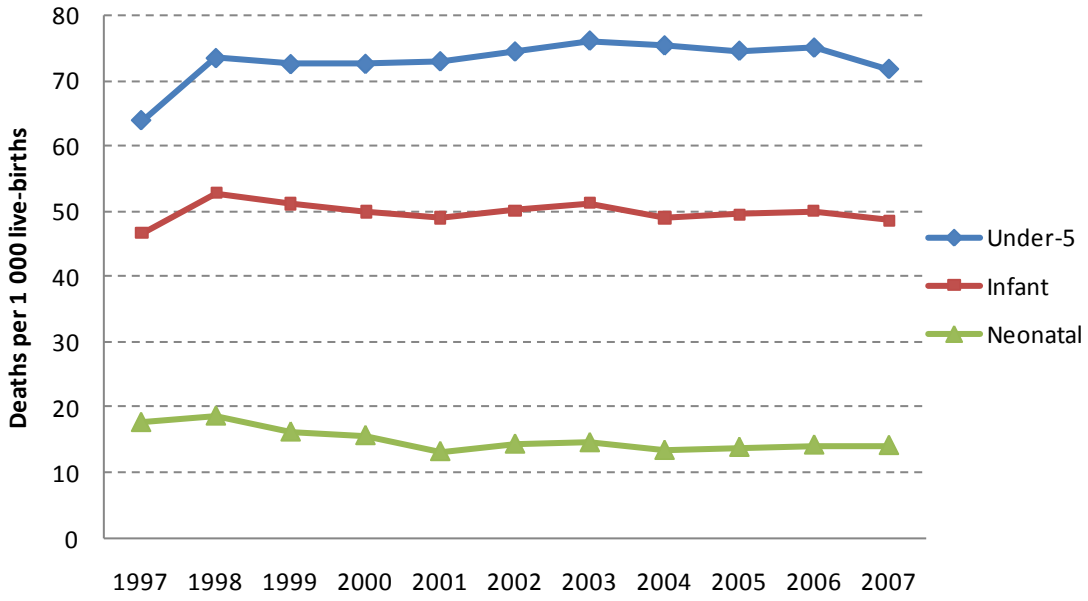


Figure 5.3: Under-5, infant and neonatal mortality rates per 1 000 live-births, 1997–2007

The adjusted early neonatal mortality causes of death rates (Figure 5.4) show some causes increasing, others decreasing and some remaining unchanged, producing no overall net effect in level. Declining trends are seen in deaths attributed to complications of pre-term birth (short gestation) and low birth weight, respiratory distress syndrome and congenital abnormalities. Mortality due to birth asphyxia and other perinatal conditions increased. This pattern is quite different from that seen in the unadjusted data (Figure 4.7). Unfortunately, these trends cannot be validated against the PPIP trend data, as the PPIP data are based on a changing set of health facilities, as the system was extended to include additional facilities.

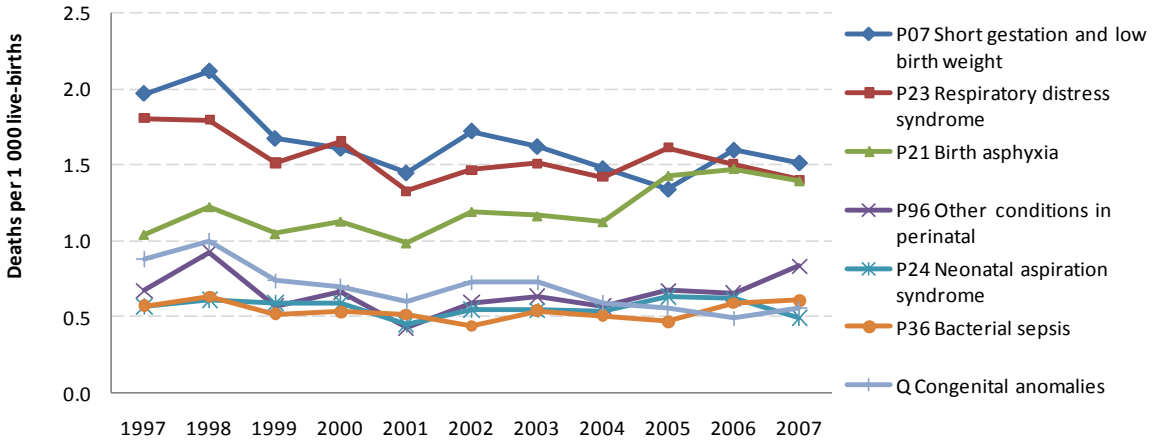


Figure 5.4: Early neonatal death rates per 1 000 live-births by cause, 1997–2007, corrected for under-registration

Figure 5.5 shows the trend in the adjusted late neonatal mortality rate until 2005, the point at which the incorrect coding to P-codes was corrected. High rates of mortality due to perinatal digestive system disorders in 1998/9 (although wrongly coded) are consistent with the cholera epidemic experienced in parts of the country and its effect on infant deaths. The trend in mortality due to congenital pneumonia (although wrongly coded) may reflect pneumonias related to HIV infection, and is seen to have peaked in 2003, which is consistent with the pattern of the trend in the 2–3 month peak over time observed in Chapter 3. The post-neonatal age group also shows a decline in the death rates from congenital causes.

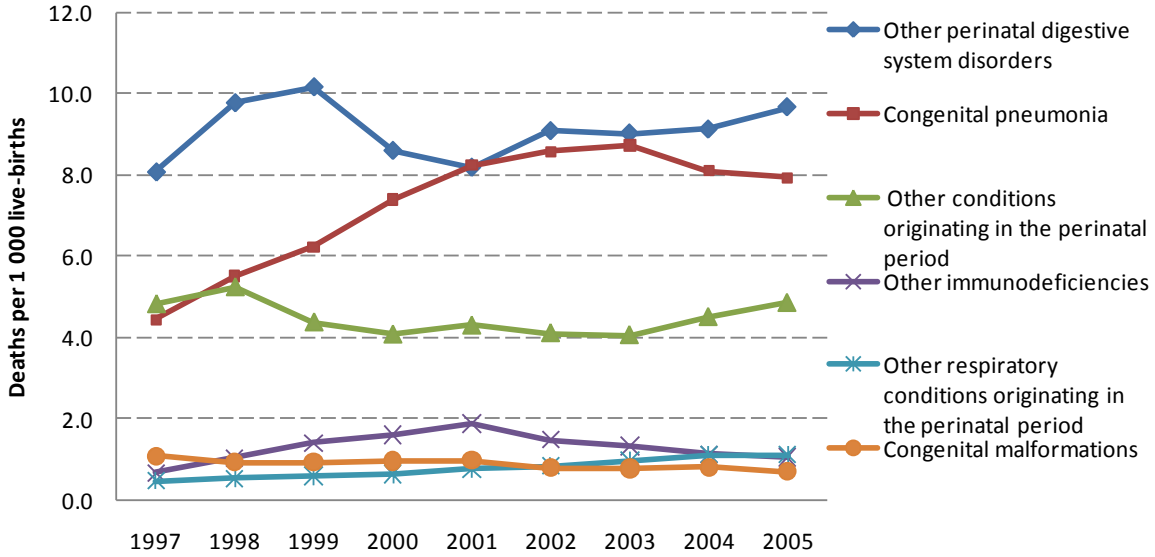


Figure 5.5: Post-neonatal death rates per 1 000 live-births by cause, 1997–2005, corrected for under-registration

Figure 5.6 shows the ranking of the causes affecting infant mortality in 2006 and 2007. This shows that the infectious diseases (diarrhoea and lower respiratory infections) and the ill-defined causes were the leading causes of death.

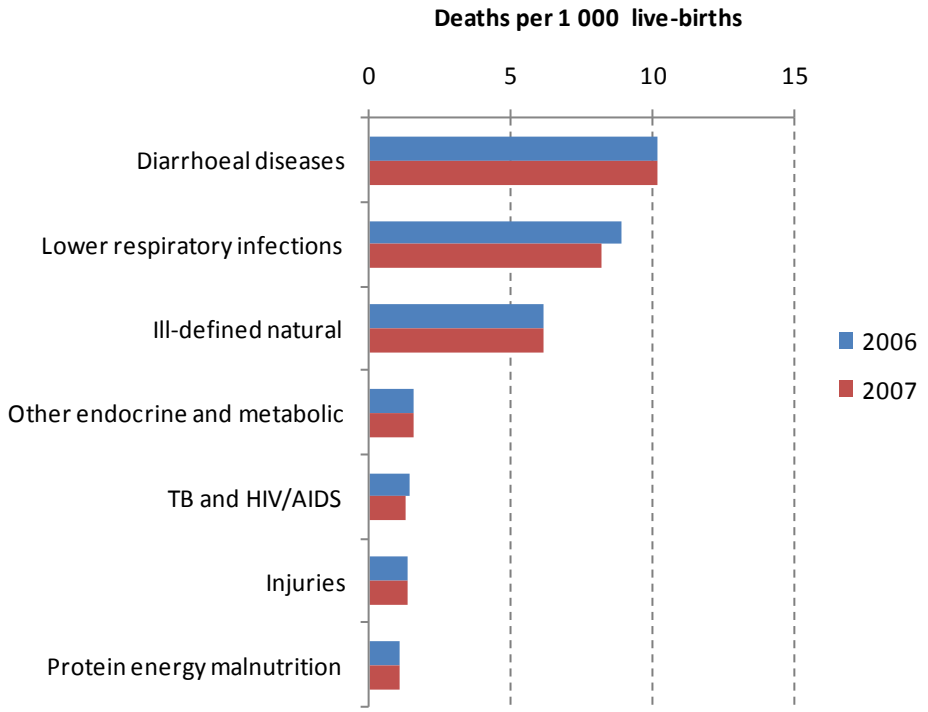


Figure 5.6: Infant death rates per 1 000 live-births by cause, 2006 and 2007, corrected for under-registration

In order to assess the trend in the infant deaths over the full period, the causes of the post-neonatal deaths (>28 days) were re-coded in order to allocate the wrongly assigned P-codes to more appropriate causes of infant death depending on the age at death. For example, congenital pneumonia (P23) was re-coded to pneumonia, organism unspecified (J18) and other perinatal digestive system disorder (P78) was re-coded to diarrhoea and gastroenteritis of presumed infectious origin (A09), etc. In addition, lower respiratory infections, TB and HIV were combined as there is mis-attribution of HIV, and these three causes followed the same time trend with a decline starting in 2003 (Figure 5.7). Diarrhoeal diseases increased in 1998 and 1999, and then declined to be followed by a gentle increase until 2006. As seen before, the neonatal mortality rate decreased until 2001 to a level of about 14 per 1 000 live-births and then remained constant.

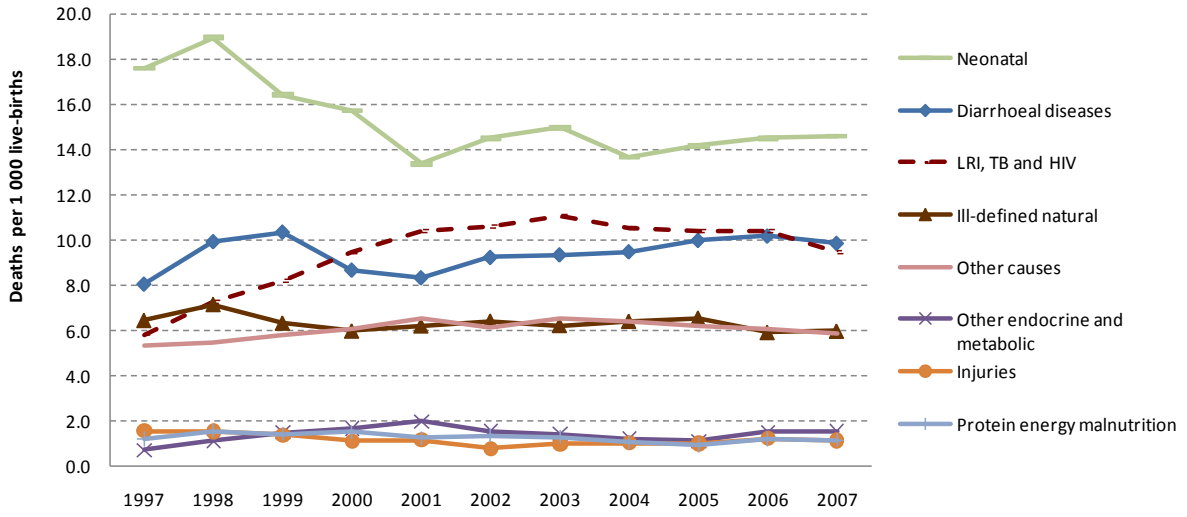


Figure 5.7: Causes of infant deaths, 1997–2007, after recoding P-codes and adjusting for under-registration

The adjusted deaths of children aged from 1–4 years old are shown in Figure 5.8. The cause of death trend is similar to that of the younger age group, with rates peaking in about 2004. The injury trend, however, is noteworthy and it is possible that the adjustment for under-registration is not appropriate for this age group in the earlier years of this period. The trend in the rate of death due to ill-defined causes of death also shows an unusual increase between 2003 and 2004. Examination of the data by province identified that between 2003 and 2004, the numbers of ill-defined doubled for KwaZulu-Natal and increased by 80% for Eastern Cape. In 2006, the numbers for these two provinces reverted to levels that were consistent with the earlier trend. The increases for these years were not seen in any other province or for any other cause, and must be assumed to have been isolated instances of temporary misclassification. In contrast, the higher rate in ill-defined causes in 2005 is accompanied by lower rates from some of the specified causes for that year.

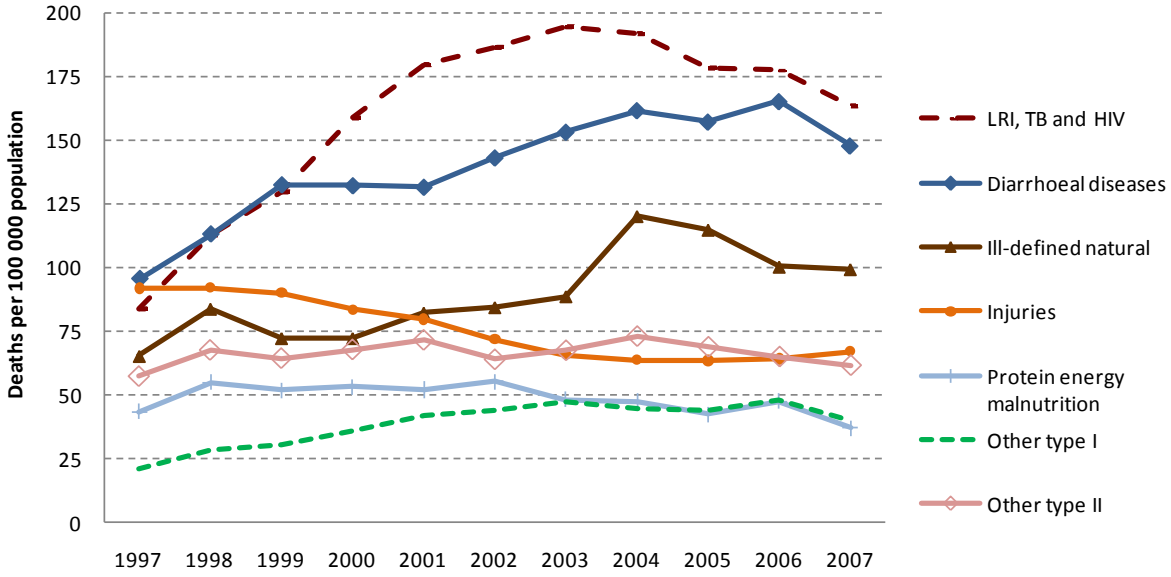


Figure 5.8: Estimated death rates of children (1–4 years) per 100 000 by cause, 1997–2007

Injury rates

The same adjustment factor was applied to the injury deaths reported by Stats SA. Figure 5.9 shows the adjusted and unadjusted injury death rates, as well as the data from the four cities based on NIMSS and ACDIS. The NIMSS data were adjusted with a proportional redistribution of the undetermined deaths. The data suggest that the overall adjustment for incompleteness used for the Stats SA data is not appropriate for injury deaths. This point was also observed in the Initial National Burden of Disease, which concluded that the completeness of registration of child injury deaths is higher than that for natural causes. When adjustments are applied to the under-1 year olds (Figure 5.10), there is a suggestion that there may be an urban-rural difference in injury mortality rates. It is impossible to be sure of the trend in the child injury mortality rates. The introduction of legal termination of pregnancy in 1998 and the steady increase in the number of terminations may have contributed to a decline in the injury mortality rate among infants, but would not be expected to affect the injury rates in children aged from 1–4 years.

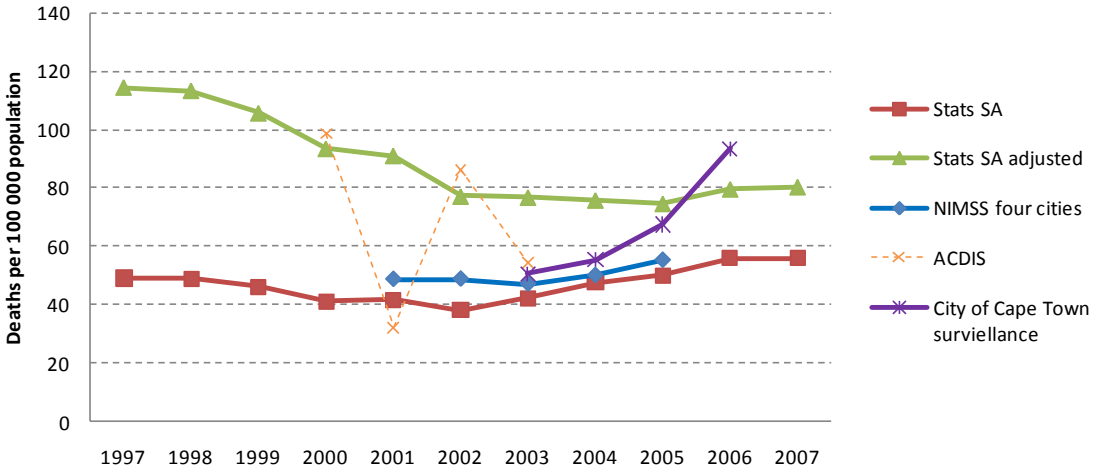


Figure 5.9: Estimated injury death rates of children under 5 years per 100 000 by cause, 1997–2007

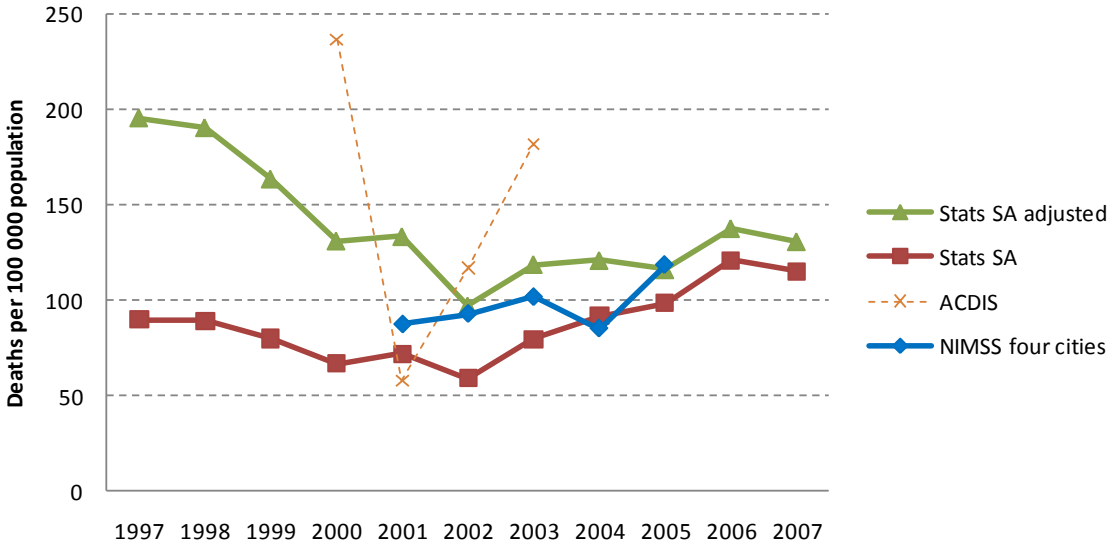


Figure 5.10: Estimated injury death rates of children under 1 years per 100 000 by cause, 1997–2007

Conclusion

Applying the adjustment of under-registration, as well as recoding the P-codes, provides trends in the cause of death rates that are not implausible. While there are a few trends that lack coherence, for example, the increase in the ill-defined deaths in the Eastern Cape and KwaZulu-Natal between 2003 and 2004 among children from 1–4 years of age, many of the trends observed in the data are coherent.

These trends suggest that the neonatal mortality rate declined between 1997 and 2001 and then remained level. The decline appears to have stagnated through an increasing trend in deaths from birth asphyxia which had not abated by 2007.

In contrast, mortality rates in the post-neonatal age group increased, resulting in a largely unchanged infant mortality rate over the period. A marked increase in the mortality rate from diarrhoea can be observed in 1998 and 1999. Mortality from pneumonia, TB and HIV showed a clear increase that peaked in 2003. Injury mortality rates among infants appear to have declined between 1997 and 2001, and then remained level.

Mortality rates in the 1–4 year age group increased over this period but do not appear to have peaked by 2007. However, this may be a function of a certain amount of smoothing involved in the indirect method used by Darikwa and Dorrington (2011) to estimate the rates. While mortality from pneumonia, TB and HIV may have declined since about 2003, deaths from diarrhoea and ill-defined causes have not shown a similar decline.

Injury mortality rates appear to have declined. However, the adjustment factor may be too big for children aged from 1–4 years. The explanation for this is that the injury deaths may have been more completely registered than natural causes. In 2007, the injury death rate for children under 5 years of age was between about 60 and 80 per 100 000.

Chapter 6. Model estimates of child mortality trends

Introduction

In the absence of reliable data for infant and under-5 mortality from vital registration, estimates have to be derived from models. Essentially, there are two types of modelling approaches. The first is to pool available estimates and to fit a regression to the data (weighted by relevance or accuracy), while the second is to derive estimates that are consistent with estimates of the numbers in the population, taking into account estimates of fertility and migration (demographic projection). Examples of the first approach are estimates produced by the Inter-agency Group for Child Mortality Estimation (IGME), the Institute for Health Metrics and Evaluation (IHME) and Garenne and Gakusi (2010), and examples of the second approach are estimates produced by UN Population Division and the Actuarial Society of South Africa (ASSA).

The benefits of considering estimates from models is that they not only provide an alternative estimate against which to check the reasonableness of any new estimates, but because of the extent that they make use of other information (such as the incidence or prevalence of HIV or estimates from other countries), they provide an indication of major trends (peaks and troughs) in the rates over time.

Comparison of models

Various international organisations have developed demographic models to project basic population and health indicators in regions of the world where there is a paucity of information, and to standardise country-level estimates being used across settings. Previously, the United Nations agencies, including the WHO, UNAIDS, UNDP and UNICEF, each produced their own infant and child mortality estimates, based on census and survey results supplied by member countries, but these were not necessarily consistent with each other (Inter-agency Group for Child Mortality Estimation, 2007). The agencies tend to base their estimates on smoothed trends from demographically adjusted estimates from a variety of sources. In recent years, the agencies have made adjustments to allow for the impact of AIDS on child mortality. The IGME has compiled a single set of country child mortality estimates derived from a mixture of country-based data sources including complete and partial vital registration systems, demographic and health surveys, census and sample registration systems, and databases maintained by the UNICEF and WHO. The IGME has made use of the UNAIDS estimates of the impact of HIV on child mortality. Recently, IGME methods have changed to recalculate direct estimates with

shorter reference periods, replacing the five-year periods used in previous estimations, thereby increasing the number of data points available for use in the projection (UNICEF, 2011).

The Institute for Health Metrics and Evaluation (IHME), based at the University of Washington, has also derived estimates of child mortality. Murray et al. (2007) apply a different method from that used by IGME to produce child mortality estimates, based on the statistical compilation of survey and vital registration data, which they argue has the advantage over other approaches of being reproducible. They used Loess regression to fit a polynomial, a method of weighted least squares that gives more weight to points nearer the fitted trend and less weight to points further away. The same group have published new sets of estimates using a Gaussian Process to model the child mortality rate, with the latest being forecasts for 2010 (Lozano et al., 2011).

The ASSA model is an AIDS and demographic population projection model developed by the Actuarial Society of South Africa (www.actuarialsociety.org.za). The model produces estimates of child mortality that have been derived by extrapolating the underlying downward trend in non-AIDS mortality and adding estimates of AIDS deaths, derived by taking into account the levels of HIV prevalence and mother-to-child transmission of HIV. The model projects AIDS infection, mortality and a range of other indicators based on numerous data sources, including censuses, surveys and vital registration. It also utilises estimates of the number of HIV/AIDS cases and new infections, derived from a behavioural model of heterosexual transmission (Dorrington et al., 2005). The ASSA2003 model revised the projections of the earlier ASSA2002 model, based on the latest available epidemiological data incorporating several interventions, including the impact of antiretroviral treatment on the epidemic (Dorrington et al., 2005). This model was further updated to produce the ASSA2008 version released in early 2011 (Actuarial Society of South Africa, 2011).

The Every Death Counts report (2008) reviewed estimates of under-5 mortality from the various models in the context of South Africa's progress towards MDG 4. In Figure 6.1, this comparison is updated with subsequent projections by the US Census Bureau (from their International Database), the estimates from the UN Population division (2011), the 2010 estimates from the IHME (Lozano et al., 2011), the most recent estimates from IGME group (2011) and the most recent ASSA model (Actuarial Society of South Africa, 2011). Also included on the figure are the estimates from Garenne and Gakusi (2010), which used logistic regression to synthesise the under-5 mortality trend from direct estimates derived from the 1998 DHS, and the 2001 Census

and 2007 Community Survey questions on deaths in the household. The projections all show an initial decrease in the under-5 mortality rate, but by 1995, the estimate ranged from 52–78. Thereafter, most of the models show an increasing trend, although the trajectories differ. The latest 2010 IHME estimate stands out as being quite different and reaching a low of 37.3 per 1 000 live-births in 2000, while the other estimates range from 69 to 85 per 1 000 live-births in that year. The ASSA2003 model estimates show the highest peak.

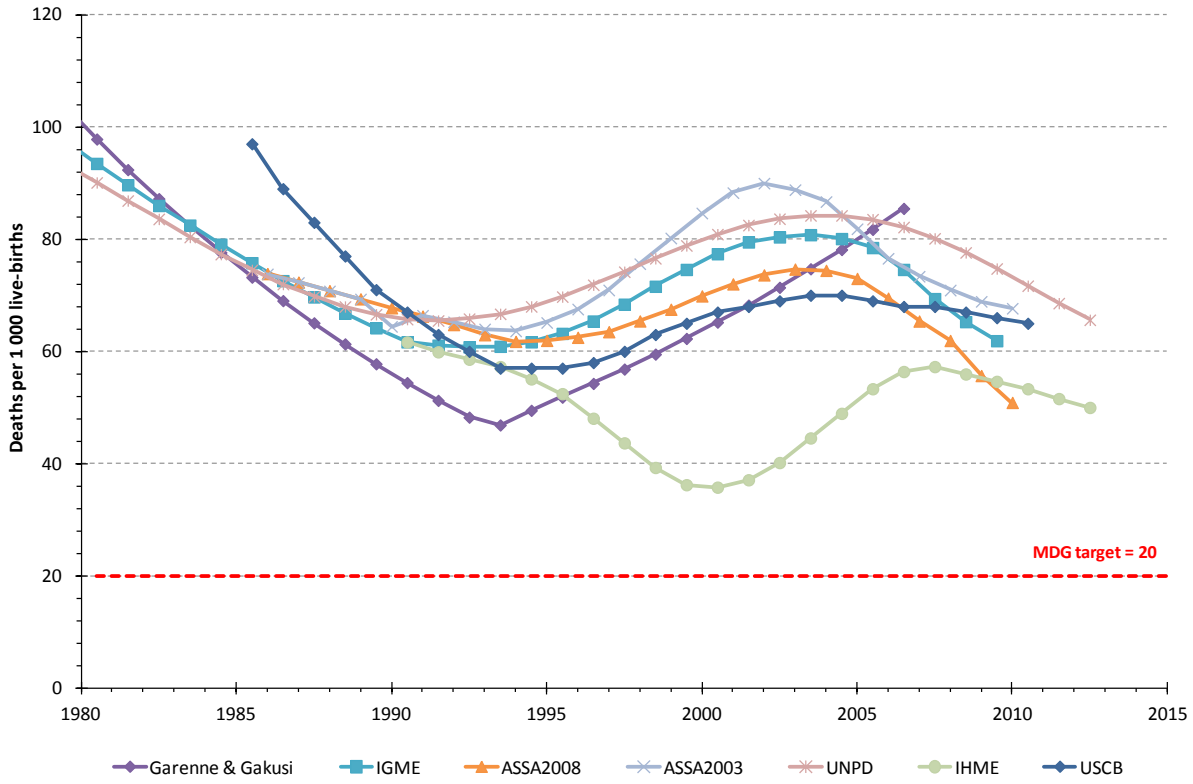


Figure 6.1: Model estimates of South Africa under-5 mortality rate compared with the SA MDG target

The ASSA2003 model

According to the ASSA2003 model using the default assumptions, the infant and under-5 mortality rates had similar trends at national level, both peaking around 2001 (Figure 6.2). The infant and under-5 mortality rose significantly from 48 and 65 deaths respectively in 1990 to a peak of 60 and 89 in 2001 (Dorrington et al., 2005). Both rates declined after 2001, mainly as a result of the impact of the (overly optimistic) prevention of mother-to-child transmission assumptions in the model.

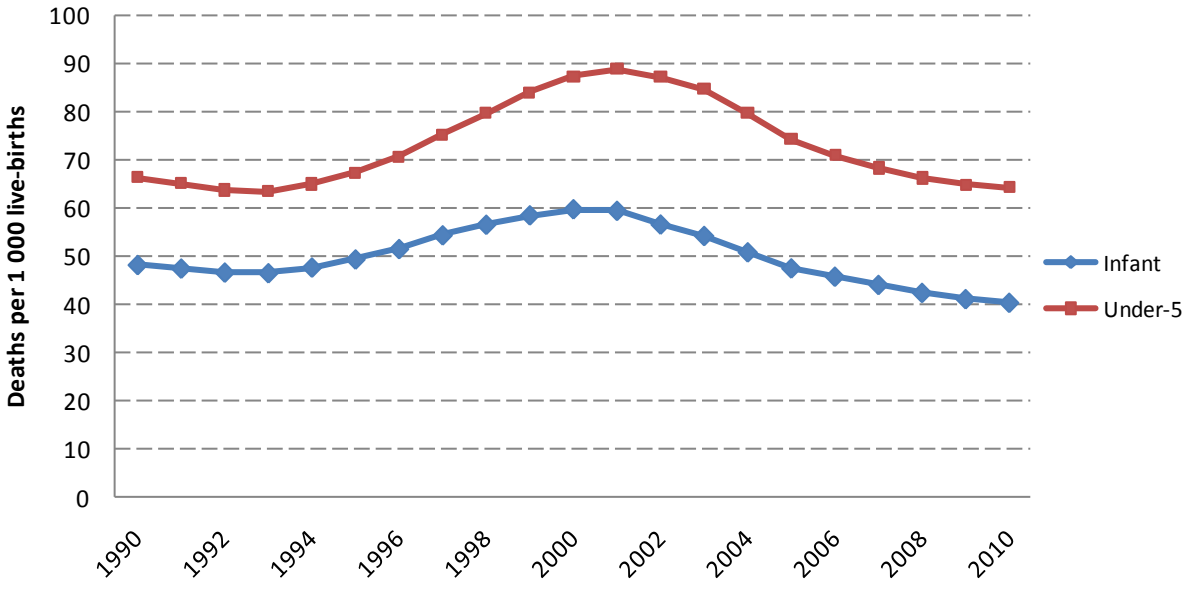


Figure 6.2: ASSA2003 trend in the infant and under-5 mortality rates
Source: Dorrington et al., 2006

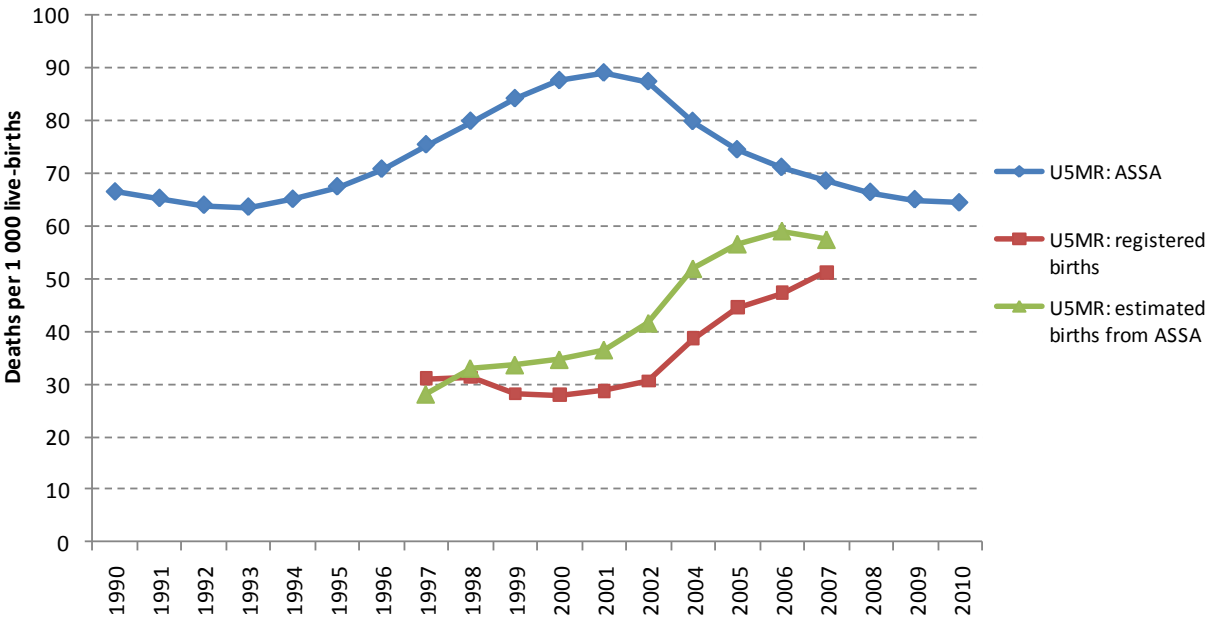


Figure 6.3: Comparison of under-5 mortality rate estimate by the ASSA2003 model with that implied by unadjusted vital registration data

Figure 6.3 contrasts the trend in the ASSA2003 under-5 mortality rates with those based on the vital registration data using different estimates of the number of births as denominator. The estimate based on the registered births (including late registrations from previous years) is 32% of the ASSA2003 estimate in 2000 and the value based on an estimate of the projected births from ASSA is 40% of the ASSA2003 estimate. However, the trends are quite different, with the

ASSA model projecting a declining mortality trend after 2001, while the empirical data shows an increasing trend over the same period. This is in contrast to the situation in KwaZulu-Natal for an earlier period in which the trend of the ASSA2003 model was consistent with the empirical data from a HDSS, albeit that the empirical estimates span quite a wide range (Box 6.1).

Investigations into the assumptions of the model suggest that the ASSA2003 model tends to overestimate the impact of HIV on under-5 mortality (Dorrington and Bradshaw, 2007). However, on the other hand, the PMTCT intervention program is assumed in the model to have begun in 2001 and phased in over a 5-year period, reaching an overly optimistic level of 90% coverage. Although the UN estimated that about 30% of the HIV-infected pregnant women in 2005 received the nevirapine prophylaxis in South Africa, an increase from 22% in 2004 (UNICEF 2007), this is only slightly more than half of what has been recorded by the District Health Barometer in 2004 and 2005 (Barron et al., 2005; Barron et al., 2006). A sensitivity analysis of the PMTCT assumptions utilised by the ASSA2003 model was therefore undertaken to investigate the effect of varying the uptake rates of the PMTCT assumptions, using three additional scenarios as shown in Table 6.1.

Table 6.1: Different uptake rates of the PMTCT intervention program in the ASSA2003 model in each subsequent year

	ASSA2003 default	Constant increase by 5% of PMTCT	Constant increase by 10% of PMTCT	No PMTCT
Year 1 (2001)	10	10	10	0
Year 2	40	15	20	0
Year 3	60	20	30	0
Year 4	80	25	40	0
Year 5	90	30	50	0
Year 6	90	35	60	0
Year 7	90	40	70	0
Year 8	90	45	80	0
Year 9	90	50	90	0
Subsequent	90	55	90	0

It can be seen from Figure 6.4 that the greater the increase in the PMTCT program each year, the greater the reduction in under-5 mortality. After 2000, the under-5 mortality estimates are bound between the default (lower bound) and no PMTCT (upper bound) assumptions. The difference between the two scenarios widens rapidly at first, then stabilises to approximately a difference of

12 deaths after 2006, when the forecast PMTCT assumptions in the default become constant. Although the projected decline in under-5 mortality is probably less marked than that resulting from the default scenario relating to PMTCT, the level would be within 10% and the overall pattern would remain the same.

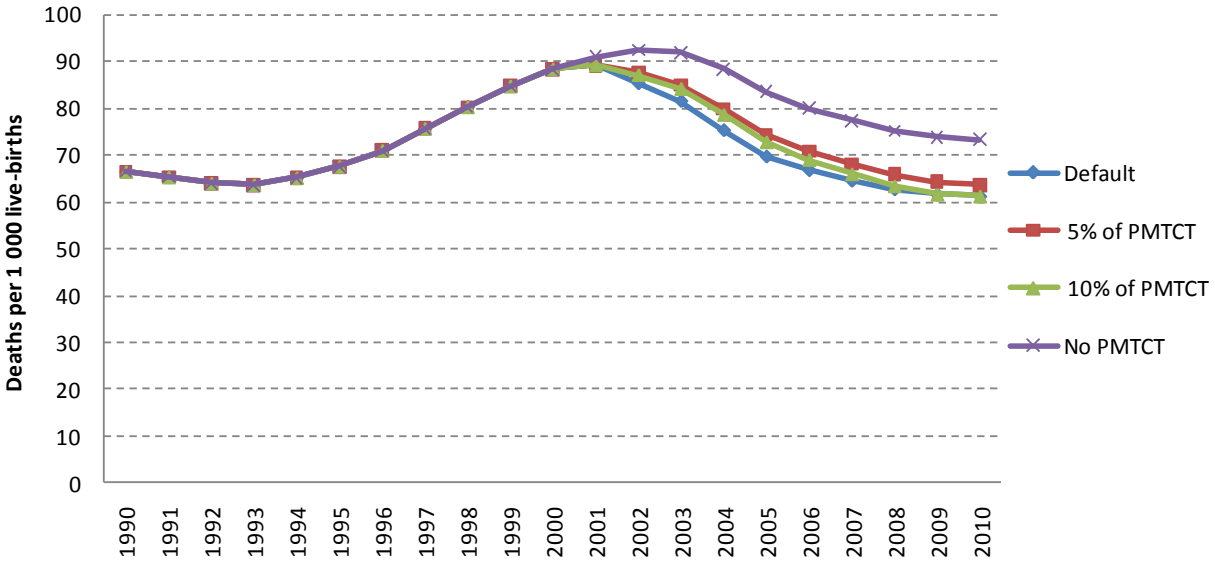


Figure 6.4: The effect of varying the perinatal transmission rates on under-5 mortality

Conclusion

While the general trend in the U5MR rate is quite apparent, the variation in the model projections reflects a degree of uncertainty in the exact trajectory of the U5MR in the recent period. Most projections reflect a reversal in the trend of under-5 mortality during the 1990s. However, there is no agreement about the lowest level reached before the reversal, nor the exact course that the rate followed over the change of the millennium. The latest estimates from IHME appear to weight the trend in the vital registration without allowing for improvements in registration, and is implausibly different from the other models. The statistical model by Garenne and Gakusi, based on DHS data, appears to exaggerate the decline in U5MR, reaching a minimum that is too low and it does not identify the peak turning point prior to 2006, which is a feature of all the models that model the mortality as a function of the incidence of HIV.

The under-5 mortality trend, projected by the ASSA2003 model, reflects the trend in the empirical data up to 2000, but is completely different from that observed in the vital registration data (which undoubtedly reflects an element of rising completeness as well). The ASSA2003 overstated the roll-out of PMTCT, but this would not account for a major change in the projected

Box 6.1: Comparison of estimates with ASSA2003, KwaZulu-Natal province

Figure 6.1.1 presents various estimates of under-5 mortality in the province of KwaZulu-Natal, based on data from surveys, the 1996 census and facility-based questionnaires using diverse methodologies, as well as projections from the ASSA2003 model.

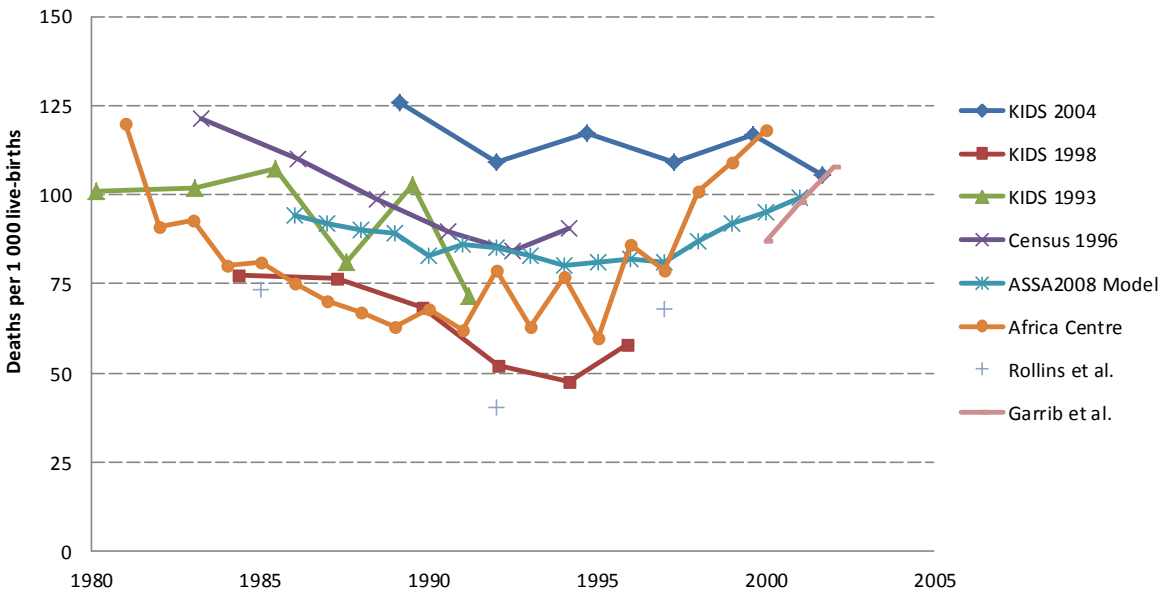


Figure B6.1.1: Comparison of under-5 mortality estimates from selected data sources representing KwaZulu-Natal

The KwaZulu-Natal Income Dynamics Survey (KIDS) is a panel study that has been conducted roughly every five years since its inception in 1993. Figure 6.1.1 shows three trends in under-5 mortality, representing three waves of data. These estimates have been calculated using the 'children ever born-children surviving' method developed by Brass (1968). The 1996 census estimate for Africans also utilised the Brass method and has been adjusted for the misstatement of stillbirths. The estimates from the birth histories from the Africa Centre Demographic Information System (ACDIS) were calculated directly in the same way exposure to risk rates from Demographic and Health Surveys are calculated (Rutstein and Rojas, 2006). Directly calculated rates may understate the true rates slightly, due to the omission of dead children during interviews (Sullivan et al., 1990). The prevalence of maternal HIV also affects survey-based estimates downwards, due to HIV-infected mothers not being questioned in household surveys about the survival of their children. However, this bias is thought not to exceed 5%–7% for the births reported in the last 5 years.

The ACDIS trend is consistent with the national picture from the 1998 SADHS, except that the levels are higher and the reversal in the trend started a little earlier in this rural setting. The Garrib et al., (2006) trend represents central death rates and not the probability of dying in the first year of life (U5MR). The three points of Rollins et al., (1997) have been derived from data collected at clinics using the preceding birth technique (Brass and Macrae, 1984) but it is unclear what this represents as the authors did not convert the proportion surviving into a standard life table measure. While there is considerable variation between the empirical estimates, the ASSA model shows a trend consistent with the ACDIS trend for this period and a slightly lower level than the 1996 census.

trend. Assumptions around the survival of HIV-infected children were revisited in the development of the ASSA2008 model, but it appears as if this model may underestimate the under-5 mortality rates.

The estimates of the U5MR in 2006 range from a low of 55 per 1 000 live-births (IHME) to a high of 85 (Garenne and Gakusi). If one excludes the extreme estimates (IHME, Garenne and Gakusi, and the UNPD) the estimates from the other models fall in the range of 70 to 80.

Chapter 7. Conclusion and recommendations

Monitoring progress on MDG 4 in South Africa has been extremely challenging. Vital registration is incomplete, there has not been a reliable household survey collecting detailed birth history information since the 1998 SADHS. There have been significant data quality problems with several surveys and the 2001 census regarding the data for child mortality estimates. Furthermore, the indirect method of estimating mortality from information on the survival of children reported by mothers is biased by the correlation of mortality of mothers and their children due to HIV/AIDS.

This review shows that there was a continuous rise in the number of registered child deaths since 1997, which peaked in 2006. Analysis of the 2007 Community Survey data, correcting for data errors and attempting to allow for bias due to the impact of AIDS on the estimates, provides empirical estimates for child mortality rates that suggest that in 2006, the U5MR was about 75 per 1 000 live-births and the IMR was about 50 per 1 000 live-births. It also indicates that the U5MR has not changed much since about 1998, but this may be a result of the methodology, which could have smoothed out a peaking in rates over this period.

Examination of trends in the infant deaths by fine ages revealed an AIDS signature age pattern over time, with an increase in deaths in babies aged from 2–3 months. Comparison of the causes of death for the 2–3 month olds with the 4–5 month old babies indicates that pneumonia, ill-defined causes and, to a lesser extent, diarrhoea account for a large part of the increase in this age group. The population register data indicates that deaths of babies aged from 2–3 months peaked in 2003 for the Western Cape and in 2005 in the remaining provinces, indicating the impact of the PMTCT programme, which was initiated earlier in the Western Cape.

The plausibility of the estimates of completeness over time was assessed by examining implied age-specific trends in the rates by cause of death. These suggest that while the overall U5MR did not change, some counteracting trends were observed. The neonatal mortality rate (under 28 days) declined from about 18 per 1 000 live-births at the beginning of the period to about 14 per 1 000 live births in 2001, and remained level thereafter. There was a decline in deaths resulting from low birth weight and respiratory distress syndrome, but an increase in the death rate associated with birth asphyxia. In the late neonatal period (7–28 days), deaths from sepsis and lower respiratory infections increased. When the P-codes were reassigned, diarrhoea, lower

respiratory infections and ill-defined causes were the most common causes of death among infants. Reported HIV, TB and lower respiratory disease deaths showed similar trends increasing from 1997 to a peak in 2003. Death rates from diarrhoea showed a peak in 1998/9 and then after a dip, increased steadily over the period. Death rates for children from 1–4 years of age increased over the period with a peak in 2004. Reported HIV, TB and lower respiratory disease deaths also showed similar trends to each other in this age group, peaking in 2003/4. Some strange patterns were observed in the data. The number of deaths due to ill-defined conditions doubled for KwaZulu-Natal and the Eastern Cape in 2004 and 2005, and then reverted to their previous levels. While the increased number in 2005 was accompanied by a decrease in specified causes, this was not the case for 2004. The number of diarrhoeal deaths and some other causes dropped in 2007, particularly in the North West province. Injury death rates declined by one-third. The factors used to correct for incompleteness of reporting do not appear to have caused these patterns, with the exception of the injury death rates, which might have been more completely reported due to the legal requirements of investigation (and thus the rates were a bit lower than estimated).

The 'Big Five' health challenges (HIV/AIDS, pregnancy and childbirth complications, newborn illness, childhood infections and malnutrition), identified by the South African Every Death Counts Working Group (2008), clearly remain the priority challenges in order to meet MDG 4. The 2010 evaluation of the South African prevention of mother-to-child transmission programme (SA PMTCT, 2010) through a nationally representative sample of infants at 6 weeks postpartum who were HIV-exposed, which gave the HIV transmission rate from mother to child as 3.5%, shows a remarkable decline in the transmission from earlier levels of about 10%,[3] which indicates that the U5MR can be expected to decline. However, the gains in preventing peri-partum transmission need to be supported by efforts to prevent transmission from breast feeding. The importance of exclusive breastfeeding up to 6 months of age has been recognised. The National Department of Health (2012) recommends that mothers who are HIV-positive should breastfeed exclusively and that the mother and/or baby should receive antiretroviral treatment or prophylaxis, based on research that shows that when antiretroviral treatment or prophylaxis is used by either the mother or baby, HIV transmission through breastfeeding is significantly reduced. The data, however, indicate that attention also needs to be given to other aspects. The three main causes of neonatal deaths are complications of prematurity, intra-partum-related

[3] SA PMTCT Evaluation shows that virtual elimination of paediatric HIV is possible with intensified effort. MRC Media Statement, June 2011. http://www.mrc.ac.za/pressreleases/2011/10press2011.htm

deaths and infections. The PPIP indicates that many of these deaths are preventable and points to the need to improve the quality of care at birth, including improved management of labour, resuscitation of the asphyxiated neonates and care of the premature babies. The South African Every Death Counts Working Group (2008) also highlighted the need to improve the quality of sexual and reproductive health services, as well as antenatal care. While a proportion of the diarrhoeal disease deaths are likely to be HIV-related, and the introduction of the rotavirus into the routine immunisations during 2009 can be expected to reduce the mortality, more attention needs to be given to reducing the number of deaths from diarrhoea. UNICEF and WHO (2009) have proposed a 7-point plan for the comprehensive control of diarrhoea. South Africa has some way to go on many of these strategies, including ensuring widespread availability of oral rehydration solution and zinc treatment, supporting exclusive breast feeding, promoting hand-washing, ensuring access to adequate quantity and quality of water, and improved sanitation.

The estimates from the 2007 Community Survey imply that the completeness of vital registration for children has increased considerably over the period 1997–2006, particularly since 2001. By 2006, the completeness had increased from less than 50% in 1997 to 88% for infants and 60% for children aged from 1–4 years. This differential is unexpected, as completeness might have been expected to increase with age. However, despite the variations in the estimates of U5MR from other models, they all confirm this age pattern of completeness, i.e. higher levels of completeness for the infants compared with the older children of 1–4 years of age. Efforts to improve vital registration in South Africa are beginning to establish the routine data as a possibility for monitoring child mortality. However, a concerted effort will be needed to improve quality of the cause of death information and the completeness of death registration for young children so that the data can be used at district level (Groenewald et al., 2012).

This review has highlighted several aspects in the vital registration data that will need to be taking into account in the 2nd National Burden of Disease Study that will attempt to derive coherent estimates in the trends in child mortality. It will be important to analyse the data according to the cause groupings and age groupings identified by the Child Health Epidemiology Reference Group (CHERG) for programmatic relevance (Black et al., 2010). The study will also need to take into account the anomalies observed in the data, such as the unexplained high numbers of registered deaths in 1998 and the unexplained high number of deaths for children aged from 1–4 years in 2004. Identifying the mis-attributed deaths from AIDS will be the major challenge.

From the review, it can also be seen that data systems in the health sector have an extremely important role to play in managing health facilities and provide important indicators of child health, including mortality rates for certain age groups (e.g. perinatal mortality rates), the cause of death profile and factors associated with preventable deaths. However, such data are insufficient for providing the under-5 mortality rates, as many deaths occur outside of health facilities and hence are not recorded by these systems. Similarly, surveillance data from selected populations have provided useful benchmarks for this review, but cannot provide nationally representative data.

Model-based estimates have provided a range of trajectories of child mortality. All the models reflect the reversal in the downward trend in under-5 mortality rates during the 1990s but there is little agreement about either the lowest level that was reached or the path that rates have followed in the new millennium. Given the uncertainty in the trajectory of child mortality at a national level, it is critical that South Africa conducts a good quality DHS-type survey as soon as possible. Data from a full pregnancy history need to be collected from a sufficiently large sample of women in order to get a direct estimate of the historical trend in the U5MR. The impact of HIV will need to be taken into account in the analysis of these data. This will help to inform a synthesised estimate of the trend in U5MR that can then also be used for forecasting rates.

In conclusion, South Africa has seen vast improvements in the registration of child deaths over the period 1997–2007. Despite these improvements, the vital registration system cannot be used to generate child mortality rates without adjusting for completeness. In addition, the cause of death information cannot be used at face value. The empirical data suggest that there relatively no change in mortality rates in this period, with infant and under-5 mortality rates reaching a plateau, with the highest level in 2003. However, it is possible that the method of indirect estimation used average rates over various periods, which may have flattened the peaking in rates suggested by the various models. There is an indication of a slight decline in both the under-5 and infant national mortality rate in 2007. This is supported by the fact that child mortality rates have declined in some sub-populations of the Western Cape and in rural KwaZulu-Natal, starting at earlier dates, and that most of the model projections suggest that the U5MR would decline.

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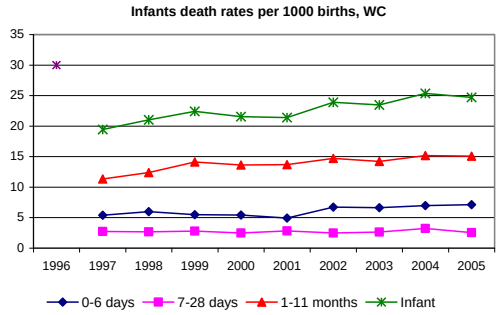
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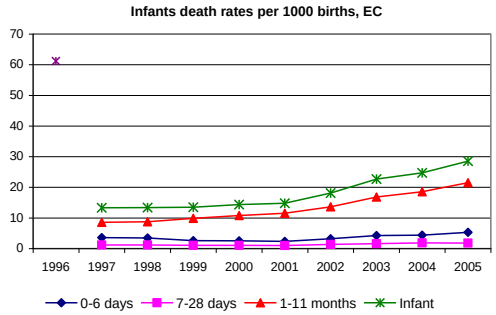
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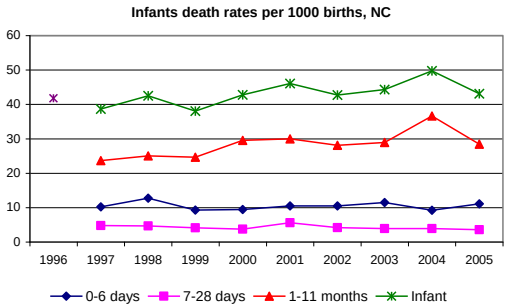
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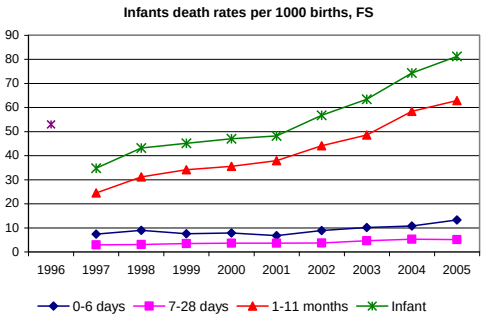
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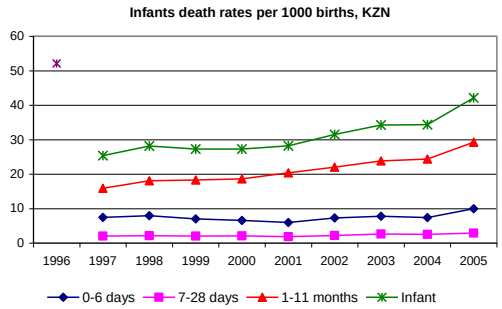
Appendix A: Early neonatal, late neonatal and post-neonatal mortality rates by province

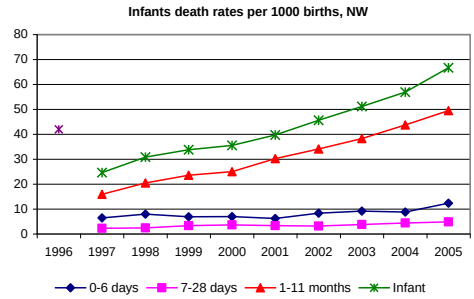


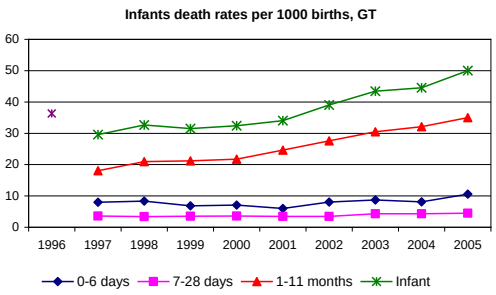


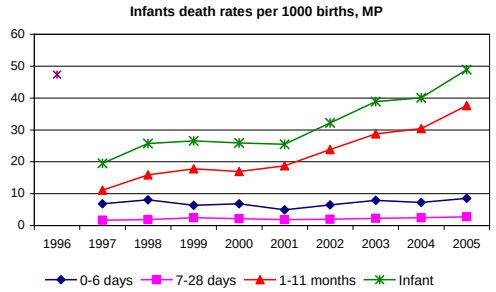


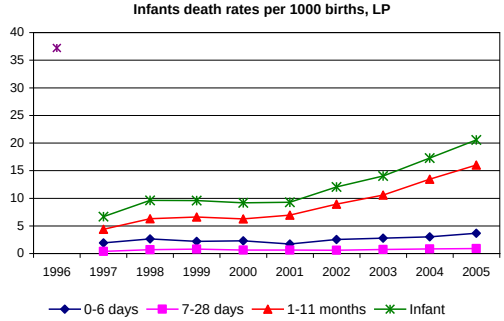












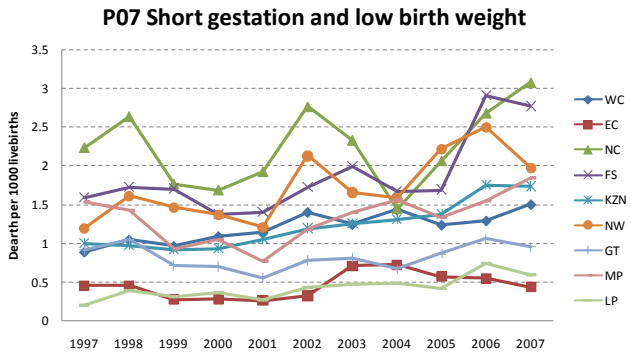
Appendix B: Number of births and population (0–4 years) ASSA2003

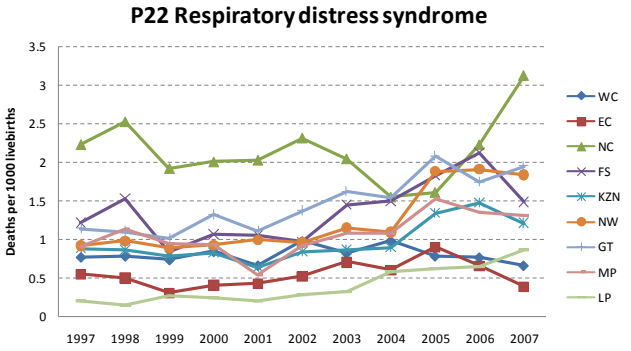
Year	Births	1-4 years
1997	1 154 226	4 130 582
1998	1 149 711	4 168 667
1999	1 143 246	4 192 904
2000	1 134 620	4 199 757
2001	1 128 469	4 199 757
2002	1 124 624	4 141 246
2003	1 118 771	4 139 732
2004	1 111 539	4 051 196
2005	1 103 623	4 024 819
2006	1 095 651	4 013 172
2007	1 087 930	4 003 366

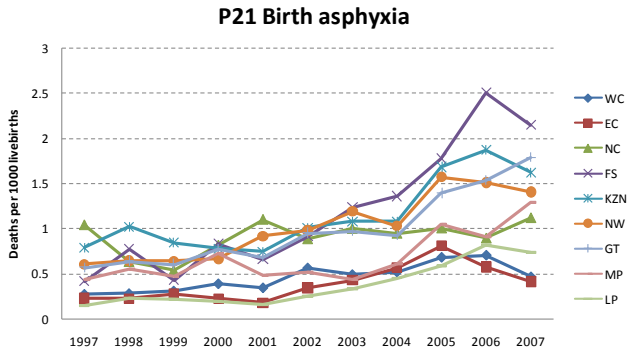
Appendix C: ICD-10 codes of the categories and single causes of child deaths

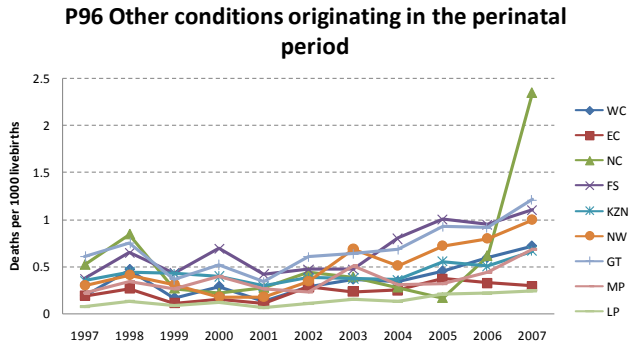
Category	Single cause of death	ICD 10 Codes
Diarrhoeal disease	Diarrhoeal disease	A00-A09 K52
TB and HIV	Tuberculosis	A15-A16 U51 U52 B90
	HIV/AIDS	B20-B24 B33 B59 C46 D84
Lower respiratory infections	Lower respiratory infections	J09-J18 J20-J22 P23
Perinatal conditions	Preterm birth complications	P05 P07 P22 P25-P28 P77
	Birth asphyxia and trauma	P02 P03 P10-P15 P20 P21 P24
	Infectious conditions	P23 P35-P39
	Other non-infectious conditions arising in the perinatal period	P00 P01 P04 P08 P29 P50-P76 P78-P94
	Neural tube defects	Q00 Q03 Q05
	Cleft lip/palate	Q35-Q37
	Congenital heart anomalies	Q20-Q28
	Congenital disorders of GIT	Q38-Q45
	Urogenital malformations	Q50-Q64
	Foetal alcohol syndrome	Q86
	Down syndrome and other chromosomal anomalies	Q90
	Other chromosomal abnormalities	Q91-Q99
	Perinatal death unspecified cause	P96
Other childhood conditions	All other causes of death under 5 years of age	A16-19 A31 A37 A46 A49 A50 A80 A93 A99 B00-B02 B05 B06 B15 B19 B25 B34 B37 B38 B43 B45 B49 B50 B54 B58 B59 B64 B99 C16 C22 C34 C56 C64 C69 C71 C74 C76 C80 C81 C85 C92 C95 D18 D34 D37 D43 D50 D53 D57-59 D61 D64-D66 D68-D70 D81 D82 D86 E03 E14-E16 E26 E32 E34 E40-E44 E46 E51 E66 E71 E74 E77 E80 E83-E88 F10 G12 G37 G40 G41 G47 G58 G70 G71 G80 G90 G91 G93 H66 I10 I11 I24 I26 I27 I40 I42 I46-I48 I50 I60-I64 I80 I82 I86 I88 K25-K29 K31 K36 K40 K42 K45 K46 K50-K52 K55 K57 K59-K63 K65 K66 K70 K72-K76 K92 L00-L03 L08 L23 L30 L51 L53 L98 M00 M19 M43 M66 N04 N05 N12 N15 N17-N19 N39 N61 U51

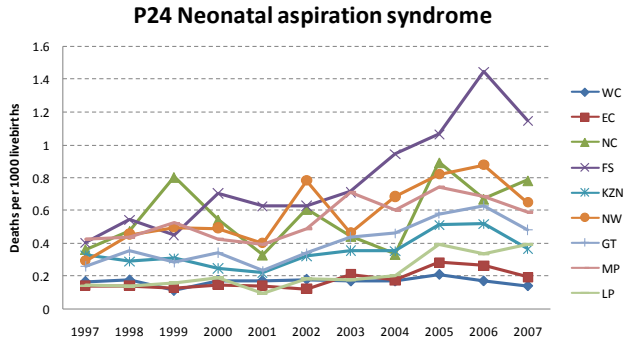
Appendix D: Leading causes of death for newborns (0–6 days) by province, 1997–2007

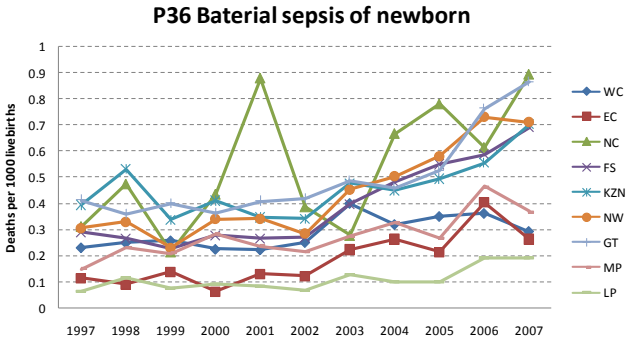


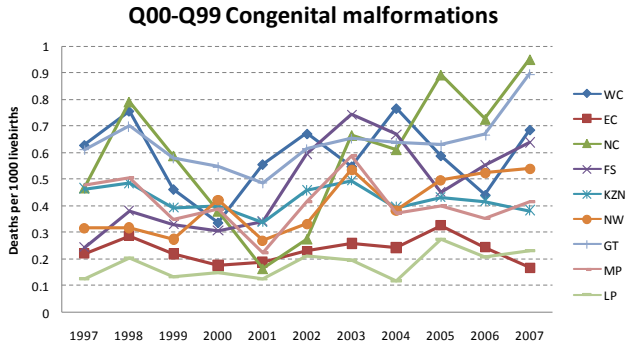




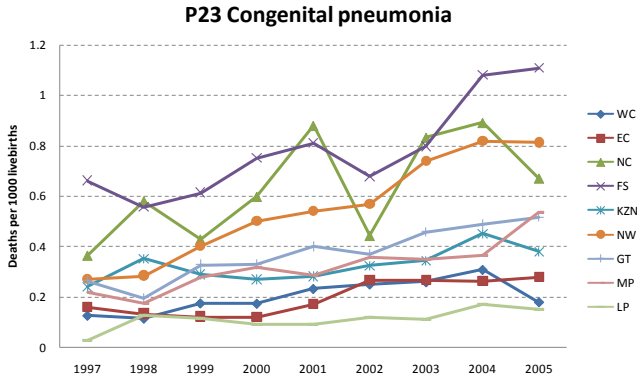


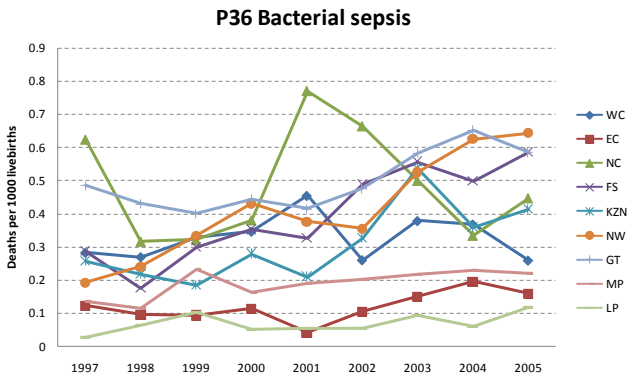


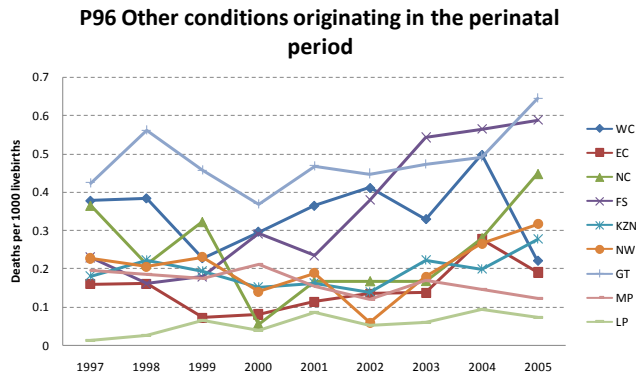


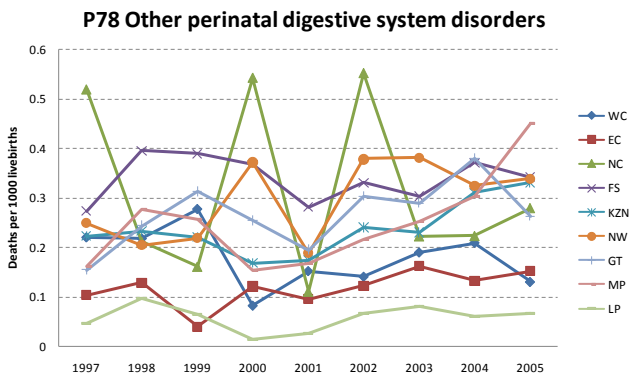


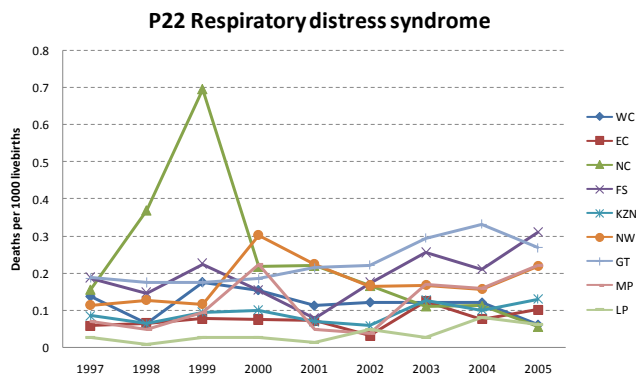
Appendix E: Leading causes of death for infants (7–27 days) by province, 1997–2005

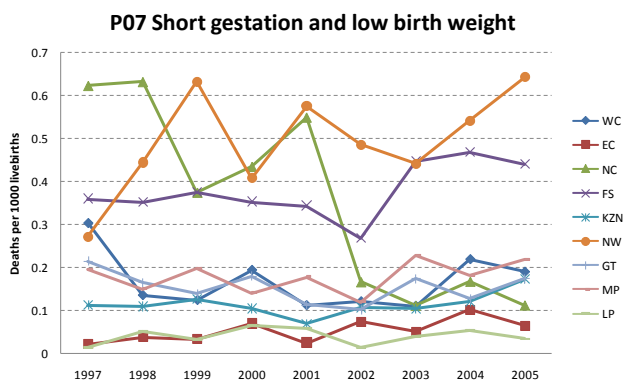


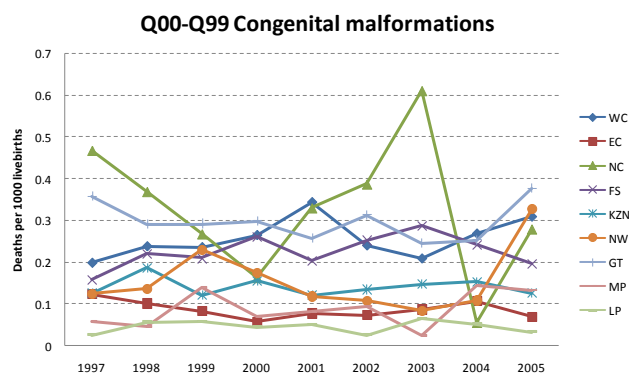




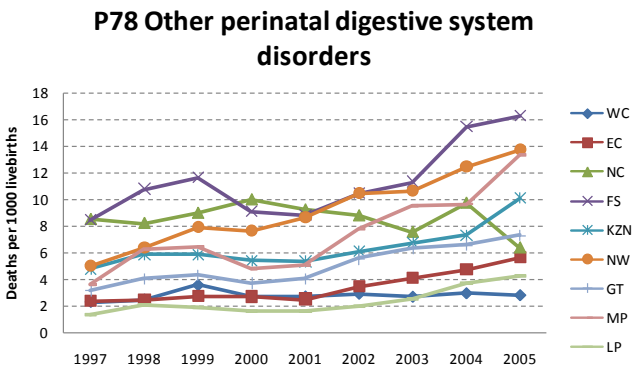


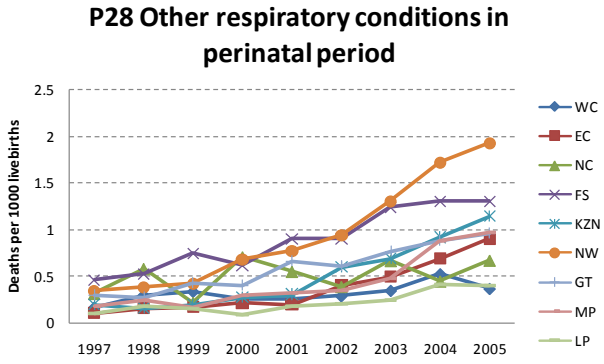


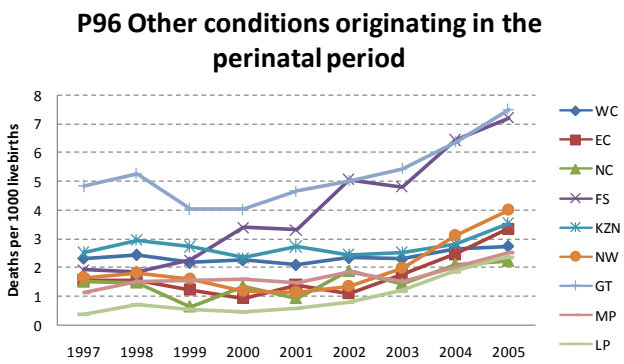


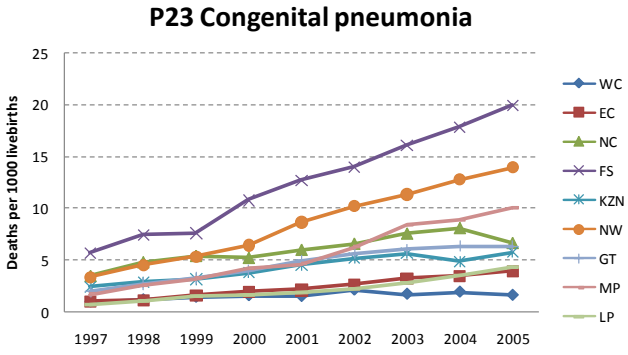


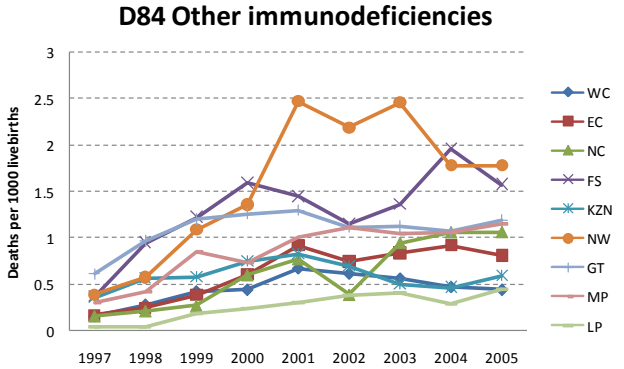
Appendix F: Leading causes of death for infants (1–11 months) by province, 1997–2005

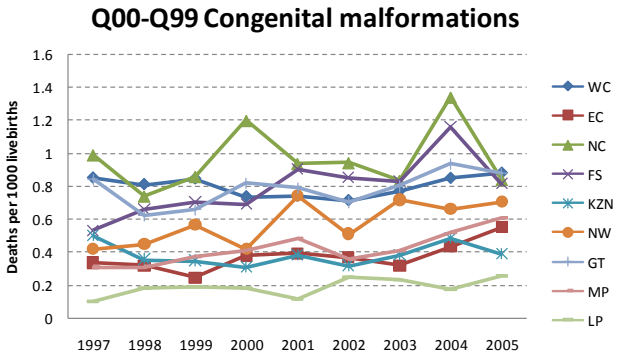












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Burden of Disease Research Unit

