Rates and causes of child mortality in rural KwaZulu-Natal

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Declaration and Preface

This paper is original work and has not been submitted to this or any other university. It was prepared and revised solely by Anupam V. Garrib, 203519065, Department of Community Health, School of Family and Public Health Medicine, Nelson R Mandela School of Medicine, University of KwaZulu-Natal.

Analysis was based on data collected by the Africa Centre for Health & Population Studies, University of KwaZulu Natal through the Africa Centre Demographic Information System (ACDIS). The Africa Centre Demographic Information System is supported by the Wellcome Trust (Grant numbers #65377 and #77760).

The author was not involved in the design of ACDIS or the verbal autopsy component of ACDIS. The author did supervise the data collection and managed the verbal autopsy component of ACDIS for part of the period during which the data used in this dissertation were collected. This included scientific input, staff management, data entry, data validation and data quality management.

Signed: 

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Presentations

i. Garrib A., Bennish M. Child mortality in rural KwaZulu-Natal. DEMSA, Joint Population Conference, Durban, South Africa, 7 October 2004.

ii. Garrib A. Child mortality in rural KwaZulu-Natal. School of Family and Public Health Medicine Research day, Durban, South Africa, 1 June 2005.

Publications

Garrib A., Jaffar S., Knight S., Bradshaw D., Bennish M. Rates and causes of child mortality in rural South Africa.

The article was based on the analysis described in the dissertation, and was submitted and reviewed by the journal "AIDS". The editors did not accept the article. The comments from the reviewers were incorporated into the dissertation as appropriate, as many of these were not relevant to this document. The article has subsequently been resubmitted to another journal.

Acronyms & abbreviations

ACDIS	– Africa Centre Demographic Information System
AIDS	– Acquired Immune Deficiency Syndrome
ASSA 2002	- Actuarial Society of South Africa, AIDS model 2002
DHS	- Demographic and health survey
DoH	- Department of Health
DSS	– Demographic surveillance system
DTN	– Death notification form
GIS	– Geographic information system
GNI	- Gross national income
GOBI	- Growth montoring, oral rehydration, breast feeding, immunisation
HIV	– Human Immunodeficiency Virus
KZN	– KwaZulu-Natal
LRTI	- Lower respiratory tract infections
MDG	- Millenium Development Goals
NMR	– Neonatal mortality rate
PNMR	– Post neonatal mortality rate
PMTCT	– Prevention of mother to child transmission
SANBD	– South African national burden of disease study
Stats SA	– Statistics South Africa
STI	– Sexually transmitted infection
UNICEF	- United Nations Children's Fund
VA	– Verbal autopsy

WHO – World Health Organisation

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Dedication

This dissertation is dedicated to my parents for all they have done for me.

Abstract

i. Background

Recent gains in child survival are being threatened by the HIV epidemic. Monitoring child mortality rates is essential to understanding the impact of the epidemic, but is constrained by a lack of data. A community-based survey was used to determine child mortality rates in a rural area with high HIV prevalence, located in the Hlabisa sub-district of the KwaZulu-Natal Province, South Africa.

ii. Methods

The study was conducted between 1 January 2000 and 31 December 2002 on deaths in children under the age of 15 years. Children were followed up through 4-monthly home visits. Cause of death was ascertained by verbal autopsy. Rates were calculated using Poisson methods.

iii. Results

Infant and under-5 mortality ratios were respectively, 59.6 and 97.1 deaths per 1000 live births. Infant and under-5 mortality rates were, respectively, 67.5 and 21.1 deaths per 1000 child-years. HIV/AIDS was attributed to 41% of deaths in the under-5 age group, with a mortality rate of 8.6 per 1000 person years. Lower respiratory infections caused an estimated 24.9 deaths per 1000 person years in children under 1 year of age.

iv. Discussion

In rural South Africa, infant and child mortality levels are high, with HIV/AIDS estimated as the single largest cause of death. Improving the coverage of interventions known to impact on child mortality is required urgently.

Chapter 1: Introduction

1.1 Background

Dramatic reductions in child mortality occurred in the twentieth century in both developed and developing countries. These gains that occurred over many decades are now being eroded in many developing countries, in relatively short time, by the progression of the HIV/AIDS epidemic, such that the decline in child mortality rates has slowed in some countries and begun to reverse in others (Ahmad *et al.*, 2000).

Infant and child mortality levels are important and commonly used indicators of socio-economic development. Reducing child mortality has become a focus in the international community with its inclusion in the Millennium Development Goals (MDG). Monitoring child mortality is essential in order to measure changes in child health, and to inform and evaluate intervention strategies. This is particularly important in light of the rapid and major impact HIV/AIDS is having on populations, particularly in Southern Africa.

However, in most of Africa monitoring child mortality is constrained by the lack of reliable data. One way to monitor mortality is through vital registration systems. However, it is estimated that less than 10% of Africa is covered by death registration systems, and that the deaths of infants and younger children are less likely to be reported than the deaths of adults (Mathers *et al.*, 2005). In South Africa, significant improvement in death reporting has occurred and it is estimated that approximately 90% of adult deaths were registered in 2000. The proportion of child deaths reported is uncertain (Dorrington

et al., 2001).The extent of selection bias, from only a proportion of deaths being reported, is unclear.

Information on cause specific mortality patterns in sub-Saharan Africa is also limited and generally of poor quality (Bah, 1998). Monitoring cause-specific mortality is vitally important in order to determine health priorities, to guide the allocation of scarce resources, inform the development of health programmes and to evaluate the impact of disease specific interventions (Snow *et al.*, 1992). Cause-specific mortality patterns are changing with increasing prevalence of HIV/AIDS in the population. As well as having a direct impact on child mortality, HIV increases the frequency of other infections, such as tuberculosis, diarrhoea and meningitis.

In developing countries these data are rarely available routinely. In addition, it has been suggested that the number of research studies that are providing data on child mortality is decreasing and there are now fewer studies of adequate quality coming out of the countries with the highest mortality burdens (Rudan *et al.*, 2005). Population-based surveys are an important source of data on child mortality rates and cause specific mortality patterns.

1.2 Current state of knowledge on child mortality

Burden of diseases studies have generated estimates of child mortality rates and causes at the national level, but due to the lack of data these are often based on models, rather than directly measured, and are subject to a high degree of uncertainty. National estimates also

do not reflect the difference between areas and groups within a country. In many countries there are differences in child health between rural and urban communities, and between rich and poor.

It is also known that HIV/AIDS is having a substantial effect on child mortality levels, and those countries that are experiencing generalised epidemics are showing further worsening of infant and child mortality levels.[1] In Southern Africa, the region with the highest HIV prevalence, life expectancy has fallen from 62 years in 1990 – 1995 to 48 years in 2000 – 2005 (United Nations, 2004b). In the seven Southern African countries that have HIV prevalence higher than 20% (Botswana, Zambia, Zimbabwe, South Africa, Namibia, Lesotho, Swaziland), average life expectancy at birth is expected to drop below 40 years between 2010 and 2015 (United Nations, 2004a).

The neonatal period is a high risk period for children, and recent studies have estimated that neonatal deaths contribute 40% of deaths in children under the age of five years (Lawn et al., 2005). Other important contributing factors to high infant and child mortality levels are malnutrition, low birth weight and maternal health. It is estimated that malnutrition is an underlying factor in up to 50% of child deaths (Bryce et al., 2005). Low birth weight in children is also a significant contributing factor to child deaths in the first years of life. It has been shown that the health of a child is critically influenced by the health and survival of their mothers. Children who have mothers that are ill or who

[1] A generalized epidemic is one that is affecting the general population rather than being limited to high-risk groups. (World UNAIDS report 2004)

have died have poorer survival that children whose mothers are well, despite their HIV status (Newell et al., 2004a).

1.3 Knowledge gaps in child mortality

There are few recent estimates of child mortality rates in South Africa, particularly from rural areas, and most of the recent estimates have been generated using modelling tools. Until recently South Africa had the largest number of people in the world living with HIV/AIDS, this is now India, and as the epidemic matures it is necessary to monitor the impact of this on child health. Interventions against the HIV/AIDS epidemic are being introduced and monitoring child mortality levels will provide a measure of the impact of these at the community level. Monitoring the causes of child mortality is also important. As resources are diverted to the HIV comprehensive care programmes, it is important to monitor the impact that this has on other health programmes and causes of child mortality. If these programmes suffer due to a lack of resources, this may impact on their effectiveness and the causes of death that they were intended to address may increase in frequency.

While it is known that inequities in health status between racial groups, and rural and urban groups persist, the extent of these is not known. Since the end of the apartheid system in 1994, many large-scale social programmes have been introduced to improve the health and living conditions of disadvantaged communities. The impact that these have had on outcomes such as mortality of children is not known. In addition, as the burden of the HIV epidemic is concentrated in poor communities, these inequities in

health status may have worsened. Our ability to monitor these changes is limited due to a lack of data.

1.4 Significance of this study

In this study an established demographic surveillance system was used to determine mortality rates, and a verbal autopsy (VA) method to estimate cause of death. This study, with its limitations, provides estimates of all-cause and cause-specific mortality in young children in a rural South African population, broken down by age and sex. It highlights an important source of data that policy makers should be aware of.

The longitudinal nature of the data and its source in a rural community provides an estimate of the effects of HIV/AIDS among children in this population, and helps fill a gap in currently available public health data. The results may be used to inform intervention strategies. It also establishes baseline estimates against which to measure the ongoing effects of the HIV/AIDS epidemic on child health, and to measure the impact of interventions against the epidemic.

There is little published information on rates and causes of mortality in the early adolescent age group in Africa. Deaths in children aged between 5 and 15 years are not normally included under the term 'child mortality', however due to the availability of this data from the study site, it was decided to include them in the analysis.

This study also provides some information on the use of VA in child deaths in high HIV prevalence areas. VA is a tool that has been used to estimate causes of death in young children but its diagnostic ability is thought to be poor. It is a tool that needs to be further assessed and developed for use in high HIV prevalence areas.

1.5 Study hypothesis

The hypothesis is that rates of all-cause mortality are high in this population, and HIV/AIDS is now the single most important determinant of mortality.

1.6 Study aim

The aim was to determine age and cause specific mortality rates and patterns in children under the age of 15 years in the Africa Centre Demographic Surveillance Site (ACDIS[2]) in KwaZulu-Natal, between January 2000 and December 2002.

1.7 Study objectives

The following study objectives apply to the study population in the Hlabisa sub-district for the period 2000 – 2002.

i. To calculate overall childhood mortality rates by age and sex.
ii. To describe childhood cause-specific mortality patterns.
iii. To calculate childhood cause-specific mortality rates by age and sex.
iv. To describe birth and death settings of children in the study area.

[2] ACDIS is a Wellcome Trust Funded demographic surveillance site located in northern KwaZulu-Natal Province. At this site a population living within a defined geographic area is followed up longitudinally. Further details about ACDIS are presented later in this document in section xx.

v. To calculate the proportion of childhood deaths reported to have been registered with local authorities by age group.

1.8 Operational definitions

The term 'child' is often used to refer to children under the age of 5 years. However in this dissertation/ study, the term is used to refer to children under the age of 15 years.

1.9 Organisation of the report

This report is organised into chapters. Chapter 1 establishes the aims and objectives of this study and what the study is expected to contribute to the body of knowledge. Chapter 2 details the methods and results of the literature review. The literature review explores what is known about child mortality locally, nationally and internationally and places this study within that context. Chapter 3 presents the methods of the study as well as a description of the study site. Chapter 4 presents the results of the study. The discussion of the results and their link to the literature review are presented in chapter 5, followed by the conclusions and recommendations in chapter 6.

Chapter 2: literature review

2.1 Introduction

The purpose of the literature review was to assess the current state of knowledge on methods of estimating child mortality, as well as the levels and causes of child mortality both internationally and within South Africa. In addition, information on determinants of child mortality as well as current knowledge on interventions to impact on child mortality was reviewed.

2.2 Literature review method

Studies used in this literature review were identified through a Pubmed and Medline search for English language sources using the following keywords: child mortality, child survival, infant mortality, verbal autopsy, post-mortem interview, sub-Saharan Africa, South Africa. The *related articles* link was also used and the reference sections of articles were searched for other relevant references.

2.3 The use of child mortality data

Monitoring child mortality levels is essential to provide information for public health planning, monitoring and evaluation (Black et al., 2003, Rudan et al., 2005). This information is essential at a national level to monitor trends and measure inequities between groups; but also at a local level so that public health programmes can respond appropriately to local health problems (Black et al., 2003, David et al., 1991). Cause specific mortality data are equally important to assess the health status of a population, prioritise health problems, monitor trends in mortality from specific causes, guide the

focus of public health interventions, and to monitor the effect of interventions against particular causes of child deaths (INDEPTH Network., 2002, Parashar et al., 2003, Rudan et al., 2005).

Infant and under-5 mortality ratios are a commonly used index of child health (Black *et al.*, 2003). They are used as indicators of socio-economic development, access to and quality of health care, and as a measure of the impact of health interventions. While under-5 mortality rates are sensitive to changes in a wide range of factors, as an aggregate measure it does not necessarily allow you to differentiate changes in any of the particular factors (David *et al.*, 1991).

However, in many countries the data required to monitor child mortality levels and cause specific patterns are not available. This occurs mostly in those countries that have the highest child mortality burden (Rudan *et al.*, 2005). Various indirect methods of estimating child mortality and cause specific patterns have been developed to fill this data gap, and these are described briefly.

2.4 Methods of estimating child mortality levels

There are various methods of estimating child mortality, and the method of choice is dependent on the available data and available resources with which to generate data. Direct and indirect methods can be used to estimate the true birth and death rates of populations where coverage of vital registration is not complete. Methods and sources of data to estimate child mortality levels are described.

2.5 Direct methods of estimating child mortality

2.5.1 Vital registration systems

Vital registration systems are routine systems that provide a continuous register of births and deaths, with cause of death, in a population. It has been suggested that a well functioning vital registration system with good coverage of vital events, and an estimation of the cause of death of the individual, is the best way to monitor child mortality (Ahmad et al., 2000, Sibai, 2004). This provides a continuous source of data, which can be used to estimate national as well as local rates and causes of death. However, vital registration systems are inadequate in most developing countries. Less than 10% of African countries are covered by death registration systems (Mathers *et al.*, 2005). Wilkinson et al (1997) found that 74 % of children aged between 12 and 35 months living in a rural area of South Africa had not had their births registered with the local Department of Home Affairs (Wilkinson *et al.*, 1997).

In those counties that do have vital registration systems, a number of factors can lead to bias in the estimates of mortality. Births may only be registered some time after the event when it is necessary to access social grants or register a child in school (Sibai, 2004). The registration of deaths tends to be less complete than the registration of births. Deaths in young children are also more likely to not be registered than the deaths of older children or adults (Jewkes and Wood, 1998). In most African societies, children die at home and are buried quickly without having had any contact with the health services. When coverage of these systems is incomplete, the poor tend to be underrepresented and it is

likely that these communities have different cause of death profiles (Black et al., 2003, Sibai, 2004).

Even in a vital registration system with a good coverage of the population, causes of death can be inaccurate if the death was sudden, signs and symptoms were non specific, or the death was attributed to a stigmatised condition (Sibai, 2004). When children die in hospital, cause of death may be difficult to assign because of poor diagnostic facilities. Even when diagnostic facilities are available, accurate diagnoses can still be difficult to make, for example, in settings where laboratory testing for malaria is available, children can be falsely diagnosed with malaria when they have asymptomatic parasitaemia (as most children in endemic areas carry parasites) combined with meningitis or severe pneumonia.

In a recent trial of pneumococcal conjugate vaccine among infants in rural Gambia, vaccination reduced all-cause mortality by 16% but the trial could not demonstrate an effect on acute lower respiratory tract infection (LRTI) specific mortality, despite good clinical surveillance and enhanced x-ray and other facilities. These findings indicate that it was not possible to accurately assign causes of death and that the burden of acute lower respiratory infection was much greater than had ever been estimated in the past for all-cause mortality to fall by as much as 16% (Cutts *et al.*, 2005).

2.5.2 Sample registration surveys

Some countries where vital registration systems are incomplete have adopted sample registration surveys. A comprehensive registration of the population is conducted in several representative areas, and births and deaths are actively sought and enumerated. Cause specific mortality data are generated using interview or VA methods, however these may incorrectly classify causes of death leading to bias (Black *et al.*, 2003). Sample registration surveys allow the measurement of short term population growth in-between the censuses, and monitoring of the impact of any interventions or programmes that are running in those areas. The application of results to other communities is dependent on whether the sampled population is truly representative of the wider population. India has used this system successfully since the 1960's, and it is now also used in Bangladesh and China.

2.5.3 Longitudinal survey data

Demographic surveillance sites (DSS) enumerate populations within a defined geographic area, and have continuous surveillance for birth, death and migration events within the population. The demographic data that are generated are more accurate, and they can be provided longitudinally, allowing the monitoring of trends within a population. There are few dedicated demographic sites as they are expensive and do not tend to be representative of the population as a whole. Even if they are representative of the population when they are set up, they do not remain as such as they are often part of other research studies, usually to follow up populations in intervention studies, for example vaccine trials. However they are able to provide regular and up to date estimates

of child mortality levels. Verbal autopsy methods are often used to generate cause specific mortality data. The results from these sites can be used as a means of calibrating birth and death rates generated from the vital registration system.

South Africa has three demographic surveillance sites that are able to provide in-depth information on population change and the factors that influence it. These are Agincourt in the Limpopo province, Dikgale in the Limpopo province and the Africa Centre for Health and Population Studies in the KwaZulu-Natal province (INDEPTH Network., 2002).

2.5.4 Censuses

A census is the systematic enumeration of the population of a country. These are conducted between five and ten years apart. They are not performed in many developing countries as they are expensive and require skilled technical personnel. The data are often only published years after the survey was completed, and may therefore be outdated before they are published. For example, in a setting where there is rapid progression of an HIV/AIDS epidemic, such as in southern Africa, the current levels of mortality may not be reflected by data collected some years earlier (David *et al.*, 1991).

2.5.5 Household surveys

In this method, questionnaires are administered to a household. Women in the household are asked questions on their fertility histories and these data are analysed by various methods, described below, to produce estimates of child mortality rates. Examples of

these surveys include the Demographic and Health Surveys (DHS), October Household Surveys and the Multiple Indicator Cluster Surveys (MICS) (Mahy, 2003).

2.5.6 Birth history method

A woman is asked about each of her previous births, including the date of birth and date of death of every child. Child mortality can then be estimated by time period and age of the child. This method requires a skilled interviewer and is intensive and costly. It requires women can report adequately on dates such as dates of birth and death of children. If well performed, this method can provide data on a period two and a half to twelve years prior to the data collection (David *et al.*, 1991). One of the key assumptions underlying the birth history method is that maternal and child mortality are not related. This is unlikely to hold in most high HIV prevalence settings, and has an impact on the use of this method in these areas, as will be discussed later (Mahy, 2003).

2.6 Indirect Methods of estimating child mortality

2.6.1 Brass method or the Children ever born/children surviving (CEB/CS)

Women of reproductive age are asked about the number of live births they have ever had and the number of the children that are still alive. Child mortality is estimated, based on the mothers age, for various time points in the past. This method is of limited use for recent estimates, but gives estimates of trends and levels for the period 5 to 15 years prior to the survey (David et al., 1991, Mahy, 2003). There are similar assumptions made in this method as in the birth history method.

2.6.2 Previous birth technique

Women who attend health services shortly before or after a birth are asked questions on their preceding birth and whether or not the child is surviving. Often this information is already collected by the health services and can be accessed easily and with little expense. More accurate data may be gathered if the questions are asked before or at delivery, as the mother may see some benefit to her care by answering the questions at this point. However, coverage of immunisation services is higher than utilisation of delivery services therefore if a woman is asked the questions when she brings her child for immunisation, the sample size may be greater but the data may be less accurate (WHO/UNICEF, 1994). This method provides more recent estimates of mortality, and is best used at the local or district level. The data collected refer to mortality trends amongst users of the health services. This should be taken into consideration when extrapolating mortality levels to the community.

2.7 Impact of HIV on methods of estimating child mortality

Both the methods that rely on household survey data to assess child mortality; that is the birth history and Brass methods, make a key assumption that maternal and child mortality are not related. If they are correlated, child mortality estimates would be biased as the birth histories of mothers who have died would not be captured in the survey, and these mothers would be likely to have had children who died, who would also not be included in the survey.

With HIV this assumption is violated as there is a correlation between maternal and child mortality. Mothers who have HIV will transmit the infection to their children in between 15 to 45% of cases, and children who are HIV infected have higher mortality rates than children who are not infected. In addition, the uninfected children of HIV infected mothers have higher mortality than the children of mothers who are not infected (Newell *et al.*, 2004a). The children of women who die of HIV/AIDS will therefore be under-represented in a survey, and child mortality levels will be underestimated (Mahy, 2003, Zaba et al., 2003).

A second assumption in the indirect estimation methods is that child mortality is independent of the mothers age. This assumption is also violated in high HIV settings. Maternal HIV infection is linked to a woman's age, and therefore child mortality will be linked to a woman's age.

The final assumption is that child mortality levels can be estimated using model life tables. Model life tables are used to estimate life expectancy and risk of dying at a particular age, based on age specific mortality risks for a given population. Often the age specific mortality risks are not available for a particular population, and a model life table that approximates the mortality experience of that population can be used to generate an estimate. Currently available model life tables do not allow accurate estimation of child mortality levels in high HIV prevalence settings (Mahy, 2003). Model life tables predict lower levels of child mortality relative to infant mortality when compared with empiric data. There is little empiric data from settings with high HIV prevalence on which to

generate these models and those available models do not therefore generate robust estimates of child mortality in high HIV settings.

A study estimating the potential bias resulting from using indirect methods in high HIV prevalence settings found that there was a significant bias in the estimates even at HIV prevalence levels as low as 5 percent. Corrections of this bias were difficult to achieve, and the authors recommended that indirect methods were not used to estimate child mortality in high HIV prevalence settings (Mahy, 2003).

In the case of direct methods, only one assumption, that the mortality of mothers and children are not correlated, is violated. In high HIV settings the bias that this introduces can be estimated and corrected for, although it is suggested that this technique only be applied to estimates of child mortality in the 5 years preceding the survey (Mahy, 2003).

2.8 Methods of estimating cause of death

2.8.1 Routine systems

As with calculating mortality levels, the data collected through routine systems would be the best method of monitoring cause specific mortality patterns. Death certification by medical personnel assigns a cause of death to each deceased individual. However, these systems are generally not in place in developing countries. A large proportion of deaths in these settings occur without the individual having accessed medical services, and the death is registered without a medical opinion on the cause (Mathers *et al.*, 2005).

2.8.2 Health service data

The causes of death of children who die in hospital can be used to estimate mortality profiles in a community. Hospital mortality rates however are influenced by health seeking behaviour, the quality of the health service and inequities in the utilisation of health services (David *et al.*, 1991). In addition, diagnoses like HIV may be deliberately omitted from records due to the stigma attached to the diagnosis. Caution must be exercised in extrapolating the results as, due to these factors, the true community based mortality patterns may be quite different.

2.8.3 Post mortem interviews or verbal autopsies

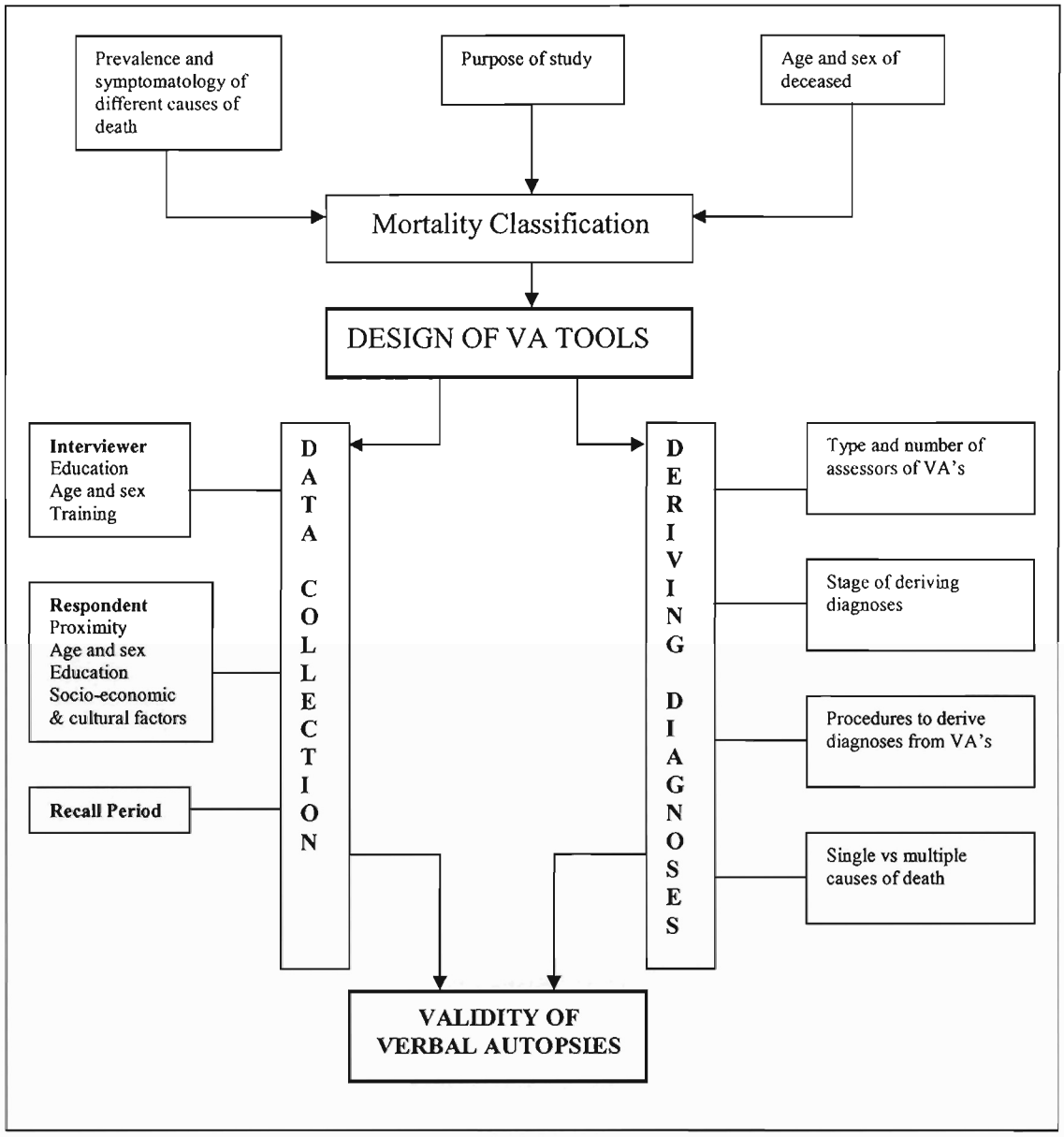
The VA technique is an indirect method used to establish cause of death by conducting a detailed interview with a member of the family, preferably the caregiver, of the deceased. The VA method has been used to generate cause-specific mortality data in areas where people may not access health services before death, vital registration systems are weak, and cause of death data are incomplete or unreliable (Anker, 1997, Chandramohan et al., 1994, Snow et al., 1992, Todd et al., 1994). The tool has most often been used in research settings, demographic surveillance sites, descriptive studies or controlled trials of disease-specific interventions; but is now also used in sample registration systems in India and China. VA data can be used to establish the public health importance of different causes of death, to study trends in cause-specific mortality over time, to identify ways to reduce mortality, to evaluate the effect of health interventions, and to investigate differentials in cause specific mortality between groups (Anker et al., 1999, Chandramohan et al., 1994). The method has been used extensively to investigate the causes of death in children.

A key assumption of VA's is that each cause of death has a distinct set of signs and symptoms that can be recognised, remembered and reported by an informant (Anker et al., 1999, Chandramohan et al., 1994). Conditions like neonatal tetanus, rabies or injuries are therefore better suited to VA than conditions that have signs or symptoms that overlap (Anker *et al.*, 1999). There is significant overlap between the symptoms of acute respiratory infection and malaria, and in malaria endemic areas it is accepted that VA is not a good method to determine acute lower respiratory infection prevalence as many of these deaths may be misclassified as malaria deaths. A Kenyan study estimated sensitivity of 28% and specificity of 91% for respiratory infection diagnoses in a malaria endemic area (WHO/UNICEF, 1994, Snow et al., 1992). Many common causes of death present with signs and symptoms that are not easily distinguishable. With very young children in particular, the sign and symptoms of serious illness often overlap. For instance, it would be almost impossible to distinguish between sepsis and pneumonia in the newborn based on VA (WHO/UNICEF, 1994).

The ability of VA's to accurately diagnose a cause of death is influenced by a number of factors including the cause of death, the true cause specific mortality fractions of that cause of death in the population, the prevalence of other causes of death in the population, the interviewer, the characteristics of the deceased, the design and content of the questionnaire, the field procedures, the method used to attribute the cause of death, and the classification of the causes of death (Chandramohan *et al.*, 1994). In addition, cultural factors may influence the willingness to have a VA interview, how the signs and

symptoms are interpreted and reported by the informant, and whether or not it is appropriate to report certain illnesses or causes of death (Anker *et al.*, 1999). This can lead to significant misclassification of causes of death, which is the major limitation of the VA method. These factors have been summarised in figure 1, and some of the key factors are discussed in greater detail.

Figure 1: Determinants of validity of verbal autopsies[3]



[3] Taken from Chandramohan, D., G. H. Maude, et al. (1994). "Verbal autopsies for adult deaths: issues in their development and validation." Int J Epidemiol **23**(2): 213-22.

2.8.3.1 Verbal autopsy questionnaire

Various formats of VA questionnaires have been tested. These include an open narrative format, checklist of symptoms, structured modular questionnaires and combinations of these. The format of the questionnaire influences the type of interviewer and assessor required. An unstructured questionnaire will require a highly skilled interviewer. More structured questionnaires allow the use of less skilled interviewers, as well as the use of computer-based algorithms to assign causes of death. There are advantages and disadvantages to each format which have all been discussed in the literature (Chandramohan *et al.*, 1994).

2.8.3.2 Interviewer

There is no consensus as to whether medically trained or lay interviewers are preferable. Medically trained interviewers are expensive to employ and scarce in many developing countries, and are also more likely to interpret the responses of the informants in the interview. Lay interviewers need a very structured questionnaire. Cultural factors may influence the choice of the most appropriate interviewer (Chandramohan *et al.*, 1994).

2.8.3.3 Mortality classification

The mortality classification to be used may be developed before or after the development of the verbal autopsy tool and will be influenced by the study design and study purpose. A study focussed on malaria may have very broad categories for other causes of death, which will impact on the sensitivity and specificity of VA to make those diagnoses. The choice of categories will affect the complexity of diagnostic algorithms and the ability of the assessors to reach a diagnosis (Chandramohan *et al.*, 1994).

2.8.3.4 Attributing cause of death

Procedures used to derive the diagnosis vary and may include the following:

- Physician derived diagnoses
- Pre-defined diagnostic algorithms
- Artificial neural networks
- Combinations of the above methods (Boulle *et al.*, 2001).

Physician review of the questionnaires is the most commonly used method of deriving VA diagnoses, and between one and four physicians may be used. The physicians interpretation of the data will be influenced by their experience of disease prevalence in hospitals, which may not be the same as disease prevalence in the community (Snow *et al.*, 1992). In studies of a particular disease, there is a tendency to attribute more deaths to that cause of interest (Bang *et al.*, 1992).

2.8.3.5 Other causes of death

The prevalence of other causes of death can influence the ability of VA to diagnose particular causes of death. It has been shown that VA has inadequate sensitivity and specificity to diagnose acute respiratory infection in high malaria prevalence areas.

2.8.3.6 Recall bias

There is no consensus as to when the best time is to conduct the interview. There has to be a balance between limiting recall bias and not causing the bereaved family any further grief by conducting the interview too soon after the death event.

2.8.3.7 Single or multiple causes of death

The sensitivity and specificity of the VA method can also be influenced by whether single or multiple causes of deaths are generated. In child deaths particularly there is often more than one cause that contributes to a death, and ignoring multiple causes could lead to misleading results (Chandramohan *et al.*, 1994). For example, HIV/AIDS could be the underlying cause of malnutrition or tuberculosis. Using multiple causes gives a better estimation of the true burden of a particular cause of death, and helps estimate the true impact that an intervention may have.

To determine the impact of these factors on the validity of VA's, validation studies are often conducted. The results obtained from the VA are compared with a medical diagnosis. Hospital diagnoses are most often used as the reference standard as post mortems are rarely available in the situations in which VA's are conducted. Validation studies generate sensitivity and specificity levels for the VA method to diagnose a particular cause of death at a particular site. This can then be used to adjust for misclassification of causes of death (Chandramohan *et al.*, 2001).

Using hospital diagnoses as the reference standard may suffer selection bias as individuals who die in hospital may be of a higher socio-economic status and therefore have a different cause of death profile. The standard of the hospital diagnosis is also important. As discussed above (section 2.5.1), hospital diagnoses can be subject to misclassification, even in areas where reasonable diagnostic facilities exist, which in turn leads to a bias in the estimates of sensitivity and specificity. While the tool is widely used

in developing country settings, there is no standardisation of the methods or tools, which makes cross-site comparisons of data difficult.

2.9 Measures of child mortality

There are several measures of child mortality that can be used to measure child health. There is much controversy over whether some of these measures should be referred to as rates or ratios. Some of these measures are commonly referred to as rates but are in fact ratios (INDEPTH Network., 2002). The most common examples of this are the neonatal, infant and under-5 mortality rates that are calculated using live births as the denominator. In this dissertation these will be referred to as ratios. The true rates, calculated with the number of deaths as the numerator and person years lived within that age group as the denominator, will be referred to as rates in this dissertation.

2.9.1 Neonatal mortality ratio (NMR)

This is the number of children who die within the first 28 days of life, divided by the number of live births in the year, per 1000. This is used as an indicator of perinatal care. The measure is further divided into the early and late neonatal mortality ratios. The early neonatal mortality ratio includes deaths that occur within the first 7 days of life, and reflects the quality of the health services provided to the mother in the antenatal period and during delivery. The late neonatal mortality ratio includes deaths that occur from the 8^{th} to 28^{th} day after delivery. Both these rates however, will also be affected by birth defects as well as maternal factors.

2.9.2 Post neonatal mortality ratio (PNMR)

The post neonatal mortality ratio includes deaths that occur from the 29th to the 365th day after delivery, divided by the number of live births in the year, per 1000. In comparisons between groups, this can be used as a reflection of the health and nutritional status of infants.

2.9.3 Infant mortality ratio

This is the number of deaths that have occurred in children under the age of one year divided by the number of live births in that year, per 1000. As the number of person years lived by children under the age of 1 year is difficult to estimate, the number of live births in the year is used to approximate this (INDEPTH Network., 2002). Some children who die will have been born in the previous year. This can also be considered to be a risk rather than a rate, as it is the number of individuals that developed the outcome during the follow up period divided by all those at risk.

This measure is widely used as an indicator of socio-economic development, living standards, and the availability and quality of health care. There are intrauterine and extra-uterine factors that affect the infant mortality ratio (Romani and Anderson, 2002). Intrauterine factors have greatest affect on the neonatal mortality ratio and extra-uterine factors on the post neonatal mortality ratio (Rip *et al.*, 1998). A reduction in infant mortality ratio is viewed as a measure of success and development within a country (Romani and Anderson, 2002).

2.9.4 Under-5 mortality rate and ratio

The under-5 mortality ratio is most commonly quoted in the literature and is referred to as the under-5 mortality rate. This is the number of deaths among children under 5 years old in a given year, per 1000 live births in the same year. This is also referred to as the probability of dying between birth and exactly 5 years of age expressed per 1000 live births (INDEPTH Network., 2002). The under-5 mortality rate is the number of deaths among children under-5 years old per 1000 person years observed in the population of children who are under 5 years old.

The under-5 mortality ratio is widely used as an indicator of the cumulative exposure to risk of death during the first 5 years of life. The causes of death that influence the infant mortality ratio continue to be a risk factor in the early years of childhood, and this will be reflected in the under 5 mortality ratio. It is often also used a measure of the impact of child survival interventions (Ahmad *et al.*, 2000). A criticism of this composite measures when used at the national level, is that it does not reflect inequalities between social and economic groups and geographical areas (World Health Organisation, 2005).

These different measures described above can also be used to give an indication of the cause of death profile in a country. The infant mortality rate is composed of the NMR and the PNMR. In developing countries that have high infectious disease burdens, more deaths occur in the post-neonatal period, and this is therefore the most important determinant of the infant mortality rate. As the health status of a population improves and the overall mortality rates fall, the infectious disease burden falls and the NMR

becomes the most important determinant of the infant mortality rate. The ratio of the NMR to the PNMR changes as the infant mortality rate drops (Black *et al.*, 2003). Typically, as the under-5 mortality rate decreases, the proportion of deaths occurring within the first year of life increases, and as the infant mortality rate decreases, the proportion of deaths occurring within the first month of life increases (Hill and Pande, 1997).

2.10 Global changes in child survival

Much has been written on the reductions in child mortality rates that were seen in both developed and developing countries in the last century (Ahmad et al., 2000, Black et al., 2003, Walker N et al., 2002). These reductions were evident in developed countries from the end of the 19th century, and were echoed in developing countries in the latter half of the 20th century. Sub-Saharan Africa however, showed the lowest rate of decline of child mortality levels of all the regions of the developing world over the 30 year period between 1960 and 1990 (Hill and Pande, 1997). From the mid 1980's it was noticed that the rate of decline of child mortality levels had began to slow and even reverse in some settings. This was not unexpected in countries that had low mortality rates to begin with, but the same trend was also seen in countries that still had high mortality levels (Ahmad et al., 2000, Black et al., 2003).

Despite the vast overall improvements in child health, more than 10 million children under the age of 5 years still die every year, 40% of these in the neonatal period (Ahmad et al., 2000, Lawn et al., 2005). Most of these deaths occur in developing countries. In

Africa approximately 15% of newborn children will die before reaching their 5th birthday, compared to a global risk of 7% (Ahmad *et al.*, 2000).

2.11 Determinants of child mortality

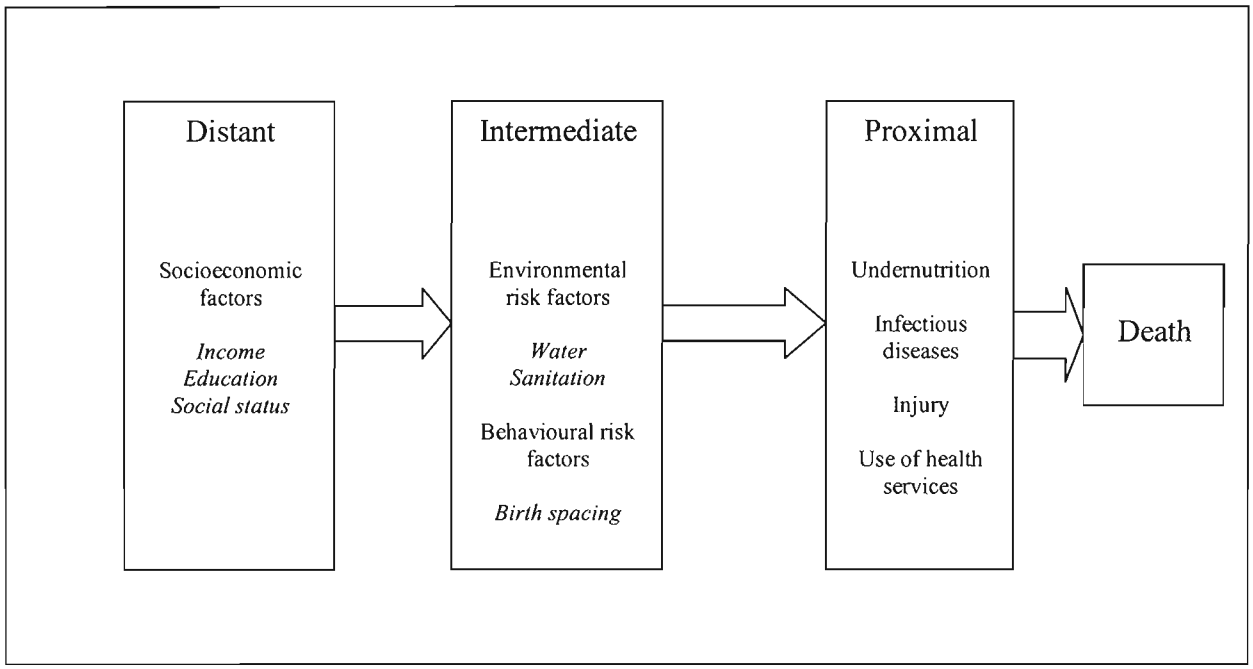
The decline in child mortality levels had been credited to a combination of socio-economic development and improvements in health care (Victora *et al.*, 2003). The development of several health care interventions, mostly preventive rather than curative programmes, led to improved maternal and child health. These included immunisation programmes, availability of antibiotics, oral rehydration therapy, a focus on obstetric care, and nutrition of mothers and children (Ahmad *et al.*, 2000).

The reversal of the downward trend in developing countries on the other hand, has been attributed to the progression of the HIV/AIDS epidemic, the slow rate of economic development in developing countries, political instability and restrictions on health spending (Ahmad et al., 2000, Zaba et al., 2003, World Health Organisation, 2005). In sub-Saharan Africa in addition, rates of under-nutrition have not declined. The largest determinant is thought to be the progression of the HIV/AIDS epidemic.

In trying to understand the shifts in child mortality levels, attempts have been made to understand and estimate the risk factors and determinants of child mortality, and the causal pathways between these. It is now widely accepted that child deaths are commonly the result of more than one factor or as a result of interactions between these factors (Black et al., 2003, Romani and Anderson, 2002). Figure 2 represents a

determinant framework that depicts how the known determinants are believed to act to result in a child death.

Figure 2: Determinants of child mortality [4]



Socio-economic factors such as income, education and social status are distal determinants of mortality that act through intermediate, environmental and behavioural factors, and proximal determinants to result in the death of a child. The proximal determinants are factors that are nearer in time to the terminal event and include health-seeking behaviour and illnesses or injury (Black et al., 2003, Moseley and Chen, 1984).

A number of studies have shown an association between income and mortality, although there is much variability around this, suggesting that there are other factors that play a

[4] Based on Black, R. E., S. S. Morris, *et al.* (2003). "Where and why are 10 million children dying every year?" Lancet **361**(9376): 2226-34.

role. Table 1 shows a selection of infant and child mortality levels as well as Gross National Income (GNI) [5] levels for selected countries. At the macro level, countries with higher GNI's have lower infant and child mortality levels, although this is not consistent. Botswana for instance has a higher GNI than South Africa and yet has higher under-5 mortality rates. Ghana and India have GNI's much lower than South Africa's and yet have mortality levels that are comparable.

Other factors that have been shown to have an impact include intermediate factors such as maternal education level, which influences a mother's health seeking behaviour and health care practices, thus resulting in an impact on child survival. Urban households have been shown to have lower child mortality levels than rural households. Cultural factors such as a preference for male children impacts on the survival of female children through selectively ending pregnancies with female foetuses, lower utilisation of health services or less access to food for female children (Victora *et al.*, 2003).

[5] Gross national income. Previously known as Gross National Product, Gross National Income comprises the total value of goods and services produced within a country (i.e. its Gross Domestic Product), together with its income received from other countries (notably interest and dividends), less similar payments made to other countries. Source: http://en.wikipedia.org/wiki/Gross_National_Income
Accessed 3 November 2005

Table 1: Mortality rates [6] and Gross National Income levels for selected countries

Country	Neonatal Mortality rate*	Infant Mortality rate*	Under-5 Mortality rate*	GNI per capita US $[a]
Uganda	33	88	140	270
Nigeria	48	100	198	400
Ghana	30	57	95	380
Zambia	37	95	182	440
India	43	68	87	620
Swaziland	-	-	153	1 660
South Africa	20	45	66	3 650
Botswana	-	-	112	4 340
United Kingdom	4	5	6	33 940

*Mortality rates per 1000 live births for 2003. Source http://www.who.int/child-adolescent-health/OVERVIEW/CHILD-HEALTH/Mortality_Rates_03.pdf

[a]Gross National Income per capita for 2004. Source

http://siteresources.worldbank.org/DATASTATISTICS/Resources/GNIPC.pdf

While the determinants are understood, the causal pathways whereby these impact on child deaths are less well understood. How do the socio-economic determinants act to produce a biological outcome in the form of the death of a child? Suggested explanations are that poor children are more exposed to the risks for disease through unsafe water supplies and inadequate sanitation and indoor air pollution. Poor housing conditions and crowding lead to higher exposure to disease vectors, and poor nutrition creates greater susceptibility to developing infections. The poorest children are also least likely to receive the interventions that would offset these increased risks, are less likely to seek

[6] These are in fact mortality ratios as they have been calculated used live births as denominator. They have been left as rates here as they were reported as such in the source.

care when they fall ill, and are less likely to receive the appropriate care for their illness (Victora *et al.*, 2003).

2.12 The impact of HIV on child mortality

2.12.1 Mechanisms of action

As mentioned above, much of the increase in child mortality is suggested to be due to the progression of the HIV/AIDS epidemic and it is believed that the full impact of the epidemic has not yet been seen in child mortality (Adetunji, 2000). This is because HIV prevalence is still rising in many settings. Also, as HIV infection often passes from men to women and then to children, children are the last to be infected in a family, though they may be the first to die. Mortality rates in HIV infected children are very high in the absence of any interventions, and most infected children will have died by the age of 5 years. However there is little information available on the natural history of HIV infection on children in sub-Saharan Africa.

HIV/AIDS influences child mortality in a number of ways, although the full extent and method of this impact is still being debated. HIV can be transmitted directly from HIV infected mother to child in-utero, during delivery or through breastfeeding in 15-45% of cases where there are no specific interventions to prevent this (Newell *et al.*, 2004a). The timing of acquisition of HIV in a child is believed to be an important determinant of the survival of the infected child. Children who are infected in-utero or during delivery have been shown to have higher mortality rates than those that are infected post delivery through breastfeeding (Newell et al., 2004a, Newell et al., 2004b).

Indirectly, HIV can increase child mortality through increased mortality of mothers. Maternal death has been shown to be associated with increased child mortality, and maternal death is more frequent in children who have HIV positive mothers. The period just before and after a mothers death are particularly dangerous for a child, although that is true both for HIV-infected and uninfected children (Newell et al., 2004a, Zaba et al., 2003). Mortality of HIV infected children is high, and there is evidence to suggest that the mortality of children of infected mothers is higher than the mortality of children whose mothers are not infected, again regardless of whether the children are infected or not (Adetunji, 2000, Newell et al., 2004a, Newell et al., 2004b). Mothers are key to securing shelter, food and education and other resources for a child. Children who do not live with their mothers or whose mothers are not alive, do poorly with respect to these factors.

Other indirect mechanisms include loss of income if a parent or breadwinner dies and the resultant effects of poverty, social disruption, and increased prevalence of other diseases like tuberculosis. Resources within the household may be diverted to care for sick adults, and resources may be diverted within the health sector to care for patients with HIV/AIDS (Walker N et al., 2002, Adetunji, 2000).

2.12.2 Proportion of the increase in child mortality due to HIV

The main factor determining the impact of HIV on child mortality is the adult HIV prevalence rate, although the impact is mediated by the quality of health care available, socio-economic status, and the background level of child mortality (Adetunji, 2000,

Newell et al., 2004a, Nicoll et al., 1994). The impact of HIV on fertility and on population structure will also affect mortality rates. HIV infected women are likely to have lower fertility than HIV uninfected women as they are more likely to suffer infertility from other sexually transmitted infections, to be widowed, to be ill or to avoid falling pregnant if they are aware of their status. In addition there is high mortality among women of reproductive age. High HIV prevalence amongst women of reproductive age may therefore result in a decreased number of births, a denominator used in many child health measures, and result in a reduction in the absolute number of deaths even if there are increasing mortality rates (Nicoll *et al.*, 1994).

Difficulty in estimating the size of the impact is compounded by the lack of cause specific mortality data, and a lack of information on the natural history of HIV infection in children in developing countries. Adetunji (2000), in an analysis of DHS data, found that countries with an adult HIV prevalence of more than 5% had seen rises in the child mortality levels, while in countries with lower prevalence, child mortality levels had decreased (Adetunji, 2000). DHS's have generally not included HIV testing, so differences in mortality rates between infected and uninfected children cannot be estimated. Mortality in HIV uninfected children is indicative of background mortality in children. Knowledge of background mortality is essential to assess the additional impact that HIV will have on child mortality. Fewer HIV infected children will survive in a setting with high background mortality than in a setting with low mortality (Zaba *et al.*, 2003). It has also been suggested that countries that have lower background child mortality will experience a greater increase in child mortality levels than countries that

already have high child mortality, as in high child mortality settings many of the HIV infected children will not have survived anyway.

The contribution of HIV/AIDS to overall under-5 year mortality in sub-Saharan Africa is increasing, with the greatest rise in the countries of southern Africa. It has been estimated that in 1999 HIV accounted for almost 8% of all-cause mortality in under-5's in sub-Saharan Africa (Walker *et al.*, 2002). Newell (2004) estimated that in those sub-Saharan African countries with high prevalence rates, HIV is causing up to half of all deaths in children under the age of 5 years (Newell *et al.*, 2004a). In South Africa the mortality risk of infected children has been estimated to be 12 times that of uninfected children (Newell *et al.*, 2004b).

South Africa has a very high HIV prevalence rate amongst pregnant women attending public antenatal clinics. In the 2003 South African antenatal HIV sero-prevalence survey, KwaZulu Natal had the highest provincial HIV prevalence rate amongst antenatal attendees of 38% (95% CI: 35, 40), as compared with a national HIV prevalence of 28% (95%CI: 27, 29). (Department of Health, 2004) In the study area, HIV prevalence among women attending public antenatal clinics was estimated to have increased from 7% amongst women aged 20 – 24 years in 1992 to 51% in the same age group by 2001(Abdool Karrim SS. and Abdool Karim Q., 2005).

Interventions to prevent the transmission of HIV from mother to child have only recently been introduced in the country and the coverage and quality of the programme is

uncertain. Anti-retroviral treatment for children was introduced in 2004 and very few children are currently on the treatment programme. In comparison to other southern African countries, South Africa's child mortality rates are moderately high taking into account that we have one of the highest GNI's in the region and a good health infrastructure. These factors together suggest that the HIV/AIDS epidemic is having a growing effect on child mortality rates in South Africa.

2.13 Child mortality rates in South Africa

2.13.1 Sources of data

Levels of infant and child mortality have been difficult to estimate in South Africa due to a lack of reliable data on both births and deaths. The current state of the vital registration system has to be understood within the historical and political context of the country. The racial stratification of the population affected vital registration systems as it did other sectors of society (Bah SM., 1998). Registration of vital events has been compulsory for all races living in urban areas since 1924, but for Africans in rural areas it was voluntary until recently (Bourne, 1995). The most accurate data available was for the white population, and even this suffered due to the lack of registration of deaths (Rothberg *et al.*, 1984).

In 1975 four "homelands"; Transkei, Boputhatswana, Venda and Ciskei (the TBVC states), elected to become 'independent' of South Africa. They were then excluded from the South African vital registration system, and therefore from estimates of national child mortality levels. Estimates of mortality levels varied considerably depending on whether

or not data from the TBVC states were included in the calculations. Political change in the early 1990's saw changes in geographical boundaries when the TBVC states were re-incorporated into the country and 9 new provinces were formed. In 1998, a new combined Department of Health (DoH) and Department of Home Affairs (DoHA) death certificate was introduced to improve coverage of registration of vital events. Traditional leaders were incorporated to improve the coverage of events that occurred outside of the health services, although there has been some debate over the effect that this has had on the quality of cause of death data generated.

The completeness of registrations of births and deaths, has improved significantly, and in 1999 – 2000 the MRC estimated that 89% of deaths among adults (more than 15 years of age) were registered (Dorrington RE *et al.*, 2001). However, vital registration system coverage in rural areas is still poorer than in urban areas, with estimates of coverage varying from 24 – 84% (Wood and Jewkes, 1998, Nannan et al., 1998, StatsSA., 2002). In addition, under-reporting of deaths among children is greater than among adults. Late registration of births also contributes to poor data, with an estimated 19% (range 10 – 60%) of births being registered within the first year of life (Nannan et al., 1998, Wood and Jewkes, 1998). This impacts on the available denominators for the calculation of child health measures.

2.13.2 Child mortality rate estimates

Under the *apartheid* system, access to health care, economic opportunities, housing and education, all determinants of child mortality, was determined by racial group and was

very unequal (Romani and Anderson, 2002, Burgard and Treiman, 2005). Resources and services available to the black population were of far lesser quantity and quality than those available to the white population. As a result there were large inequities in child mortality rates between race groups reflecting the differences in socio-economic and other factors (Nannan et al., 1998, Rip et al., 1998). Mortality rates in the white population were lowest and approximated mortality rates in developed countries. In 1983 the infant mortality ratio for the white population was estimated at 14 deaths per 1000 live births (Rip *et al.*, 1998). In contrast, the infant mortality ratio for the black population for the period 1975-1979 was estimated at 81 deaths per 1000 live births (Chimere-Dan, 1993).

Recent estimates of overall child mortality rates in South Africa and in KZN are listed in Table 2. The 1998 DHS used birth histories from a national sample of women aged 15-49 years to estimate infant and under-5 mortality ratios for the 5 years preceding 1998 (Department of Health *et al.*, 2002). The South African National Burden of Disease Study (SANBD) used a modelling approach calibrated to empirical data to estimate mortality levels and causes. This study estimated that there were 106 000 deaths in children under the age of 5 years, and 7800 deaths in children aged 5-14 years, in the year 2000 (Bradshaw et al., 2003a, Bradshaw et al., 2005). The latest version of the Actuarial Society of South Africa demographic model ASSA2002, estimated a national infant mortality ratio of 56 deaths per 1000 live births and an under 5-mortality ratio of 87 deaths per 1000 live births (Dorrington *et al.*, 2004).

Table 2: Recent estimates of infant and child mortality ratios in South Africa

	National		KwaZulu-Natal Province	
	Infant mortality ratio	**Under-5 mortality ratio**	**Infant mortality ratio**	**Under-5 mortality ratio**
Demographic and Health Survey, 1998[1] (Department of Health et al., 2002)	45	59	52	75
South African National Burden of Diseases Study, 2000[2] (Bradshaw *et al.*, 2003a)	60	95	68	116
ASSA2002 Model, 2004[2] (Dorrington et al., 2004)	56	87		

[1] Estimated using indirect methods

[2] Estimated using modelling techniques

These studies show that the mortality rates in the KZN province are higher than the national estimates, demonstrating that the national estimates do not reflect the differences in health status between provinces. Bradshaw et al (2005) found that the under-5 mortality ratio in KZN province was 2.5 times higher than the under-5 mortality ratio in the Western cape (Bradshaw *et al.*, 2005). However, this information was based on modelling and is subject to bias. Similarly, national and regional estimates do not reflect the differences in child mortality levels between groups, for example between race, and between rural and urban groups.

One study estimated child mortality levels in the Hlabisa sub-district using the previous birth technique. The data were collected from women attending public antenatal clinics in the area during July 1997 to July 1998. The infant mortality ratio was estimated at 53 deaths per 1000 total births (95% CI: 42, 71) and the under-5 mortality ratio at 70 deaths per 1000 population (95% CI: 53, 98). These mortality rates would have applied to the period 2 years prior to the data collection. The results of the study were reported in a scientific letter and so are not peer reviewed. Unfortunately it was not clear why the under-5 mortality ratio is reported per 1000 population or why the infant mortality ratio is reported per 1000 total births (Wilkinson D. and Sach M., 1999). Another study from the nearby Mosvold hospital, using the previous birth technique, found an infant mortality rate of 62 per 1000 live births (Buchmann et al., 1992).

The data from the studies listed above are difficult to interpret as the estimates are based on indirect methods or modelling, using assumptions that may not hold true.

2.14 Causes of child mortality

These data are usually generated from the medical certification of deaths. In most developing countries these data, if available, are unreliable. Few people will have access to medical care before death. Many children die at home unattended by health personnel, and at health facilities, diagnostic facilities are limited and record keeping is poor. Research studies that estimate cause-specific mortality patterns are limited in quality and number, and do not generate enough data on which to make assessments about large areas (Bryce *et al.*, 2005).

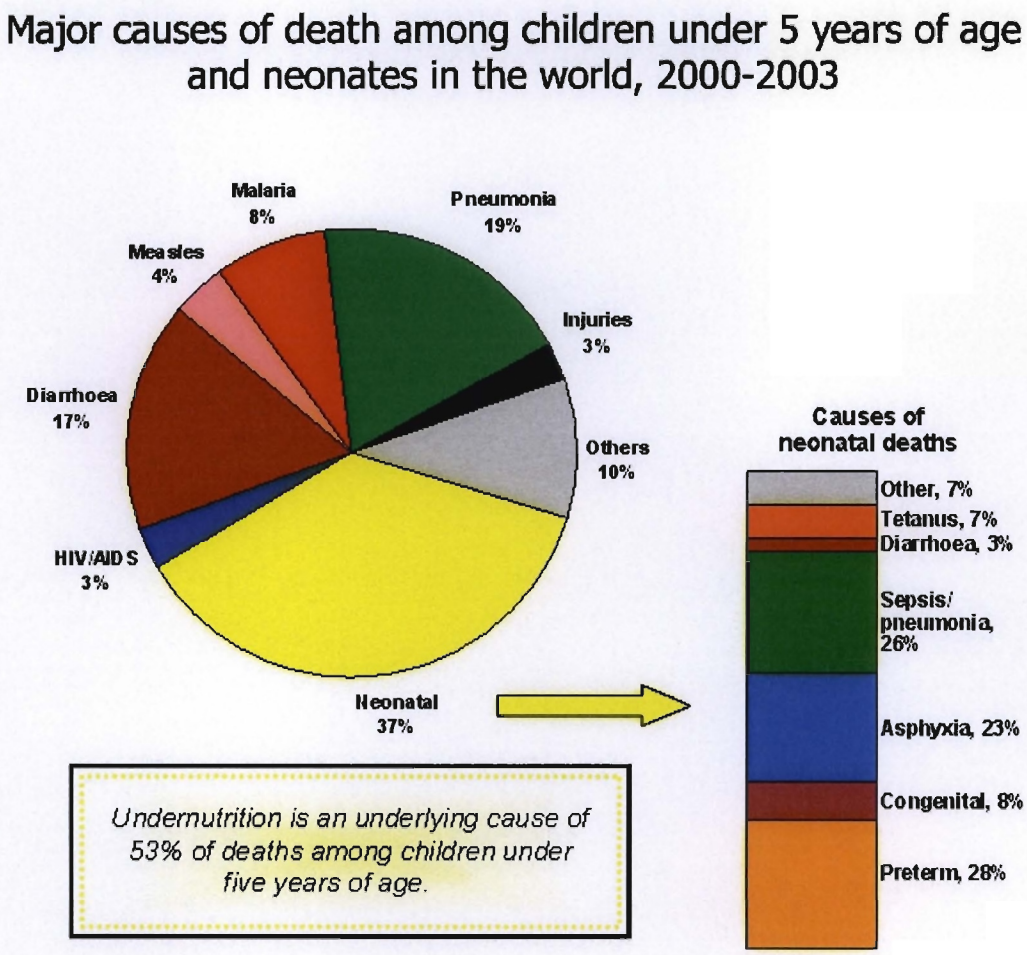
Cause of death patterns vary by age groups of children, they vary over time, and across and within regions. In developing countries, communicable diseases remain the most common causes of death, although the profile of communicable diseases has changed over time. Due to high immunisation coverage mortality attributable to both tetanus and measles has fallen. As the overall levels of infant and child mortality change, so do the predominant causes of death, for example as the neonatal mortality rate decreases, fewer deaths are due to infective causes (Knippenberg et al., 2005, Lawn et al., 2005). In developed countries, deaths due to some infective causes, like tetanus, were almost eliminated with the introduction of immunisation and treatment interventions. In countries with low child mortality levels, there are few deaths due to infectious diseases or injuries.

Figure 3 shows WHO estimates of the major causes of child deaths globally. Diarrhoea and LRTI are common causes of death in developing countries, while the proportion of deaths due to malaria and HIV vary between regions. Globally, HIV is attributed to a small proportion of deaths in children, however this varies significantly by region.

LRTI is among the leading causes of child mortality globally, both as an underlying and as an associated cause of death. In 2000 almost 2 million children were estimated to have died from acute respiratory infections, 70% in Africa and Southeast Asia. Williams (2002) estimated that 22% of deaths in Africa were due to LRTI (Williams BG *et al.*, 2002). A recent pneumococcal vaccine trial in the Gambia, showed a 16% reduction in

all-cause mortality (Cutts *et al.*, 2005). Treating LRTI could therefore have a larger effect on all cause mortality than just the effect on LRTI attributable mortality.

Figure 3 : Causes of death in children under the age of 5 years, 2000 - 2003, (World Health Organisation, 2005) [7]



[7] Taken from World Health Organisation website www.who.int/child-adolescent-health/OVERVIEW/CHILD_HEALTH/map_00-03_world.jpg. Accessed 11 November 2005

Malnutrition plays a contributory role in some of the most important causes of death in children. Malnutrition is an underlying cause of death in 53% of deaths in children younger than 5 years, and this is often not reflected in mortality data (Bryce *et al.*, 2005). The association between malnutrition and all cause mortality is well known, but there is also an association between malnutrition and death due to diarrhoea and lower respiratory tract infections (Rice *et al.*, 2000). Malnutrition decreases the ability of the body to resist infection, and as a result nutritional interventions are recognised as an important strategy in decreasing deaths due to respiratory infections and diarrhoea.

Mortality due to diarrhoea is declining globally. Kosek in 2000, estimated that diarrhoea accounted for 21% of all deaths in children under the age of 5 years, approximately 1.6-2.5 million deaths per year (Kosek *et al.*, 2003).

2.14.1 South African estimates of causes of child mortality

The most recent estimates of the causes of child mortality in South Africa come from the SANBD study, and from a recent release of data collected from the Department of Home Affairs by Statistics South Africa (Stats SA). The SANDB study, using an adapted version of the Global Burden of Disease list of causes of death estimated that HIV/AIDS was the leading cause of death in children under the age of 5 years. In this study cause specific mortality data from three sources were used. Data on natural deaths came from Stats SA, who captured data from death certificates received from the Department of Home Affairs. Data on deaths due to external causes, i.e injuries and accidents, came from the Population register and from the National Injury Mortality Surveillance Study.

Table 3 lists the top ten causes of death in children under the age of 5 years as estimated in the SANBD study.

Table 3: Top ten causes of death in children under 5 years, South African National Burden of Disease Study, South Africa, 2000

Rank	Cause of death	Deaths	%
1	HIV/AIDS	42 749	40.3
2	Low birth weight	11 876	11.2
3	Diarrhoeal diseases	10 786	10.2
4	Lower respiratory infections	6 110	5.8
5	Protein-energy malnutrition	4 564	4.3
6	Neonatal infections	2 920	2.8
7	Birth asphyxia and trauma	2 584	2.4
8	Congenital heart disease	1 238	1.2
9	Road traffic accidents	1 219	1.1
10	Bacterial meningitis	1 141	1.1
	All causes	106 070	

The Department of Home Affairs in South Africa collects data on all certified deaths in the country. Statistics South Africa (Stats SA) recently published data from all death certificates received by the Department of Home Affairs for the period 1997 to 2003 (Statistics South Africa, 2005). Table 4 lists the top ten natural causes of death for selected age groups for the year 2001. As is expected, causes of death differed by age group. HIV/AIDS does not feature strongly on this table as a cause of death, although the proportions of deaths due to associated causes like tuberculosis and pneumonia showed an increase (Statistics South Africa, 2005). These data reflect what is being recorded on

death certificates and it is possible that due to the prevailing stigma, many clinicians are still reluctant to record HIV as the cause of death.

There is little published on the causes of death in the 5-14 year age group in South Africa and globally. Not a lot of public health attention is paid to this group, as they have relatively low mortality having survived the major threats of childhood. Many of the causes of death that occur in this age group are preventable (Flisher AJ *et al.*, 1992). In South Africa, external causes of death like road traffic accidents, drowning and homicide form a significant proportion of deaths in this group, more so in boys than girls (Bradshaw *et al.*, 2003a). Road traffic accidents have been estimated to be responsible for over half of non-natural deaths in the 10-14 age group (Flisher AJ et al., 1992, Knobel et al., 1984).

Table 4: The top ten underlying natural causes of death for selected age groups: 2001

Broad group of cause of death (ICD-10 code)	Less than 1 year		1-4 years		0-14 years	
	Rank	%	Rank	%	Rank	%
Respiratory and cardiovascular disorders – perinatal (P20 – P29)	1	30.5			1	19.2
Digestive system disorders of foetus and newborn (P75 – P78)	2	17.9			2	11.2
Other disorders originating in the perinatal period (P90 – P96)	3	11.1			3	7.0
Infections specific to the perinatal period (P35 – P39)	4	5.3			7	3.3
Disorders related to length of gestation and foetal growth (P05 – P08)	5	4.6			9	2.9
Certain disorders involving the immune mechanism (D80 – D89)	6	3.9	5	4.1	6	3.6
Foetus and newborn affected by maternal factors (P00 – P04)	7	2.2				
Haemorrhagic and haematological disorders of foetus and newborn (P50 – P61)	8	2.2				
Transitory endocrine and metabolic disorders specific to foetus and newborn (P70 – P74)	9	1.8				
Malnutrition (E40 – E46)	10	1.7	3	8.1	8	3.1
Intestinal infectious diseases (A00 – A09)			1	20.7	4	5.8
Influenza and pneumonia (J10 – J18)			2	13.0	5	3.9
Tuberculosis (A15 – A 19)			4	5.7	10	2.3
Human immunodeficiency virus [HIV] diseases (B20 – B24)			6	3.0		
Other viral diseases (B25 – B34)			7	2.0		
Inflammatory diseases of the central nervous system (G00 – G09)			8	1.6		
Other forms of heart disease (I30 – I52)			9	1.4		
Metabolic disorders (E70 – E88)			10	1.2		

Using the Actuarial Society of South Africa demographic model ASSA2002, Dorrington et al (2004) estimated that the prevalence of HIV in children aged between 0-14 years was 1.7% in 2004, and that 42% of the deaths in the same age group were due to HIV/AIDS (Dorrington *et al.*, 2004). There are no estimates of causes of child mortality from the area in which this study was conducted, however published data on the adult deaths showed that HIV/AIDS was the leading cause of death amongst adults, responsible for 48% of deaths in people over the age of 15 years, and 74% of deaths amongst women aged between 15 and 44 years (Hosegood *et al.*, 2004b).

2.15 International response to child mortality

The Millennium Development Goals, adopted in 2000, committed the global community to addressing poverty and ill health (Sachs, 2004). A number of the goals are focussed on health in recognition of the fact that good health is essential to the development of countries and the breaking of the poverty cycle. Millennium Development Goal number four (MDG-4) focuses on child health. The goal is "to reduce mortality in children under the age of 5 years by two-thirds between 1990 and 2015".

2.15.1 Interventions to address high child mortality.

The first 'child survival revolution' of the 1980's, spearheaded by the United Nations Children's Fund (UNICEF), developed out of recognition of the need to address high child mortality levels. The strategy was built around a package of interventions grouped under the acronym GOBI (Growth monitoring, Oral rehydration, Breast feeding, Immunisation) (World Health Organisation, 2005, UNICEF, 1983). The child health

programmes that were developed as a result of this focussed on these specific services implemented as vertical programmes rather than as an integrated child health programme. Many criticisms were levied at this strategy, and a lack of cause specific mortality data made it difficult to determine whether subsequent gains in child survival had been due to particular programmes (Ahmad *et al.*, 2000). It was believed that this approach led to substitution effects in child mortality, that is a child who had both diarrhoea and LRTI would be treated for the LRTI through a vertical initiative but die from the diarrhoea; resurgence of malaria, lower levels of vaccination coverage, and health service utilisation (Rutstein, 2000).

More recently, as it became clear that the gains that had been made in child survival are being eroded, renewed interest in child mortality has developed. The difference between the strategies being put forward now and those of the 1980's, is that the focus is on the delivery of an integrated child health strategy with health systems strengthening as a key factor. The argument is that gains in child survival will not be sustained without strong health systems. Implementing programmes, including those that are community based, that do not have health systems strengthening components could result in further weakening of already fragile health systems.

Integration of child health programmes means different things at different levels. For the patient it means case management and being able to receive several interventions at one health care visit. For the point of care it means taking the opportunity that a health visit offers to provide several interventions that might not be related to the purpose of the visit.

For the health system, it means integrating all the management, support and policy level issues so that resources can be made available to deliver the services (World Health Organisation, 2005). An example of an integrated strategy to address child mortality is the Integrated Management of Childhood Illness (IMCI) approach. It is an approach that looks to address both the proximal and distal determinants of child health, and incorporates the care of the individual child with community and health system issues.

The interventions that need to be implemented to address a large part of the child mortality problem are known. These are mentioned here but will be discussed further in chapter 5. Jones et al (2003) have recently summarised the evidence base for these interventions (Jones *et al.*, 2003). The authors identified a series of preventive and treatment interventions for which there was sufficient evidence of effect, and that were cost effective enough for implementation at high levels of coverage in low-income countries. These interventions are listed in Table 5. They also estimated that while some interventions; breastfeeding, measles vaccination and Vitamin A, had very high coverage, most other interventions had low coverage and were not reaching the children that needed them. It was estimated that if coverage of all the interventions could be increased to 99%, two-thirds of the current child deaths could be prevented (Jones *et al.*, 2003). While it is perhaps unlikely that any intervention will receive this high level of coverage, this paper demonstrates that many of the tools needed to tackle the child mortality burden, and achieve global targets for its reduction, already exist and have a sufficient evidence base to support them.

Table 5: Interventions with sufficient evidence of effect for implementation at high levels of coverage in low-income countries[8]

Preventive interventions	Breast feeding
	Insecticide treated nets
	Complementary feeding
	Water, sanitation, hygiene
	Hib vaccine
	Zinc
	Vitamin A
	Antenatal steroids
	Tetanus toxoid
	Nevirapine and replacement feeding
	Clean delivery
	Measles vaccine
	Antimalarial intermittent presumptive treatment in pregnancy
Treatment interventions	Oral rehydration therapy
	Antibiotics for pneumonia
	Antimalarials
	Antibiotics for sepsis
	Antibiotics for dysentry
	Zinc
	Vitamin A

There is also recognition of the need to specifically address the burden of neonatal mortality in order to achieve the MDG-4. There are common misconceptions that addressing the causes of neonatal mortality requires expensive high tech interventions.

[8] Taken from Jones G., Steketee RW., et al. (2003). "How many child deaths can we prevent this year?" The Lancet **362**(9377): 65-71.

However reductions in neonatal mortality have been achieved in low income countries using low technology community based interventions, and care delivered by non-professionals (Knippenberg *et al.*, 2005).

In summary, there is a lack of empirical data on child mortality rates and causes in South Africa, as in many developing countries. In response to this, this study aims to determine levels of child mortality in an area of high HIV prevalence. Child mortality is an area of renewed international focus currently, and developing countries are having to address this burden in order to achieve international targets for health and social development. The lack of reliable data makes the estimation of the problem as well as the monitoring of progress to achieving the targets difficult. In addition, in areas of high HIV prevalence it is difficult to estimate the true contribution of HIV/AIDS to the child mortality rates. The next chapter will describe the study area and study methods used.

Chapter 3: Research methodology

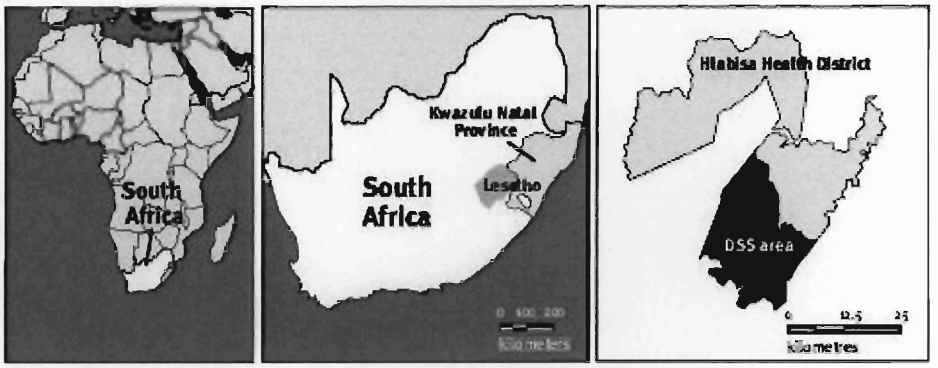
3.1 Introduction

In this chapter is a detailed description of the study site and all the methods of data collection and data validation. This site has several ongoing studies and has been well researched. The information that has been gathered about the site, as well as the description of the complex surveillance system employed at the site is essential for the understanding and interpretation of the data used in this analysis.

3.2 Study area

The Africa Centre Demographic Information System (ACDIS) is an established demographic surveillance site (DSS) in northern KwaZulu-Natal, South Africa. The DSS is situated within the Hlabisa sub-district of the larger Umkhanyakude district. The sub-district has a population of approximately 210 000 people. The demographic surveillance area forms part of the Hlabisa sub-district (see Figure 4). It is a 435 km^2 area, in which there are 11 000 inhabited homesteads, housing approximately 90 000 people, 65 000 of whom are residents and 25 000 non-residents (definitions given below) (INDEPTH Network., 2002). The surveillance area is predominantly rural with a small township located in its southern tip. The resident population is Zulu speaking, and there are several tribal areas, each under the local authority of a tribal chief or inkosi (INDEPTH Network., 2002).

Figure 4: Map situating the Africa Centre Demographic Surveillance Site

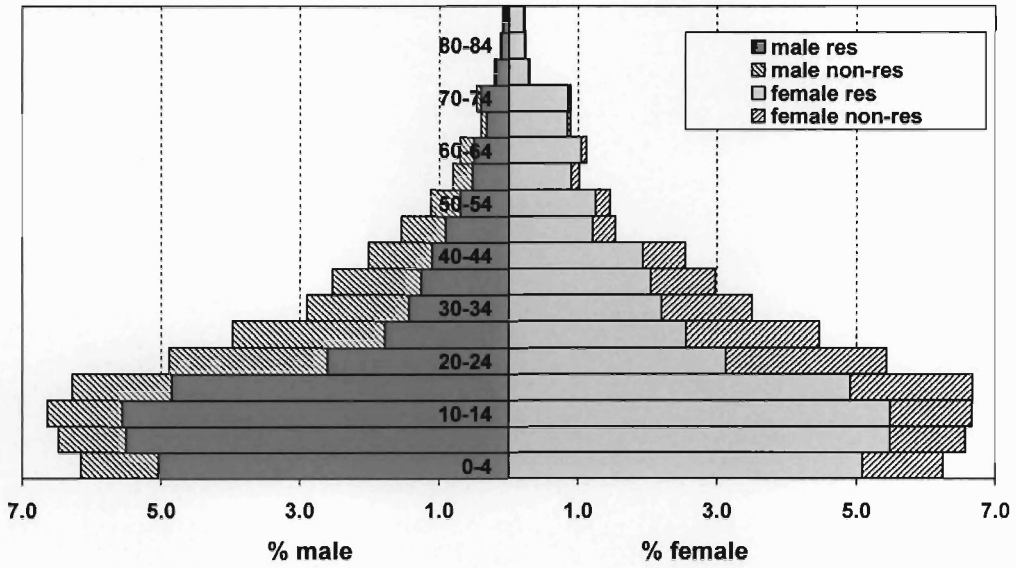


Within ACDIS, the population under surveillance was characterised by three key concepts. Individuals are part of social groups or households that reside at a physical place or homestead. A household within ACDIS was a self-defined social unit. Individuals may be resident or non-resident members. A resident member of a household was defined as someone who had spent most nights in the surveillance area since the last fieldworker visit. In this way, each person is linked to both a social group and a physical location within the area (INDEPTH Network., 2002, Hosegood and Timaeus, 2005).

3.2.1 Description of the population structure

On January 1, 2001, 86 469 individuals were registered in ACDIS. Approximately 80 percent of these individuals were resident members (Hosegood and Timaeus, 2005). Twelve percent of the population was under the age of 5 years (Figure 5).

Figure 5: Percentage age-sex distribution of resident and non-resident population, ACDIS 1st January 2001 (Chimbwete CE and Herbst AJ, 2003)



3.2.2 Description of socio-economic indicators

In 2000 38% of households in ACDIS had access to piped water, 39% of households reported having no toilet facilities and unemployment rates were 39% (Chimbwete CE and Herbst AJ, 2003).

3.2.3 Description of the health services

Health care in the public sector has been free for pregnant women and children under the age of 6 years since 1994. In the surveillance area there were 6 fixed primary health nurse-run clinics. Approximately 40 km away from the surveillance area is the district referral hospital, which is staffed by non-specialist medical personnel. In 1997 it was estimated that within the Hlabisa sub-district, 91% of women attended an antenatal clinic at least once during their pregnancy and most had been given tetanus toxoid, 83%

delivered in a health facility, and 76% of children had received all recommended vaccine doses for a child under the age of 1 year (Wilkinson *et al.*, 1997).

As already mentioned, the 2003 South African antenatal HIV sero-prevalence survey estimated a provincial HIV prevalence rate amongst antenatal attendees of 38% (95% CI: 35, 40) for KZN (Department of Health, 2004). In the study area, HIV prevalence among women attending public antenatal clinics was estimated at 51% amongst women aged 20 – 24 years in 2001(Abdool Karrim SS. and Abdool Karim Q., 2005). A programme providing nevirapine for the prevention of mother to child transmission of HIV began in December 2001. Exclusive breastfeeding rates in this population in 2000 were low (Bland RM. *et al.*, 2002). The provincial Department of Health has begun the implementation of IMCI but coverage is low.

3.3 Study design

This was an observational cohort study. The cohort was an open cohort and individuals were followed up through routine four-monthly home visits. In the event of a death, a follow up visit was conducted by the VA nurse-interviewer. Inclusion and exclusion criteria are described in section 3.4, and further detail on follow up is included in sections 3.5 and 3.7. [9]

[9] From the perspective of ACDIS this is not a secondary analysis, as it was always the intention to conduct this analysis. For the purposes of this report, it will be treated as a secondary analysis as, although the author did manage the study for a period, the author of this study was not involved in the ACDIS study design in any way and did not contribute to setting up of ACDIS or the verbal autopsies. In addition, this was submitted to the Research Ethics Committee as a secondary analysis.

3.4 Study population

Of the population that was under surveillance in ACDIS between 1 January 2000 and 31 December 2002, all children under the age of 15 years were included in this analysis. Both resident and non-resident members were included, and all reported deaths that occurred in children under the age of 15 years were included. Any deaths identified as stillbirths or as non-members of ACDIS during the VA interviews, were excluded from the analysis.

3.5 Data Collection

The data collection in the DSS commenced, with an initial census, on 1 January 2000. After the initial census, households were visited by a fieldworker three times a year and data collected on individual events including births, deaths, migrations, pregnancies and marriages; as well as on households and homesteads. Both resident and non-resident members were followed up. Apart from the standard questions, there were additional socio-economic questionnaires, sexual history questionnaires, and a separate verbal autopsy team that followed up all deaths (Hosegood and Timaeus, 2005). Most of the routine household and individual level data are collected from proxy informants, i.e. one person who provides all the required information for the household. However, in some instances, individual members are sought, for instance for the sexual history questionnaires, HIV surveillance and the verbal autopsy questionnaires.

The fieldworkers were people from the local community who had been trained to administer the questionnaires. They were all fluent in the local language Zulu, and had, at

a minimum, secondary school level education. They underwent an intensive training process to become fieldworkers, which included training in interviewing skills as well as training in all the questionnaires.

3.5.1 Measurement instruments

Various questionnaires were used in ACDIS for data collection. These questionnaires were developed, and piloted at the site before being used in the field. There are separate forms for registration of new members, and for updating the details and movements of old members since the last fieldworker visit. The information on the numbers of live births came from a Pregnancy Outcome Notification questionnaire, designed to prospectively collect data on the outcomes of pregnancies notified through the routine visits to households. Deaths were notified using a Death Notification Form (DTN). The questionnaires used in the verbal autopsies are discussed below (section 3.6).

3.5.2 Data handling

Data collected in ACDIS were double entered into a relational database, specifically developed for the site. The VA data were single entered into a separate database, which could then be linked via individual identifiers to the main database. There was a dedicated data capturer for the verbal autopsy team. Ongoing data cleaning of the VA and the main database had occurred.

3.6 Verbal autopsies

3.6.1 Notification of deaths

Deaths that occurred were reported through the routine visits, using a DTN. These forms were passed to the VA team who then planned a visit to the household.

3.6.2 The verbal autopsy questionnaire

The questionnaires used were developed based on preliminary work done in the local health services and tools that had been used elsewhere. There were three sections to the questionnaire: an open narrative section in which the informant was asked to relate in their own words the course of the illness, a checklist of signs and symptoms, and a section with age specific questionnaires enquiring in detail about specific signs and symptoms. Within this section there were specific questionnaires for neonatal deaths, deaths in children aged >28 days to 5 years, deaths in those older than 5 years to adulthood, and deaths due to injuries or tetanus.

3.6.3 The interviewer

As the history required was mostly a medical history, professional nurses were used as interviewers. The nurses were trained on the use of the questionnaire and in bereavement counselling. Periodic refresher training was carried out. The interviewers were fluent in Zulu, the local language, in which the interviews were conducted.

3.6.4 The informant

The ideal informant was someone who witnessed the course of the illness that resulted in the death, and who was able and willing to recall and report this coherently at the time of the interview. In the case of a child death, this was most often the mother. In most cases, the informant of choice was found at the homestead at which the deceased was resident at the time of death. Before the interview began, the interviewer explained the reason for the interview and took verbal consent for the conduct of the interview. More than one informant might have been used if present, and if neither informant objected.

3.6.5 Recording of the interview

The interview was conducted in Zulu, translated and recorded by the interviewer on to the questionnaire.

3.6.6 The timing of the interview

Visits to the household were conducted a minimum of four months after the death event.

3.6.7 Deaths eligible for a VA interview and eligibility of informants

VA interviews were conducted for every death in resident or non-resident members of ACDIS, for which an appropriate informant for the interview could be found. An appropriate informant was defined as someone who had witnessed the course of the illness of the deceased and was willing and able to relate this information to the interviewer. Second hand information about the illnesses related to the death were considered insufficiently reliable. The VA nurse tried to find an informant for all deaths

in the surveillance area, and visited informants outside of the surveillance area if required.

3.6.8 Generating the cause of death

The questionnaires were analysed independently by two physicians who determined the underlying and contributory causes of death on the basis of the information in the questionnaire. A set of criteria was provided as a guide to the physicians but this was not prescriptive and physicians were asked to use their clinical judgement in determining the cause of death. The algorithm provided to the physicians as a guideline to making the diagnosis of AIDS was as follows:

> Presence of malnutrition + severe oral thrush + repeated chest infections in the last year OR tuberculosis (Essential features)
>
> AND chronic diarrhoea (>2 weeks) OR treatment for tuberculosis OR meningitis/encephalitis in the last year OR failure to thrive OR severe weight loss (Supportive features)

A complete list of the suggested algorithms is available in appendix A.

A diagnosis of tuberculosis was only made if the individual had been diagnosed with tuberculosis in the health services and was on treatment at the time of death. This was adopted as it is very difficult to differentiate between the signs and symptoms of AIDS and tuberculosis, and it was thought that this rule might reduce misclassification of deaths

due to tuberculosis.[10] However it may also result in an underestimation of the burden of disease due to tuberculosis.

If there was a discrepancy in the cause of death assigned, the two physicians discussed the case and attempted to reconcile their differences. If they were not able to reconcile, an 'undetermined/disagree' cause of death was assigned to that case. If there was inadequate information on which to make a diagnosis, an 'undetermined/insufficient information' cause of death was assigned.

Physicians were asked to assign an underlying cause of death to each case. This, according to the WHO ICD-10, is the illness or injury that initiated the series of events that led to the death. They could also assign an immediate cause of death and up to three associated causes of death. Only the underlying cause of death was used in this analysis, as immediate and associated causes were not available at the time of data extraction.

3.6.9 Categorising causes of death

Each assigned cause of death was then given an ICD-10 code. This was done by the verbal autopsy physician rather than the physicians assigning the cause of death. Causes of death were further grouped into categories, according to the modified Burden of Disease cause of death list that was used in the South African National Burden of Disease study. The groups are as follows:

[10] The use of this convention is not standard in sites that use verbal autopsies and it has not been validated at this site either in adults or children.

Group I: the pretransitional causes include communicable diseases, maternal causes, perinatal causes and nutritional causes of death,

Group II: the non-communicable causes

Group III: injuries

HIV/AIDS: is part of group I but was considered separately because of the burden it contributes (Bradshaw *et al.*, 2003a).

Within each group are several categories of causes of death such as tuberculosis, malaria or malignant neoplasms. In the SANBD study, deaths with an ill-defined cause were redistributed proportionally by age and sex to other causes of death within the category. This was not done in this study and the undefined cases are presented as a separate group.

3.6.10 Methods to ensure validity

There is ongoing training of the fieldworkers on all aspects of the field visits and interviews. There are supervised visits, and a proportion of all visits to households are redone as a quality control measure. There is a tracking unit that visits the households that are difficult to find and even follows them up by visiting in nearby towns of Richards Bay and Durban, and even as far as Johannesburg.

In addition, the ACDIS data specifically minimizes under-reporting of deaths of individuals who move prior to death by including both resident and non-resident individuals in the all-cause and cause-specific mortality estimates. The ability of ACDIS to observe the survival status of non-resident household members over time is facilitated

through the close social connections they maintain with resident household members, and frequent return visits to the surveillance area (Hosegood *et al.*, 2004a).

The accurate recording of pregnancies and their outcomes was very difficult. The prospective follow up of pregnancies may underreport pregnancies and their outcomes for a number of reasons, including that it is not culturally acceptable to report a pregnancy, the proxy informant may not be aware that the woman is pregnant especially if the woman is not a resident member, the timing of the visit to the household, or the outcome of the pregnancy may not be reported if there was a miscarriage, abortion or neonatal death.

Within the verbal autopsies, there were a series of measures used to ensure quality. The questionnaires were first checked by the senior verbal autopsy nurse for mistakes and for missing data. They were then checked by the verbal autopsy physician, who determined if there was sufficient information on the questionnaire on which to assign a diagnosis. If there was not sufficient information questionnaires were sent back to the field for a re-interview or the nurse was asked to find another informant.

A validation study of the questionnaire was attempted for child deaths that had occurred at hospital, comparing the diagnoses generated by the VA method with hospital diagnoses as the reference standard. However, there were an insufficient number of the records of child deaths available at the hospital against which to compare. Only a comparison of the adult questionnaires could be made which comprised 109 deaths. This

showed that sensitivity, specificity and positive predictive value were 80%, 82% and 85% respectively for diagnoses of AIDS related adult deaths (Hosegood *et al.*, 2004b).

3.7 Data Analysis

As already stated, all deaths occurring in ACDIS between 01 January 2000 and 31 December 2002, to children who were less than 15 years at the time of death, were included in this analysis.

The observation period in this analysis was calculated as the number of days an individual was followed up as a member of a household in the surveillance area. Follow-up time began at the start of membership of a household, which would have occurred at the start of the study, birth or in-migration into the area. Follow-up time ended at the end of the study period, or at the end of membership of a household in the study area, which would have occurred at death or out-migration from the area. For a description of the methods of follow up of individuals, see section 3.5.

The following standard age categories were used in the analysis and were defined *a priori*: neonatal period from birth to 28 days, post-neonatal period from 29 days to 1 year, 1 to 4 years, 5 to 9 years and 10 to 14 years. In addition, where appropriate, age groups were combined for analysis into an under 1 year infant group, and an under-5 year age group. Each child contributed observation time to the relevant age category, as they got older.

Categorical data were compared between groups using chi-squared tests in univariate analyses. Numbers of observations were greater than 5 and thus did not warrant the use of Fishers exact tests. Overall and cause specific mortality rates, stratified by age at death, were calculated using Poisson regression methods. Mortality rates were calculated by dividing the number of deaths by the person-time of observation. Mortality ratios were also calculated with live births as a denominator for comparison with other published data. Data were analysed using Stata 7 (Stata Corporation, Texas, USA). *P*-values of less than 0.05 were accepted as significant.

3.8 Ethics and permissions

The Research Ethics Committee of the Nelson R Mandela School of Medicine, University of KwaZulu-Natal, approved this study. (Ref E150/04)

Ethical approval for the verbal autopsy component of ACDIS was included in the ethical approval for ACDIS, submitted as the following protocol: A socio-demographic platform for population-based reproductive health research in a rural health district of KwaZulu-Natal. GC Solarsh, Paediatrics, AJ Herbst, Africa Centre. (Ref E009/00)

Permission to use the ACDIS data was obtained from the Population Studies Group of the Africa Centre for Health and Population Studies, University of KwaZulu-Natal.

Chapter 4: Results

4.1 Introduction

Results are presented on the analysis of mortality rates and causes in children under the age of 15 years between 1 January 2000 and 31 December 2002, from a demographic surveillance site in a rural area of northern KwaZulu-Natal.

Within the cohort there were records on 46 722 individuals under the age of 15 years and a total of 112 711 person years of follow up. There were 792 deaths in children, of which 48% (378) were in girls and 52% (414) in boys. There were 87 neonatal deaths, 55% of which were in boys. Most neonatal deaths (82%) occurred in the first week of life. The neonatal deaths accounted for 13% of the 686 deaths of children under 5 years. Infant deaths accounted for 61% of deaths in children under the age of 5 years and 53% of deaths in the under 15 group. Deaths in children under the age of 5 years accounted for 87% of all deaths, and 53% of these deaths were in boys.

4.2 Mortality rates

Over the three-year period neonatal, infant and under-5 age specific mortality rates (95% CI) per 1000 child-years were, respectively, 183.2 (148.5, 226.0), 67.5 (61.3, 74.2), and 21.1 (19.5, 22.7) (Table 6). Mortality rates were lower in girls than in boys in all age groups. For the year 2002, mortality rate ratios (95% CI) in the under-1 and under-5 age groups were 1.4 (1.0, 2.1) and 1.3 (1.0, 1.7) respectively (Table 7). However there was no significant difference overall in the under-1, under-5 or under-15 groups. Mortality rates were also examined by age group for each year of the study (data not shown). The

numbers in each age group were small and there were no significant differences by year. Tests for trend in the mortality rates over the three-year period were not significant for both the under-1 ($p=0.6$) and under-5 mortality age groups ($p=0.1$).

Table 6: Mortality rates (95% CI) per 1000 person-years by age group and sex in ACDIS, 2000 - 2002

	Girls			Boys			Overall		
Age Group	**Deaths**	**PYO***	**Mortality rates**	**Deaths**	**PYO**	**Mortality rates**	**Deaths**	**PYO**	**Mortality rates**
Neonatal	39	2 320	168.1 (122.8, 230.0)	48	2 429	197.6 (148.9, 262.2)	87	4 749	183.2 (148.5, 226.0)
Post-neonatal	159	2 835	56.4 (48.3, 65.9)	173	2 916	59.3 (51.1, 68.8)	332	5 752	57.9 (52.0, 64.5)
1-4 years	126	13 218	9.5 (7.9, 11.3)	140	13 086	10.7 (9.1, 12.6)	266	26 303	10.1 (8.9, 11.4)
5-9 years	41	17 244	2.4 (1.8, 3.2)	37	17 290	2.1 (1.6, 3.0)	78	34 535	2.3 (1.8, 2.8)
10-14 years	13	17 571	0.7 (0.4, 1.3)	16	17 483	0.9 (0.6, 1.5)	29	35 055	0.8 (0.6, 1.2)
All ages combined	378	56 485	6.7 (6.1, 7.4)	414	56 226	7.4 (6.7, 8.1)	792	11 271	7.0 (6.6, 7.5)
Under-1	198	3 067	64.9 (56.5, 74.6)	221	3 160	69.9 (61.3, 79.8)	419	6 227	67.5 (61.3, 74.2)
Under-5	324	16 284	19.9 (17.8, 22.1)	361	16 246	22.2 (20.0, 24.6)	685	32 530	21.1 (19.5, 22.7)

*Person years of observation

Table 7: Under-1 and under-5 mortality rates per 1000 person years, and rate ratios (95%CI) for girls and boys in ACDIS by year, 2000 – 2002

		Mortality rates per 1000 person years		Rate ratio
		Girls	Boys	
2000	Under-1	73.4	65.5	0.9 (0.7, 1.2)
	Under-5	19.5	19.9	1.0 (0.8, 1.3)
2001	Under-1	66.7	67.8	1.0 (0.7, 1.4)
	Under-5	21.2	21.5	1.0 (0.8, 1.3)
2002	Under-1	53.5	77.0	1.4 (1.0, 2.1)*
	Under-5	19.0	25.5	1.3 (1.0, 1.7)#
2000-2002	Under-1	64.9	69.9	1.1 (0.9, 1.3)
	Under-5	19.9	22.2	1.1 (1.0, 1.3)

*p=0.04

#p=0.03

Using the number of live births per year as the denominator (Table 8), the overall neonatal mortality ratio was 12.3 deaths per 1000 live births; infant mortality ratio was 59.3 deaths per 1000 live births per year, while the under-5 mortality ratio was 97.0 deaths per 1000 live births per year. The number of live births decreased by 14% over the three-year period.

Table 8: Neonatal, infant and under-5 mortality ratios (number of deaths) per 1000 live births in ACDIS, 2000 - 2002

	2000	2001	2002	2000-2002
Number of live births	2532	2358	2173	7063
Neonatal mortality rate[1] (Deaths)	11.1 (28)	8.9 (21)	17.5 (38)	12.3 (87)
Post-neonatal mortality rate[2] (Deaths)	48.6 (123)	50.0 (118)	41.9 (91)	47.0 (332)
Infant mortality rate[3] (Deaths)	59.6 (151)	58.9 (139)	59.4 (129)	59.3 (419)
Under-5 mortality rate[4] (Deaths)	86.9 (220)	98.0 (231)	107.7 (234)	97.0 (685)

[1] Deaths between 0 and 28 days of age per 1000 live births

[2] Deaths between 29 and 365 days per 1000 live births

[3] Deaths under 1 year of age per 1000 live births

[4] Deaths under 5 years of age per 1000 live births

4.3 Attributed causes of death (Table 9)

Overall, for all children under the age of 15 years, HIV/AIDS was the most common attributed cause of death (39.1%), and LRTI was the second most commonly attributed cause of death, constituting together over 60% of all deaths.

Table 9: Attributed causes of death for all children under 15 years, ACDIS 2000 to 2002

Attributed cause of death	Deaths	Percent
HIV/AIDS	310	39.1
LRTI	174	22.0
Birth asphyxia and trauma	34	4.3
Undefined	34	4.3
Diarrhoeal diseases	30	3.8
Protein-energy malnutrition	30	3.8
Low birth weight	25	3.2
Road traffic accidents	21	2.7
Meningitis	20	2.5
Congenital anomalies	18	2.3
Other unintentional injuries	17	2.2
Septicaemia	16	2.0
Other infectious and parasitic	15	1.9
Drownings	9	1.1
Malignancies	8	1.0
Tuberculosis	7	0.9
Other perinatal conditions	6	0.8
Epilepsy	5	0.6
Digestive diseases	3	0.4
Respiratory diseases	3	0.4
Genitourinary diseases	2	0.3
Homicide and violence	2	0.3
Cardiovascular diseases	1	0.1
Cot death	1	0.1
Other neoplasms	1	0.1
Total	792	100

The breakdown of causes of death by age group is presented in Table 10. Birth asphyxia (35.6%) and low birth weight and prematurity (26.4%) were recorded as the leading causes of death in the neonatal period. Most of these deaths occurred in the early neonatal period, with 44% occurring on the day of birth. LRTI and other infectious causes contributed a further 22% of deaths.

In the post-neonatal period (29 days to 1 year) LRTI was recorded as the most common cause of death (43.1%), and HIV/AIDS was assigned as cause of death in 34.0% of cases. HIV/AIDS remained the commonest assigned cause of death in the 1 to 4 year age group (60.9%). LRTI, diarrhoea and malnutrition contributed a further 6% of deaths each.

As was expected, injury related deaths became more common in the 5 to 9 year and 10 to 14 year age groups, although HIV/AIDS remained the most common attributed cause of death. Road traffic accidents and drowning were the most commonly attributed causes of accidental deaths. Seventy-six percent (16/21) of the deceased in road traffic accidents were pedestrians, majority of these were in the 5-9 year age group.

Table 10: Causes of death by age group, ACDIS 2000 - 2002

0 to 28 days	Deaths	29 days to 1 yr	Deaths	1-4 years	Deaths	5-9 years	Deaths	10-14 years	Deaths
Birth asphyxia and trauma	31 (36%)	LRTI	143 (43%)	HIV/AIDS	162 (61%)	HIV/AIDS	26 (33%)	HIV/AIDS	5 (17%)
Low birth weight	23 (26%)	HIV/AIDS	113 (34%)	Diarrhoeal diseases	17 (6%)	Road traffic accidents	11 (14%)	Malignancies	4 (14%)
LRTI	12 (14%)	Diarrhoeal diseases	12 (4%)	LRTI	16 (6%)	Meningitis	6 (8%)	Other infectious and parasitic	4 (14%)
Other perinatal conditions	6 (7%)	Septicaemia	12 (4%)	Protein-energy malnutrition	16 (6%)	Drownings	5 (6%)	Road traffic accidents	4 (14%)
HIV/AIDS	4 (5%)	Undetermined	12 (4%)	Undetermined	14 (5%)	Epilepsy	4 (5%)	Meningitis	3 (10%)
Undetermined	4 (5%)	Protein-energy malnutrition	9 (3%)	Congenital anomalies	8 (3%)	Undetermined	4 (5%)	Drownings	2 (7%)
Congenital anomalies	3 (3%)	Congenital anomalies	6 (2%)	Other unintentional injuries	7 (3%)	Other infectious and parasitic	4 (5%)	Tuberculosis	2 (7%)
Other infectious and parasitic	2 (2%)	Meningitis	6 (2%)	Meningitis	5 (2%)	Other unintentional injuries	4 (5%)	Cardiovascular diseases	1 (3%)
Protein-energy malnutrition	1 (1%)	Other unintentional injuries	6 (2%)	Road traffic accidents	5 (2%)	Protein-energy malnutrition	4 (5%)	Diarrhoeal diseases	1 (3%)
Septicaemia	1 (1%)	Tuberculosis	3 (1%)	Malignancies	3 (1%)	LRTI	3 (4%)	Epilepsy	1 (3%)
		Birth asphyxia and trauma	2(1%)	Other infectious and parasitic	3 (1%)	Digestive diseases	2 (3%)	Other neoplasms	1 (3%)
		Low birth weight	2 (1%)	Homicide and violence	2 (0.8%)	Congenital anomalies	1 (1%)	Respiratory diseases	1 (3%)
		Other infectious and parasitic	2 (1%)	Septicaemia	2 (0.8%)	Genitourinary diseases	1 (1%)		
		Cot death	1 (0.3%)	Tuberculosis	2 (0.8%)	Malignancies	1 (1%)		
		Drownings	1(0.3%)	Birth asphyxia and trauma	1 (0.4%)	Respiratory diseases	1 (1%)		
		Genitourinary diseases	1(0.3%)	Digestive diseases	1 (0.4%)	Septicaemia	1 (1%)		
		Road traffic accidents	1(0.3%)	Drownings	1 (0.4%)				
				Respiratory diseases	1 (0.4%)				
Total	87 (100%)	Total	332 (100%)	Total	266 (100%)	Total	78 (100%)	Total	29 (100%)

4.3.1 HIV/AIDS as a cause of death (Table 11)

Mortality rates due to HIV/AIDS varied significantly between age groups. In the postneonatal age group, HIV/AIDS was attributed to 19.8 (95% CI: 16.5, 23.8) deaths per 1000 child-years, the highest rate in any age group. The lowest mortality rate of 0.1 (95% CI: 0.06, 0.3) deaths per 1000 child years of observation was in the 10-14 year age group. For all children under the age of 5 years, HIV/AIDS was attributed to 8.6 (95% CI: 7.6, 9.6) deaths per 1000 years of observation. There was no significant increase in mortality due to HIV/AIDS in under-fives over the 3 year period. In the 1-4 year age group mortality increased from 5 (95% CI: 4, 6) deaths per 1000 person years in 2000 to 7 (95% CI: 6, 9) deaths per 1000 person years in 2002 but this was not statistically significant (p=0.05). Mortality HIV/AIDS was attributed to 39.1% of deaths overall, and 40.7% in the under 5 years age group.

Table 11: Mortality rates (95%CI) due to HIV/AIDS by person-years observation in ACDIS, 2000 - 2002

Age Group	Deaths	PYO*	Mortality rate
Neonatal	4	475	8.4 (3.2, 22.4)
Postneonatal	114	5 752	19.8 (16.5, 23.8)
1-4 years	161	26 303	6.1 (5.2, 7.1)
5-9 years	26	34 535	0.8 (0.5, 1.1)
10-14 years	5	35 055	0.1 (0.06, 0.3)
Under 5	279	32 530	8.6 (7.6, 9.6)
Under 15	310	102 120	3.0 (2.7, 3.4)

* Person years of observation

4.3.2 LRTI (Table 12)

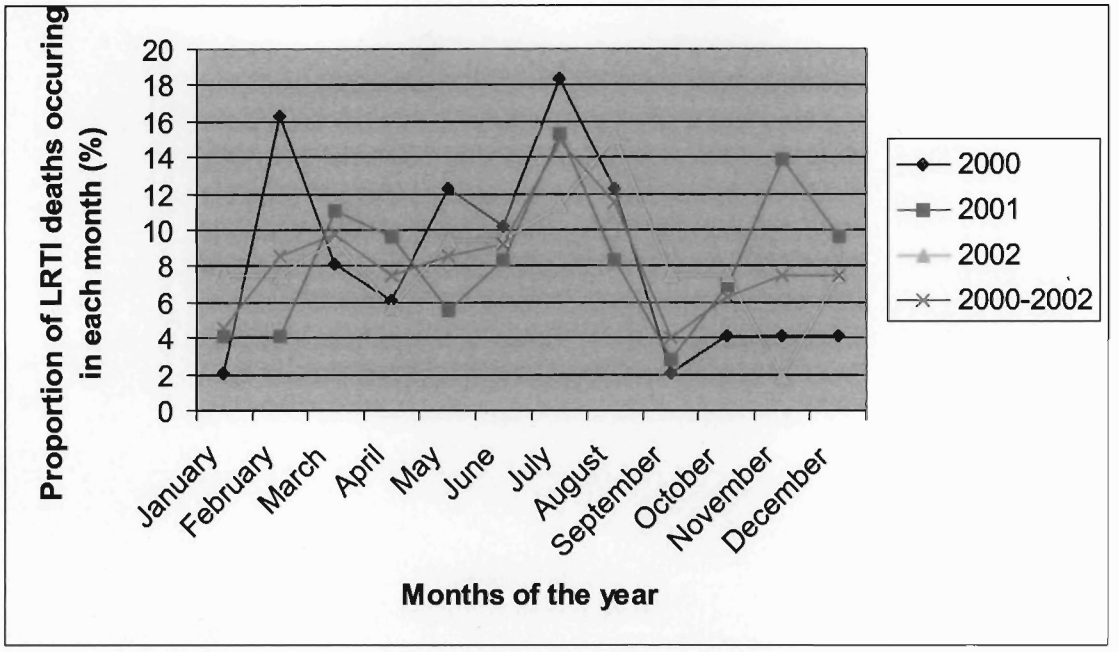
This was the second most commonly attributed cause of death overall and the most common in the postneonatal age group. Mortality rates (95% CI) attributed to LRTI were 24.9 (21.3, 29.1) deaths per 1000 child years of observation in the under-1 age group, 4.9 (4.0, 6.1) deaths per 1000 child years for children under 5 years of age, and 1.7 (1.5, 2.0) deaths per 1000 child years of observation for children under 15 years. There were no deaths due to LRTI in the 10-14 year age group. In each year the highest number of LRTI attributed deaths occurred in the months of July or August, the winter months (Figure 6). For the 3 years combined the largest proportion of LRTI deaths occurred in the month of July.

Table 12: Mortality rates (95%CI) due to LRTI by person years of observation and age group, ACDIS 2000-2002

Age Group	Deaths	PYO*	Mortality rate
Neonatal	12	4 749	25.3 (14.3, 44.5)
Postneonatal	143	5 752	24.9 (21.1, 29.3)
1-4 years	16	26 303	0.6 (0.4, 1.0)
5-9 years	3	345 345	0.1 (0.03, 0.3)
Under 1	155	6 227	24.9 (21.3, 29.1)
Under 5	171	3 253	5.3 (4.5, 6.1)
Under 15	174	102 120	1.7 (1.5, 2.0)

* Person years of observation

Figure 6: Proportion of LRTI deaths occurring in each month by year, 2000-2002



4.3.3 Diarrhoea

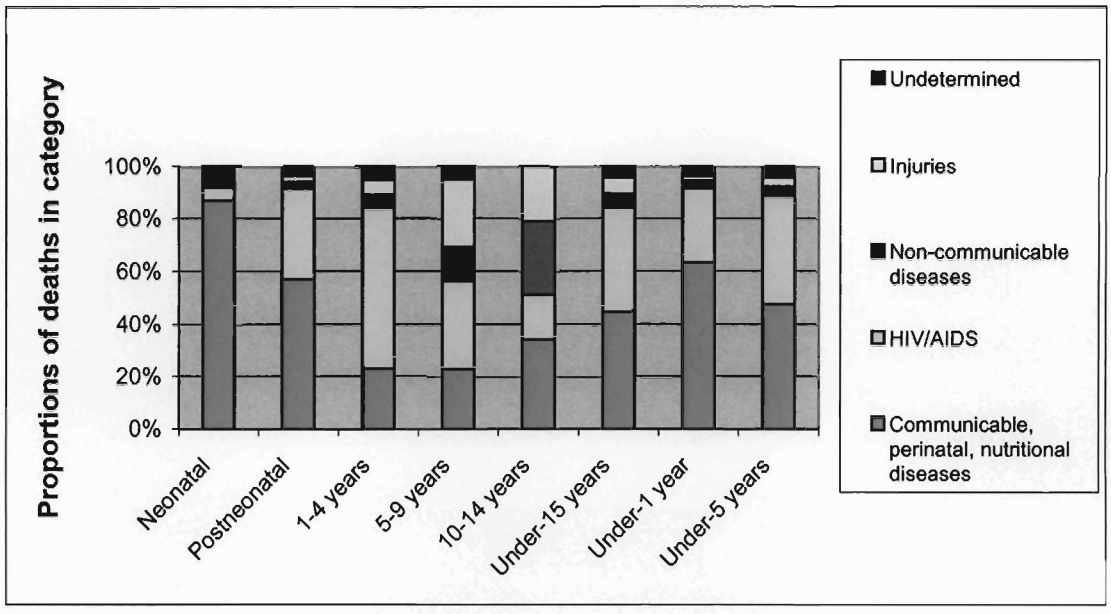
Overall diarrhoea was only attributed to 4% of deaths, 6% in the 1-4 year age group. The highest mortality rate due to diarrhoea was in the post neonatal age group with a rate of 2.1 (1.2, 3.7) deaths per 1000 child years. In the under-1 and under-5 age groups, mortality rates due to diarrhoea were 1.9 (1.1, 3.4) and 0.9 (0.6, 1.3) deaths per 1000 years of observation respectively.

4.3.4 Burden of disease groups of causes of death (Figure 7)

Using the burden of disease classification, for all ages combined the majority of deaths fell into the pre-transitional group of the communicable, perinatal and nutritional causes of death (45.1%, 357/792). Five percent (42/792) of deaths were attributed to non-communicable diseases and 6.2% (49/792) to injuries. In 4.3% (34/792) of cases an

undetermined cause of death was assigned. As was expected the proportions of deaths due to non-communicable diseases and injury groups were highest in the 5-9 and 10-14 year age groups.

Figure 7: Proportions of deaths in Burden of Disease categories of causes of death



4.4 Delivery setting

These data were only collected prospectively, i.e. for births that occurred after 2000 and were registered at birth as members of ACDIS. In table 13 are presented the results of the available data on location of birth. Majority of these children were delivered in hospitals (48.3%) rather than clinics (24.7%). Altogether, 73% of those births were delivered in a setting where they would have been attended by medical personnel i.e. a hospital, clinic or general practitioners office; 11% of births occurred outside of a health facility.

Mortality rates were calculated for births that were attended and unattended by medical personnel for children under the age of one year, and children under the age of 5 years. In the under-1 age group, 88% (369/419) of the deaths occurred in children who had been born between 2000 and 2002. However the data on the delivery setting was missing for 37% of these children. There was a lower mortality rate in children whose deliveries occurred in health facilities [46.4 (40.2, 53.6) deaths per 1000 child years] than children who did not deliver in health facilities [72.3 (53.6, 97.5) deaths per 1000 child years]. Children on whom the data were missing or unknown, had the highest mortality rates of 143.7 (123.5, 167.3) deaths per 1000 child years. This difference was significant ($p<0.0001$). The same pattern was seen in children under the age of 5 years.

Table 13: Location of birth for all births registered in ACDIS, 2000 – 2002

Location of birth	**Proportion of all births (%)**
Hospital	48.3
Clinic	24.7
Home	10.7
General practitioner	0.4
Other	0.3
School	0.1
Missing	15.5
Total	100.0

4.5 Death setting

These data were available on 89% (708/793) of the deaths. Overall the majority of deaths occurred at home (44.2%), with the hospital being the second most common place of death (28.5%). Few deaths occurred at clinics (3.2%). These proportions however did differ by age group as seen in Table 14. In the early neonatal period, i.e. the first 7 days of life, most deaths (53.5%) occurred in hospital. The proportion of deaths occurring in hospital gradually decreases with increasing age until reaching a low of 17.9% in the 5-9 year age group. The proportion of deaths occurring at home increases after the neonatal period to the older age groups where approximately half of deaths occur at home. In the 9-14 age group however, this appears to be reversed with more deaths occurring in hospital than at home. The category of 'other' includes all other settings and would include for example deaths on the roads, at work or in bodies of water.

Table 14: Proportions of deaths occurring in each setting by age group for all deaths in ACDIS, 2000 – 2002

Proportion of deaths occurring in each setting	**Age group**						
	0-7days	**8-28days**	**Post-neonatal**	**1-4years**	**5-9years**	**9-14years**	**Total**
Hospital	53.5	37.5	24.4	28.9	17.9	34.5	28.5
Home	19.7	43.8	47	48.5	47.4	24.1	44.2
Clinic	4.2	6.3	3.6	2.6	2.6	0	3.2
Missing	11.3	6.3	12.9	9.4	5.1	13.8	10.6
Other	11.3	6.3	12.3	10.5	26.9	27.6	13.5

4.6 Proportion of cases reported to the local authorities.

Information on whether or not a death certificate was acquired for the deceased was available in 203 (26%) deaths. As this question was introduced partway through the time period under study, the data were not available for all the deaths. In 74% (142/203) of these deaths a death certificate was reported to have been issued. This varied from 75% (18/24) amongst neonates to 68% (53/78) in the 1 to 4 year age group to 87% (13/15) amongst 10 to 14 year olds. In 11% (23/203) of deaths, no death certificate was reported to be issued and in 15% (30/203) of deaths the informant had not known whether or not a certificate had been issued. In those deaths where it was reported that a certificate had been issued, 29% (43/150) could show the interviewer the certificate.

For the year 2002 alone, 57% of the data were available. The proportions of respondents reporting that a death certificate was issued was 77%, 10% had not had a death certificate issued and 13% were not sure if a death certificate was issued.

Chapter 5: Discussion

5.1 Introduction

This observational cohort study was conducted in a rural South African population in Kwa-Zulu Natal. The study was conducted in an open cohort of approximately 46, 722 children under the age of 15 years, under surveillance between 2000 and 2002. This dissertation provides an example of directly measured child mortality rates and cause-specific patterns from a poor rural community with very high HIV prevalence.

Information is critical for the management of child survival programmes, to monitor the impact of interventions and progress towards national and international goals. The lack of readily available health information from developing countries remains a serious problem. This study contributes empirical data, in an area where there is little available, which can be used by policy makers.

5.2 Child mortality rates

The population under study here is a predominantly rural African population. Mortality rates were expected to be higher than the national estimates reflecting continued inequities in health between different areas, in addition to a high HIV burden. The study showed high child mortality, with an under-5 mortality rate of 21.1 deaths per 1000 child-years of observation. The person time denominator is not often available for the calculation of mortality rates and there are few references against which to compare this result. Using live births as denominator, the under 5 mortality ratio was 97.1 deaths per 1000 live births. This estimate is lower than the KZN provincial estimate generated in the

SANBD study of 116 deaths per 1000 live births. Reasons for the difference could include the different study designs employed, or the ACDIS site may have a lower mortality rate due to the research studies ongoing in the population. The infant mortality ratio was 59.6 deaths per 1000 live births and the infant mortality rate was 67.9 deaths per 1000 child years of observation, higher than the estimates of recent studies from South Africa.

The neonatal mortality ratio in this population is low at 12.6 deaths per 1000 live births. This could be a reflection of the high rate of utilisation of services for maternal health in the population, however it could also be that some neonatal deaths have been missed, resulting in a selection bias. If pregnancies have not been notified to the visiting fieldworkers and a neonatal death occurs before the next visit of the fieldworker, that pregnancy and death may not be reported at all.

Mortality was approximately 10% higher in boys than girls overall, but the difference was only significant in 2002. The differences between boys and girls might be due to a higher death rate in young boys in the neonatal period, which has been well documented. As discussed, power was low for stratified analyses. We did not have power to break the analysis down further into age and sex categories.

There were no significant changes in mortality rates between the three years of the study. This might be due to the small study size. The study did not have the power to stratify analyses by year and examine differences in mortality by year and this is indicated by the

wide confidence intervals of the year-specific mortality rates. They suggest that there might have been real differences between the years, which could have been picked up with a larger sample size.

5.2.1 Changes in mortality rates in rural South Africa

Population based surveillance studies like the one used in this study, allow follow up of a cohort of children to determine mortality rates more accurately. This is vitally important to monitor given the possible effects of the HIV epidemic, as well as recently introduced interventions against the epidemic. The DHS reported an under-5 mortality ratio of 59 deaths per year per 1000 live births for the 5-year period prior to 1998, much lower than that reported in our study (Department of Health *et al.*, 2002). Bradshaw et al reported an under 5-year mortality ratio of 95 deaths per 1000 live births in 2000, similar to that reported in our study (Bradshaw *et al.*, 2003a). While it is possible that mortality rates have been increasing rapidly due to the effect of the HIV/AIDS epidemic, the reliability of the findings from these two studies is unclear as they used indirect techniques and modelling to estimate their mortality rates. Comparison with the results of this study is difficult. Continued monitoring of the mortality rates is necessary to determine their trend.

5.2.2 Comparison of mortality rates with other countries

A comparison of our mortality rates with those in other countries that have low HIV prevalence, could give an indication of the effects of HIV in South Africa, although such comparisons are difficult because of the inherent differences between countries in the

availability, utilisation and quality of health services, the differences in cause specific mortality profiles between countries, and differences in socio-economic factors. Our rates are lower than those reported from other parts of Southern Africa, like in Botswana (refer table 1). This might be because the HIV/AIDS epidemic is older and HIV prevalence higher in those countries than in South Africa, or for some of the reasons mentioned above.

5.2.3 Generalisability of findings

A key consideration is whether these results can be extrapolated to other rural areas in the province and the country, or to other developing countries. Broadly speaking our study area had several important features differentiating it from other settings. Firstly, our study population comprised mostly a poor rural community, with a periurban township on the border. It is probably reflective of other rural areas in the province and the country. However, these results may not generalise to urban areas where mortality rates may be lower because of higher income, better education and awareness of health risks, better quality of health care or other reasons. Secondly, utilisation of health services is high in this setting (Case *et al.*, 2005). Most women attend antenatal care, deliver within health settings and children receive immunisation (Wilkinson *et al.*, 1997). This is probably similar across South Africa. In other countries in sub-Saharan Africa, only about a third of women will deliver with a skilled attendant present where as in this study over 73% of women delivered with a skilled attendant (Knippenberg *et al.*, 2005). When good access to health care is provided such as in research settings, mortality can reduce substantially.

Thirdly, this site had a particularly high HIV prevalence, which may be similar in other South and Southern African sites, but not the case in other sites.

Other rural sites in South Africa will probably have similar health system features as this setting, and may have similar HIV prevalence, making the results of the study relevant to them. Not many other rural areas have data on HIV prevalence, which prevents any direct comparisons. As the study site was a surveillance site that has had several research studies operating in it, this may have impacted on child health indicators by altering access to health services, and as a result the mortality rates at this site might be lower than at other rural sites in the province.

Our study size was relatively modest, as is indicated by the wide confidence intervals on some analyses (for example the rate ratios of death of boys to girls), and was conducted over a relatively short time-span of three years. Thus, caution needs to be exercised when interpreting the findings, which need to be confirmed in other, ideally larger, studies. Alternatively validation of the data needs to occur to assist in its interpretation.

5.3 Cause-specific mortality

The majority of deaths in children in developing countries are from preventable causes. Diarrhoea and pneumonia remain among the most common causes of deaths in children under the age of 5 years in sub-Saharan Africa, while the proportions of deaths due to malaria, AIDS and neonatal disorders varies significantly between countries in the region (Black RE *et al.*, 2003).

5.3.1 HIV/AIDS as a cause of death

The HIV mortality rate in children under the age of 15 years was 3.0 (95% CI: 2.7, 3.4) deaths per 1000 child years of observation, and the under-5 year mortality rate was 8.6 (95% CI: 7.6, 9.6) deaths per 1000 child years of observation. HIV/AIDS was assigned as the cause of death in 40.7% of deaths in children under the age of 5 years. This is consistent with the results of the SANBD study (Bradshaw *et al.*, 2003a). In this study, undefined causes of death were not redistributed to other causes within the cause of death list as in the SANBD study; this may underestimate the proportions of deaths due to particular causes.

There was no difference in mortality rates due to HIV over the three years. This could be due to the study size, there being insufficient number of events to pick up the differences between the years. It is also possible that childhood mortality from HIV has peaked and that the rates have stabilised. A longer follow-up of this population or a larger sample size will be needed to ascertain this.

As discussed, KZN province and the study site have very high HIV prevalence amongst pregnant women in the area. The proportion of deaths due to HIV/AIDS is therefore not surprising, as this is the main determinant of the impact of the epidemic on child mortality. With the commencement of the PMTCT programme in 2001, the number of deaths due to HIV/AIDS in children should reduce in the coming years, although this study did not have the power to detect this. Continued monitoring of the infant and under-5 mortality rates at the population level would provide an indication of the effectiveness

of the programme. These rates should decrease with increased coverage of the programme; however this may be confounded by the quality of the PMTCT services if these are found to be poor.

The use of the VA method to determine HIV deaths deserves further discussion, and will also be addressed in section 5.6 on bias. Although criteria for making diagnoses were suggested to the physicians, they were asked to use their clinical judgement in making diagnoses. Deaths due to HIV/AIDS may have similar signs and symptoms as deaths due to malnutrition or tuberculosis, and could easily be misclassified. Some children may have shown no signs of HIV disease at all and succumbed to an opportunistic infection like a *pneumocystis carinii* pneumonia that may have been misclassified as a LRTI.

HIV may also have an impact on the prevalence of other illnesses, for instance it may increase the incidence of other infectious diseases in uninfected people, and therefore result in a higher burden of disease. Without a validation study of the VA it is difficult to estimate the true burden of HIV related deaths in this population. The consistency with the results of the SANBD study in terms of the proportion of deaths due to HIV is supportive of the findings of this study.

5.3.2 Lower respiratory tract infections as a cause of death

Lower respiratory infections were found to be a common cause or contributory factor in childhood deaths in this study, and were attributed as a cause of death in 22.0% of deaths in children under the age of fifteen years, 24.9% in under fives. This is probably an

underestimate of the burden of LRTI, as LRTI would be a contributory cause of death in some of the deaths assigned to HIV. Our data suggest that there is need for targeted interventions to improve the management of LRTIs in South Africa.

5.3.3 Diarrhoea

Diarrhoea as a cause of death amongst children has been declining at the global level over the last three decades (Parashar UD *et al.*, 2003). Diarrhoea was an attributed cause in 4.2% of deaths in study children under 5 years. The SANBD study found that for 2000, diarrhoea accounted for 10% of deaths amongst children under the age of 5 years, and was the third highest cause of death in this age group after HIV and low birth weight (Bradshaw *et al.*, 2003a). As multiple causes of death were not included in this analysis, the true burden of diarrhoea is not reflected in the results. If diarrhoea and LRTI were both present at the time of death, but the physician estimated that LRTI was the underlying cause of death, the presence of diarrhoea at the time of death will not be reflected. Our estimation of the burden of diarrhoeal disease was also influenced by misclassification through the VA method, as the presence of diarrhoea was included as an essential feature in the suggested criteria for the diagnosis of AIDS deaths.

5.3.4 Malnutrition

Malnutrition was estimated to cause 3.8% of deaths in children under the age of 5 years. This is almost certainly an underestimate of the impact of malnutrition on mortality. Many children who had signs of malnutrition may have been attributed an HIV/AIDS cause of death. Again malnutrition was an essential feature in the suggested algorithm for

the diagnosis of an AIDS death, and this may have contributed to misclassification. As has been discussed in the literature review, malnutrition is an important contributory factor to mortality, and had contributory causes of death been included in this analysis, this would have been more accurately reflected.

5.3.5 Neonatal causes of death

Deaths in the neonatal period form a significant proportion of deaths in children under the age of 5 years. Despite the majority of women delivering within health facilities, birth asphyxia and birth trauma were the most common attributed causes of death in neonates. It is not possible from VA to determine which deaths were due to intra-uterine events and which could be attributed to poor health service delivery. This could be a reflection of the quality of the services provided in the health facilities, as these causes of death often result from poorly managed labour and delivery or lack of access to obstetric services (World Health Organisation, 2005). As access to services and quality of health care delivery improves, deaths due to birth asphyxia should decrease, however they will not disappear altogether as some intrauterine events will still occur.

Infectious causes of death were attributed to 23% of all neonatal deaths. Due to the high level of antenatal care coverage and immunisation of women and children against tetanus, this is not seen as a cause of death in this study but is a significant cause of mortality in newborns in other developing countries. The signs and symptoms in the deaths of very young children are particularly hard to interpret on interview, and it can be

very difficult to differentiate between infectious causes of death by VA. These results must therefore be interpreted with caution.

5.3.6 Causes of death in the older child and early adolescent

The early adolescent period is often neglected in analyses of child mortality levels and causes. In our study, we observed 107 deaths in the age-group 5 – 14 years. Twenty-nine percent of these were deaths attributed to HIV/AIDS and 14% to road traffic accidents. There is a gap in identifying and addressing the health issues of children who survive the early childhood health challenges. While the numbers of deaths are small in the 5-14 age group, the causes of death are largely preventable and, having survived the high mortality period of early childhood, these children would have had a greater likelihood of surviving to adulthood.

5.4 Delivery settings

Our study also showed that 12% of babies were delivered in the community and 73% of deliveries were at a health facility, with 15% of the data missing. Of children born at health facilities, twice as many were delivered in hospitals than in clinics. In the area there were 6 fixed clinics, one of which was a community health centre that operated 24 hours a day (the rest were open from 08h00 to 16h30). While obstetric services were available at all the clinics, most of the clinic-based deliveries occured at the community health centre. The other clinics did not have after hour's services. One of the clinics was not open for part of the period of this study, as there was faction fighting in the area. The high delivery rate in hospitals could be due to women either not demanding this service at

clinics for reasons of accessibility, due to the service not being available at the clinics, or choice i.e. they were bypassing the clinics to attend the hospital preferentially. This needs to be investigated to ensure that services at clinics are adequately utilised and additional pressure taken off the hospital services.

5.5 Reporting of child deaths in the routine systems

In South Africa, as in many other settings, there is underreporting of child deaths to health authorities. In our study, in only 26% of the deaths that were included in this analysis, were data available on whether or not the death had been reported, as data collection for this began part way through the study. Of this data, 74% of respondents reported that a death certificate had been issued. This is encouraging, as is the high rate of registering of neonatal deaths (75% of deaths where the information was available), as these are more likely to be underreported to the authorities. It will be necessary to repeat this analysis with a larger dataset and to monitor this over time to have a better idea of the true level of reporting of deaths to the authorities. These are important data as they could provide a reference on which to calibrate national data on the numbers of child deaths reported.

5.6 Sources of bias

5.6.1 Selection bias

Households in the study area were visited repeatedly to ascertain survival of its members. The ACDIS data specifically minimizes under-reporting of deaths of individuals who move prior to death by including both resident and non-resident individuals in the

mortality estimates. The ability to observe the survival status of non-resident household members is facilitated through the close social connections maintained with household informants, and their frequent return visits to the DSA (Hosegood *et al.*, 2004b). Deaths in the early neonatal period may have been missed, especially in the household members that were not resident in the area. Missed deaths will have lead to an underestimate of the rates of death, although the extent of this bias is impossible to ascertain.

The number of recorded live births in ACDIS decreased from 2532 in 2000 to 2173 in 2002; a 14% decrease in the number of births over the three-year period. This has an impact on the calculation of the infant mortality and child mortality rates. Potential explanations are that live births are not being adequately recorded in ACDIS, either as they are not being reported or not recorded by the field staff. It could also be as a result of decreasing fertility due to the availability of contraceptives or the effect of the HIV epidemic.

By visiting households regularly, and maintaining links with the community, the research study may have influenced health-seeking behaviour in the community. It has been documented that communities where research is conducted can have better health outcomes than other settings. Demographic surveillance sites are well researched and may not be representative of the rest of the population. While this study did not provide any intervention or health messages, other ongoing studies in the area may have influenced health-seeking behaviour. We believe that this bias, which will have led to a reduction in the mortality rates, is likely to be small.

5.6.2 Information bias

5.6.2.1 Bias from the verbal autopsy method

The limitations of this methodology have been discussed extensively in the literature. If the deceased or the family of the deceased moved before the visit to the household, reliable information may not have been obtained about the course of illness of the deceased and this could influence the validity of the cause –specific mortality data. In the case of child deaths, usually the best informant would be the mother of the child. Data on the type of informant were not available, so the extent of this bias could not be estimated.

In areas where both malaria and LRTI are prevalent, the sensitivity and specificity of VA to correctly identify cause of death (as compared against hospital diagnoses) has been shown to be very low (Anker et al., 1999, Kahn et al., 2000, Snow et al., 1992). In a study conducted in Kenya, the sensitivity and specificity against hospital diagnoses were, respectively, 28% and 91% for acute respiratory infections and 46% and 89% for malaria, suggesting that large proportions of causes of deaths are misclassified (Snow *et al.*, 1992). While there is no malaria in the study area the signs and symptoms of AIDS deaths are also common in deaths due to tuberculosis and malnutrition and could result in similar misclassification.

The sensitivity and specificity of VA varies with the algorithms used, study design, cultural setting, mix of diseases in the population, and cause of death. VA is a tool that works best for causes of death that have easily distinguishable sets of signs and symptoms. This is not the case for HIV. Signs and symptoms of HIV illnesses are easily

confused with other chronic illnesses like tuberculosis, which is also very prevalent in South Africa or chronic malnutrition.

There is little information on the validity of VA to distinguish HIV deaths in children or of the use of verbal autopsies in high HIV prevalence areas (Dowell SF *et al.*, 1993). Dowell et al (1993) used the verbal autopsy method to ascertain cause of death in children born to HIV-seronegative and HIV-seropositive mothers. The study showed low sensitivity, specificity and predictive value for identifying deaths in children associated with maternal HIV infection. However some of this was due to the fact that two-thirds of children born to the HIV-infected mothers would not have been HIV infected and this would have biased the results of the study.

Knowing the sensitivity and specificity of the instrument against a reference diagnosis would allow more accurate estimation of the cause specific mortality fractions, although this will not eliminate all misclassification error (Maude and Ross, 1997, Jaffar et al., 2003). The lack of a validation study for the use of the VA method in deaths of children at this site is a limitation of the study. Furthermore, the analysis only used a single cause of death for each case. In children, more than one disease is often present at the time of death and deciding on the primary cause of death can be difficult. The use of multiple causes of death can help give a better estimate of the true burden of specific causes of death and reduce misclassification error (Anker, 1997).

The VA interviews were conducted a minimum of four months after the death, in an effort to reduce discomfort to the family. However, the longer the time between the death and the interview, the greater the recall bias. Data on the time of the interview relative to the time of death were not available for this analysis.

In this application of the verbal autopsy method, specific rules were used to try and reduce misclassification error. Deaths were only attributed to tuberculosis if the deceased was on treatment at the time of death. This was because the signs and symptoms of HIV and tuberculosis disease overlap. However, this will underestimate the burden of disease due to tuberculosis as some may not have been adequately treated, or may have had drug resistant infections. Diagnosis of tuberculosis infection is also more difficult to make in HIV positive individuals are they are more likely to have pauci-bacilliary disease.

As there is a lack of standardised diagnostic criteria and tools in VA, it is difficult to compare the findings of this study with other community-based studies to determine cause of death profiles in other settings. Because of the limitations discussed above, the data on cause-specific mortality need to be interpreted with caution. We do not know how accurately the causes of deaths have been estimated. At best, these data give an indication of broad trends and provide a baseline against which changes in cause-specific mortality can be assessed in the future. As much of sub-Saharan Africa is without routine systems to monitor cause specific mortality patterns, it is important to further develop tools like VA that can be used to determine cause of death where such information is not

available. These tools need to be properly validated and correctly applied in the situations in which they are used to ensure the correct interpretation and adjustment of the data.

5.7 Public health response to these findings

According to Moseley and Chen, *"child mortality should be studied as a chronic disease process with multifactorial origins than as an acute, single-cause phenomenon"* (Moseley and Chen, 1984). A comprehensive strategy to address rising child mortality levels needs to address both the proximal and the distal determinants of infant and child mortality (Romani and Anderson, 2002). Ensuring adequate water provision, sanitation, housing and education are as essential as health promotion activities, providing immunisation and appropriate curative care.

In this study, HIV/AIDS was the major cause of mortality in children. In a region with such high HIV prevalence, there is unlikely to be substantial improvements in mortality rates unless the epidemic is controlled (Ahmad *et al.*, 2000). The rising child mortality rates will be moderated by the introduction of interventions against the epidemic. Key interventions needed include behavioural programmes to reduce the spread of the disease to young women, the PMTCT programme and the ARV drug treatment programme. The PMTCT programme in the area began in 2001 and the study did not have the power to detect any effects of this programme. The ARV rollout began during 2004. These programmes should reduce child mortality due to HIV/AIDS, and shift the mortality patterns such that HIV mortality will be deferred in children on treatment. The continued

monitoring of mortality rates will allow the detection of the population level impact of these programmes.

It is also argued that from the global perspective, HIV/AIDS causes a relatively small proportion of child deaths and the large resource allocation to HIV/AIDS programmes disadvantages those programmes addressing other important causes of death (Jones *et al.*, 2003). In South Africa, the addition of the comprehensive programme for the care of HIV infected individuals on an already burdened health system has raised concerns that other health care interventions may suffer as a result of the resource diversion. Using the resources given to deliver interventions against HIV/AIDS to strengthen health systems and increase access to all interventions will make a greater difference to the achievement of child health goals (Walker *et al.*, 2002).

5.7.1 The South African Primary Health Care norms and standards

The South African Department of Health has outlined an integrated package of essential primary health care services that has to be made available to the entire population of South Africa. This is outlined in the document Primary Health Care norms and standards, and provides guidance to the district and provincial health services on what services they have to provide, and to the public on the quality of care that they can expect to receive (Department of Health., 2000). This package of care includes most of the interventions that were discussed earlier, to reduce child mortality. Increased attention needs to be given to improving the coverage and quality of these interventions to larger proportions of mothers and children in an effective manner, as the evidence suggests that this should

reduce child mortality (Jones *et al.*, 2003). The most appropriate delivery strategies to deliver these interventions or to increase coverage has to be found, taking into account local epidemiological profiles, health system capacities and community preferences. Despite many interventions globally to address inequities in child health in the past, these still exist between rich and poor. Child health programmes need to be targeted towards the poor, as evidence has shown that they are not the ones to benefit first from these interventions (Victora *et al.*, 2003).

In the longer term, the sustainability of these programmes and sustained reductions in child mortality requires strengthening of the national health system at all levels, as health systems and the health care that they provide are responsible for some part of the child mortality burden (World Health Organisation, 2005).

Chapter 6: Conclusions and Recommendations

Levels of child mortality in South Africa are increasing and much of this has been attributed to the impact of the HIV epidemic. The data from this study gives evidence of levels and causes of child deaths, and addresses a gap in available data on child health in rural South Africa. The study found high levels of child mortality and highlights HIV/AIDS as a priority condition.

The availability of reliable data is essential for the prioritisation of health programmes, the planning and monitoring of health interventions that are responsive to local needs, and the appropriate use of limited health resources. While routine information systems are accepted as the best method of providing this information on an ongoing basis, there continue to be problems with these systems, and they need to be strengthened. Studies like this one need to continue to provide ongoing information that can be used by as an evidence base by policy makers to inform their decision-making and priority setting. Further analyses with larger numbers of events accrued over a longer period of time will provide better estimations of mortality rates and can be used to monitor trends in child mortality. This is essential in order to monitor the impact of the HIV/AIDS epidemic, to monitor the population level impact of interventions like the PMTCT programme, and to monitor progress towards national and international goals in child health.

The introduction, since 1994, of other social programmes focussed on improving sanitation and water supplies, improving access to medical care for mothers and children, education and social grants should also have an impact on existing common causes of

child deaths such as malnutrition, diarrhoea and lower respiratory infections. Continued monitoring of child mortality levels will give a population level measure of the impact of these initiatives.

There are few studies that are using verbal autopsies in South Africa. This is a tool that could be useful for the monitoring of cause specific patterns and means of developing it as a tool needs to be explored. A validation study of the instruments and field procedures in ACDIS needs to be conducted, not only to assess the usefulness of the tool in a high HIV prevalence setting but also to assess the level of misclassification in these results to aid in their interpretation.

Our study suggests that HIV/AIDS is the now leading cause of death in children under the age of 15 in rural South Africa. Interventions that address the HIV epidemic are crucial. While it can be argued that the diversion of resources to HIV is not justified globally, in an area where 40% of child deaths are due to HIV, this is most certainly a priority and the resource allocation is justified. This is an example of how these data can be useful in setting appropriate health policies.

There is little data from the developing world on the natural history of HIV infection in children, and it would now be inappropriate to conduct observational cohort studies to observe this. Other ways have to be found to explain exactly how and to what extent HIV impacts on child mortality, especially with the introduction of prevention and treatment programmes.

The literature shows a strong relationship between maternal health status and child survival, suggesting that keeping mothers alive will contribute to decreasing child mortality rates (Newell *et al.*, 2004b). In a high HIV prevalence area such as the KwaZulu Natal province, improving the coverage of the programme for the prevention of mother to child transmission of HIV is essential, as is improving the quality and uptake of the service.

The provision of antiretroviral therapy is also important, both to infected children as well as to infected women. Providing antiretroviral therapy for mothers will contribute to the survival of their children both by prevention the transmission of HIV to their children and by keeping the mothers healthier and alive for longer, thus decreasing mortality risk for both HIV infected and uninfected children. Providing therapy to children may defer some of the mortality to a later stage, and will probably also alter the cause specific mortality profile of the population.

Targeted interventions against specific illnesses are also required. For instance, deaths from LRTI were high in this setting and seasonal patterns in the numbers of deaths could be seen. Targeted interventions to improve the management of lower respiratory infections are needed. On the basis of evidence from other studies in Africa, improving the management of lower respiratory infections could have an impact on overall child mortality that is greater than the cause specific mortality fraction. Improved clinical management of illnesses in children at all levels of health facilities is required. In the study area the implementation of IMCI was incomplete. Strengthening the IMCI training

of staff, and the implementation of the health system and community components will improve the quality of care provided and educate the community about presenting to the health services appropriately.

The strategies to address child mortality are not limited to the delivery of health services and collaboration with other sectors to address improved delivery of water, sanitation and other basic services is required. The alleviation of poverty could impact on child mortality levels in a number of ways, not least by addressing the contribution that malnutrition makes to child mortality levels. Linking the services provided by the Department of Health with those provided for instance by the Department of Social Welfare, that will facilitate children accessing other basic services like grant support is required.

In order to address the high child mortality levels in the country, there needs to be political commitment and recognition of child mortality as a priority area for the Department of Health. Policy decisions addressing child health issues will lead to resource flows to support those policies and thereby improved service delivery. There is a need to transfer the available knowledge on interventions that will improve child survival into programmes that will reach the population that needs them, in an equitable way (Jones *et al.*, 2003). The South African Department of Health has a series of comprehensive policies on the services that should be available at its health facilities and through its health staff. However, we have some data on how policies like the primary health care package are being implemented, on the coverage of the interventions, whether

or not appropriately trained and equipped staff are available at the service delivery points to deliver the interventions. A better understanding of the barriers to service provision will help design more effective delivery strategies that take local factors into account (World Health Organisation, 2005).

Health has been firmly entrenched in the South Africa constitution as a human right. While South Africa is making progress on many fronts with respect to child health, levels of child mortality in the country are high, and will continue to rise as the HIV epidemic progresses unless interventions can be delivered at high levels of coverage in an equitable and locally appropriate way.

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Appendix A

Algorithms for common diagnoses in deaths in children under the age of 15 years

Neonates (<29 days)

Stillbirth: the child failed to cry, breath or move after birth

Low birth weight/prematurity: pregnancy ended early or pregnancy ended at < 28 weeks or < 7 months or the child was very small at birth (E)

Malformation: a malformation was present at birth (E)

Birth asphyxia/birth trauma: no fever (hot body) + not able to cry in a normal way after birth + not very small at birth + no prematurity (E) and convulsions/spasms or nor able to breath in a normal way after birth or not able to suck in a normal way after birth or bruises, marks or injury on body or head after birth (S)

Neonatal tetanus: able to suck or cry at birth but stopped doing so at least 2 days after birth + convulsions/spasms during 2 weeks prior to death (E) and/or mother no proof of tetanus vaccination of index pregnancy or born at home or birth assistant not trained (A)

Meningitis/encephalitis: fever + bulging fontanelle + convulsions (E)

Lower respiratory tract infection: (fever + difficult or fast breathing) or (fever + chest indrawing) or (local term for pneumonia) (E) and/or crackling in the chest (A)

Diarrhoea/dysentery: frequent loose or liquid stool or local term for diarrhoea

Bacteraemia/septicaemia: fever + became unresponsive/unconscious + absence of pneumonia or meningitis (E) and (stopped being able to suck) or (stopped being able to cry) or waters broke >1 day before labour (S) and/or (redness or drainage form umbilical cord or skin rash with bumps containing pus) (A)

Children > 28 days and less than 5 years

Malformation: a malformation was present at birth (E)

Malnutrition: local term for malnutrition or the child was very thin with loose skin or the child suffered from swelling of the body or parts of the body (E)

Diarrhoea/dysentery: frequent loose or liquid stool or local term for diarrhoea

Lower respiratory tract infection: (fever + difficult or fast breathing) or (fever + chest indrawing) or (local term for pneumonia) (E) and/or crackling in the chest (A)

Meningitis/encephalitis: fever + (bulging fontanelle or stiff neck) (E) and/or convulsions/spasms (A)

Cerebral malaria: fever + loss of consciousness + convulsions + no meningitis (E)

Bacteraemia/septicaemia: fever + no meningitis + no pneumonia + no malaria (E) and (stopped being able to respond to a voice or stopped being able to follow movements with his/her eyes) (S)

AIDS: malnutrition + severe oral thrush + (repeated chest infections in the last year or tuberculosis) (E) and (chronic diarrhoea (>2 weeks) or treatment for tuberculosis or meningitis/encephalitis in the last year or failure to thrive or severe weight loss) (S)

Epilepsy: known epileptic + dying during or shortly after an epileptic attack + no other infection at the time of death (E)

Tuberculosis: medically diagnosed with tuberculosis

Adults and children of 5 years and more

Pulmonary tuberculosis & AIDS: loss of weight + cough with sputum>21 days + repeated episodes of illnesses prior to death + no COPD (E) and (diarrhoea or

loose/liquid stool for > 21 days or severe mouth infections for >21 days or swollen glands) (S) and/or age < 65 or partner died recently or body rash or sores or became unconscious within 2 days of final illness (A)

Pulmonary tuberculosis: cough with sputum>21 days + fever on and off + no diarrhoea > 21 days nor no loose/liquid stool for >21 days and no COPD (E) and/or (bloody sputum or loss of weight) (A) or had treatment for PTB at time of death and no diarrhoea or no loose/liquid stool for >21 days (E)

AIDS: loss of weight + fever > 28 days + repeated episodes of illness prior to death (E) and (diarrhoea or loose/liquid stool for > 21 days or severe mouth infections for >21 days or swollen glands) (S) and/or age < 65 or partner died recently or body rash or sores or became unconscious within 2 days of final illness (A)

Breast cancer: severe weight loss + swelling or ulcer in the breast for > 30 days (E)

Cervix cancer: severe weight loss + abnormal vaginal bleeding for > 30 days (E)

Oesophagus cancer: severe weight loss + dysphagia for > 30 days starting with solids followed by dysphagia for liquids (E)

Gastro-intestinal cancer: severe weight loss + abdominal mass for > 30 days (E) and (blood in stool or vomiting blood or difficulty passing stool for > 30 days) (S)

Liver cancer: severe weight loss + mass in right side of the abdomen for > 30 days + sever abdominal pain for > 30 days + jaundice (E)

Acute abdominal condition: severe abdominal pain + rapid onset abdominal distension + vomiting + no diarrhoea (E) or Acute abdominal condition: abdominal pain + vomitus that looked black or like blood or faeces for < 14 days

Liver cirrhosis: slow onset abdominal distension > 14 days + absence of severe abdominal pain (E) and (swelling around the ankles or jaundice or vomiting of blood) (S) and/or previous alcohol abuse or loss of weight or slow onset unconsciousness before death (A)

Chronic obstructive pulmonary disease (COPD): cough with sputum for > 60 days + shortness of breath on and off + no weight loss + no swelling around ankles (E) and/or smoker or medically diagnosed with asthma or wheezing (A)

Congestive heart failure (CHF): slow onset of continuos shortness of breath + swelling around the ankles + no cough with sputum for > 21 days (E) and/or (medically diagnosed hypertension or swelling in the right upper abdomen or abdominal distension) (A) or Congestive heart failure (CHF): medically diagnosed hypertension + no cough with sputum for > 21 days (E) and (swelling of ankles or continuous shortness of breath) (S)

Cerebrovascular accident (CVA): sudden onset of unconsciousness + age > 45 years + absence of (high fever or pregnancy or delivery within 2 weeks or injuries) (E) and (paralysis of one side of the body or speech impairment after a period of unconsciousness) which appeared shortly before death (S) and/or medically diagnosed hypertension (A)

Ischaemic heart disease: sudden, severe and continuous chest pain over sternum + died within 1 week after start of the chest pain + absence of cough with sputum (E) and/or shortness of breath (A)

Acute diarrhoea: loose or liquid stool > 2 times/day lasting < 22 days (E) and (blood or mucus in stool or abdominal pain or vomiting) (A) acute febrile illness (AFI): severe or

continuous fever for < 21 days + absence of any other infectious illness diagnosed by the Vas (E)

Lower respiratory tract infection: AFI + cough with sputum < 21 days + absence of jaundice (E) and (chest pain or shortness of breath) (S)

Anaemia: very pale looking + absence of all other diseases diagnosed by Vas (E) and (swelling of the ankles or shortness of breath)

Meningitis: high fever for < 21 days + neck stiffness or severe neck pain + absence of repeated episodes of illnesses (E) and (became unconscious within 2 days of onset of disease or convulsions) (S)

Malaria: high fever for < 21 days + absence of repeated episodes of illnesses + no meningitis (E) and (became unconscious within 2 days of onset of disease or black urine) (S)

Diabetes: medically diagnosed diabetes (E) and (rapid onset of unconsciousness or gangrene of lower limbs) (S)

Epilepsy: known epileptic + dying during or shortly after an epileptic attack + no other infection at the time of death (E)