

https://dspace.org/

Comparing health inequalities in maternal health: An analysis of the South African Demographic and Health Surveys (SADHS) 1998 and 2016

Holden, Celeste Claire

2023-09

University of the Witwatersrand, Johannesburg

https://hdl.handle.net/10539/44826

Holden, Celeste Claire. (2023). Comparing health inequalities in maternal health: An analysis of the South African Demographic and Health Surveys (SADHS) 1998 and 2016. [Masters dissertation, University of the Witwatersrand, Johannesburg]. WIReDSpace. https://hdl.handle.net/10539/44826

Downloaded from a DSpace repository. https://dspace.org/



DEPARTMENT OF PUBLIC HEALTH

RESEARCH REPORT

Comparing health inequalities in maternal health: An analysis of the South African Demographic and Health Surveys (SADHS) 1998 and 2016

A Research report submitted to the School of Public Health

Faculty of Health Sciences, University of Witwatersrand

In partial fulfilment of the requirements for the degree of Master of Public Health

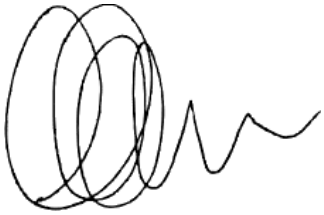
Submitted by Celeste Claire Holden

Student number: 707526

Johannesburg, 2023

DECLARATION

I Celeste Claire Holden declare that this Research Report is my own, unaided work. It is being submitted for the Degree of Master of Public Health (MPH) at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at any other University.



(Signature of candidate)

11 September 2023 in Johannesburg

ABSTRACT

Background: Inadequate access to maternal health services (MHS) is directly linked to maternal and neonatal mortality and morbidity. South Africa (SA) is known to be an unequal society. Researching and documenting the utilisation and access to MHS can assist in the appropriate redirection of services to ensure equitable service delivery. The study identifies differences in MHS access between ethnicity groups, residence, province, maternal education level and household wealth quintile. The study quantifies the inequalities in access to MHS in SA in 1998 and 2016, and then evaluates the change in inequalities between the two periods.

Methods: Data was analysed from the 1998 and 2016 South African Demographic and Health Surveys. First. the study identifies differences in MHS access between ethnic groups, residence, province, maternal education level and household wealth quintile using regression analyses. Then, the inequalities related to access of MHS in 1998 and 2016 are calculated using the relative (RII) and slope (SII) index of inequality and the concentration index (CI). Lastly, the inequalities between 1998 and 2016 were compared using generalised linear models, indicating whether inequalities increased, decreased, or remained the same. All analyses were done in Stata and adjusted for the multistage-stratified sampling of the surveys.

Results: Utilisation of MHS in SA varies between different groups based on ethnicity, residence, province, mothers' education level, and wealth quintile. In 1998 and 2016, Black/African women have the least utilisation of all MHS. A clear pattern is seen where women with higher education and high wealth quintile, have increased MHS utilisation. In most cases, the inequalities narrowed between 1998 and 2016 for all MHS. However, inequalities are still present in 2016 for many MHS. For example, using simple inequality measures, the largest inequalities in 2016 are seen between women of different ethnicities accessing four or more antenatal visits (ANC4), where there is a 11.1 percentage point difference between the highest group (White & Indian/Asian) and the lowest group (Black/African). For complex inequality measures, there are still significant relative and absolute inequalities in antenatal visits in 2016 for maternal education (RII: 1.25; SII: 1.14) and household wealth quintile (RII: 1.23; SII: 1.11).

Conclusions: Between 1998 and 2016, population-level utilisation to MHS increased in all MHS and the majority of within group inequalities narrowed over time. However, inequalities still exist in all maternal health outcomes. SA has implemented multiple programmes and policies to address inequalities in MHS and decrease maternal mortality and morbidity. However, these need to be continuously monitored and evaluated based on the latest data to ensure that efforts are going towards addressing the specific groups where inequalities are still present.

TABLE OF CONTENTS

DECLARATION i
ABSTRACT ii
LIST OF TABLES v
LIST OF FIGURES v
LIST OF ABBREVIATIONS vi
1. CHAPTER ONE: INTRODUCTION, BACKGROUND, AND PROBLEM STATEMENT 1
1.1. Background 1
1.2. Literature Review 1
1.2.1. Key MHS indicators 2
1.2.2. Inequalities related to MHS coverage 3
1.2.3. South Africa's efforts to reduce maternal and infant mortality 5
1.3. Problem Statement 7
1.4. Justification 7
1.5. Research Question 8
1.6. Research Aim 8
1.7. Research Objectives 8
2. CHAPTER TWO: METHODOLOGY 9
2.1. Primary Study Data 9
2.1.1. Background 9
2.1.2. Study Design 10
2.1.3. Study Setting 10
2.1.4. Study Population 10
2.1.5. Study Sample 10
2.1.6. Data Collection 11
2.2. Secondary Study Methods 11
2.2.1. Study Design 11
2.2.2. Study Setting 11
2.2.3. Study Population 11
2.2.4. Study Sample 11
2.2.5. Data Processing 12
2.2.6. Outcome Variables 13
2.2.7. Exposure Variables ..... **Error! Bookmark not defined.**
2.2.8. Confounding variables 15
2.3. Data Analysis 16
2.3.1. Objective One: Bivariate Multiple Regression Analyses 16

2.3.2. Objective Two: Inequality Analysis 17
2.3.3. Objective Three: Trend analysis 19
3. CHAPTER 3: RESULTS 21
3.1. Objective 1: Socio-demographic factors associated with MHS indicators 23
3.2. Objective 2: Absolute and relative inequalities of MHS indicators 31
3.3. Objective 3: Changes in MHS inequalities between 1998 and 2016 34
4. CHAPTER 4: DISCUSSION AND CONCLUSION 40
4.1. Discussion 40
4.2. Conclusion 45
REFERENCES 47
APPENDIX A: PLAGARISM DECLARATION 54
APPENDIX B: ETHICS WAIVER CERTIFICATE 55
APPENDIX C: TURNITIN REPORT SIGNED 56
APPENDIX D: TURNITIN MOTIVATION FROM SUPERVISOR 57
APPENDIX E: RII AND SII STATA COMMANDS (OBJECTIVE 2) 58
APPENDIX F: CONCENTRATION INDEX (CI) STATA COMMANDS (OBJECTIVE 2) 59
APPENDIX F: TREND ANALYSIS STATA COMMANDS (OBJECTIVE 3) 60

LIST OF TABLES

Table 1: Maternal healthcare services included in the 1998 and 2016 SADHS.....11
Table 2: 1998 and 2016 SADHS datasets downloaded from the DHS website 12
Table 3 : Variables from SADHS data sets and the new variables that were created for analysis.....14
Table 4: Outcome variables used in the research report ..... **Error! Bookmark not defined.**
Table 5: Exposure variables used in the research report 15
Table 6: Distribution of the sample related to women who had given birth in the last 5 years prior to each survey, according to background characteristics, 1998 and 2016 SADHS.....22
Table 7: Distribution of outcome variables based on background characteristics, 1998 and 2016 23
Table 8: Poisson regression of Antenatal visits and logistic regression of four or more antenatal visits, by background characteristics, SADHS 1998 and 2016...**Error! Bookmark not defined.**
Table 9: Logistic regression of Skilled Birth Attendant and Institutional Delivery by background characteristics, SADHS 1998 and 2016 28
Table 10: Simple absolute and relative inequality results for maternal healthcare services by background characteristics.....35
Table 11: Relative Index of Inequality, Slope Index of Inequality, Concentration Index, and trend of maternal health services by ordinal background characteristics between 1998 and 2016 36

LIST OF FIGURES

Figure 1-Figure 8: RII and SII results for antenatal visits, ANC4+, SBA and Institutional delivery, SADHS 1998 and 2016.....36-38

LIST OF ABBREVIATIONS

ANC	-	Antenatal Care
ARV	-	Antiretroviral
BANC	-	Basic Antenatal Care
CI	-	Concentration Index
CHW	-	Community Health Worker
DHS	-	Demographic and Health Survey
DoH	-	Department of Health
EAs	-	Enumeration Areas
HSRC	-	Human Sciences and Research Council
IFSS	-	Internet file streaming system
LIC	-	Low Income Country
LMIC	-	Low- and Middle- Income Countries
MHS	-	Maternal Healthcare Services
MMT	-	Maternal Mortality Rate
NCCEMD	-	National Confidential Enquiry into Maternal Deaths Committee
NDoH	-	National Department of Health
NHIS/SA	-	National Health Information System of South Africa
NMT	-	Neonatal Mortality Rate
NSDA	-	Negotiated Service Delivery Agreement
PHC	-	Primary Health Care
PPS	-	Probability Proportional to Size
RII	-	Relative Index of Inequality
RMNCH	-	Reproductive, Maternal, New-born, and Child Health
SA	-	South Africa
SDG	-	Sustainable Development Goal
SBA	-	Skilled Birth Attendant
SADHS	-	South Africa Demographic and Health Survey
SES	-	Socioeconomic Status
SII	-	Slope Index of Inequality
UN	-	United Nations
WBOTS	-	Ward-Based Outreach Teams
WHO	-	World Health Organization

1. CHAPTER ONE: INTRODUCTION, BACKGROUND, AND PROBLEM STATEMENT

1.1. BACKGROUND

Maternal health is the foundation of a productive and well society (1,2). The United Nation's (UN) Millennium Development Goals (MDGs) had a goal to reduce maternal mortality by 75% by 2015 (3), however maternal and infant deaths still occur worldwide due to inadequate maternal healthcare services (MHS) (4–6). A large proportion of these deaths occurring in Sub-Saharan Africa (SSA) (4–6). Reducing maternal mortality and providing equitable access to MHS has multiple benefits for society, such as improved levels of education attainment and higher productivity (6–8).

Similar to the MDGs goal above, one of the United Nations (UN) Sustainable Development Goal (SDG) is to "ensure healthy lives and promote well-being for all at all ages" (pg.10 (9)) by 2030, which includes the target of reducing maternal morbidity and mortality (9). However, ensuring equitable access to adequate MHS proves to be one of the most challenging tasks in the public health sector (10,11). Inequalities in health, specifically regarding MHS, are needed to be evaluated in order to guide policy makers make appropriate resource allocations (12–14).

1.2. LITERATURE REVIEW

MHS influence neonatal, infant, and maternal mortality and morbidity before, during, and after birth (15–19). Maternal mortality has been specifically linked to a variety of factors such as poor socio-economic conditions, inadequately-trained healthcare workers, poor healthcare infrastructure, healthcare facilities being inaccessible (1,5,6,20). These factors influence the access and utilisation of MHS which leads to increased risk of haemorrhage, complications related to maternal hypertension, and infections during childbirth (6,20,21).

Maternal mortality has steadily declined in South Africa (22). In 2009 maternal mortality was 2275 but halved by 2015 to 1097 deaths. This decline has largely been due to improved HIV treatment of pregnant women (22). Unfortunately in 2015 the MMR (maternal mortality rate) is still too high in some of the provinces in SA, such as KwaZulu-Natal, which had the third lowest GDP and the highest number of maternal deaths in the country (22). This

indicates that sociodemographic factors need to be addressed at a provincial level in order to decrease the MMR across all provinces (22). This study will also look at inequalities for each MHS at a provincial level to ascertain whether inequalities exist in access and utilisation of MHS in South Africa between provinces.

1.2.1. KEY MHS INDICATORS

The MHS indicators this study will focus on include (i) antenatal care (ANC) attendance, (ii) institutional delivery, and (iii) skilled birth attendance (SBA). These MHS give insight into MHS utilisation and coverage, which is important to monitor (17). However it is important to note that various authors state that MHS indicators in the DHS do not give any information regarding the quality of the MHS care afforded to patients (17,23,24). Thus, quality of care will not be looked at in this study.

Antenatal care (ANC) from a trained healthcare professional is widely known to reduce the risks of maternal and infant morbidity and mortality risks during pregnancy, delivery, and the postnatal period by screening for complications and monitoring both mother and child (15–19). Women who receive ANC are more likely to have their child delivered in a healthcare facility by a skilled birth attendant (SBA), which further reduces the risk of both maternal and infant morbidity and mortality (19,25–27). The Basic Antenatal Care (BANC) approach was initiated by the South African Department of Health (DoH) in 1998. The BANC approach emphasizes early identification and management of any complications surrounding the pregnancy, and also aims to promote healthy behaviours and lifestyles for pregnant women. which aims to ensure that all women in SA receive four focussed antenatal visits. BANC has been shown to be as effective in terms of maternal and perinatal outcomes and seems to be acceptable to SA women (28). A minimum of four ANC visits (ANC4+) still remains a widely used maternal heath indicator in the literature and is used in this study (17,29,30). However, from 2016, WHO recommends that all pregnant women should attend at eight or more ANC appointments (17,29). However, in resource-constrained contexts such as sub-Saharan Africa, having even just one ANC visit is still an important outcome to monitor (17,31). The already available 2016 SADHS report found that 94% of women in SA attended ANC at least once prior to the birth of their most recent child, and approximately 75% went to four or more antenatal visits (26). Although these numbers are high, there are disparities in ANC coverage between sub-populations (14,26,32).

(i) Institutional delivery and skilled birth attendant (SBA)

During delivery, access to a skilled birth attendant (SBA) at a healthcare institution or facility decreases the risk of problems such as infections during labour, thus reducing maternal and infant morbidity and mortality (15,27,33). WHO defines a SBA as a person "trained to proficiency in the skills needed to manage normal (uncomplicated) pregnancies, childbirth and the immediate postnatal period, and in the identification, management and referral of complications in women and newborns" (34,35). It is well accepted globally that maternal and infant health can be improved (especially during delivery) by increased access to a competent health care professional who is working in a hygienic environment, has the correct equipment, medicines, and an efficient referral system in place (27,33). Thus, the number of deliveries assisted by a SBA has become a key process indicator for monitoring maternal health (34,36). However, SBA is only truly impactful on the level of maternal mortality if it occurs within a well-functioning and enabling health care system (33). The existing 2016 SADHS report states that in 1998, only 83% births were assisted by a SBA, which increased by 14% in 2016 to 97% (25,26).

1.2.2. Inequalities related to MHS coverage

The majority of both infant and maternal mortality occurs in LMICs (37,38) and although there has been a 34% decrease in maternal mortality rate (MMR) globally, 95% of all maternal deaths occurred in LMICs in 2020 (38). There has also been a decrease in global neonatal deaths, but SSA is still burdened with the highest neonatal mortality rate in the world (27 deaths per 1000 live births)(37). These statistics from the WHO indicate global inequality regarding the burden of maternal and infant mortality, which needs to be explored and analysed in order for these inequalities to be addressed.

This study will investigate *inequalities* in MHS, in SA between 1998 and 2016. Inequality and inequity need to be distinguished from each other for clarity. Inequality in health refers to the unequal distribution of health associated resources between different populations based on their differences (39). Inequity on the other hand is a more complex and complicated ethical issue, described as "unfair and avoidable differences in health and access to health services"(40), often caused by social exclusion and poor and/or corrupt governance (40). Inequities put already underprivileged people at even further disadvantage (40).

The Reproductive, Maternal, Newborn and Child Health (RMNCH) report by WHO reported that inequalities are still present for most RMNCH indicators even though some progress has been made to reduce them (13). WHO found that the main inequalities exist between the richest and poorest, the most and least educated, and between urban and rural populations (13). Echoing this, literature, including a systematic review (41), has revealed that the variation in MHS utilisation in LMICs is known to be highly influenced by socioeconomic status and maternal education level (11–13,41). A study in Kenya found that those in the highest wealth quintile are increasingly likely to have four or more ANC visits, and a SBA (11).

In SA, although there have been definite increases in the utilisation of MHS, studies done in 2008 and 2012 have found that some inequalities to access and utilisation to MHS still persist (14,32). A study looking at the 1998 SADHS results also found that health inequalities persist in SA, discriminating against the poor (42). Inequalities are were also found between the rural and urban populations (42). These inequalities seem to be widening, especially with respect to socio-economic status and ANC attendance; residence and SBA; and between provinces for most MHS (14).

Some supply side issues of MHS provision have been identified as a cause for these inequalities. These include corruption, inadequate governance (43,44), and poor service delivery (especially in rural areas)(42). In addition, demand side factors also effect the utilisation of MHS (12,45). A Meta-Synthesis of Qualitative Studies regarding the use of ANC services in LMICs suggests that MHS are sometimes underutilised due to a misalignment between the services provided and cultural and social beliefs of some women (12,45). This was seen in Limpopo, SA, where although ANC services are free, they are not fully utilised by pregnant Black African women (45). Women also seem to underutilise MHS when they have experienced poor quality of care (or they have heard that the facility delivers poor quality care) (12). Both supply and demand factors and important to consider if inequalities relating to MHS uptake continue to persist.

Health differentials, referred to as exposure variables in this study, were selected from the PROGRESS-plus framework. The PROGRESS-Plus framework is a useful tool for researchers and policymakers to identify and address health inequalities by targeting specific social determinants of health (46–48). PROGRESS-Plus is an acronym standing for **P**lace of Residence

(such as province, urban or rural), **R**ace (referred to as ethnicity in this study), **O**ccupation, **G**ender, **R**eligion, **E**ducation, **S**ocioeconomic and **S**ocial capital, where 'Plus' category includes other categories such as age, sexual orientation, and disability (49,50). The acronym 'PROGRESS-Plus' framework has been developed to ensure that the issue of equity and equality is made a priority in research. The PROGRESS factors are each justified based on their on their different disease burdens and their potential to impact the access and utilisation of healthcare resources (50). PROGRESS-Plus is a framework developed to help identify and address health inequalities by looking at the social determinants of health (46). The PROGRESS-Plus framework has been used all over the world to identify and reduce health inequalities (46–48). A study which looked at 23 LMICs using the PROGRESS-Plus Framework found that socioeconomic status, education, and geographic location were among the most important factors contributing to health disparities in these countries (48).

The SADHS reports do not report on inequality as they did not undertake any inequality analyses when reporting on their data sets (51,52). However, they do give basic distribution information of each MHS outcome, which is similar to the information you can see in Table 6 of this report.

1.2.3. South Africa's efforts to reduce maternal and infant mortality

There is a continuing commitment to reduce maternal mortality rates (MMRs), especially in LMICs (53). Policy makers, organisations, and governments are striving to improve population health, and to decrease inequalities in healthcare access and utilisation based on socio-economic status, ethnicity, education and other factors (54–57). In 2010, in line with this aim, the Negotiated Service Delivery Agreement (NSDA) was signed. It identifies the reduction in maternal and child mortality as important outcomes which need to be addressed (28). The NSDA emphasises the need to strengthen the healthcare system and improve functioning of Public Health Care (PHC) services and the health system at a provincial and at a district level (28). To this end, the National Department of Health (NDoH) introduced free health care services for mothers and children and has been working to the strengthen Primary Health Care (PHC) services, especially in rural areas (28). Within the NDoH, there are Maternal and the Child Health Groups which work on policy formulation, coordination, and monitoring and evaluation of MHS, among other functions. In each province there is a unit responsible for

facilitating implementation of the maternal and child healthcare interventions as well as monitoring and evaluating these (28). Further, in each district there are teams, such as PHC outreach teams who endeavour improve MHS accessibility for all South African women (28). However, despite improvements in coverage of all MHS and improved MHS access in rural areas, there are still significant healthcare sector challenges such as service delivery bottlenecks (28).

1.2.4. Ethnicity in research in the South African context

In the South African context, it is widely known that the Black/African population has been underserved since the Apartheid era, and the white population has had a disproportionate amount of wealth and opportunities (16,54). Prior to 1994, the highly segregated health system was focused mainly on the hospital sector and primary health care (PHC) services were underdeveloped and health services were systematically underfunded among the black population group (54,58). The government has made efforts to deal with the legacy that Apartheid left behind in all areas of society. However, the various government policies have not led actually to a decrease in the imbalances between the rich and the poor including access to free basic health services to pregnant women (16,54). Thus, this study explores inequalities related to ethnicity in order to establish whether these imbalances have been addressed.

The terms ethnicity and race are used interchangeably in the DHS reports (1998 and 2016) with the term 'ethnicity' used more commonly and ethnicity used as the variable name in both 1998 and 2016 SADHS STATA data sets. There is no mention of discriminating between the terms 'race' and 'ethnicity' in the SADHS reports reviewed or the data reviewed (52,59). However, it is recognised that there is an ongoing debate surrounding race and ethnicity regarding their meanings and how and when to include race or ethnicity as exposure variables in research.

Race is defined by Mirriam Webster as "any one of the groups that humans are often divided into based on physical traits regarded as common among people of shared ancestry"(60). Ethnicity is defined by The Oxford English Dictionary as "[t]he fact or state of belonging to a social group that has a common national or cultural tradition."(60,61). Both race and ethnicity seem to have an element of a social construct and their biological

understanding remains limited. However, both can provide an important lens through which we can study racism and equity in health and society (60). There has been arguments against the "arbitrary separation of race and ethnicity."(60,62). The SADHS census data takes this approach and does not discriminate between the two variables and are thus they are seen as interchangeable in this study.

1.3. PROBLEM STATEMENT

In South Africa (SA), inequalities exist in access and utilisation to healthcare services and seen in various health outcomes (11,14,32,63,64). Reducing health inequalities is an essential step towards universal healthcare (UHC) and reaching the third SDG to "ensure healthy lives and promote well-being for all at all ages" (pg.10 (9)) by 2030 (9,13). Research highlighting persistent health inequalities can guide policy makers promote health in disadvantaged subgroups (12–14). The World Health Organization (WHO) recognises that both inequalities and inequities in health need to be continuously monitored (13) as both are essential in directing policy makers towards greater justice in health (40,65) by guiding allocation of resources (10,41,66).

1.4. JUSTIFICATION

In 1994, SA got a new democratic government who have implemented many policies that have improved overall access to health care (16,64). However, despite improvement in overall access, some health inequalities in SA seem to be worsening (14,32,64). Access to MHS often reveal health inequalities within and between countries, making MHS indicators useful for monitoring (14). In SA there is a need for further assessment of access and utilisation of MHS at a population level to determine where inequalities exist (14,32) which this study proposes to do. A study by Wabiri et al. (2016) undertook sub-analyses of two South African National HIV Prevalence, Incidence, Behaviour and Communication Surveys and found widening inequalities associated with various aspects of MHS in both 2008 and 2012 data sets (14). These inequalities were found to exist between the urban and rural populations and within across socio-economic groups (14). This proposed study aims to do a similar analysis; however, using different sources, namely the South African Demographic and Health Surveys (SADHS).

The Demographic and Health Survey (DHS) program is known for producing good quality demographic and health data around the world (67). Nationally representative surveys such as the DHS are designed to collect data on health indicators to allow for monitoring and evaluation of health and allow for comparison within and between countries (51). The DHS aims to provide a better understanding of the health status of a given population by providing information on key topics such as child health and reproductive health (51). Information collected from DHS studies also aims to assist the NDoH to plan and prioritise health programmes and improve service delivery (16,52,59,68). There is a large (eighteen-year) gap between the 1998 and 2016 data, making these data sets good for comparison. There has not been much research done on the 2016 SADHS dataset as it has only been in the public domain since 2019. The 1998 and 2016 SADHS reports describe some of the associations between MHS and some socio-demographic factors however, they do not provide the statistical significance of the associations and do not include any formal analysis of inequality.

1.5. RESEARCH QUESTION

Has there been any change in maternal healthcare service inequalities in South Africa between 1998 and 2016?

1.6. RESEARCH AIM

To describe and compare inequalities in maternal health service indicators in South Africa in 1998 and 2016.

1.7. RESEARCH OBJECTIVES

1. To analyse the socio-demographic factors associated with selected maternal health indicators in South Africa in 1998 and 2016.

2. To quantify the absolute and relative inequalities for selected maternal health indicators in South Africa in 1998 and 2016.

3. To evaluate the change in inequalities for selected maternal health indicators between 1998 and 2016.

2. CHAPTER TWO: METHODOLOGY

This study is a secondary data analysis of the South African demographic and health survey (SADHS) data from 1998 and 2016. No additional primary data was collected for this study. The primary SADHS study will be described first, followed by the secondary data methods.

2.1. PRIMARY STUDY

2.1.1. BACKGROUND

The South Africa Demographic and Health Survey (SADHS) is a nationally representative cross-sectional household survey. The SADHS is conducted in South Africa in collaboration with the worldwide Demographic and Health Survey (DHS) Program (15). SADHS data has already been collected for both 1998 and 2016 and is accessible in the public domain from the DHS website (69), following registration and a formal request for access.

SADHS collects a variety of demographic and health indicators primarily to provide current, basic demographic information such childhood mortality, fertility, maternal, and child health indicators, among many other health topics (16,52). The SADHS consists of three questionnaires, namely the Household, Adult, and Woman Questionnaires. First, the Household Questionnaire was used to list all the usual members and visitors in the selected households. Basic information was then collected on the characteristics of each person listed in the household, including his/her age, sex, education, work status and relationship to the head of the household. Household information such as details regarding the dwelling itself including water and sanitation was gathered (25). Another important purpose of the Household Questionnaire was to identify women and adults who were eligible for interview for the individual questionnaires, namely the Adult and Woman Questionnaires. The individual questionnaire of interest in this study is the Woman's Questionnaire which was used to collect information from all women in the household aged 15-49 (25).

The SADHS samples are representative at national level, provincial level and between urban and non-urban areas. They each followed a two-stage sample design by using probability proportional to size (PPS) sampling in the first stage, followed by systematic sampling (15).

2.1.2. Study Design

Description and analyses of two cross sectional data sets, namely the 1998 and 2016 SADHS data sets.

2.1.3. Study Setting

South Africa including all provinces, rural and urban areas.

2.1.4. Study Population

The South African population. The SADHS data sets are meant to be representative of the entire South African population at a national level, provincial level and between urban and rural areas. Of the eligible households identified to participate in the SADHS surveys, adults in every second household were identified to complete an adult questionnaire. Women aged 15-49 and men aged 15-59 were eligible for the standard individual questionnaire, as well as a South Africa-specific module on adult health. Women aged 15-49 were asked to complete a woman's questionnaire (15).

2.1.5. Study Sample

South African women aged 15-49 who had a live birth 5 years preceding the respective SADHS surveys. In the 1998 SADHS study, 4,992 women qualified and in the 2016 SADHS study, 3,036 women qualified. Both studies applied a two-stage sampling design by using proportional to size (PPS) in the first stage, and systematic sampling in stage two.

SADHS 1998 sample: 12,860 households were selected to participate in the 1998 SADHS. 12,247 households were occupied and interviewed, yielding a response rate of 96.9%. Every second household was selected for the adult health survey and a woman's survey. 11,735 women were interviewed yielding a 95.2% response rate (70). 4,992 women aged 15-49 had a live birth within 5 years preceding the 1998 survey.

SADHS 2016 sample: 15,292 households were selected for the 2016 SADHS sample, of which 13,288 were occupied. 11,083 people in the occupied houses were interviewed - a response rate of 83%. 9,878 eligible women aged 15-49 completed individual adult interviews and of this number, there were 3,036 women aged 15-49 who had had a live birth within 5 years preceding the 2016 survey (15).

2.1.6. Data Collection

The SADHS data is compiled from cross-sectional household surveys that were done face-to-face and in all provinces, in both urban and rural areas (16,52).

SADHS 1998: Paper-based questionnaires were used (25).

SADHS 2016: Data collection was done using a tablet, using the Computer assisted Interview System (CAPI)(59).

2.2. SECONDARY STUDY METHODS

2.2.1. Study Design

Description and analyses of two cross sectional data sets, namely the 1998 and 2016 SADHS data sets.

2.2.2. Study Setting

South Africa, including all provinces, rural and urban areas.

2.2.3. Study Population

South African woman aged 15-49 who have had at least one live birth within 5 years preceding the SADHS surveys.

2.2.4. Study Sample

The entire study population will be used as the sample; no further sampling will be done. Table 1 below outlines the sample groups used in the study for 1998 and 2016.

Table 1: Maternal healthcare services included in the 1998 and 2016 SADHS

Indicator	Definition	Sample size 1998	Sample size 2016
Number of Antenatal care visits (ANC)	Number of antenatal visits for their most recent pregnancy in the last 5 years preceding the survey	4122	3036
Four or more antenatal care visits (ANC 4+)	Four or more antenatal visits for their most recent pregnancy in the last 5 years preceding the survey	4122	3036
Skilled Birth Attendance (SBA)	Births in the five years preceding the survey that were delivered by a SBA	4992	3572
Institutional delivery	Births in the five years preceding the survey that were delivered in a health facility	4992	3572

2.2.5. Data Processing

(i) Step One: Downloading the relevant SADHS data

The 1998 and 2016 SADHS data was downloaded from the DHS website (71). Data from the household questionnaire will provide information regarding the mother's socio-demographic information and the woman's questionnaire will provide information on the mother's use of all MHS of her most recent delivery in the last 5 years preceding the SADHS data sets. There is also a separate data set (compiled based on the woman's questionnaire) with details of the live births recorded in each data set. The following data downloaded from the DHS site are outlined in table 2 below.

Table 2: 1998 and 2016 SADHS datasets downloaded from the DHS website

Year	Dataset code	Dataset name and contents
1998	ZABR31DT	Birth data
	ZAWI31DT	Wealth Index data
2016	ZABR71DT	Birth data including wealth index data

(ii) Step Two: Data cleaning, converting, and merging relevant datasets

The data sets all had to be converted from wide format to long format. Wide data refers to data where each observation (row) contains a single variable with multiple values, and long data is when each observation contains multiple variables, each with a single value. Then the 1998 birth data (ZABR31DT) and wealth data (ZAWI31DT) were merged into one data set. The data then had to be "survey set" to declare the data as a survey. A weight variable was created and defined, and a weighting (100 0000) was applied to both the 1998 and 2016 data sets. In instances where strata only had one sampling unit, issues were caused when applying the weighting. This issue was fixed by using the average of the variances from the strata with multiple sampling units for each stratum with a singleton PSU. Ridits then needed to be created in order to do the complex inequality analyses.

(iii) Step Three: Replicating the tables found in the DHS reports

Using the maternal health variables and the sociodemographic variables created above, and the variables available in the data, tables were replicated to match the reports for the 1998 and 2016 SADHS data sets. Full reports for both the 1998 and 2016 SADHS data are available (15,25).

(iv) Step Four: Matching variables between 1998 and 2016 and merging the datasets

This section outlines the changes to existing variables and the and new variables that needed to be created so that the 1998 and 2016 datasets match.

The "ethnicity" variable posed two issues in the data analysis, which lead to the choice to merge certain ethnicity groups to ensure that analysis could be done in align with the study objectives. First**, "**Indian" and "Asian" differ as ethnic group categories in each data, which meant that they could not be compared over time if left as separate groups. Thus they had to be combined into one category being: "Indian/Asian". The second issue was that "Indian/Asian" had 100% for institutional delivery and SBA in the 2016 dataset, which is an issue in logistic regression. Thus we had to merge"Indian/Asian" with "White" to enable a logistic regression analysis. It made sense to merge the groups as they seem to be the two groups with highest utilisation of MHS. These changes to the data in order to do analyses are seen as limitations in the study.

Household wealth quintile, generated from household assets, is used in this study to act as a proxy for the mother's socioeconomic status. Wealth has been shown to be an important determinant of mortality and health care use. It is extensively used in the field of health inequalities research, especially in studies on low and middle-income countries (LMICs). Wealth was measured using an index based on household ownership of assets, such as durable consumer goods, housing quality, water and sanitary facilities and other amenities (72). The assets were combined into a wealth index using Principal Components Analysis (PCA) derived weights, created by the World Bank (72–74). Despite its limitations (75), the wealth index is widely used as measure of economic status in developing countries (72,74,76).

2.2.1. Outcome Variables

Table 4, although similar to table 3, outlines and explains all of the outcome variables in this study. Access to MHS was measured by: utilisation of antenatal clinics; the presence of a skilled birth attendant (SBA) at birth and whether the birth took place at a health institution such as a hospital or clinic or not. The MHS described are the primary outcome variables in this study.

Table 3 : Variables from SADHS data sets and the new variables that were created for analysis

Variable name	How the variable was presented in the SADHS raw data	The new variable made
Ethnicity	1998 • Black/African • White • Coloured • Asian 2016 • Black/African • White • Coloured • Indian	Categorical: • Black/African • White & Indian/Asian • Coloured
Mother's age at birth:	Continuous numeric variable: Mothers date of birth (mdob) variable in cmc format, and babies date of birth (bdob) variable in cmc format, used to calculate mothers age at birth into a continuous numeric variable	Categorical variable • <20 years old • 20-34 years old • 35+ years old
Birth order	Continuous numeric variable: 0-98	Categorical variable • "1" • "2-3" • "4-5" • "6+"
Skilled ANC attendant	Categorical variable with the following categories: • "No one" • "Doctor" • "Nurse/midwife" • "TBA" • "CHW" • "Relative/other"	Binary: "yes" or "no" The following categories fell under "yes": • "Doctor" • "Nurse/midwife" The following categories fell under "no": • "No one" • "TBA" • "CHW" • "Relative/other"
4+ ANC visits	This variable is available as a binary variable in the 2016 dataset, but not for the 1998 dataset and thus needed to be created in the 1998 dataset using the continuous numeric variable: "Number of ANC visits".	Binary: • <4 ANC visits • ≥4 ANC visits

2.2.2. Outcome and Exposure Variables

Table 4: Outcome and exposure variables used in the research report

Variable name	Variable details	Explanation of variable
Outcome variables		
ANC visits (attendance)	Number of ANC visits (continuous variable) • *0-20 ANC visits*	Number of antenatal care visits during pregnancy for most recent birth. ANC attendance is with a skilled healthcare professional. A skilled healthcare professional may include medical doctors, nurses and midwives (19).
	4+ ANC visits (categorical binary variable) • *< 4 ANC visits* • *≥ 4 ANC visits*	
Institutional delivery	Categorical binary variable • *Health institution* • *Other*	"Health institution" refers to a hygienic facility such as clinic or hospital (16). "Other" refers to having birth anywhere other than a health facility.
Skilled birth attendance (SBA)	Categorical binary variable • *Skilled birth attendant (SBA)* • *Other/None*	Only the most qualified person is considered. A skilled provider includes a doctor and nurse/midwife.
Exposure variables		
Population group - Ethnicity	Categorical: 4 groups • Black/African • Coloured • White • Indian/Asian	The Indian and Asian groups have only been grouped because in 1998 there was only an "Asian" group and in 2016 there was only an "Indian" group and thus they were not comparable and needed to be merged.
Province	Categorical: • Eastern Cape • Free State • Gauteng • KwaZulu Natal • Limpopo • Mpumalanga • North West • Northern Cape • Western Cape	The nine provinces of South Africa.
Place of residence	Categorical/binary: • Rural • Urban	These residential groups are as per the SADHS data sets.
Maternal education (highest level)	Categorical: 4 categories • None • Completed Primary School • Completed High School • Completed University/Tertiary education	The mother's highest level of education attainment.

Household wealth quintile	Categorical: 5 categories (quintiles) • Quintile 1 • Quintile 2 • Quintile 3 • Quintile 4 • Quintile 5	The SADHS separated household wealth into quintiles based on the household's assets and the value of their assets (15). Quintile 1 (poorest) to quintile 5 (richest).

2.2.3. CONFOUNDING VARIABLES

Confounding variables are factors which may result in an incorrect conclusion due to associations with both outcome and exposure. Confounding variables are extraneous variables that can influence the relationship between the independent variable and the dependent variable in a research study. Confounding variables are often related to both the independent and dependent variables, which can lead to the appearance of a false relationship between the two. Confounding variables are used in multiple regression analyses in order to make sure that the correlation between the outcome and exposure variables is not due to other factors. Potential confounders in this study include:

Birth order/parity: Births of lower order seem to be more likely to be assisted by a SBA compared to higher order births (25,77). In the 2016 SADHS report, SBA during delivery was shown to decline with birth order (15).

Age of mother at birth: The age of mother at birth has been seen to influence the utilisation of MHS (41,77,78). Some studies done in SA and Nepal show that older maternal age is a positive predictor of maternal health care (77,78). However, the mother's age at birth

2.3. DATA ANALYSIS

All data analyses was done in the statistical program STATA (version 16). As explained in the data processing section, weighting was specified to ensure the data has the correct distribution as per the DHS guidelines. In order to ensure that the weighting is applied, the command *svy* was used before every command to ensure the correct weighting is applied. Where *svy* is not allowed, weighting was applied in the command manually.

2.3.1. OBJECTIVE ONE: BIVARIATE MULTIPLE REGRESSION ANALYSES

Prior to ascertaining the associations between the outcome and explanatory variables needed to answer objective one, the values for the distribution table (table 6) were computed using

the *tabulate* command. Each MHS outcome variable was tabulated by each explanatory variable. Logistic and Poisson regression analyses were done to answer objective one. Logistic regression was used to ascertain the association between binary outcome variables (Skilled birth attendant, 4+ ANC visits, and Institutional delivery) and the chosen explanatory variables: Ethnicity, Residence, Province, Household wealth, Maternal education level, and the confounding variables: Age of mother and birth order. Poisson regression was used to ascertain the association between the continuous variable (Number of ANC visits, which consists of count data) and the same above explanatory variables. Poisson regression is the classical approach when analysing count data (79), which is why it was chosen for this study. Poisson regression assumes that the mean value and the variance in the data are equal. However, in many cases the variance exceeds the mean, which is known as "overdispersion". In the case of overdispersion negative binomial regression can be used to analyse count data as it accounts for this overdispersion. In the absence of overdispersion, Poisson regression and negative binomial regression often give the same results (79).

Multiple regression analyses were then done to ascertain the association of the outcome variables and the explanatory variables, those of which were found to have a significant association in the bivariate analysis, while considering the confounding variables (birth order and mother's age at birth) as well as the other explanatory variables except for 'province' which was removed from the multiple regression analyses. The p values for all the above tests will be described to ascertain the significance of the associations.

2.3.2. Objective Two: Inequality Analysis

Simple and complex inequality measures were used to answer objective two. Both will be described below. STATA commands and explanations for this analysis are attached in Appendix C and Appendix D.

Simple inequality measures

The simple relative inequality is the rate ratio (highest group divided by the lowest group), while the simple absolute inequality is the rate difference (the difference between the highest group's values and lowest group's values). The relative inequality represents the proportional difference between the highest group and the lowest group. It is important to keep in mind the limitations of each type of inequality calculation. For example, simple relative inequalities

tend to be larger when looking at outcomes with low overall levels such as mortality whereas simple absolute inequalities, tend to be small at extremes where levels are extremely low or extremely high (72)

Complex inequality measures

Complex inequality measures were be done for each outcome variable per each explanatory variable using three inequality measures: the Slope Index of Inequality (SII) for quantifying absolute inequalities; and the Relative Index of Inequality (RII) and Concentration Index (CI) for assessing the magnitude of relative inequalities (14,80,81). SII and RII, being complex measures, both take into account the entire distribution of the population rather than just comparing just the highest and lowest ends of a data set (14,32,82). This is done by creating ridits when preparing for data analysis. A ridit is a statistical measure used in inequality analysis to compare the distribution of a variable between two or more groups. It is a rank-based measure that assigns a value between 0 and 1 to each observation in a dataset, based on its rank within its respective group. The ridit values are then used to compare the distribution of the variable between groups. For example, if we have two groups with different income levels, we can use ridits to compare the income distribution between these groups. This can help us to determine if one group is more unequal than the other, or if there are significant differences in income distribution between the groups. Ridits are particularly useful in inequality analysis because they are less sensitive to outliers and extreme values than other measures such as the mean or median. They can also be used to compare distributions of variables that are not normally distributed or have different scales. In addition, ridits can be easily calculated using standard statistical software and are easy to interpret, making them a valuable tool for researchers and policymakers working on issues related to inequality.

RII and SII have been chosen as they are "recommended when making comparisons over time or across populations" (14,83,84). The SII refers to the absolute difference in the health outcome when moving from the lowest group (eg. the poorest group) to the highest group (eg. the wealthiest group) (14,85,86). Essentially, to derive the RII and SII results, a regression line through the ridits were constructed using generalised linear models (GLM) (66,87,88).

The relative index of inequality (RII) is used to compare rates of mortality or morbidity caused by a specific disease for example, between those in different sub-populations, such as people in different socio-economic classes (89). The RII calculates the proportionate difference in an outcome/s across a chosen group, such as people in different socio-economic groups (14). For example, an RII above 1 indicates that the outcome is more prevalent among the highest group (eg. the wealthy population. The SII represents the absolute effect on health outcome of going from the lowest group (e.g. poorest) to the highest group (e.g. wealthiest) (14,85,86).

The concentration index (CI) and its normalization, is widely used in research related to inequalities in health (85,90–92). The CI is defined with reference to the Lorenz curve (91). The Lorenz curve plots the cumulative share of the variable against the cumulative share of the population. The CI measures the deviation from this line. The CI is bounded between –1 and 1. If there is no inequality present the CI will be zero (91). The sign and magnitude of the CI give information regarding where inequality exists and how strong the relationship is between a health outcome and an exposure variable (93). As an example, let us consider socioeconomic status (SES) and number of antenatal visits. If the CI is negative (a negative value between 0 and -1) then it indicates that the health outcome is concentrated among the poorer population. However, if the CI is positive (a positive value between 0 and 1) then the health outcome is more concentrated in the wealthier population. Normalisation of the CI using either Wagstaff's and Erreygers' normalizations when looking at binary health outcomes (90). There is debate concerning which is best, but there has been no conclusion in this regard (93). This study used the Wagstaff correction.

2.3.3. Objective Three: Trend analysis

Trend analysis compares the change in inequalities over time. The trend in RII and SII over time was be assessed by using a GLM with the inclusion of the two-way interaction term by year for each of the exposure variables. The two-way interaction term was used to assess if there was any change over time (94). The trends in RII and SII over the period of 1998–2016 will be tested by estimating the p-value for an interaction term between rank score and years since baseline. This was done for each outcome. In this study, the 1998 survey was coded 1, and the 2016 survey coded 2. Appendix E contains the STATA commands for the trend analysis.

The RII trend results show whether the relative inequalities increased or decreased over time. RII trend results range from zero upwards. If the RII is above 1 it indicates a widening of inequalities over time (14). The higher the coefficient, the higher the increase in relative inequality it represents. If the If the coefficient is below 1 (0<1), it indicates that the relative ratio decreased inequality over time.

The SII trend results show whether the absolute inequalities increased or decreased over time. Unlike RII trend results, SII trend results go from negative to positive numbers. A negative SII trend (<1) results indicates a decrease in absolute inequality over time, whereas a positive SII trend (>1) result shows a widening in absolute inequality.

2.4. STUDY LIMITATIONS

This study was done using population data, which means that the population groups (such as ethnicity) were not evenly distributed, but rather collected, distributed, and weighted according to South Africa's actual population distribution. This resulted in some groups having more in their sample than others. Ideally, comparisons by groups require adequately large sample sizes in each group to ensure reliable results with small confidence intervals. However, it is important to note are still valid as they consider proportions of each group separately, however comparisons across different populations should be made with caution due to the differences in sample sizes.

Another issue which arose due to using population data was that some sample groups were so small that they caused issues in the regression analyses. 'Indian/Asian' was such an example where their sample group was too small for the regression analyses and inequality analyses to work. We considered their outcomes, which seemed similar to that of the 'White' population and so we made the decision to group them so that they could be included in the study, otherwise they would have to be left out completely in some of the analyses.

Lastly it must be mentioned that It is difficult to get information on maternal mortality as one has to use the "sisterhood method" data collection method, which is not an ideal

method for data collection. Thus, it is more common in literature and research to use MHS access and utilization to determine health inequalities.

3. CHAPTER 3: RESULTS

This section will outline the key results for each of the three study objectives and describe the patterns seen. However, first a brief description of the distribution of the sample of the 1998 and 2016 SADHS will be given (Table 6), followed by a summary of the within-group distribution MHS for each exposure variable (Table 7). Table 6 shows that the distribution changed slightly within groups between 1998 and 2016, mirroring the changes seen in the population over time. Looking at ethnicity, the Black/African population has higher (about a 7% increase) in representation in 2016 compared to 1998, with the other ethnic groups seeing a decrease in 2016. The rural and urban population distribution changed from nearly a 50-50 split in the 1998 sample, to urban having increased representation (+-64%) in the 2016 sample.

Moving to table 7, the changes over time based on the different population groups are made clear using the key, where red text indicates a decrease in MHS for that group, whereas green text indicates an increase in MHS utilisation. Bold text indicates a change which constitutes 10% or more over time. Looking at the number of antenatal visits, many groups saw a decrease in the mean number of antenatal visits in 2016, especially the urban population. Moving to the ANC 4+, mixed results are seen here, but a notable increase in the Eastern Cape (+12.5%) and the North West (+17.8%) with notable decrease in ANC4+ for Gauteng, which coincides with the decreased number of antenatal visits for the urban population observed in 2016. Both SBA and institutional delivery saw an increase in almost all population groups utilising these services, many of which increased by more than 10% in 2016, compared to 1998. The next section of the results will focus on the associations between the MHS outcome variables and the socio-economic exposure variables to ascertain any significant association, followed by analysing the magnitude of possible inequalities that may exist within the population groups in both 1998 and 2016 respectively. Lastly the results will look at whether the inequalities found have narrowed or widened over time.

Table 6: Distribution of the sample related to women who had given birth in the last 5 years prior to each survey, according to background characteristics, 1998 and 2016 SADHS

	SADHS 1998	SADHS 2016	SADHS 1998	SADHS 2016
Outcome variable	**Antenatal data** (Most recent pregnancy in the last 5 years)		**Delivery data** (All births in the last 5 years)	
Total Sample size (n)	4122	3036	4992	3572
Ethnicity				
Black/African	3425 (83.6%)	2751 (90.6%)	4149 (83.7%)	3238 (90.7%)
White	183 (4.5%)	48 (1.6%)	250 (5.4%)	58 (1.6%)
Coloured	391 (9.5%)	206 (6.8%)	445 (9.0%)	238 (6.7%)
Indian/Asian	97 (2.4%)	30 (<0.1%)	114 (2.2%)	35 (0.01%)
Residence				
Rural	1986 (51.8%)	1094 (36.0%)	2522 (50.5%)	1291 (36.1%)
Urban	2136 (48.2%)	1942 (64.0%)	2470 (49.5%)	2281 (63.9%)
Province				
Western Cape	344 (8.4%)	276 (9.1%)	400 (8.0%)	314 (8.8%)
Eastern Cape	572 (13.9%)	335 (11.0%)	741 (14.9%)	398 (11.1%)
Northern Cape	87 (2.1%)	61 (<0.1%)	102 (2.0%)	69 (1.9%)
Free State	224 (5.4%)	145 (4.8%)	257 (5%)	164 (4.6%)
KwaZulu Natal	873 (21.2%)	555 (18.3%)	1094 (21.9%)	654 (18.3%)
North West	299 (7.3%)	244 (8.1%)	340 (6.8%)	283 (7.9%)
Gauteng	829 (20.1%)	842 (28%)	954 (19.1%)	1013 (28.4%)
Mpumalanga	317 (7.7%)	278 (9.2%)	379 (7.6%)	332 (9.3%)
Limpopo	579 (14.0%)	301 (9.9%)	724 (14.5%)	347 (9.7%)
Mother's education level				
No education	342 (8.3%)	42 (13.8%)	453 (9.1%)	50 (1.4%)
Primary	1109 (26.9%)	249 (8.2%)	1404 (28.1%)	320 (9.0%)
Secondary	2394 (58.1%)	2394 (78.9%)	2799 (56.1%)	2805 (78.5%)
Higher	278 (6.7%)	351 (11.6%)	336 (6.7%)	397 (11.1%)
Household wealth quintile				
Quintile 1: Poorest	879 (21.3%)	650 (21.4%)	1184 (23.7%)	787 (22.0%)
Quintile 2: Poorer	986 (23.9%)	739 (24.4%)	1192 (23.9%)	865 (24.2%)
Quintile 3: Middle	851 (20.6%)	671 (22.1%)	996 (20.0%)	788 (22.1%)
Quintile 4: Richer	809 (19.6%)	557 (18.4%)	899 (18.0%)	657 (18.4%)
Quintile 5: Richest	598 (14.5%)	418 (13.8%)	722 (14.5%)	476 (13.3%)
Mother's age at birth				
<20	681 (16.5%)	432 (14.2%)	835 (16.7%)	549 (15.4%)
20-34	2785 (67.6%)	2200 (72.5%)	3407 (68.3%)	2574 (72.1%)
35-49	655 (15.9%)	404 (13.3%)	751 (15.0%)	449 (12.6%)
Birth order				
1	1356 (32.9%)	1035 (34.1%)	1652 (33.1%)	1272 (35.6%)
2-3	1678 (40.7%)	1582 (52.1%)	2008 (40.2%)	1816 (50.8%)
4-5	699 (17.0%)	335 (11.0%)	847 (17.0%)	380 (10.6%)
6+	388 (9.4%)	84 (27.8%)	486 (9.7%)	104 (2.9%)

Table 7: Distribution of outcome variables based on background characteristics, 1998 and 2016

	Total Number of ANC Visits (Mean # of visits)			4+ ANC Visits (% who had 4 or more antenatal visits)			Skilled Birth Attendant (% who had a SBA)			Institutional Delivery (% who had an institutional delivery)		
	1998 n=4112	**2016** n=3036	**Change**	**1998** n=4112	**2016** n=3036	**Change**	**1998** n=4992	**2016** n=3572	**Change**	**1998** n=4992	**2016** n=3572	**Change**
Ethnicity												
Black/African	5.71	5.28	-0.43	81.2%	81.1%	-0.1%	85.8%	96.5%	**+10.7%**	81.1%	95.9%	**+14.8%**
White & Indian/Asian*	9.50	6.35	-3.15	87.1%	87.3%	+0.2%	99.0%	98.7%	-0.3-	99.0%	98.7%	-0.3%
Coloured	6.87	6.43	-0.44	84.5%	92.3%	+7.8%	95.9%	98.6%	+2.7%	93.7%	98.4%	+0.7%
Residence												
Rural	5.42	5.42	0	78.9%	85.1%	+6.2%	79.8%	94.6%	**+14.8%**	74.4%	94.2%	**+19.8%**
Urban	6.83	5.37	-1.46	85.4%	80.2%	-5.2%	95.4%	97.9%	+2.5%	92.6%	97.2%	+4.6%
Province												
Western Cape	7.12	6.75	-0.37	87.0%	92.7%	+5.7%	97.7%	99.2%	+1.5%	95.8%	98.9%	+3.1%
Eastern Cape	5.20	5.71	+0.51	73.8%	86.3%	**+12.5%**	78.3%	92.8%	**+14.5%**	73.9%	92.0%	**+18.1%**
Northern Cape	7.50	5.20	-2.30	87.7%	81.7%	-6%	92.2%	97.6%	+5.4%	87.6%	97.8%	**+10.2%**
Free State	5.69	6.37	+0.68	80.3%	85.6%	+5.3%	89.5%	96.3%	+4.1%	86.4%	96.0%	+9.6%
Kwazulu-Natal	6.20	5.30	-0.90	84.8%	84.7%	-0.1%	86.5%	96.4%	+9.9%	83.6%	95.9%	**+12.3%**
North West	5.56	6.00	+0.40	73.7%	91.5%	**+17.8%**	90.6%	96.0%	+5.4%	86.0%	95.6%	+9.6%
Gauteng	6.80	4.58	-2.22	85.7%	72.1%	**-13.6%**	95.9%	97.6%	+1.7%	92.7%	97.0%	+4.3%
Mpumalanga	5.60	5.10	-0.50	80.7%	78.4%	-2.3%	78.1%	96.5%	**+18.4%**	75.7%	95.3%	**+19.6%**
Limpopo	5.98	5.54	-0.44	83.6%	85.4%	+1.8%	84.3%	97.8%	**+13.5%**	75.0%	97.7%	**+22.7%**
Mother's education level												
No education	5.28	5.03	-0.25	77.8%	83.0%	+5.2%	67.7%	88.5%	**+20.8%**	59.5%	85.9%	**+26.4%**
Primary	5.48	5.32	-0.04	80.0%	83.5%	+3.5%	80.4%	92.4%	**+12%**	75.4%	92.1%	**+16.7%**
Secondary	6.30	5.27	-1.03	82.8%	81.2%	-1.6%	92.8%	97.1%	+4.3%	89.7%	96.3%	+6.6%
Higher	8.30	6.27	-2.03	91.1%	86.6%	-4.5%	98.9%	98.4%	-0.5%	96.9%	99.4%	+2.5%
Household wealth quintile												
Quintile 1: Poorest	5.06	5.04	-0.02	76.5%	78.4%	+1.9%	73.1%	92.6%	**+19.5%**	67.0%	91.8%	**+24.8%**
Quintile 2: Poorer	5.80	5.17	-0.63	81.9%	81.7%	-0.2%	85.1%	96.3%	**+11.2%**	80.7%	95.8%	**+15.1%**
Quintile 3: Middle	5.63	5.40	-0.23	83.2%	83.7%	+0.5%	90.4%	98.4%	+8.0%	85.7%	98.3%	**+12.6%**
Quintile 4: Richer	6.51	5.55	-0.96	82.3%	82.4%	+0.1%	97.1%	98.5%	+1.4%	94.1%	96.9%	+2.8%
Quintile 5: Richest	8.37	6.09	-2.28	90.1%	85.0%	-5.1%	98.7%	98.9%	+0.2%	98.4%	99.4%	+1.0%
Mother's age at birth												
<20	5.74	5.02	-0.72	77.9%	81.6%	+3.7%	91.2%	97.8%	+6.6%	88.4%	97.5%	+9.1%
20-34	6.28	5.51	-0.77	83.0%	83.0%	0%	87.0%	96.9%	**+15.9%**	82.9%	96.2%	**+13.3%**
35-49	5.79	5.12	-0.67	82.9%	76.8%	-6.1%	86.5%	94.4%	+7.9%	80.5%	93.9%	**+13.4%**
Birth order												
1	6.33	5.49	-0.84	81.6%	85.8%	+4.2%	94.0%	98.2%	+4.2%	91.5%	98.4%	+6.9%
2-3	6.28	5.41	-0.87	83.4%	80.5%	-2.9%	87.4%	97.1%	+9.7%	83.7%	96.4%	**+12.7%**
4-5	5.82	5.09	-0.73	82.0%	76.7%	-5.3%	81.5%	93.1%	**+11.6%**	76.2%	91.5%	**+15.3%**
6+	5.22	4.98	-0.24	78.6%	81.5%	+2,9%	76.5%	84.5%	+8.0%	67.6%	81.7%	**+14.1%**

Green: Increase; Red: Decrease; **Bold: Change >10%**

3.1. OBJECTIVE 1: Socio-demographic factors associated with MHS indicators

The results for objective one are presented in table 8 and table 9. Table 8 covers the antenatal visits and the 4+ ANC visits, while table 9 covers the results for SBA and institutional delivery. The bivariate and multiple regression results of the confounding variables (Age of mother and parity) are also included in these tables. but will not be explored in detail in this this section. However, they were included in the multiple regression analyses to check for confounding.

(i) Number of Antenatal visits

In 1998, looking at ethnicity bivariate analyses results, White and Indian/Asian group had a increased incidence risk ratio (IRR), meaning that they had 1,6 times increased chance of having one extra antenatal visit compared to the Black/African women (table 8). When applying a multiple regression approach, the relative ratio decreased, but still remained higher (IRR = 1.35; $p<0.001$) for the White & Indian/Asian population compared to the Black/African population. This means that the White & Indian/Asian population had a 1.35 times increased chance of having an antenatal visit compared to the base group, the Black/African population. In 2016, the only bivariate result which was statistically significant indicated that the Coloured population had an increased chance of one extra antenatal visit (IRR=1.22; $p<0.001$). None of the multiple regression results are statistically significant in 2016 for ethnicity (table 8).

Moving to geographic location, Mpumalanga was used as the base group as it seemed to have the lowest number of antenatal visits in the country in both 1998 and 2016, which would work well as a comparison group. The results for the 1998 bivariate analyses show more statistically significant results as well as higher IRRs for all provinces, except Limpopo, when compared to the multiple regression results. The bivariate results show that women in the Western Cape had a higher chance of going to an extra antenatal visit compared to a women in Mpumalanga (IRR=1.28; $p<0.001$), which was echoed in the multiple regression results which also had the Western Cape at the top for antenatal visits. The multiple regression results which were statistically significant analyses included the Western Cape (1.11; $p<0.05$), Northern Cape (1.09; $p<0.5$); Kwazulu-Natal (1.06; $p<0.01$) and Limpopo (1.13; $p<0.01$) (table 8). These provinces all had slightly increased utilisation to antenatal visits compared to Mpumalanga. Although not statistically significant, Gauteng had the lowest IRR for antenatal visits (0.95; $p>0.05$) in 1998 (table 8). In 2016, a similar pattern is seen where the province with the highest chance of having one extra antenatal visit continued to be the Western Cape. The bivariate result for Western Cape was IRR=1.32 ($p<0.001$) which decreased slightly when applying multiple regression to an IRR=1.26 ($p<0.001$). In addition to Western Cape, Eastern Cape (1.14; $p<0.01$); Free State (1.23; $p<0.001$); North West (1.16; $p<0.001$); Limpopo (1.09; $p>0.05$) all had statistically significant increased chances of going to one additional antenatal

visit. Again, Gauteng had the least number of antenatal visits in the country in 2016 (0.87; p<0.05), followed by Mpumalanga, the base group (table 8).

Moving to mother's education level, the multiple regression results for 1998 and 2016, the risk ratios are all close to one, indicating that all groups, despite education level, have a similar chance of having one extra antenatal visit. However, the bivariate results showed a clear pattern of increased antenatal utilisation as the mother's education level increased. In 1998, women with higher education had a 1.37 (p>0.05) increased chance of having one extra antenatal visit compared to the group with no education. In 2016, the IRR decreased to 1.25 (p>0.05), but still shows that women with higher education had a higher chance of having an extra antenatal visit (table 8).

Last, wealth quintile will be discussed. In 1998, all multiple regression results are statistically significant. Compared to the poorest group, all the other groups had a slightly increased chance of having one antenatal visit. This pattern indicates that the more money the mother had, the more chance she had of accessing antenatal care. In 2016 only the richest group – quintile 5 (1.19; p<0.001) had a statistically significant result which is a decrease from 1998 but still illustrates that the richest group (quintile 5) has an increased chance of having an extra antenatal visit. All the results in both 1998 and 2016 from both the bivariate and multiple regression analyses showed a similar pattern of increased chances of accessing antenatal care as you move up in wealth quintile (table 8).

(i) ANC4+

All the results for ethnicity (table 8) show an increased odds of having four or more antenatal visits for both the Coloured and the White & Indian/Asian populations compared to the Black/African population. The bivariate results show much higher odds ratios (ORs), which decrease when multiple regression is applied. The multiple regression results indicate that in 1998 the White & Indian/Asian group had the highest odds of utilising 4+ ANC visits (1.14; p>0.05), but in 2016 the coloured group were the highest (1.51; p>0.05), meaning that the Coloured population had 51% increased odds of having 4+ ANC visits. However, these results are not significant and should be analysed with caution.

Moving to residence, looking at both bivariate and multiple regression results, in 1998 the urban population seem to have had slightly increased odds of utilising 4+ ANC visits (1.01; p>0.05). Interestingly the results show that this is reversed in 2016 where the rural population have increased odds of utilising 4+ ANC visits (0.78; p>0.05). The OR of 0.78 for urban population means that the urban population have 22% reduced odds of having 4 or more antenatal visits.

In 1998, only three provinces have statistically significant results including Western Cape (1.94; p<0.01), KwaZulu Natal (1.58; p<0.01), and Limpopo (1.62; p<0.001) where all these provinces had increased odds of having four or more antenatal visits compared to Mpumalanga. In 2016, there were six provinces (Western Cape, Eastern Cape, Free State, KwaZulu Natal, North West, and Limpopo) which gleaned significant results, all of which had increased odds of having four or more antenatal visits compared to Mpumalanga (table 7). Interestingly, in 2016, the Eastern Cape and the North West saw quite an increase in the odds of having accessed four or more antenatal visits compared to Mpumalanga.

In 1998, women with higher education had nearly twice the odds of having more than four antenatal visits, compared to mothers with no education (table 8). Women with primary and secondary education, also showed slightly increased odds (but less than mothers with higher education) of having four or more antenatal visits compared to mothers with no education, however these results are not statistically significant. Similarly, in 2016, none of the results were statistically significant, however, the ORs were all lower than one, indicating that the odds of having four or more ANC visits is not very different between women with different levels of education. Looking at wealth quintile, a pattern of (mostly) increasing odds of having more than 4 antenatal visits as the wealth quintile increases. In 1998, all the multiple regression results are statistically significant where the odds of having four or more antenatal visits are increased for groups with increased wealth. In 2016, the pattern was similar to 1998, however only two of the groups. Middle (quintile 3), and richest (quintile 5) had increased odds of having four or more antenatal visits, compared to the poorest group (quintile 1).

Table 8: Poisson regression and logistic regression of Number of ANC visits and Four or more ANC visits by background characteristics, SADHS 1998 and 2016

	Number of ANC Visits: Poisson regression analysis				Four or more antenatal visits (ANC4+) Logistic Regression Analysis			
	1998 n=4122		**2016 n=3036**		**1998 n=4122**		**2016 n=3036**	
	Bivariate IRRs (95 % CI)	Multiple regression IRRs (95 % CI)	Bivariate IRRs (95 % CI)	Multiple regression IRRs (95 % CI)	Bivariate ORs (95 % CI)	Multiple regression ORs (95 % CI)	Bivariate ORs (95 % CI)	Multiple regression ORs (95 % CI)
Ethnicity*								
Black/African (base)	1	1	1	1	1	1	1	1
White and Indian/Asian	1.59 (1.43-1.76)***	1.35 (1.20-1.51)***	1.20 (0.99-1.45)	1.04 (0.85-1.27)	1.70 (1.00-2.89)*	1.14 (0.61-2.12)	1.61 (0.61-4.28)	1.24 (0.38-4.02)
Coloured	1.21 (1.14-1.30)***	1.06 (0.97-1.15)	1.22 (1.12-1.33)***	0.99 (0.88-1.11)	1.71 (1.22-2.40)*	1.04 (0.74-1.46)	2.80 (1.75-4.48)***	1.51 (0.87-2.63)
Residence								
Rural (base)	1	1	1	1	1	1	1	1
Urban	1.12 (1.08-1.16)***	1.04 (0.99-1.09)	0.99 (0.94-1.04)	0.98 (0.93-1.03)	1.06 (0.90-1.26)	1.01 (0.78-1.29)	0.71 (0.55-0.90)**	0.78 (0.57-1.06)
Province								
Mpumalanga (base)	1	1	1	1	1	1	1	1
Western Cape	1.28 (1.18-1.39)***	1.11 (1.00-1.22)*	1.32 (1.21-1.45)***	1.26 (1.11-1.43)***	2.44 (1.54-3.88)***	1.94 (1.23-3.07)**	3.51 (1.95-6.30)***	2.94 (1.56-5.54)**
Eastern Cape	1.00 (0.95-1.06)	1.02 (0.97-1.08)	1.12 (1.04-1.20)**	1.14 (1.05-1.23)**	0.96 (0.74-1.25)	1.12 (0.85-1.47)	1.73 (1.14-2.65)*	1.86 (1.25-2.75)**
Northern Cape	1.19 (1.11-1.27)***	1.09 (1.01-1.81)*	1.02 (0.94-1.10)	1.01 (0.92-1.11)	1.46 (1.04-2.06)*	1.31 (0.89-1.90)	1.24 (0.81-1.90)	1.04 (0.65-1.65)
Free State	1.08 (1.00-1.17)*	1.03 (0.96-1.11)	1.25 (1.14-1.36)***	1.23 (1.12-1.35)***	1.17 (0.82-1.67)	1.05 (0.73-1.51)	1.64 (1.03-2.60)*	1.70 (1.08-2.68)*
Kwazulu Natal	1.09 (1.03-1.15)**	1.06 (1.00-1.11)*	1.04 (0.97-1.11)	1.02 (0.96-1.09)	1.52 (1.11-2.09)**	1.58 (1.16-2.15)**	1.53 (1.01-2.32)*	1.51 (1.03-2.20)*
North West	1.06 (0.99-1.13)	1.04 (0.98-1.11)	1.18 (1.10-1.30)***	1.16 (1.08-1.25)***	1.20 (0.86-1.68)	1.13 (0.82-1.57)	2.97 (1.93-4.55)***	2.88 (1.94-4.26)***
Gauteng	1.04 (0.97-1.12)	0.95 (0.88-1.01)	0.90 (0.81-0.99)*	0.87 (0.79-0.96)**	0.89 (0.65-1.22)	0.75 (0.54-1.05)	0.71 (0.47-1.07)	0.73 (0.50-1.08)
Limpopo	1.09 (1.03-1.15)**	1.13 (1.07-1.20)***	1.09 (1.01-1.16)*	1.09 (1.02-1.17)*	1.47 (1.09-1.97)**	1.62 (1.23-2.15)***	1.61 (1.03-2.50)*	1.66 (1.10-2.50)*
Mother's education level								
No education (base)	1	1	1	1	1	1	1	1
Primary	1.10 (0.97-1.15)	1.02 (0.94-1.11)	1.06 (0.89-1.25)	1.01 (0.85-1.2)	1.24 (0.90-1.70)	1.27 (0.91-1.77)	1.04 (0.33-3.33)	0.85 (0.26-2.72)
Secondary	1.10 (1.02-1.20)*	1.01 (0.93-1.10)	1.05 (0.91-1.21)	0.97 (0.82-1.14)	1.28 (0.94-1.74)	1.19 (085-1.65)	0.88 (0.30-2.60)	0.60 (0.20-1.81)
Higher	1.37 (1.24-1.51)***	1.11 (1.00-1.23)	1.25 (1.08-1.45)**	1.07 (0.90-1.27)	2.36 (1.49-3.73)***	1.69 (1.05-2.73)*	1.33 (0.41-4.27)	0.75 (0.23-2.44
Household wealth quintile								
Quintile 1: Poorest (base)	1	1	1	1	1	1	1	1
Quintile 2: Poorer	1.11 (1.05-1.17)***	1.09 (1.03-1.15)**	1.03 (0.94-1.12)	1.02 (0.95-1.10)	1.37 (1.07-1.75)*	1.40 (1.08-1.82)*	1.22 (0.84-1.79)	1.27 (0.90-1.79)
Quintile 3: Middle	1.10 (1.05-1.16)***	1.09 (1.03-1.15)**	1.07 (0.98-1.17)	1.07 (0.99-1.17)	1.55 (1.20-2.02)***	1.67 (1.23-2.26)***	1.42 (0.94-2.13)	1.64 (1.11-2.44)*
Quintile 4: Richer	1.21 (1.14-1.29)***	1.15 (1.07-1.24)***	1.1 (1.01-1.20)*	1.08 (0.99-1.18)	1.42 (1.09-1.85)**	1.46 (1.02-2.09)*	1.29 (0.85-1.97)	1.46 (0.96-2.22)
Quintile 5: Richest	1.47 (1.38-1.57)***	1.26 (1.16-1.37)***	1.2 (1.09-1.34)***	1.19 (1.06-1.34)**	2.28 (1.60-3.23)***	2.07 (1.30-3.31)*	1.55 (0.92-2.61	1.87 (1.04-3.38)*
Mother's age at birth								
<20	1	1	1	1	1	1	1	1
20-34	1.09 (1.04-1.14)***	1.07 (1.01-1.13)*	1.10 (1.03-1.17)**	1.11 (1.04-1.19)**	1.35 (1.10-1.65)**	1.57 (1.20-2.05)***	1.10 (0.80-1.52)	1.53 (1.01-2.31)*
35-49	1.03 (0.97-1.09)	1.04 (0.97-1.13)	1.02 (0.94-1.11)	1.03 (0.93-1.14)	1.18 (0.90-1.56)	1.54 (1.06-2.24)*	0.75 (0.49-1.15)	1.04 (0.58-1.87)
Birth order								
1st child	1.13 (1.05-1.21)**	1.07 (0.98-1.17)	1.10 (0.98-1.25)	1.10 (0.95-1.27)	1.25 (0.95-1.64)	1.37 (0.93-2.02)	1.37 (0.78-2.42)	1.52 (0.76-3.03)
2-3 children	1.12 (1.04-1.20)**	1.03 (0.96-1.13)	1.09 (0.96-1.23)	1.06 (0.93-1.21)	1.13 (0.88-1.46)	1.04 (0.75-1.44)	0.94 (0.54-1.62)	0.90 (0.48-1.68)
4-5 children	1.07 (0.99-1.16)	1.04 (0.96-1.12)	1.02 (0.89-1.18)	1.04 (0.91-1.19)	1.02 (0.76-1.36)	1.01 (0.73-1.39)	0.75 (0.39-1.44)	0.81 0.41-1.60)
6+ children (base)	1	1	1	1	1	1	1	1

***: p<0,05 **: p<0.01 ***: p<0,001**

Table 9: Logistic regression of Skilled Birth Attendant and Institutional Delivery by background characteristics, SADHS 1998 and 2016

	Skilled birth attendant: Logistic Regression Analysis				Institutional Delivery: Logistic Regression Analysis			
	1998 (n=4992)		**2016 (n=3572)**		**1998 (n=4992)**		**2016 (n=3572)**	
	Bivariate OR (95 % CI)	Multiple regression* OR (95 % CI)	Bivariate OR (95 % CI)	Multiple regression* OR (95 % CI)	Bivariate OR (95 % CI)	Multiple regression* OR (95 % CI)	Bivariate OR (95 % CI)	Multiple regression* OR (95 % CI)
Ethnicity								
Black/African (base)	1	1	1	1	1	1	1	1
White and Indian/Asian	17.17 (2.32-127.08)**	1.72 (0.09-33.58)	2.64 (0.37-18.94)	0.97 (0.09-10.06)	24.24 (2.91-202.07)**	2.39 (0.16-35.42)	3.12 (0.43-22.36)	0.58 (0.04-7.99)
Coloured	3.85 (2.35-6.31)***	1.09 (0.58-2.02)	2.52 (0.85-7.44)	0.79 (0.31-1.98)	3.46 (2.29-5.22)***	1.15 (0.60-2.21	2.55 (0.99-6.56)	1.05 (0.36-3.03)
Residence								
Rural (base)	1	1	1	1	1	1	1	1
Urban	5.18 (3.81-7.03)***	1.82 (1.25-2.65)**	2.62 (1.58-4.34)***	1.57 (0.89-2.76)	4.34 (3.32-5.65)***	1.63 (1.21-2.18)**	2.14 (1.37-3.36)**	1.38 (0.82-2.32)
Province								
Mpumalanga (base)	1	1	1	1	1	1	1	1
Western Cape	11.92 (5.35-26.58)***	4.89 (1.99-12.05)**	4.41 (0.99-19.64)	2.06 (0.63-6.77)	7.34 (3.97-13.57)***	2.97 (1.26-7.03)*	4.26 (1.22-14.88)*	1.98 (0.54-7.29)
Eastern Cape	1.01 (0.67-1.52)	1.51 (0.96-12.05)**	0.47 (0.23-0.95)*	0.59 (0.30-1.14)	0.912 (0.64-1.31)	1.36 (0.92-2.02)	0.57 (0.31-1.05)	0.68 (0.38-1.23)
Northern Cape	3.33 (1.74-6.36)***	2.13 (1.03-4.43)*	1.50 (0.58-3.87)	1.14 (0.43-3.01)	2.27 (1.30-3.98)**	1.43 (0.73-2.80)	2.15 (0.91-5.10)	1.53 (0.62-3.78)
Free State	2.39 (1.33-4.28)**	1.91 (1.06-3.44)*	0.95 (0.39-2.31)	0.51 (0.20-1.30)	2.04 (1.19-3.49)*	1.64 (0.99-2.71)	1.19 (0.54-2.64)	0.74 (0.32-1.73)
Kwazulu Natal	1.80 (1.16-2.77)**	2.76 (1.79-4.26)***	0.10 (0.47-2.12)	0.96 (0.49-1.88)	1.63 (1.06-2.51)*	2.47 (1.63-3.74)***	1.16 (0.59-2.29)	1.08 (0.57-2.03)
North West	2.69 (1.38-5.25)**	2.71 (1.39-5.28)**	0.88 (0.40-1.91)	0.77 (0.37-1.61)	1.98 (1.18-3.30)*	1.89 (1.14-3.15)*	1.08 (0.51-2.26)	0.97 (0.48-1.95)
Gauteng	6.58 (3.43-12.61)***	2.54 (1.30-4.97)**	1.50 (0.59-3.86)	0.86 (0.34-2.15)	4.10 (2.42-6.96)***	1.73 (1.00-2.99)*	1.58 (0.70-3.54)	0.96 (043-2.17)
Limpopo	1.51 (0.90-2.51)	2.41 (1.30-4.97)**	1.61 (0.69-3.79)	2.09 (0.94-4.63)	0.96 (0.59-1.57)	1.45 (0.91-2.30)	2.11 (0.97-4.60)	2.61 (1.25-5.49)*
Mother's education level								
No education (base)	1	1	1	1	1	1	1	1
Primary	1.95 (1.32-2.88)**	1.75 (1.14-2.67)*	1.91 (0.71-5.10)	1.23 (0.40-3.79)	2.08 (1.53-2.84)***	1.79 (1.27-2.51)**	1.91 (0.71-5.10)	1.50 (0.53-4.24)
Secondary	6.10 (4.30-8.64)***	3.37 (2.21-5.15)***	4.31 (1.75-10.62)**	1.48 (0.47-4.60)	5.92 (4.35-8.06)***	3.18 (2.19-4.64)***	4.31 (1.75-10.62)**	1.51 (0.55-4.17)
Higher	44.35 (18.75-104.41)***	14.76 (4.33-50.25)***	25.49 (6.63-98.05)***	1.56 (0.38-6.47)	21.43 (9.88-46.50)***	4.99 (2.14-11.64)***	25.49 (6.63-98.05)***	6.49 (1.29-32.67)*
Household wealth quintile								
Quintile 1: Poorest (base)	1	1	1	1	1	1	1	1
Quintile 2: Poorer	2.09 (1.55-2.84)***	1.61 (1.17-2.21)**	2.09 (1.07-4.08)*	1.55 (0.80-2.98)	2.06 (1.55-2.73)***	1.74 (1.31-2.31)***	2.03 (1.09-3.80)*	1.51 (0.81-2.78)
Quintile 3: Middle	3.48 (2.49-4.87)***	2.12 (1.42-3.14)***	4.99 (2.44-10.22)***	3.77 (1.71-8.30)**	2.94 (2.15-4.03)***	1.96 (1.37-2.80)***	5.27 (2.48-11.20)***	4.16 (1.76-9.85)**
Quintile 4: Richer	12.30 (6.64-22.79)***	3.85 (1.97-7.55)***	5.40 (2.25-13.00)***	3.44 (1.23-9.64)*	7.87 (5.11-12.13)***	2.98 (1.81-4.90)***	2.84 (1.43-5.66)**	1.67 (0.69-3.99)
Quintile 5: Richest	27.96 (12.28-63.70)***	5.57 (1.41-21.91)*	7.03 (2.02-24.49)**	3.20 (0.71-14.49)	31.01 (14.54-66.14)***	7.75 (2.53-23.78)***	15.54 (2.82-85.78)**	5.75 (0.67-49.47
Mother's age at birth								
<20	1	1	1	1	1	1	1	1
20-34	0.65 (0.48-0.87)**	1.01 (0.66-1.54)	0.69 (0.300-1.57)	0.97 (0.35-2.70)	0.64 (0.49-0.83)**	0.96 (0.66-1.40)	0.65 (0.35-1.19)	1.20 (0.50-2.88)
35-49	0.62 (0.43-0.90)*	1.96 (1.00-3.84)*	0.38 (0.15-0.95)*	1.16 (0.33-4.08)	0.54 (0.40-0.74)***	1.64 (0.94-2.85)	0.39 (0.18-0.82)*	1.71 (0.56-5.22)
Birth order								
1st child	4.83 (3.46-6.74)***	2.64 (1.44-4.83)**	10.02 (4.25-23.61)***	7.51 (2.47-22.89)***	5.13 (3.82-6.89)***	2.71 (1.64-4.47)***	13.75 (5.92-31.96)***	14.17 (4.56-44.09)***
2-3 children	2.14 (1.55-2.94)***	1.20 (0.80-1.82)	6.20 (2.98-12.88)***	4.70 (1.92-11.47)**	2.46 (1.90-3.20)***	1.37 (0.95-1.98)	5.96 (3.00-11.88)***	5.67 (2.44-13.18)***
4-5 children	1.36 (0.98-1.89)	1.10 (0.75-1.63)	2.46 (1.04-5.85)*	2.18 (0.96-4.95)	1.54 (1.20-1.96)**	1.27 (0.95-1.69)	2.41 (1.07-5.45)*	2.49 (1.15-5.39)*
6+ children (base)	1	1	1	1	1	1	1	1

*: p<0,05 **: p<0.01 ***: p<0,001

(i) Skilled birth attendant (SBA)

Starting with ethnicity, the only statistically significant results were seen in the 1998 bivariate results, which showed that the White & Indian/Asian group had around seventeen times the odds of having a SBA and the Coloured group had almost four times the odds of having a SBA compared to the Black/African group. However, these ORs for both the White & Indian/Asian. group and the Coloured group decreased significantly in the multiple regression results. The same pattern was seen again in the 2016 results, although the ORs were quite a lot smaller.

Moving to residence, in both 1998 and 2016, the urban population have increased odds of having a SBA. The ORs were higher in the bivariate results and decreased in the multiple regression results, but both analyses showed the urban population having increased odds of having a SBA. In 1998, the urban population had 1.83 increased odds of having a SBA compared to the rural population.

In both 1998 and 2016, for bivariate and multiple regression results, the Western Cape has the highest odds of having a SBA. The 1998 multiple regression results showed Western Cape (4.89; $p<0.01$) having nearly five times the odds of having a SBA (table 8). In 1998, Mpumalanga, the base group, had the least odds of having a SBA. The multiple regression results for 1998 showed that the other provinces all had statistically significant increased odds of having a SBA compared to Mpumalanga. In 2016, the bivariate results showed that the Eastern Cape had the lowest odds of having a SBA (0.47; $p<0.01$), however the multiple regression results indicated that the Free State had the lowest odds of having a SBA (0.51; $p>0.05$), followed closely by the Eastern Cape (0.59; $p>0.05$).

In 1998, the odds of having a SBA increased significantly for each increase in education level: Primary (1.75; $p<0.05$), Secondary (3.37; $p<0.001$) and, Higher (14.76; $p<0.001$). In 2016, none of the ORs are statistically significant and all the ORs seem to have decreased dramatically compared to those seen in 1998. This may indicate a narrowing of inequality associated with SBA between women with different education levels.

A similar pattern is seen for wealth quintile, where the higher the group, the increased odds are that a women would utilise a SBA. This pattern is more profound in the 1998 data, whereas the 2016 multiple regression data shows that compared to women with no

education, all women in the higher wealth quintiles have about three times the odds of having a SBA, with the women in the second quintile having the highest odds (3.77; $p<0.01$).

(ii) Institutional delivery

Looking at ethnicity, the ORs seen in the multiple regression results are non-significant. This shows that when other explanatory and confounding variables are added to the equation, the relationship between ethnicity and institutional delivery is weak. However, both the multiple regression results and the bivariate analysis in 1998 show that the Black/African group utilised institutional delivery the least, followed by the Coloured population and the group with the highest odds of utilising institutional delivery was the White & Indian/Asian group. In 1998 the bivariate results showed that the White & Indian/Asian population had 24 times the odds of utilising institutional delivery (table 8). In 2016 the ORs were much decreased, and the bivariate results reflected a similar pattern to that seen in 1998, however when applying multiple regression, the White & Indian/Asian group has the lowest odds of utilising institutional delivery.

In 1998, the urban population had nearly twice the odds having an institutional delivery compared to the rural population when looking at the multiple regression results (table 8). In 2016, the result for multiple regression in not significant, however the OR still indicates increased utilisation of institutional delivery for the urban population.

As with SBA, some of the 1998 results for province were significant, but in 2016, none were significant. In addition, the 1998 results showed increased odds of most provinces having an institutional delivery compared to those in 2016. In 1998, as with SBA, the Western Cape had nearly three times the odds of having an institutional delivery compared to women in Mpumalanga (2.97; $p<0.05$). KwaZulu Natal followed closely behind (2.47; $p<0.001$), followed by the North West (1.89; $p<0.05$), and then Gauteng (1.73; $p<0.05$) (table 8). In 2016, most of the ORs decreased compared to those in 1998, except for Eastern Cape (0.68; $p>0.05$) and Limpopo (2.61; $p<0.05$).

In the 1998 results, there is a clear pattern seen for both education and wealth quintile, where the odds of having a SBA increase with every increase in education level or wealth quintile. The bivariate analyses show that women with higher education had 20 times the odds of

having an institutional delivery than a woman with no education (21.43, p<0.001). The multiple regression results show smaller odds ratios but are still large and significant. For instance, women with higher education in 2016 have over 6 times the odds of having an institutional delivery than a women with no education, and a woman in the highest wealth quintile also have nearly 6 times the odds of having an institutional delivery compared to the poorest women.

(iii) Overall patterns across MHS outcomes

Starting with ethnicity, none of the multiple regression results were significant except for antenatal visits. This indicates that there is no statistically significant association between ethnic group and the odds of having access to having four or more antenatal visits, an SBA, or an institutional delivery. Geographically, the results indicate that Mpumalanga, Gauteng, and the Eastern Cape have the least access to the MHS overall. As education levels increase, access to all MHS also increase. The highest ORs for both SBA and institutional delivery are seen in "education level", indicating that there are large discrepancies in access to a SBA and institutional delivery between the groups with different levels of education. Similarly, looking at wealth quintile, the results suggest that with each increase in wealth quintile, the access to all MHS also increase.

3.2. OBJECTIVE 2: ABSOLUTE AND RELATIVE INEQUALITIES OF MHS INDICATORS

This section will present the simple absolute and relative inequality measures (table 10), followed by the complex inequality measures (table 11). Across all populations and MHS, inequalities have decreased over time. The complex inequality results (table 11) mirror the simple inequality results (table 10). The numbers are not exactly the same between the simple and complex inequality results as the simple inequalities just take the extreme values into account, whereas the complex inequality measures look at the population as a whole.

Starting with simple inequality indicators (table 10), in 1998 the majority of populations saw a decrease in both absolute and relative inequalities in 2016 compared to 1998 across all MHS. There were some notably large decreases in the simple absolute and relative inequalities specifically for both SBA and institutional delivery. The only MHS where the

simple inequalities increased in 2016 was ANC4+ for ethnicity, where the simple absolute inequality was 5.9 in 1998 which means that the highest group (White & Indian/Asian) had 6 percentage point different in utilising 4+ ANC visits than the lowest group (Black/African). This then increased to 11.1 percentage points in 2016. Similarly, the relative inequality increased. In 1998, the relative ratio was 1.07, increasing to 1.14 in 2016. So, in 1998 the White & Indian/Asian population had 7% increased chance of having 4+ ANC visits, which then increased in 2016 to 14% increased chance of having 4+ ANC visits compared to the Black/African group.

Moving to complex inequality results (table 11; figure 1), a similar pattern to the simple inequality results is seen, where all of the inequalities seemed to decrease over time. The RII and SII results are also illustrated in figures 1-8, which clearly depict the decrease in both absolute and relative inequalities over time.

Starting antenatal visits, in all three populations (residence, maternal education level and household wealth quintile) the RII and SII were quite high in 1998 indicating wide inequalities within these groups. These are seen especially when looking at the very high SII results for all three populations, indicating very large absolute inequalities in utilisation of MHS in 1998. Starting with residence, there was a decrease in all inequality measures (RII, SII and CI) over time, indicating that in 1998 the MHS utilisation was much higher in urban areas, however, in 2016 MHS improved utilisation in rural areas. The decrease in inequalities may be the result increased MHS access and utilisation in the rural areas in SA but may also be attributed to decreased access and utilisation of MHS in urban areas in 2016. Residence seems to have the lowest level on inequality for antenatal visits in 2016 with an RII of nearly 1, indicating equality between the urban and rural population, the CI result which is very close to zero – also indicative of equality between the two groups (-0.003; $p>0.05$).

The pattern seen in 1998 and 2016 for mother's education level and wealth quintile are similar. The RII, SII and CI in 1998 are all large, indicating that the women with the most education and money, had more antenatal visits on average. Although these numbers all decreased significantly in 2016, they still indicate that inequality still exists within these groups. The CI results mirror these findings, where in all three groups the inequality decreases, illustrated by a lower CI. The RII for antenatal visits and wealth index was one of

the highest RIIs (1,69) in 1998, indicating that the wealthiest group (quintile 5) had nearly two times the chance having one extra antenatal visit, compared to the poorest group (quintile 1). Similarly, the SII results in 1998 are the largest for the entire analysis, showing that in 1998 there was a absolute difference of over 3 antenatal visits between the richest and poorest groups. These both decreased significantly in 2016, showing progress towards equality in ANC access and utilisation. However, the 2016 results still indicate the presence of inequality between the richest (quintile 5) and the poorest (quintile 1).

Looking at ANC4+, the inequalities are slightly smaller in 1998 compared to antenatal visits in all the groups. However, the inequalities are still higher in 1998 than they are in 2016, showing a decrease in absolute and relative inequalities over time. As seen in the objective one results, residence shows a reversal in inequality where the RII is 0.87 ($p<0.01$) in 2016 indicating that those in rural areas have about a 13% increased utilisation of ANC4+, whereas in 1998 the urban population had slightly increased (16%) utilisation of ANC4+ (1.16; $p<0.001$). All the trend results for RII, SII, and CI results show that inequalities have decreased over time and in 2016 the RII and SII results are close to 1, indicating low levels of inequality for ANC4+.

Moving to skilled birth attendant (SBA) and institutional delivery, a similar pattern is seen. In 1998 the inequalities are quite large for all groups with RII, SII and CI results. For SBA the highest inequality seen in 1998 is seen in residence with an RII of 1.43 ($p<0.001$), indicating that women in urban areas had a 43% increased chance of having a SBA compared to rural women. In 2016 this decreased to an RII of 0.75 ($p<0.001$), indicating that rural women have a 25% increased chance of having SBA compared to those living in urban areas. Wealth quintile and education level show a similar trend to antenatal visits and ANC4+, showing fairly high inequalities in 1998 and a definite decrease in 2016, where RII results are closer to 1, indicating narrowing of inequality. For instance, the CI for SBA and maternal education level in 1998 was 0.390 ($p<0.001$) which decreased to 0.192 ($p<0.001$) in 2016. The decrease in CIs to numbers closer to zero, which is seen across all MHS outcome variables for residence, wealth quintile and education level, indicates a narrowing of inequality over time. However, since all Cis (except for residence related to antenatal visits) are still above zero, they indicate that the more advantaged populations still have better MHS utilisation in 2016.

3.3. OBJECTIVE 3: CHANGES IN MHS INEQUALITIES BETWEEN 1998 AND 2016

The results for objective three are presented in table 11. All the results indicate narrowing inequalities for all MHS for each explanatory variable (table 11). The RII trend results indicate whether or not the RII decreased over time. If the RII trend is less than zero, this indicates that the relative inequality has decreased overtime. All the RII trend results how a decrease in the relative inequalities over time for all MHS.

Looking at the SII rend results, the sign in front of the number shows the direction of the inequality. A negative number indicates a narrowing or lessening of absolute inequality , whereas a positive number indicates a widening of inequality over time. The numbers refer to the absolute difference in the highest and lowest groups, over the entire population. As seen in table 11, all of the SII results are negative, indicating a reduction in absolute inequalities over time. Antenatal visits show impressive SII trend reductions, such as a 2.93 reduction in the difference of antenatal visits between the rural and urban populations and a 1.26 reduction in the difference of antenatal visits between the least and most educated.

The rest of the SII trend results, especially SBA and institutional delivery, show an absolute decrease in the absolute inequality by 20-30% for all groups.

Table 10: Simple absolute and relative inequality results for maternal healthcare services by background characteristics

	ANC Visits				ANC4+				Skilled birth attendant				Institutional delivery			
	1998 n=4122		2016 n=3036		1998 n=4122		2016 n=3036		1998 n=4992		2016 n=3572		1998 n=4992		2016 n=3572	
	Group	Result	Group	Result	Group	Result	Group	Result	Group	Result	Group	Result	Group	Result	Group	Result
Ethnicity																
Highest	White, Ind/As	9.50	White, Ind/As	6.35	White, Ind/As	87.1%	White, Ind/As	92.3%	White, Ind/As	99.0%	White, Ind/As	98.7%	White, Ind/As	99.0%	White, Ind/As	98.7%
Lowest	Black/African	5.71	Black/African	5.28	Black/African	81.2%	Black/African	81.2%	Black/African	85.8%	Black/African	96.5%	Black/African	81.1%	Black/African	95,9%
Absolute difference		*3.79*		1.07↓		*5.9%*		*11.1%*↑		13.2%		2.2%↓		17.9%		2.8%↓
Relative ratio		*1.66*		*1.20*↓		*1.07*		*1.14*↑		1.15		1.02↓		1.22		1.03↓
Residence																
Highest	Urban	6.83	Rural	5.42	Urban	85.4%	Rural	85.1%	Urban	95.4%	Urban	97.8%	Urban	92.6%	Urban	97.2%
Lowest	Rural	5.42	Urban	5.37	Rural	78.9%	Urban	80.2%	Rural	79.8%	Rural	94.6%	Rural	74.4%	Rural	94.2%
Absolute difference		*1.41*		*0.05*↓		*6.5%*		*4.9%*↓		15.6%		3.2%↓		18.2%		3%↓
Relative ratio		*1.26*		*1.01*↓		*1.08*		*1.06*↓		1.20		1.03↓		1.24		1.03↓
Province																
Highest	NC	7.50	WC	6.75	NC	87.7%	WC	92.7%	WC	97.7%	WC	99.2%	WC	95.8%	WC	98.9%
Lowest	Mpumalanga	5.30	Gauteng	4.58	North West	73.7%	Gauteng	72.1%	Mpumalanga	78.1%	EC	92.8%	EC	73.9%	EC	92.0%
Absolute difference		*2.20*		*2.16*↓		*14.0%*		*20.6%*↑		19.6%		6.4%↓		21.9%		6.9%↓
Relative ratio		*1.42*		*1.47*↑		*1.19*		*1.29*↑		1.25		1.07↓		1.30		1.08↓
Mother's education level																
Highest	Higher ed	8.29	Higher ed	6.27	Higher ed	91.1%	Higher ed	86.6%	Higher ed	98.9%	Higher ed	98.4%	Higher ed	96.9%	Higher ed	99.4%
Lowest	No Education	5.28	No Education	5.03	No Education	77.8%	No Education	83.0%	No Education	67.7%	No Education	88.5%	No education	59.5%	No education	85.9%
Absolute difference		*3.01*		*1.24* ↓		*12.3%*		*3.6*↓		31.2%		9.9%↓		37.4%		13.5%↓
Relative ratio		*1.57*		*1.25*↓		*1.17*		*1.04*↓		1.46		1.11↓		1.63		1.16↓
Household wealth quintile																
Highest	Richest	8.37	Richest	6.09	Richest	90.1%	Richest	85.0%	Richest	98.7%	Richest	99.4%	Richest	98.4%	Richest	99.4%
Lowest	Poorest	5.06	Poorest	5.04	Poorest	76.5%	Poorest	78.4%	Poorest	73.1%	Poorest	92.6%	Poorest	67.0%	Poorest	91.8%
Absolute difference		*3.31*		*1.05*↓		*13.6%*		*6.6%* ↓		25.6%		6.8%↓		31.4%		7.6%↓
Relative ratio		*1.65*		*1.21*↓		*1.18*		*1.08*↓		1.35		1.07↓		1.47		1.08↓
Mother's age at birth																
Highest	20-34	6.28	20-34	5.51	20-34	83.0%	20-34	83.0%	20-34	91.2%	20-34	97.8%	20-34	88.4%	20-34	97.5%
Lowest	<20	5.74	<20	5.02	<20	77.9%	<20	76.8%	<20	86.5%	<20	94.4%	<20	80.5%	<20	93.9%
Absolute difference		*0.54*		*0.49*↓		*5.1%*		*6.2%*↑		4.7%		3.4%↓		7.9%		3.9%↓
Relative ratio		*1.09*		*1.09*↓		*1.07*		*1.08*↑		1.05		1.04↓		1.10		1.04↓
Birth order																
Highest	1st child	6.33	1st child	5.49	2nd or 3rd child	83.4%	1st child	85.8%	1st child	94.0%	1st child	98.2%	1st child	91.5%	1st child	98.4%
Lowest	>6th child	5.22	>6th child	4.98	6th + child	78.6%	4th or 5th child	76.7%	>6th child	76.6%	>6th child	84.5%	>6th child	67.6%	>6th child	81.7%
Absolute difference		*1.11*		*0.51*↓		*4.8%*		*9.1%*↑		17.5%		13.7%↓		23.9%		16.7%↓
Relative ratio		*1.21*		*1.10*↓		*1.06*		*1.12*↑		1.23		1.16↓		1.35		1.20↓

Table 11: Relative Index of Inequality, Slope Index of Inequality, Concentration Index, and trend of maternal health services by ordinal background characteristics between 1998 and 2016

	Relative Index of Inequality (RII)		RII Trend	Slope Index of Inequality (SII)		SII Trend	Concentration Index (CI)	
	1998	**2016**		**1998**	**2016**	**1998 - 2016**	**1998**	**2016**
Antenatal visits								
Residence	1.55 (1.42-1.70)***	0.98 ↓ (0.92-1.04)	0.62 (0.54-0.71)***	2.67 (2.18-3.16)***	- 0.98 ↓ (-0.44-0.25)	-2.93 (-3.38- -2.47)***	0.069***	-0.003 ↓
Maternal education level	1.50 (1.37-1.64)***	1.25 ↓ (1.16-1.35)***	0.82 (0.69-0.98)*	2.43 (1.95-2.89)***	1.14 ↓ (0.73-1.55)***	-1.26 (-1.75- -0.76)***	0.065***	0.023*** ↓
Household wealth quintile	1.69 (1.55-1.83)***	1.23↓ (1.11-1.33)***	0.70 (0.60-0.81)***	3.18 (2.71-3.66)***	1.11 ↓ (0.62-1.60)***	-2.05 (-2.44 - -1.66)***	0.104***	0.040*** ↓
4+ ANC visits								
Residence	1.16 (1.08-1.25)***	0.87 ↓ (0.81-0.93)***	0.76 (0.67-0.85)***	0.12 (0.01-0.23)	-0.11 ↓ (-0.23-0.19)	-0.23 (-0.29- -0.16)***	0.104***	-0.077** ↓
Maternal education level	1.14 (1.07-1.19)***	1.05↓ (0.95-1.15)	0.92 (0.80-1.07)	0.12 (0.01-0.22)*	0.07 ↓ (-0.08-0.22)	-0.06 (-14- 0.09)	0.106***	0.022 ↓
Household wealth quintile	1.17 (1.11-1.24)***	1.12↓ (1.01-1.22)***	0.92 (0.82-1.04)	0.14 (0.04-0.24)**	0.09 ↓ (-0.02-0.20)	-0.07 (-0.12- -0.01)*	0.145***	0.073 ↓
Skilled birth attendant								
Residence	1.43 (1.34-1.52)***	1.07 ↓ (1.04-1.11)***	0.75 (0.70-0.81)***	0.31 (0.20-0.42)***	0.07↓ (-0.07-0.20))	-0.25 (-0.29- -0.20)***	0.358***	0.236*** ↓
Maternal education level	1.33 (1.28-1.37)***	1.05 ↓ (1.03-1.08)***	0.79 (0.76-0.83)***	0.33 (0.23-0.43)***	0.07↓ (-0.08-0.23)	-0.21 (-0.24- -0.18)***	0.390***	0.192*** ↓
Household wealth quintile	1.36 (1.30-1.41)***	1.06 ↓ (1.04-1.01)***	0.78 (0.75-0.82)***	0.32 (0.23-0.42)***	0.08 ↓ (-0.04-0.19)	-0.22 (‘-0.25-‘-0.19)***	0.474***	0.386*** ↓
Institutional delivery								
Residence	1.55 (1.43-1.69)***	1.06 ↓ (1.03-1.10)***	0.69 (0.63-0.75)***	0.37 (0.26-0.47)***	0.06 ↓ (-0.07-0.19)	-0.31 (-0.38 - -0.23)***	0.330***	0.186*** ↓
Maternal education level	1.44 (1.38-1.51)***	1.08 ↓ (1.06-1.10)***	0,17 (0.09-0.25)***	0.39 (0.30-0.49)***	0.09↓ (-0.06-0.25)***	-0.25 (-0.29- -0.021***)	0.369***	0.210*** ↓
Household wealth quintile	1.51 (1.43-1.59)***	1.08 ↓ (1.05-1.11)***	0.71 (0.67-0.76)***	0.39 (0.30-0.48)***	0.08 ↓ (-0.03-0.20)	-0.29 (-0.32 - -0.25)***	0.441***	0.354*** ↓

***: p<0,05 **: p<0.01 ***: p<0,001**

Figure 1-Figure 8: RII and SII results for antenatal visits, ANC4+, SBA and Institutional delivery, SADHS 1998 and 2016

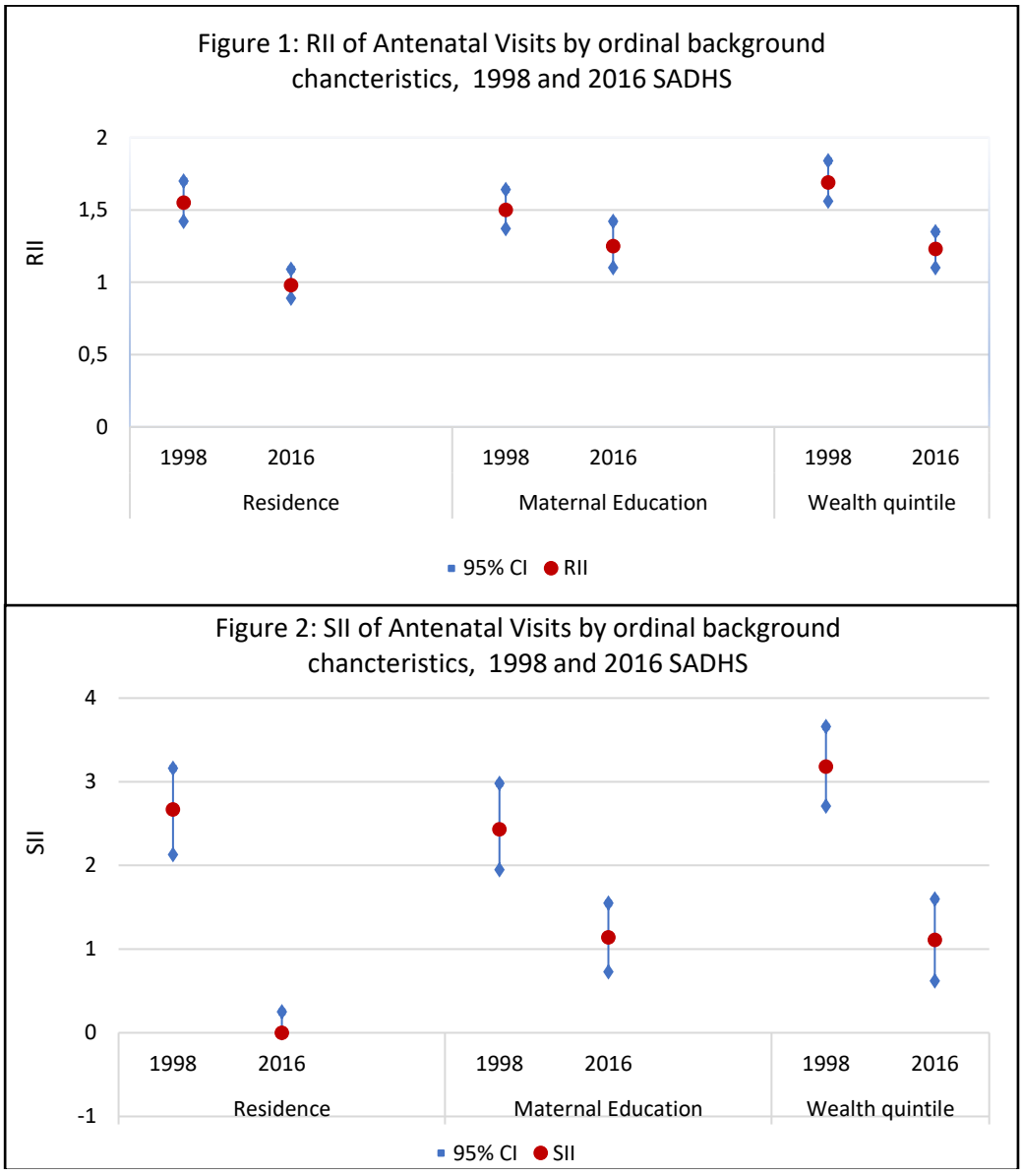


Figure 3: RII of ANC4+ by ordinal background chancteristics, 1998 and 2016 SADHS

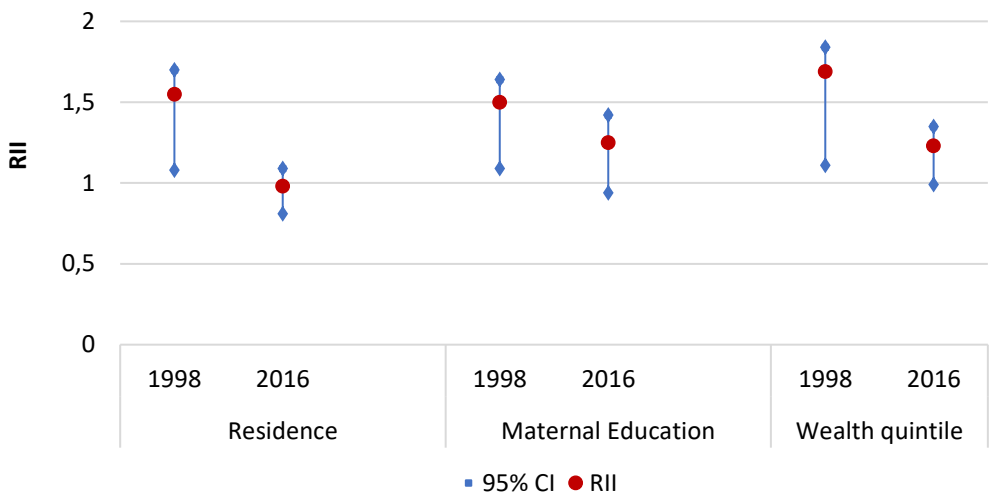


Figure 4: SII of ANC4+ by ordinal background chancteristics, 1998 and 2016 SADHS

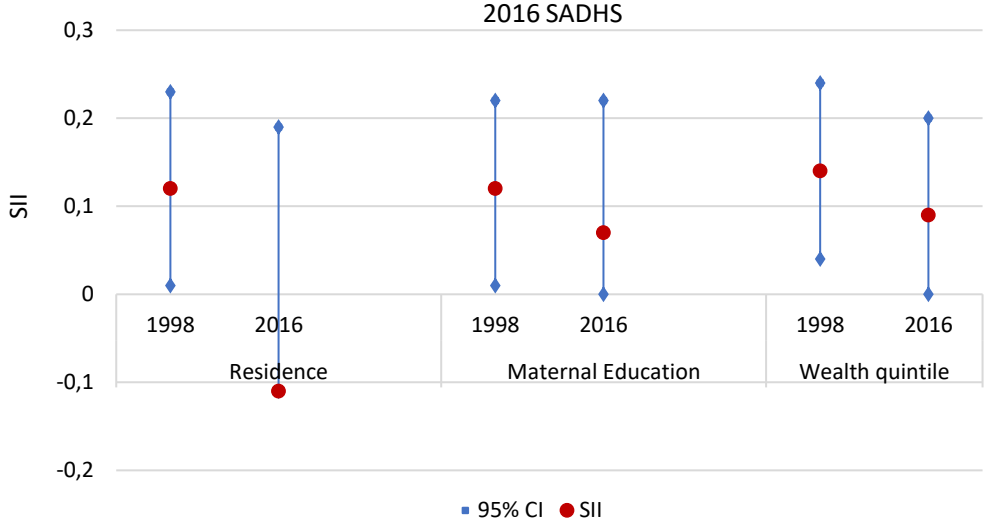


Figure 5: RII of SBA by ordinal background chancteristics, 1998 and 2016 SADHS

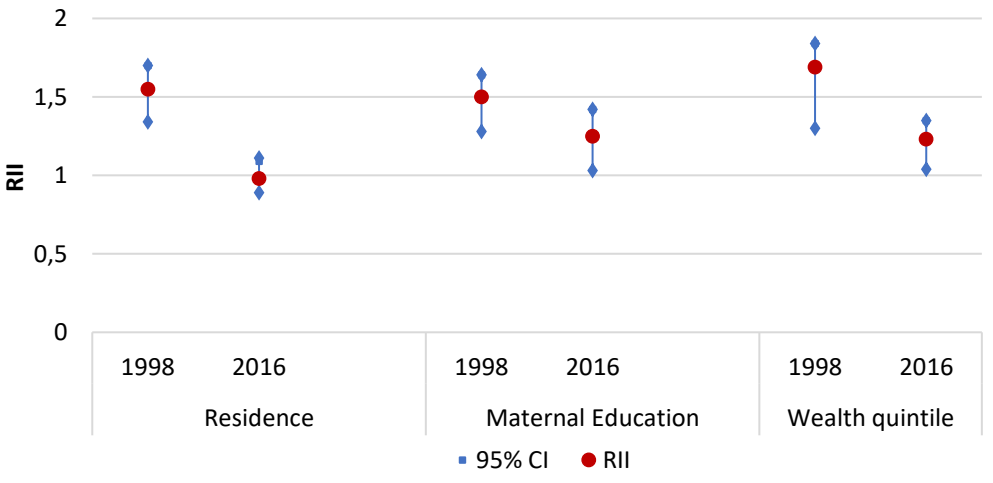


Figure 6: SII of SBA by ordinal background chancteristics, 1998 and 2016 SADHS

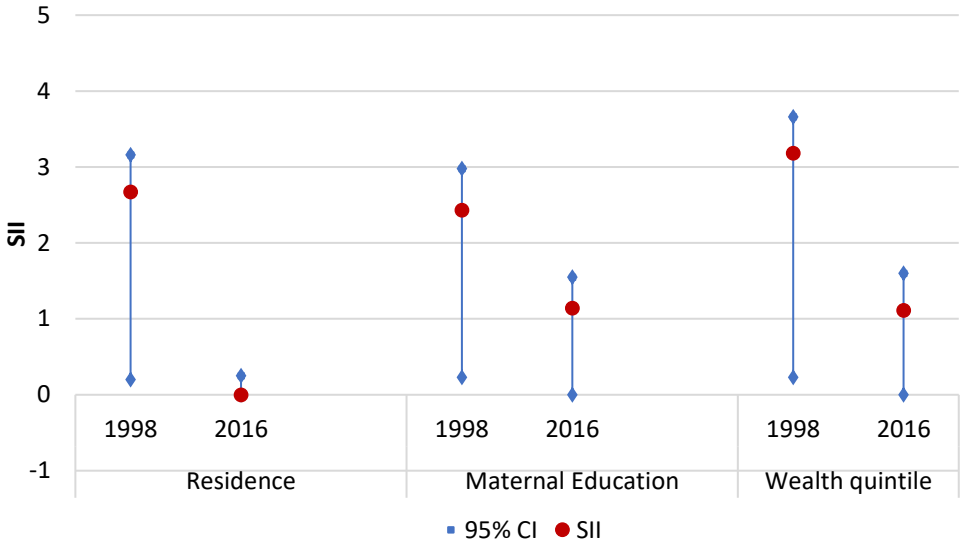


Figure 7: RII of institutional delivery by ordinal background chancteristics, 1998 and 2016 SADHS

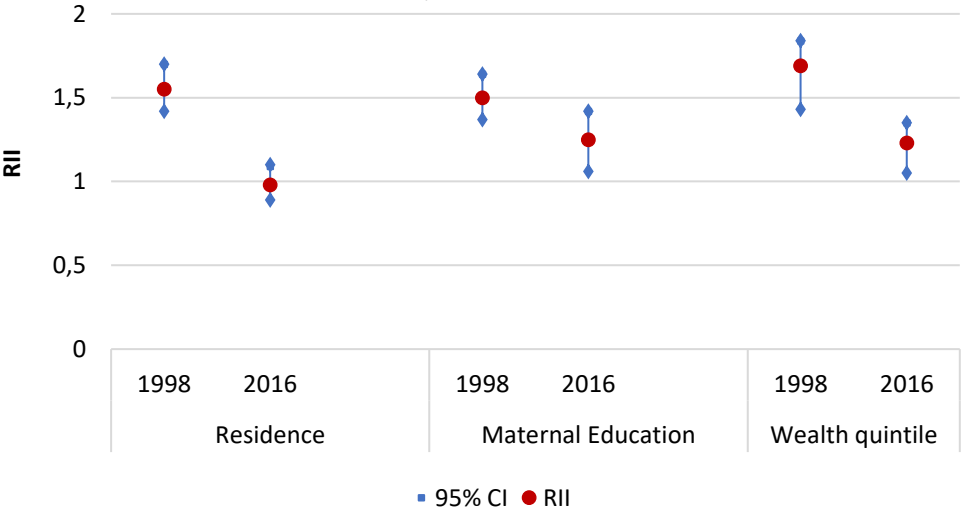
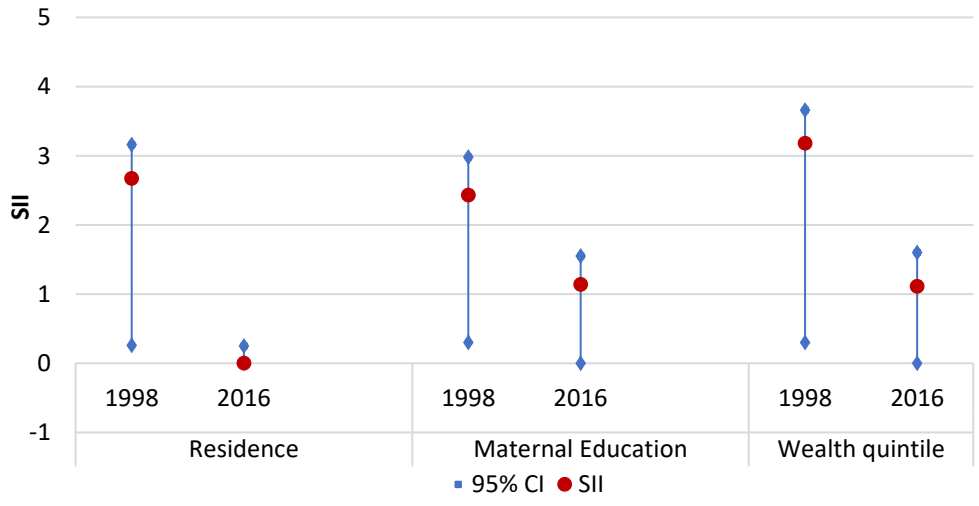


Figure 8: SII of Institutional delivery by ordinal background chancteristics, 1998 and 2016 SADHS



4. CHAPTER 4: DISCUSSION AND CONCLUSION

4.1. DISCUSSION

Inequalities related to access and utilisation of maternal healthcare in South Africa is a complex issue that is influenced by several factors such as social, economic, geographical, and cultural factors. A significant amount of maternal and infant deaths still occur in SSA despite interventions, such as antenatal care, in place to ensure a safe pregnancy for mother and child (95). One study highlighted that only 54% of pregnant women in SSA went to the recommended 4 or more ANC visits between 2011-2015 (95). This study looked at the Demographic and Health Survey (DHS) data for 36 SSA countries and found that women who do not meet the goal of going to 4 antenatal visits require roughly two more visits to reach this target. These women were concentrated among the poorer populations. Among the rich women in SSA, many exceeded 4 ANC visits by 2 visits, meaning they were getting 6+ ANC visits, while the poorer women in SSA were getting only 2 ANC visits on average (95). These disparities seemed to be due to differences in wealth, education, and area of residency, which are essentially the social determinants of health (95). Similarly, this study has also found that differences in wealth quintiles, levels of education, and residence impact access and utilisation of all MHS in SA. These social determinants of health will be described further below, with reference to the results from this study and other literature on each social determinant and how they have each been found to influence MHS access and utilisation.

First, ethnicity as a social determinant of maternal healthcare will be discussed. It is important to note that within group analyses is difficult using population data as the sample size of each group is not equal but rather representative of the South African population.

This study found that Black African women, the majority population, had the poorest utilisation to all MHS in both 1998 and 2016, even though improvement was seen. In the Apartheid era South Africa's health system was divided along racial lines with one healthcare system heavily resourced benefiting the white minority population, and another systematically under-resourced for the majority Black/African population (54,58). The results from the 1998 dataset echoes the inequalities seen soon after Apartheid ended, seeing the Black/African population severely underserved for all MHS. Although the increase in MHS coverage has improved for the

Black/African population, in 2016 they still have the lowest coverage for all MHS compared to the other ethnic groups. According to a report by the Human Rights Watch, "black women in South Africa are more likely to have limited access to maternal healthcare services and experience poorer maternal health outcomes compared to their white counterparts." (96) These disparities are attributed to the above mentioned historical inequalities and discrimination, which continue to affect access to healthcare services for black women in South Africa (54,58).

Second, residence will be discussed. This study shows that in 1998 rural women had decreased access to all MHS, however in 2016 the inequality between the rural and urban population improved. However, this improvement may not just be due to improvements in the rural regions but may be due to worsening MHS access and utilisation in urban areas. In SA, rural areas have less healthcare facilities with fewer trained staff and inadequate infrastructure and resources (33). However, some of these factors have been addressed, illustrated by the decrease in health inequalities between the urban and rural populations in 2016. The results from this study that illustrate the decreased inequalities between urban and rural populations will be outlined below. First looking at the RII trend results in table 11, all RII trends for residence for all MHS are statistically significant and are below one, indicating that the inequality over time has decreased. These results also point to the inequality that is still present in 2016 being in favour of the rural population. The SII trend results in table 11 are all statistically significant for residence and all indicate a decrease in the absolute inequality for residence over time for all MHS. The last results which indicate that inequalities have decreased for residence for all MHS are the CI results (table 11) which show CI results in 2016 which are much closer to zero than the Cis in 1998 for residence across all MHS outcome variables, showing a reduction in inequality for residence over time. The decrease in inequality may be due to the government's efforts since 1994 to improve access to PHC facilities particularly for rural populations. The public healthcare system has made it a goal to provide wider healthcare coverage through a network of community-level care services, PHC facilities and hospitals throughout SA (97).

However that is not to say that structural barriers continue to pose a barrier for rural women in SA to access MHS due to long distances to get to healthcare facilities, poor road infrastructure and networks, and poor access to transport services (98).

The next section will look at wealth and education as indicators for MHS utilisation. A systematic review (41) revealed that the utilisation of MHS in LMICs is known to be highly influenced by socioeconomic status and maternal education level (11–13,41). A similar study done in SA echoed that inequalities in MHS still exist many years after Apartheid has ended, despite the government's effort to decrease them (14). In addition, the poorest and least educated women had the least access to MHS in 1998, which improved over time, but inequalities still exist in these groups in 2016.

This study illustrates a clear example of where within-group inequalities still exist with regards to antenatal visits for both wealth quintile (RII: 1.23) and maternal education (RII: 1.25) meaning that the richest and most educated groups had about a 25% increased chance of having one extra antenatal visit than the poorest group, least educated women. These results show that in 2016, the richer, more educated women still have increased access to antenatal care, compared to the lower groups in 2016. Similarly, WHO found that the main inequalities exist between the richest and poorest, least and most educated, and between urban and rural populations (13). Initiatives aimed at addressing the inequalities between women with different education and wealth statuses need to take a progressive approach – this means that they should aim to level out the access of accessibility and quality of healthcare received by women in all groups (57).

Fortunately, when considering the 2016 results, particularly the complex inequality results and the trend analyses (table 11; fig 1-8), majority of within-group inequalities have narrowed over time. However, antenatal visits and ANC4+ see mixed results. This may indicate that prior to delivery, women experience varying access to antenatal care, but at the point of delivery, services are more readily available to all groups of women in South Africa. The average number of antenatal visits show a decrease in overall coverage for all background characteristics, and mixed results were seen for ANC4+. This decrease in coverage for an essential service such as antenatal visits need to be addressed.

Most of the results in this study indicate a narrowing of inequalities over time, however some of the simple inequality results point to an increase in inequality between provinces. For instance, in 2016, ANC 4+ shows that the Western Cape has the highest access, with Gauteng having the lowest with a large 20.6% decrease in the point difference (absolute inequality) of having 4+ ANC visits. Gauteng had the lowest coverage for antenatal visits and ANC4+. A study conducted in Gauteng

interviewed women in the labour wards post-delivery about their antenatal experience (99). Although ANC attendance was found to be high (97%), only 46% had antenatal care before 20 weeks gestation. Among those who tried to attend their first visit before the 20 week mark, a third were given a follow up date about a month later, resulting in further delay in accessing ANC. Many of the women in the study said that when they first went to the clinic, no antenatal care or screening was done, indicating poor quality of care. The study also found inadequate booking procedures and delays in diagnosing pregnancy were further reasons why women in Gauteng are not accessing ANC (99). Gauteng is not the only province of interest. The Eastern Cape had the lowest coverage for both SBA and Institutional delivery in 2016. One reason for this may be that The Eastern Cape is the plagued with corruption (44), which may be a contributing factor to these low levels of MHS coverage (14,44). A similar study looking at inequalities related to MHS in SA found that inequalities increased over time between provinces for most MHS; socio-economic status and ANC attendance; and residence and SBA (14).

Maternal deaths in SA are monitored and recorded by the National Committee on the Confidential Enquiry into Maternal Deaths (NCCEMD). The report identifies "patient-orientated factors" as contributing to 45.9% of maternal deaths. The two leading patient-orientated factors include excessive waiting times and delays when seeking a healthcare professional, and infrequent attendance of antenatal visits (33,100). Patient orientated barriers to accessing MHS also include affordability, availability, and acceptability barriers. Affordability can be measured by looking at the total costs incurred by the woman on the day of her appointment or delivery as a percentage of annual household expenditure. Acceptability can be measured qualitatively by asking patients whether they find their waiting times acceptable and/or how they feel the healthcare professionals have treated them – whether they felt heard or not. Lastly, availability can be assessed by looking at the travel time and the distance travelled to access MHS (33). These factors are important to research in order to remove the remaining barriers in the way of achieving universal healthcare. If the aim is for all women in SA to use MHS, then more needs to be done to identify and respond to these specific patient-oriented barriers. This requires improving the healthcare system and allowing it to align with the women who are using it (33).

As many of inequalities seem to have decreased over time, the next section of the discussion will outline the various reasons why the inequalities may have decreased over time. SA started

enquiring into maternal deaths in 1997, publishing the first report in 1998, followed by similar reports every three years. These reports have shown a continuous reduction in potentially preventable maternal deaths since 2008. The antiretroviral (ARV) treatment programme for HIV-positive women has contributed to a decrease in preventable maternal deaths, however, deaths due to hypertension and haemorrhage still remain high (101). The Negotiated Service Delivery Agreement (NSDA) was signed in 2010 and shows that SA is committed to reducing mortality and morbidity amongst mothers and children. The NSDA identified reductions in maternal and child mortality as important health outcomes for the South Africa to monitor and achieve (28). To further improve MHS, the NDoH has conducted programs aimed at continuously improving the knowledge and skills of healthcare professionals. The NDoH has conducted an intensive outreach in training healthcare professionals in managing obstetric emergencies which have decreased maternal deaths by nearly 30%, however the expansion of these programmes to all areas of the country still in process (102).

In SA there has also been efforts to develop strategies to improve the identification of patient/community-related factors related to maternal deaths. Strategies to decrease these issues include improving knowledge of and access to antenatal care. One successful initiative has been to expand the reach of community health workers (CHWs) in ward-based outreach teams (WBOTS) to identify and monitor pregnant women. In addition, there has been the initiation of the "MomConnect" initiative which is an antenatal messaging service. Third, maternity waiting areas have been made available in some areas for women who live far from delivery facilities (102). However, obstetric ambulance services need to be urgently expanded in order to reach rural areas as there are still reports of (28).

Further, the National Department of Health (NDoH), has increased the frequency of antenatal visits in the third trimester to fortnightly. This has been put in place in order to promptly identify women with hypertension in pregnancy and ensure that they are referred appropriately (102). The Basic Antenatal Care (BANC) approach, which was also implemented by the NDoH, aims to ensure that all women in SA receive four focussed antenatal visits. This has been shown to be as effective in achieving reduced maternal and infant mortality and seems to be an acceptable approach for the patients (28). The BANC emphasises routine ANC care and includes education of healthy behaviours surrounding such as diet, exercise, smoking, alcohol consumption and safe sex. BANC also aims to

ensure women are identified as high risk where appropriate, and then referred correctly and timeously (28).

Overall, strategies for reducing health inequalities may include reforms in the health sector to provide more equitable resource allocation, improvement in the quality of the health services offered, and possible redesigning of interventions to ensure that service delivery is equitable (103).

Unfortunately, SA is unable to quickly increase the capacity of the healthcare system and its workers, however it has been trying to redistribute and train the existing workforce to deliver better-quality care in areas where it is needed most (101). However, improvements can only be made and sustained with good monitoring and accountability infrastructure in place (101). The investments made by the NDoH in system strengthening, by providing leadership in policies and placing an emphasis on tacking health determinants such as poverty and poor education levels should allow SA to further improve access and utilisation of all MHS, and see a reduction in the MMR, IMR and NMR (101).

4.2. CONCLUSION

A continued focus on increasing MHS coverage for the underserved populations in SA is imperative. This study highlights a continued decrease in the utilisation of MHS for less educated women, and Black/African women - who make up majority of the population but have the least coverage across all MHS in 1998 and 2016. These groups need increased access and utilisation of all MHS so as to decrease the inequalities within these groups.

SA cannot just focus on increasing levels of MHS but must comprehensively address the access constraints facing women during pregnancy and delivery. From a demand perspective, “patient-oriented” barriers described above need to continue to be addressed, particularly in rural areas and for poor women, as these groups have shown an improvement in inequality levels but are not fully equal yet. On the supply side, efforts need to concentrate on improving the health system to reduce maternal deaths owing to haemorrhage and hypertension, which are a result of poor MHS (101).

The NCCEMD has shown that increased efforts to improve and increase healthcare worker training and patient education has resulted in a decrease in maternal deaths (102). However, focus needs to be put on the healthcare system to work better, especially ensuring provincial and district

governments and departments are playing their part (102). This is essential in decreasing the inequalities between provinces and different ethnicity groups.

REFERENCES

1. Girum T, Wasie A. Correlates of maternal mortality in developing countries: an ecological study in 82 countries. Matern Heal Neonatol Perinatol. 2017;3(1):1–6.
2. Miller S, Belizán JM. The true cost of maternal death: Individual tragedy impacts family, community and nations. Reprod Health [Internet]. 2015;12(1):10–3. Available from: http://dx.doi.org/10.1186/s12978-015-0046-3
3. United Nations. Millennium Development Goals - MDGs [Internet]. [cited 2023 Mar 22]. Available from: https://www.mdgmonitor.org/millennium-development-goals/
4. Alkema L, Chou D, Hogan D, Zhang S, Moller AB, Gemmill A, et al. Global, regional, and national levels and trends in maternal mortality between 1990 and 2015, with scenario-based projections to 2030: a systematic analysis by the UN Maternal Mortality Estimation Inter-Agency Group. Lancet (London, England) [Internet]. 2016 Jan 30 [cited 2023 Mar 22];387(10017):462–74. Available from: https://pubmed.ncbi.nlm.nih.gov/26584737/
5. Black R, Laxminarayan R, Temmerman M, Walker N. Disease Control Priorities, Third Edition. Dis Control Priorities, Third Ed (Volume 2) Reprod Matern Newborn, Child Heal [Internet]. 2016 Apr 6 [cited 2023 Mar 22]; Available from: http://hdl.handle.net/10986/23833
6. Dahab R, Sakellariou D. Barriers to accessing maternal care in low income countries in Africa: A systematic review. Int J Environ Res Public Health. 2020;17(12):1–17.
7. Stenberg K, Axelson H, Sheehan P, Anderson I, Gülmezoglu AM, Temmerman M, et al. Advancing social and economic development by investing in women's and children's health: a new Global Investment Framework. Lancet (London, England) [Internet]. 2014 [cited 2023 Mar 22];383(9925):1333–54. Available from: https://pubmed.ncbi.nlm.nih.gov/24263249/
8. Jamison DT, Summers LH, Alleyne G, Arrow KJ, Berkley S, Binagwaho A, et al. Global health 2035: a world converging within a generation. Lancet (London, England) [Internet]. 2013 [cited 2023 Mar 22];382(9908):1898–955. Available from: https://pubmed.ncbi.nlm.nih.gov/24309475/
9. United Nations. The Sustainable Development Goals Report 2022. United Nations. 2022;64.
10. Yaya S, Uthman OA, Amouzou A, Ekholuenetale M, Bishwajit G. Inequalities in maternal health care utilization in Benin: a population based cross-sectional study. BMC Pregnancy Childbirth 2018 181 [Internet]. 2018 May 31 [cited 2021 Aug 23];18(1):1–9. Available from: https://bmcpregnancychildbirth.biomedcentral.com/articles/10.1186/s12884-018-1846-6
11. Yaya S, Bishwajit G, Shah V. Wealth, education and urban-rural inequality and maternal healthcare service usage in Malawi. BMJ Glob Heal. 2016;1(2):1–12.
12. Finlayson K, Downe S. Why Do Women Not Use Antenatal Services in Low- and Middle-Income Countries? A Meta-Synthesis of Qualitative Studies. PLOS Med [Internet]. 2013 Jan [cited 2021 Oct 21];10(1):e1001373. Available from: https://journals.plos.org/plosmedicine/article?id=10.1371/journal.pmed.1001373
13. World Health Organization. State of Inequallty: Reproductive, maternal, newborn and child health. 2015.
14. Wabiri N, Chersich M, Shisana O, Blaauw D, Rees H, Dwane N. Growing inequities in maternal health in South Africa: A comparison of serial national household surveys. BMC Pregnancy Childbirth [Internet]. 2016;16(1). Available from: http://dx.doi.org/10.1186/s12884-016-1048-z
15. Statistics South Africa (Stats SA), National Department of Health (NDoH), South African Medical Research Council (SAMRC), ICF. South Africa Demographic and Health Survey 2016: Key Indicator Report [Internet]. Statistics South Africa. Pretoria; 2017. Available from: https://www.statssa.gov.za/publications/Report 03-00-09/Report 03-00-092016.pdf
16. National Department of Health. South African Demographic and Health Survey. Stat South Africa [Internet]. 2003;(November):1–57. Available from: https://www.statssa.gov.za/publications/Report 03-00-09/Report 03-00-092016.pdf%0Ahttp://www.ncbi.nlm.nih.gov/pubmed/25340318
17. Nwosu CO, Ataguba JE. Socioeconomic inequalities in maternal health service utilisation: a case of

antenatal care in Nigeria using a decomposition approach. BMC Public Heal 2019 191 [Internet]. 2019 Nov 8 [cited 2021 Aug 23];19(1):1–11. Available from: https://bmcpublichealth.biomedcentral.com/articles/10.1186/s12889-019-7840-8
18. Pallikadavath S, Foss M, Stones RW. Antenatal care: Provision and inequality in rural north India. Soc Sci Med. 2004 Sep;59(6):1147–58.
19. Shibre G, Mekonnen W. Socio-economic inequalities in ANC attendance among mothers who gave birth in the past 12 months in Debre Brehan town and surrounding rural areas, North East Ethiopia: A community-based survey. Reprod Health. 2019;16(1).
20. Kyei-Nimakoh M, Carolan-Olah M, McCann T V. Access barriers to obstetric care at health facilities in sub-Saharan Africa—a systematic review. Syst Rev 2017 61 [Internet]. 2017 Jun 6 [cited 2023 Mar 22];6(1):1–16. Available from: https://systematicreviewsjournal.biomedcentral.com/articles/10.1186/s13643-017-0503-x
21. Say L, Chou D, Gemmill A, Tunçalp Ö, Moller AB, Daniels J, et al. Global causes of maternal death: a WHO systematic analysis. Lancet Glob Heal [Internet]. 2014 [cited 2023 Mar 22];2(6). Available from: https://pubmed.ncbi.nlm.nih.gov/25103301/
22. Bomela NJ. Maternal mortality by socio-demographic characteristics and cause of death in South Africa: 2007-2015. BMC Public Health. 2020;20(1):1–20.
23. Beeckman K, Louckx F, Downe S, Putman K. The relationship between antenatal care and preterm birth: the importance of content of care. Eur J Public Health [Internet]. 2013 Jun 1 [cited 2021 Oct 22];23(3):366–71. Available from: https://academic.oup.com/eurpub/article/23/3/366/541649
24. World Health Organization. COUNTDOWN TO 2015 DECADE REPORT (2000-2010) Taking stock of maternal, newborn and child survival [Internet]. 2010. Available from: http://scholar.google.com/scholar?hl=en&btnG=Search&q=intitle:Countdown+to+2015+Decade+report+(+2000+–+2010+)#7%5Cnhttp://scholar.google.com/scholar?hl=en&btnG=Search&q=intitle:Countdown+to+2015+Decade+Report+(2000-2010)%233
25. Department of Health, Measure DHS+, MRC South Africa. South Africa Demographic and Health Survey 1998: Full Report. 1998.
26. National Department of Health, Statistics South Africa (Stats SA), South African Medical Research Council (SAMRC), ICF. South Africa Demographic and Health Survey 2016: Key findings [Internet]. NDoH, Stats SA, SAMRC, and ICF. 2018. Available from: http://documents1.worldbank.org/curated/en/688761571934946384/pdf/Doing-Business-2020-Comparing-Business-Regulation-in-190-Economies.pdf
27. Adegoke A, Broek N van den. Skilled birth attendance-lessons learnt. BJOG An Int J Obstet Gynaecol [Internet]. 2009 Oct [cited 2021 Oct 23];116(SUPPL. 1):33–40. Available from: https://onlinelibrary.wiley.com/doi/full/10.1111/j.1471-0528.2009.02336.x
28. South African National Department of Health. Strategic Plan for Maternal, Newborn, Child and Women's Health (MNCWH) and Nutrition in South Africa 2012-2016. 2012.
29. World Health Organization. WHO recommendations on antenatal care for a positive pregnancy experience [Internet]. Geneva; 2016 [cited 2021 Oct 22]. Available from: https://www.who.int/publications/i/item/9789241549912
30. World Health Organization. World Health Statistics 2015: Indicator compendium. 2015.
31. Kyei NNA, Chansa C, Gabrysch S. Quality of antenatal care in Zambia: a national assessment. BMC Pregnancy Childbirth 2012 121 [Internet]. 2012 Dec 13 [cited 2021 Oct 22];12(1):1–11. Available from: https://bmcpregnancychildbirth.biomedcentral.com/articles/10.1186/1471-2393-12-151
32. Wabiri N, Chersich M, Zuma K, Blaauw D, Goudge J, Dwane N. Equity in Maternal Health in South Africa: Analysis of Health Service Access and Health Status in a National Household Survey. PLoS One. 2013;8(9).
33. Silal SP, Penn-Kekana L, Harris B, Birch S, McIntyre D. Exploring inequalities in access to and use of

maternal health services in South Africa. BMC Health Serv Res. 2012;12(1).
34. Harvey SA, Blandón YCW, McCaw-Binns A, Sandino I, Urbina L, Rodríguez C, et al. Are skilled birth attendants really skilled? A measurement method, some disturbing results and a potential way forward. Bull World Health Organ. 2007;85(10):783–90.
35. World Health Organization, ICM, FIGO. Making pregnancy safer: the critical role of the skilled attendant. Vol. 76. Geneva, Switzerland; 2004.
36. AbouZahr C, Wardlaw T. Maternal mortality at the end of a decade: signs of progress? Bull World Health Organ [Internet]. 2001 [cited 2021 Oct 24];79(6):561–73. Available from: www.who.int/bulletin
37. World Health Organization. Fact sheet: Newborn mortality [Internet]. 2021. Available from: https://www.who.int/news-room/fact-sheets/detail/levels-and-trends-in-child-mortality-report-2021
38. World Health Organization. Fact sheet: Maternal mortality [Internet]. 2021. Available from: https://www.who.int/news-room/fact-sheets/detail/maternal-mortality
39. Global Health Europe. Global Health Europe: A Platform for European Engagement in Global Health. 2009 [cited 2021 May 9]. Inequity and Inequality in Health. Available from: https://globalhealtheurope.org/values/inequity-and-inequality-in-health/
40. Braveman P, Gruskin S. Defining equity in health. J Epidemiol Community Health. 2003;57(4):254–8.
41. Say L, Raine R. A systematic review of inequalities in the use of maternal health care in developing countries: examining the scale of the problem and the importance of context Public health reviews. Bull World Health Organ [Internet]. 2007 [cited 2021 Aug 12];85(10). Available from: http://www.who.
42. Booysen F le R. Urban-rural inequalities in health care delivery in South Africa. Dev South Afr. 2003;20(5):659–73.
43. Holmberg S, Rothstein B. Dying of corruption. Health Econ Policy Law. 2011;6(4):529–47.
44. Corruption Watch. Corruption Watch. 2012 [cited 2021 Sep 24]. The sickness in E Cape health department. Available from: https://www.corruptionwatch.org.za/the-sickness-in-e-cape-health-department/
45. Ngomane S, Mulaudzi FM. Indigenous beliefs and practices that influence the delayed attendance of antenatal clinics by women in the Bohlabelo district in Limpopo, South Africa. Midwifery. 2012 Feb 1;28(1):30–8.
46. Marmot M, Allen J, Goldblatt P, Boyce T, McDeish D, Grady M, et al. Fair society, healthy lives: Strategic review of health inequalities in England post-2010. . 2010.
47. Geyer S, Hemström Ö, Peter R, Vågerö D. Education, income, and occupational class cannot be used interchangeably in social epidemiology. Empirical evidence against a common practice. J Epidemiol Community Heal [Internet]. 2006 Sep 1 [cited 2023 Mar 16];60(9):804–10. Available from: https://jech.bmj.com/content/60/9/804
48. Hosseinpoor AR, Bergen N, Schlotheuber A, Grove J. Measuring health inequalities in the context of sustainable development goals. Bull World Health Organ. 2018;96(9):654–9.
49. Tugwell P, Petticrew M, Kristjansson E, Welch V, Ueffing E, Waters E, et al. Assessing equity in systematic reviews: realising the recommendations of the Commission on Social Determinants of Health. BMJ [Internet]. 2010 Sep 13 [cited 2022 Feb 22];341(7778):873–7. Available from: https://www.bmj.com/content/341/bmj.c4739
50. O'Neill J, Tabish H, Welch V, Petticrew M, Pottie K, Clarke M, et al. Applying an equity lens to interventions: using PROGRESS ensures consideration of socially stratifying factors to illuminate inequities in health. J Clin Epidemiol [Internet]. 2014 Jan 1 [cited 2022 Feb 22];67(1):56–64. Available from: http://www.jclinepi.com/article/S089543561300334X/fulltext
51. Statistics South Africa (Stats SA). South Africa Demographic and Health Survey (SADHS) [Internet]. [cited 2021 Sep 8]. Available from: http://www.statssa.gov.za/?page_id=6634

52. National Department of Health. South Africa demographic and health survey 1998 - preliminary report. Dep Heal [Internet]. 1998; Available from: http://www.mrc.ac.za/bod/dhsfin1.pdf
53. National Department of Health (NDoH). Guidelines for Maternity Care in South Africa: A manual for clinics, community health centres and district hospitals. 2016.
54. Omotoso KO, Koch SF. Assessing changes in social determinants of health inequalities in South Africa : a decomposition analysis. Int J Equity Health [Internet]. 2018 [cited 2021 Apr 13];17:181. Available from: https://doi.org/10.1186/s12939-018-0885-y
55. Whitehead M. A typology of actions to tackle social inequalities in health. J Epidemiol Community Health [Internet]. 2007 Jun [cited 2023 Jan 4];61(6):473. Available from: /pmc/articles/PMC2465710/
56. Arcaya MC, Arcaya AL, Subramanian S V. Inequalities in health: definitions, concepts, and theories. Rev Panam Salud Publica. 2015;38(4):261–71.
57. Graham H, Kelly MP. Health inequalities: concepts, frameworks and policy. NHS, Heal Dev Agency. 2004;1–12.
58. 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. Lancet [Internet]. 2009;374(9692):817–34. Available from: http://dx.doi.org/10.1016/S0140-6736(09)60951-X
59. Statistics South Africa (Stats SA). Data Quality Report: South Africa Demographic and Health Survey 2016. 2016.
60. Flanagin A, Frey T, Christiansen SL. Updated Guidance on the Reporting of Race and Ethnicity in Medical and Science Journals. JAMA - J Am Med Assoc. 2021;326(7):621–7.
61. Powe NR. Black Kidney Function Matters: Use or Misuse of Race? JAMA [Internet]. 2020 Aug 25 [cited 2023 Sep 1];324(8):737–8. Available from: https://jamanetwork.com/journals/jama/fullarticle/2769035
62. Neal RE, Morse M. Racial health inequities and clinical algorithms a time for action. Clin J Am Soc Nephrol [Internet]. 2021 Jul 1 [cited 2023 Sep 1];16(7):1120–1. Available from: https://journals.lww.com/cjasn/fulltext/2021/07000/racial_health_inequities_and_clinical_algorithms_.23.aspx
63. Ataguba JE, Akazili J, McIntyre D. Socioeconomic-related health inequality in South Africa: Evidence from General Household Surveys. Int J Equity Health [Internet]. 2011 Nov 10 [cited 2020 Jun 26];10(1):48. Available from: http://equityhealthj.biomedcentral.com/articles/10.1186/1475-9276-10-48
64. Sanders D, Chopra M. Key Challenges to Achieving Health for All in an Inequitable Society: The Case of South Africa. https://doi.org/102105/AJPH2005062679 [Internet]. 2011 Oct 10 [cited 2021 Aug 23];96(1):73–8. Available from: http://ajph.aphapublications.org/
65. World Health Organization. Health Equity Monitor [Internet]. 2021 [cited 2021 Apr 30]. Available from: https://www.who.int/data/gho/health-equity
66. Khang YH, Yun SC, Lynch JW. Monitoring trends in socioeconomic health inequalities: it matters how you measure. BMC Public Heal 2008 81 [Internet]. 2008 Feb 20 [cited 2021 Aug 23];8(1):1–6. Available from: https://link.springer.com/articles/10.1186/1471-2458-8-66
67. USAID, The Demographic and Health Surveys (DHS) Program. The Demographic and Health Surveys (DHS) Program [Internet]. [cited 2021 Oct 20]. Available from: https://dhsprogram.com/
68. The DHS program, USAID. The DHS Program [Internet]. [cited 2021 Sep 8]. Available from: https://www.dhsprogram.com/Data/
69. USAID. The DHS Program - Available Datasets [Internet]. [cited 2021 May 9]. Available from: https://dhsprogram.com/data/available-datasets.cfm
70. National Department of Health, South African Medical Research Council (SAMRC). South Africa demographic and health survey 1998 - preliminary report. Dep Heal [Internet]. 2015; Available from: http://www.mrc.ac.za/bod/dhsfin1.pdf

71. The DHS Program - South Africa: Standard DHS, 2016 Dataset [Internet]. [cited 2020 Jul 5]. Available from: https://www.dhsprogram.com/data/dataset/South-Africa_Standard-DHS_2016.cfm
72. Houweling TAJ, Kunst AE, Huisman M, Mackenbach JP. Using relative and absolute measures for monitoring health inequalities: Experiences from cross-national analyses on maternal and child health. Int J Equity Health [Internet]. 2007 Oct 29 [cited 2022 Sep 1];6(1):1–9. Available from: https://equityhealthj.biomedcentral.com/articles/10.1186/1475-9276-6-15
73. Gwatkin DR, Rutstein S, Johnson K, Suliman E, Wagstaff A, Amouzou A. Socio-economic differences in health, nutrition, and population within developing countries: an overview. Niger J Clin Pract. 2007;10(4):272–82.
74. Filmer D, Pritchett LH. Estimating wealth effects without expenditure data--or tears: an application to educational enrollments in states of India. Demography [Internet]. 2001 Feb 1 [cited 2022 Nov 9];38(1):115–32. Available from: https://pubmed.ncbi.nlm.nih.gov/11227840/
75. Houweling TA, Kunst AE, Mackenbach JP. Measuring health inequality among children in developing countries: does the choice of the indicator of economic status matter? Int J Equity Heal 2003 21 [Internet]. 2003 Oct 9 [cited 2022 Nov 9];2(1):1–12. Available from: https://equityhealthj.biomedcentral.com/articles/10.1186/1475-9276-2-8
76. Bollen KA, Glanville JL, Stecklov G. Economic status proxies in studies of fertility in developing countries: Does the measure matter? https://doi.org/101080/00324720213796 [Internet]. 2010 [cited 2022 Nov 9];56(1):81–96. Available from: https://www.tandfonline.com/doi/abs/10.1080/00324720213796
77. Joshi C, Torvaldsen S, Hodgson R, Hayen A. Factors associated with the use and quality of antenatal care in Nepal: a population-based study using the demographic and health survey data. BMC Pregnancy Childbirth [Internet]. 2014 Mar 3 [cited 2021 Oct 22];14(1). Available from: https://pubmed.ncbi.nlm.nih.gov/24589139/
78. Magadi MA, Agwanda AO, Obare FO. A comparative analysis of the use of maternal health services between teenagers and older mothers in sub-Saharan Africa: Evidence from Demographic and Health Surveys (DHS). Soc Sci Med. 2007 Mar;64(6):1311–25.
79. Schober P, Vetter TR. Count Data in Medical Research: Poisson Regression and Negative Binomial Regression. Anesth Analg. 2021;132(5):1378–9.
80. Carr-hill R, Chalmers-dixon P. The Public Health Observatory Handbook of Health Inequalities Measurement. 2005. 197 p.
81. World Health Organization. Handbook on Health Inequality Monitoring: With a Special Focus on Low- and Middle-Income Countries [Internet]. 2013 [cited 2021 Sep 24]. Available from: https://books.google.co.za/books?id=GLIXDAAAQBAJ&printsec=frontcover&source=gbs_ge_summary_r&cad=0#v=onepage&q&f=false
82. Moreno-Betancur M, Latouche A, Menvielle G, Kunst AE, Rey G. Relative Index of Inequality and Slope Index of Inequality. Epidemiology [Internet]. 2015 Jul 4 [cited 2021 Apr 16];26(4):518–27. Available from: http://journals.lww.com/00001648-201507000-00012
83. Bambra C. Health inequalities and welfare state regimes: theoretical insights on a public health 'puzzle.' J Epidemiol Community Heal [Internet]. 2011 Sep 1 [cited 2021 Aug 23];65(9):740–5. Available from: https://jech.bmj.com/content/65/9/740
84. Mackenbach JP, Kunst AE. Measuring the magnitude of socio-economic inequalities in health: An overview of available measures illustrated with two examples from Europe. Soc Sci Med. 1997 Mar 1;44(6):757–71.
85. Wagstaff A, Paci P, van Doorslaer E. On the measurement of inequalities in health. Soc Sci Med. 1991 Jan 1;33(5):545–57.
86. Wagstaff A. Socioeconomic inequalities in child mortality : comparisons across nine developing countries. 2000;19–29.
87. Barros AJ, Hirakata VN. Alternatives for logistic regression in cross-sectional studies: an empirical

comparison of models that directly estimate the prevalence ratio. BMC Med Res Methodol 2003 31 [Internet]. 2003 Oct 20 [cited 2021 Oct 24];3(1):1–13. Available from: https://bmcmedresmethodol.biomedcentral.com/articles/10.1186/1471-2288-3-21
88. Spiegelman D, Hertzmark E. Easy SAS Calculations for Risk or Prevalence Ratios and Differences. Am J Epidemiol [Internet]. 2005 Aug 1 [cited 2021 Aug 23];162(3):199–200. Available from: https://academic.oup.com/aje/article/162/3/199/171116
89. Sergeant JC, Firth D. Relative index of inequality: definition, estimation, and inference. Biostatistics [Internet]. 2006 Apr 1 [cited 2022 Feb 22];7(2):213–24. Available from: https://academic.oup.com/biostatistics/article/7/2/213/238694
90. Ataguba JE. A short note revisiting the concentration index: Does the normalization of the concentration index matter? Heal Econ (United Kingdom). 2022;31(7):1506–12.
91. O'Donnell O, van Doorslaer E, Wagstaff A, Lindelow M. The Concentration Index. In: Analyzing Health Equity Using Household Survey Data: A Guide to Techniques and Their Implementation: A Guide to Techniques and Their Implementation. 2008. p. 95–108.
92. Wagstaff A. The bounds of the concentration index when the variable of interest is binary, with an application to immunization inequality. Health Econ [Internet]. 2005 Apr 1 [cited 2021 Nov 13];14(4):429–32. Available from: https://onlinelibrary.wiley.com/doi/full/10.1002/hec.953
93. Ataguba JEO, Alaba O. Explaining health inequalities in South Africa: A political economy perspective. http://dx.doi.org/101080/0376835X2012730962 [Internet]. 2012 Dec [cited 2021 Aug 23];29(5):756–64. Available from: https://www.tandfonline.com/doi/abs/10.1080/0376835X.2012.730962
94. Ernstsen L, Strand BH, Nilsen SM, Espnes GA, Krokstad S. Trends in absolute and relative educational inequalities in four modifiable ischaemic heart disease risk factors: Repeated cross-sectional surveys from the Nord-Trøndelag Health Study (HUNT) 1984-2008. BMC Public Health [Internet]. 2012;12(1):1. Available from: http://www.biomedcentral.com/1471-2458/12/1471-2458-12-266
95. Obse AG, Ataguba JE. Explaining socioeconomic disparities and gaps in the use of antenatal care services in 36 countries in sub-Saharan Africa. Health Policy Plan. 2021;36(5):651–61.
96. Van Den Broek NR, Graham WJ. "Stop Making Excuses." Hum Rights Watch [Internet]. 2011 Oct [cited 2023 Mar 16];116(SUPPL. 1):18–21. Available from: https://www.hrw.org/report/2011/08/08/stop-making-excuses/accountability-maternal-health-care-south-africa
97. Gaede B, Versteeg M. The State of the Right to Health in Rural South Africa. South African Heal Rev. 2011;99–106.
98. SANAC. Let Our Actions Count South Africa ' S National Strategic Plan for. 2017;(March). Available from: http://sanac.org.za/2017/05/11/download-the-full-version-of-the-national-strategic-plan-for-hiv-tb-and-stis-2017-2022/
99. Solarin I, Black V. "They told me to come back": Women's antenatal care booking experience in inner-city johannesburg. Matern Child Health J [Internet]. 2013 Feb 19 [cited 2023 Jan 4];17(2):359–67. Available from: https://link.springer.com/article/10.1007/s10995-012-1019-6
100. NCCMD. Saving Mothers 2005-2007 : Fourth report on confidential enquiries into maternal deaths in South Africa. 2009.
101. Rhoda NR, Velaphi S, Gebhardt GS, Kauchali S, P Barron. Reducing neonatal deaths in South Africa: Progress and challenges. South African Med J. 2018;108(3):S9–16.
102. Moodley J, Fawcus S, Pattinson R. Improvements in maternal mortality in South Africa. SAMJ Res. 2018;3(March):1–5.
103. Mwageni E, Masanja H, Juma Z, Momburi D, Mkilindi Y, Mbuya C, et al. Socio-economic status and health inequalities in Rural Tanzania: Evidence from the rufiji demographic surveillance system. Meas Heal Equity Small Areas Find from Demogr Surveill Syst. 2018;19–32.

104. StataCorp LLC. Stata Functions Reference Manual. Stata Press. 2021. 175 p.
105. Erreygers G. Correcting the Concentration Index. J Health Econ. 2009 Mar 1;28(2):504–15.
106. Kakwani N, Wagstaff A, Van Doorslaer E. Socioeconomic inequalities in health: Measurement, computation, and statistical inference. J Econom. 1997 Mar 1;77(1):87–103.

APPENDIX A: PLAGARISM DECLARATION

PLAGIARISM DECLARATION TO BE SIGNED BY ALL HIGHER DEGREE STUDENTS

SENATE PLAGIARISM POLICY

I Celeste Claire Holden (Student number: 707526) am a student registered for the degree of Master of Public Health in the academic year 2022/3 .

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: 32/3.2023



APPENDIX B: ETHICS WAIVER CERTIFICATE

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)

Human Research Ethics Committee (Medical)

Research Office Secretariat:
Faculty of Health Sciences, Phillip Tobias Health Sciences Building, 3rd Floor, Office 301/2/4, 29 Princess of Wales Terrace, Parktown, 2193
Private Bag 3, Wits 2050
Office email: HREC-Medical.ResearchOffice@wits.ac.za
Website: www.wits.ac.za/research/about-our-research/ethics-and-research-integrity/

Ref: W-CBP-220124-01 24/01/2022

TO WHOM IT MAY CONCERN:

Waiver:	This certifies that the following research does not require clearance from the Human Research Ethics Committee (Medical)
Investigator:	Miss Celeste Holden
Supervisor:	Dr Duane Blaauw
Department:	Public Health
Project title:	Comparing health inequalities in maternal health: An analysis of the South African Demographic and Health Surveys (SADHS) 1998 and 2016
Reason:	Review of information in the public domain. No human participants will be involved in the study.

CB Penny

Dr CB Penny

Chairperson: Human Research Ethics Committee (Medical)

Copy – HREC (Medical) Secretariat: Ms Zanele Ndlovu, Ms Mapula Ramaila and Mr Rhulani Mkansi

APPENDIX C: TURNITIN REPORT SIGNED

C HOLDEN 707526 RR .pdf

ORIGINALITY REPORT

16%	13%	11%	7%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	Submitted to University of Witwatersrand Student Paper	3%
2	www.ncbi.nlm.nih.gov Internet Source	1%
3	dhsprogram.com Internet Source	1%
4	samj.org.za Internet Source	1%
5	link.springer.com Internet Source	<1%
6	wiredspace.wits.ac.za Internet Source	<1%
7	theses.gla.ac.uk Internet Source	<1%
8	www.ajol.info Internet Source	<1%
9	core.ac.uk Internet Source	<1%

APPENDIX D: TURNITIN MOTIVATION FROM SUPERVISOR

The Centre for Health Policy
Health Policy and Systems Research

UNIVERSITY OF THE WITWATERSRAND JOHANNESBURG

31 March 2023

Celeste Holden Turnitin Report

This is to confirm that I have checked the detailed Turnitin report for Celeste Holden's MPH research report, and can confirm that the high similarity index of 16% does not constitute plagiarism. A significant proportion of the similarity is from her previously submitted protocol.

Yours sincerely



Dr Duane Blaauw, Supervisor

APPENDIX E: RII AND SII STATA COMMANDS (OBJECTIVE 2)

In STATA, RII and SII were both calculated using genialised linear models (glms) using the options to differentiate the calculations. The model is defined using the "family" and "link" options. The family option refers to the distribution of the dependant/outcome variable as so the binary variables had "binary" as their family, and the continuous variable (antenatal visits) had "Poisson" as its family. The link function for RII is 'log' and for SII is 'identity' (94).

Looking at RII for the three binary MHS outcome variables (SBA, Institutional delivery, and 4+ ANC), the family Is 'binary' as the outcome variables are binary, and the link function is 'log', so for example if we are finding out the RII for SBA (sba) and the wealth quintile (the ridit variable of wealth index: rwlthind5), the command in STATA would look like this:

RII: *glm sba rwlthindex [pw=wgt], fam(bin) link (log) eform*

The SII was similar, although the link function was identity, and there would be no 'eform' as SII does not require the log of the answer. The command line would be:

SII: glm sba rwlthind5 [pw=wgt], fam(bin) link (identity)

However, for the variable number of antenatal visits (ancvis), the family and link functions changes as this is a numeric variable unlike the other three categorical, binary outcome variables which all followed the same coding as above.

RII: glm ancvis rwlthind5 [pw=wgt], fam(poisson) link(log)

SII: glm ancvis rwlthind5 [pw=wgt], fam(poisson) link(identity)

Where 'glm' specifies generalised linear model; 'ancvis' is the outcome variable is number of antenatal visits; '[pw=wgt]' specifies the weighting which has already been inputted, since *svy* cannot be used; family refers to the distribution of the outcome variable and in this case is specified as poisson and the link function is specfied as 'log' for RII and 'identity' for SII. These are informed by Ernsten et al. 2012 (94) and edited to suite each example based of the explanatory and outcome variable types by using the STATA manual (104).

APPENDIX F: CONCENTRATION INDEX (CI) STATA COMMANDS (OBJECTIVE 2)

The Stata *conindex* command was used to calculate the CI for each outcome variable for the categorical exposure variables. Stata command *conindex* provides point estimates and standard errors of a range of concentration indices and also graphs concentration curves (and Lorenz curves)(91). The option "Wagstaff" is used in conjunction with the conindex command as it then computes the normalised concentration indices for bounded variables (92,105). In the same example, a CI value of 1 or higher indicates that health (e.g. the percentage of women who have visited ANC services) is concentrated amongst the disadvantaged; zero representing total equality and a CI of less than 1 indicates health concentrated among the advantaged population (106). Bounded limits then need to be defined, which refer to the number of available categories of the outcome variable, so for the three binary variables the bounded limits would be 0-1 and for number of antenatal visits, the bounded limits would be 0-30. In STATA, the command to calculate the concentration index for SBA (sba) and wealth quintile (wlthind5) would look like this:

conindex sba, rankvar(wlthind5) bounded limits(0 1) wagstaff svy

APPENDIX F: TREND ANALYSIS STATA COMMANDS (OBJECTIVE 3)

In STATA, glms were also used to compute the trend analyses. First the 1998 and 2016 datasets had to be merged and then the analyses could take place. Second, interaction terms had to be created using the ridit explanatory variables and the year variable. Third, glms were used to compute the trend for SII and RII values. Examples of glm command lines for SBA and wealth quintile:

RII:

svy: glm sbabinary rwlthind5 wlthXyear, fam(bin) link(log) eform search

SII:

Svy: glm sbabinary rwlthind5 wlthXyear, fam(poisson) link(indentity) irls

Where 'svy' specifies survey weighting; 'glm' specifies we are doing a general linear model; 'rwlthind5' is the ridit variable from the original wealth quintile variable; 'wlthXyear' is the interaction term created; 'fam' refers to the family of the outcome variable which is binary in the case of the binary outcome variable SBA (in this case); and the 'link' function is then specified as log; "irls" and "search" are used at the end to assist in convergence. "eform" was used only in RII glm calculations in order to get the log of the number as the answer. These are informed by Ernsten et al. 2012 (94) and edited to suite each example based of the explanatory and outcome variable types by using the STATA manual (104)