Provincial differentials in under-five mortality in South Africa

by

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Howard College Campus

Durban

February 2017

Declaration

Submitted in partial fulfilment of the requirements for the degree of Masters in Population Studies, in the Graduate Programme in the School of Built Environment and Development Studies, University of KwaZulu-Natal, Durban, South Africa.

I declare that this dissertation is my own unaided work. All citations, references and borrowed ideas have been duly acknowledged. It is being submitted for the degree of Masters in Population Studies in the Faculty of Humanities, Development and Social Science, University of KwaZulu-Natal, Durban, South Africa. None of the present work has been submitted previously for any degree or examination in any other University.

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Date

Abstract

Producing child mortality estimates at a provincial level is equally as important as producing estimates at a national level. This allows for a more equity focused and results-driven approach to tackling every area’s apparent need, which will allow previously disadvantaged groups are given greater priority when addressing reductions in child mortality. It is the overall aim of this research to derive estimates of child mortality for the provinces of South Africa using the 2016 Community Survey and to assess the results in relation to socioeconomic and socio-demographic determinants. The estimation of child mortality is achieved through the use of indirect methods in alignment with a life table of best fit.

The infant mortality rate (IMR) and the under-five mortality rate (U5MR) were estimated nationally at 55.1 and 76.1 per 1000 live births respectively. There are clear and significant provincial differentials amongst the observed levels of child mortality estimates suggesting largely that there are still pre-existing inequities, inequalities and internal challenges. The estimates obtained are reasonable, and those at national and provincial level are in agreement with results from other research.

In evaluating the differentials in child mortality with associated independent variables of interest, it is evident that child mortality is higher amongst females with a lower socioeconomic status (SES) and educational attainment. In addition, there are disparities between socio-demographic variables such as race and province of residence. These results are confirmed by multilevel regression models of child mortality.

The findings of this study may aid the government in implementing policies more effectively at provincial levels and enforce more focused decisions in the battle for the reduction of child mortality in South Africa.

Acknowledgements

To my supervisor, Ms. Nompumelelo Nzimande, I would like to express my sincere gratitude for giving me the academic support to complete this dissertation. Thank you for your invaluable guidance, time, advice and patience. This would have never been possible without you.

To my mother, Bernie Rademeyer, and my sister, Fazeeda Pieters, thank you for the support you have given me in your own special way. You have inspired and encouraged me to always pursue my goals.

To Jose Dunn, you are my support and encouragement and I am grateful for the motivation, love and care that you have constantly given me throughout this journey.

To Priya Konan, thank you for your unquantifiable support and everlasting care that you always expressed towards me.

Thank you to the National Research Foundation (NRF) for the financial assistance towards the completion of my degree, as well as Mr Len Anderson, for your unfailing financial support.

Above all, I thank God for accompanying me through this journey for nothing would have been possible.

It is to you that I dedicate this dissertation.

Acronyms

AIDS	Acquired Immune Deficiency Syndrome
CEB	Children ever born
CD	Children dead
CS	Children surviving
CI	Confidence Interval
CMR	Crude mortality rate
CS	Community Survey
HAART	Highly Active Antiretroviral Treatment
HIV	Human Immunodeficiency Virus
HSRC	Human Sciences Research Council
IGME	United Nations Inter-agency Group for Child Mortality Estimation
IMR	Infant mortality rate
MDG	Millennium Development Goal
PCA	Principal Component Analysis
PMTCT	Prevention of Mother to Child Transmission
SDG	Sustainable Development Goal
SES	Socioeconomic Status
StatsSA	Statistics South Africa
U5MR	Under-five mortality rate
UNDP	United Nations Development Programme
UNICEF	United Nations International Children's Emergency Fund
WHO	World Health Organisation

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CHAPTER ONE

INTRODUCTION

1.1 Background

Renewing the promise of survival for children relies on tracking, monitoring levels and addressing the leading determinants of death. According to the latest estimates produced by the World Health Organization (WHO) it was evident that 5.9 million deaths amongst children under five that occurred in 2015 and approximately half were caused by infectious diseases and conditions (You et al., 2015). Disparities and inequalities surrounding child health and child mortality is a growing concern for the international public health community. Leaders of nations signed various declarations, effective and strategic healthcare policies were mandated, and child survival was prioritised to ensure that child mortality will be reduced to a noteworthy level (WHO, 1978), however globally levels remain unacceptable. Reducing child mortality to improve the health of children globally was one of the eight Millennium Development Goals (MDGs) (UNDP, 2010) and is now integrated into the Sustainable Development Goals (SDGs) (You et al., 2015).

Given the knowledge that Sub-Saharan Africa has substantially higher child mortality estimates than the rest of the world, it is not surprising that almost half of all under-five deaths are attributable to mal-nutrition. Equally, the majority of neonatal deaths occur among new-born infants of low birth weight within countries that suffer from the highest burden of child mortality (You et al., 2015). In Africa, developing appropriate policies and strategies is constrained by a lack of reliable child mortality data and statistics, particularly in the least developed countries that evidently has the highest levels of child mortality (Garrib et al., 2006). According to Garrib et al (2006) less than 10% of Africa is covered by death registration systems. The absence of complete vital registration within South Africa entails that national child mortality estimates have to be estimated using census and survey data. This can be accomplished through the utilisation of indirect and direct techniques. Census and surveys contain questions about the total numbers of births and total numbers of surviving children are used to produce indirect estimates (Darikwa, 2009) and direct estimation is derived mainly from birth history data obtained from the Demographic and Health Surveys as well as reported deaths. Independent groups have developed mortality trends and estimates for the country however, these estimates vary significantly. Therefore, through indirect estimation, adjustment of the number of deaths for underreporting can be used to estimate child mortality rates and child mortality trends over time in countries where there is incomplete vital registration (Hill and David, 1988) such as South Africa.

According the United Nations, there has been a distinctive decline in child mortality within South Africa from 61 deaths per 1000 live births in 1990 to 45 deaths per 1000 live births in 2012 (IGME, 2013). Although the decline is significantly noticeable, the performance and progress of the country in reducing child mortality is relatively low compared to many other countries' performance. The world has made substantial progress in reducing the under-five mortality rate by 47 per cent in the period 1990-2012. South Africa has attained a reduction of approximately 26 per cent, which is why MDG 4, of rates of 18 and 20 per 1000 live births for infant and under-five mortality rates respectively was unachievable by 2015 (Statistics South Africa, 2013). Although HIV/AIDS is usually quoted as the main reason for this low performance, the role of socioeconomic determinants should not be ignored, especially since there was a significant decline in HIV related deaths after the commencement of initiatives such as the Prevention of mother to child transmission (PMTCT) (Dorrington, Johnson, Bradshaw et al.. 2006; Nannan, Dorrington, Laubscher et al., 2012; Kerber, Lawnb, Johnson et al., 2013). It has been reported that the health of infants and children in South Africa is largely influenced by social and economic conditions under which they live and approximately 66 per cent of children in the country live in poverty (Coovadia et al., 2009).

Despite the fact that there have been substantial improvements in the registration of child deaths during 1997–2007, reaching levels of 90% completeness for infants and 60% for children aged 1–4 years, South Africa cannot use vital statistics to measure child mortality without adjusting for it (Nannan et al., 2012). Monitoring child mortality rates poses a challenge for low- and middle-income countries. It should be highlighted that vital registration is often incomplete, with many deaths, particularly amongst the poorest rural families, not being recorded (Nannan et al., 2012). To achieve the overall goal of reductions in child mortality, health planners and international agencies are advocating that more resources be allocated to health sector, while health researchers are concentrating efforts at identifying cost-effective strategies to realise this goal. These two pathways combined will pave the way for exceptional progress. In challenging economic positions, which have adversely affected the nations earning and spending ability, it is very important to identify and rank factors that affect child mortality for effective health interventions, effective public health strategies and cost-effective outcomes. This will assist in prioritising the factors that needs to be addressed with urgency in order to combat child mortality (Nannan et al., 2012).

This research aims to explore national levels and provincial differentials of child mortality within South Africa; and observe how the levels of child mortality varies between provinces due to varying factors and determinants that are the driving force behind the observed levels of infant and child mortality (Mosley and Chen, 1984).

1.2 Justification for the study

Child mortality rates within South Africa have been found to be much higher in certain geographical areas and amongst the previously disadvantaged social and population groups. South Africa was recognised as a global leader in the conceptualisation and development of the primary health care approach however, substantial achievements were then disjointed and were of limited impact because of hostile state interventions and inadequate policy interventions prior to and throughout the apartheid era. Despite structural reform and genuine commitment to achieving healthcare targets, a series of obstacles continue to limit the full implementation of primary health care currently. This is inclusive of health worker shortages and inequities in resource distribution; shortcomings of political, public sector and medical-health leadership; and a complex and protracted health transition. A major investment towards primary health care must go beyond addressing these persisting challenges, and more broadly incorporate innovative health system designs and experimental work at scale, in order to reorient the over-bureaucratised and often rigid primary care system that is underscoring the reduction of child mortality provincially (Kautzky and Tollman, 2008).

Many studies in different countries have indicated that the geographic distribution of health problems and their relationship to potential risk factors can be invaluable for cost effective intervention planning. Addressing inequalities in health status and access to health care services within countries is as important as addressing these issues among and between countries, and in order to work towards further reductions of child mortality within South Africa it is essential that efforts be focused more on lower, provincial, administrative levels as opposed to concentrating only on the level of mortality at national level (Freedman, Waldman, Pinho et al., 2005). It is commendable to state that concerted efforts are being made by the government and several non-governmental organizations to reduce child mortality however most of the efforts are focused on implementing AIDS treatment programmes, as well as HIV/AIDS awareness campaigns. It is therefore, important to widen the scope and depth of studies on child health and survival in the country, especially from a provincial perspective and in addition be considerate of other influential determinants such as socioeconomic status. Aside from biological factors that are important determinants of child mortality, socioeconomic and demographic factors may also significantly contribute to high and unequal levels of child mortality. Most child deaths are caused by diseases that are readily preventable or treatable through cost effective interventions. Cost-effective action can be taken immediately to save children's lives by expanding effective preventive and curative interventions (You et al., 2015). According to South Africa Every Death Counts Writing Group (2008) audit is powerful especially if the data analysed and produced can mobilize action in the forms of interventions and programs and tracking the levels and trends through demographic analysis of child mortality is central to saving the lives of many children. Examination of data is a useful method, but the outcome should lead to mortality reduction. Continued monitoring of the infant and under-5 mortality rates at the population level will provide an indication of the effectiveness of existing programs as these rates should decrease with increased coverage of the proposed programs (Garrib et al., 2006). The study will therefore focus on national and provincial estimates of child mortality as well as the socioeconomic causes of child mortality.

1.3 Importance of the study

Accurate and timely estimates of child mortality at lower geographical units are very important for a country in order to evaluate the effectiveness of intervention programmes as well as for policy planning. In addition, studying this in relation to socioeconomic and demographic factors will assist with more streamlined and effective decisions.

Investing in the health and wellbeing of the children of South Africa is an investment for the future development of the country. South Africa still has a relatively large youthful population with a third of the population under 15 years of age and the health of the children should essentially be a priority (Bradshaw et al., 2003). Many monumental achievements have been obtained during the early era of democracy in South Africa, however many inconsistencies remain. These inconsistencies entail that at least 260 women, babies, and children die every day in South Africa (South Africa Every Death Counts Writing Group, 2008). This toll is too high for a country such as South Africa that holds status of a middle-income country and with a large capacity to provide public services (South Africa Every Death Counts Writing Group, 2008). Significant improvement in the death reporting within the country has occurred, however the proportion of child deaths reported is uncertain (Garrib et al., 2006). It is apparent though that there has been a significant rise in recent levels resultant of HIV/AIDS contributing to noticeable increases of the under-five mortality rates (U5MRs). However, uncertainty remains against understanding the extent to which improved death registration has contributed to the apparent increase in the number of child deaths or other factors that have dictated the varying levels (Nannan et al., 2012). While it is evident that some provinces in post-apartheid South Africa have prospered both socially and economically, there is notable variance between the provinces. Therefore, an empirical study on the impact of socioeconomic determinants on child survival will be important for policy-makers and relevant government bodies as it will indicate inequalities in socio-economic conditions and access to health care services. Among the varying explanations that the study seeks to explore, it will also indicate the level of access to healthcare in the provinces as explained by the place of residence (per urban and rural differentials) and therefore existing health policies could thus be improved upon. From the academic perspective, the results obtained will add to existing literature on levels of child mortality within South Africa as well as the socioeconomic challenges and determinants of child mortality.

1.4 Aims and objectives of the research

This work aims to examine socioeconomic determinants and how these various determinants influence the level and rate of child mortality overall, using women of reproductive ages by the provinces of South Africa as the study population.

The primary aim of this research is to estimate child mortality rates for South Africa using the 2016 South African Community Survey and to study the provincial differentials in relation to various socioeconomic determinants.

The study aims to achieve four specific objectives. First, it attempts to estimate levels of under-five mortality in South Africa. Secondly, to investigate the provincial differences in under-five mortality within South Africa. Thirdly to investigate the factors associated with the provincial differences in under-five mortality in South Africa in addition to other variables of association and lastly to describe methodological challenges in the estimation of under-five mortality

From this, four main research questions are derived at:

1. What are the observed levels of under-five mortality in South Africa?
2. What are the provincial differences of under-five mortality in South Africa?
3. What are factors associated with the provincial differentials in under-five mortality in South Africa in addition to other variables of association?
4. What are the methodological issues to be considered when analysing data on under-five mortality?

1.5 Statements of hypothesis

The hypothesis is that there are significant provincial variations of child mortality associated with demographic and socioeconomic differentials in the country, hence deriving estimates at lower administrative levels helps to achieve faster and greater reduction of child mortality within the country.

1.6 Dissertation structure

The study is divided into 5 chapters. Chapter 1 provides an introduction to the study by providing background, importance and justification for the study. The significance of the study is further demonstrated through the aims and objectives that are presented for the study. Chapter 2 reviews the literature relevant to this research. A combination of empirical and theoretical evidences of child mortality worldwide is reviewed in relation to available data and statistics as well as the relevant analytical framework. Recent estimates and trends in South Africa's child mortality are reviewed and scrutiny is also projected towards the determinants of child mortality. Chapter 3 is indicative of the study population, the variables that will be manipulated for the analysis as well as the methods and models applied to achieve the objectives of this research. Descriptions of how statistical tools will be utilised to examine the relationship between variables will also be discussed in this chapter. Chapter 4 presents the detailed results, the analysis of those results as well as elaborates and deliberates on the results obtained and produced. Chapter 5 provides a platform for discussion, the major conclusions that can be inferred from the research, limitations of the research and the scope for future research.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter reviews the existing literature on child mortality. It considers the empirical estimates of child mortality at global, national and provincial levels as well as the underlying determinants of child mortality. This review is comprised of various interlinking sections. The first section provides an understanding of child mortality by defining child mortality as well as highlighting the importance of tracking child mortality and the obstacles curtailing child mortality. Subsequent to this a global overview of child mortality is described and contextual and empirical evidences of child mortality within Africa are provided. The preceding section pays more scrutiny towards child mortality in South Africa. Child mortality levels are examined in the South African context from an empirical, national and provincial perspective. This section also highlights the main determinants of child mortality within South Africa as well as the HIV endemic. The last section explores the Mosley and Chen analytical framework and further informs the key determinants of child mortality as per theoretical evidences. This is reflected by demographic and socio-economic variables as well as studies based on the determinants affecting child mortality are reviewed. The review is concluded by highlighting key future prospects in attempts to curtail child mortality.

2.2 Understanding child mortality

Estimates developed by the UN Inter-agency Group for Child Mortality Estimation (IGME, 2015) reveals that child survival remains an urgent concern as approximately 16 000 children continually die daily. This estimation is equivalent to 11 deaths occurring every minute. Without any further acceleration to the current pace of reduction in under-five mortality, a projected 69 million children will die before they reach their fifth birthday between 2016 and 2030 (You et al., 2015). A staggering 4.4 million of children younger than five lose their lives in 2030 alone (Lui et al., 2015). These numbers are still unacceptably high and a consolidated effort is needed to further accelerate the pace of progress, therefore the world must invest further to end preventable child deaths.

2.2.1 Defining child mortality

Child mortality, more commonly known as child death, refers to the death of infants and children under the age of 5 years old, depending on definition. Child mortality age groups are categorised by neonatal (0–27 days), comprising of early neonatal (0–6 days) and late neonatal (7–27 days); post-neonatal (1–11 months); and children (1–4 years) (Nannan et al., 2012). The first 28 days of life is the most vulnerable time for a child's survival and this period is significantly important because a large portion of the under-five child death occurs during the neonatal period. Also, health interventions needed to address the major causes of neonatal deaths generally differ from those needed to address under-five deaths. Additionally, it is also closely linked to those pathways that are necessary to protect maternal health (You et al, 2015). For health programmes and interventions the key distinction is between outlining new-borns (younger than 1 month) in the neonatal period, and babies and children aged 1–59 months. Demographically, the key age groups are infants (0–11 months) measured by the infant mortality rate (IMR) and children (1–4 years) measured by the child mortality rate (CMR), both expressed as values per 1000 live births. Both age groups are inclusive of and measured by the Under-5 Mortality Rate (U5MR) (Nannan et al., 2012). Under-five mortality rate is defined as the probability, expressed as a rate per 1 000 live births, of a child born in a specified year dying before reaching the age of five years (United Nations, 2003; UNDP, 2010).

2.2.2 The importance of tracking child mortality

Child mortality is considered to be one of the key measures of a country's health system, and rates of child mortality of an area have long been believed to be important indicators of health status and socioeconomic development (Kabir, Islam, Ahmed et al., 2001; IGME 2013). This is because children in particular are highly sensitive to various changes that affect the health of the entire population, such as disease epidemics and economic development, as well as other changes that affect general living conditions, such as social well-being and the quality of the environment (Reidpath and Allotey, 2003). Biologically, children have much weaker immune systems than adults and are therefore far more vulnerable to environmental or social complications and ills (Caldwell, 1996). In addition, they are unable to care for themselves and are become completely dependent on others. As a result, children are generally the first group and most strongly affected by standards of living. Therefore, any notable improvements and advances in health or social conditions are often first observed in improvements in child mortality (Omran, 1971).The United Nations (2003) has noted that under-five mortality reflects the social, economic and environmental conditions, including healthcare, in which children and others in society live (UNDP, 2010) and this single measure of child mortality is sufficient as a broad socioeconomic or health status indicator of a country (Hill, 1991). Therefore, measures of child mortality are necessary for making population projections and information on trends, both national and disaggregated, is used to evaluate the impact of existing interventions (Hill, 1991).

Reducing child mortality has been identified as one of the eight Millennium Development Goals (MDGs) (United Nations, 2000). MDG 4 was aimed at reducing child mortality, measurable by the infant and under-5 mortality rates, by 2015 to at least two-thirds of the rate that it was recorded in 1990. These indicators are not only an index of the health status of children, they are an important component of life expectancy, and provides an indication of the overall health and development status of the country (Nannan et al., 2012). With the end of the MDG era, the international community agreed on a new framework – the Sustainable Development Goals (SDGs). The proposed SDG target for child mortality represents a renewed commitment to the world's children that stated by 2030, preventable deaths of new-borns and children under five years of age are to end. All countries are to aim to reduce neonatal mortality to as low as 12 deaths per 1 000 live births and under-five mortality to at least as low as 25 deaths per 1 000 live births (You et al, 2015). In order to continue to accelerate progress, it is critical to ensure that every pregnant woman and every new-born has access to and receives good quality care and life-saving interventions. The vast majority of maternal and new-born deaths can be prevented by relatively straightforward effective interventions that are directly influenced by timely and accurate estimates and measures of child mortality (You et al., 2015).

Evidence-based estimation of child mortality is the cornerstone for tracking progress towards child survival goals and for planning national and global health strategies, policies and interventions on child health and well-being (Black, Morris and Bryce, 2003; You et al., 2015). Renewing the promise of survival for children relies on tracking and addressing the leading causes of deaths. Understanding the levels and causes of child mortality provides important public health insights. Most child deaths are caused by diseases that are readily preventable or treatable with proven, cost-effective interventions that are adequately directed by regional and provincial estimates (You et al., 2015). The extent of variation between provincial determinants of child mortality highlights the need for disaggregation at regional and global levels to allow public health intervention efforts to be focused appropriately. The availability of valid child mortality estimation and provincial differentials at country and provincial level will be an important determinant of success in meeting and in measuring progress towards the newly adopted Sustainable Development Goals (Black, Morris and Bryce, 2003). Expanded efforts to improve the completeness and accuracy of available data are needed (Black, Morris and Bryce, 2003) and action must be taken immediately to save children's lives by expanding effective preventive and curative interventions through observable estimates (You et al., 2015).

2.2.3 Obstacles and challenges curtailing child mortality

Inadequate data estimates of child mortality are hindering the mobilisation of equity-focused strategies and interventions at a national, provincial and district level (You et al., 2015). The activities involved in tracking child mortality at the country level can be divided into three main components: the mortality data that exists; a reasonable time series of mortality estimates; and ways of filling data gaps that arise. Unfortunately, within the lesser developed countries the major problem with vital registration as a data source is its poor quality. In many developing countries, vital registration as well as the recording of the population by age in childhood is often incomplete and subject to error. A further problem with vital registration systems is the frequent delay in compilation and publication. A more frequent measurement of mortality is advantageous however if a country is facing economic hardships and has a high child mortality level, attempting to measure child mortality every year will absorb significant country resources which could be utilized to reduce child mortality through immunization and vaccination rather than constantly having to produce timeous estimates child mortality. This is extremely difficult though as producing recent and reliable statistics are needed to monitor and track progress as well as to guide interventions in the needed direction (United Nations, 1995). However, interventions and programmes are not always as effective as they initially should be.

Most programmes in place to address MDG 4 were reactionary rather than proactive planning. Reactionary planning is about donor-driven programmes, which are not need-based. Unfortunately, some donor-driven programmes do not always address the problems within the given context (Atun, Bennett and Duran, 2008). Additionally, the programmes may even lack acknowledgement of cultural diversity and collaboration between Western, more modern, healthcare practices and workers and traditional health practitioners. This is evidently observable from HIV/AIDS programmes that are more vertically designed, poorly contextualised, and do not acknowledge cultural diversity. Vertical programmes are designed mostly by policymakers with minimal or no consultation with the affected population. The programmes are strategically designed to respond to an epidemic and to meet specified health outcomes within a specified time. Providers need training, and the implementation of vertical programmes leads to a selective approach that excludes the comprehensive approach promoted in primary health settings context (Atun, Bennett and Duran, 2008; Mulaudzi et al., 2016). Even though vertical programmes sometimes attain set health outcomes, they do not respond to determinants rooted in cultural practices, health promotion behaviours, literacy levels, and socio-economic status of the given country and context. This entails that the populations needs may not be entirely considered therefore hindering the effectiveness of outcomes (Mulaudzi et al., 2016).

Apart from the inadequacies in data collection, analysis, and interventions; other socio-economic and health-related determinants of child mortality continually thrive even though these factors are preventable and modifiable. Unfortunately, the situation still remains unmanageable, especially in developing countries. This is due to obstacles that are prevalent at the infrastructure level or at the community level. Healthcare delivery systems are still currently suffering from inequitable distribution of facilities, weak primary healthcare set-up, poor quality of offered services, non-existing referral services, logistics barriers, overburdened healthcare facilities (IGME, 2015; Shrivastava et al., 2013) scarcity of healthcare professionals, and a negative attitude of health workers towards the community (Thompson and Keeling, 2012). However, the issue of child mortality ventures beyond healthcare service delivery and accessibility. At an individual level, particular interest is directed towards women because if poverty relief mechanisms are intensified to improve the socio-economic status of women then this will automatically have a ripple effect on the underlying determinants that contribute to child mortality such as household income, access to healthcare services, mother’s employment status as well as educational attainment (Mulaudzi et al., 2016). All these sources will be utilised to prevent child death and ensure better health-related outcomes.

Other determinants of child mortality at a provincial level are context specific to factors such as local customs and practices, rural/urban residence, poor knowledge, educational status, and total income earned (Ramalho et al., 2013; Zhu et al., 2012). These are among the many constraints that are hindering the reduction of child mortality and hampering desirable and achievable results at a global, national and district level.

2.3 Global overview of child mortality

Major progress has been made in reducing child mortality throughout the world since 1990 (Jones et al., 2003). The number of under-five deaths worldwide has declined from 12.7 million in 1990 to 5.9 million in 2015. That entails 16 000 child deaths every day as compared to 35 000 child deaths daily in 1990. Encouragingly, this progress has been accelerating in recent years and has saved millions of lives of children under age five. In 1990 the world recorded 91 under-five child deaths per 1000 live births and with a 53 percent decline by 2015 the under-five mortality for the world was estimated at 43 per 1000 live births. The developed regions made substantial progress totalling a 60 percent decline and the developing regions threaded close behind with a 53 percent decline in under-five mortality. The remarkable decline in under-five mortality since 2000 has saved the lives of 48 million children under age five. These children would not have survived to celebrate their fifth birthday if the under-five mortality rate from 2000 onward remained at a constant level. These children are living evidence of the power of consolidated global commitments (You et al., 2015).

At the country level, approximately a third of countries have reduced their under-five mortality by two thirds or more and achieved the MDG 4 target set in 2000. Among these countries are 12 low-income countries inclusive of Cambodia, Ethiopia, Eritrea, Liberia, Madagascar, Malawi, Mozambique, Nepal, Niger, Rwanda, Uganda, and United Republic of Tanzania. Another dozen are lower-middle income countries inclusive of Armenia, Bangladesh, Bhutan, Bolivia, Egypt, El Salvador, Georgia, Indonesia, Kyrgyzstan, Nicaragua, Timor-Leste and Yemen. In addition to these achievements, 74 countries reduced their under-five mortality rates by at least half, and another 41 countries by at least 30 percent (You et al., 2015).

According to estimates developed by the United Nations Inter-Agency Group for Child Mortality Estimation (IGCME), under-five mortality rates in 2012 were highest in Sierra Leone, with an estimated 182 deaths per 1000 live births and lowest in Iceland and Luxembourg, where there are fewer than 2.5 deaths per 1000 live births (IGME, 2013). This was indication that the level of mortality has been found to be highly correlated with the relative development status of a country, with 25 times higher rates in the least developed countries compared to the most developed countries. This was indicated by an estimated 153 deaths of children per 1000 live births in the least developed regions compared to 6 deaths of children per 1000 live births in the most developed regions (World Bank, 2013). Many influential factors play a contributory role in aggravating child mortality trends, including socioeconomic class. UNICEF has reported that the world's poorest children are 2.7 times less likely than the richest ones to have a skilled attendant at birth that plays a direct role on their survival (UNICEF, 2014). However, despite limited resources, 24 out of 81 low-income and lower-middle-income countries have met the MDG target for reducing under-five mortality by two thirds and approximately 70 percent of all countries have at least halved their rates of child mortality. These regions defied their circumstances and remarkable progress was noted in areas such as Eastern Asia, in 1990 they recorded their under-five mortality as 53 per 1000 live births and reduced it to 11 per 1000 live births in 2015. Latin America and the Caribbean experience under-five mortality of 54 per 1000 live births in 1990 and in 2015 observed an estimation of 18 per 1000 live births. Under-five mortality in Northern Africa in 1990 was estimated at 73 per 1000 live births and endured notable declines as by 2015 under-five mortality was estimated at 24 per 1000 live births (You et al., 2015).

Brazil, one of the world's poorer nations, succeeded in significantly reducing child mortality. The country as a whole has met MDG 4 and achieved a decline from 61 per 1000 live births in 1990 to 16 per 1000 live births in 2015, a 73 percent reduction. Although Brazil has also managed to reduce regional inequities in child mortality in the past 25 years, disparities still persist in the country that entails indigenous children are twice as likely to die before reaching their first birthday as other Brazilian children. However this example illustrates that even for a country that holds a poorer global status, greater efforts to reduce disparities at the sub-national level and across different groups are required to achieve equity in child survival and lower mortality levels overall (You et al., 2015).

Despite substantial gains in improving child survival, progress has been insufficient to achieve MDG 4 worldwide (You et al., 2015) and more than 10 million children younger than 5 years still die every year (Black, Morris and Bryce, 2003). Worldwide, between 1990 and 2015, 236 million children died before their fifth birthday. Had the necessary progress been made since 2000 to achieve MDG 4, 14 million more children would have survived to age five since 2000. Projections indicate that if current trends continue, around half of the 69 million child deaths between 2016 and 2030 will occur during the neonatal period. The share of neonatal deaths is projected to increase from 45 percent of under-five deaths in 2015 to 52 percent in 2030 (You et al., 2015).

While every nation has experienced some level of decline, there is a great amount of disparity in the overall amount of decline. For instance, countries such as Turkey, Estonia, and Saudi Arabia have had a greater than 80 percent decline in rates of child mortality while in countries like Botswana, Zimbabwe, Lesotho and Swaziland where child mortality had been reversed that they have yet to achieve a decline of 10-20 percent in order to reach the rates evident in 1990. (UNICEF, 2013). Southern Asia is another region in particular where acceleration in reducing child mortality is urgently required. The under-five mortality rate in this region is still fairly high estimated at 51 deaths per 1000 live births in 2015. Three in 10 global under-five deaths occur in Southern Asia. It was clear that even though the 53 percent decline in the under-five mortality rate globally was monumental it was not merely enough to achieve the MDG 4 target particularly in Caucasus and Central Asia, Oceania, Southern Asia and sub-Saharan Africa (You et al., 2015).

It is clear that much work remains to give every child a fair chance of survival even in low-mortality countries. The substantial progress in reducing child mortality over the past 25 years provides a clear message that indicates with the right commitments, concerted efforts and political will, bold and ambitious goals are within reach (You et al., 2015).

2.4 Child mortality in Africa

Sub-Saharan Africa suffers from poor management of registration systems making it extremely difficult to estimate, monitor and track child mortality data in relation to the regions development and progress. With an array of social and environmental challenges such as poverty, inequality, political instability and violence; capturing basic administrative data and preparing for national censuses are the most unlikely to be on the agenda of a region that is battling such issues. The sub-Saharan African region is constrained by a lack of reliable data and statistics that is used to derive at timely and accurate estimates that can effectively enforce and inform the applicable policies and interventions (Sachs, 2003).

2.4.1 Empirical evidence of child mortality in Africa

Accelerating progress in child survival urgently requires greater attention to ending preventable child deaths in sub-Saharan Africa. 1 child in 12 in sub-Saharan Africa dies before his or her fifth birthday. This estimate is far higher than the average ratio of 1 child in 147, in high-income countries. Even though the under-five mortality rate is the key focal area, focus is also needed to prevent neonatal deaths. Continued preventive and curative life-saving interventions derived from accurate and timely estimates is needed to provide children beyond the neonatal period in countries where the post-neonatal mortality rate is still high, particularly in sub-Saharan African, where post-neonatal deaths account for at least 60 percent of under-five deaths (You et al., 2015).

Even though sub-Saharan Africa is the region with the highest under-five mortality rate in the world, with an under-five mortality rate of 83 per 1000 live births in 2015, there has been a substantive acceleration. The annual rate of reduction increased from 1.6 percent in 1990s to 4.1 percent in 2000–2015. The under-five mortality rate was recorded at 180 per 1000 live births and saw steady decreases that totalled to 175 per 1000 live births in 1995, 154 per 1000 live births in 2000, 127 per 1000 live births in 2005, 101 per 1000 live births in 2010 and then by 2015 dropped to its lowest estimates yet. From the period 1990 to 2015, sub-Saharan Africa witnessed a decline in under-five mortality rates by 54 per cent. Even though there was a 3.1 percent annual rate of reduction between 1990 and 2015 this was not merely enough to achieve the MDG target of 60 per 1000 live births by 2015 (You et al., 2015).

Of the 49 sub-Saharan African countries, all but 5 had a higher annual rate of reduction in the 2000–2015 periods as compared with the 1990s. Also, 21 sub- Saharan African countries have at least tripled their annual rates of reduction from the 1990s or reversed an increasing mortality trend in 2000– 2015 compared with the 1990s. These countries include Angola, Botswana, Burkina Faso, Burundi, Cameroon, Central African Republic, Congo, Côte d'Ivoire, Gabon, Kenya, Lesotho, Mauritania, Namibia, Rwanda, Senegal, Sierra Leone, Somalia, South Africa, Swaziland, Zambia and Zimbabwe (You et al., 2015).

2.5 Child mortality in South Africa

Investing in the health and wellbeing of the children of South Africa is an investment in the future development of our country. South Africa still has a relatively youthful population with a third of the population under 15 years of age (Bradshaw, Bourne and Nannan, 2003). There were approximately 5.3 million children in South Africa each year between 2006 and 2010, representing around 11 percent of the total population each year. The number of children aged under-five years appears to be decreasing over time however the total population continues to increase. This is reflected in the gradually decreasing proportion of children under-five years over time (Statistics South Africa, 2012).

Although South Africa has progressed well over the past decade, its child mortality rates are still higher than other countries with similar economic status such as Brazil, China, and Mexico as well as a number of other less developed countries including Namibia, Indonesia, Bangladesh, Philippines and many of the North African countries. South Africa's child mortality rates are not far from the rates of countries whose development indices are far below those of South Africa such as for Botswana, Rwanda, Tanzania and India (World Bank, 2013; UNICEF, 2014).

2.5.1 Empirical evidence of child mortality in South Africa

Derived from Nannan et al (2012) it can be concluded that there have been substantial improvements in the registration of child deaths during 1997–2007, reaching levels of 90% completeness for infants and 60% for children aged 1–4 years (Nannan et al., 2012).
The registered number deaths under 5 years of age reached a peak in 2006. The recorded infant deaths increased rapidly from 24 734 in 1997 to 48 239 in 2006, and then declined to 46 553 in 2007. The same pattern was observed for deaths of children from 1–4 years of age, increasing from 7 751 in 1997 to 16 058 in 2006, and falling to 14 782 in 2007. From 1997 until 2006, this constitutes a 95 percent and 107 percent increase in recorded deaths for infants and 1–4 year olds, respectively. It should be acknowledged that much of this increase is due to an increase in the registration of deaths and underlying reasoning or causation. This assumption was reinforced by results from the Agincourt Health and Demographic Surveillance Site, which suggests that there was an increase in death registration of children

less than 5 years of age from less than 10 percent to over 30 percent during the late 1990s (Kahn, 2006; Nannan et al., 2012).

Monitoring progress on MDG 4 in South Africa has been extremely challenging. Vital registration is incomplete and there have been significant data quality problems with several surveys and the 2001 census regarding the data for child mortality estimates (Bradshaw, Bourne and Nannan, 2003; Nannan et al., 2012). Udjo (2005), on the basis of his analysis of the survivorship reports of the 1996 census noted that childhood mortality levels have increased across all population groups within South Africa (UNDP, 2010). Udjo (2008) produced estimates of child mortality from the 2001 census and concluded that infant mortality was 69 per 1 000 live boys and 65 per 1 000 live girls in 2001, falling to 56 and 53, respectively, by 2006, based on the 2007 Community Survey data. However Dorrington and Moultrie (2008) argued that the analysis by Udjo (2008) is to some extent flawed due to issues of poor fertility data, which argue that the 2001 census data were subject to editing and imputation rules, which generated significant proportions of data, and hence no sensible estimates of child mortality could be derived from this census (Dorrington, et al., 2004). The application of the HIV Estimation Model proposed by Ward and Zaba (2009) deems of great importance, especially regarding the South African population. South Africa's generalised epidemic began in the first half of the 1990s, necessitating an adjustment to correct for bias due to the fact that the data does not capture information on the survival of children of mothers who were not alive at the time of the survey. Failure to apply such an adjustment results in an underestimate of the child mortality rates (Nannan et al., 2012).

2.5.2 Provincial estimates of child mortality in South Africa

Child mortality in South Africa is characterised by large spatial differentials which are strongly associated with the level of socio-economic disparities. Geographically, the country is divided into nine different provinces each reflecting broad differences in geography, environment, population, and development. In the poorer provinces like Limpopo and Mpumalanga, there are relatively low levels of infrastructure development (housing, water, sanitation and electricity), education and income, higher unemployment rates, and poor health care services (UNICEF, 2013; HSRC, 2014a). In contrast, in richer provinces like the Western Cape and Gauteng there are better infrastructure development, higher income and education levels. Child mortality rates in the poorer provinces are usually estimated to be very high compared to the richer provinces. In 2010, there were about 5.2 million children aged under-five years in South Africa, representing 10.5 percent of all people in the country. The majority of these children were black Africans and most of them lived in KwaZulu-Natal and Gauteng. The relative number of children aged under-five years to the total population in each province indicated higher proportions of children in KwaZulu-Natal, Eastern Cape and Limpopo (Statistics South Africa, 2012).

According to Statistics South Africa (2012) over 39.9 percent of children were regarded as having a very good health status, 50.5 percent of children had a good health status, 5.6 percent of the children were regarded as having fair health and 1.8 percent being regarded as having poor health. The proportions for those regarding the health of children as very good were higher in Western Cape, Eastern Cape and Gauteng, where over 40 percent of children in each province were regarded as having very good health. Limpopo and KwaZulu-Natal had higher proportions of children whose health was regarded as poor. The highest proportion of those regarding the health status of children as very good was observed among the white population group, with about two-thirds of children being regarded as having very good health. The lowest proportion was for the black African children of whom 37.7 percent were regarded as having very good health. Less than 1 percent of children from the white population group were regarded as in fair or poor health (Statistics South Africa, 2012).

Most provinces showed a general increase in the number of deaths over the period. However, an unusual decrease and levelling off was seen in deaths in KwaZulu-Natal and the Eastern Cape beginning in 1998 and 1999, with numbers increasing again by 2002. This pattern is not seen in other provinces, and although the reason for it is not clear, it may be due to administrative deficiencies in those provinces. Apart from this, it is possible that provincial boundary changes in 2005/6 may have affected some of the provincial trends over this period (Nannan et al., 2012). There has generally been a decrease in the number of deaths occurring in the country between 2006 and 2009. The number of deaths that occurred between 2006 and 2009 for children aged under-five years decreased by 21.6 percent from 64 346 in 2006 to 50 471 in 2009. The decline was greatest between 2008 and 2009 when the number of children's death decreased by 17.3 percent from 61 062 to 50 471. The proportion of under-five deaths was approximately 10 percent between 2006 and 2008 and declined to 8.8 percent in 2009. These proportions are very similar to the proportion of the population aged under-five years. Both Western Cape and Eastern Cape showed the lowest proportion of child deaths relative to all deaths in each of these provinces. The proportions of child deaths in these provinces, as well as those in KwaZulu-Natal, were less than 10 percent of the total number of deaths in each of these provinces. There was a consistent notable decrease in the proportion of child deaths for the deceased who were residing in KwaZulu-Natal and Gauteng. North West had the highest proportion of child deaths in comparison to the total number of deaths in the province. Limpopo showed an increase in the proportion of child deaths relative to all deaths in the province between 2006 and 2008, but a decrease between 2008 and 2009. By 2009, at least 10 percent of deaths in the Free State, North West, Gauteng and Limpopo occurred among children aged under-five years (Statistics South Africa, 2012).

The provincial disparities in the under-five mortality rates in South Africa estimated from the 2007 Community Survey indicated that each province was way above the international set target for the country. Limpopo had the highest recorded under-five mortality within the province of 110 per 1000 live births. Trending close to this estimate was both the Eastern Cape and North West at 105 per 1000 live births, Mpumalanga at 101 per 1000 live births, KwaZulu-Natal at 98 per 1000 live births and the Free State at 97 per 1000 Live births. The lower estimates were observed in Gauteng with 86 per 1000 live births and the Northern Cape with 85 per 1000 live births. the lowest under-five mortality rate for this period was in the Western Cape with 78 per 1000 live births (UNDP, 2010).

2.5.3 Determinants of child mortality in South Africa

Child mortality is preventable however is still widespread within South Africa because of the socio-demographic context of the country as well as deficiencies in the healthcare delivery system (Ramalho et al, 2013). A wide range of demographic parameters such as male child, African/black race, young maternal age, low birth weight, high parity, high birth order, short inter-pregnancy interval contributes to the levels of child mortality within South Africa (IGME, 2015; Hussaini, Ritenour and Coonrod, 2013; Mehal et al., 2012; Uddin, Hossain and Ullah, 2009). Also inclusive are social and economic parameters such as home delivery, unskilled delivery, social inequalities and inequities, financial restraints, lack of quality antenatal care, limited access to healthcare services or poorly trained and unskilled health professionals, exclusive breastfeeding, inadequate immunization, poor sanitation practices, and poor maternal education attainment have been recognized as the potential risk determinants in the causation of child mortality, particularly within South Africa (IGME, 2015; Mehal et al., 2012; Ramalho et al., 2013; Thompson and Keeling, 2012; Uddin, Hossain and Ullah, 2009; Zhu et al., 2012).

According to the South Africa Every Death Counts Writing Group (2008) within South Africa, the Problem Identification Programme (PIP) identified five main challenges contributing to child mortality rates. These are pregnancy and childbirth problems; newborn illnesses; childhood illnesses; HIV and AIDS; and malnutrition. These contribute to 260 deaths daily, with 75 000 children not living to their fifth birthday (South Africa Every Death Counts Writing Group, 2008). All five of these challenges have poverty as the overarching cause. Most child deaths are related to gender disparity, poverty, poor household knowledge of child health, nutrition practices, and poor sanitation (You, New and Wardlaw, 2011). Education, poverty and gender issues directly affect the prevention of child mortality. It affects access to treatment during ill health, appropriate housing, safe water, food security and sound nutritional status. Accordingly, although a significant decline in poverty levels was noted in the period 1999–2005, South Africa has continually battles with unemployment issues and many people do not have secure jobs (Mulaudzi et al., 2016). Living in poverty paves way for other household and environmental challenges to bloom. Living conditions deteriorate which directly affects the survival of children. An estimated 1.5 million child deaths are related to unhygienic conditions, with an estimated 88 per cent caused by diarrhea (Black, Morris and Bryce, 2003). Inadequate sanitation such as communal toilets and the bucket system continues to create unhygienic conditions that undermine child survival in South Africa (Langford, Bartman and Roaf, 2013; Mulaudzi et al., 2016). The provision of sanitation, water and proper housing will reduce diarrhoea and respiratory conditions, which are the causes of approximately 22 per cent of deaths in under-one-year-olds (Mayosi et al., 2012).

If managing living conditions become challenging and unaffordable for families then accessing appropriate and affordable medical services are even more challenging. Approximately 70 per cent of South Africans use traditional methods or consult with traditional healers before considering modern medical care (Van Rensburg, 2004). This is problematic because it is uncertain how child healthcare workers and professionals collaborate with traditional healers as the first line of healthcare provision for under-five-year-old children's preventive and curative healthcare. With the increasing number of children on treatment regimes, a lack of collaboration between these two sectors can lead to challenges such as drug interactions that might lead to an increased complications and child mortality (Mulaudzi et al., 2016).

Regardless of accessing the existing medical facilities it is also acknowledgeable that the management of emergencies involving child care is another shortcoming. Healthcare workers reported a lack of skills in advanced emergency care for children under 5 years old (Gnanalingham, Harris and Didcock, 2006). The facility may be available however number of suitably qualified personnel's is quickly declining. Fifty-three per cent of child mortality is resultant of factors preventable by healthcare providers (South Africa Every Death Counts Writing Group, 2008). However, healthcare providers cannot be solely responsible for the increase in child mortality. This assertion is based on the fact that many children die at home from diseases such as diarrhoea and if mothers were more health literate, or even more literate on the whole, they would recognise the signs and symptoms of such serious illnesses and take action to manage the identified problems and prevent any fatalities (Mulaudzi et al., 2016; Statistics South Africa, 2013).

South Africa's high infant mortality rate has occurred against a backdrop of sustained economic growth between 1994 and early 2010. Economic growth differs significantly across its nine provinces and the results show high levels of income inequality (Booysen et al., 2008). Medical assistance is more readily accessed by wealthier households. Poorer households are excluded because of comparatively higher direct and indirect costs to access facilities (Porter, 2002). Furthermore, the development of the national economy has been centered around the major urban capitals whereas 70 per cent of South Africa's poor live in the rural districts (Bryceson , 2002a; Bryceson, 2002b). Rural South Africa, therefore, not only experiences high levels of poverty and income inequality, but also less access to services and facilities. These facilities include infrastructure, clinics, water and sanitation that vary widely across the rural urban divide, as well as across the nine provinces. The risk of infant mortality, therefore, appears to be increased by a material deprivation squeeze that combines income inequality on the one hand with the unequal distribution of disease and other services (Houwelling et al., 2005).

2.5.4 The impact of HIV/AIDS in South Africa

Levels of child mortality in South Africa are increasing and much of this has been attributed to the impact of the HIV epidemic. The lack of readily available health information from developing countries, critical for the management of child survival programmes, remains a serious problem (Garrib et al., 2006). The deterioration in child health continued despite the introduction of free health care and nutrition programmes and was attributable to paediatric AIDS, correspond with the high prevalence of HIV observed among pregnant women (Bradshaw, Bourne and Nannan, 2003). Although HIV and AIDS is not common among children aged under-five years in South Africa, it is an important health condition from the public health perspective in South Africa and cannot be ignored and adjusted for statistically (Statistics South Africa, 2012).

According to Statistics South Africa (2012) reports on HIV and AIDS based health on conditions reported from the General Household Surveys (2006–2010) indicates that 3 500 children were reported as having HIV/AIDS in 2006, increasing to 5 144 in 2007 and then declining to 4 947 in 2008. This translated to 0.1 percent of children aged under-five years having HIV/AIDS over the 2006–2008 periods. The number of children aged under-five years that died from HIV disease fluctuated between 2006 and 2009. It was 973 in 2006, decreasing to 740 in 2007, increased slightly to 824 in 2008 after which it declined again to 778 in 2009. The proportion of deaths due to HIV disease over the four-year period was between 1.2 percent and 1.5 percent each year (Statistics South Africa, 2012).

According to Garenne and Gakusi (2005) since the mid-1960s, South Africa experienced one of the most rapid declines in child mortality in Africa, reports reveal estimates from 188 per 1 000 in 1968 to 48 per 1 000 in 1992, which is considerably higher for the earlier period and lower at the point of reversal due to AIDS compared the estimates of others.
Based on historical estimates of child mortality developed by United Nations Inter-agency Group for Child Mortality Estimation (IGME, 2013), South Africa's U5MR in the period 1990-2012 fell from 61 to 45 deaths per 1000 live births. However, the decline has not been consistent as in many other countries or the worldwide pattern. A number of research have documented that because of the HIV endemic there had been a reversal of child mortality beginning from mid-1990 and lasting to 2005, after which it has started to decline at a higher rate due to the introduction of the Prevention of Mother-to-Child Transmission (PMTCT) programme (Dorrington, Johnson, Bradshaw et al., 2006; Nannan, Dorrington, Laubscher et al., 2012; Kerbera, Lawnb, Johnson et al., 2013).

HIV/AIDS was the cause of 1.3 percent of the deaths in 1997 and 1.6 percent in 2001, but does not feature for later years and is implausibly low. In contrast, the Cape Town mortality surveillance shows that in 2006, 8 percent of infant deaths in that city were due to HIV/AIDS, despite this city having a lower HIV prevalence than the country as a whole (Nannan et al., 2012).

In rural South Africa, infant and child mortality levels are high, with HIV/AIDS estimated as the single largest cause of death. A community-based survey was aimed at determining child mortality rates in a rural area of South Africa with high HIV prevalence on deaths in children under the age of 15 years. Mortality ratios were 59.6 deaths per 1000 live births for infants and 97.1 for children under 5 years of age. Infant and under-5 mortality rates were, respectively, 67.5 and 21.1 deaths per 1000 person-years. HIV/AIDS was attributed to 41 percent of deaths in the under-5 age group (Garrib et al., 2006).

A similar demographic site in the Limpopo Province of South Africa, estimated an under-5 mortality ratio of 56 deaths per 1000 live births between 1998 and 2000. It was discovered that HIV/AIDS was attributed to 22 percent of deaths in children under the age of 5 years; however, HIV prevalence among women attending public antenatal clinic in that province was much lower than that in KwaZulu-Natal during 2000 (Garrib et al., 2006).

2.6 The Mosley and Chen analytical framework

Development of the most effective interventions requires an understanding of the determinants of child mortality. These determinants include socioeconomic factors, such as income, social status, and education, which work through an intermediate level of environmental and behavioural risk factors. These risk factors, in turn, lead to the proximal causes of death, such as under-nutrition, infectious diseases, and injury (Black, Morris and Bryce, 2003).

Studies on child mortality have accumulated a huge list of possible determinants, including individual and community level factors such as maternal age, race, income, sanitation, water source, electricity, urban/rural residence, region of residence, household composition, occupation, female education, and access to health care (Caldwell, 1979; Hobcraft, McDonald and Rutstein, 1985; Victora, Wagstaff, Schellenberg et al., 2003; Wang, 2003; Omariba, Beaujot and Rajulton, 2007; Kembo and Ginneken, 2009).

The theoretical framework is based on the conceptual framework of child survival for developing countries proposed by Mosley and Chen (1984) for the analysis of the impact of socioeconomic factors and bio-demographic (bio-medical) factors on infant and child mortality. This framework clearly identifies the proximate and socioeconomic determinants of infant and child mortality. Mosley and Chen (1984) set the framework of child survival based on the assumption that socioeconomic factors of child mortality primarily operate through a common set of intermediate factors. The assumptions stipulate that in an optimal setting, over 97 percent of children born can be expected to survive until their fifth birthday. The proximate determinants through which the socioeconomic factors operate influence infant and child mortality. Socioeconomic, biological and environmental factors are the driving force behind the reduction of infant and child mortality.

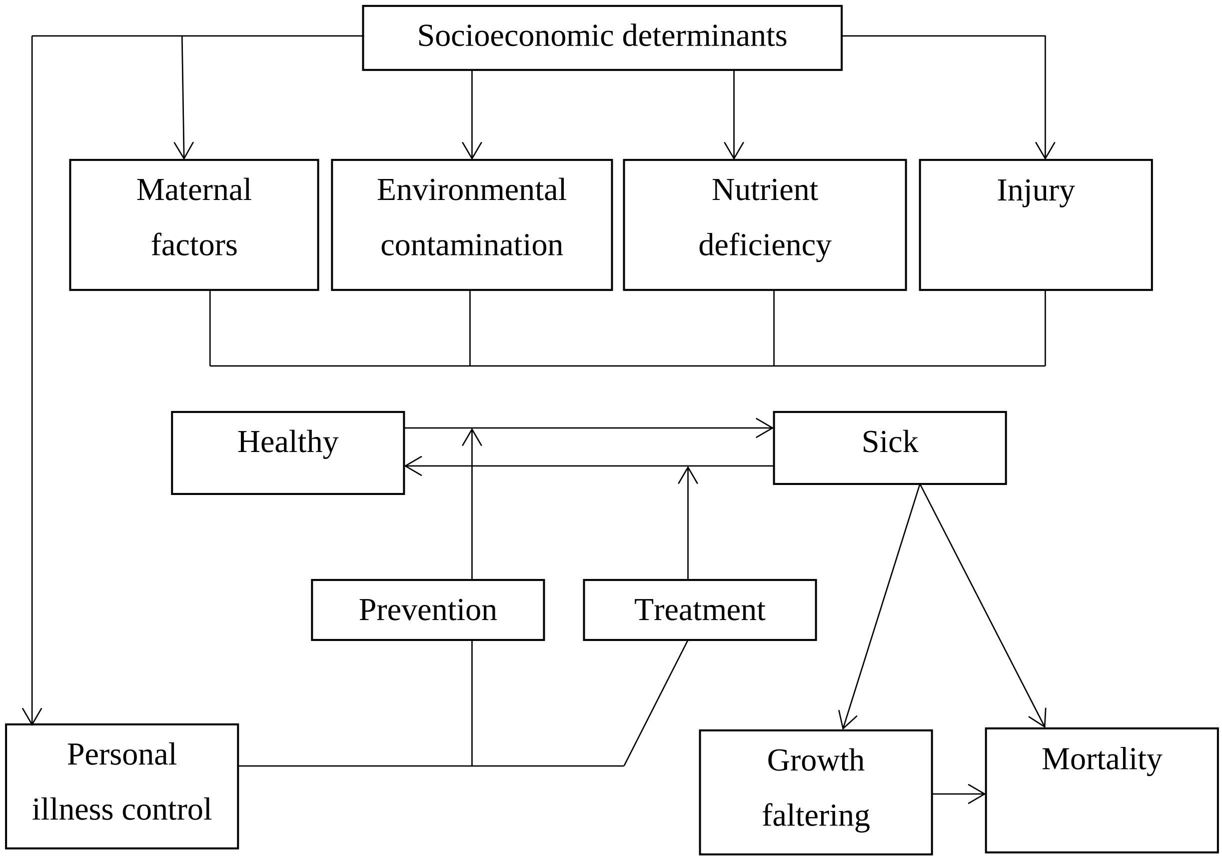
Mosley and Chen (1984) further categorized a set of proximate determinants into five general groups that directly affect infant and child mortality. The five grouped proximate determinants that directly affect infant and child mortality are maternal factors inclusive of variables such as age, parity and birth intervals with each of these factors having an impact on infant and child mortality through affecting maternal health; environmental contaminations that spread or transmits infectious disease to mothers or children; nutrient deficiency (calories, protein and micro nutrient deficiency); injury related to physical, burn and poisoning; and personal illness control (immunization, bed net or malaria prophylaxis). This includes both traditional and modern preventative measures to avoid disease during pregnancy and child births (Mosley and Chen, 1984).

Mosley and Chen (1984) also categorized the socioeconomic determinants of infant and child mortality in to individual, household and community level variables. On the individual level parental skills, health and time are the three main determinants of child survival. Parental skills have an important implication for child survival that is usually measured by educational attainments. Maternal education may improve child survival through care seeking, morbidity and nutrition status while paternal education particularly is strongly associated with occupation, household income and household decision-making. However, the mothers' education level is the primary important determinant for child survivals. Due to strong biological association between the mothers and child during pregnancy and lactation, mother's educational levels influence her health, nutritional status, reproductive behaviours and knowledge of child care practice associated with nutrition, hygiene, preventative care and disease treatment (Mosley and Chen, 1984).

A mother's time is linked to economic activities, particularly income generating activities that increase child survival. In the more traditional societies, the labour division by sex enables the mother to allocate more time for child care. However, in the majority of developing countries mother's time for children also depend on the economic situation of the household (Mosley and Chen, 1984). Traditional norms and attitudes are another important individual level variable within the socio-cultural dimension that shapes and modifies the individual's economic choice and health outcomes. One of the important determinants of this category is the power relations that exist within the household and is strongly associated with social norms. In most traditional societies the mother is responsible for childcare and therefore she may have little allocation of resources in related to the time use, expenditure allocation, nutritional choice and health practices (Mosley and Chen, 1984). Household levels factors consider income and wealth on child survival. A variety of goods, services and assets influence child survival through operating through the intermediate factors of child survival (Mosley and Chen, 1984). Similarly, community level factors are inclusive of the ecological setting such as climate, soil, rainfall, temperature, altitude, and seasonality.

These variables, particularly in the more rural areas, influence child and infant mortality though the availability of income generating work, use of medical facilities, infrastructure and health system variables. The availability of health service are crucial determinates for child survival (Mosley and Chen, 1984). These differences result in notable urban and rural differentials of child mortality. Figure 2.1, below, depicts the theoretical framework developed by Mosley and Chen (1984) in the form of a diagram as presented by Fuentes, Pfütze and Seck (2006).

Figure 2.1: The Mosely and Chen (1984) theoretical framework



Source: Fuentes, Pfütze and Seck (2006); Mosley and Chen (1984)

2.7 Evidence of child mortality

The determinants of child mortality are of interest in both the social and medical spheres however both adopt different approaches. The medical aspect of child mortality focuses more on the biological processes leading to death. The social interests of child mortality do not address the medical causes of death but the determinants, levels and patterns of mortality in populations. Though occasionally the mechanism through which the determinants operates to produce the observed mortality pattern or trend may not be that noticeable. However, it must be acknowledged that both medical and social sciences have contributed significantly to the understanding of child mortality, especially within developing countries, where the increase in and the spread of HIV/AIDS has risen, and malnutrition and forced migration are resultant of wars and political instabilities that further accelerate the pace of child mortality (Lawn, Cousens and Zupan, 2005).

2.7.1 Demographic variables

Maternal age at birth

In a number of studies conducted in different parts of the world, it has been revealed that birth to women younger than age 18 and older than age 35, have a higher risk of infant child mortality during first and older births. It is believed that a young mother is not biologically matured and a much older mother experiences complications, thus the possibility of pregnancy related complications are high (Jolly et al, 2000). According to Ezra and Gurum (2002), children born to younger mothers, aged 15-19 years old, and older mothers, aged 35-49, were more likely to die as compared to children born to mothers in the age category 25-34 years old. Mturi and Curtis (1995) used data from 1991/92 DHS in Tanzania to study the determinants of infant and child mortality and concluded that demographic and biological factors, inclusive of teenage pregnancies (younger than 20 years old) had a more pronounced impact on infant and child mortality whereas determinants of interest (such as socioeconomic determinants) of child mortality were not as significant as elsewhere in Africa (Mturi and Curtis, 1995).

Sex of child

The sex of a child has also been acknowledged to be a determinant and a cause of gender differential in mortality (Kosher, 1993). Increased female participation in labour has enable women to have a positive perception of their own worth, and by extension the worth of their female children. This is resultant of the net effect of improving the relative survival of female children (Kosher, 1993). Another proposition to explain the narrowing of gender differentials in infant mortality rate among working women is that these women have less time to discriminate or provide preferential treatment. Without preferential treatment for males, infant female mortality rates are less likely to differ significantly from that of males (Kosher and Parasuraman, 1998).

Birth order/ interval

Goro (2007) stated that birth order was a powerful and significant determinant of infant mortality. Evidence from the 2005-06 Zimbabwean DHS revealed that birth order with short preceding birth intervals was significantly associated with higher risk of infant and child mortality and multiple births contributed to increase infant and child mortality (Kombo and Ginneken, 2009). Adopted from the 2005 Ethiopian DHS, Kumar and Gemechis (2010) employed a cross tabulation technique to examine the selected socioeconomic, bio-demographic and maternal health care factors that determine child mortality in Ethiopia. The result indicated that of the observed variables, birth interval has a significant impact on lowering the risk of child mortality. Similarly, within the context of Zimbabwe, socioeconomic determinants are minutely insignificant on the effect of infant and child mortality. This further reinforces the notion that the influence of birth order and preceding birth intervals are more pronounced on child mortality than the other determinants (Kombo and Ginneken, 2009).

Ezra and Gurum (2002) employed a logistic regression model to investigate the impact of birth interval on infant and child mortality within communities of Ethiopia that were characterized by high fertility, prolonged breast feeding practices and poor living conditions. From the study it was apparent that short birth interval (of less than18 months) were significantly associated with infant and child mortality as compared to long birth interval (of more than 24 months). This concluded that the influence of short birth interval was more distinct on infant mortality compared to its weaker influence on child mortality. Similarly, Manda (1999) employed the Cox regression to investigate the effect of birth interval and birth order by considering other relevant determinants on infant and child mortality. The results demonstrated that birth interval significantly affected infant mortality; however, the impact is much weaker on child mortality.

2.7.2 Social and economic variables

Mother's employment status

One of the benefits that are usually evident from a woman's participation in the labour force is that a higher percentage of her earnings will be directed towards child welfare needs, compared with earnings of the males (Mencher, 1988). This evidently translates women's employment attainment to the increased exposure and access to relevant information about child health and wellbeing; nutritious, medical and survival needs; as well as information about better childcare practices. However, these benefits may counterbalance the reduction in the time available to provide personal and timely care of their children. The consequence of this is a shortened breastfeeding period, and thus the nutrition of infants is adversely affected.

This contradiction is evident from a bivariate analysis of 1981 India census data that revealed that rural, working women have a higher child-mortality rate than non-working women (Basu and Basu, 1991).

Mother's education

Education of parents, especially mother's education has contributed immensely to the determinants of the level of under-five mortality. Maternal education, ranging between the duration of four to six years, has been investigated to be associated with a 20 percent decline in infant mortality (Syamala, 2004). It becomes clear that children born to mothers that obtain some education are in better position of survival than those that are not (Ware, 1984). This is because educated mothers are more informed of the contemporary healthcare practices and utilize the availability of health facilities. Also, better educated mothers employ important hygienic practices which are directly associated with preventing child diseases (Abou-Ali, 2003).

Twum-Baah et al (1994) indicated that children born to mothers with higher educational levels are associated with lower risk of infant and child mortality as compared to children born to mothers with primary education level or non-educated. Goro (2007) used data from 1993, 1998, and 2003 DHS surveys in Ghana to examine the determinants of infant and child mortality in three northern regions by utilising a multivariate logistic regression model. It was evident that the educational status of mothers had a significant impact on child mortality. These stipulations were reinforced by Kumar and Gemechis (2010), who stipulated that a mother's educational status has a significant impact on lowering the risk of child mortality.

Urban/ rural residence

Urban/rural residence is a critical health determinant as the health experiences of those living within the different locations differ significantly. The influence of rural-urban disparities in children's health cannot be ignored especially since the disparities are so wide that it demands attention. In Zimbabwe, infant and child mortality differentials exist between urban-rural residence because of regional differences and availability of healthcare infrastructure (Zimbabwe Central Statistical Office/ Macro International Inc, 2007). Sahn and Stifle (2003) utilised data from DHS of 24 African countries, and concluded that infant mortality in urban areas lower relative to in rural areas. Various factors contribute for this urban- rural variation such as better education levels and the improvement of public and health infrastructures in urban areas than in rural areas – as noted in the outline of the framework. However, it should be noted that the HIV/AIDS epidemic is partly responsible for the high risk of infant and child mortality in Africa, particularly in sub-Saharan countries. A study conducted in Kenya by Hill (2001) found that urban areas are associated with higher risks of infant and child mortality than rural areas, however, controlling for HIV prevalence child mortality are significantly lower in urban areas (Hill et al., 2001). Generally, it is assumed that infant and child mortality in urban areas is lower than observable levels in rural areas.

Mustafa and Odimegwu (2008) utilised the 2003 Kenya DHS data and examined socioeconomic determinants of infant mortality rate both urban and rural setting. They found that regional variations exist in infant and child mortality between the difference provinces of Kenya. A similar situation was evident in Malawi. Baker (1999) applied the Brass indirect estimation of child mortality to the population of Malawi. He found that the significant variation of child mortality between the different districts of Malawi and it was educational variations between those regions that contributed to the regional variation of infant and child mortality. It seems that in many parts of Africa children that reside in rural areas have an elevated risk of death than those who reside in rural areas. Wang (2003) utilised data from 2000 DHS in Ethiopia to examine the effect of environmental factors on infant and child mortality by using three hazard models. Key findings indicated that infant and child mortality are high for those children born in rural areas than urban areas.

Household income level

The income level of the household is also an important factor determining the level of mortality among children. In situations where there are low or no income earnings, there will be limited or no access to the basic needs of children under-five. These needs may include hygiene, shelter and food. Therefore, in a society where inequality is rife and the gap between the rich and the poor is widening, the variations in income may translate to variations in affordability and accessibility to basic human needs, and may result into rising rates of malnutrition and mortality. In Kenya, most socioeconomic factors are not associated with an elevated risk of infant and child mortality however children born in the richest households automatically have a lower probability of mortality relative to children born in the poorer households (Mustafa and Odimegwu, 2008).

2.7.3 Household and environmental variables

Environmental health factors play an important role in child survival even when controlling for socio-economic variation (Anderson et al., 2002; Franz and FitzRoy, 2006). Rainham and McDowell (2005) found child survival, like all population health outcomes, is clearly linked to the environment. The most widely tested environmental health indicators are access to clean water and sanitation. Access to clean water and improved sanitation is one of the most important factors in human health, with over 1 billion people in the developing world living without access to safe drinking water, while 2 to 3 billion lack basic sanitation (Balint, 1999; Franz and FitzRoy, 2006). The literature on determinants of mortality finds a strong positive correlation between access to water, improved sanitation and child survival (Schultz, 1980). However, within-and between-country variation presents great barriers to controlling for health risks associated with poor access to potable water and adequate sanitation (Balint, 1999; Franz and FitzRoy, 2006).

Baker (1999) stated that variations of child mortality in Malawi are not influenced by sanitation. This conclusion was evident from an analysis of wealth indexes in Malawi. However, it becomes difficult to accept that access to adequate sanitation has a minute effect on child mortality, taking into consideration the structure of Mosley and Chens framework (Mosley and Chen, 1984). Mutunga (2004) used data from 2003 DHS in Kenya to investigate the impact of socioeconomic and environmental variables of infant and child mortality in urban areas of Kenya. The results show that the infant and child mortality were lower for those who had access to drinking water and sanitation facilities, and users of low polluting fuels as their main source of cooking. (Mutunga, 2004). Also evident was the relation between poor environmental conditions and the elevated risk of infant and child mortality. Safe water, sanitation and electricity are not adequately distributed in Ethiopia; with a mere 20 percent of the total population located in urban areas have access to these much needed facilities (Wang, 2003). Similarly in Malawi, Espo (2002) suggested and reinforced the notion that there is a strong correlation between the source of drinking water and sanitation facilities on infant mortality.

2.8 Summary

To address the public health problem of child mortality, solutions exist within the formulation of comprehensive evidence-based policy that directly tackles the contextualized risk factors, barriers and determinants. Additional strategies like sustained political commitment (IGME, 2015), an increased involvement of the community (Shrivastava et al., 2013), supervision and monitoring of the health workers, strengthening of existing infrastructure, expansion of healthcare facilities, partnerships with non-governmental organization and community-based organizations, collaboration with private sector physicians (Bhutta et al., 2012; IGME, 2015; Shrivastava et al., 2013), quality-assured antenatal care, advocating institutional delivery, training of healthcare staff in different aspects of newborn care, ensuring universal immunization (Thompson and Keeling, 2012; Uddain, Ritenour and Coonrod, 2013; Zhu et al., 2012), increasing awareness among the outreach workers/mothers about myths and misconceptions associated with pregnancy and infant care/danger signals in newborn requiring immediate referral/importance of maintaining hand hygiene/exclusive breastfeeding, and establishment of functional referral system, if implemented, can additionally assist in rapidly reducing and tackling child mortality (Bhutta et al., 2012; IGME, 2015; Mehal et al., 2012).

Planned implementation supplemented with continuous monitoring and timely evaluation of public health interventions at primary healthcare level can bridge the existing gap and thus the burden of child mortality (IGME, 2015). We must consider though that nothing is in isolation and to start tackling one challenge demands a ripple effect to ensure that no determinant and contributor of child mortality at any level is left unrecognized.

CHAPTER THREE
DATA AND METHODS

3.1 Introduction

This chapter discusses design and methodological approach explored to respond to the research questions raised. The primary objective of the study presented was to investigate the provincial differentials in under-five mortality in South Africa and the secondary objectives were to determine the factors that are associated with under-five mortality in South Africa. The first part of the chapter provides a brief description of the primary data source, which is the 2016 Community Survey (CS). This is done to provide a foundation for understanding the possible limitations of the study contained in the concluding section of the chapter. This chapter also provides a description of the study sample and variables that were investigated. The research design and method of data collection is also reviewed. The latter part of the chapter explores the different variables used to analyse the factors that are associated with under-five mortality as well as the methods employed in the analysis of the secondary data. The chapter concludes with an overview of the research questions that were used to guide the study.

3.2 Research design

This research will adopt a quantitative approach to estimating levels and determinants of child mortality in South Africa. Numerical data will be utilized to answer the structured research questions as posed in Chapter 1.

In natural sciences and social sciences, quantitative research is the systematic empirical investigation of observable phenomena via statistical, mathematical or computational techniques. The objective of quantitative research is to develop and employ mathematical models, theories and/or hypotheses pertaining to phenomena. The process of measurement is central to quantitative research because it provides the fundamental connection between empirical observation and mathematical expression of quantitative relationships. Quantitative data is any data that is in numerical form such as statistics and percentages (Babbie, 2010). Quantitative research is primarily concerned with demonstrating cause-effect relationships (Gunter, 2002). Quantitative methods emphasize objective measurements and the statistical, mathematical, or numerical analysis of data collected through a variety of methods such as questionnaires and surveys. This data can then be manipulated by using computational techniques. Quantitative research focuses on gathering numerical data and generalizing it across groups of people or to explain a particular phenomenon. Quantitative researchers try to recognize and isolate specific variables contained within the study framework, seek correlation, relationships and causality. Quantitative research allows for a broader study, involving a greater number of subjects, and enhancing the generalization of the results. Applying well-established standards means that the research can be replicated, and then analyzed and compared with similar studies. This can allow the researcher to summarize vast sources of information and make comparisons across categories and over time (Babbie, 2010)

The research employs two methods of inquiry which are explanatory and exploratory. The explanatory and exploratory quantitative design utilises the CS 2016 data to investigate the provincial differentials of under-five mortality in South Africa as well as the factors associated with under-five mortality in South Africa.

Explanatory research is an attempt to connect ideas to understand cause and effect so that researchers can explain what is occurring. Explanatory research investigates how things come together and interact. When using explanatory design, the researcher derives hypotheses from existing literature and employs statistical techniques in manipulating data to test the hypothesis. This will be further utilised to analyse numeric data (Maxwell and Mittapalli, 2008).

The choice to use quantitative explanatory design was made with consideration for two reasons. The first reason was that the topic's reference population is the under-five age category of South Africa and the result will allow for generalisation of findings. The second reason was based on the quest to explore factors associated with under-five mortality in South Africa with provincial differentials as an added focus. There was need to have a study design that would make it possible to both determine the levels of under-five mortality in South Africa and explain the factors that are associated with under-five mortality in South Africa.

The objective of exploratory research is to gather preliminary information that will help define problems and suggest hypotheses. It is conducted to determine the nature of the problem and provide a better understanding of the problem (Singh, 2007). Quantitative exploratory research relies on secondary research such as reviewing available literature and data, in this situation – the CS 2016. Exploratory research takes place when problems are in the preliminary stage and is utilised when the issue is new and when data is difficult to collect. Exploratory research is flexible and can address an array of research questions that are then used to generate formal hypotheses (Creswell, 2013).

Exploratory research intends merely to explore the research questions and does not intend to offer final and conclusive solutions to existing problems. In this research, we will explore the determinants of childhood mortality through the adoption of a multivariate analysis (Singh, 2007).

Exploratory research leaves room for further research. The choice to utilise exploratory research was made with the consideration of the objectives of the research, which are to explore the factors associated with under-five mortality in South Africa. Exploratory research is effective in laying down the ground work that will lead to future studies. Future researchers can explore a more qualitative approach to this objective as to why we are witnessing the observed levels (Babbie, 2010).

3.3 Data

3.3.1 Community Survey 2016

The demand for data at lower geographic levels continues to increase and in light of this the Community survey was initiated to bridge the gap between censuses in providing data at lower geographic levels in the country for planning purposes (Statistics South Africa, 2016b). The CS was first conducted in 2007 and is a large-scale household based survey aimed at providing reliable demographic and socio-economic data at local municipality level. Community Survey 2016 is the second largest survey undertaken by Statistics South Africa following the one conducted in 2007. The survey remains one of the main data sources that provide indicators at national, provincial and municipal levels for planning and monitoring the performance of specific development programmes such as education, health, sanitation, water supply, housing and transport. In addition, the survey provides demographic information critical in understanding population-development nexus. The CS 2016 bridges the data gap between Census 2011 and the upcoming Census 2021 (Statistics South Africa, 2016b).

The CS not only adds to the trend in data regarding socio-economic aspects but more importantly provides the latest evidence on the levels and differentials regarding demographic drivers (fertility, migration and mortality). The goal of CS 2016 is to provide indicators that will inform the implementation, monitoring and evaluation of development programmes for communities at local municipality level (Statistics South Africa, 2016b).

The key objectives of CS 2016 are:

- To provide an estimate of the population count by local municipality.
- To provide an estimate of the household count by local municipality
- The measurement of demographic factors such as fertility, mortality and migration.
- The measurement of socio-economic factors such as employment, unemployment, and the extent of poverty in households.
- The measurement of access to facilities and services, such as piped water, sanitation and electricity for lighting (Statistics South Africa, 2016b).

Eligible persons for enumeration are all persons present in the household(s) of the sampled dwelling units on the reference night (midnight 6th March 2016 to 7th March 2016) including visitors. Members of the household who were absent overnight, for example, working, travelling, at entertainment or religious gatherings but returned the next day were counted. For purposes of Stats SA a household is a group of persons who live together, and provide for themselves jointly with food and other essentials for living, or a person who lives alone (Statistics South Africa, 2016b).

The target population for CS 2016 is the non-institutional population residing in private dwellings in the country. The institutional and transient population is out of scope (OOS) for CS 2016. The OOS rate is defined as the proportion of DUs in which no eligible household was found to the total number of sampled dwelling units (including any additional DUs identified during data collection). Therefore, people who are homeless or those residing in hospitals, prisons; military barracks, etc. were ineligible for CS 2016. The types of institutions which were excluded from the CS 2016 sampling frame are inclusive of a non-residential hotel; hospital/ frail care-centre; old age homes; child care institution/ orphanage; boarding school hostel; initiation school; convent/ monastery/ religious retreat; defence force barracks/ camp/ ship in harbor; prison/ correctional institution/ police cells; community/

church hall (in cases of refuge for disaster) and a refugee camp/ shelter for the homeless (Statistics South Africa, 2016b).

CS 2016 is based on a single-stage sample design whereby all eligible Census 2011 enumerated areas (EA) were included in the initial frame and a selection of dwelling units (DU) within the eligible EAs was taken based on the sample design. EAs which do not include any DUs as part of the target population were excluded from the sampling frame, including those EAs with a very small number of eligible DUs. The EAs in the congested informal settlements were sub-divided into smaller parts called segments for ease of location and identification of structures during data collection. One or more segments were selected based on the required EA sample size. The dwelling units were then sampled from the selected segment(s) using the systematic sampling technique, and this resulted in a two stage design for EAs in the informal settlements (Statistics South Africa, 2016b).

The final sample size for CS 2016 was 1 370 809 DUs sampled from a total of 93 427 EAs in the country. Table 3.1 gives the distribution of the CS 2016 DU sample by province.

Table 3.1: Distribution of CS 2016 DU sample by province

Province	**Number of In-scope EAs**	**Number of Sampled DUs**
Western Cape	9 851	149 100
Eastern Cape	15 742	195 301
Northern Cape	2 742	36 125
Free State	5 595	83 645
KwaZulu-Natal	15 719	219 182
North West	6 726	102 120
Gauteng	19 022	331 125
Mpumalanga	7 197	105 058
Limpopo	10 833	149 153
South Africa	**93 427**	**1 370 809**

(Statistics South Africa, 2016b).

3.3.2 Study Sample

The research aim is to estimate levels of child mortality, nationally and provincially within South Africa, therefore even though the focus is on children the study population are the women of reproductive age (15 – 34 years) that have given birth to those children. The study sample obtained from the CS 2016 is 592 290 females of reproductive ages 15 – 34 years. This sample will then represent 10 074 770 of the female population of age category 15 – 34 within South Africa. Table is indicative of the number of cases and percentage value of the study population. Table 3.2 also provides the weighted values of the study population relative to the entire South African population.

The decision to restrict age categories of 15 – 34 was based on the premise that if we proceed further than age categories 30 – 34 we now venture out of analysing under-five mortality and include the mortality of children that are not under the age of five. This would take from the scope and focus of the research.

Table 3.2: Distribution of the study sample by age category

5 year age groups	Frequency	Weighted frequency	Percentage
15-19	152 118	2 549 139	25.68
20-24	153 085	2 643 461	25.85
25-29	150 868	2 614 246	25.47
30-34	136 219	2 267 924	23.00
Total	**592 290**	**10 074 770**	**100.00**

Own calculation from CS 2016

3.4 Estimation of the levels of childhood mortality

3.4.1 Children ever born /Children surviving method

The number of children that have died from those that have ever been born alive, expressed as a proportion, yields vigorous estimates of child mortality. The births to a group of women follow some distribution over time, and the time since birth is the length of exposure to the risk of dying of each person. The proportion dead among the children ever borne by a group of women will therefore depend on the distribution of the children by length of exposure to the risk of dying and upon the mortality risks themselves. By allowing for the effects of the distribution of the births in time, such a proportion of dead children can be converted into a conventional mortality measure expressing their average experience. The proportions of children dead classified by the mother's five-year age group can provide estimates of the probabilities of dying between birth and various childhood ages (United Nations, 1983).

The children ever born/ children surviving technique was developed by Brass (1975) and has evolved with each new refinement over the years (United Nations, 1983). This technique requires information on the number of women and the number of children ever born to women aged 15-49 years, by age of mother in five-year age groups (numbered 1 to 7), and the number of those children born to women in each age group who survived to the time of the survey and provide the information (Darikwa, 2009).

Brass was the first to develop a procedure for converting proportions dead of children ever born reported by women in age groups 15-19; 20-24; 25-29; 30-34; 35-39; 40-44 and 45-49 into estimates of the probability of dying before attaining certain exact childhood ages. An important assumption made in the development of this method is that the risk of dying of a child is a function only of the age of the child and not of other factors, such as mother's age of the child's birth order (United Nations, 1983).

One can use this method together with model life tables to determine mortality levels and trends over time. Mortality rates and trends can be determined using the Brass technique for a period of about ten years prior to the census or survey relatively well (Hill, 1991). The Brass technique has the advantage of not requiring women to recall exact date of death of their children and very little information is required to apply it. This method, which uses data of births and deaths of children over many years, is not as prone to sampling errors as with methods that make use of data over one year period (Hill, 1991). It should also be acknowledged that the estimate of infant mortality determined from young women is prone to sampling errors because they still have few births (Darikwa, 2009).

Estimation of child mortality using data classified by age

The type of input data needed is children ever born classified by five-year age group of mother; children surviving or dead classified by five-year age group of mother as well as women classified by five-year age groups (United Nations, 1983).

Computational procedure

The first step of the computational procedure is to calculate the average parity per woman. Parity *P*(1) refers to age group 15 – 19, *P*(2) to 20 – 24 and so forth.

$$P(i) = CEB(i) / FP(i) \qquad \text{[Equation 3.1]}$$

CEB(i) denotes the number of children ever born by women in age group *i*, and FP(i) is the total number of women in age group *i*. It should be noted that variable *i* refers to the different five-year age groups considered, thus the value *i* = 1 represents age group 15 – 19 and so on.

The next step is to calculate the proportion of children dead for each age group of mother. The proportion of children dead, D(i), is defined as the ratio of reported children dead to reported children ever born. If we denote the total number of women in age group *i* by *W (i)*, the number of children ever born to the women in age group *i* by *CEB(i)* and those children who died by *CD(i)* then the proportion of children dead, *D(i)* is given by:

$$D(i) = CD / CEB(i), \qquad \text{[Equation 3.2]}$$

An appropriate model life table is to be selected. The age pattern of child mortality has an important bearing on the translation of a proportion dead into a standard ${}_nq_0$, and on the translation of that ${}_nq_0$ into a common index such as U5MR. A perfect fit of the data to any model is unlikely; however, one should select the model that best represents the range of observations available.

The Trussell variant is described as the most successful model and these correction factors have been found to be superior to both Sullivan's and Brass's correction factors (Adegbola, 1977). This is because Trussell's correction factors make use of parities for the women aged 15-19(P1), 20-24(P2) and 25-29(P3), which cover a wider segment of the fertility experiences of the population. The correction factor for the Trussell variant of the Brass technique is given by:

$$k(i) = a(i) + b(i)\,(P(1) / P(2)) + c(i)(P(2) / P(3)), \qquad \text{[Equation 3.3]}$$

where *a(i), b(i)* and *c(i)* are coefficients derived from the Princeton West model life table.

Subsequent to this, probabilities of dying, q(x), are obtained from different values of exact age x as the product of reported proportions dead, D(i), and the corresponding multipliers, k(i). This is denoted by:

$$q(x) = k(i) \times D(i) \qquad \text{[Equation 3.4]}$$

Once q(x) is estimated, its complement l(x), the probability of surviving from birth to exact age x, is readily obtained by:

$$l(x) = 1 - q(x) \qquad \text{[Equation 3.5]}$$

The final procedure is to calculate the reference period. The reference period, t(x), is an estimate of the number of years before the survey date to which the child mortality estimates, q(x), obtained is referred to. The value of t(x) is estimated by means of an equation whose coefficients were estimated from stimulated cases by using linear regression.

$$t(x) = (i) + b(i)\,(P(1) / P(2)) + c(i)(P(2) / P(3)), \qquad \text{[Equation 3.6]}$$

where *a(i), b(i)* and *c(i)* are given coefficients from the Princeton West life table as determined by simulation and regression on the average parities as was done for multipliers (United Nations, 1983). An incorrect choice of the model life table will result in unreliable estimates. Additionally, the reliability of the estimates depends on the quality of the data. The period of the children's exposure to the risk of dying depends on the mother's age and any misreporting of a mother's age may result in biased mortality estimates being obtained.

Caveats and Warnings

Application of the method in populations with generalized HIV epidemics requires great care The age patterns of child mortality in South Africa have changed over the past decade due to the effects of HIV and use of model life tables will introduce bias that will need correcting. South Africa has one of the highest levels of HIV prevalence among women aged 15-49 years. The HIV epidemic compromises the validity of some of the assumptions of the Brass technique. HIV prevalence levels vary with the age of women and thus, the risk of children dying is now also dependent on the age of the mother (Darikwa, 2009).

The high mortality in HIV infected women might result in underreporting of births and deaths of children born to these women. Due to the fact that there is higher mortality in the children of the HIV infected women this results in underestimation of mortality rates for the given period (Blacker and Brass, 2005; Darikwa, 2009).

The assumption that the age pattern of mortality in the population can be represented by a standard model life table is also violated as HIV has caused changes in the age-specific mortality patterns for the young adults and the children. Thus the model life tables will not be appropriate for estimating the age specific mortality patterns of the HIV population and will result in the introduction of biases in the estimation of child mortality (Darikwa, 2009).
The estimated overall HIV prevalence rate is approximately 12,7% of the total South African population. The total number of people living with HIV is estimated at approximately 7,03 million in 2016. For adults aged 15–49 years, an estimated 18,9% of the population is HIV positive (Statistics South Africa, 2016c).

Approximately one-fifth of South African women in their reproductive ages are HIV positive. HIV prevalence among the youth aged 15-24 has declined over time from 7,6% in 2002 to 5,6 in 2016. The rate at which the population in South Africa is being infected is declining year on year from 1,77% in 2002 to 1,27% in 2016 (Statistics South Africa, 2016c).

Due to the factors mentioned above, adjusting childhood mortality measures is imperative in order to ascertain plausible estimates. The estimate used for the adjustment to the mortality figures with the incorporation of HIV prevalence will be the 2016 HIV prevalence amongst females of age category 15 – 49 which was established as 22.3% (Statistics South Africa, 2016c). The national estimate was utilised as it was the most recent estimate of HIV prevalence amongst women of ages 15 – 49, which is in alignment with the 2016 CS data set. Table 3.3 provides the estimates for 2002 to 2012 that will be utilised for the correction factors when applied to the HIV correction model proposed by Zaba (2009).

Table 3.3: HIV prevalence estimates for females of reproductive ages 15-49 in South Africa, 2002-2012

Year	**Women 15 – 49**
2002	19.6
2003	19.8
2004	19.9
2005	20.0
2006	20.1
2007	20.3
2008	20.5
2009	20.7
2010	20.9
2011	21.2
2012	21.5

Source: Statistics South Africa, 2016c

3.4.2 Correction for the influence of HIV

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

$$q(z)^t = q(z)^e + n(z) \qquad \text{[Equation 3.7]}$$

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

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

$$n(z) = aPREV + b(PREV)^2, \qquad \text{[Equation 3.8]}$$

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

$$n(z)=aPREV+b(PREV)^2 +cPREV15, \qquad \text{[Equation 3.9]}$$

where *PREV15* is HIV prevalence in women aged 15-19 years, expressed as a proportion and *a, b* and *c* are all the coefficients from the Princeton West model life table (Ward and Zaba, 2008).

3.5 Determinants of childhood mortality

3.5.1 Dependent variable

It is common amongst scientists and researchers to examine mortality as the dependent variable (Mosley and Chen, 1984). Ideally, measurement of factors influencing childhood mortality is best conducted by using event history models that are able to explore the effect of each covariate on the timing of childhood mortality. This however, is not possible with the CS 2016, since birth histories were not collected from women of reproductive ages. To circumvent this, another approach had to be explored. The dependent variable was determined using two measures, total children ever born and total children surviving.

Section F of the CS 2016 regarding fertility was asked only to females between the ages of 12 and 50 years in the sampled dwelling unit. The purpose of the fertility questions was to collect information on the country's current and lifetime fertility. Lifetime fertility is the number of children ever born alive during the entire reproductive period of the woman. All the fertility questions referred to the female's biological children (i.e. the children that the female had given birth to) (Statistics South Africa, 2016a).

The first step in investigating child mortality outcomes involves establishing how many total children were ever born alive to women of age groups 12 – 50. This referred to all children born to a woman, whether in or out of marriage, whether born in a present or a previous marriage or union, and whether living or dead at the time of the survey. Stillbirths (children born dead) are not included (Statistics South Africa, 2016a). This question was asked to females who had ever given birth:

How many children has *(name)* **ever given birth to that were born alive?**

Total children ever born must equal the sum of total children surviving and total children no longer alive. This question was asked to females who had ever given birth. Only biological children were included. The enumerator were instructed to include all biological children that were still alive, either still living in the household or adults, as well as children living elsewhere (Statistics South Africa, 2016a).

How many of (*name)***'s children are still alive?**

The collection of data was restricted to females in age categories 15 – 34 and who had a minimum of one child born alive and a maximum of eleven children born alive and equally still surviving.

Alternatively, one could use the question that refers to children no longer alive. This question was asked to females who had ever given birth. The enumerator was instructed to exclude stillbirths (i.e. children born dead) and miscarriages, and to include only biological children (i.e. children the female gave birth to) (Statistics South Africa, 2016a).

How many of (*name)***'s children are no longer alive?**

The manipulation of the above stated questions will allow for the retrieval of the dependent variable.

3.5.2 Independent variables

It is imperative to state that independent variables of interest are obtained at an individual level and these are the attributes of the mother. There is the assumption that the attributes of the mother (such as population group) is directly correlated to the attributes of the child (Maccoby, 2000).

For the purposes of the study, the Mosley and Chen analytical framework (Mosley and Chen, 1984) was used to distinguish between the independent and dependent variables. Based on this, the study aimed to establish whether a relationship exists between socioeconomic factors and child mortality. Other factors that could have affected the relationship between socioeconomic status and child mortality are included in the statistical model analysis. The key independent variable is province. Other explanatory factors that were included in data analysis were population group, SES, level of educational attainment and urban/rural residence. Table 3.4 below shows summary statistics of the distribution of the study sample for each independent variable.

Table 3.4: Demographic distribution of the study sample for each independent variable

		Age category			
Demographic	**Sub-category**	**15 – 19**	**20 – 24**	**25 – 29**	**30 – 34**
Education	Primary	203 785	98 707	122 724	141 566
	Secondary	2 280 700	2 221 582	2 059 703	1 729 982
	Tertiary	26 462	239 468	332 460	295 388
Race	Black/African	2 140 964	2 227 495	2 218 969	1 881 981
	White	143 231	149 321	142 083	140 375
	Indian/Asian	48 322	52 797	55 867	57 911
	Coloured	216 622	213 849	197 328	187 658
Place of Residence	Urban	1 422 167	1 643 029	1 703 554	1 509 937
	Rural	1 126 972	1 00 432	910 693	757 987
Socioeconomic Status	Low	590 627	592 416	539 292	438 539
	Middle	1 254 188	1 319 161	1 308 083	1 093 773
	High	460 061	473 856	510 203	516 188
Province	Northern Cape	57 261	53 071	52 412	48 474
	Eastern Cape	391 116	352 277	312 803	270 204
	Western Cape	249 027	280 915	275 584	254 717
	Limpopo	327 589	295 256	275 518	234 087
	Mpumalanga	210 042	214 364	218 769	178 800
	Free State	134 975	134 987	137 013	121 229
	KwaZulu – Natal	538 265	543 645	529 822	446 915
	Gauteng	470 345	601 422	645 173	564 309
	North West	170 518	167 526	167 153	148 469

Weighted : Own calculation from CS 2016

3.5.2.1 Key independent variable: Province of residence

South Africa has nine provinces, which are Western Cape, Eastern Cape, Northern Cape, Free State, KwaZulu-Natal, North West, Gauteng, Mpumalanga and Limpopo. The provinces have different levels of development and growth. Children from more developed provinces that have more available healthcare facilities have a better chance of survival than those children from less developed provinces (Meintjes and Hall, 2010). Province is a key independent variable in this study. It should be noted that the other variables are control variables. This will enable the data analysis to isolate the impact of socioeconomic status by province to paint a clearer portrait of provincial estimates of under-five mortality.

The CS 2016 asks respondents:

In which province does name usually live?

3.5.2.2 Mother's Education

Education is one of the most important components of human development as it sets the foundation for other interlinking aspects. Individuals with a higher level of education are more likely to engage in health-promoting behaviour and lifestyles, have higher employability and better economic conditions (Cutler, 2007; Sanchez-Vaznaugh, et al., 2009). Quality education encourages technology shifts and innovation that are necessary to solve present-day challenges. Through education, individuals are prepared for future engagement in the labour market, which directly affects their quality of life as well as the economy of the country. This implies that schools are the building blocks for the learning and socialisation (Statistics South Africa, 2012).

According to Caldwell and McDonald (1982), it is suggested that schooling introduces parents to a global culture, principally of Western origin, which weakens their ties to traditional cultures. It is evident that schooling conveys a new family system in which women and children are allocated higher priorities in terms of healthcare and in which parents can make decisions about health and childcare without reference to their elders (Caldwell and McDonald, 1982).

The CS 2016 asks: *What is the highest level of education that (name) has successfully completed?*

This variable can be further categorised and recorded as no schooling, primary education, secondary education or tertiary education.

3.5.2.3 Place of residence/ Rural-urban

Place of residence can have a significant impact on the health status of individuals. It often determines access to health care, resources, and living conditions and so on (Kuate-Defo, 2006). For instance rural areas are often associated with poor infrastructure, poor living conditions and poor sanitation services in comparison to the urban areas (Hallman, 2005). On average, child health outcomes are better in urban than in rural areas of developing countries (Van de Poel et al, 2008). In South Africa this is divided between rural, metropolitan and urban as well as non-metropolitan areas, disaggregated by province.

3.5.2.4 Race/ Population group

Population groups within South Africa are divided into four categories, which are African, Coloured, Indian/Asian and White. There are observed variations between race and childhood mortality therefore deriving at the conclusion to include population group/ racial category for analysis (Chitiga et al, 2010).

The demographics section of the CS 2016 asks:

What population group does (name) belong to?

This question was asked to determine the population group of all persons in the household. Enumerators were instructed to ask everyone in the household, even if the population group may seem obvious, and not to assume. They also had to note that this was a sensitive question to some respondents who would not want to identify themselves according to any population group.

During the phase of data editing, the variable population group was coded into four categories. These were Black African, Coloured, Indian/Asian, and White. The question was asked even when the population group of a person seemed obvious (Statistics South Africa, 2016a).

3.5.2.5 Socioeconomic status

Socioeconomic status (SES) is commonly conceptualized as the social standing of an individual or group. It is often measured as a combination of education, income and occupation (Bradley, 2002). SES is concerned with individuals, families and or household's capacity to create and consume goods that are valued by society (McIntosh and Zey, 1989). It is well documented that wealth differences amongst households have an impact on child related outcomes (Houwelling, Kunst and Mackenbach, 2003) as indicated in Chapter 2, therefore the data analysis will be inclusive of controlling for SES. Households will be classified into three categories namely low, medium and high. Household variables will be determined using principal component analysis (PCA), which is discussed below.

Principal Component Analysis

There has been an increased concern about the broad influences of socioeconomic factors on child health in the developing world (Thomas, 2007).

Like most studies on health and socioeconomic status in relation to child mortality, Hill and Pebley (1989) have argued that declines in child mortality in past decades could be attributed to general socioeconomic change. This is guided by Mosley and Chen's (1984) framework that speculates that child survival is positively associated with socioeconomic status.

While occupation, educational levels, and incomes have been important measures of socioeconomic status in the past, recent studies have attempted to devise new measures of socioeconomic status based on indices derived from proxy variables (Montgomery et al, 2000). It is evident from an array of literature, more and more researchers throughout the world are adopting the PCA method in relation to child mortality (Godson and Nnamdi, 2012; Singh et al., 2011; Wagstaff, 2003; Welaga et al., 2013).

PCA is a useful statistical technique that is commonly utilised for finding patterns in data of high dimensions. The rationale of the usage of PCA stems from the literature that suggests that the quality of the housing structure and the amenities that the household possess is a good measure of the living standard of the household as several studies have found a high correlation between household income and asset indices (Montgomery et al., 2000).

PCA is a statistical technique that linearly transforms an original set of variables within a data set into a substantially smaller set of uncorrelated variables that represents most of the information in the original data set (Dunteman, 1989). PCA is used to reduce the dimensionality of original data set while retaining its variation as much as possible (Dunteman, 1989; Jollife, 2002).

The PCA method transforms a large number of variables into one measure, forming a smaller number of uncorrelated factors that preserve information from these variables (Filmer and Pritchett, 2001).

The method is a multivariate technique that analyzes a data table in which observations are described by several inter-correlated quantitative dependent variables. Its goal is to extract the important information from the table, to represent it as a set of new orthogonal variables called principal components, and to display the pattern of similarity of the observations and of the variables as points in maps (Abdi and Williams, 2010). The retention of the variation in the components is achieved through the techniques ability to assign weights to the original variables and the components that are then created explains the variation in the original variables The first component is the linear composite of the variables combined and is calculated as:

$$y_1 = a_{11}\, x_{1j} + a_{12}\, x_{2j} + \ldots. + a_{1k}\, x_k = \sum a_{1n}\, x_{ni} \qquad \text{[Equation 3.10]}$$

Where x_{1i} is the variable *i* for household *j*, and are factor loadings (linear coefficients) for the component n and variable *i*. The principal component analysis extracts factor loadings from n components, and generates scoring factors, which are weights applied to the variables normalized by their means and standard deviations (Filmer and Pritchett, 2001).

The index was created using five variables indicating whether a household has access to water, a flush toilet facility, energy/electricity and household goods such as fridge and motor vehicle.

Access to water

Information on access to water was collected using the question '**What is the household's MAIN source of water for drinking?**' Water source was divided into those that had access to piped water and those that did not for PCA. Piped water refers to water obtained from pipe inside the dwelling, outside the dwelling but in the yard, and from an access point outside the yard. Water source was included in the analysis as there is a significant relationship between source of water and socioeconomic status as access to water is a predictor of SES (Dungumaro, 2007; Klasen, 2000). As households in the lowest income census tracts have no access to piped water (Evans and Kantrowitz, 2002).

Toilet facility

Toilet facility included in PCA was indication whether a household had a flush toilet connected either to sewerage system or to a septic tank. Data on toilet facility was obtained using the question '**Which is the main type of toilet facility available for use in this household?**'. Poor children are more exposed to risks of disease through inadequate sanitation which is a direct pathway to a higher exposure of disease vectors (Nattey, Masanja and Klipstein-Grobusch, 2013).

Source of energy

The CS 2016 collected data on energy sources that households utilise. The question that was asked is **'Does the household use the following energy sources?'.** All households that used electricity were considered as electricity fuels purposes such as heating, cooking and lighting. Energy source was classified into those households that had access to electricity and those that did not. The decision to incorporate electricity into the PCA is because electricity is affordable to only a minority of households especially within rural areas (Kahn et al., 2007a).

Household goods: fridge and motor vehicle

CS 2016 collected data about the ownership of household goods and from the available data three household goods were included in the PCA. These are fridge, television and internet facilities. The survey asked '**Does the household own any of the following in working order?**' Fridge and motor vehicle were retained because of the high factor loadings when PCA was initially run for the household variables. The decisions to retain such variables were also based on the affordability of these goods. Access to a motor vehicle has important implications for child survival especially if it entails emergency situations whereby travel to a hospital or healthcare facility is needed.

Table 3.5 below gives a detailed account of the variables used when generating PCA. The output from PCA is a table of factor scores or weights for each variable. Generally, a variable with a positive factor score is associated with higher SES, and conversely a variable with a negative factor score is associated with lower SES. Using the factor scores from the first principal component as weights, a dependent variable can then be constructed for each household (Y1) which has a mean equal to zero, and a standard deviation equal to one. This dependent variable can be regarded as the households 'socio-economic' score, and the higher the household socio-economic score, the higher the implied SES of that household (Vyas and Kumaranayake, 2006). Interpreting the weights from our example, an urban South African household with more assets, piped drinking water to residence, flush toilet facility that leads to a sewer and access would attain a higher SES score. The variables were chosen over other variables available in the dataset due to the high factor loadings that these variables retained.

Table 3.5: Factor scoring from SES indices generated using PCA

	Factor loadings	**Factor Scores**	**Mean**	**SD**	**FS/SD**
Has pipe water	0.5233	0.2471	0.8747	0.3311	0.7463
Has flush toilet	0.6942	0.3278	0.5683	0.4953	0.6618
Has electricity	0.7250	0.3423	0.9116	0.2839	1.2058
Has refrigerator	0.7601	0.3589	0.8075	0.3942	0.9104
Has a motor vehicle	0.5086	0.2401	0.8087	0.4494	0.5343

Own calculation from CS 2016

3.6 Modelling

The application of a negative binomial regression analysis will be used to understand provincial differentials in child mortality controlling for relevant factors (Brockerhoff and Hewett, 2000). These factors are indicated in the framework proposed by Mosley and Chen (1984). Socioeconomic determinants will be categorized into the individual level, taking into consideration educational attainment and skills; the household level that will examine income and wealth. Accompanying this will be the scrutiny of proximate determinants such as sanitation and access to basic services (Mosley and Chen, 1984).

As assumed for a negative binomial model the response variable, or dependent variable, is a count variable therefore the negative binomial model, as compared to other count models is assumed to be the most appropriate model. It is assumed that the dependent variable is over-dispersed and does not have an excessive number of zeros (Lawless, 1987).

In negative binomial regression, the mean of *y* is determined by the exposure time *ti* and a set of *k* regressor variables (the *x's*). The expression relating these quantities is

$$\mu i = exp\ (\ln(ti) + \beta 1x1i + \beta 2x2i + \cdots + \beta kxk\mathrm{i}) \qquad \text{[Equation 3.11]}$$

Often, $x1 \equiv 1$, in which case $\beta 1$ is called the *intercept*. The regression coefficients $\beta 1$, $\beta 2$, …, βk are unknown parameters that are estimated from a set of data. Their estimates are symbolized as $b1$, $b2$, …,bk (Cameron and Trivedi, 2001; Fitriyah et al., 2015).

Alternatively, a logistic regression will also be utilised for comparison of the data produced against the negative binomial model. A logistic regression is a statistical method for analysing a dataset in which there are one or more independent variables that determine an outcome. In the logit model the log odds of the outcome is modeled as a linear combination of the predictor variables (Hosmer and Lemeshow, 2000). The outcome is measured with a binary variable. A binary variable is one that has only two possible outcomes. Binary or binomial logistic regression is the form of regression, which is used when the dependent variable is dichotomous, and independent variables are any type (discrete and continuous). The dependent variables can take probability of success ‘p’ and ‘1-p’probability of failure (Reddy and Alemayehu, 2015).

Since the model is used to test the association of the two variables, we used odd ratio

$$\text{Logit} = \log \left[\frac{P}{1-P}\right] = \exp\ (\ \beta1 + \beta2\ \ X1 + \beta2X2 + \ldots .. + \beta k\ XK) \qquad \text{[Equation 3.12]}$$

where P represents the probability of no death; 1-P is the probability of a death; β0 is the constant term; x1, x2 ….xk are the independent variables and β1, β2 …βk is the coefficient of independent variable. The ratio of probability success to probability of failure is P/1-P is odd ratio (Reddy and Alemayehu, 2015).

The Statistical package used to analyse the data is STATA version 13. The analysis is undertaken on a multivariate analysis which determines the relationship between the dependent variable and the independent variables. The proportion of children dying will be used as the exposure variable. A multivariate analysis involves the observation and analysis of more than one statistical outcome variable at a time. The technique will be used to explore the relationship between under-five mortality and the determinants of child mortality at a provincial level.

3.7 Limitations of the study

From the chosen method, one cannot expect more than a rough estimate of the level of child mortality from questions on survival of children. Demographers often compute levels of mortality from estimates of Q*(x)* and model life tables. The estimates produced from model life tables fall close to the true value of life expectancy in general. This reinforced the adoption of indirect methods of estimation for child mortality (Garenne, 1982).

The data source for this study, the CS 2016, primarily collected data for objectives different from this study. In relation to child mortality, only some selected socioeconomic and demographic factors are considered. In addition, biological causes of child deaths are not within the scope of the study. A variety of other procedures can be used to measure and scale the proximate determinants of child survival, ranging from sophisticated biological analysis of environmental and food specimens, to medical examination of children, to visual observations of the environment in which these children reside in. Some methods are more precise than others, but not necessarily better for population-based research. Collection of qualitative data may have provided such information however; it is difficult to do so for a nationally representative sample.

3.8 Summary

The purpose of this chapter was to describe the research methodology and variables used in the study and provide an explanation of the procedures used to analyse the secondary data**.** The quantitative methods of enquiry were discussed as well as the background and study sample provided by the 2016 CS. Using the 2016 South African Community Survey in alignment with specific statistical tools (multivariate analysis), the researcher will be able to investigate whether a relationship exists between under-five mortality (dependent variable) and different socioeconomic factors (independent variable).

CHAPTER FOUR

RESULTS

4.1 Introduction

Estimates of the levels in infant and under-five mortality rates were derived from the South African 2016 CS. The family of model life tables of interest for this dissertation were the Princeton model life tables. It was evident that the Princeton model life tables did not dramatically alter the estimates of child mortality that were produced. The estimates were produced using indirect methods as well as the Princeton West life table. The utilisation of the model like table allowed for the production of child mortality rates as well as reference dates in infant and under-five mortality. This chapter presents these results. The first section presents differentials in proportions of children dead by the various independent variables. The second section presents indirect estimates of infant and child mortality as well as the corrected HIV results. In addition to this, estimates produced from this research are compared against other existing literature. The final part of this chapter displays the results obtained from the multivariate analysis.

4.2 Differentials in proportion of dead children among those ever born

South Africa holds a rich background of historical events that have continually had an influence on the current challenges that we continually endure, such as child mortality. Child mortality has been directly influenced by past inequalities that have brought rise to the variations that one can currently observe from the levels of child mortality. These manifest themselves disaggregated estimates by key independent variables such as race, place of residence, educational attainment and socioeconomic status. This section discusses variations in proportion dead of children ever born by important indicators that represent the population of South Africa. Of importance for this study are variations in socio-demographic and socio-economic differentials.

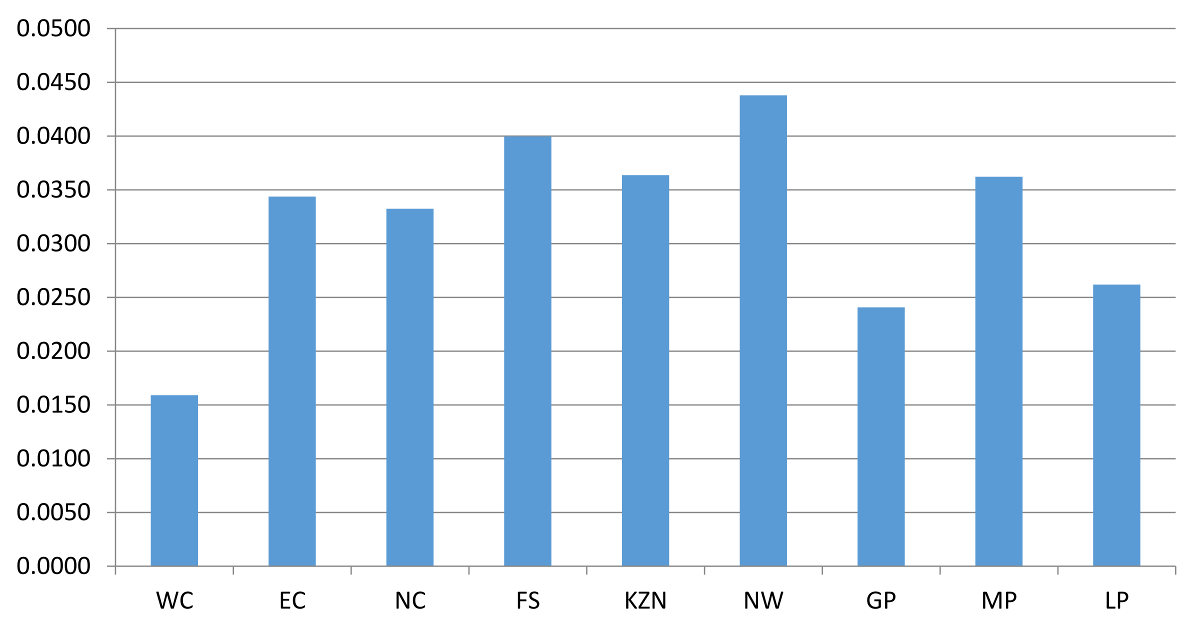
The South African 2016 CS asked questions from women of reproductive ages on total children born alive and total children surviving prior to the CS. This data was captured in the person file. These data are used to determine estimates of child mortality at national and provincial levels. There is a total of 8 481 425 total children ever born alive to 10 074 774 women in reproductive ages categories 15 – 34 of which 8 219 138 have survived and 262 286 have died. These figures are represented in Appendix A as weighted totals. Additionally, in Appendix A are the weighted totals for the female population aged 15 – 34, total children ever born alive, total children surviving and total children dead to explore differentiations in female age category, female educational attainment, place of residence, province of residence and socioeconomic status by proportion dead of children ever born.

4.3 Socio-demographic differentials

4.3.1 Province

South Africa as a country is divided into nine provinces, each with its own inequalities, challenges and encounters. It is evident from existing literature that each province struggles with its own trials in alleviating child mortality. Trials and challenges that are long ranging from access to basic services to mere standards of living (Coovadia, 2009). It is observable from the results produced from the CS 2016 that there are existing differentials in proportion dead of children ever born disaggregated by province. As per Table A7 in Appendix A, the North West has the highest estimation of proportion dead of children ever born. This value is estimated at 0.0438, followed by 0.0398 for the Free State and 0.0364 for KwaZulu-Natal. These three provinces have the highest estimations of proportion dead of children ever born as compared to other provinces that have significantly lower estimations. The Western Cape has the smallest proportion dead of children ever born estimated at 0.0159, closely followed by Gauteng that has an estimation of 0.0241. These estimates are much lower than the national estimation, calculated at 0.0309 for proportion dead of children ever born.
These results are captured graphically in Figure 4.1 below. The variation by province are reflective of the high inequalities that are existing within South Africa.

Figure 4.1: Proportion dead of children ever born by province, 2016

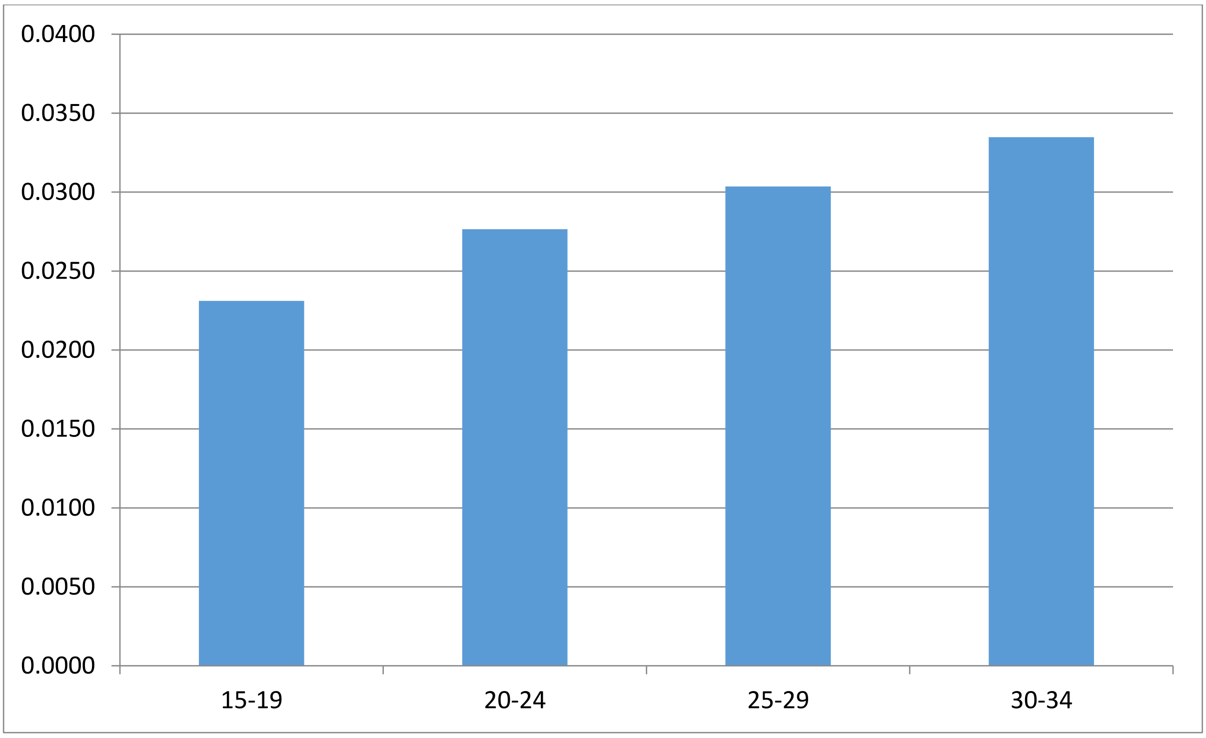


Own calculation from CS 2016

4.3.2 Current age of female

From Figure 4.2 below it is clear that proportion dead of children ever born increase with the age group of mother as expected. As displayed in Appendix A, Table A22 displays the successive increases in proportions dead of children ever born. Age category 15-19 years old has the lowest estimated value of *D(i)* of 0.0231; age category 20-24 has a notable increase of 0.0044, estimated at 0.0277; closely followed by 0.0304 for age category 25-29 and lastly at the largest estimation of 0.0335 for age category 30-34. The portions rise successively with each age category with age category 15-19 accumulating the lowest proportion dead of children ever born and age category 30-34 accumulating the highest proportion dead of children ever born. The higher proportion dead of children ever born for women age 30 - 34 is merely a function of high exposure to child death due to a female's lifetime fertility. Additionally, the proportions dead of children ever born should rise by age category as women are choosing to delay their first birth and the peak age of child bearing is in the 20-24 age group (Udjo, 2014).

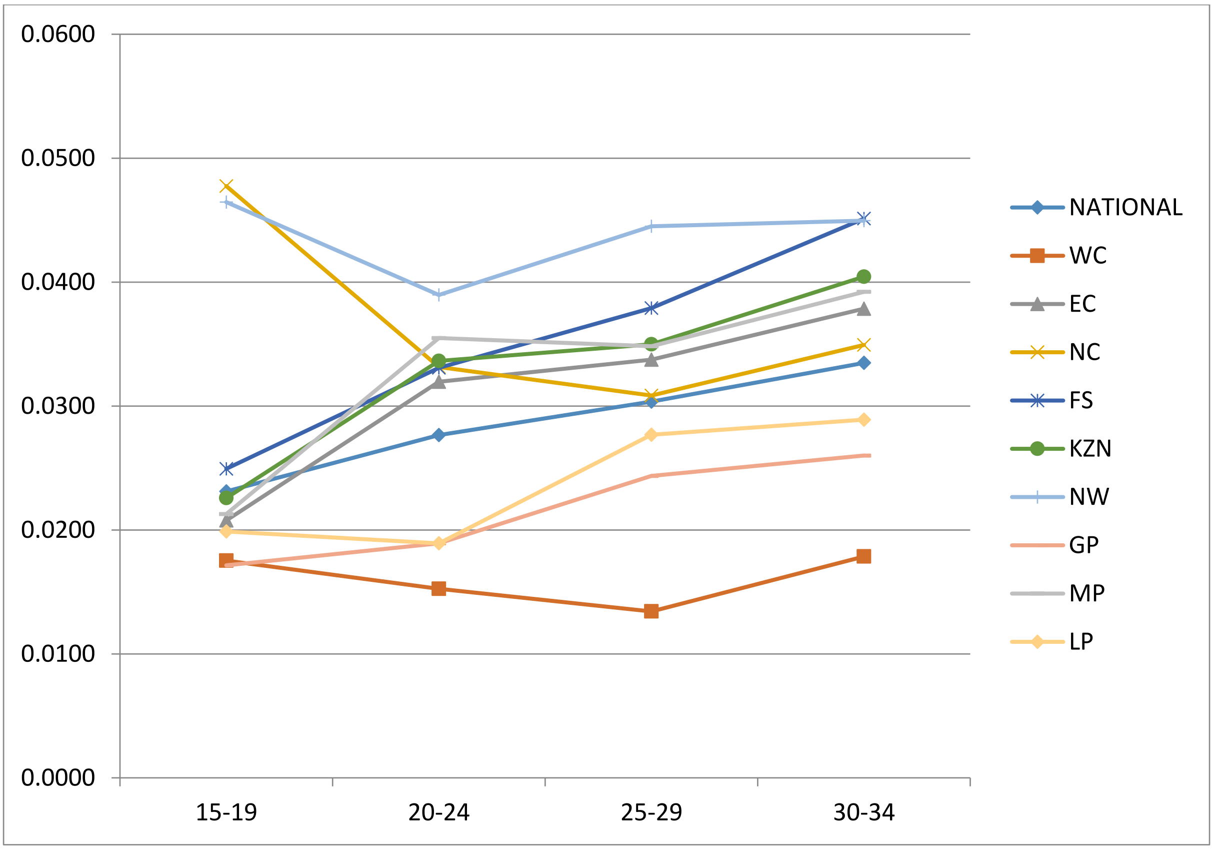
Figure 4.2: Proportion dead of children ever born by females of reproductive age categories in South Africa, 2016



Own calculation from CS 2016

Figure 4.3 below displays the proportion dead of children ever born by province and age categories 15-34 of females in reproductive ages. The North West and Northern Cape depict deviant patterns from the rest of the provinces as there is a higher proportion dead of children ever born in age category 15-19 than there is in 20-24. This can be expected as many studies suggest that age categories 15-19 produce estimates that are unreliable and generally deviant (United Nations, 1983). The Western Cape displays the lowest proportions dead of children ever born, successively declining from age categories 15-19 to 25-29 before inclining again to age category 30-34. This is merely a function of higher exposure to child death as per one's lifetime fertility experiences. The rest of the provinces, such as KwaZulu-Natal, Gauteng and Limpopo, displays similar patterns of successive increases in proportions dead of children ever born by age category. These patterns are similar to the national pattern.

Figure 4.3: Proportion dead of children ever born in South Africa by female age categories and province, 2016

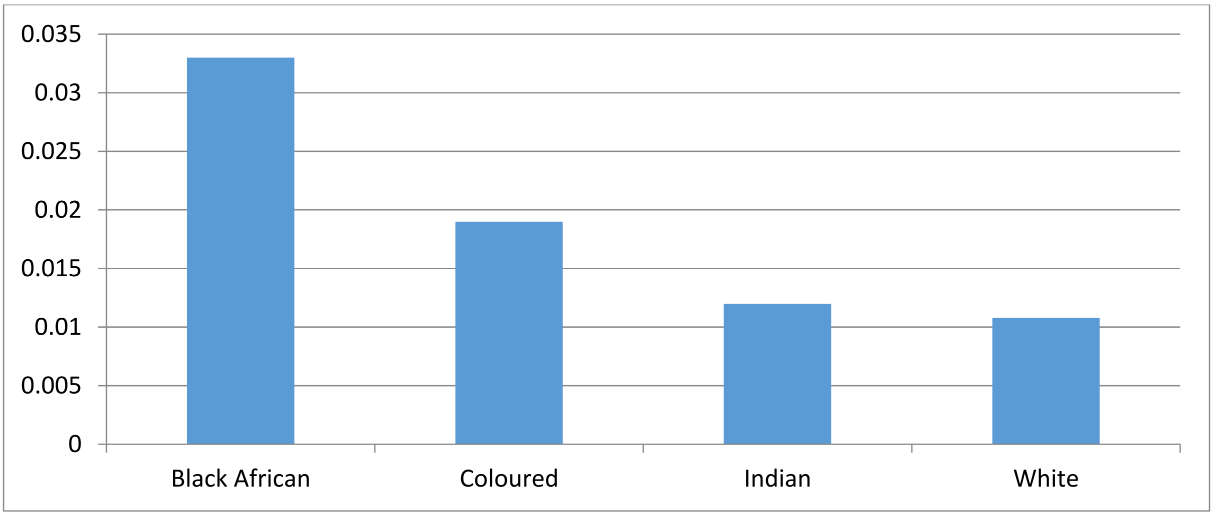


Own calculation from CS 2016

4.3.3 Population group

As observed from other studies within South Africa that have considered race in alignment with child mortality (Worku, 2011), it is evident that the Black African population group experiences higher deaths of children amongst those born alive in comparison to all other population groups. This is confirmed in Figure 4.4, where we observe higher proportions of children dead of those ever born to African women compared to Whites and Coloureds. Even though the White and Indian racial groups had significantly smaller sample sizes, they were still included in the analysis to depict variation. However, it should be acknowledged that as per table 3.4, in the methods chapter, the sample for the White population was relatively smaller therefore; the estimates disaggregated by population group might be subjected to random fluctuation. Estimates of proportion dead of children ever born by population group presented in Figure 4.4 are ranked as expected, with the highest rates among the Black Africans followed by the Coloured, Indian and White population groups, in that order. It is evidently clear that racial differences in childhood mortality still exist in South Africa. The African population group indicates a higher proportion dead of children ever born. This estimation is approximately more than twice as high as compared to the White and Indian population groups.

Figure 4.4: Proportion dead of children ever born by population group in South Africa, 2016

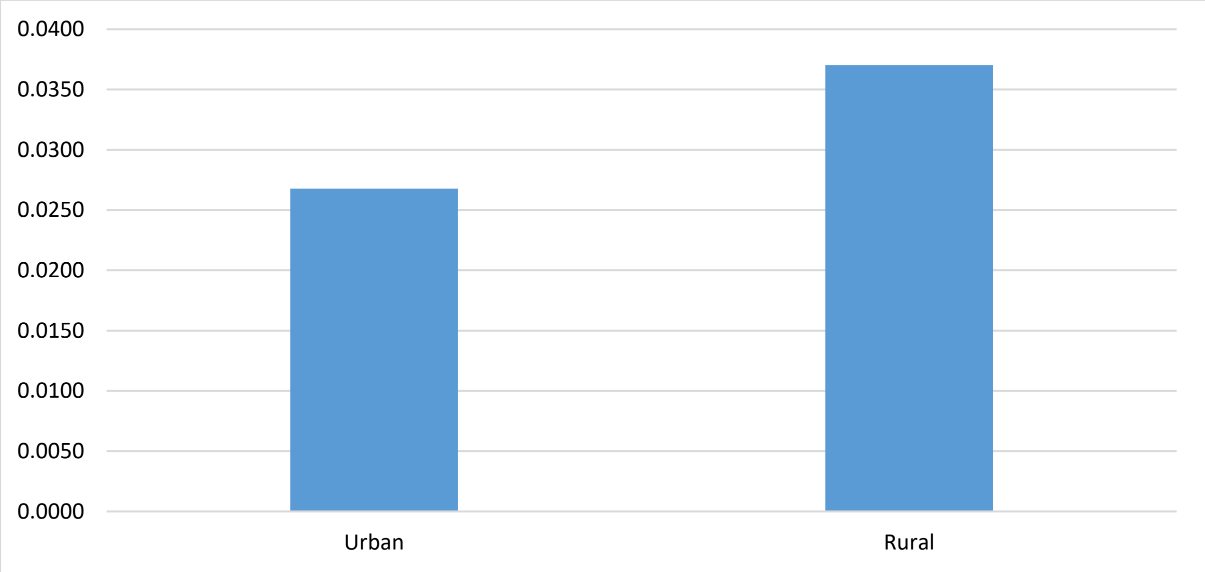


Own calculation from CS 2016

4.3.4 Place of residence

The variation by place or residence confirms that rural women experience higher mortality for their children compared to those that reside within urban areas. Females that resided within urban areas yielded a larger estimation, 0.0268, as compared to those that resided in rural areas, 0.0370, of proportions dead of children ever born. This is presented in Figure 4.5 below. These variations can be attributable to access to healthcare facilities and services as well as other characteristics that are associated with rural areas such as a higher poverty levels and a lower income threshold that are direct determinants of the affordability and access to healthcare services (Kickbusch, 2011).

Figure 4.5: Proportion dead of children ever born by place of residence in South Africa, 2016



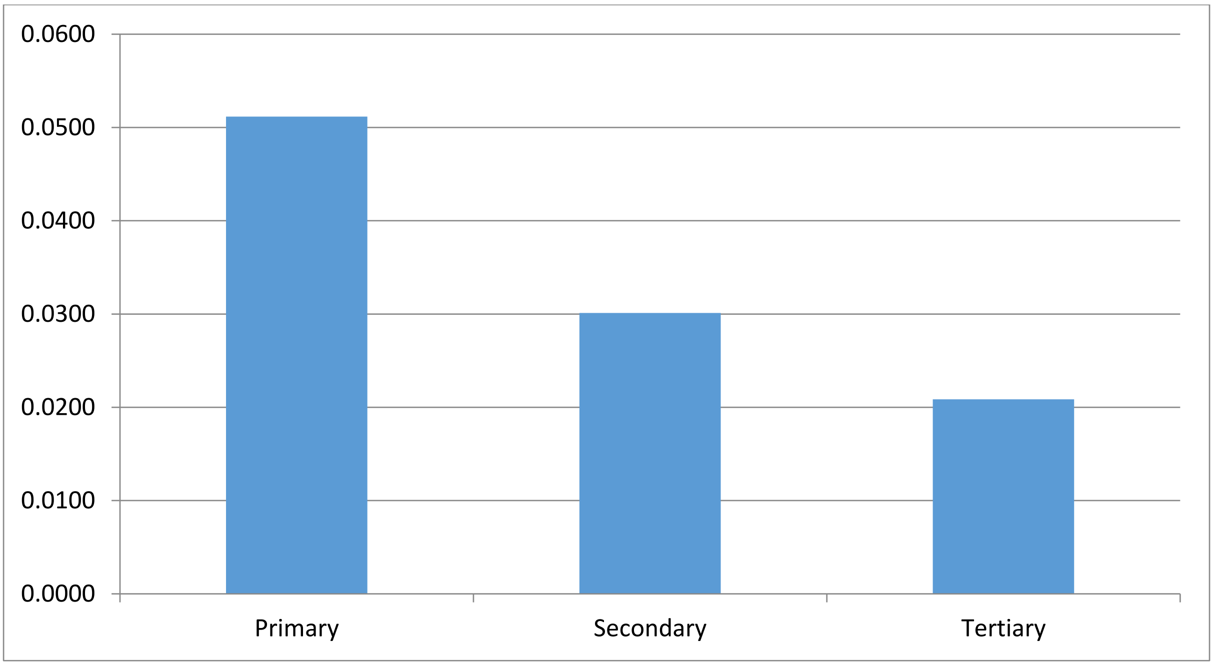
Own calculation from CS 2016

4.4 Socio-economic differentials

4.4.1 Educational attainment

Education plays a vital role in many arenas of life, especially mortality. This is reinforced by the notion that indicates that the more educated one is, the more likely they are to adopt preventative and life-saving measures. This is strengthened by ones acquired knowledge and exposure to educative measures (Rosenstock, 2005). Also, more educated people are more likely to adopt new medical technologies and purchase better healthcare (Lleras and Lichtenburg, 2002). Child mortality by educational attainment as shown in Figure 4.6 is indicative that women with lower levels of education have higher proportions dead of children ever born. This distribution confirms that educational attainment is equally important in the outcome of child death. It may not necessarily be the attainment of a higher educational status that is a direct relay to child mortality. As noted the variation from secondary to tertiary is significantly lower but not extremely deviant as the variation from primary to secondary. Basic literacy skills play a vital role in facilitating the reduction of child deaths. This because a mother may easily communicate health difficulties that a child is experiencing that can prevent death (Das Gupta, 1990).

Figure 4.6: Proportion dead of children ever born by educational attainment in South Africa, 2016



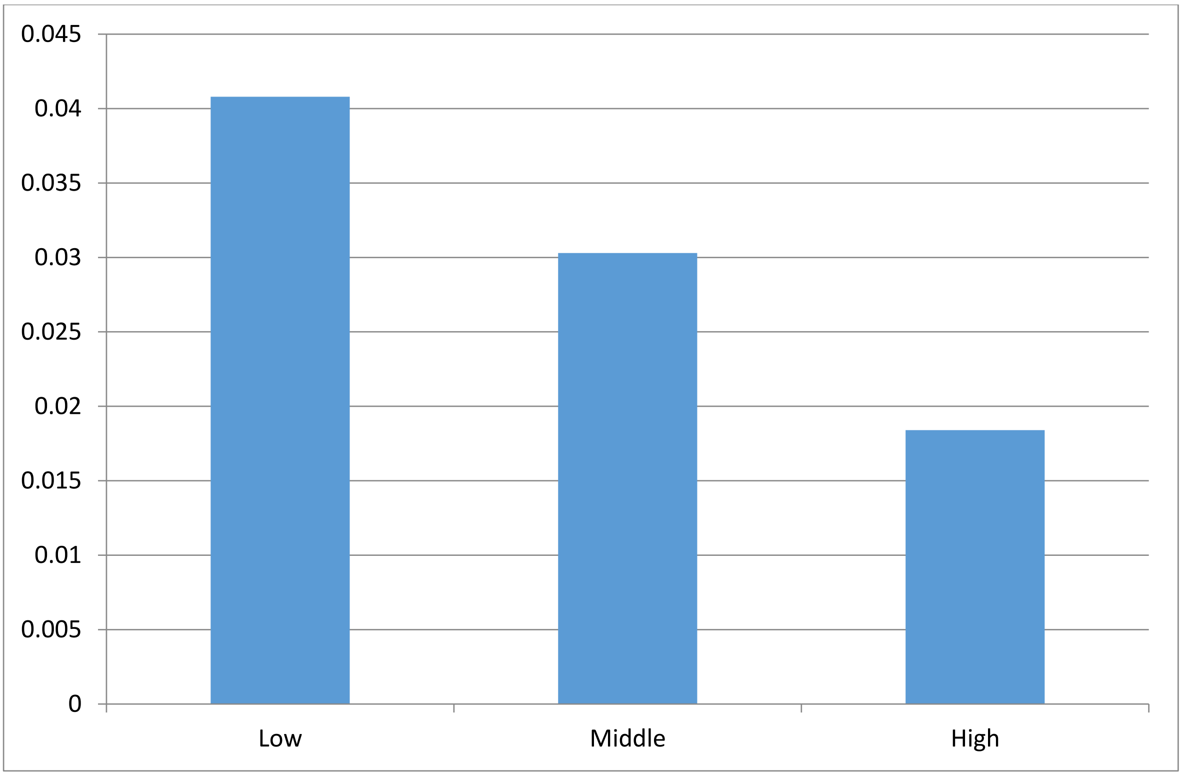
Own calculation from CS 2016

4.4.2 Socioeconomic Status

Individuals that reside in households may have a tendency to over and under-report true income levels, therefore using total income earned per household may not represent a true reflection of socioeconomic status and results may be biased (Smith, 1995). Instead of utilising income, a SES index is generated that takes into consideration the attainment of household assets and goods that will reflect the status of the socioeconomic status of the household.

Figure 4.7 depicts notable variations in proportion dead of children ever born by socioeconomic status irrespective on how this is measured. The indices have been categorised into low, middle and high for ease of interpretation of the results. As expected, households with a higher SES attainment has a lower proportion dead of children ever born, estimated at 0.0184 than households with medium SES estimated at 0.0303. Households with the lowest SES attainment have the highest proportions dead of children ever born estimated at 0.0408.

Figure 4.7: Proportion dead of children ever born by SES in South Africa, 2016



Own calculation from CS 2016

4.5 Child mortality estimates from the 2016 South African CS

According to the numerous collections of literature, it is evident that child mortality has been decreasing progressively within South Africa (Kahn et al., 2007b). To demonstrate and reinforce this, indirect methods of child mortality estimation was utilised.

The method utilised to produce estimates of childhood mortality from the 2016 CS was the Trussell variant of the Brass technique for indirect estimation (United Nations, 1983). The details of the methods are presented in Chapter three. Estimates from the method are presented in the subsection below. The under-five mortality rates that correspond to the infant mortality rates estimated using the Brass technique were estimated using the ratio of $q(5)$ / $q(1)$ from the Princeton West level model life tables. The Princeton West level model life table was chosen as they have a similar shape (rates by age) of mortality to that of South Africa.

4.5.1 Mortality estimates from the Brass technique

The implied infant and under-five mortality rates presented in Table 4.1 below were derived using the Princeton West model life table. Table 4.2 presents the IMR and U5MR obtained from the analysis for South Africa, disaggregated by province. Derived from Table 4.1, Table 4.2 only considers age categories 20-24 and 25-29 when producing estimates of IMR and U5MR. When these estimates are adjusted, by restricting the age category of the study population and by restricting the total number of children ever born alive and total number of children still alive to 7, the estimates produced are in alignment with estimates produced from previous research and studies (Udjo, 2014). In addition to this, the consideration of these age categories was also based on the premise that age categories 15-19 produce unreliable estimates; ages 35 and above venture out of estimates of under-five mortality as children are now past the age threshold of 5 (Brass, 1975; United Nations, 1983) and finally because the fertility pattern of females within South Africa have changed over time. There has been a notable difference in fertility patterns within South Africa (Brass, 1975; Moultrie and Timeaus, 2003). For various reasoning females are now delaying first birth, therefore they are most likely to have their first birth in age categories 20-24 and 25-29.

From Table 4.1, age category 20-24 is denoted by age(x) 2 and age category 25-29 is denoted by age(x) 3, it is evident that all indirect estimates of child mortality as well as the IMR and U5MR increase between age categories 20-24 to 25-29. All except Gauteng that displays a decline between age 2 and 3. Gauteng has an IMR of 14.9 per 1000 live births for age category 20-24 as compared to 10.5 per 1000 live births for age category 25-29 and a U5MR of 10.5 per 1000 live births for age category 20-24 as compared to 14.9 per 1000 live births for age category 25-29. This reveals that there are more experiences of child death in age category 20-24 than there are in age category 25-29. The Western Cape, the province with a very low estimate of IMR and U5MR, has a small but notable incline in the IMR for age category 20-24 (12 per 1000 live births) and age category 25-29 (15.1 per 1000 live births. Likewise for the U5MR where there is a smaller increase between age category 20-24 (17 per 1000 live births) and age category 25-29 (21.4 per 1000 live births). The other provinces have higher estimates of IMR and U5MR particularly for categories 25-29. There are significant variances between the provinces and age categories that should be highlighted. The Northern Cape and Limpopo have the highest estimates of U5MR for age category 25-29 in comparison to the national estimates. The North West and Northern Cape displays the highest estimates of IMR for age category 25-29. This is expected as it should be acknowledged that the successive increases of child mortality estimates rise per age category as there is more lifetime exposure to dying per successive age category.

Table 4.1: National and provincial estimates of under-five mortality in South Africa by age and province, 2016

Provinces	Age (x)	D(i)	Indirect mortality estimates q(x)	Alpha	q(1) per 1000 live births	q(5) per 1000 live births	Reference date t(x)
Western Cape	2	0.0153	0.0143	-0.9155	12	17	2014.3
	3	0.0134	0.0196	-0.7959	15.1	21.4	2009.9
Eastern Cape	2	0.0320	0.0305	-0.5304	25.5	35.9	2014.1
	3	0.0337	0.1634	0.3426	130.2	176	2010.5
Northern Cape	2	0.0331	0.0325	-0.4967	27.2	38.3	2014.1
	3	0.0308	0.2607	0.638	212.8	278.4	2011
KwaZulu – Natal	2	0.0350	0.0316	-0.5111	26.4	37.3	2014.2
	3	0.0404	0.0959	0.0374	75.2	104	2010.2
Gauteng	2	0.0189	0.0179	-0.8044	14.9	21.1	2014.4
	3	0.0244	0.0136	-0.9823	10.5	14.9	2009.8
Free State	2	0.0331	0.0325	-0.498	27.1	38.2	2014.3
	3	0.0379	0.1802	0.4016	144.2	193.8	2010.7
North West	2	0.0390	0.0383	-0.4126	32	45	2014.2
	3	0.0445	0.2275	0.5481	184.2	243.7	2010.9
Limpopo	2	0.0189	0.0185	-0.7855	15.4	21.9	2014.2
	3	0.0277	0.2073	0.4887	167.1	222.5	2010.8
Mpumalanga	2	0.0355	0.0338	-0.4766	28.3	39.9	2014.2
	3	0.0348	0.1364	0.2363	108	147.3	2010.4
National	2	0.0277	0.0264	-0.604	22.1	31.2	2014.2
	3	0.0304	0.1118	0.1228	88	121	2010.3

Own calculation from CS 2016

Table 4.2 is composed of the IMR and U5MR by province. The implied estimates in infant and under-five mortality that is presented in Table 4.2 suggests that childhood mortality has been declining from the period of 2011 to 2016. The observed estimates are consistent with the reversal in the childhood mortality decline observed in some provinces due to the effective rollout of HIV preventative and treatment options available (Fairall et al, 2008). The Western Cape and Gauteng reveal significantly lower estimates of IMR and U5MR. For Gauteng the IMR and U5MR is estimated at 18 per 1000 live births; for the Western Cape the IMR is estimated at 13.6 per 1000 live births and the U5MR is calculated at 38.4 per 1000 live births. Also displaying a significant decline is KwaZulu-Natal with an estimated 50.8 per 1000 live births for the IMR and 70.7 per 1000 live births for the U5MR. These are contrasted against previous estimates produced from secondary data (Udjo, 2014).

The estimated levels of IMR and U5MR might seem exceptionally higher for some provinces and be over-estimated, such as the North West with estimates of 167.1 and 144.4 per 1000 live births for IMR and U5MR respectively, as depicted in Table 4.2. It is important to note that for Gauteng; almost all of the under-five deaths are attributed to infant deaths as the estimate is calculated at 18 deaths per 1000 live births respectively. U5MR captures IMR therefore the IMR is reflected in the U5MR (Jamison, Feachem and Makgoba, 2006). It should also be taken into consideration that the model life table that has been used was developed in the pre-HIV era. The model life table does not taken into consideration the influence of HIV; furthermore, the age pattern of childhood mortality could be different from that experienced by children in populations affected by the epidemic.

Table 4.2: Indirect estimates of U5MR for South Africa, 2016

Provinces	IMR per 1000 live births	U5MR per 1000 live briths
Western Cape	13.6	38.4
Eastern Cape	77.9	106
Northern Cape	120	158.4
KwaZulu – Natal	50.8	70.7
Gauteng	18	18
Free State	85.7	116
North West	108.1	144.4
Limpopo	91.3	122.2
Mpumalanga	68.2	93.6
National	**55.1**	**76.1**

Own calculation from CS 20116

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

South Africa is a country that still endures the burden of HIV, which is reflected through the prevalence within the population (Statistic South Africa, 2016c). To ensure that the influence of HIV is taken into consideration, the basic regression method for correcting for HIV within child mortality, as per Zaba, is adopted. This is a necessary measure because the regression coefficients used to convert the proportions dead could bias the estimated indirect mortality measures q(x), as these were derived using mortality schedules before the HIV epidemic. Therefore, to correct for the influence of HIV, the basic regression model was applied to the estimates. Table 4.3 relays the prevalence at each respective reference date, per province, that will be utilised to effectively correct for the influence of HIV. Table 4.3 below also provides a platform of comparison between the unadjusted values of q(x) and the adjusted values of q(x). As presented, it is clear that all consecutive values increase notably after the influence of HIV is taken into consideration. Amongst the provinces with the highest increases are the Eastern Cape, KwaZulu-Natal and Limpopo. These provinces suffer with the highest prevalence of the disease (HSRC, 2014b).

Table 4.3: National and provincial estimates of q(x) adjusted for prevalence at reference date and HIV in South Africa by age and province, 2016

Provinces	Age (x)	Reference date t(x)	Prevalence at reference date	Correction factor n(z)	q(x) unadjusted	q(x) adjusted for HIV
Western Cape	2	2014.3	22.0	0.2533	0.0143	0.2676
	3	2009.9	20.7	0.2480	0.0196	0.2676
Eastern Cape	2	2014.1	22.0	0.2533	0.0305	0.2838
	3	2010.5	20.9	0.2505	0.1634	0.4139
Northern Cape	2	2014.1	22.0	0.2533	0.0325	0.2858
	3	2011	21.2	0.2541	0.2607	0.5148
KwaZulu – Natal	2	2014.2	22.0	0.2533	0.0316	0.2849
	3	2010.2	20.9	0.2505	0.0959	0.3464
Gauteng	2	2014.4	22.0	0.2533	0.0179	0.2712
	3	2009.8	20.7	0.2505	0.0136	0.2641
Free State	2	2014.3	22.0	0.2533	0.0325	0.2858
	3	2010.7	20.9	0.2505	0.1802	0.4307
North West	2	2014.2	22.0	0.2533	0.0383	0.2916
	3	2010.9	20.9	0.2505	0.2275	0.2526
Limpopo	2	2014.2	22.0	0.2533	0.0185	0.2718
	3	2010.8	20.9	0.2505	0.2073	0.4578
Mpumalanga	2	2014.2	22.0	0.2533	0.0338	0.2871
	3	2010.4	20.9	0.2505	0.1364	0.3869
National	2	2014.2	22.0	0.2533	0.0264	0.2797
	3	2010.3	20.9	0.2505	0.1118	0.3623

Own calculation from CS 2016

4.6 Multivariate analysis

In addition to examining the levels of childhood mortality in South Africa, disaggregated by province, one of the objectives of this dissertation is to explore the determinants of childhood mortality. The effect of socioeconomic status as a determinant of childhood mortality is observed after controlling for other known covariates of under-five mortality, such as the socio-demographic and socioeconomic factors. This is accomplished through determining and exploring if controlling for SES changes the effect of population group, female educational attainment, place of residence and province on childhood mortality. Reference groups, denoted by (R), that were chosen were generally based on groups that were perceived as being more susceptible to child mortality. These are the Black African racial group; lowest level of education (primary school attainment); and those that were categorised as having the lowest SES. Urban residence and the Western Cape Province were also chosen as reference groups however these reference groups have significantly lower child mortality estimates than their counterparts.

4.6.1 Results from the negative binomial regression

Table 4.4 presents results of a negative binomial regression model of the number of children dead of children ever born. Observed from Model I it is apparent that all racial categories have relative differences in the study. Model I shows that Coloureds have 0.6075 reduced risk of having a child death as compared to the reference group, Black Africans. This implies that there is a 40% less chance of a child death amongst females from the Coloured population as compared to females from the Black population. As presented, it is evident that Coloured racial group has an incidence rate ratio (IRR) of 0.6075, that is almost twice as large as those estimated for the White (IRR = 0.3242) and the Indian (IRR = 0.3567) racial groups. This implies that Indian females have a 65% less chance of experiencing a child death and White females have a 68% less chance of experiencing a child death.

Education was introduced as a covariate in Model II to test if child deaths are affected by educational attainment. As per Table 4.4, it is evident that when education is introduced into Model II there is a slight decrease in the effect of the Coloured race group from an IRR of 0.6075 to an IRR of 0.6007 however, there are slight increases in effect observed between the White and Indian racial groups from an IRR of 0.3567 to 0.3890 within the Indian race group; and from and IRR of 0.3242 to 0.360 within the White race group. This implies that the Indian, female population now has a 61% less chance of experiencing a child death and the White, female population now has a 64% less chance of experiencing a child death. Model II reveals that females with a secondary (IRR = 0.5483) and tertiary (IRR = 0.3945) educational attainment have reduced relative risks of experiencing a child death as compared to the reference group, primary education. Also observable from Model II is that females who attained a secondary education, has a 45% less chance of experiencing a child death as compared to females who had a primary school education. Females with tertiary educational attainment (IRR= 0.3945) had the lowest relative risks of experiencing a child death in comparison to females that gained primary and secondary education.

In Model III, place of residence is introduced into the model as a covariate to test if child deaths are affected by variations in areas of residence. For the previously added variables, such as race and education, we observed a significant incline in the IRR from Model II to Model III, especially amongst the Coloured race group that has the largest observed incline of an IRR from 0.6007 in Model II to an IRR of 0.6586 in Model III. In addition to this, it is observed in Table 4.4 that rural residence has a significantly higher IRR of 1.2755 of experiencing a child death than urban residence.

Like Model III, when another variable of interest is added to Model IV, province, to test if child deaths area affected by the province that the mother resides in, it is observable that all other variables that were previously added to the model, such race, education and residence, have a significant increase in the IRR. From the provincial perspective, it is evident that provinces such as Free State (IRR = 2.1554) and North West (IRR = 2.1114) have significantly larger relative risks in comparison to the reference province, the Western Cape. It is clear that these two provinces are most likely to experience a child death compared to the Western Cape. Provinces like Limpopo (IRR= 1.3274) and Gauteng (IRR = 1.4339) as presented in Table 4.4, have lower risks of experiencing a child death. The other provinces, Eastern Cape (IRR = 1.7048), Northern Cape (IRR = 1.9733), KwaZulu-Natal (IRR = 1.9388) and Mpumalanga (IRR = 1.8342), are statistically significance and all display increased relative risks of experiencing a child death than the Western Cape.
In the final model, Model V, SES is introduced as a covariate to test if socioeconomic status has an effect on child death. The middle SES (IRR = 0.7934) and high SES (IRR = 0.6113) categories display significantly different relevant risks and are statistically significant. Both

the middle and high SES categories have reduced relative risks of experiencing a child death as compared to the reference category, low SES. Upon the addition of the SES variable in Model V it is observed that the relative risks for the multivariate analysis on covariates such as race, education and place of residence increases in effect while the relative risk of province displays slight declines in effect.

The log likelihood is included in each model to assess which model displays a significantly greater fit in comparison to the other models. The log likelihood should always be negative with higher values that are closer to zero indicating a better fitting model (Royall and Tsou, 2003). Both the log likelihood and the log pseudolikelihood are presented in Table 4.4. The log pseudolikelihood was attained from the weighted estimations and the log likelihood was attained from the unweighted estimations to form a basis of comparison. It is evident from the results obtained that both the log likelihood and the log pseudolikelihood are increasing in strength after every successive model is executed. The log likelihood for the first five models are presented at -60486.869 for Model I, -58016.2 for Model II, -57917.769 for Model III. -57643.306 for Model IV and -52544.477 for Model V. As the log likelihood increases in strength so does the explanatory power of the variables.

It can be concluded from these results that in South Africa, for females of reproductive age categories 15 – 34, who are Black, attained a lower level of education, resided within rural areas, particularly with provinces such as the Free State and North West and had a lower economic status were more susceptible to experiencing a child death.

Table 4.4: Determinants of childhood mortality from Negative Binomial Regression Model

		Negative Binomial Model				
		Model I	**Model II**	**Model III**	**Model IV**	**Model V**
		IRR [95% C.I]	**IRR [95% C.I]**	**IRR [95% C.I]**	**IRR [95% C.I]**	**IRR [95% C.I]**
Race Black/African(R)	Coloured	0.6075*** [0.55-0.66]	0.6007*** [0.55-0.65]	0.6586*** [0.60-0.75]	0.8184*** [0.74-0.90]	0.8394** [0.76-0.93]
	Indian/Asian	0.3567*** [0.26-0.49]	0.3890*** [0.29-0.55]	0.4432*** [0.32-0.61]	0.4220*** [0.31-0.58]	0.5179*** [0.37-0.72]
	White	0.3242*** [0.26-0.40]	0.3604*** [0.29-0.45]	0.3878*** [0.31-0.48]	0.4016*** [0.32-0.50]	0.4598*** [0.36-0.59]
Education Primary (R)	Secondary		0.5483*** [0.52-0.58]	0.5644*** [0.54-0.59]	0.5794*** [0.55-0.61]	0.6127*** [0.58-0.65]
	Tertiary		0.3945*** [0.36-0.43]	0.4174*** [0.38-0.46]	0.4363*** [0.40-0.48]	0.4981*** [0.45-0.55]
Place of Residence Urban (R)	Rural			1.2755*** [1.23-1.32]	1.2032*** [1.15-1.25]	1.0948*** [1.05-1.15]
Province Western Cape(R)	Eastern Cape				1.7048*** [1.53-1.90]	1.5885*** [1.48-1.78]
	Northern Cape				1.9733*** [1.72-1.26]	1.9335*** [1.68-2.23]
	Free State				2.1554*** [1.92-2.42]	2.0969*** [1.86-2.37]
	KwaZulu-Natal				1.9388*** [1.74-2.16]	1.8944*** [1.70-2.12]
	North West				2.1114*** [1.89-2.36]	2.1352*** [1.90-2.40]
	Gauteng				1.4339*** [1.29-1.59]	1.4251*** [1.28-1.59]
	Mpumalanga				1.8342*** [1.64-2.06]	1.8237[1.62-2.06]***
	Limpopo				1.3274*** [1.18-1.49]	1.3147*** [1.17-1.48]
SES Low (R)	Medium					0.7934*** [0.76-0.83]
	High					0.6113** [0.57-0.66]
N		295 796	287 125	287 125	287 125	259 986
Log likelihood		-60486.869	-58016.2	-57917.769	-57643.306	-52544.477
Log pseudolikelihood		-978327.74	-939417.75	-937742.81	-933173.23	-849989.25

significant at ***p<0.001 **p<0.01 *p<0.05

Own calculation from CS 2016

4.7 Summary

This study attempted to present differentials of childhood mortality by population group, female educational attainment, urban-rural residence, province and an index of socioeconomic status. The main contribution of this paper lies in the results that present child mortality disaggregated by province levels as well as the dependency of child wellbeing on socio-demographic and socioeconomic factors.

CHAPTER FIVE

DISCUSSION AND CONCLUSION

5.1 Introduction

This chapter seeks to expand knowledge and contribute to the growing body of literature on the levels of child mortality as well as the differentials and factors associated with child mortality. The overall objective of this research was to produce updated child mortality estimates using data from the 2016 South African Community Survey. In addition, the aim was to use these estimates to explore the factors associated with child mortality and accompanying provincial differentials. This chapter explores the extent to which these objectives have been met. This chapter will provide insight into the extent to which social and demographic disparities depicts the levels of observed child mortality. The first part of this chapter seeks to address the key research questions and objectives raised by this research through an extensive discussion of the data source and quality, the experience of methodological challenges, the observed levels and provincial differentials in child mortality as well as the factors associated with child mortality. The limitations of the study are discussed before the scope for future research and recommendations for future studies are suggested. In addition to this, policy implications and suggestions will also be proposed before conclusions are reached based on the findings.

5.2 Discussion

Globally, child mortality has been declining significantly, even within the less developed nations as the roll-out of necessary treatments and preventative measures have been prioritised by leaders of all walks across the world (Black, 2010). South Africa has also seen significant declines within the levels of child mortality both at a national and provincial level. This decline is expected as the country has strengthened its ability to improve the living and health conditions of the growing population. One of the reasons attributed to this change in child mortality patterns is the complex association between socioeconomic factors, that the government is increasingly attempting to rectify and redress, and mortality (Kahn et al., 2007b).

5.2.1 Data sources and data quality

The primary data source that was utilised for this research was the CS 2016. Generally, the data obtained from the 2016 Community Survey was of a good standard. This is very important given that vital registration systems captures data that is often incomplete and cannot be relied upon to provide accurate estimates of child mortality that is directly estimated. The results obtained using indirect methods may be regarded as reliable estimates of the levels of child mortality. The 2016 CS data had to be interrogated and edited before being used in child mortality estimation. The inclusion of total children ever born alive, and total children still alive, computed for both male and females made it possible to generate estimates of total children dead, per variable of interest. These results are presented in the tables in Appendix A. The data from the Community Survey 2016 had to be cleaned in order to capture the population of interest, which were females in reproductive age categories 15-34. In the process, women who were of ages 35 and above, had given birth to children alive, and still had children surviving were excluded from the analysis. Brass’s original method assumes that the age of the mother can serve as a proxy for the age of her children and thus for how long they have been exposed to the risk of dying. The method assumes that the mortality rates reflect the time period when the children were born, not the age of their mothers. (Brass, 1964; Brass, 1975). If we were to include females of reproductive age categories of 35 and above then we would venture out of estimating under-five mortality.

5.2.2 Levels of child mortality

The evidence provided here by the estimates produced reveals that the IMR and U5MR have been significantly decreasing over the past few years and even though there is a noticeable decrease for the decade under review, it is almost depicted as if IMR and U5MR have been levelling off and is constant within the past recent years. As per the estimates produced, it seems as though South Africa is now reducing child mortality as at a much slower pace than it was in the past. Although child mortality in South Africa has declined substantially, there is growing concern that after the period that marked an extensive reversal of mortality observations, mainly due to HIV in alignment with the rollout of extensive treatment regimes, child mortality has now stagnated. The level of child mortality is still significantly higher than the mortality experiences of other countries that are on a similar level of development as South Africa (You et al., 2015). The analysis has shown that an application of an adaptation of the basic Ward and Zaba (2008) regression technique to the children ever born/children surviving data from the 2016 CS can be used to produce rough estimates of levels and time estimates of infant mortality and under-five mortality rates for the whole of South Africa. These estimates were compared in conjunction with unadjusted estimates produced.

Estimates of infant and under-five mortality rates at national and province level are generated indirectly using the person data from the 2016 CS. In attempting to estimate child mortality for varying provinces, it is often difficult to construct accurate estimates because population sizes amongst provinces tend vary, resulting in unstable estimates.

Having produced child mortality estimates, the first important approach is to compare the estimates produced from this research to those presented elsewhere. In this regard, the national level estimates can be compared with reports from Stats SA, the UN Inter-agency Group for Mortality Estimation (IGME) (You et al., 2015), and from estimates published by Udjo (2014). Table 5.1 presents the estimates of infant and under-five mortality rates from these institutions as well as the estimates from this research and estimates from a recently published paper by Udjo (2014). One must be considerate of the controversy that exists about the estimates of child mortality in South Africa. For example, estimates of both the IMR and the U5MR from Stats SA (Statistics South Africa, 2015) and the UN IGME (You et al., 2015) are significantly lower when compared to the estimates produced by Udjo (2014) and this research. This is because each of institutions might have used different approaches and data sources to derive at their corresponding values. Nonetheless, it can be concluded that the estimates from this research are quite reasonable and consistent with most of the other estimates of IMR and U5MR that have been produced by Udjo (2014) that has similarly adopted the indirect estimation of child mortality. In comparing against the research paper produced by Udjo (2014), it is evident that when comparing the results produced for IMR and U5MR on a national level both the IMR and U5MR have declined significantly. As per Table 5.1 the IMR declined from 60 per 1000 live births (Udjo, 2014), from the 2011 population census, to 55.1 per 1000 live births, from the CS 2016. Additionally the U5MR has also declined significantly from 80 per 1000 live births (Udjo, 2014) to 76.1 per 1000 live births as produced by this research from the CS 2016.

Table 5.1: Comparisons of national IMR and U5MR from various sources

Source	IMR per 1000 Births	U5MR per 1000 Births	Year estimate applies
UN IGME	35.00	47.00	2011
Udjo	60.00	80.00	2011
Stats SA	34.4	45.1	2015
*2016 CS, Indirect	55.1	76.1	2016

*According to this research estimate

When South Africa adopted the Constitution and signed and ratified the Convention on the Rights of the Child, it was agreed upon that child will be put first. This meant that children will become priority and that measurable lengths will be taken to that children's rights to survival and development are respected, promoted and protected (King-Shung and Proudlock, 2002). Child deaths are significant as it relays important markers of a country’s progress in meeting its fundamental obligations to children and healthcare goals. The death of a child is a reflection that society has not adequately promoted and protected the child's rights to survival and development (King-Shung and Proudlock, 2002).

Gathered from the results produced by Udjo (2014) and this research, that reveals a significant decline in both the IMR and U5MR from 2011 – 2016, it is evident that South Africa is still making attempts to reach health goals that were set out in the MDGs and SDGs. The SDGs are directly linked to Africa’s Agenda 2063 that calls for sustainable development and transformation. The linkages of the SDGs and the 2063 Agenda are focused on the wider implications of factors that underscore the importance of child mortality as well as the development frameworks that are related to in influencing policy at national level (UNECA, 2016). As the period of the SDGs began it was evident that South Africa had made significant progress on MDG 4 in reducing child mortality however the levels of child mortality remain unacceptably high and the task of reducing child mortality remains a global priority. The momentum harvested during the period of the MDGs must be sustained (UNECA, 2016). The SDG called for a complete depletion of child mortality, that by 2030, preventable deaths of new-borns and children under five years of age are to end and all countries, including South Africa, are to aim to reduce under-five mortality to at least as low as 25 deaths per 1 000 live births (You et al, 2015). A target that is well in South Africa’s reach. The decline observed from results reveals that South Africa has been proactive in ensuring that the necessary policies and implementation strategies are in place to reduce under-five mortality. These initiatives and strategies were inclusive of the intensified prevention of malnutrition and strengthening of immunization coverage. In addition to this, South Africa has continually aimed to ensure that free healthcare facilities were expanded on and were made easily accessible to the public (King-Shung and Proudlock, 2002). The South African Government's Social Security System aims to provide cash assistance to the most vulnerable South Africans and includes grants that are specifically provided for children to ensure that the child is given the basic nutritional and medical requirements needed (UNICEF, 2007). This has aided the decline in child mortality. However, while the intervention in social and health spheres are strong and promise a declining child mortality rate, they are not sufficient to reduce under-five mortality rates to the previously set target for South Africa of 20 deaths per thousand live births or lower by 2015 as per MDG 4.

5.2.3 Provincial differentials in child mortality

Provision of health care was also extremely unequal under apartheid era, distributed separately by population group and residential area and likewise by province. The apartheid system allocated resources unequally by race, and this had a direct impact on the retention of facilities per area as 'White areas' has access to sophisticated services in contrast to those living in homeland areas that were often lacking in available facilities resulting in travelling great distances to access basic services (Burgard & Treiman, 2006). This largely broadened the divide between provinces and gave rise to the existing inequities.

In order to effectively address the problem and work towards further reductions of child mortality in the country it is essential that efforts be focused on lower provincial levels as opposed to concentrating only on the level of mortality nationally (Freedman, Waldman, Pinho et al., 2005).

To persist forward, the construction of reliable estimates of child mortality at a provincial level is the first stepping stone. Ultimately, the overall objective of this research was to produce estimates of child mortality for the provinces of South Africa using the 2016 CS data, and further assess the differentials in child mortality in relation to SES which could further depict existing challenges of poverty and inequality.

In attempting to compare the provincial estimates of child mortality, it must be noted that there are very few sources to compare with. Table 5.2 presents a basis for comparison between results produced from this research and results produced by Udjo (2014). Table 5.2 also highlights that the results obtained provincially do not conform to what is expected. The discrepancy in the results obtained are attributable to either the method of choice adopted or the quality of data at a provincial level. However, there are notable declines in the IMR and U5MR in provinces such as Gauteng. Current estimates of U5MR from the CS 2016 suggests that Gauteng displays an IMR of 18 per 1000 live births as compared to Udjo (2014) that has estimated the IMR to be 56.3 per 1000 live births. It must be noted that almost all U5MR, estimated at 18 per 1000 live births, is attributed to the IMR as compared to Udjo (2014) that has produced an estimate of U5MR of 75.1 per 1000 live births for Gauteng. Similarly, there is also an observable decline in provinces such as the Western Cape and KwaZulu-Natal from Udjo (2014) to estimates produced from the CS 2016. This suggests that these provinces are doing exceptionally well on reducing child deaths. On the contrary, other provinces show an increase or stagnation in child mortality estimates in comparison with the results presented by Udjo (2014). Mpumalanga displays a very minute decline in the U5MR of 96 per 1000 live births as produced by Udjo (2014) to 93.6 per 1000 live births as produced from the CS 2016. The estimates produced from the CS 2016 for the Eastern Cape and Limpopo reveals a remarkable incline in the IMR and U5MR, which indicates that these provinces are not doing enough to effectively reduce child mortality and maintain a steady rate of reduction.

As per the results produced from this dissertation, it is evident that there are widespread disparities of IMR and U5MR between the provinces. Differences between provinces can be explained by the fact that some provinces such as the Eastern Cape have a largely rural population that is poorer, has lower levels of education, poorer access to health facilities and overall poor living conditions as compared to provinces such as the Western Cape that has more access to basic services provided to the population, higher levels of education and more households with piped water inside the household. Such facts also relay the socioeconomic standing of the province (King-Shung and Proudlock, 2002). The difference in child mortality between rural and urban areas also reflects the gaps in socio economic conditions and access to health services between urban and rural areas (King-Shung and Proudlock, 2002).

When poverty strikes a family, the youngest members become the immediate victims. Even though 2.86 million children benefit from the child support grant provide by the government, there are still 55% of children belonging to households that are living under the ultra-poverty line of R800 or less a month (UNICEF, 2007). The poorest provinces were found to be those with larger rural populations and little access to employment opportunities. Approximately 63 percent of African children lived in ultra-poor households. Provinces such as Limpopo and the Eastern Cape had the most poverty stricken profiles, with approximately three-quarters of children living under the ultra-poverty line (UNICEF, 2007). Poverty levels are higher in the provinces that have higher estimates of child mortality. In 2006, the majority of the population in seven out of the nine provinces in South Africa were living below the upper-bound poverty line. The highest poverty levels were found in Limpopo, where three-quarters (74,4%) of all residents were poor, followed closely by Eastern Cape (69,5%) and KwaZulu-Natal (69,1%). The poor were the minority in two provinces, which were the Western Cape (36,9%) and Gauteng (32,4%) (Statistics South Africa, 2014). From the estimates produced from this research, it is evident that these Gauteng and the Western Cape have the lowest estimates of IMR and U5MR. According to Pena and Bacallao (2002), poverty is directly linked to severe forms of undernutrition, particularly in children. Undernutrition remains a serious problem for the children of South Africa. According to Bamford (2012), the 2005 National Food Consumption Survey, it was found that 18% of children were stunted, 9.3% were underweight and 4.5% were wasted. Stunting was evidently higher in children living in rural farming areas (24.5%), tribal areas (19.5%) and urban informal areas (18.5%). The predominantly rural/tribal areas of South Africa are concentrated largely within the Eastern Cape, Northern Cape and the flat plains of Limpopo. These provinces are equally dominated by the Black population groups that evidently have higher proportions dead of children ever born.

Primary healthcare facilities as well as outreach teams play an important role in ensuring that children receive preventive services (Bamford, 2012). Immunisation plays an effective role in preventing child death (Riley et al., 1986). Gauteng has done exceptionally well in ensuring that the provinces immunisation rates remain relatively high (Bamford, 2012). This is reflected in the significantly lower estimates of child mortality in Gauteng. However, provinces such as Mpumalanga and the Eastern Cape have the lowest recorded number of children that are immunised at 71.9% and 81.5% respectively. The reflection of the significantly higher child mortality estimates within these provinces could be a direct indication of the lower immunisation coverage. This is unacceptably low in comparison to the national estimation of 94.2% (Bamford, 2012). Regardless of the poor coverage rates of immunisation in some provinces it is evident that the average number of visits to primary healthcare facilities for children under-five has remained fairly stable in the past few years, increasing from 4.3 visits in 2008 to 4.6 visits in 2011. However, there is considerable variation between provinces. Children from the Free State only visited health facilities an average of 3.6 times in 2011 (Bamford, 2012). This is relatively low compared to Limpopo that recorded 6.3 visits for 2011. The other provinces had an average that was close to the national estimate of 4.6 visits for 2011. These were ranging between 4.1 and 4.8 visits for 2011 (Bamford, 2012).

An estimated 450 000 children were living with HIV in SA. HIV infection, as a single contributing factor, is the cause of approximately 30% to 60% of child deaths. South Africa ensures the provision of antiretroviral therapy (ART) for all HIV-infected children under five. The number of children receiving ART has significantly increased, with 40 000 children being initiated on ART during 2011. However, systems for tracking progress in initiating and maintaining children on ART needs to be strengthened to ensure that child death attributable to HIV is reduced (Bamford, 2012). There are still varying differences in HIV prevalence by province. In 2012, it is estimated that 12.2% of the population were HIV positive, which is 1.2 million (HSRC, 2014b). According to the Health Science Research Council (2014), the overall HIV prevalence differed substantially by province. Geographical differences were disaggregated by locality type and by province. Rural informal area residents had a significantly higher HIV prevalence than did urban formal area residents. The four provinces with the highest estimates of HIV-prevalence were KwaZulu-Natal (16.9%), Mpumalanga (14.1%), Free State (14.0 %), and the North West (13.3%). The lowest prevalence was within the Western Cape (5.0%) (HSRC, 2014b).

Reducing social and geographical disparities in the coverage of high impact health interventions is critical towards accelerating reductions in child mortality. Sustainable approaches such as upgrading human resources for health, improving the quality of clinical care and expanding community outreach services for child health, are needed especially in provinces that are still challenged with high estimates of child mortality. Interventions such as family planning for birth spacing, appropriate nutrition and hand-washing are highly effective in preventing child deaths. These need to be applied more widely, especially within the provinces that are still suffering with high rates of child mortality (UNECA, 2016).

Table 5.2: Comparison of provincial IMR and U5MR from an additional source

Provinces	IMR per 1000 births	Udjo (2014) IMR per 1000 births	U5MR per 1000 births	Udjo (2014) U5MR per 1000 births
Western Cape	13.6*	27.2	38.4*	36.1
Eastern Cape	77.9*	57.3	106*	75.6
Northern Cape	120*	56.2	158.4*	76.5
KwaZulu – Natal	50.8*	79.2	70.7*	102.9
Gauteng	18*	56.3	18*	75.1
Free State	85.7*	80.6	116*	104.1
North West	108.1*	68.5	144.4*	89.4
Limpopo	91.3*	49.7	122.2*	67.0
Mpumalanga	68.2*	72.3	93.6*	96.0

*****According to this research estimate

5.2.4 Factors associated with child mortality

According to Braistein, Brinkhof and Dabis (2006), it is evident that child mortality is relatively higher in countries where poverty and HIV are high. As per this research, it can be established that both socioeconomic and socio-demographic factors influence childhood mortality. As per the results presented in Table 5.3, that displays a comparison between the negative binomial and logistic model, it is evident that all the factors of interest for both models have a very strong significance. The logistic regression model was also performed, as outlined in Chapter 3, to validate the credibility of the results obtained from the negative binomial regression as well to form a basis of comparison between the two models. All variables revealed a significant relationship between the independent and dependent variables, expect urban and rural residences that displayed no apparent significance in both models to the dependent variable. Though the reasoning is not clearly apparent from other literature that child mortality is significantly higher in rural and economically disadvantaged areas than it is in urban, economically- stable areas (Kickbusch 2011).

As presented in Table 5.3, it is also evident that the Coloured female population has significantly higher odds than the White and Indian female populations. To reinforce what is currently observable by the research, it should be acknowledged that various researchers have shown that there is a statistically significant association between race and child mortality. This is more apparent amongst Black and Coloured females as it is evident that their children are more vulnerable to mortality in comparison with White and Indian mothers (Dorrington, Timaeus, Moultrie and Nannan, 2004; Worku, 2011). Worku (2011) further suggests that child mortality is higher among black, rural, uneducated and poor South African females.

According to UNICEF (2009), there is a significant association between low socio-economic status of the mother and child mortality in South Africa. Poor socio-economic conditions and poverty are indirect causes of child mortality because the survival of the child is significantly influenced by socio-economic factors that affect the mother's capacity to provide adequate care and health services to the child (Lawn, Cousens and Zupan, 2005). It is important to acknowledge socioeconomic and structural barriers in order to effectively reduce child mortality. Access to clean tap water is a key indicator of quality of life because poor water and sanitation conditions are high risk factors for an array of diseases which children die from (World Bank, 2009). It is evident that South African households have better access to clean and piped water in comparison to other Sub-Saharan African countries (Dovi, 2007). Winkley, Cubbin and Aim (2006), suggests that the ownership of flush toilets at home is a reliable indicator of social status. Dovi (2007) suggests that South African households have better access to flush toilets, and that ownership of flush toilet and this is a direct indicator of the improved socioeconomic status of the population. Ownership of televisions at home is a measure of a higher social status in developing nations such as South Africa, because of the affordability of attaining one. Attaining a television at home enables the family to continually update themselves on the latest news regarding important issues of health and access to services provided by the community. Access to television at home enables the family to follow up current news on basic services provided to the population. In general, ownership of valuable household assets is an indicator of a higher SES; likewise, low SES is an indicator of the lack of household assets at the household level.

Table 5.3: Determinants of child mortality from the negative binomial and logistic model

		Negative Binomial Model **IRR** **[95% CI]**	**Logistic Model** **OR** **[95% CI]**
Race Black/African(R)	Coloured	0.8394** [0.76-0.93]	0.8524** [0.77-0.95]
	Indian/Asian	0.5179*** [0.37-0.72]	0.4985*** [0.36-0.69]
	White	0.4598*** [0.36-0.59]	0.4676*** [0.37-0.59]
Education Primary (R)	Secondary	0.6127*** [0.58-0.65]	0.4717*** [0.45-0.49]
	Tertiary	0.4981*** [0.45-0.55]	0.3429*** [0.31-0.38]
Place of Residence Urban (R)	Rural	1.0948*** [1.05-1.15]	1.1136*** [1.06-1.17]
Province Western Cape(R)	Eastern Cape	1.5885*** [1.48-1.78]	1.6370*** [1.46-1.84]
	Northern Cape	1.9335*** [1.68-2.23]	2.0956*** [1.81-2.43]
	Free State	2.0969*** [1.86-2.37]	2.2198*** [1.94-2.51]
	KwaZulu-Natal	1.8944*** [1.70-2.12]	2.0166*** [1.80-2.25]
	North West	2.1352*** [1.90-2.40]	2.2757*** [2.02-2.57]
	Gauteng	1.4251*** [1.28-1.59]	1.4613*** [1.31-1.63]
	Mpumalanga	1.8237[1.62-2.06]***	1.9338*** [1.71-2.19]
	Limpopo	1.3147*** [1.17-1.48]	1.3717*** [1.21-1.55]
SES Low (R)	Medium	0.7934*** [0.76-0.83]	0.7493*** [0.72-0.78]
	High	0.6113** [0.57-0.66]	0.5684*** [0.53-0.61]
N		259 986	260 128
Log likelihood		-52544.477	-51676.007
Log pseudolikelihood		-849989.25	-836107.15

Significant at ***p<0.001 **p<0.01 *p<0.05

Own calculation from CS 2016

5.3 Limitations of the study

The major limitations of this research is the quality of the Community Survey and the applicability of the Ward and Zaba (2009) HIV correction method to South Africa. The more minor limitations of this study are the scope that excludes the inclusion of biological factors.

All the analyses in this research are exclusively based on the 2016 South African CS data. Therefore, the significance and reliability of the results depends on the quality of the CS data which includes the quality of enumeration and data processing. One must acknowledge that any flaw or shortfall that occurs in the CS data might seriously impact the results that the research has produced.

The Ward & Zaba method assumes that the HIV population of a country has been stable in the past 40 years (Ward and Zaba, 2008). HIV / AIDS started surfacing in South Africa in the mid-1980's and only became a major area of concern in the mid-1990's as HIV prevalence rate increased (Schoub et al., 1990). The prevalence of HIV has been on the increase and has started levelling off in the recent past. It becomes appropriate to consider the suitability of using Ward and Zaba (2008) adjustments in an environment of increasing incidence and prevalence of HIV. According to Statistics South Africa, even though the prevalence rate of HIV amongst women of reproductive age categories have been minutely fluctuating, it has not been entirely stable (Statistics South Africa, 2016c). The method fails to correct for the instability of the prevalence rates within the population affected by HIV. The research used the proportion of HIV prevalence at the time of birth to the prevalence at the time of the survey to adjust Ward and Zaba's (2008) correction factors. The accuracy of this adjustment depends on the accuracy of the time reference among other factors. There is also the issue of time referencing that is generally a problem with the Brass technique. The impact of HIV on the time reference is currently and may possibly affect the accuracy of the estimates.

The initial selection of the variables considered was based on relative importance as presented by the theoretical framework, and that has been included in other literature. It should be noted that there may be other variables that may have a significant impact on child mortality, inclusive and exclusive of the data set that have not been taken into account. Additionally, non-HIV deaths may also be changing, but not necessarily due to the changes in HIV prevalence rates. This research, as guided by the theoretical framework, does not take into consideration the biological factors that are associated with child mortality, therefore deriving at conclusions for the extent of which non-HIV and other health related deaths is out of scope for this research.

5.4 Scope for future research

There is a need for research that can disaggregate child mortality estimates by male and female separately. This may shed light on higher mortality experiences between the sexes and additionally explanations as to why, if any, higher mortality experiences from one sex contrasted against another can be explored at a national or provincial level. These may also provide a pathway to the exploration in data capturing or reporting biases and errors.

The assumption of constant HIV prevalence among women of childbearing age by Ward and Zaba (2009) is not entirely true and needs further and in-depth investigation to determine the extent of overestimation. In addition, future research aspirations should equally consider the impact on mortality of later infection through causes other than mother to child transmission of children born to women at older ages.

Another opportunity exists whereby the researcher could reproduce the results of this research using data from other sources so that it would be possible to see the changes in child mortality with the changes in poverty and inequality and other socioeconomic variables. One must take heed of the fact that if this notion is explored then the usage of longitudinal data would produce more accurate estimates and results.

5.5 Recommendations

This study has provided the national and provincial estimates of child mortality as well as the factors associated with child mortality. Based on the results, this study can briefly provide general recommendations that will aid the reduction of child mortality within the South African population.

The World Health Organization (2005) encourages governments in developing nations throughout the world to promote primary health care and disseminate health education messages to rural and urban communities by using communicative devices as assistive tools. However, it must be noted that this is not entirely sufficient as simply listening to health-related messages does not necessarily result in behavioural change. However, this obstacle could also be tackled by the usage of health promotion and education programmes conducted by the South African Department of Health (UNICEF, 2011). This must be effectively utilised by creating awareness amongst communities and continually promoting involvement of the people.

The first recommendation is regarding improving the living conditions of the country so that there is a positive shift in SES, from lower to middle status. This can be achieved through redressing inequities and access to basic services. However, this cannot be done in isolation. Initiatives to create job opportunities to empower the population economically will aid in bridging the gap between the richer and poorer. This will enable the population to also sustain their livelihoods.

Piped water at a household level should be easily accessible to the entire population. In addition, regular refuse removal services are to be provided in areas that are in dire need of such services. In alignment with waste disposal, all alternative toilet systems needs to be eliminated and the population at large should have access to flush toilets. This is more sanitary and safer, especially in areas that are more prone to disease stricken conditions.

5.6 Conclusion

The overall conclusion drawn from this research is that it is possible to use indirect methods to estimate the level of child mortality using the 2016 Community Survey, regardless of the biases and challenges that the data has presented. The results produced has indicated that child mortality has significantly declined at a national level, in alignment with the production of previous research estimates however does not decline overall on a provincial level. Even though there is a notable decline nationally and amongst some provinces, it should be acknowledged that the pace of reduction directly sheds light on the lack of improvement in child health priorities. This research also highlighted that socio-demographic indicators as well as province of residence is influential to child mortality. This could possibly be a result of intervention programmes against HIV not being adequate to maintain the accelerated decline in mortality rates. However, one must take heed of the fact that these intervention programmes may have been effectively good enough to stop the deterioration in child health outcomes and child death. Even though many institutions, organisations and largely the government, focuses on the Prevention of Mother to Child Transmission (PMTCT) and

Highly Active Antiretroviral Therapy (HAART) programmes, it is as important to direct an equal amount of attention to preventative measures in the fight against HIV.

From this research we can not only isolate the staggering decline in child mortality to unfocused priorities as there is equally a need to address issues of inequality, poverty alleviation, basic public service delivery and educational attainment in order to reduce child mortality. Despite policies put in place for reduction of child mortality in the country, South Africa’s child mortality rate is still high and it is very unlikely that the country achieves the target that they are aiming for. This research has claimed that one approach to bring better outcomes is to address child mortality at lower provincial levels and has tried to provide the evidences gained from the latest available CS data. The results obtained may help the government to implement policies more effectively and make more focused decisions towards better reduction of child mortality within the country at provincial levels.

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Appendix A: Tables

Table A1: Average parities of females by province in South Africa, 2016

x	NAT	WC	EC	NC	FS	KZN	NW	GP	MP	LP
1	0.1253	0.1024	0.1531	0.1529	0.1102	0.1383	0.1304	0.0883	0.1389	0.1315
2	0.5971	0.5020	0.6619	0.7594	0.6085	0.6109	0.6819	0.4892	0.6631	0.6745
3	1.1224	1.0121	1.1975	1.3706	1.2209	1.0942	1.2936	0.9932	1.1544	1.2781
5	1.6091	1.4849	1.7004	1.9202	1.7180	1.5100	1.8349	1.4655	1.6555	1.8739
	0.8418	0.7769	0.8498	1.013	0.8947	1.0502	0.9564	0.7906	0.8855	0.9128

Table A2: Average parities per province

WC	EC	NC	FS	KZN	NW	GP	MP	LP	WC
0.7769	0.8498	1.013	0.8947	1.0502	0.9564	0.7906	0.8855	0.9128	0.7769

Table A3: Weighted values of children dead by women of reproductive age categories nationally

	W	CEB	CS	CD	D(i)
15-19	2 549 139	319 482	312 098	7 384	0.0231
20-24	2 643 461	1 578 488	1 534 839	43 648	0.0277
25-29	2 614 246	2 934 117	2 845 046	89 071	0.0304
30-34	2 267 924	3 649 338	3 527 155	122 183	0.0335
TOTAL	10 074 770	8 481 425	8 219 138	262 286	0.0309

Table A4: Weighted values of children dead by women of reproductive age categories in the Western Cape

	W	CEB	CS	CD	D(i)
15-19	249 027	25 492	25 045	447	0.0175
20-24	280 915	141 031	138 880	2 151	0.0153
25-29	275 584	278 917	275 172	3 745	0.0134
30-34	254 717	378 240	371 485	6 755	0.0179
TOTAL	1 060 243	823 680	810 582	13 098	0.0159

Table A5: Weighted values of children dead by women of reproductive age categories in the Eastern Cape

	W	CEB	CS	CD	D(i)
15-19	391 116	59 896	58 652	1 244	0.0208
20-24	352 277	233 165	225 712	7 453	0.0320
25-29	312 803	374 587	361 945	12 642	0.0337
30-34	270 204	459 466	442 072	17 394	0.0379
TOTAL	1 326 400	1 127 114	1 088 381	38 733	0.0344

Table A6: Weighted values of children dead by women of reproductive age categories in the Northern Cape

	W	CEB	CS	CD	D(i)
15-19	57 261	8 754	8 336	418	0.0477
20-24	53 071	40 302	38 966	1 336	0.0331
25-29	52 412	71 836	69 620	2 216	0.0308
30-34	48 474	93 080	89 829	3 251	0.0349
TOTAL	211 218	213 972	206 751	7 221	0.0337

Table A7: Weighted values of children dead by women of reproductive age categories in the Free State

	W	**CEB**	**CS**	**CD**	**D(i)**
15-19	134 975	14 878	14 507	371	0.0249
20-24	134 987	82 142	79 424	2 718	0.0331
25-29	137 013	167 278	160 938	6 340	0.0379
30-34	121 229	208 267	198 870	9 397	0.0451
TOTAL	528 204	472 565	453 739	18 826	0.0398

Table A8: Weighted values of children dead by women of reproductive age categories in KwaZulu-Natal

	W	**CEB**	**CS**	**CD**	**D(i)**
15-19	538 265	74 459	72 778	1 681	0.0226
20-24	543 645	332 091	320 920	11 171	0.0336
25-29	529 822	579 740	559 458	20 282	0.0350
30-34	446 915	674 849	647 558	27 291	0.0404
TOTAL	1 581 647	1 661 139	1 600 714	60 428	0.0364

Table A9: Weighted values of children dead by women of reproductive age categories in North West

	W	**CEB**	**CS**	**CD**	**D(i)**
15-19	170 518	22 236	21 203	1 033	0.0465
20-24	167 526	114 241	109 790	4 451	0.0390
25-29	167 153	216 234	206 611	9 623	0.0445
30-34	148 469	272 428	260 179	12 249	0.0450
TOTAL	653 666	625 139	597 783	27 356	0.0438

Table A10: Weighted values of children dead by women of reproductive age categories in Gauteng

	W	CEB	CS	CD	D(i)
15-19	470 345	41 521	40 809	712	0.0171
20-24	601 422	294 222	288 653	5 569	0.0189
25-29	645 173	640 780	625 167	15 613	0.0244
30-34	564 309	827 014	805 505	21 509	0.0260
TOTAL	2 281 249	1 803 537	1 760 134	43 403	0.0241

Table A11: Weighted values of children dead by women of reproductive age categories in Mpumalanga

	W	CEB	CS	CD	D(i)
15-19	210 042	29 178	28 557	621	0.0213
20-24	214 364	142 144	137 099	5 045	0.0355
25-29	218 769	252 539	243 743	8 796	0.0348
30-34	178 800	295 995	284 387	11 608	0.0392
TOTAL	812 975	719 856	693 786	20 070	0.0288

Table A12: Weighted values of children dead by women of reproductive age categories in Limpopo

	W	CEB	CS	CD	D(i)
15-19	327 589	43 068	42 212	856	0.0199
20-24	295 256	199 161	195 393	3 768	0.0189
25-29	275 518	352 144	342 394	9 750	0.0277
30-34	234 807	440 004	427 287	12 717	0.0289
TOTAL	1 133 170	1 034 377	1 007 286	27 091	0.0262

Table A13: Proportion dead of children ever born by women of the African population group

	TCEB	TCS	TCD	D(i)
15-19	289 546	282 871	6 675	0.0231
20-24	1 416 946	1 376 028	40918	0.0289
25-29	2 601 615	2 517 742	83 873	0.0322
30-34	3 138 126	3 024 145	113 981	0.0363
TOTAL	7 446 233	7 200 786	245 447	0.0330

Table A14: Proportion dead of children ever born by women of the Coloured population group

	TCEB	TCS	TCD	D(i)
15-19	25 641	24 964	677	0.0264
20-24	122 249	119 855	2 394	0.0196
25-29	220 111	216 368	3 743	0.0170
30-34	305 909	299 938	5 971	0.0195
TOTAL	673 910	661 125	12 785	0.0190

Table A15: Proportion dead of children ever born by women of the Indian population group

	TCEB	TCS	TCD	D(i)
15-19	1 327	1 327	0	0.000
20-24	10 072	9 858	214	0.021
25-29	30 432	30 173	259	0.009
30-34	57 009	56 273	736	0.013
TOTAL	98 840	97 631	1 209	0.012

Table A16: Proportion dead of children ever born by women of the White population group

	TCEB	TCS	TCD	D(i)
15-19	2 969	2 937	32	0.0108
20-24	29 229	29 095	134	0.0046
25-29	81 961	80 765	1 196	0.0146
30-34	148 296	146 811	1 485	0.0100
TOTAL	262 455	259 608	2 847	0.0108

Table A17: Proportion dead of children ever born by women that attained primary education

	TCEB	TCS	TCD	D(i)
15-19	30 818	29 513	1 305	0.0423
20-24	101 199	96 678	4 521	0.0447
25-29	198 565	188 527	10 038	0.0506
30-34	306 830	290 077	16 753	0.0546
TOTAL	637 412	604 795	32 617	0.0512

Table A18: Proportion dead of children ever born by women that attained secondary education

	TCEB	TCS	TCD	D(i)
15-19	280 338	274 372	5 966	0.0213
20-24	1 364 386	1 327 642	36 744	0.0269
25-29	2 413 757	2 342 313	71 444	0.0296
30-34	2 840 759	2 747 180	93 579	0.0329
TOTAL	6 899 240	6 691 507	207 733	0.0301

Table A19: Proportion dead of children ever born by women that attained tertiary education

	TCEB	TCS	TCD	D(i)
15-19	2 712	2 630	82	0.0302
20-24	72 331	71 043	1 288	0.0178
25-29	231 590	226 696	4 894	0.0211
30-34	362 897	355 193	7 704	0.0212
TOTAL	669 530	655 562	13 968	0.0209

Table A20: Proportion dead of children ever born by women that reside in urban areas

	TCEB	TCS	TCD	D(i)
15-19	147 015	143 856	3 159	0.0215
20-24	868 941	848 329	20 612	0.0237
25-29	1 766 844	1 719 976	46 868	0.0265
30-34	2 265 386	2 200 849	64 537	0.0285
TOTAL	5 048 186	4 913 010	135 176	0.0268

Table A21: Proportion dead of children ever born by women that reside in rural areas

	TCEB	TCS	TCD	D(i)
15-19	172 468	168 241	4 227	0.0245
20-24	709 549	686 510	23 039	0.0325
25-29	1 167 277	1 125 069	42 208	0.0362
30-34	1 383 955	1 326 307	57 648	0.0417
TOTAL	3 433 249	3 306 127	127 122	0.0370

Table A22: Proportion dead of children ever born by women in reproductive age groups

	TCEB	TCS	TCD	D(i)
15-19	319 483	312 099	7 384	0.0231
20-24	1 578 486	1 534 839	43 647	0.0277
25-29	2 934 117	2 845 049	89 068	0.0304
30-34	3 649 338	3 527 156	122 182	0.0335
TOTAL	8 481 424	8 219 143	262 281	0.0309

Table A23: Proportion dead of children ever born by women of low SES

	TCEB	TCS	TCD	D(i)
15-19	94 018	91 393	2 625	0.0279
20-24	412 265	397 187	15 078	0.0366
25-29	689 033	661 294	27 739	0.0403
30-34	823 672	786 827	36 845	0.0447
TOTAL	2 018 988	1 936 701	82 287	0.0408

Table A24: Proportion dead of children ever born by women of medium SES

	TCEB	TCS	TCD	D(i)
15-19	147440	144128	3312	0.0225
20-24	775502	756064	19438	0.0251
25-29	1449921	1408009	41912	0.0289
30-34	1838334	1775492	62842	0.0342
TOTAL	4211197	4083693	127504	0.0303

Table A25: Proportion dead of children ever born by women of high SES

	TCEB	TCS	TCD	D(i)
15-19	22 744	22 382	362	0.0159
20-24	154 245	151 379	2 866	0.0186
25-29	431 412	423 302	8 110	0.0188
30-34	743 265	729 707	13 558	0.0182
TOTAL	1 351 666	1 326 770	24 896	0.0184