Characterising perinatal mortality in South Africa: A cross-sectional analysis using Demographic Health Survey data

Ruvimbo Faith Forget

Supervisors

Dr. Sana Mahtab (MBBS, MPH, PhD)

Prof. Eustasius Musenge (PhD)

Dr. Chenai Mlandu (MSC, PhD)

A research report submitted in partial fulfillment of the requirements for the degree of Master of Epidemiology (Epidemiology and Biostatistics) to the Faculty of Health Sciences, School of Public Health, University of the Witwatersrand, Johannesburg,2024

DECLARATION

I declare that this dissertation is my original work and has been conducted under the guidance of my supervisors. All the sources used in this research have been properly acknowledged and referenced. This dissertation has not been submitted for any other qualification at any other institution. I take full responsibility for the content, analysis, interpretations, and conclusions presented in this dissertation.

Ruvimbo Faith Forget

ABSTRACT

Background: Perinatal mortality defined as the death of a fetus at or after 22 weeks of gestation and the death of liveborn in the first 7 days of life is a significant public health concern in Sub-Saharan Africa including countries like South Africa. While South Africa may be on track in meeting the Sustainable Development Goal (SDG) targets of reducing perinatal mortality, there are significant disparities within the country, with some provinces showing considerably higher rates of perinatal mortality. This underscores the need to investigate individual and community level factors associated with perinatal mortality to facilitate more effective targeted interventions.

Aim: This study aims to investigate individual (maternal and neonatal) and community-level characteristics associated with perinatal mortality in South Africa using the Demographic and Health Survey (DHS) data in 2016.

Methods: A cross-sectional design was used in analysing secondary data from 8,514 women of reproductive age. Perinatal mortality was the primary outcome and was calculated using total counts of perinatal mortality divided by the number of live births and multiplied by 1,000 at national and provincial level. Multivariable logistic regression models were used to identify the factors associated with perinatal mortality adjusting for survey design. Furthermore, random effects were incorporated at cluster level in the multilevel logistic regression to estimate community level effects.

Results: The national perinatal mortality rate was 31 per 1,000 live births, with significant regional disparities. Women with a history of terminated pregnancies had four times the odds of perinatal mortality compared to those without (AOR 4.24; 95% CI: 2.25–6.48). Women aged 25–34 years (AOR 2.51; 95% CI: 1.46–4.31) and those aged 34+ (AOR 3.62; 95% CI: 2.14–6.14) were significantly likely to experience perinatal mortality. Women who tested positive for HIV during pregnancy were significantly less likely to have perinatal mortality (AOR 0.60; 95% CI: 0.41–0.86). Perinatal mortality significantly varied by province, higher odds of perinatal mortality were observed in the Northern Cape (AOR 2.16; 95% CI: 1.12–12.33) and North West (AOR 3.31; 95% CI: 1.16–9.42) compared to the Western Cape. Household wealth was protective, with women from richer households less likely to experience perinatal mortality than those from poorer households (AOR 0.58; 95% CI: 0.36–0.96). About 20% of the variance was attributed to cluster/community effects.

Conclusions: The study showed high levels of perinatal mortality at national and provincial level. Individual level factors like terminated pregnancy, maternal age, parity and HIV transmission, as well as community level factors like household wealth and province were associated perinatal mortality. Policymakers should consider tailored interventions at multiple levels including improving access and quality of maternal healthcare particularly among women of low socioeconomic status and enhancing uptake family planning services among women of reproductive age. Additionally, interventions tailored for provinces with high levels of perinatal mortality should be considered.

Keywords: Perinatal mortality, stillbirths, neonatal deaths, maternal health, provincial disparities, South Africa

ACKNOWLEDGEMENT

I would like to express my deepest gratitude to my three supervisors, Dr Sana Mahtab, Prof. Eustatius Musenge, and Dr Chenai Mlandu, for their invaluable guidance, support, and mentorship throughout the entire research process. Your expertise has been instrumental in shaping this dissertation and enhancing my research skills.

I am also indebted to my family, partner and friends for their unwavering support, love, and understanding during this demanding journey. Your constant encouragement, patience, and belief in my abilities have been a source of strength and motivation. Your sacrifices and understanding of the demands of this research endeavour have been crucial in my ability to pursue and complete this dissertation.

Table of Contents

List of Figures

List of Tables

Nomenclature/ Abbreviation List

ANC – Antenatal Care

AOR – Adjusted Odds Ratio

CI – Confidence Interval

DHS – Demographic Health Survey

ENND – Early Neonatal Death

LMIC – Low- and Middle-Income Countries

MCH – Maternal and Child Health

NMR – Neonatal Mortality Rate

PMR – Perinatal Mortality Rate

SBR – Stillbirth Rate

SDG – Sustainable Development Goal

SSA – Sub-Saharan Africa

WHO – World Health Organization

Chapter 1 – Introduction

This chapter outlines the background of the study, problem statement, rationale, aim, objectives, and conceptual framework.

1.1 Background

Perinatal mortality is the death of a foetus or a newborn baby within a period that is calculated between 28 weeks of gestation to the first week after birth[1]. Perinatal deaths include stillbirths and early neonatal death. Stillbirths can be categorised into antepartum and intrapartum stillbirths. Antepartum stillbirths occur when the fetus (at or after 28 weeks of gestation i.e., 7 months of pregnancy) dies in the womb before labor begins and intrapartum stillbirths occur when the fetus dies during labor or delivery (with the weight of at least 1000g). Neonatal deaths are also categorised into early and late neonatal deaths. Early neonatal deaths are the deaths of a fetus within a week after birth and late neonatal death is the death of a fetus that occurs after the first week of giving birth and before 28 days of birth [1,2].

Perinatal mortality remains high in low-and middle-income countries (LMICs)[3]. Approximately 2.6 million stillbirths occur worldwide each year, with 98% occurring in LMICs[3]. In sub-Saharan Africa (SSA), the stillbirth rate (SBR) is about 10 times higher compared to high-income countries[4]. While high-income countries typically have SBRs below 5 per 1000 births, many LMICs report rates exceeding 25 per 1000 births. Additionally, there were 2.5 million neonatal deaths globally in 2017, with the majority (73%) occurring during the first week after birth. The global neonatal mortality rate (NMR) was 18 per 1000 live births in that year[2,5]. SSA had a much higher neonatal mortality rate of 28 per 1000 live births in 2018 compared to other regions and significantly above the NMR target of 12 per 1000 live births by 2030[6,7].

The perinatal mortality rates in South Africa were estimated at SBR of 17.9 per 1000 births in 2017[8], which is higher than the global target of reducing the SBR to 12 per 1000 live births by 2030 [9]. In addition, there are some notable disparities within the country, with some provinces reporting higher rates than the national average. For example, a hospital in the Eastern Cape reported an NMR of 31.1 per 1000 live births during 2015-2016, where the national average was 18.1 per 1000 live births, highlighting the need for targeted interventions across all provinces to reduce perinatal mortality rates[10]. Efforts must be intensified to achieve significant reductions in perinatal mortality rates across South Africa and other regions of sub-Saharan Africa to meet global health targets.

Perinatal mortality has been associated with maternal, neonatal, and community factors such as parity, mother's age, attending antenatal care (ANC) visits mother's education, birth weight, skilled birth attendant, previous history of perinatal mortality, socio-economic status (SES) birth interval, autonomy in decision making, travel distance to health facility, place of delivery and residency[11,12]. Although, efforts are being made to reduce perinatal mortality through equitable access to care and the betterment of quality care for maternal and child health, perinatal mortality remains a public health concern [13]. Previous studies conducted in South Africa on perinatal mortality have identified individual (maternal and neonatal) factors of perinatal mortality [14,15]. However, there is a lack of assessment of community-level factors and factors that influence perinatal mortality in high-prevalence regions. Hence, the overall aim of this study is to ascertain the individual and community characteristics of perinatal mortality in South Africa to inform targeted interventions.

1.2 Problem Statement

There is high perinatal mortality in LMICs as opposed to high-income countries. Most countries in LMICs fall short of reducing the perinatal mortality rate to 12 per 1000 by 2030 as set by the World

Health Organization (WHO)[16]. In 2017, South Africa reported an SBR of 17.9 per 1000 births[8] and an NMR of 18.1 per 1000 births in 2016[17], which were higher than the global targets. However, recent literature shows that SA has achieved an NMR below the global target as of 2018[18]. Despite South Africa achieving the 2030 global target for neonatal mortality at the national level, significant disparities persist across provinces. Despite initiatives aimed at ensuring equity in health and enhancing the quality of maternal and child healthcare, there remains limited data and literature providing insights on the current PMRs across provinces in SA[6]. According to Statistics South Africa (Stats SA) the North West reported the highest stillbirth rate at 23 deaths per 1,000 live births and Mpumalanga the lowest at 7 deaths per 1,000 live births. However, stillbirth rates alone fail to provide a comprehensive understanding of perinatal mortality, the report did not have any data on neonatal mortality[19]. Current literature is fragmented, lacking integrated data that combines stillbirth and neonatal mortality to offer a holistic view of perinatal outcomes in South Africa.

1.3 Rationale of the Study

Perinatal mortality accounts for 40% of deaths in the overall under-five mortality[20]. It is also the best indicator of the quality of early neonatal care and antenatal care available[21]. Various antenatal and intrapartum interventions have been proven to reduce perinatal mortality, like antenatal care and improved health facility delivery [22]. However, perinatal mortality is still high in LMICs including South Africa. Few studies have been conducted to understand the driving factors of perinatal mortality in South Africa[15]. However, these studies have mainly focused on individual (maternal and neonatal) factors. There is limited investigation on the role of community factors on perinatal mortality. Therefore, the study seeks to examine individual (maternal and neonatal) and community characteristics of perinatal mortality in South Africa using the Demographic Health Survey (DHS) data. These findings will inform stakeholders and policymakers in designing comprehensive targeted interventions that will address a broad aspect of risk factors at individual and community level to end preventable perinatal mortality.

1.4 Research question

What are the individual (maternal and neonatal) and community characteristics associated with perinatal mortality in South Africa?

1.5 Aim

To investigate the individual (maternal and neonatal) and community characteristics associated with perinatal mortality in South Africa.

1.6 Objectives

1. To determine the prevalence of perinatal mortality at national and provincial level in 2016 in South Africa
2. To describe individual (maternal and neonatal) and community characteristics of perinatal mortality in 2016 in South Africa.
3. To determine the individual and community factors associated with perinatal mortality in 2016 in South Africa.

Chapter 2 – Literature Review

This chapter provides an overview of the theoretical framework, key concepts, and empirical studies, and identifies gaps in existing literature.

2.1 Demographics of South Africa

2.1.1 Population Characteristics

South Africa is a middle-income country and has a population of approximately 60.6 million [23]. The country is divided into 9 provinces, namely Gauteng (GP), Kwa-Zulu Natal (KZN), Western Cape (WC), Eastern Cape (EC), Limpopo (LP), Mpumalanga (MP), North West (NW) and Northern Cape (NC). GP, KZN, and WC account for 50% of the population, while Gauteng has the highest percentage distribution. The percentage distribution of Gauteng in June 2022 was 26.6%, followed by KZN at 19.0 % then WC at 11.9%[24]. About 17% of the population lives in informal settlements. In comparison to other provinces, Gauteng has the smallest percentage of people (approximately 57%) residing in paid-off households[25]. Approximately forty-nine percent of the population in South Africa are living under the upper-bound poverty line, having an income of less than 1200 rands [26].

South Africa's history has significantly impacted its health sector. Before 1994, access to health services, land, and basic needs were all contingent on race hierarchies. Then, black people were forced to work for low wages for the benefit of the white minority. Efforts to promote equity and negate the effects of these systems have since been implemented but much work still needs to be done [27]. South Africa has a quadruple burden of disease – a phenomenon only known to South Africa. One of the epidemics affecting the country is maternal, newborn, and child morbidity, alongside HIV and Tuberculosis, Non-communicable diseases (NCDS), and violence and injury. Studies have shown a steady decline in mortality within these epidemics[28]. However, these national-level trends do not translate to all provinces. Due to South Africa being a federal system, each provincial government decides its priorities – contributing to the disparities in health funding, health system development, and ultimately health outcomes[29]. To reach SGD targets for perinatal mortality there needs to be a combined effort from all provincial governments towards the set goal.

2.2 Overview of perinatal mortality

2.2.1 Perinatal Mortality

Perinatal mortality includes a combination of stillbirths and neonatal mortality. Stillbirth account for 40-60% of perinatal mortality[30]. WHO defines stillbirth as a baby born dead at the gestation age ≥ 28 weeks and with a birthweight of ≥ 1000g[31]. This includes both antepartum and intrapartum stillbirths, which are deaths that occur before or at the onset of labor, respectively[32]. Neonatal mortality is the death of a live baby within the first 28 days of life. This is further classified into early neonatal mortality which occurs before7 days and late neonatal mortality occurring between 7-28 days of life[30], see Figure 1. Perinatal mortality in this research refers to stillbirths (intrapartum and antepartum) and live births with only a brief survival of up to 7 days.

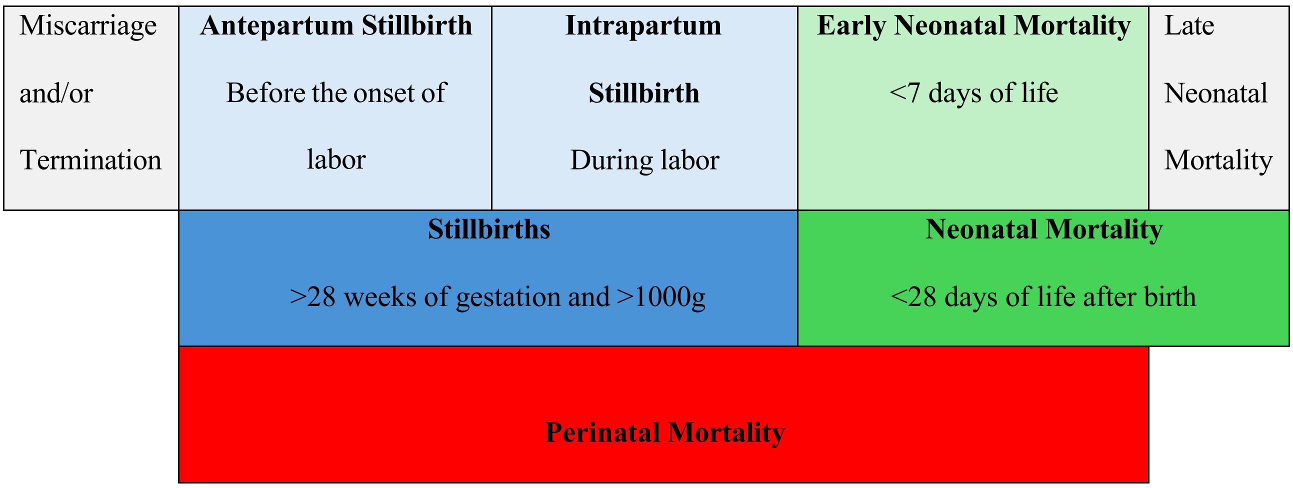

Figure 1: *Illustration of the definition of perinatal mortality*

2.2.2 The Burden of Perinatal Mortality

2.2.2.1 Stillbirths

A study in 2024 showed that 44% of global stillbirths occur in SSA[32,33]. In 2015, ten countries collectively represented about 66% of global stillbirths, with eight of these countries located in SSA [34]. In developed countries, SBRs are estimated between 4.2 – 6.8 per 1000 births. In contrast, developing countries experience higher SBRs ranging from 20 – 32 per 1000 births[32]. The risk of stillbirths is, on average, 7.6 times higher in LMICs compared to high-income countries, [35]. SSA notably exhibits significantly higher SBRs than high-income countries[33].

LMICs accounted for 84% of all stillbirths in 2019 of which 77% of these stillbirths in LMICs are concentrated in SSA[35,36]. The SBRs in these countries in SSA also differ because of the different economic and cultural disparities. A study in 2019 reported that the highest SBR was from West and Central Africa at 22.8 per 1000 births, and Eastern and Southern Africa followed at 20.5 per 1000 births[37]. There are a few studies that estimate the national and provincial SBRs in South Africa[38]. According to a report from the United Nations (UN), SA had approximately 19,612 stillbirths per 1,197, 000 total births. Therefore, recorded an SBR of 16.4 per 1000 births in 2019 with an upper and lower bound of 12.7 and 21.3 respectively [35]. The largest category of perinatal mortality in the country is stillbirths. The district hospitals and community health centres in South Africa reported that for every neonatal death, there were 2.5 stillbirths[39].

2.2.2.2 Early neonatal mortality

Globally, there were 2.4 million neonatal deaths in 2019, with SSA having the highest NMR at 27 deaths per 1000 live births. These neonatal deaths account for 36% of the under-five deaths recorded in SSA. Children born in SSA have 10 times greater risk of death in the first month than children born in a high-income country (HICs)[40]. There is a high likelihood of these numbers being significantly higher because of the underreporting that happens in LMICs.

NMRs have been experiencing a much slower decline as opposed to deaths of children between the ages of 1- 5 years. In South Africa, NMRs declined from 27.9 per 1000 live births in 1975 to 10.7 per 1000 live births in 2018, reaching its SDG target for 2030 compared to other African countries like Kenya with an NMR of 19.6 in the same year[41]. Current trends show that 64 countries will not make the neonatal mortality target by 2030[42]. Though, South Africa has managed to reach the SDG target for NMR, disparities still occur within the country. The number of neonatal deaths in South Africa varies depending on factors such as province and type of hospital. According to the 6th perinatal care survey, 46% and 39% of neonatal deaths occur in district and regional hospitals, respectively [43]. Dora Nginza Hospital, a hospital in EC, recorded an NMR of 19.4 per 1000 live births in 2019 which is higher than the national NMR[13].

2.3 Factors Associated with Perinatal Mortality

2.3.1 Individual Factors (Maternal and Neonatal Factors)

Maternal and neonatal factors are associated with perinatal mortality. Maternal factors associated with perinatal mortality include maternal education, maternal age, lack of autonomy in making decisions, employment status, parity, history of terminated pregnancies, antenatal care, smoking, and consumption of alcohol[44,45]. For instance, research from a study that retrospectively reviewed records of women who gave birth at a hospital in Asia between 2012 and 2019 stated a significant relationship between parity and perinatal survival. Multiparous women had lower chances of a perinatal death in subsequent pregnancies[46]. Other studies suggested the opposite with the reason being multiparous women underutilize ANC because of experience with childbirth, therefore exposing them to undetected pregnancy risks[47]. Women under 20 years and over 35 were significantly at a higher risk for adverse pregnancy outcomes. Younger women are at a higher risk due to barriers like stigma, financial constraints, and a lack of education regarding pregnancy and ANC services. Older women were also considered to have a higher risk because of possible chronic conditions and comorbidities[48].

Maternal education and employment status were also mentioned as key factors in determining perinatal mortality. More educated women have a reduced risk of perinatal death. This was because they were more likely to engage with healthcare services and were more informed about pregnancy-related complications. The same trend was noted amongst women who were employed. These women had better access to health care and were able to make decisions about their health which decreased their odds of adverse pregnancy outcomes[49].

Neonatal factors linked with perinatal mortality include birth weight and HIV transmission. For instance, an earlier study in the Free State Province of SA showed that perinatal mortality was higher in children with lower gestational age and birth weight[50]. Babies born with birthweights over 1000g are more likely to survive than those born weighing less[43]. Studies indicate that HIV-positive mothers have a higher risk of perinatal mortality compared to those who are HIV-negative. Factors such as maternal immunosuppression, increased susceptibility to infections, and the potential for vertical transmission of the virus to the infant increased the risk of perinatal mortality. Consequently, untreated HIV is linked to complications during pregnancy and childbirth, leading to higher rates of adverse outcomes[51].

Previous research has also established an increased risk of perinatal mortality with four or fewer ANC visits[23]. In SSA, about 46-69% of women attend at least one ANC visit. However, attendance of ANC visits falls short of the optimal 4 or more ANC visits. Antenatal care (ANC) is crucial to maternal healthcare and aims to improve pregnancy outcomes by managing perinatal complications through services like screenings, health education, and treatment[23,52].

2.3.2 Community Factors

Evidence from the literature shows that place of residence, cultural norms, family size, family income, place of delivery, geographic accessibility to health facilities, and access to clean water supply are some of the community factors associated with perinatal mortality[53]. Socio-economic status (SES) is deemed to be a very important determinant of health outcomes. Individuals with a low SES are usually unable to get adequate medical care[54]. Previous studies revealed that women with a low SES were less likely to receive prenatal care[55] and low SES was associated with pregnancy complications such as Early Neonatal Death (ENND) and stillbirth[55,56]. Utilizing the Global Network Socioeconomic Status Index (GN-SES), a study was able to show that a higher SES was linked to more antenatal visits, increased facility births, lower parity, and higher education. The GN-SES was a good substitute for using household wealth to determine economic status since the data could sometimes be unreliable and inaccurate[56]. Similarly, the DHS considered multiple indicator variables and household characteristics to determine and correlate economic status with a household's overall economic standing[57].

SES standing can also determine access to clean drinking water. Poor household water supply can affect maternal and child health outcomes. Globally, approximately 1.2 billion people lack access to drinking water. In 2020 it was recorded that 50% of healthcare facilities do not have basic water services[58]. Studies have shown the negative impact that unsafe water, sanitation, and hygiene (WASH) practices has on child health[59–61]. Poor WASH conditions affect perinatal mortality, particularly through the mechanism of infections. There are a significant number of bacterial infections associated with perinatal deaths, including Escherichia coli (E. coli) which is largely found in areas with poor WASH conditions[58,62]. Only about 9-52.5% of women in regions of Africa and the Middle East are giving birth in good water and sanitation environments[58].

WASH conditions are dependent on place of residence. A significant proportion of households in developing countries are deprived of basic WASH facilities. However, the availability of basic water and sanitation services varies significantly across different regions and countries. Urban households and regions with a higher SES are more likely to use basic WASH facilities[63]. This is true with other factors that are associated with perinatal mortality.

Poor access to health facilities has also been found to be associated with perinatal mortality. Lack of transportation from home to healthcare facilities was identified among the causes of avoidable perinatal mortalities[43]. Women who had to travel longer distances to healthcare facilities experienced higher perinatal mortality because long distances meant increased costs, thus limiting their access to essential maternal healthcare services including ANC and skilled delivery.

2.3.3 Conceptual Framework

The conceptual framework within which the relationship between the different factors and perinatal mortality is formed in this study is shown in **(Figure 2)** below. This framework is similar, but not identical, to that used in a scoping review titled "Factors associated with infant mortality in Nigeria: A scoping review". Their model adopts a socioecological model to categorize risk factors at various levels, drawing from others cited in the study [64]. These models emphasize the hierarchical and interconnected nature of determinants of infant mortality, ranging from individual maternal, and child characteristics and broader public policy[65,66].

The conceptual framework of this study as depicted in **(Figure 2)**, considered two major categories of variable influences on perinatal mortality. The first include individual factor variables (maternal education, age, antenatal care, employment, birth weight). The second set includes community factor (family size, province, access to water, urban/ rural, family income). Finally, these factors are interconnected and directly lead to the outcome of perinatal mortality. This was created to summarize the associations and findings from the literature review conducted.

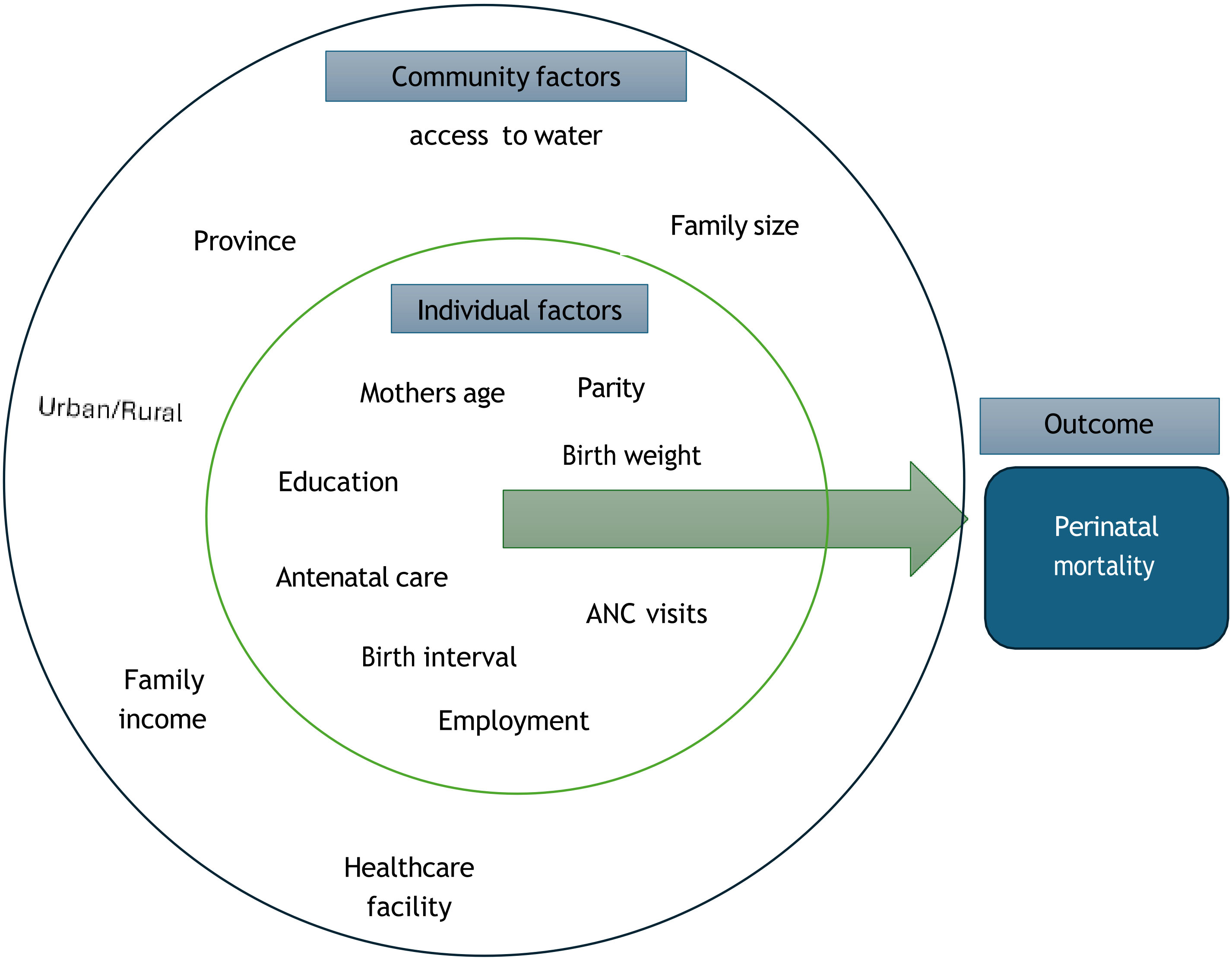

Figure 2: *Conceptual Framework*

Chapter 3 – Methods

This chapter outlines the research design, population and sampling methods, data collection techniques, analysis procedures, and ethical considerations.

3.1 Study design

This is a cross-sectional study using secondary data from the Demographic Health Survey in South Africa. This study aims to assess the characteristics of perinatal mortality in South Africa.

3.2 Study site

The study takes place in South Africa. South Africa is a middle-income country and has a population of approximately 60 million people in which most of the population (49.1 million, 81%) is made up of Black Africans [18]. The country is divided into 9 provinces: Western Cape, Eastern Cape, Free State, Gauteng, KZN, Mpumalanga, Northern Cape, and North West. The survey was established in 2016, and this study will utilise all the data collected from the survey's inception. The map of South Africa and its provinces is depicted in Figure 3.

Figure 3: *Map showing the nine provinces of South Africa.*

3.3 Study population

All pregnant women of reproductive age (15-49) residing in South Africa. Women who had a miscarriage or terminated their pregnancy (foetus dying before the 28^{th} week of gestation) in the last pregnancy were excluded in the study.

3.4 Sampling

Demographic and Health Surveys are population-based surveys that are representative of the nation they are taken in. Since DHS data is designed to collect information on reproductive health, child health, fertility, and mortality, the target population is women of reproductive and children under five living in residential households.

The DHS based their sampling on the Statistics SA Master Sample Frame (MSF) which was created using 2011 census geographical areas. Geographical areas, defined as enumeration areas (EAs) were randomly selected with a probability based on population size and stratification characteristics. These areas were used as the Primary Sampling Units (PSUs). Depending on the size of EAs, they were either pooled together or split to fit a certain size. To ensure comparability across provinces, each province was stratified into urban, traditional, or farm areas. This yielded 26 sampling strata with PSUs allocated by power allocation within these strata. Furthermore, every PSU had an estimated number of residential dwelling units (DUs).

The DHS involved a stratified two-stage sampling design. In the first stage, PSUs were selected based on their power allocation. In total, 750 of these areas PSUs were selected for the survey. Out of the 750 PSUs, 468 were in urban areas, 224 in traditional areas, and 58 in farms. In the second stage, a fixed number of 20 DUs were systematically selected. Every household in a selected DU was eligible to be interviewed[67,68].

After a household has been selected, trained interviewers then visit the selected households to collect demographic and health data from eligible individuals without replacing those households that do not consent. For the survey, a woman from a selected household is approached and consents to an individual interview. The household survey can be answered by any knowledgeable person who is 15 or older and lives in the sampled household. The questions asked in this survey help to determine information on the household itself, i.e., water and sanitation facilities. Additionally, the questions asked also to provide means to identify eligible women for the individual interviews and children under five[42]. Once an eligible woman has been identified for the woman's questionnaire, which consists of maternal and child health questions.

3.5 Data collection

3.5.1 Instrument of data collection

The DHS data is collected from survey questionnaires, geographic location, and biomarker testing. The inclusion criteria for the surveys are all women of childbearing age (15-49) and men aged 15-54/59. The questionnaires are in three parts, namely, the household questionnaire, the women's questionnaire, and the men's questionnaire. In this study only, the women were considered for analysis.

The questionnaires are standardized across countries, and this is used to compare data between these countries. The model questionnaires are taken as is by most countries. Some variables are either added or deleted to suit the context of the country the survey has been done in. DHS questionnaires have been reviewed and modified since the first phases. These changes are catered for through the different recode definitions that come with each new phase. This helps to track the variables that have been added or dropped.

For the variables that can be measured and evaluated independently such as weight, height, haemoglobin, and HIV, biomarker measurements are taken. In this section of the questionnaires, survey participants would have consented to have their blood specimens collected and transported to a lab and other measures taken. The samples are tested according to standardized procedures. These procedures ensure that the test reaches optimal sensitivity and specificity[42].

3.5.2 Sample power calculation

This study did not conduct any sampling but calculated sample power to assess the adequacy of sample size and detect differences in exposure effects on the outcome. This was a secondary data analysis, and we performed post hoc power calculations based on the final known number of perinatal mortalities in the analysis sample to determine if we have the power to detect difference in perinatal mortality by risk factors. Power calculations were calculated using the chi-squared test comparing two independent proportions using Stata version 18. The final sample size after data management and cleaning was 8514. The proportion of perinatal mortality was 31% and of live births was 69%. A study conducted in SA found the prevalence of perinatal mortality at 3.6%. We computed the power for different percentages:

```
. power twoproportion 0.036, test(chi2) n(8514) oratio(0.521) continuity

Estimated power for a two-sample proportions test
Pearson's chi-squared test
H0: p2 = p1  versus  Ha: p2 != p1

Study parameters:

        alpha =    0.0500
            N =     8,514
  N per group =     4,257
        delta =    0.5210  (odds ratio)
           p1 =    0.0360
           p2 =    0.0191
   odds ratio =    0.5210

Estimated power:

        power =    0.9970
```

Figure 4: *Statistical power calculation as a function of sample size*

Figure 4 shows that with the total sample size of 8514 participants had a power of 99%, and there it had adequate power to detect differences in perinatal mortality by risk factors.

3.5.3 Data management

The data management involved cleaning and recording variables, checking for missing data, and outliers, and generating new variables where necessary. We excluded variables with more than 20% missingness from the analysis to reduce potential bias and ensure the robustness of the results. Less than 20% of missing data is commonly acceptable benchmark in research, according to Peng et al,2006[43]. The data was stored safely and could be accessed in a password-protected device.

3.5.4 Measurement of Variables

The variable definitions are outlined in Table 1 below. The outcome variable is perinatal mortality, defined as death of a fetus at or beyond 22 weeks of gestation, encompassing both stillbirths (infants born without signs of life) and early neonatal deaths (infants who die within the first seven days after birth)[1]. The explanatory variables include maternal characteristics such as age, marital status, parity, and community characteristics such as province, residency, household wealth index, household size and head as well as source of drinking water as defined in Table 1.

Table 1: Measurement of variables and variable definitions

Variable	Definition	Measurement
Dependent Variable		
Perinatal Mortality	Stillbirths and early neonatal deaths (within 7 days of life)	1 = Perinatal mortality
		0 = No perinatal mortality
Explanatory Variables		
Individual Characteristics		
Ever Terminated Pregnancy, Employment Status, HIV Transmission.	Binary variables indicating: History of terminated pregnancy, employment, HIV transmission from mother to child.	1 = Yes
		0 = No
Age Category	Mother's age at birth	Categorical: (e.g., 15–19, 20–34, 35+)
Education	The highest level of education attained	Categorical: (e.g., no education, primary, secondary, higher)
Marital Status	Mother's marital status	Categorical: (e.g., married, single, divorced)

Community-Level Factors		
Type of Residence, Household Head,	Binary variables , type of residence (urban/rural), household head status,	1 = Yes 0 = No
Province	Geographical province/region	Categorical: List of provinces
Source of Drinking water		Categorical
Household Wealth Index	Economic status based on household assets	Ordinal: Wealth quintiles (e.g., poorest to richest)
Household Size	Number of members in the household	Categorical variable

3.6 Data analysis

All analyses accounted for survey design. The data was set to account for the survey design using the *svy* command including survey weights, cluster and stratification variables before conducting analyses. The first objective described the individual (maternal and neonatal) and community characteristics of perinatal mortality in South Africa. We summarised the characteristics of mothers using frequencies and proportions for caterogical variables (all variables were categorical). The Pearson' chi-square test was used to describe the characteristics of women by perinatal mortality. The second objective described the prevalence of PMR at national and provincial level in South Africa. PMR was calculated using total counts of perinatal mortality divided by the number of live births and multiplied by 1,000 at national and by provincial level[3].

The third objective determined individual and community factors associated with perinatal mortality in South Africa using logistic regression for bivariate and multivariable analysis. We used logistic regression for testing associations, and this test met one of the assumptions which states that the outcome should be binary, coded 0 and 1. In our study the outcome perinatal mortality was coded as 0 for no presence of perinatal mortality and 1 if otherwise. We also addressed an assumption relating to independence of observations by applying appropriate multilevel logistic regression models (inclusion random effects at cluster level) that account for correlation within clusters. Firstly, stepwise logistic regression using a p-value of <0.20 as a selection criterion was used to identify explanatory variables considered for the multivariable logistic regression analysis. Thereafter, we built a multilevel logistic regression model to test for the association between perinatal mortality and selected explanatory variables. We further extended this model by adding random effects at cluster level to test for cluster or community level effects. The models with and without random effects were compared using Akaike Information Criterion (AIC) and the Bayesian Information Criterion (BIC). The model with the lower BIC was considered the model with a better fit to the data. The Intracluster Correlation Coefficient (ICC) was used test for the proportion of overall variance attributable to cluster-level or community level differences, see Table 2.

Table 2: Overall analysis plan and detail of variables

Research Objectives	Variables	Analysis Plan
1. To describe individual (maternal and neonatal) and community characteristics of perinatal mortality in South Africa.	**Outcome variable** – perinatal mortality (SB and ENND) **Explanatory variables** – ever terminated pregnancy, age category, parity, education, employment status, marital status, smoking, ethnicity, first antenatal care visit, number of ANC visits, ever tested for HIV, HIV transmission, birth weight, birth interval, type of delivery, health insurance, type of residence, province, household wealth index, household head, place of delivery, household size, drinking water, delivery care	Describe the characteristics of mothers using frequencies and proportions for categorical variables (all variables were categorical). Pearson' chi-square test used to describe the characteristics of women by perinatal mortality.
To determine the prevalence of perinatal mortality at national and provincial level in 2016 in South Africa	**Outcome variable** – perinatal mortality (stillbirths and early neonatal deaths) **Explanatory variable** – province	Calculated by summing the counts of perinatal deaths divided by the number of live births and multiplied by 1,000 at national and province level. Used graphs to show the prevalence of PMR nationally and across provinces in SA

3. To determine individual and community factors associated with perinatal deaths in South Africa.	**Outcome variable** – perinatal mortality (stillbirths and early neonatal deaths) **Explanatory variables** – ever terminated pregnancy, parity, education, age of mother, employment status, marital status, ethnicity, HIV transmission, type of residence, province, household wealth index, household head, , household size, drinking water.	Determine factors associated with perinatal deaths. • Stepwise logistic regression at p-value <0.20 to select explanatory variables • Bivariate logistic regression to explore the relationships between characteristics of perinatal death • Multivariable logistic regression model between explanatory variables and perinatal mortality adjusting for random effects at cluster level. unadjusted model.

3.8 Ethical considerations

The study utilized openly available data from the DHS program and was therefore exempt from ethics approval. However, access to the data requires submitting a formal request to the DHS program. The request included relevant contact information, the research project title, the study objectives, and a brief description of the analysis to be done. Permission to access and download data is sent via email. Upon downloading, the datasets must not be shared with other people without written consent from the DHS program. Additionally, all the reports and publications utilizing the requested data must be submitted to The DHS Program Data Archive in Portable Document Format (PDF).

Chapter 4 – Results

This chapter presents the descriptive statistics, results for each research objective, and the key findings derived from the analysis

4.1 Characteristics of Women in South Africa

Table 3 presents the characteristics of the study population (N = 8,514). Most participants (90.9%) had never experienced a terminated pregnancy, and 83.8% had ever been tested for HIV. The majority (87.6%) had secondary or higher education, 60.3% had never been in a union, and 63.5% were not employed in the past year. Age distribution was balanced across 15–24 (34.2%), 25–34 (31.6%), and 35+ years (34.2%). Most participants were Black African (86.4%), and 16% of the women were from KwaZulu-Natal (16.0%). Over half resided in urban areas (56.4%), and 42.6% were from poor households. Female-headed households accounted for 57.6%, and 81.9% had access to improved water. Most households had fewer than eight members (88.6%), while 11.4% had eight or more members. Female-headed households were more common (57.6%) than male-headed households (42.4%). Access to improved drinking water was high, with 81.9% of households reporting an improved source, compared to 18.1% relying on unimproved sources.

Table 3: Characteristics of study participants in South Africa

	Total
	(N = 8514)
Ever had a terminated pregnancy	
No	7735 (90.9%)
Yes	779 (9.1%)
HIV Transmission	
No	1284 (15.1%)
Yes	6629 (77.9%)
dont know	601 (7.1%)
Highest educational level	
No/primary education	1052 (12.4%)
Secondary or Higher Education	7462 (87.6%)
Current marital status	
Never in Union	5134 (60.3%)

Ever Married	3380 (39.7%)
Employment status	
Not employed in last 12 months	5409 (63.5%)
Employed or employed at some point in the last 12 months	3105 (36.5%)
Parity	
no births	8030 (94.3%)
2 or more births	484 (5.7%)
Age in 5-year groups	
15-24	2913 (34.2%)
25-34	2692 (31.6%)
35+	2909 (34.2%)
Ethnicity	
black-african	7359 (86.4%)
White	214 (2.5%)
Other	941 (11.1%)
Region	
western cape	656 (7.7%)
eastern cape	1041 (12.2%)
northern cape	718 (8.4%)
free state	854 (10.0%)
kwazulu-natal	1360 (16.0%)
north west	863 (10.1%)
Gauteng	863 (10.1%)
Mpumalanga	1054 (12.4%)
Limpopo	1105 (13.0%)
Residence	
Urban	4805 (56.4%)
Rural	3709 (43.6%)
Wealth index combined	
Poor	3628 (42.6%)
Middle	1956 (23.0%)
Rich	2930 (34.4%)
Household size	
< 8 members	7542 (88.6%)
>= 8 members	972 (11.4%)
Sex of household head	
Male	3611 (42.4%)
Female	4903 (57.6%)
Source of drinking water)	
improved water source	6977 (81.9%)
unimproved water source	1537 (18.1%)

4.2 Individual characteristics (maternal and child) by perinatal mortality

A total of 8,514 women were included in the analysis, of whom 8,269 (97%) had live births and 254 (3%) experienced perinatal mortality using weighted estimates. Perinatal mortality was significantly higher amongst those who ever had a terminated pregnancy (10%) compared to those who never terminated pregnancy (2%) ($F = 111.2$; $p < 0.001$). Those who were HIV positive experienced higher perinatal mortality (3%) compared to those who tested negative (1%) ($F = 20.93$; $p < 0.001$). Perinatal mortality was slightly higher among women who had knowledge of HIV transmission (5%) compared to those who lacked knowledge about HIV transmission (3%), and those who had no knowledge (2%) ($F = 5.72$; $p = 0.004$).

Women with no education or primary education experienced higher perinatal mortality (6%), than those with secondary or higher education (3%) ($F = 24.52$; $p < 0.001$). Women were married before had higher perinatal mortality (4%) compared to those who never in a union (2%) ($F = 19.25$; $p < 0.001$). Perinatal mortality did not differ between the employed and unemployed women (3%) ($F = 0.13$; $p = 0.722$). Perinatal mortality was significantly higher among women with two or more births (9%) compared to those with no births (3%) ($F = 23.41$; $p < 0.001$). Older maternal age was associated with higher perinatal mortality, with women aged 35 years and above experiencing higher perinatal mortality (5%) compared to women aged 25–34 (4%) and those aged 15–24 (1%) ($F = 20.43$; $p < 0.001$). Black-African women experienced higher perinatal mortality (3%) compared to White women (1%) ($F = 3.40$; $p = 0.039$) and other ethnic groups (2%), see Table 4.

Community characteristics by perinatal mortality

Rural women experienced higher perinatal mortality (4%) compared to urban women (3%) ($F = 4.42$; $p = 0.036$).. Perinatal mortality did not differ by household size ($F = 0.31$; $p = 0.577$), household head ($F = 0.33$; $p = 0.565$) and source of drinking water ($F = 0.05$; $p = 0.825$), see Table 5.

Table 4: Individual characteristics of study participants by perinatal mortality in South Africa

Variables	Unweighted		Total	Weighted		Total	F-statistic; p-value
	Live Birth 8238	**Perinatal mortality** 276	8514	**Live Birth** 8269	**Perinatal mortality** 254	8514	
Ever had a terminated pregnancy							
No	7,538 (97%)	197 (3%)	7,735 (100%)	7544(98%)	177.5 (2%)	7,721 (100%)	**F= 111.2; <0.001**
Yes	700 (90%)	79 (10%)	779 (100%)	716.9 (90%)	76.07 (10%)	793 (100%)	
HIV transmission							
No	1,225 (95%)	59 (5%)	1,284 (100%)	1105 (95%)	53.41 (5%)	1,158 (100%)	
Yes	6,427 (97%)	202 (3%)	6,629 (100%)	6560 (97%)	188.8 (3%)	6,748 (100%)	**F= 5.72; 0.004**
Don't know	586 (98%)	15 (2%)	601 (100%)	595.8 (98%)	11.32 (2%)	607 (100%)	
Highest educational level							
No/primary education	982 (93%)	70 (7%)	1,052 (100%)	889.4 (94%)	53.14 (6%)	942.5 (100%)	**F=24.52; <0.001**
Secondary or Higher Education	7,256 (97%)	206 (3%)	7,462 (100%)	7371 (97%)	200.4 (3%)	7,571 (100%)	
Current marital status							
Never in Union	5,013 (98%)	121 (2%)	5,134 (100%)	4888 (98%)	104.2 (2%)	4,992 (100%)	**F= 19.25; <0.001**
Ever married	3,225 (95%)	155 (5%)	3,380 (100%)	3373 (96%)	149.4 (4%)	3,522 (100%)	
Employment status							
Not employed in last 12 months	5,241 (97%)	168 (3%)	5,409 (100%)	5081 (97%)	152.7 (3%)	5,233 (100%)	F= 0.13; 0.722
Employed or employed at some point in the last 12 months	2,997 (97%)	108 (3%)	3,105 (100%)	3180 (97%)	100.8 (3%)	3,281 (100%)	
Parity (births in last five years)							

No births	7,799 (97%)	231 (3%)	8,030 (100%)	7790 (97%)	214.1 (3%)	8,004 (100%)	**F=23.41; <0.001**
2 or more births	439 (91%)	45 (9%)	484 (100%)	470.7 (92%)	39.47 (8%)	510.1 (100%)	
Age in 5-year groups							
15-24	2,878 (99%)	35 (1%)	2,913 (100%)	2810 (99%)	31.43 (1%)	2,842 (100%)	**F=20.43; <0.001**
25-34	2,594 (96%)	98 (4%)	2,692 (100%)	2685 (97%)	91.61 (3%)	2,777 (100%)	
35+	2,766 (95%)	143 (5%)	2,909 (100%)	2765 (95%)	130.5 (5%)	2,896 (100%)	
Timing of 1st antenatal check (months)							
First-trimester	1,374 (95%)	67 (5%)	1,441 (100%)	1371 (96%)	63.74 (4%)	1,435 (100%)	
Second trimester	1,214 (95%)	59 (5%)	1,273 (100%)	1212 (95%)	49.8 (5%)	1,262 (100%)	**F=4.19; 0.003**
Third trimester	138 (97%)	5 (3%)	143 (100%)	140.3 (95%)	7.275 (5%)	147.5 (100%)	
Other	25 (93%)	2 (7%)	27 (100%)	16.76 (90%)	1.675 (10%)	18.43 (100%)	
Missing	5,487 (97%)	143 (3%)	5,630 (100%)	5520 (98%)	131.1(2%)	5,630 (100%)	
Ethnicity							
Black-African	7,107 (97%)	252 (3%)	7,359 (100%)	7155 (97%)	233 (3%)	7,388 (100%)	**F= 3. 40; 0.039**
White	212 (99%)	2 (1%)	214 (100%)	263.2 (99%)	1355 (1%)	264.5 (100%)	
Other	919 (98%)	22 (2%)	941 (100%)	842.4 (98%)	19.24 (2%)	881.7 (100%)	

Table 5: Community characteristics of study participants by perinatal mortality in South Africa

Variables	**Unweighted**		**Total**	**Weighted**		**Total**	**F-statistic**
	Live Birth 8238	**Perinatal Death** 276	8514	**Live Birth** 8269	**Perinatal Death** 254	8514	
Residence							
Urban	4,673 (97%)	132 (3%)	4,805 (100%)	5580 (97%)	150.4 (3%)	5,731 (100%)	**F= 4.42; 0.036**
Rural	3,565 (96%)	144 (4%)	3,709 (100%)	2680 (96%)	103.2 (4%)	2,783 (100%)	
Household size							
< 8 members	7,296 (97%)	246 (3%)	7,542 (100%)	7435 (97%)	224.9 (3%)	7,660 (100%)	F=0.31; 0.577
> 8 members	942 (97%)	30 (3%)	972 (100%)	825 (97%)	28.7 (3%)	853.7 (100%)	
Sex of household head							
Male	3,493 (97%)	118 (3%)	3,611 (100%)	3705 (97%)	119.7 (3%)	3,825 (100%)	F=0.33; 0.565
Female	4,745 (97 %)	158 (3%)	4,903 (100%)	4556 (97%)	133.9 (3%)	4,689 (100%)	
Source of drinking water							
Improved water source	6,749 (97%)	228 (3%)	6,977 (100%)	7004 (97%)	216.2 (3%)	7,220 (100%)	F=0.05; 0.825
Unimproved water source	1,489 (97%)	48 (3%)	1,537 (100%)	1257 (97%)	37.35 (3%)	1,294 (100%)	

4.2 Perinatal mortality rates across South Africa

The characteristics of women by perinatal outcomes in South Africa were described using bar graph (a) the average perinatal mortality rate across provinces (Figure 5).

Figure 5 below shows the average PMR across various provinces in South Africa. The PMR ranged from 20 to nearly 50 perinatal deaths per 1000 live births, highlighting regional differences in perinatal mortality. North West had the highest PMR (50 per 1000 live births), followed by Mpumalanga (48 per 1000 live births), Northern Cape (38 per 1000 live births) and Eastern Cape (35 per 1000 live births), respectively. While, Western Cape had the lowest PMR (17 per 1000 live births) followed by Limpopo (21 per 1000 live births) and then KZN (23 per 1000 live births).

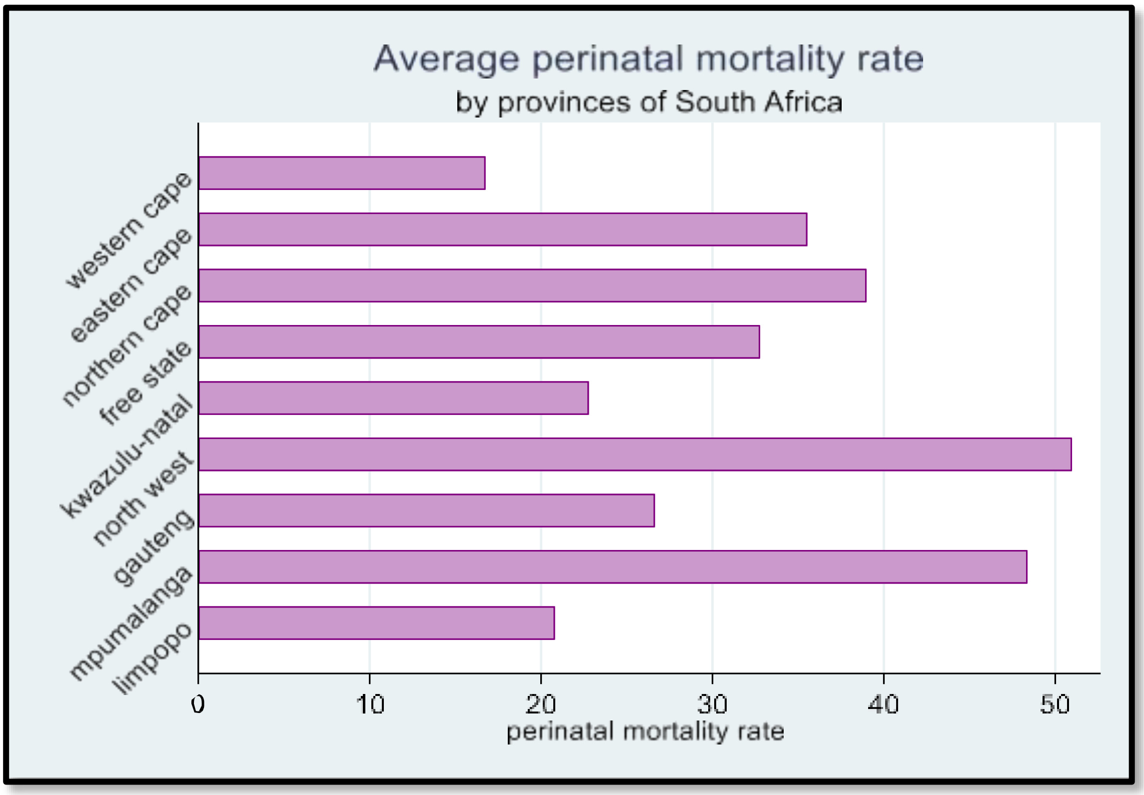

***Figure 5**: Distribution of PMR across provinces in South Africa.*

4.3 Factors associated with perinatal mortality

Table 5 shows the bivariate and multivariable analysis of factors associated with perinatal mortality.

For the multivariable logistic regression, two models were fitted: Model A, without random effects at cluster level and Model B with random effects at cluster level. Model B with random effects at cluster level had a lower BIC than Model A, thus Model B was chosen as a model with a better fit. ICC was 0.1964 showing that 20% of the variance was attributed to community level characteristics see Table .7

Table 6: Comparison of Multilevel logistic regression models with or without cluster random effects

	Model A	**Model B**
AIC	2081.586	2030.987
BIC	2243.724	2179.025
ICC		0.1964

Both individual and cummunity factors were significantly associated with perinatal mortality. Women who had ever experienced a terminated pregnancy had more than four times the odds of perinatal mortality compared to those who had not (AOR 4.24; 95% CI 2.25–6.48). Maternal age was also a strong predictor, with women aged 25–34 (AOR 2.51; 95% CI 1.46–4.31 and 34+ years (AOR 3.62; 95% CI 2.14-6.14) having higher odds of perinatal mortality compared to those aged 15–24 years. Education was protective in the unadjusted model, but the effect was attenuated and no longer statistically significant after adjustment (AOR 0.69; 95% CI 0.47–1.01, p=0.053). White women demonstrated significantly lower odds of perinatal mortality relative to Black African women in the unadjusted model (OR 0.16; 95% CI 0.04–0.69), though this association was attenuated and lost statistical significance in the adjusted model (AOR 0.18; 95% CI 0.04–0.82). Women who reported HIV transmission during pregnancy had a 40% reduction in the odds of perinatal mortality compared to those who did not (OR 0.58; 95% CI 0.39–0.87, p=0.009).

Compared to women residing in the Western Cape, those in the Northern Cape and North West provinces had significantly higher odds of perinatal mortality in the adjusted analysis (AOR 2.16; 95% CI 1.00–4.66 and AOR 3.31; 95% CI 1.03–4.71, respectively). Women in the Eastern Cape and Mpumalanga initially showed increased odds in unadjusted models (OR 2.14; 95% CI 0.99–4.46 and OR 2.86; 95% CI 0.80–4.21, respectively), but these associations were attenuated and no longer significant after adjustment. No significant associations were observed for women residing in Free State, KwaZulu-Natal, Gauteng, or Limpopo. Household wealth showed a protective effect. Compared to women from poor households, those from rich households had significantly lower odds of perinatal mortality (AOR 0.58; 95% CI 0.36–0.96).

Table 7: Unadjusted and adjusted association of factors associated with perinatal deaths among women

	Unadjusted ORs	95% CI	p-value	Adjusted ORs	95% CI	p-value
Ever had a terminated pregnancy						
No	Reference					
Yes	4.51	[3.32-6.12]	**0.000**	4.24	[2.25-6.48]	**0.000**
Mother's age						
15-24	Reference					
25-34	3.05	[1.82-5.11]	**0.000**	2.51	[1.46-4.31]	**0.001**
35+	4.22	[2.61-6.82]	**0.000**	3.62	[2.14-6.14]	**0.000**
Parity						
No births	Reference					
2 or more births	3.05	[1.89-4.90]	**0.000**	3.64	[2.16-6.15]	**0.000**
Education						
No education/primary education	Reference					
Secondary or Higher Education	0.46	[0.33-0.63]	**0.000**	0.69	[0.47-1.01]	0.053
Ethnicity						
Black African	Reference					
White	0.16	[0.04-0.69]	**0.014**	0.18	[0.04-0.82]	0.026
Other	0.70	[0.39-1.27]	0.243	0.95	[0.45-1.96]	0.880

HIV transmission						
No	Reference					
Yes	0.6	[0.41-0.86]	**0.005**	0.58	[0.39-0.87]	**0.009**
Don't know	0.39	[0.20-0.78]	**0.008**	0.47	[0.22-1.02]	0.058
Province						
Western cape	Reference					
Eastern cape	2.04	[1.06-3.95]	**0.034**	1.44	[0.67-3.06]	0.349
Northern cape	2.4	[1.20-4.79]	**0.013**	2.16	[1.00-4.66]	**0.049**
Free state	1.83	[0.88-3.82]	0.106	2.86	[0.80-4.21]	0.152
KwaZulu-Natal	1.37	[0.70-2.68]	0.365	1.72	[0.50-2.38]	0.818
North-west	3.4	[1.76-6.57]	**0.000**	3.31	[1.03-4.71]	**0.042**
Gauteng	1.33	[0.56-3.15]	0.511	1.57	[0.43-2.45]	0.946
Mpumalanga	2.88	[1.52-5.46]	**0.001**	2.14	[0.99-4.46]	**0.054**
Limpopo	1.18	[0.58-2.38]	0.648	1.41	[0.38-1.97]	0.732
Household wealth		[-]				
Poor	Reference					
Middle	0.79	[0.51-1.22]	0.284	0.78	[0.49-1.24]	0.303
Rich	0.47	[0.31-0.72]	**0.001**	0.58	[0.36-0.96]	**0.032**

Chapter 5 – Discussion

This chapter provides an interpretation of the findings, explores their implications, outlines the study's limitations, and proposes recommendations for future research.

5.1 Main Findings

This study aimed to examine the individual and community-level determinants of perinatal mortality in South Africa. Our study found significant differences in perinatal mortality by provinces, and the national perinatal mortality was 31%. This was comparable to findings from other SSA countries like Nigeria and African countries included in one of the systematic reviews (i.e., Ethiopia, Tanzania, Zimbabwe, Uganda, Ghana, Côte d'Ivoire Burkina Faso, Kenya, Rwanda, Malawi, and Mozambique) where perinatal mortality rates were generally high. Aso, similar studies in the SSA reported significant provincial or sub-national parities in perinatal mortality[69,70]. Our study also found that both individual factors including pregnancy termination, mother's age, mother's educational level, marital status, ethnicity, ever tested for HIV, HIV transmission, as well as community factors including province and household wealth were associated with perinatal mortality.

The findings showed that mothers with a history of terminated pregnancies were associated with a higher likelihood of perinatal mortality compared to mothers without any history of terminated pregnancy. These findings are consistent with earlier studies[71,72]. Possible underlying reasons could be biologically or socially related These studies considered both spontaneous and induced abortions as terminated pregnancies[71,52]. A previous prospective study of 1, 737 pregnant women reported that women with a history of recurrent miscarriages had increased odds of perinatal mortality, the study that also considered spontaneous abortions alone and showed an increased risk of perinatal mortality in women with a history of spontaneous abortions [72]. Another study retrospective study with a sample of 2,985 women showed that women who had undergone an induced abortion before reported had an increased the risk of preterm deliveries which is one of the leading causes of perinatal mortality[73]. Also, cultural factors play a role, as some women are pressured to conceive soon after a pregnancy loss, without having fully recovered[72].

Our findings show the need to integrate family planning in preconception and prenatal care. The Ministry of Health should expand access to modern contraceptives, counseling, and reproductive health education to women of reproductive age to prevent unintended pregnancies. Post-abortion care must also be improved, with standardised follow-up and support for future pregnancy planning. Integrating reproductive history screening into routine antenatal care can also help identify women who have a high risk of perinatal mortality early. Health workers should be trained to gather this information respectfully and use it to guide care. These measures can help reduce the risk of perinatal mortality amongst women who have a history of terminated pregnancy.

Our study also showed higher odds of perinatal mortality among women aged 25–34 years (AOR 2.51; 95% CI 1.46–4.31) and those aged 35 and older (AOR 3.62; 95% CI 2.14–4.16), when compared to younger women aged 15–24 years. This aligns with a meta-analysis conducted in Ethiopia, which reported that women of advanced maternal age had a 1.58-fold higher risk of perinatal mortality than younger women[74,75].Similarly, a systematic review and meta-analysis quantifying outcomes for women aged ≥40 indicated more than a doubling of risk for stillbirth and other adverse perinatal outcomes (adjusted relative risk approx. 2.16 for stillbirth), further reinforcing the vulnerability associated with older age in pregnancy[76]. This increased risks among older mothers could be attributed to an increase in obstetric complications such as preeclampsia, gestational diabetes, placenta-related conditions, and preterm delivery as well as age-related declines in physiological resilience[77]. Collectively, our findings reflect established biological and epidemiological patterns, emphasizing the importance of age-sensitive antenatal care and counseling for older expectant mothers.

The study also found that mothers with two or more children had 61% higher odds of perinatal mortality compared to those with no children. This result aligns with findings from a research study analyzing data from 27 SSA countries found that women with multiparous and grand multiparous mothers had 1.35 times (AOR = 1.35, 95% CI: 1.25, 1.47) and 1.69 times (AOR = 1.69, 95% CI: 1.53, 1.86) higher odds of perinatal mortality compared to primiparous mother, respectively. Another study in Sekota Town in Northern Ethiopia recorded that neonates born from primigravida mothers compared to multi-gravida mothers were 50 % less likely to have mortality outcomes than morbidity outcomes (AOR =0.50, 95% CI: 0.30-0.90) but contrasts with a study from Jimma, Western Ethiopia[78,79]. The increased risk may be due to inadequate nutrition as result of taking take of many children, especially among women in poverty, resulting in malnutrition during pregnancy and after, potentially leading to perinatal mortality. Therefore, family planning programs should prioritize optimal birth spacing for maternal recovery and improved nutrition to reduce perinatal mortality. Additionally, we need to provide targeted nutritional support for women with multiple pregnancies, which can help mitigate risks associated with frequent pregnancies.

We also noted that known HIV transmission was significantly associated with perinatal mortality. Women who had HIV transmission during pregnancy had 42% fewer odds of experiencing perinatal mortality as opposed to mothers who did not know, and this was consistent with many studies[62]. Mothers who are living with HIV face a heightened risk of transmitting the virus to their infants, either during pregnancy, childbirth or through breastfeeding. This vertical transmission of the virus can result in serious health complications for newborns, including stillbirths and neonatal deaths. However, our findings are contrary, this could be that women who had HIV during pregnancy were under Prevention of mother-to-child transmission (PMTCT) programs, which includes antiretroviral therapy and monitoring of adherence, and thus preventing vertical transmission. This underscores the necessity of continued efforts to expand access to PMTCT services and ensure that pregnant women living with HIV receive the care and support needed to protect their infants from infection and reduce the incidence of perinatal mortality[80].

Our study also found significant provincial disparities in perinatal mortality. Compared to the Western Cape, mothers in Northern Cape and North West provinces had significantly higher odds of perinatal mortality. These findings are consistent with national health equity reports, which highlight persistent gaps in maternal and newborn care coverage across provinces. The variation in outcomes may reflect differences in health system capacity, accessibility of emergency obstetric services, or broader socio-economic inequalities. The Ministry of Health should prioritize province-specific strategies, such as investing in maternal health infrastructure and human resources in high-risk provinces like the Northern Cape and NorthWest. Although rural residence showed no significant in the adjusted model, our findings suggests that other factors, such as wealth or provincial factors could obscure this relationship. Rural areas may still require targeted outreach programs, especially for ANC services and timely referrals, to address structural barriers to care.

Household wealth was also significantly associated with perinatal mortality. Compared to mothers from poor households, those from wealthier households had a reduced likelihood of perinatal mortality. These findings are consistent with previous studies showing that socio-economic status influences access to nutrition, health services, and maternal education, all of which contribute to pregnancy outcomes. This mirrors broader sub-Saharan African evidence: a multilevel analysis found reduced perinatal mortality rates among middle and richer wealth households (AORs approximately 0.93) compared to the poorest households. This could be explained by the fact that women from richer wealth households have improved access to quality antenatal care, better nutrition and safer birthing environments which reduces the likelihood of pregnancy complications and adverse pregnancy outcomes [76 77]. Interventions such as social protection schemes like maternal vouchers, conditional cash transfers, or community health insurance could help address structural and financial barriers of access to care among women of low socioeconomic status and reduce perinatal mortality. The study also that the inclusion of random effects at the cluster/community level improved the model. These findings show that interventions aimed at reducing perinatal mortality should also be targeted in communities.

In light of these findings, policymakers should consider tailored interventions at multiple levels. Provinces with high perinatal mortality should receive increased funding and technical support to improve maternal and newborn care. Health facilities should be equipped to handle complications irrespective of delivery mode, and rural outreach must be strengthened. Community-level health promotion and financial risk protection for poor households can address the social determinants of perinatal health. These multi-level strategies are essential to achieving equitable and improved outcomes for mothers and newborns across the country.

5.2 Strengths and limitations

The dissertation used DHS data with large, nationally representative samples, making our findings generalizable to the population. The data is also reliable because of standardised practices of collecting DHS data. However, this study was subject to the limitations of a cross-sectional study making it difficult to establish causality. There was potential for recall bias, especially for the variables that relied on the mother's memory like birth intervals, parity, and antenatal care visits. Another limitation of this study was the exclusion of certain important variables, like healthcare facility distance, antenatal care, autonomy, and affordability of healthcare due to heavily missing data.

5.3 Recommendations

Future studies should consider longitudinal studies to observe how changes in factors over time influence perinatal mortality. Additionally, clinical records should be used for collecting maternal and child health indicators to improve accuracy.

5.4 Conclusion

The study found high levels of perinatal mortality at national level and disparities by provinces. Individual level factors like terminated pregnancy, maternal age, parity and HIV transmission, as well as community level factors like household wealth and province influenced perinatal mortality. Policymakers should consider tailored interventions at multiple levels including improving access and quality of maternal healthcare particularly among women of low socioeconomic status and increasing uptake family planning services among women of reproductive age. Furthermore, there should specific targeted interventions in provinces with high levels of perinatal mortality.

References

1. Malinga NS, du Preez A, Rabie T. Maternal and neonatal factors associated with perinatal deaths in a South African healthcare institution. Health SA Gesondheid. 2020;25:1–7.

2. Gebremichael MW, Tsadik M, Abebe HT, Gebreegzabiher A, Beyene S, Aregawi AB, et al. Trends and causes of neonatal mortality from 2010 to 2017 at a Health and Demographic Surveillance site in Northern Ethiopia. Glob Health Action. 2023;16(1).

3. Aminu M, Unkels R, Mdegela M, Utz B, Adaji S, van den Broek N. Causes of and factors associated with stillbirth in low- and middle-income countries: a systematic literature review. BJOG [Internet]. 2014 Sep 1 [cited 2022 Oct 22];121 Suppl 4:141–53. Available from: https://pubmed.ncbi.nlm.nih.gov/25236649/

4. Saleem S, Tikmani SS, McClure EM, Moore JL, Azam SI, Dhaded SM, et al. Trends and determinants of stillbirth in developing countries: Results from the Global Network's Population-Based Birth Registry. Reprod Health [Internet]. 2018 Jun 22 [cited 2022 Oct 14];15(1):23–30. Available from: https://reproductive-health-journal.biomedcentral.com/articles/10.1186/s12978-018-0526-3

5. Lehtonen L, Gimeno A, Parra-Llorca A, Vento M. Early neonatal death: A challenge worldwide. Semin Fetal Neonatal Med. 2017 Jun 1;22(3):153–60.

6. Ogallo W, Speakman S, Akinwande V, Varshney KR, Walcott-Bryant A, Wayua C, et al. Identifying Factors Associated with Neonatal Mortality in Sub-Saharan Africa using Machine Learning.

7. Masaba BB, Mmusi-Phetoe RM. Neonatal survival in sub-sahara: A review of kenya and south africa. J Multidiscip Healthc. 2020;13:709–16.

8. McGee SA, Chola L, Tugendhaft A, Mubaiwa V, Moran N, McKerrow N, et al. Strategic planning for saving the lives of mothers, newborns and children and preventing stillbirths in KwaZulu-Natal province South Africa: Modelling using the Lives Saved Tool (LiST). BMC Public Health. 2016 Jan 19;16(1).

9. Hug L, Liu Y, Nie W, Sharrow D, You D, Cao B, et al. The Demographic and Health Surveys (DHS) Program, ICF.

10. Nieuwoudt L, Mackay CA, Mda S. Causes of and Modifiable Factors Contributing to Neonatal Deaths at Dora Nginza Hospital in the Eastern Cape, South Africa. Glob Pediatr Health. 2022 Jan 1;9.

11. Girma D, Abita Z, Fetene G, Birie B. Individual and community-level factors of perinatal mortality in the high mortality regions of Ethiopia: a multilevel mixed-effect analysis. BMC Public Health. 2022 Dec 1;22(1).

12. Mahtab S, Madhi SA, Baillie VL, Els T, Thwala BN, Onyango D, et al. Causes of death identified in neonates enrolled through Child Health and Mortality Prevention Surveillance (CHAMPS), December 2016 –December 2021. PLOS Global Public Health. 2023 Mar 1;3(3).

13. Nieuwoudt L, Mackay CA, Mda S. Causes of and Modifiable Factors Contributing to Neonatal Deaths at Dora Nginza Hospital in the Eastern Cape, South Africa. Glob Pediatr Health. 2022 Jan 1;9.

14. Malinga NS, du Preez A, Rabie T. Maternal and neonatal factors associated with perinatal deaths in a South African healthcare institution. Health SA Gesondheid. 2020;25:1–7.

15. Rhoda NR, Greenfield D, Muller M, Prinsloo R, Pattinson RC, Kauchali S, et al. Experiences with perinatal death reviews in South Africa--the Perinatal Problem Identification Programme: scaling up from programme to province to country. BJOG. 2014 Sep 1;121:160–6.

16. Leslie HH, nther Fink G, Nsona H, Kruk ME. Obstetric Facility Quality and Newborn Mortality in Malawi: A Cross-Sectional Study. 2016 [cited 2022 Sep 2]; Available from: http://mics.

17. Nieuwoudt L, Mackay CA, Mda S. Causes of and Modifiable Factors Contributing to Neonatal Deaths at Dora Nginza Hospital in the Eastern Cape, South Africa. Glob Pediatr Health. 2022 Jan 1;9.

18. Hug L, Lee S, Liu Y, Mishra A, Sharrow D, You D, et al. London School of Hygiene & Tropical Medicine Trevor Croft, The Demographic and Health Surveys (DHS) Program, ICF. 2020.

19. Saving Mothers.

20. Tiruneh D, Assefa N, Mengiste B. Perinatal mortality and its determinants in Sub Saharan African countries: systematic review and meta-analysis. Matern Health Neonatol Perinatol. 2021 Dec;7(1).

21. Tiruneh D, Assefa N, Mengiste B. Perinatal mortality and its determinants in Sub Saharan African countries: systematic review and meta-analysis. Matern Health Neonatol Perinatol. 2021 Dec;7(1).

22. Blencowe H, Cousens S. Review: Addressing the challenge of neonatal mortality. Tropical Medicine & International Health [Internet]. 2013 Mar 1 [cited 2022 Sep

2];18(3):303–12. Available from: https://onlinelibrary.wiley.com/doi/full/10.1111/tmi.12048

23. Hlongwane TMAG, Bozkurt B, Barreix MC, Pattinson R, Gülmezoglu M, Vannevel V, et al. Implementing antenatal care recommendations, South Africa. Bull World Health Organ [Internet]. 2021 Mar 3 [cited 2023 Mar 23];99(3):220. Available from: /pmc/articles/PMC7941100/

24. Mid-year population Estimates, 2022 Risenga Maluleke Statistician-General Statistics South Africa.

25. Mid-year population estimates 2022. [cited 2023 May 4]; Available from: www.statssa.gov.za,info@statssa.gov.za,Tel+27123108911

26. Five facts about poverty in South Africa | Statistics South Africa [Internet]. [cited 2023 Jun 21]. Available from: https://www.statssa.gov.za/?p=12075

27. Coovadia H, Jewkes R, Barron P, Sanders D, Mcintyre D. The health and health system of South Africa: historical roots of current public health challenges. Health in South Africa [Internet]. 1. Available from: www.thelancet.com

28. Pillay-Van Wyk V, Msemburi W, Laubscher R, Dorrington RE, Groenewald P, Glass T, et al. Articles Mortality trends and diff erentials in South Africa from 1997 to 2012: second National Burden of Disease Study [Internet]. 2016. Available from: www.thelancet.com/lancetgh

29. Achoki T, Sartorius B, Watkins D, Glenn SD, Kengne AP, Oni T, et al. Health trends, inequalities and opportunities in South Africa's provinces, 1990-2019: findings from the Global Burden of Disease 2019 Study. J Epidemiol Community Health (1978). 2022;76(5):471–81.

30. Barfield WD. Standard terminology for fetal, infant, and perinatal deaths. Pediatrics. 2016 May 1;137(5).

31. Aminu M, Bar-Zeev S, van den Broek N. Cause of and factors associated with stillbirth: a systematic review of classification systems. Vol. 96, Acta Obstetricia et Gynecologica Scandinavica. Wiley-Blackwell; 2017. p. 519–28.

32. Smith GC, Fretts RC. Stillbirth. The Lancet. 2007 Nov 17;370(9600):1715–25.

33. Mukherjee A, Di Stefano L, Blencowe H, Mee P. Determinants of stillbirths in sub-Saharan Africa: A systematic review. Vol. 131, BJOG: An International Journal of Obstetrics and Gynaecology. John Wiley and Sons Inc; 2024. p. 140–50.

34. Lawn JE, Blencowe H, Waiswa P, Amouzou A, Mathers C, Hogan D, et al. Stillbirths: Rates, risk factors, and acceleration towards 2030. The Lancet. 2016 Feb 6;387(10018):587–603.

35. United Nations Inter-agency Group for Child Mortality Estimation, You D, Hug L, Mishra A, Blencowe H, Moran A. A neglected tragedy : the global burden of stillbirths.

36. Alem AZ, Yeshaw Y, Liyew AM, Tesema GA, Alamneh TS, Worku MG, et al. Timely initiation of antenatal care and its associated factors among pregnant women in sub-Saharan Africa: A multicountry analysis of Demographic and Health Surveys. PLoS One [Internet]. 2022 Jan 1 [cited 2023 Mar 16];17(1). Available from: /pmc/articles/PMC8746770/

37. Hug L, You D, Blencowe H, Mishra A, Wang Z, Fix MJ, et al. Global, regional, and national estimates and trends in stillbirths from 2000 to 2019: a systematic assessment.

Lancet [Internet]. 2021 Aug 8 [cited 2022 Oct 14];398(10302):772. Available from: /pmc/articles/PMC8417352/

38. Ntuli ST, Malangu N. An investigation of the stillbirths at a tertiary hospital in Limpopo province of South Africa. Glob J Health Sci. 2012;4(6):141–7.

39. Hlongwane TM, Botha T, Nkosi BS, Pattinson RC. South African Family Practice. 2022; Available from: https://doi.org/10.4102/safp.

40. Ali MM, Bellizzi S, Boerma T. Measuring stillbirth and perinatal mortality rates through household surveys: a population-based analysis using an integrated approach to data quality assessment and adjustment with 157 surveys from 53 countries. Lancet Glob Health. 2023 Jun 1;11(6):e854–61.

41. Masaba BB, Mmusi-Phetoe RM. Neonatal survival in sub-sahara: A review of kenya and south africa. J Multidiscip Healthc. 2020;13:709–16.

42. Hug L, Liu Y, Nie W, Sharrow D, You D, Cao B, et al. The Demographic and Health Surveys (DHS) Program, ICF.

43. rhoda-et-al-2018-reducing-neonatal-deaths-in-south-africa-progress-and-challenges.

44. Muglia LJ, Benhalima K, Tong S, Ozanne S. Maternal factors during pregnancy influencing maternal, fetal, and childhood outcomes. Vol. 20, BMC Medicine. BioMed Central Ltd; 2022.

45. Karlsen S, Say L, Souza JP, Hogue CJ, Calles DL, Gülmezoglu AM, et al. The relationship between maternal education and mortality among women giving birth in health care institutions: Analysis of the cross sectional WHO Global Survey on Maternal and Perinatal Health. BMC Public Health. 2011;11.

46. Genc S, Emeklioglu CN, Cingillioglu B, Akturk E, Turhan Ozkan H, Mihmanli V. The effect of parity on obstetric and perinatal outcomes in pregnancies at the age of 40 and above: A retrospective study. Croat Med J. 2021 Apr 1;62(2):130–6.

47. Matiang'i M, Karanja S, Wanzala P, Ngure K, Luciani A. Effects of mother related factors on perinatal outcomes-a study of mothers seeking antenatal care at public and non-public health facilities in Kisii County, Kenya. J Public Health Afr. 2017;8(2):165–9.

48. Yahaya H, Adeyemo QE, Kumah A. Adverse perinatal outcomes and their associated determinants in Sub-Saharan Africa. Journal of Medicine, Surgery, and Public Health. 2024 Aug;3:100124.

49. Zegeye B, Ahinkorah BO, Ameyaw EK, Budu E, Seidu AA, Olorunsaiye CZ, et al. Disparities in use of skilled birth attendants and neonatal mortality rate in Guinea over two decades. BMC Pregnancy Childbirth. 2022 Dec 1;22(1).

50. Malinga NS, du Preez A, Rabie T. Maternal and neonatal factors associated with perinatal deaths in a South African healthcare institution. Health SA Gesondheid. 2020;25:1–7.

51. Santosa WB, Staines-Urias E, Tshivuila-Matala COO, Norris SA, Hemelaar J. Perinatal outcomes associated with maternal HIV and antiretroviral therapy in pregnancies with accurate gestational age in South Africa. AIDS. 2019 Aug 1;33(10):1623–33.

52. Miltenburg AS, Van Der Eem L, Nyanza EC, Van Pelt S, Ndaki P, Basinda N, et al. Antenatal care and opportunities for quality improvement of service provision in resource limited settings: A mixed methods study. 2017 [cited 2023 Mar 29]; Available from: https://doi.org/10.1371/journal.pone.0188279

53. Kebede E, Kekulawala M. Risk factors for stillbirth and early neonatal death: a case-control study in tertiary hospitals in Addis Ababa, Ethiopia. BMC Pregnancy Childbirth. 2021 Dec 1;21(1).

54. Kim MK, Lee SM, Bae SH, Kim HJ, Lim NG, Yoon SJ, et al. Socioeconomic status can affect pregnancy outcomes and complications, even with a universal healthcare system. Int J Equity Health. 2018 Jan 5;17(1):2.

55. Darling EK, Grenier L, Nussey L, Murray-Davis B, Hutton EK, Vanstone M. Access to midwifery care for people of low socio-economic status: A qualitative descriptive study. BMC Pregnancy Childbirth. 2019 Nov 12;19(1).

56. Patel AB, Bann CM, Kolhe CS, Lokangaka A, Tshefu A, Bauserman M, et al. The Global Network Socioeconomic Status Index as a predictor of stillbirths, perinatal mortality, and neonatal mortality in rural communities in low and lower middle income country sites of the Global Network for Women's and Children's Health Research. PLoS One. 2022 Aug 1;17(8 August).

57. Rutstein SO. The DHS Wealth Index: Approaches for Rural and Urban Areas [Internet]. 2008. Available from: www.measuredhs.com

58. Cameron L, Chase C, Contreras Suarez D. Relationship between water and sanitation and maternal health: Evidence from Indonesia. World Dev. 2021 Nov 1;147.

59. Fuente D, Allaire M, Jeuland M, Whittington D. Forecasts of mortality and economic losses from poor water and sanitation in sub-Saharan Africa. PLoS One. 2020;15(3).

60. Ghimire PR, Agho KE, Renzaho A, Christou A, Nisha MK, Dibley M, et al. Socio-economic predictors of stillbirths in Nepal (2001-2011). PLoS One. 2017 Jul 1;12(7).

61. Wolf J, Prüss-Ustün A, Cumming O, Bartram J, Bonjour S, Cairncross S, et al. Systematic review: Assessing the impact of drinking water and sanitation on diarrhoeal disease in low- and middle-income settings: Systematic review and meta-regression. Tropical Medicine and International Health. 2014;19(8):928–42.

62. McClure EM, Dudley DJ, Reddy UM, Goldenberg RL. Infectious causes of stillbirth: A clinical perspective. Vol. 53, Clinical Obstetrics and Gynecology. 2010. p. 635–45.

63. Rahut DB, Singh A, Sonobe T. WASH facilities prevalence and determinants: Evidence from 42 developing countries. Front Environ Sci. 2022 Nov 4;10.

64. Nwanze LD, Siuliman A, Ibrahim N. Factors associated with infant mortality in Nigeria: A scoping review. PLoS One. 2023 Oct 13;18(11 November).

65. Masud Ahmed S. Women focused development intervention reduces neonatal mortality in rural Bangladesh: A study of the pathways of influence [Internet]. 2006. Available from: https://www.researchgate.net/publication/293762038

66. Lavin T, Pattinson RC, Kelty E, Pillay Y, Preen DB. The impact of implementing the 2016 WHO Recommendations on Antenatal Care for a Positive Pregnancy Experience on perinatal deaths: An interrupted time-series analysis in Mpumalanga province, South Africa. BMJ Glob Health. 2020 Dec 8;5(12).

67. SADHS2016.

68. Naidoo Y, Joubert L, Nhakaniso K, Nzeribe E, Akinsolu FT, Okova D, et al. Socioeconomic determinants of male contraceptive use in South Africa: a secondary analysis of the 2016 SADHS data. BMC Public Health [Internet]. 2024 Oct 9;24(1):2756. Available from: https://bmcpublichealth.biomedcentral.com/articles/10.1186/s12889-024-20295-1

69. Tiruneh D, Assefa N, Mengiste B. Perinatal mortality and its determinants in Sub Saharan African countries: systematic review and meta-analysis. Matern Health Neonatol Perinatol. 2021 Dec;7(1).

70. Ezeh OK, Uche-Nwachi EO, Abada UD, Agho KE. Community-and proximate-level factors associated with perinatal mortality in Nigeria: Evidence from a nationwide household survey. Vol. 19, BMC Public Health. BioMed Central Ltd.; 2019.

71. Debelew GT. Magnitude and Determinants of Perinatal Mortality in Southwest Ethiopia. J Pregnancy. 2020;2020.

72. Ali N, Elbarazi I, Ghazal-Aswad S, Al-Maskari F, Al-Rifai RH, Oulhaj A, et al. Impact of recurrent miscarriage on maternal outcomes in subsequent pregnancy: The mutaba'ah study. Int J Womens Health. 2020;12:1171–9.

73. Yu JY, Jiang B, Zhang XJ, Wei SS, He WC. History of induced abortion and the risk of preterm birth: a retrospective cohort study. Journal of Maternal-Fetal and Neonatal Medicine. 2023;36(1).

74. Damian DJ, Njau B, Lisasi E, Msuya SE, Boulle A. Trends in maternal and neonatal mortality in South Africa: A systematic review. Syst Rev. 2019 Mar 27;8(1).

75. 1. Bekele GG, Yohannes Roga E, Gonfa DN, Yami AT, Fekene DB, Kabale WD. The effects of advanced maternal age on perinatal mortality in Ethiopia: A systematic review and meta-analysis. SAGE Open Medicine. 2023;11. doi:10.1177/20503121231201282

76. 1 Saccone G, Gragnano E, Ilardi B, Marrone V, Strina I, Venturella R, Berghella V, Zullo F. Maternal and perinatal complications according to maternal age: A systematic review and meta-analysis. Int J Gynaecol Obstet. 2022 Oct;159(1):43-55. doi: 10.1002/ijgo.14100. Epub 2022 Feb 7. PMID: 35044694;

PMCID: PMC9543904.

77. Bezie MM, Asebe HA, Asnake AA, Fente BM, Negussie YM, Asmare ZA, Melkam M, Seifu BL. Factors associated with perinatal mortality in sub-Saharan Africa: A multilevel analysis. PLoS One. 2024 Nov 21;19(11):e0314096. doi: 10.1371/journal.pone.0314096. PMID: 39570972; PMCID: PMC11581209..

78. Nkonki LL, Chopra M, Doherty TM, Jackson D, Robberstad B. Explaining household socio-economic related child health inequalities using multiple methods in three diverse settings in South Africa. Int J Equity Health. 2011 Apr 4;10:13. doi: 10.1186/1475-9276-10-13. PMID: 21463530; PMCID: PMC3086829.Debelew GT. Magnitude and Determinants of Perinatal Mortality in Southwest Ethiopia. J Pregnancy. 2020;2020.

79. Calvert C, Ronsmans C. The contribution of HIV to pregnancy-related mortality: A systematic review and meta-analysis. Vol. 27, AIDS. 2013. p. 1631–9.

80. Chi BH, Mbori-Ngacha D, Essajee S, Mofenson LM, Tsiouris F, Mahy M, et al. Accelerating progress towards the elimination of mother-to-child transmission of HIV: a narrative review. 2020; Available from: http://onlinelibrary.wiley.com/doi/10.1002/jia2.25571/full

Appendices

Appendix A: AIC and BIC

Model A

```
. estat ic

Akaike's information criterion and Bayesian information criterion
```

Model	N	ll(null)	ll(model)	df	AIC	BIC
.	8,514	.	-1017.793	23	2081.586	2243.724

Note: BIC uses N = number of observations. See [R] BIC note.

Model B

```
. estat ic

Akaike's information criterion and Bayesian information criterion
```

Model	N	ll(null)	ll(model)	df	AIC	BIC
.	8,514	.	-994.4933	21	2030.987	2179.025

Note: BIC uses N = number of observations. See [R] BIC note.

```
. estat icc

Residual intraclass correlation
```

Level	ICC	Std. err.	[95% conf.	interval]
psu1	.1963743	.0413729	.1275331	.2900227

Appendix B: Plagiarism declaration

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

FACULTY OF HEALTH SCIENCES

PLAGIARISM DECLARATION TO BE SIGNED BY ALL HIGHER DEGREE STUDENTS

SENATE PLAGIARISM POLICY: APPENDIX ONE

I Ruvimbo Faith Forget (Student number: 1688451) am a student

registered for the degree of Masters in Epidemiology and Biostatistics in the academic year 2022-2024

I hereby declare the following:

- I am aware that plagiarism (the use of someone else's work without their permission and/or without acknowledging the original source) is wrong.
- I confirm that the work submitted for assessment for the above degree is my own unaided work except where I have explicitly indicated otherwise.
- I have followed the required conventions in referencing the thoughts and ideas of others.
- I understand that the University of the Witwatersrand may take disciplinary action against me if there is a belief that this is not my own unaided work or that I have failed to acknowledge the source of the ideas or words in my writing.
- I have included as an appendix a report from "Turnitin" (or other approved plagiarism detection) software indicating the level of plagiarism in my research document.

Signature: ______________ Date: 18 Nov 2024

Appendix C: Turnitin Report

ForgetRF2024COMH7175AResearchReport.docx

ORIGINALITY REPORT

13%	11%	11%	%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	wiredspace.wits.ac.za Internet Source	1%
2	bmcpublichealth.biomedcentral.com Internet Source	1%
3	pdffox.com Internet Source	1%
4	erepository.uonbi.ac.ke:8080 Internet Source	<1%
5	datacatalog.ihsn.org Internet Source	<1%
6	Musonda Makasa, Patrick Kaonga, Choolwe Jacobs, Mpundu Makasa, Bellington Vwalika. "Predictors of perinatal mortality in the seven major hospitals of Lusaka Zambia: A Case Control Study", Cold Spring Harbor Laboratory, 2024 Publication	<1%
7	www.repository.up.ac.za Internet Source	<1%

Appendix D: Stata Codes

Code used to code perinatal deaths

```
//rename variable so that it is not detected as an ambigious variable

rename b6_0* b6_*

// intrapartum stillbirths : death during delivery

gen intrapartum_stillbirth = .

forvalues i = 1/20 {

capture replace intrapartum_stillbirth = b6_`i' if b6_`i' <=100  &   m19_`i'  >=1000

}

replace intrapartum_stillbirth = 1 if intrapartum_stillbirth ==100

replace intrapartum_stillbirth = 0 if intrapartum_stillbirth ==.

label define intrapartum_stillbirth 1 " intrapartum_stillbirth"  0 "non_stillbirth"

label values intrapartum_stillbirth intrapartum_stillbirth


// early neonatal death : during first week of birth

gen neonatal_death = .

forvalues i = 1/20 {

capture replace neonatal_death =  b6_`i' if  b6_`i' >=101 & b6_`i' <=107

}

replace neonatal_death = 1 if inrange(neonatal_death ,101, 107)

replace neonatal_death= 0 if  neonatal_death ==.

label define neonatal_death 1 " neonatal_death"   0 "non_neonatal_death"

label values neonatal_death neonatal_death
```

Code used to survey set data

```
cap gen psu1 = v001

cap gen strata1 = v023

cap gen wt=v005/1000000

svyset psu1 [pw = wt], strata(strata1) singleunit(centered)
```

Code used for multivariable logistic regression

```
svy: logit perinatal_death i.ever_terminated i.age_category i.parity i.education
i.marital_status i.ethnicity i.tested_hiv i.hiv_transmission i.anc_visits i.birth_weight
i.birth_interval i.type_of_delivery i.province i.residence i.household_wealth , or
```