Multilevel determinants of under-five deaths in South Africa: Evidence from 2016 Demographic Health Survey

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ABSTRACT

Background: The world has made significant progress in reducing under-five mortality rates. On the contrary, the under-five mortality rate remains high in sub-Saharan Africa. Although South Africa has a low under-five mortality rate in the region, the national target has failed to meet the required global standards. The main objective in this study was to determine multilevel determinants of deaths of children under-five years old in South Africa.

Methods: The study used secondary data from the South Africa Demographic Health Survey which was conducted in 2016. The bivariate and multivariate (multilevel logistic regression) analyses were used.

Results: The findings show that the sex of a child, population group, level of education, household wealth, type of toilet facility, place of residence and province were associated with under-five deaths. About 5.6% of male children died before the age of five years, while 4.4% of female children died before the age of five years. The study revealed that black women reported the highest under-five deaths (5.3%) compared to other population groups. The prevalence of under-five deaths was higher for women with primary education (7.4%) Under-five deaths decreased with increase in household wealth status; the prevalence of under-five deaths was higher among women from poor households (6.0%). Furthermore, children who used toilet facilities were more likely to die before the age of five compared to children with no toilet facilities. Under-five mortality rate showed variations at the provincial level. Children from the Eastern Cape province as well as from the North West province were more likely to die under the age of five years compared to children from the Gauteng province.

Conclusion: The study identified factors associated with under-five the deaths. The results demonstrated that there is a slow progress in reducing under-five mortality rate. The study calls for the improvement of child health services in rural areas, further improvement in ambulance services, and a functional rapid response system for emergencies in remote rural areas.

Keywords: under-five deaths; under-five mortality rate; South Africa; multilevel analysis

DECLARATION

I, Tshediso Vodka Barwe (27156222), declare that this work titled "Multilevel determinants of under-five deaths in South Africa: Evidence from 2016 Demographic Health Survey" is my original research work, and has never been submitted for any degree or examination in any other university or institution. I declare that the information contained in this document is a true copy of my thesis and has been approved for submission by my thesis supervisor. This work was supervised by Dr Mluleki Tsawe, and co-supervised by Dr Osuafor, from the Department of Population Studies and Demography. This work is submitted in partial fulfilment of the requirements for the degree Master of Social Science in Population Studies and Sustainable Development at the North-West University, Mafikeng Campus, South Africa.

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Finally, I dedicate this mini dissertation to my late special mother, Meitjie Idah Barwe, your son is a star now. May your soul keep resting in peace, my angel.

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ABBREVIATIONS/ACRONYMS

AIC	-	Akaike Information Criterion
BaSSREC	-	Basic and Social Sciences Research Ethics Committee
DUs	-	Dwelling Units
EBF	-	Exclusive Breastfeeding
ICC	-	Intra-Class Correlation
MDGs	-	Millennium Development Goals
MOR	-	Median Odds Ratio
NDoH	-	National Department of Health
OR	-	Odds Ratio
PCV	-	Proportional Change in Variance
PSU	-	Primary Sampling Unit
SADHS	-	South Africa Demographic Health Surveys
SAM	-	Severe acute malnutrition
SDG	-	Sustainable Development Goals
SSA	-	Sub-Saharan Africa
VIF	-	Variance Inflation Factor

CHAPTER 1: INTRODUCTION

1.1 Background to the study

The world has made the significant progress since 1990 in reducing child mortality. This can be substantiated from the evidence provided by Sanyang (2019); Word Health Organization (2020); Worku et al. (2021) that globally the rates of under-five mortality declined drastically from 12.6 million to 5.0 million between 1990 and 2020. Regardless of the world's effort and progress in reducing child mortality, sub-Saharan Africa region have made slow progress and still have highest under-five mortality rate. Several studies indicated that under-five mortality rate in sub-Saharan Africa was 16 times higher than the average child death rate in Europe and North America (Aheto, 2019; Hug et al., 2019). Tadesse (2021) found the average rate of child death in sub-Saharan Africa in 2018 was 78 deaths per 1000 live births. Mathews et al. (2016) indicated that the world has a disproportionate number of deaths among children under-five years of age, with a high rate in sub-Saharan Africa region where many of these deaths occur in rural areas. The National Department of Health et al. (2019) showed that 49% of under-five deaths are from rural areas in South Africa, while only 38% is observed in urban areas. Rural areas in South Africa lack sufficient child health care facilities in comparison to their urban counterparts (de Villiers, 2021).

Yaya et al. (2018) argued that children born in health institutions other than public are 17% more likely to die before reaching five years when compared to children of same age born in public health institutions in South Africa. A study in Nigeria by Adeyinka et al. (2020) revealed that there is a significant relationship between under-five deaths and place of delivery. A study by Bamford et al. (2018) showed that over 50% of all under-five deaths occurred in the health facilities of South Africa in 2015. This raised concern about health practices associated with children under five years old in South Africa. As a result, Bamford et al. (2018) and Guta et al. (2018) indicated that more interventions are needed to curb the rate of under-five deaths in public health facilities by prioritising more cautious measures and the need for highly skilled health workers.

Furthermore, Bamford et al. (2018) reported that the under-five mortality rate in health facilities ranged from 43.5% in the Eastern Cape to 67.7% in the Northern Cape. Under-five mortality

rates have shown variations within South African provinces. Evidence from the household census in 2011 showed that 54 580 deaths r of children under-five years old were reported (Statistics South Africa, 2019). KwaZulu-Natal reported the highest number of deaths for children under 5 years (27,19%), followed by Gauteng (15,74%), Eastern Cape (14%), Limpopo (10%), Mpumalanga (9%) and North West (9%), with the lowest under-five mortality rates reported in the Free State (7%), Western Cape (4%) and Northern Cape (2%) provinces (Statistics South Africa, 2019). Further studies, including the study of Mathews et al. (2016); Tesfa et al. (2021), provided evidence that environmental and behavioural factors, maternal and child factors, as well as socio-demographic factors have the greatest influence in the survival of children under five years in East African countries such as Burundi, Rwanda and Tanzania. The study by Rademeyer (2017) showed that under-five mortality is an indicator for overall socioeconomic status of a country.

1.2 Statement of the problem

To achieve national and international goals, a variety of policies, programs, and strategies have been developed (Goga et al., 2019). South Africa did not meet the Millennium Development Goals (MDGs), and if nothing is done the country is unlikely to meet Sustainable Development Goals (SDGs). One of the SDGs is to end the preventable deaths of children under five years of age by 2030 (target 3). Countries can achieve this target by reducing under-five mortality to less than 25 deaths per 1 000 live births (Ayele et al., 2021). The latest statistics show that South Africa has an under-five mortality rate of 42 deaths per 1000 live births in the five years preceding the survey (National Department of Health et al., 2019). This is the results of poor health services and poverty. There are provincial differences in under-five mortality for different population groups in South Africa. Amongst population groups in South Africa, the under-five mortality rate is higher in the black population than in the other groups (Rademeyer, 2017). At the provincial level, Mpumalanga, North West, Eastern Cape, and Free State have the higher under-five mortality rates ranging from 63–70 deaths per 1000 live births for the 10 years preceding the survey (National Department of Health et al., 2019). South Africa is expected to reduce its under-five mortality rate by at least 17 deaths per 1000 live births by 2030; understanding the complex factors determining under-five deaths is important for key role-players of child health interventions to effectively design strategies aimed at achieving the SDG targets.

1.3 Main objective of the study

The main objective of the study is to determine the multilevel determinants of under-five deaths in South Africa.

1.3.1. Specific objectives of the study

The study aims to answer the following specific objectives:

- To examine the prevalence of under-five deaths by background factors.
- To estimate the under-five mortality rate in South Africa by province.
- To investigate the statistical relationship between background factors and under-five deaths.

1.4 Research questions

The study aims to answer the following research questions:

- What is the prevalence of under-five deaths?
- What is the under-five mortality rate in South Africa by province?
- Are there any statistical relationships between background factors and under-five deaths in South Africa?

1.5 Significance of the study and rationale

South Africa is working on reducing the under-five mortality rate with respect to the mandate of SDGs (Ajulor, 2018). To plan and properly evaluate the healthcare system on health deliveries and outstanding health outcomes, health care practitioners as well as policy makers need precise and full data on the number of deaths and reasons for the children's' deaths. The study aims to present the role of social and economic factors in reducing under-five mortality. The findings from the study can provide information to programmes working on under-five mortality. Previous studies discovered that child health is good indicator and measure for overall countries' health status, not only child health and wellbeing (Boerma et al., 2018; Organisation for Economic Co-operation and Development, 2021; Prada & Sanchez-Fernandez, 2021). To conclude, this means that South Africa needs to improve the performance of the health system

and child health targets must be met in SDGs (target 3) to rectify the failure of meeting the Millennium Development Goal 4 (Statistics South Africa, 2015). As a result, there is a need to conduct the current study because credible and timely estimates of childhood mortality are required to track progress toward South Africa's SDG 3 target. Furthermore, under-five mortality rates are used to track changes in child survival as well as the quality of health care provided to children at various stages of their lives in each community.

1.6 Scope of the study

The study will focus on under-five deaths in South Africa. The study will analyse children aged between 0–59 months in relation to whether they are alive or dead. The study will use the data from the 2016 South Africa Demographic and Health Survey (SADHS).

1.7 Definition of concepts

Under-five deaths – this study operationally defines under-five deaths as deaths to children under the age of five years (Statistics South Africa, 2021).

Under-five mortality - is the probability of dying between birth and the fifth birthday, the rate is expressed as per 1000 live births (National Department of Health et al., 2019).

Live births - means the complete expulsion or extraction of the child from its mother irrespective of the duration of pregnancy. After such expulsion or extraction, the child breathes or shows any other evidence of life such as beating of the heart, pulsation of the umbilical cord or definite movement of voluntary muscles, whether or not the umbilical cord has been cut or the placenta is attached (Kelly et al., 2021).

1.8 Organisation of the study

The presentation of this study has five chapters. Chapter one comprises an introduction, background of the study, statement of the problem, research questions, objective, significance of the study, the scope of the study and lastly definition of concepts. Chapter two entails a literature review, theoretical framework, and conceptual framework. Chapter three provides a methodology and study limitations. Chapter four describes the analysis of data and presentation

of the results. Chapter five discusses the results, makes recommendations and provides the conclusion.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

This chapter reviews the context of child deaths, the associated socio-demographic factors, and the theoretical and conceptual frameworks.

2.2 Under-five deaths in the context of South Africa

In South Africa, under-five mortality rate has declined which is a positive outcome. However, it should be highlighted that the rate is significantly high compared to countries in of upper middle income. Few typical causes of under-five deaths have been identified in the country. Based on the report from South Africa Demographic and Health Survey (SADHS), it has been reported that common leading cause of death in children below five years is stunting (27%) as it is the prevalent cause of malnutrition (National Department of Health et al., 2019). The cause of malnutrition in Sub-Saharan is commonly poverty and inequalities in socioeconomic status, of which are common in South Africa (Modjadji & Mashishi, 2020). Despite having the high rates of child poverty, Limpopo Province, one of South Africa's nine provinces, is the least wealthy and has the lowest per-capita spending on primary healthcare. A study by Gavhi et al. (2020) identified that Severe Acute Malnutrition led to the death of 30.9% children below the age of five years in South Africa during 2018. A study by Muzigaba et al. (2017) states that children hospitalised for SAM in two rural hospitals in the Eastern Cape province were found to have a mortality rate of 24.4%, which is significantly higher than the WHO-acceptable threshold of fewer than 10%.

2.3 Socio-demographic factors associated with child deaths.

2.3.1 Age of the mother at childbirth

A Namibian study showed that mortality is more likely to happen in children born to mothers who are younger than 23 years or between 40–49 years (Susuman et al., 2016). Age of the mother at childbirth, specifically 35 years old and older, is identified with the high risk of dying among infants and children (Susuman et al., 2016).Several studies (Rabbani & Qayyum, 2017; Tesfa et al., 2021) conducted in different parts of the world have common findings that women who give birth at the age of 18 years or younger and women who are 35 years and older have a high risk

of experiencing under-five mortality during their first and subsequent births. In addition, it evident in the study of Deribew et al. (2016) that mothers who are 15–19 years and 35–49 years their children are more likely to die compared to children born to mothers of middle ages between 25–34 years old. The study by Makgolane (2022) found that children of mothers who are 32 years or older have the highest chance of surviving. Makgolane (2022) postulated that the older mothers possibly have the social and psychological maturity to manage the needs of childcare.

2.3.2 Marital status

Various authors have identified a significant relationship between marital status and under-five deaths, and also observed that never married and divorced women seemed to be associated with an increase in under-five deaths due to the point that they have limited resources needed for child survival (Kane, 2016; Kearney & Levine, 2017; Smith-Greenaway, 2020; Torche & Abufhele, 2021). Married mothers often get support from their partners during antenatal and postnatal care period and that reduces under-five mortality rate (Mengesha & Sahle, 2017; Mutwiri, 2021). Furthermore, single, and divorced mothers encounter challenges during antenatal and postnatal period that can be associated with increased under-five mortality rate. This is justified in the study of Smith-Greenaway and Clark (2017) elaborating that children of single and divorced mothers in African countries such as Ethiopia, Malawi, Tanzania and Kenya are 40% to 80% more likely to die thank children of married mothers.

2.3.3 Education of the mother

According to Andriano and Monden (2019), choices on health care practices including nutrition, hygiene, preventative care and disease treatment are influenced by the level of education. Children of educated mothers have better survival chances compared to mothers who are not educated. Güneş (2015); Ohonba et al. (2019) substantiated this because mothers who are educated are well informed about relevant measures preventing child deaths and are well informed about the utilization of health care services made available for child health. Moreover, educated mothers often monitor their children's health progress and adopt hygienic practices that directly prevent child diseases (Güneş, 2015; Hlongwa & Wet, 2019). In Nepal, mother's education and her decision-making power in the household are the most powerful determinants of infant mortality (Ghimire et al., 2019). It was confirmed in the study of Ndlovu (2018) that educating women and empowering them will have a greater effect on child survival. Due to their

increased involvement in health-promoting behaviours and increased understanding of many childhood illnesses, educated women had reduced infant mortality rates (Ohonba et al., 2019).

2.3.4 Employment status

The study by Akinyemi et al. (2018) suggested that children born to mothers who are working and economically active have a risk of mortality because their mothers do not spend more time with them to observe health issues. However, it can be argued in favour of International Labour Organization (2019) that employment does not have a negative influence on children's survival, especially in the neonatal period for mothers who work in the formal sector because they have the option of taking maternity leave, In sub-Saharan Africa, most women are working in the informal sector where such chances are not available. In South Africa it is generally known that unemployment is still a major issue and many people do not have consistent and reliable jobs (Nankinga et al., 2019; Olusanya et al., 2018). Employment of the mothers also has an effect on child heath through lack of time for breastfeeding (Ickes et al., 2021). Ickes et al. (2021) discovered that high levels of poverty in South Africa brought on by high unemployment rates make it harder for children to get the essentials for survival and good health, such as nutritious food and access to primary care. This was evident in KwaZulu-Natal (KZN), the province with high unemployment and illiteracy rates of 33% and 22%, respectively. More than 30% of households are in rural areas of KZN, which has the highest under-five mortality than elsewhere in the country (Hlongwa & Wet, 2019).

2.3.5 Income level

According to Tlou et al. (2018), the level of income is one of the crucial factors associated with child health. Families with a higher income have unlimited access to child health care services and can afford to pay medical expenses to avoid child death. In contrast, families with low-income levels have limited child health care services, such as access to medication. They usually use public health institutions where the service might not be sufficient to prevent children's ill health, hence putting the life of children in danger. Karra et al. (2017) supported the view that household wealth is one of the significant factors associated with under-five mortality rate, where the risk of mortality is higher for children born into poor households in comparison to children born into rich households. This can be explained by higher levels of malnutrition in the poor homesteads, as well as increased exposure to infections and the inaccessibility of healthcare

services. This could be an indication that the source of the high mortality rates for under-fives experienced over the years is rooted in the circumstances of the poorest/poor households (Lartey et al., 2016).

2.3.6 Sex of child

Gender differentials has been identified as a contributor to the mortality rate of children (Rademeyer (2017); Thurstans et al. (2020). Gender differential plays a role in reducing female child mortality when paying less attention to male child survival. However, this is being resolved by working women who do not have time to treat children differently. As a result, it can be summed up that sex of the child is insignificant to mortality among working women. In the study of Costa et al. (2017) female new-borns have an advantage in survival due to biological traits, and are less vulnerable to mortality from perinatal illnesses, congenital malformations, and infectious diseases. However, this advantage for girls is no longer evident one year after birth when they have been in contact with certain infections and diseases, which are leading causes of death in children between 1–4 years of age (Gobebo, 2021). In situations where boys and girls receive the same treatment, male children have a greater mortality rate (Thurstans et al., 2020).

2.3.7 Breastfeeding

Report on breastfeeding show that if all new-borns 0–23 months received the recommended level of breast milk, more than 800 000 children's lives may be saved annually among those under the age of five (UNICEF, 2021). It is vital to hold the knowledge that breastfeeding lowers the risk of pneumonia, diarrhoea, and malnutrition. Additionally, breastfeeding is crucial for the growth and survival of neonates. To eradicate all forms of malnutrition and enhance maternal, child, and nutrition health, the United Nations (UN) policy brief on The UN Decade of Action on Nutrition aims to increase the percentage of exclusive breastfeeding (EBF) to at least 50% by 2025 (World Health Organization, 2018). About 20% of new-born deaths and 13% of deaths in children under the age of five are prevented in India by early breastfeeding initiation and EBF for the first six months of life (World Health Organization, 2018). Despite the fact that breast milk is the primary strategy for improving a child's chances of survival, only 65% of Indian children are EBF for the first six months, and only 45% are breastfed within an hour of delivery (Marinelli et al., 2019). The literature in the study of Walters et al. (2017) revealed that only half of new-borns are

breastfed within the first hour of life globally despite strong evidence of the nutritional and immunological advantages in reducing neonatal death and morbidity.

2.3.8 Source of drinking water

A basic health requirement for maintaining the healthy growth and development of children is access to clean, safe drinking water. Diarrhoea in particular is a common disease connected to the drinking of contaminated water in South Africa and it is thought to be the cause of 20% deaths in children under the age of five (Wapenaar & Kollamparambil, 2019). According to UN General Assembly (2015), the SDG target 6.1 on sanitation and clean water aim to 'achieve universal and equitable access to safe and affordable drinking water for all.' There should be fair and equal distribution of clean water and sanitation services and no individual should be disadvantaged, especially children. Unhygienic water has health complications on child health, such as childhood diarrhoea and malnutrition. Geere and Hunter (2020) in their study found that accessible clean water in households encouraged women to seek social support when they are in perinatal period, which then lead to antenatal care visits or opt to give birth in a health care facility because hygiene is prioritized. Unimproved water supply and low levels of improved sanitation usage may also impact women during pregnancy or postnatal, Insufficient hygienic water causes poor nutrition which negatively affect breastfeeding, reduced birth weight and increases the risk of death in children (Motsima et al., 2020).

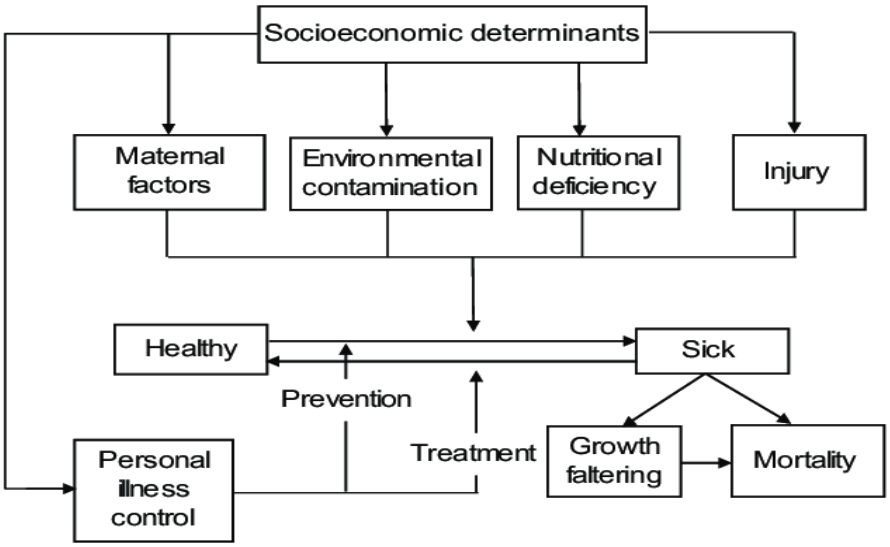
2.4 Theoretical framework

The Mosley and Chen framework (1984)

Mosley and Chen (1984) developed a framework that best analyse and research the factors that influence children's survival in developing countries. Abera and Yohannis (2021) sustain that the socio-economic and demographic determinants of under-five deaths are linked to individual and community level outcomes and are well linked and explained by Mosley and Chen (1984). The framework was built on the assumption that socioeconomic determinants of child mortality influence child mortality through a common set of biological and proximate mechanisms (Khan et al., 2018). Bello and Joseph (2014) found that Mosley and Chen (1984) categorised the determinants of infant and child mortality in socioeconomic and bio-medical determinants. The studies of Ayinmoro et al. (2019); Lu et al. (2019) emphasized that socioeconomic determinants

include community and regional determinants, while individual determinants include maternal factors, nutrition, injuries, and personal illness. The authors combined social and biological elements into an analytical framework for the study of child survival using medical and social science research methodologies. A study by Harttgen et al. (2020) found that the association between socioeconomic variables and population mortality levels and trends has traditionally been the focus of social science research on child mortality, ignoring the biomedical aspect that affect child mortality. For instance, in social science research income and education are widely measured variables and causes of child mortality in developing countries. Based on this Mosley and Chen (1984) developed a framework that include both socioeconomic and biomedical aspects. Refer to Figure 2.1.

Figure 2.1: Mosley and Chen conceptual framework.



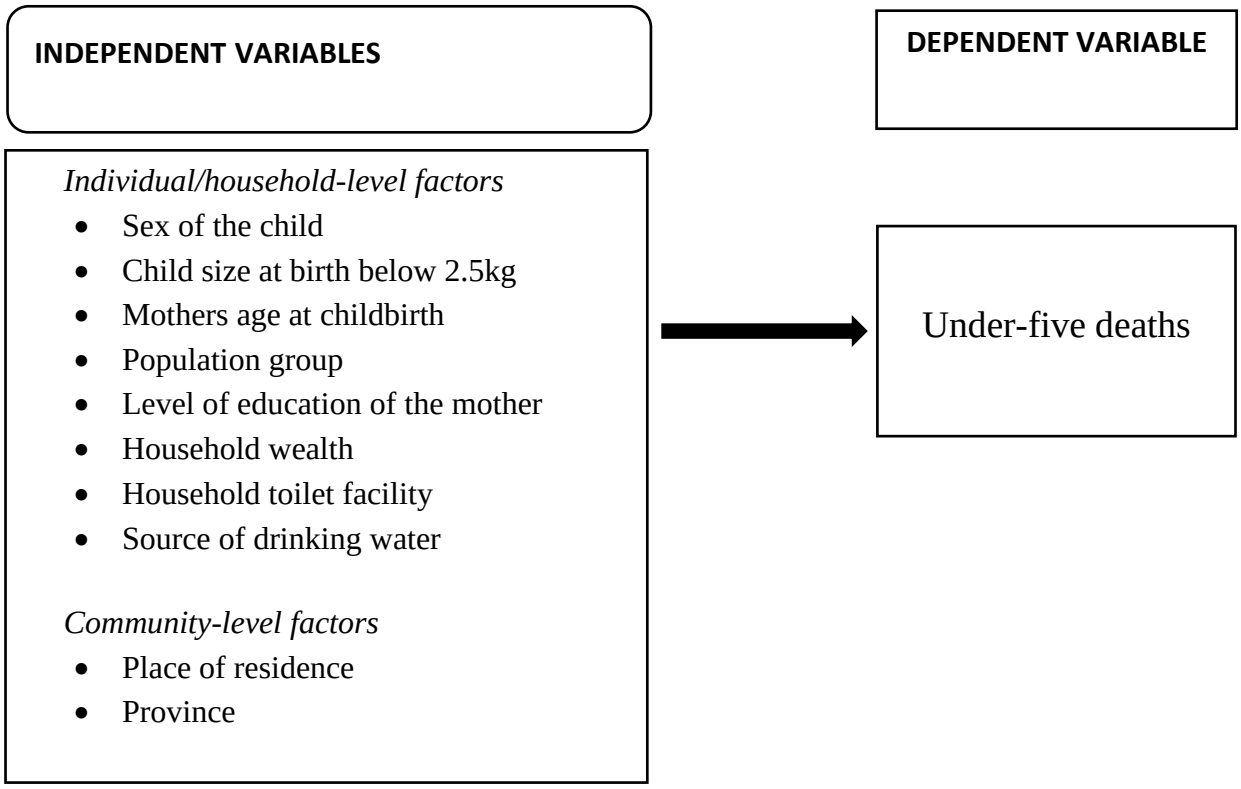
Source: Adapted from Mosley and Chen (1984)

2.5 Conceptual framework

Other studies (Fagbamigbe et al., 2021; Nyamuranga & Shin, 2019; van den Heever, 2016; Van Malderen et al., 2019) have used the conceptual framework proposed by Mosley and Chen (1984). This study adopted this framework because it best describes the variables under consideration. Refer to Figure 2.2. The study contains socio-demographic variables, including individual-level and community-level variables influencing child deaths. The individual-level factors are combined with the household-level factors. These factors include sex of the child, child size at birth, mothers' age at childbirth, mothers' education, breastfeeding status, household

wealth, household toilet facility and source of drinking water. The community-level variables include place of residence and province.

Figure 2.2: Conceptual framework depicting the multilevel determinants of under-five deaths.



CHAPTER 3: METHODOLOGY

3.1 Study setting

The study focuses on South Africa at the national level. South Africa is divided into nine Provinces, namely: Eastern Cape, Gauteng, Western Cape, Mpumalanga, Free State, Northern Cape, Limpopo Province, North West and Kwa-Zulu Natal (Statistics South Africa, 2017). The Republic of South Africa is located at the southern tip of Africa. It has a coastline on the Atlantic and Indian Oceans of approximately 2,798 kilometres (Department of Environmental Affairs, 2019). South Africa is popularly referred to as a rainbow nation because of diversity in cultures and languages. Eleven official languages, namely English, Afrikaans, isiXhosa, Setswana, Sesotho sa Leboa, isiNdebele, isiZulu, Sesotho, Xitsonga, siSwati and Tshivenda, which are all recognized in the constitution (Statistics South Africa, 2017).

3.2 Research and study design

The study employed a quantitative descriptive research approach. This approach is used to measure variables, to describe frequencies, averages, to determine correlations, and check the significance of relationships between variables (Disman et al., 2017). The descriptive research design is employed in the study. According to Siedlecki (2020), the purpose of descriptive research is to describe individuals, events, or conditions by studying them as they are in nature. Descriptive research design does not manipulate any of the variables, but only describes the sample and the variables. This research design studies the characteristics of the population and identifies problems that exist between them (Bloomfield & Fisher, 2019).

3.3 Data source

This study is based on secondary data from the SADHS, conducted in 2016. Trinh (2018) defined secondary data as the data that has been collected by other researchers or institutions and does not require the scholar to go to the field. The Demographic and Health Survey collects data on health and population and is representative nationwide (National Department of Health et al., 2019). The survey used a two-stage stratified sample design for data collection (National Department of Health et al., 2019). Stratified sample design is a situation whereby the population show a number of distinct categories (Zhao et al., 2019). In stage one, the primary sampling units (PSUs) were selected; in stage two, systematic sampling was used to select the dwelling units

(DUs) (National Department of Health et al., 2019). Systematic sampling is the arranging of the target population according to some ordering scheme and then selecting elements at regular intervals through the ordered list (Jang et al., 2020).The study analysed a weighted sample of 13 856 children whose age at death was below 60 months. A sample is a group of people who have been selected for a survey (Moser & Kalton, 2017).

3.4 Description of study variables

Dependent variable

The dependent variable for this study is whether the child is alive or dead at the time of survey. So, this variable is based on variable b5 of the birth file. Moreover, variable b7 will be used to denote the age at death in months. Therefore, children whose month at death is 059 months and B5 are coded as 1=Dead and 0=Alive. The dependent variable excludes children whose month at death or age at death is 60 months or more.

Independent variables

Ten independent variables are used in this study. The independent variables selected for this study include sex of the child, child size at birth below 2.5kg, mothers' age at childbirth, population group, mothers' education, household wealth, household toilet facility, source of drinking water, place of residence, and province.

Table 3.1: Description of variables

Independent variable	**Description**	**Coding**
Individual/household-level factors		
Sex of child	Reported sex of the child	1=Male 2=Female
Child's size at birth below 2.5kg	Reported whether the birth weight of the child was below 2.5kg	0=No 1=Yes
Age at childbirth	Respondents we asked their age at the time of birth	0=<20 1=20-29 2=30-39 3=40-49
Population group	The type of population group of the respondents	1=Black 2=Coloured

Independent variable	Description	Coding
		3=Other
Level of education	Highest level of education attained by the respondent	0=No education 1=Primary 2=Secondary+
Household wealth	Respondent's household wealth status	1=Poor 2=Average 3=Rich
Type of toilet facility	The type of toilet facility of respondent	0=None 1=Flush 2=Other
Source of drinking water	Respondent's type of drinking water	1=Piped 2=Not piped
Community-level factors		
Place of residence	Respondent's place of residence	1=Urban 2=Rural
Province	Respondent's province of residence	1=Western Cape 2=Eastern Cape 3=Northern Cape 4=Free State 5=KwaZulu-Natal 6=North West 7=Gauteng 8=Mpumalanga 9=Limpopo

3.5 Method of analysis

Stata version 14 software package was used for the analysis in this study. The study focuses on children aged 0–59 months at the time of the survey. Rates, univariate, bivariate, and multivariate analyses were used to meet the study objectives. Firslty, the under-five mortality rates were calculated using the *syncmrates* user-written command on Stata. Secondly, univariate analysis was used to describe the study sample. Thirdly, bivariate analysis with a chi-square test (χ^2) was used to estimate the prevalence of under-five deaths in South Africa. Finally, multivariate multilevel logistic regression was used to analyse individual/household-level and community factors determining under-five deaths in South Africa.

Multilevel modelling

The study applied multilevel analysis methods to account for the hierarchical nature of the SADHS data. Mulitilevel logistic regression recognises the existence of hierarchial data by allowing residual components at each level in the hierarchy. A two-level model was fitted in this study, where individuals/households (level 1) are nested within communities (level 2). The level 1 model looks at the relationships among the individual/household-level variables and under-five deaths, while the level 2 model examines the influence of community-level factors on under-five deaths. For the multivariate multilevel logistic regression analysis, the Stata *melogit* command was used.

The formula for the two-level model is shown as:

$$logit\left(\pi_{ij}\right) = log\left[\frac{\pi_{ij}}{1-\pi_{ij}}\right] = \beta_0 + \beta_1 x_{ij} + \beta_2 x_{ij} \ldots + u_{0j} + e_{0ij}$$

Where πij is the probability of an *ith* child in the *jth* community dying before the age of five, $\beta 0$ is the intercept, βn is the regression coefficient, xij is the independent variables, $u0j$ is the community level errors and $e0ij$ denotes the individual-level errors. This study fits four models. Model 0 is the null model, which was used to test for variability among the communities without any independent variable. Model 1 fits the individual/household-level factors. Model 2 was adjusted for the community-level factors. Model 3 was adjusted for both individual/household-level or community-level factors. The study also used the Intra-Class Correlation (ICC) to measure the percentage variation attributed by community level variables. The Median Odds Ratio (MOR) was used to describe the variance as Odd Ratio (OR), as the median value of distribution of the ORs were obtained from two different levels. Proportional Change in Variance (PCV) was used to measure the proportional change in the community-level variance. Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) were employed to compare two different models. Multicollinearlity was tested using the Variance Inflation Factor (VIF). Based on the findings, there was no collinearlity between the independent variables (VIF<10). The minimum VIF was 1.00, the maximum VIF was 1.81, and the mean VIF was 1.27.

3.6 Limitations

The main limitation of using cross-sectional data is that: one cannot measure causation; for example, one cannot say that poor sanitation causes under-five mortality. It is possible that some under-five deaths were underreported due to cultural and religious values. In addition, it is also possible that some data on first childbirth age may have been over or under reported. Under-five mortality results in the study may not necessarily be applicable to the current situation since the survey was collected for the 2016 Demographic Health Survey. The researcher was limited to work only with variables that were available in SADHS dataset.

3.7 Ethical considerations

Secondary data is used in this study; no primary collection was done. The SADHS program granted permission to use the dataset only for academic purposes and the dataset was not shared with any individual who did not apply for it. The researcher applied for ethical clearance from the North-West University's Basic and Social Sciences Research Ethics Committee (BaSSREC) and received clearance (ethics number NWU-01058-22-A7) before undertaking this study.

CHAPTER 4: DATA ANALYSIS AND RESULTS

4.1 Introduction

The chapter presents the results of the study. The results are presented for three types of analysis; firstly, the univariate analysis presents the percentage distribution; secondly, the bivariate analysis presents the relationship between dependent variable and population characteristics, the observation is based on the chi-square test (χ^2); and lastly, the multivariate analysis presents the relationship between individual/household level, community level factors and dependent variable.

4.2 Characteristics of the study population

Table 4.1 presents the background characteristics of the study population. The results show that 52.3% of the children in this study were males and 47.7% were females. The results show that about 96.7% of women reported that their children's size at birth was above 2.5kg and only 3.3% were below 2.5kg. The results varied based on the mother's age at childbirth. About 23.3% of women had their first child when they were younger than 20 years of age. The majority (55.7%) of women reported that they had their first child in their thirties. The results depicts that the numbers of first births decreased with an increase of maternal age, 19.7% of women had their first birth between the age of 30–39 years and only 1.4% of women had their first child when they were in their late forties. The majority (87.9%) of the study population were from the black population group and 8.6% were from the coloured population group, and 3.4% were from other population groups including whites and Indians. Regarding the mothers' level of education, evidence shows that only 3.6% of mothers had no education, while 14.0% of mothers had primary education, and most mothers (82.4%) had secondary education and higher.

Regarding the household wealth status, 43.9% of women were from poor households, whereas 22.3% were from average households, and 33.8% of women were from rich households. Fewer women (2.9%) were from households with no toilet facilities, whereas the majority (52.5%) of women were from households with flush toilets, and 44.5% of women were from other types of toilet facilities. Looking at the source of drinking water, 84.1% of the study population had access to piped water, while 15.9% do not have access to piped water. The respondents are unevenly distributed in terms of place of residence; 63.8% of women were from urban areas and

36.2% of women were from rural areas. Most women in the study were from Gauteng province (26.1%) and KwaZulu Natal (18.1%), Eastern Cape (11.6%), Western Cape (10.9%), Limpopo (10.3%), Mpumalanga (8.7%), North West (7.5%); with fewer women from Free State (4.8%) and Northern Cape (2.0%).

Table 4.1: Percentage distribution of individual/household level and community level factors of the study population

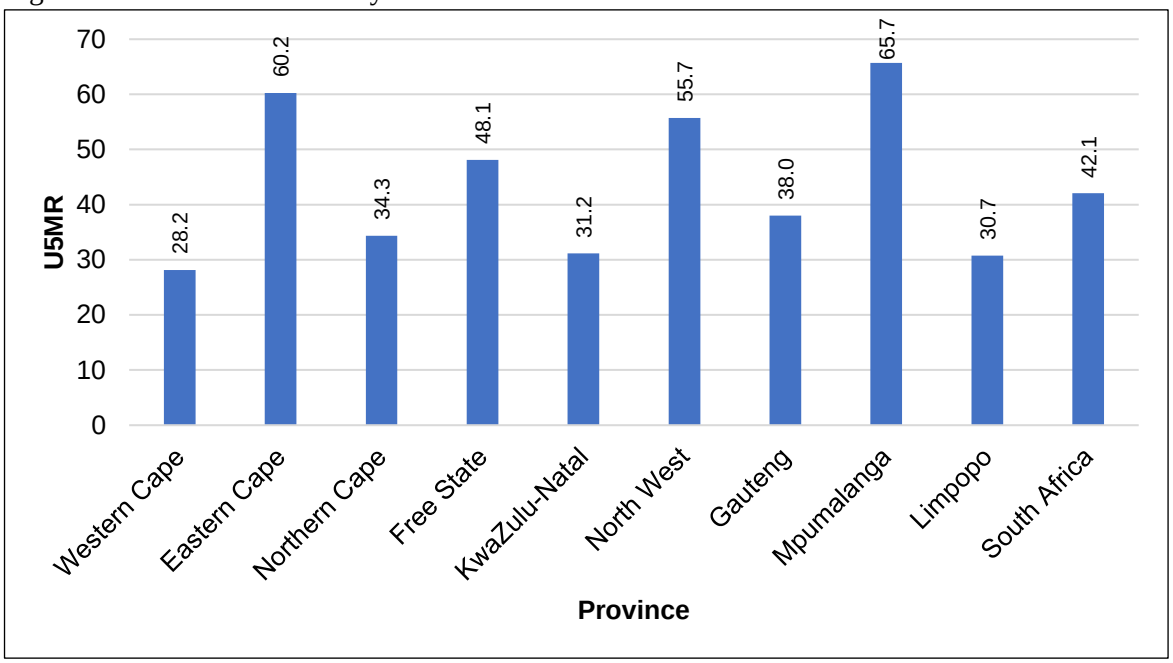
Variables	**Number**	**%**
Individual/household level factors		
Sex of child		
Male	7248	52.3
Female	6608	47.7
Child's size at birth below 2.5kg		
No	13397	96.7
Yes	459	3.3
Age at childbirth (years)		
<20	3228	23.3
20–29	7713	55.7
30–39	2726	19.7
40–49	188	1.4
Population group		
Black	12184	87.9
Coloured	1198	8.6
Other	474	3.4
Level of education		
No education	499	3.6
Primary	1945	14.0
Secondary+	11412	82.4
Household wealth		
Poor	6085	43.9
Average	3090	22.3
Rich	4680	33.8
Type of toilet facility		
None	404	2.9
Flush toilet	7280	52.5
Other	6171	44.5
Source of drinking water		
Piped	11655	84.1
Not piped	2201	15.9
Community level factors		
Place of residence		
Urban	8837	63.8
Rural	5018	36.2
Province		
Western Cape	1514	10.9
Eastern Cape	1610	11.6
Northern Cape	284	2.0
Free State	665	4.8

Variables	Number	%
KwaZulu-Natal	2502	18.1
North West	1036	7.5
Gauteng	3612	26.1
Mpumalanga	1207	8.7
Limpopo	1425	10.3
Total	**13856**	**100.0**

4.3 Under-five mortality rates

Figure 4.1 shows the under-five mortality rates (U5MR) in the provinces of South Africa (also see Figure A3 in the appendices). Western Cape had the lowest U5MR of 28.2 deaths per 1000 live births; Limpopo and KwaZulu-Natal also reported low U5MR of 30.7 deaths per and 31.2 deaths per 1000 live births respectively. The highest U5MR of 65.7 deaths per 1000 live births was reported in Mpumalanga, followed by Eastern Cape with 60.2 deaths per 1000 live births, and North West with 55.7 deaths per 1000 live births. Free State had 48.1 deaths per 1000 live births. Moreover, there were 38.0 deaths per 1000 live births in Gauteng province, and 34.3 deaths per 1000 live births in Northern Cape. Overall, the study showed that South Africa had an U5MR of 42.1 deaths per 1000 live births.

Figure 4.1: Under-five mortality rates



4.4 Prevalence of under-five deaths

Figure 4.2 shows the percentage of under-five deaths. The results show that 5.0% of children died before their fifth birthday and 95.0% of them survived.

Figure 4.2: Percentage of under-five deaths

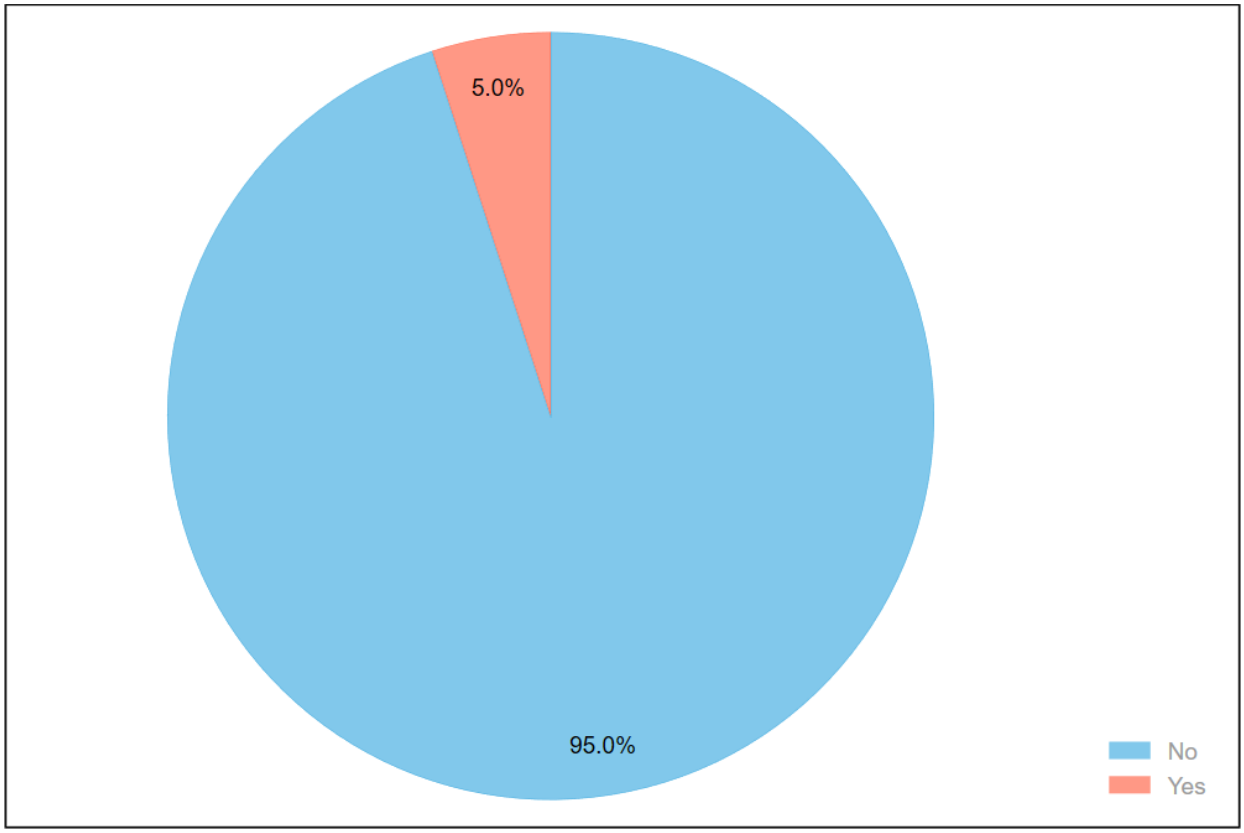


Table 4.2 presents the bivariate for the factors associated with under-five deaths. The study shows that several factors are associated with under-five deaths. The findings show that individual/household level factors (such as sex of the child, population group, level of education, household wealth, type of toilet facility) and community level factors (such as place of residence and the province) were significantly associated with under-five deaths. The results shows that 5.6% of male children died before the age of five years and 4.4% of female children died before the age of five years. The study reveals that 5.3% of black women reported that their children died before the age of five years, the results further reveal that 3.4% of coloured women reported deaths of children under-five. In comparison with mentioned population groups, it can be observed that only 1.2% of mothers from the white and Indian population groups lost their

children before the age of five years. Maternal education is found to be associated with the mortality rate of children under-five years of age.

Child death under the age of 5 years was reported by 6.0% of mothers who did not have education, 7.4% of mothers who had primary education, while 4.6% of mothers with secondary education reported deaths of children before reaching their fifth birthday. Based on the results, there was no association between child's size at birth, age of the mother and under-five deaths. Household status and child health are associates, 6.0% of poor households experienced under-five deaths, while 5.5% of average income experienced under-five deaths, and 3.3% of rich households reported deaths of children between 0–59 months. Deaths of children under-five was observed among 5.8% of women who did not have toilet facilities and only 4.1% of women who had flush toilet facility reported under-five deaths. Increased number of women (6.0%) who used other types of toilet facilities including pit toilet, bush, composting toilet, bucket toilet and chemical toilet reported that they experienced under-five deaths among their children. Based on place of residence, 5.9% of women in rural areas reported that their children died before the fifth birthday and 4.5% of women in urban areas reported under-five deaths. There are variations of under-five deaths in South African provinces (see the visual representation of these variations in Figure A2 (refer to Appendix 2); most under-five deaths were reported Mpumalanga (7.7%), Eastern Cape (7.2%) and North West (6.9%), Free State (5.3%), KwaZulu-Natal (4.8%), Northern Cape (4.6%), Gauteng (4.1%), in continuation; fewer child deaths were reported in Western Cape (3.6%) and Limpopo province (3.0%).

Table 4.2: Bivariate analysis for the factors associated with under-five deaths.

Variable	Under-five death				Total	Chi-square	
	No		Yes			Value	P-value
	%	CI	%	CI			
Individual/household level factors							
Sex of child						11.7	0.001
Male	94.4	[93.6-95.1]	5.6	[4.9-6.4]	100		
Female	95.6	[94.9-96.2]	4.4	[3.8-5.1]	100		
Child's size at birth below 2.5kg						3.4	0.064
No	94.9	[94.3-95.5]	5.1	[4.5-5.7]	100		
Yes	97.3	[95.1-98.5]	2.7	[1.5-4.9]	100		
Age at childbirth (years)						1.1	0.768
<20	95.1	[94.2-95.9]	4.9	[4.1-5.8]	100		
20–29	95.0	[94.2-95.7]	5.0	[4.3-5.8]	100		
30–39	94.7	[93.5-95.7]	5.3	[4.3-6.5]	100		
40–49	96.2	[92.7-98.0]	3.8	[2.0-7.3]	100		

Variable	Under-five death				Total	Chi-square	
	No		Yes			Value	P-value
	%	CI	%	CI			
Population group						30.2	0.000
Black	94.7	[94.0-95.3]	5.3	[4.7-6.0]	100		
Coloured	96.6	[94.0-98.1]	3.4	[1.9-6.0]	100		
Other	98.8	[97.1-99.5]	1.2	[0.5-2.9]	100		
Level of education						41.1	0.000
No education	94.0	[91.1-96.0]	6.0	[4.0-8.9]	100		
Primary	92.6	[90.7-94.1]	7.4	[5.9-9.3]	100		
Secondary+	95.4	[94.8-96.0]	4.6	[4.0-5.2]	100		
Household wealth						43.6	0.000
Poor	94.0	[93.1-94.8]	6.0	[5.2-6.9]	100		
Average	94.5	[93.0-95.7]	5.5	[4.3-7.0]	100		
Rich	96.6	[95.6-97.4]	3.4	[2.6-4.4]	100		
Type of toilet facility						36.0	0.000
None	94.2	[91.0-96.3]	5.8	[3.7-9.0]	100		
Flush toilet	95.9	[95.0-96.6]	4.1	[3.4-5.0]	100		
Other	94.0	[93.2-94.7]	6.0	[5.3-6.8]	100		
Source of drinking water						1.8	0.183
Piped	95.1	[94.4-95.7]	4.9	[4.3-5.6]	100		
Not piped	94.4	[93.2-95.5]	5.6	[4.5-6.8]	100		
Community level factors							
Place of residence						19.2	0.000
Urban	95.5	[94.7-96.2]	4.5	[3.8-5.3]	100		
Rural	94.1	[93.3-94.7]	5.9	[5.3-6.7]	100		
Province						84.7	0.000
Western Cape	96.4	[94.1-97.8]	3.6	[2.2-5.9]	100		
Eastern Cape	92.8	[91.3-94.1]	7.2	[5.9-8.7]	100		
Northern Cape	95.4	[93.3-96.8]	4.6	[3.2-6.7]	100		
Free State	94.7	[93.2-96.0]	5.3	[4.0-6.8]	100		
KwaZulu-Natal	95.2	[93.9-96.3]	4.8	[3.7-6.1]	100		
North West	93.1	[91.6-94.4]	6.9	[5.6-8.4]	100		
Gauteng	95.9	[94.0-97.2]	4.1	[2.8-6.0]	100		
Mpumalanga	92.3	[90.8-93.6]	7.7	[6.4-9.2]	100		
Limpopo	97.0	[96.0-97.8]	3.0	[2.2-4.0]	100		
Total	**95.0**	**[94.4-95.5]**	**5.0**	**[4.5-5.6]**	**100.0**		

4.5 Multilevel determinants of under-five deaths

Table 4.3 presents the multilevel findings for the relationship between under-five deaths and various factors. The findings from model three results are interpreted in this study. The findings show that the incidence of female children dying under the age of five years was less, 0.77 [95% CI: 0.66-0.89], compared to male children. The incidence of children dying under the age of five years from the black population group was 1.72 [95% CI: 1.13-2.6] times more than that of the coloured population group. The incidence of under-five deaths of children born to mothers with secondary education was 0.68 [95% CI: 0.56-0.82] times less compared with children born to mothers with primary education. The findings also showed that under-five mortality rate

decreased with household wealth status. The rate for children from poor households were 1.46 [95% CI: 1.12-1.92] times more compared to those from rich households.

The results further show that the mortality rate of children who used other types of toilet facilities were 1.63 [95% CI: 1.04-2.55] times more compared to children with no toilet facilities. The incidence of under-five deaths for children from households where piped water is not available were 0.90 [95% CI: 0.71-1.13] times less compared to children from households with piped water. The results showed that the geographical area was a factor associated with under-five deaths; the incidence of deaths of children under five years from the Eastern Cape was 1.63 [95% CI: 1.10-2.41] more compared to children from the Gauteng province. The incidence of deaths of children under the age of five years from the North West province was 1.70 [95% CI: 1.15-2.51] more compared to children from Gauteng province. Moreover, the incidence of deaths of children under five years of age from Mpumalanga was 1.85 [95% CI: 1.26-2.71] more compared to children from Gauteng province.

Table 4.3: Multilevel relationship between under-five deaths and individual/household level factors and community level factors

Variable	Model 1		Model 2		Model 3	
	AOR	**95% CI**	**AOR**	**95% CI**	**AOR**	**95% CI**
Individual/household level factors						
Sex of child						
Male®	1.00				1.00	
Female	0.77***	[0.66-0.89]			0.77***	[0.66-0.89]
Child's size at birth below 2.5kg						
No®	1.00				1.00	
Yes	0.65	[0.39-1.09]			0.64	[0.39-1.08]
Age at child birth(years)						
<20	0.99	[0.82-1.19]			0.97	[0.81-1.17]
20–29®	1.00				1.00	
30–39	1.10	[0.90-1.33]			1.11	[0.91-1.34]
40–49	0.90	[0.46-1.73]			0.91	[0.47-1.77]
Population group						
Black	1.73**	[1.20-2.50]			1.72*	[1.13-2.6]
Coloured®	1.00				1.00	
Other	0.84	[0.38-1.88]			0.85	[0.37-1.93]
Level of education						
No education	0.69	[0.46-1.02]			0.69	[0.46-1.02]
Primary®	1.00				1.00	
Secondary+	0.64***	[0.53-0.77]			0.68***	[0.56-0.82]
Household wealth						
Poor	1.43*	[1.09-1.88]			1.46**	[1.12-1.92]
Average	1.24	[0.96-1.60]			1.20	[0.93-1.55]

Variable	Model 1		Model 2		Model 3	
	AOR	95% CI	AOR	95% CI	AOR	95% CI
Rich®	1.00				1.00	
Type of toilet facility						
None®	1.00				1.00	
Flush toilet	1.38*	[0.84-2.26]			1.38	[0.84-2.29]
Other	1.58	[1.01-2.48]			1.63*	[1.04-2.55]
Source of drinking water						
Piped®	1.00				1.00	
Not piped	0.89	[0.71-1.11]			0.90*	[0.71-1.13]
Community level factors						
Place of residence						
Urban®			1.00		1.00	
Rural			1.38**	[1.13-1.70]	1.01	[0.79-1.30]
Province						
Western Cape			0.82	[0.51-1.34]	1.23	[0.73-2.07]
Eastern Cape			1.56*	[1.05-2.32]	1.63*	[1.10-2.41]
Northern Cape			0.98	[0.63-1.54]	1.27	[0.80-2.03]
Free State			1.35	[0.89-2.05]	1.42	[0.94-2.14]
KwaZulu-Natal			1.01	[0.67-1.50]	1.03	[0.70-1.54]
North West			1.64*	[1.10-2.45]	1.70**	[1.15-2.51]
Gauteng®			1.00		1.00	
Mpumalanga			1.74**	[1.18-2.58]	1.85**	[1.26-2.71]
Limpopo			0.59*	[0.38-0.93]	0.63*	[0.40-0.99]

Note: * = p<0.05; ** = p<0.01; *** = p<0.001; ® = reference category; AOR = adjusted odds ratio; CI = confidence interval

Table 4.4 presents the random effects and model fit statistics for under-five deaths in South Africa. The null model (Model 0) shows some variations in the determinants of under-five deaths (0-59 months) across the clusters (variance = 0.423 [95% CI 0.29 to 0.62]). This was attributed to between-cluster variations (ICC 11.40%). The between-cluster variations decreased from 11.40% in Model 0 to 6.32% in Model 3. About forty-eight (PCV 47.52%) of the variability in under-five deaths was explained by the Model 3. Results from the MOR confirmed that the community factors shaped the odds of under-five deaths. Model 3 was the best-fitted model because it had the lowest deviance (-2LL) and AIC.

Table 4.4: Random effects and model fit statistics for under-five deaths in South Africa

Random effects result	**Model 0 (*empty model*)**	**Model 1**	**Model 2**	**Model 3**
PSU variance (95% CI)	0.423 [0.29-0.62]	0.337 [0.22-0.53]	0.287 [0.18-0.47]	0.222 [0.12-0.40]
ICC %	11.40	9.28	8.01	6.32
MOR	1.86	1.74	1.67	1.57
PCV %	Ref	20.33	32.15	47.52
Model fitness				
-2LL	5820	5734	5754	5683
AIC	5824	5766	5776	5733
PSU	714	714	714	714

Note: Ref = reference; PSU = primary sampling unit; ICC= intra-class correlation; MOR= median odds ratio; PCV= proportional change in variance, -2LL= deviance; AIC= Akaike information criterion

CHAPTER 5: DISCUSSIONS, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter focuses on the discussion and findings of the study. Furthermore, the chapter includes a conclusion and recommendations. The study addressed two specific objectives. Firstly, the study estimated the under-five mortality rate in South Africa. Secondly, the study investigated the statistical relationship between background factors and under-five deaths.

5.2 Discussion

The study aimed to determine the multilevel factors determining under-five deaths in South Africa. The findings showed that the factors investigated, namely sex of a child, population group, level of education, household wealth, type of toilet facility, place of residence and province were associated with under-five deaths. These findings are similar to findings from other developing countries, which found associations between these factors and child deaths (Agho et al., 2020; Doku et al., 2020; Liang et al., 2018; Makgolane, 2022). The findings showed that female children had lower odds of under-five deaths. A study by Berelie et al. (2019) also found sex differentials in child survival. Moreover, in low-income counties female children are more likely to die because of gender inequalities in these societies; this was evident in the study of Ng et al. (2017) conducted in Zimbabwe. Results in the study by Kumar et al. (2021) also showed that males below the age of five years had a high risk of death compared to females.

Moreover, this study found variations in under-five deaths between the different population groups. Black women reported a higher number of child deaths. Studies conducted in sub-Saharan Africa show that ethnicity is a significant determinant of under-five deaths (Ahinkorah et al., 2020; Rademeyer, 2017; Victora et al., 2020). This finding can be explained by the history of socio-economic setting of the country, since the black population group were less privileged in terms of accessing better healthcare and high incomes to be able to make better decisions for children's health compared to other racial groups such as whites, Indians/Asians and coloureds in the country. A similar study, conducted in Brazil by Rebouças et al. (2022), found that inequalities in racial groups contribute to childhood mortality.

Education is important in the general health and health of the children. The study found that children who were born to mothers with secondary education or higher had higher odds of under-five deaths. This finding is similar to other findings (Kiross et al., 2019; Woldeamanuel & Aga, 2021). Children from women with a higher level of education have a lower risk of under-five deaths because their mothers have better understanding of health issues and can make informed decisions with regard to child health care, and they are also observant of the child's hygiene practices (Mandal et al., 2021). Additionally, Mandal et al. (2021) noted that as maternal education increases so does the involvement of a woman in family decision-making and their participation in meeting the demands of child health care. The results indicated that children born to women from rich households were less likely to die before age five. This was corroborated in prior studies by Biradar et al. (2019); Chao et al. (2018); Ekholuenetale et al. (2020) who found that household wealth is a significant determinant of under-five deaths. Several attributes of better child survival in rich households are monetary affordability of child medications and better diet, which reduced the incidence of common diseases such as malnutrition (Ward & Viner, 2017).

It can be observed from the results that there is a higher incidence of under-five deaths in children born to women who have no proper toilet facilities available. This result is consistent with the findings of a study by (Tagoe et al., 2020), which found that women with no proper toilet facilities are associated with unhygienic conditions and this can affect child health and lead to child death. Child deaths, in these circumstances, can possibly be explained by unhygienic toilet conditions where the children reside. Pit toilets, ablutions in the bush, composting toilet, bucket toilets and chemical toilets are all associated with unhygienic conditions, which have a negative effect on child health by spreading agents of diarrhoea (Adane et al., 2017; Liu et al., 2016). The results showed that rural areas had a higher prevalence of under-five deaths compared to urban areas. Rural areas often have limited health care facilities and residents are located far away from clinics and hospitals to assess health complications of a child and access relevant medical attention on time (Ahinkorah et al., 2020).

Furthermore, the findings showed that Mpumalanga, Eastern Cape, and North West had a higher prevalence of under-five deaths. This supports the results of a study by Ntsimane (2019) that showed provincial variations within South Africa for the occurrence of under-five deaths. A possible reason for the higher under-five mortality is these provinces may be the economic status

of the provinces, which affects the health system of each province. Overall, the findings are related to the conceptual framework proposed by Mosley and Chen (1984) and used in this study. Some of the selected factors have been found to be important determinants of under-five deaths.

5.3 Conclusion

The purpose of this study was to identify factors of under-five death in South Africa. The factors selected, namely sex of a child, population group, level of education, household wealth, type of toilet facility, place of residence and province are risk factors of under-five deaths. The results show that the under-five mortality rate is still the same in the country regardless of the effort to reduce it, the rate was 42 deaths per 1000 live births in 2018 and the study shows the rate is still the same. There is a need to reduce under-five mortality rate for the successfulness of the SDG 3. In summary, the results show that there is a higher incidence of under-five deaths of children born to women with low levels of education and poor wealth status in South Africa. In addition, the mortality rate of children under five years of age is higher for those born to black women compared to children born to women in other racial groups.

5.4 Recommendations

Based on the results of the study certain recommendations can be made for policymakers and the population as whole. The study calls for the improvement of child health care services in rural areas. Further improvements include the availability of ambulance services and functional rapid response system for emergencies in remote rural areas. Factors such as birth weight, toilet facility, residence, province, wealth status and maternal education should be taken into consideration when planning and formulating policies for reducing the mortality rate of children under-five years to successfully contribute to achieve the SDG target 3 by 2030. Relevant health organisations and the Department of Health should promote child health education to women of reproductive age by developing relevant policies to reduce the risks of child deaths. Since the study identified determinants of under-five mortality in the whole of South Africa, in order to make positive progress of reducing U5MR, further studies on childhood mortality should be examined at the provincial level instead of national level in the future.

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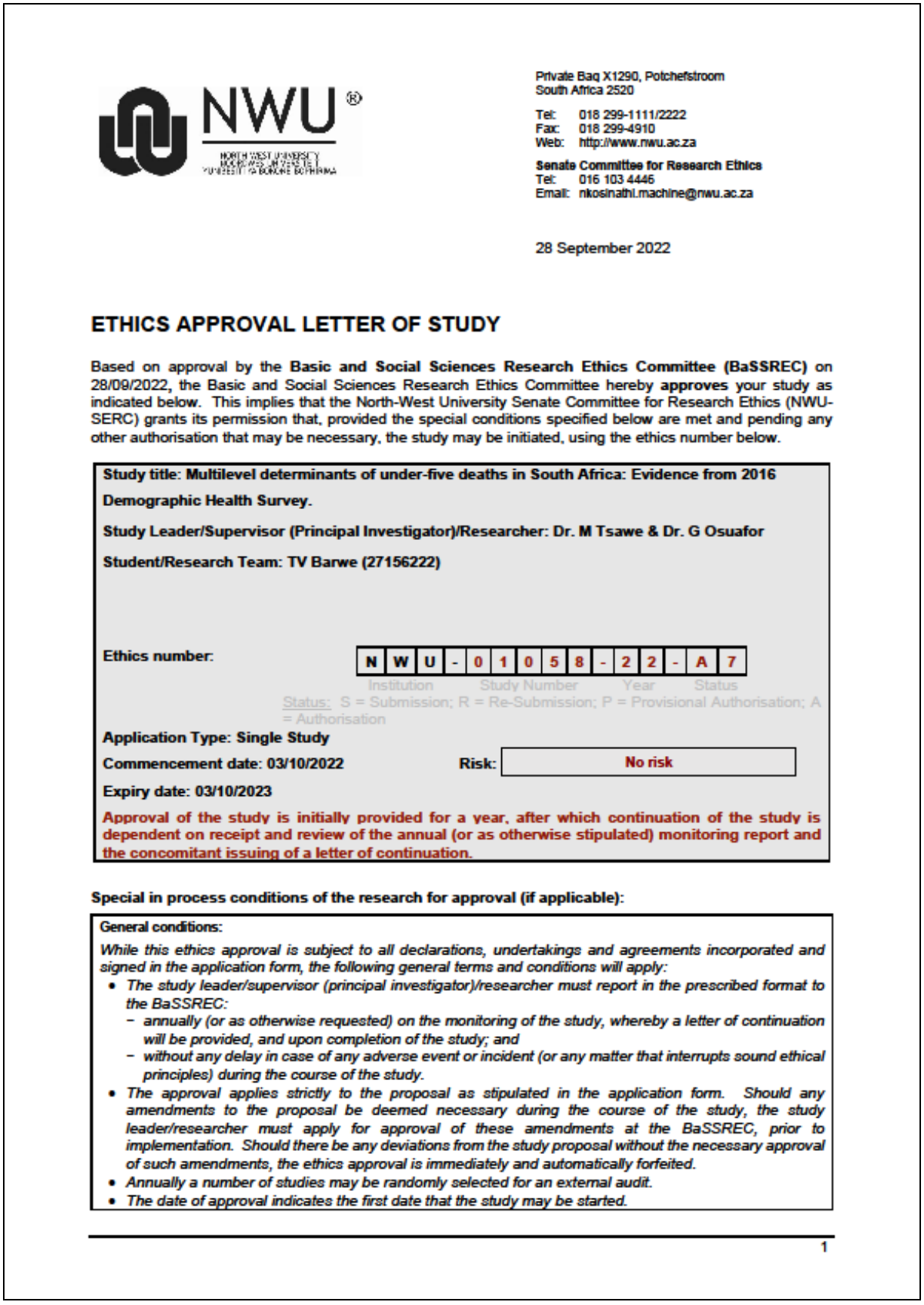
APPENDICES

Figure A1: Ethics approval letter



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28 September 2022

ETHICS APPROVAL LETTER OF STUDY

Based on approval by the **Basic and Social Sciences Research Ethics Committee (BaSSREC)** on 28/09/2022, the Basic and Social Sciences Research Ethics Committee hereby **approves** your study as indicated below. This implies that the North-West University Senate Committee for Research Ethics (NWU-SERC) grants its permission that, provided the special conditions specified below are met and pending any other authorisation that may be necessary, the study may be initiated, using the ethics number below.

Study title: Multilevel determinants of under-five deaths in South Africa: Evidence from 2016 Demographic Health Survey.

Study Leader/Supervisor (Principal Investigator)/Researcher: Dr. M Tsawe & Dr. G Osuafor

Student/Research Team: TV Barwe (27156222)

Ethics number: NWU-01058-22-A7

Institution Study Number Year Status

Status: S = Submission; R = Re-Submission; P = Provisional Authorisation; A = Authorisation

Application Type: Single Study

Commencement date: 03/10/2022 **Risk:** No risk

Expiry date: 03/10/2023

Approval of the study is initially provided for a year, after which continuation of the study is dependent on receipt and review of the annual (or as otherwise stipulated) monitoring report and the concomitant issuing of a letter of continuation.

Special in process conditions of the research for approval (if applicable):

General conditions:

While this ethics approval is subject to all declarations, undertakings and agreements incorporated and signed in the application form, the following general terms and conditions will apply:

- *The study leader/supervisor (principal investigator)/researcher must report in the prescribed format to the BaSSREC:*
  - *annually (or as otherwise requested) on the monitoring of the study, whereby a letter of continuation will be provided, and upon completion of the study; and*
  - *without any delay in case of any adverse event or incident (or any matter that interrupts sound ethical principles) during the course of the study.*
- *The approval applies strictly to the proposal as stipulated in the application form. Should any amendments to the proposal be deemed necessary during the course of the study, the study leader/researcher must apply for approval of these amendments at the BaSSREC, prior to implementation. Should there be any deviations from the study proposal without the necessary approval of such amendments, the ethics approval is immediately and automatically forfeited.*
- *Annually a number of studies may be randomly selected for an external audit.*
- *The date of approval indicates the first date that the study may be started.*

1

- *In the interest of ethical responsibility, the NWU-SCRE and BaSSREC reserves the right to:*
  - *request access to any information or data at any time during the course or after completion of the study;*
  - *to ask further questions, seek additional information, require further modification or monitor the conduct of your research or the informed consent process;*
  - *withdraw or postpone approval if:*
    - *any unethical principles or practices of the study are revealed or suspected;*
    - *it becomes apparent that any relevant information was withheld from the BaSSREC or that information has been false or misrepresented;*
    - *submission of the annual (or otherwise stipulated) monitoring report, the required amendments, or reporting of adverse events or incidents was not done in a timely manner and accurately; and / or*
    - *new institutional rules, national legislation or international conventions deem it necessary.*
- *BaSSREC can be contacted for further information or any report templates via BaSSREC-Admin@nwu.ac.za.*

The BaSSREC would like to remain at your service as scientist and researcher, and wishes you well with your study. Please do not hesitate to contact the BaSSREC or the NWU-SCRE for any further enquiries or requests for assistance.

Yours sincerely

Prof E. Idemudia

Chairperson NWU Basic and Social Sciences Research Ethics Committee

Original details: (22351930) C:\Users\22351930\Desktop\ETHICS APPROVAL LETTER OF STUDY.docm
8 November 2018

File reference: 9.1.5.4.2

Figure A2: Map of South Africa showing the prevalence of under-five deaths

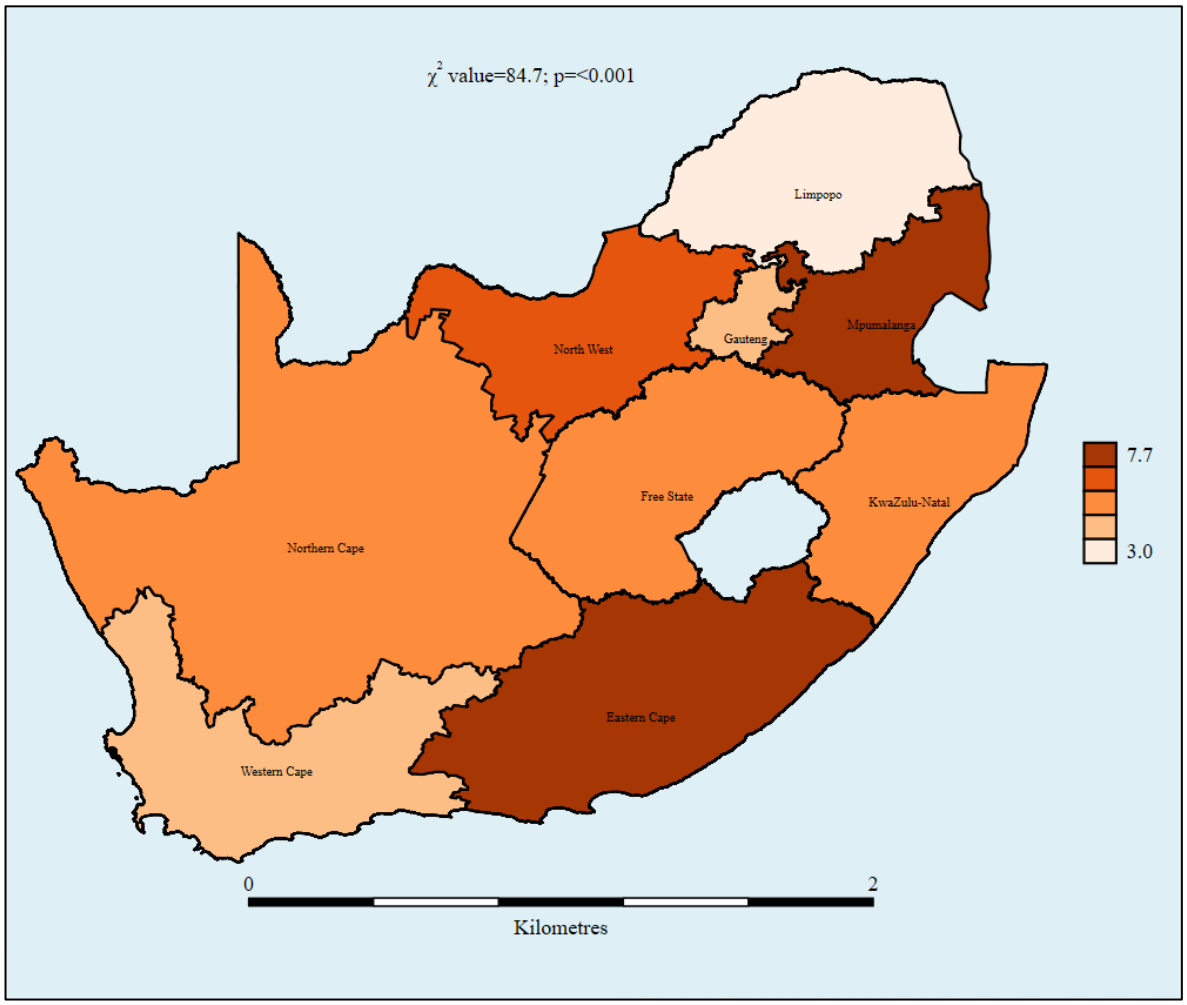

Figure A3: Under-five mortality rate by province in South Africa