Student number: 1280445

University of the Witwatersrand, Johannesburg

FACULTY OF HEALTH SCIENCES

SCHOOL OF PUBLIC HEALTH

Trends of syphilis screening among South African pregnant women (aged 15 – 49 years) in 2017.

Lucky Thembha Chauke

1280445

A research report submitted to the University of the Witwatersrand, Faculty of Health Sciences in partial fulfilment of the requirements for the degree of Master of Science in Epidemiology in the field of Infectious Disease Epidemiology.

November 2022

Declaration

I, **Lucky Thembha Chauke**, thus certify that this research report is my original work. I am submitting this work in partial fulfilment of the degree of Master of Science in Epidemiology (Infectious Disease Epidemiology) at the University of the Witwatersrand, Johannesburg. This research report has never been submitted to another university or for a different examination.

10th November 2022

Dedication

I dedicate my research report to God's glory, who made it possible for me to be part of this program at the prestigious University of the Witwatersrand. I also dedicate this work to the memory of my late mother, Mjaji Chauke, who supported me through thick and thin till her last breath. May her soul rest in peace.

Acknowledgments

I acknowledge and thank the intense contributions, guidance, and support offered by my dedicated supervisor, Dr. Tendesayi Kufa-Chakezha, from the University of Witwatersrand, School of Public Health, Department of Epidemiology and Biostatistics.

Table of Contents

List of figures

List of Tables

List of abbreviations

AIDS	Acquired Immunodeficiency Syndrome
ANC	Antenatal Care
ANCHSS	The Antenatal HIV sentinel survey
ART	Antiretroviral Therapy
CI	Confidence Interval
DHIS	District Health Information System
HIV	Human Immunodeficiency Virus
MTCT	Mother-to-child Transmission
NDoH	National Department of Health
NHLS	National Health Laboratory Service
NICD	National Institute for Communicable Diseases
OR	Odds Ratio
RPR	Rapid Plasma Regain
SDG	Sustainable Development Goals
UAT	Unlinked Anonymous Testing
UNAIDS	The Joint United Nations Programme on HIV/AIDS
USA	United States of America
WHO	World Health Organization

CHAPTER 1. INTRODUCTION

In this chapter, a discussion of the global, African, and South African coverage of maternal syphilis screening is outlined. Furthermore, a discussion of the literature on maternal syphilis prevalence, syphilis screening coverage in pregnancy, maternal syphilis in Africa, and syphilis screening and associated factors will be presented.

1.1. Background

Syphilis is an infection by a pathogen called Treponema pallidum that is transmitted sexually (1). Sexual contact with an infected person results in the transmission of the infection from one person to another. Sexual activity that can transmit syphilis includes anal, oral, and/or vaginal sex. The syphilis infection is spread through direct exposure during sexual intercourse with an infected person who has a syphilitic sore known as a chancre (1). People with syphilis infection may develop the chancre, which can also appear in the mouth or around the external genitalia, penis, anus, rectum, vagina, or on the penis (1). During pregnancy or delivery, syphilis can also spread to the unborn child (1).

Syphilis in pregnancy is known as maternal syphilis. Maternal syphilis can be transmitted to the fetus from an infected pregnant woman during the term of the pregnancy via the placenta and during birth through the infant's contact with active syphilis lesions in the birth canal (2). Pregnant women who are in the early stages of infection with syphilis have a high probability of transmission (2). Untreated maternal syphilis can cause spontaneous miscarriages, stillbirths, early neonatal deaths, intrauterine growth restriction, and perinatal deaths (2). Syphilis infection in infants can be asymptomatic and can result in complications if left untreated (2, 3). Syphilis also has consequences for infants born infected. These infants may develop skin rashes, severe anemia, enlarged liver and spleen, jaundice, nerve issues that may result in blindness or hearing impairment, meningitis, and bone damage (3).

Based on 2016 global estimates reported by the World Health Organization (WHO), syphilis is thought to infect 2 million pregnant women annually, with 1.2 million of those infections leading to transmission from mother to child (3). The WHO estimates that

syphilis infections in women who were not screened for syphilis and were not treated during their pregnancy are thought to be responsible for over 0.5 million occurrences of negative pregnancy outcomes globally in 2016. These include, among others, stillbirths, congenital syphilis, preterm babies, and neonatal deaths (3).

To eradicate congenital syphilis, the WHO launched a global initiative in 2007 that addressed issues such as: accessible, affordable, and high-quality maternal and neonatal health services; global syphilis screening of all pregnant women; treatment of pregnant women with syphilis as well as partner treatment; appropriate monitoring and evaluation of syphilis screening and treatment progress; and unwavering advocacy and country-wide political commitment (5). To further cascade the elimination of mother-to-child transmission of syphilis, HIV, and hepatitis B in 2014, WHO published recommendations with objectives that nations had to fulfill (4). The cascade is designed to achieve 95% success in the following objectives: antenatal care for pregnant women, syphilis screening of pregnant women attending ANC, and appropriate syphilis treatment for pregnant women who test positive (4).

In 2016, attributable to syphilis infection were over 300,000 fetal and neonatal deaths, coupled with early-risk deaths among infants increasing to 215,000 (14). The 2021 WHO priority goal is to reduce syphilis incidence by 90% globally, aiming for a decrease in syphilis transmissions from pregnant women to unborn babies through the implementation of early diagnosis of syphilis through screening and early initiation of treatment for pregnant women, and reducing the incidence of congenital syphilis to under 50 infections per 100,000 live infant births (4). To estimate and monitor progress on maternal syphilis screening and coverage, South Africa has since 1990 conducted annual antenatal HIV sentinel surveys until 2015, and biennially since 2015 till to date (24).

As an essential step to preventing perinatal transmission and improving treatment outcomes of syphilis in pregnancy, WHO recommends the importance of early diagnosis and detection of syphilis in pregnant women using routine syphilis screening during antenatal care appointments as an entry point (7). The main strategies for the prevention and eradication of congenital syphilis are centered on improving the quality of antenatal care services offered to all pregnant women, which should include access

to ANC services, screening for syphilis, administration of treatment for pregnant women that test syphilis positive, and follow-up care (7, 8). In developing countries, syphilis is still a major problem for public health. The aim of this study was to investigate the coverage of maternal syphilis screening and factors associated with not screening for syphilis among pregnant women during antenatal care in South Africa.

1.2. Literature review

A literature review was undertaken to examine studies of maternal syphilis. During the literature review, several themes emerged from the searches and are described below. These themes include: 1.2.1. Prevalence of maternal syphilis 1.2.2 Syphilis screening coverage in pregnancy 1.2.3 Maternal syphilis in Africa, and 1.2.4 Syphilis screening and associated factors.

1.2.1. Maternal syphilis prevalence

South African pregnant women suffer from poor birth outcomes related to syphilis and HIV infections. The critical cause of perinatal morbidity and mortality is maternal syphilis. The 2015 national surveys of South Africa estimated the prevalence of maternal syphilis at 1.5% nationally (24). A 2021 study by Hoque and colleagues finds that maternal syphilis prevalence was high among women at antenatal booking, at 3.8% (6). In their study, Hoque and colleagues concluded that there was an association between the increase of maternal syphilis and HIV infections among pregnant women.

In a congenital syphilis case surveillance conducted in South Africa from 2017 to 2019, congenital syphilis case notifications were 418 during the period from 80 facilities in 35 out of 52 districts (9). It was further discovered that the majority of the congenital syphilis cases found were from KwaZulu-Natal (52.9%) and Gauteng (28%) provinces (9). A report done by the National Institute of Communicable Diseases in South Africa showed an increase in the number of case notifications of congenital syphilis, reported at 794 for the period 2017–2020 (36).

A study discovered a decline in the global maternal and congenital syphilis burden in a comparison of estimates between 2008 and 2012 (10). It was found that there was a 38% decline in maternal syphilis prevalence, with global maternal syphilis decreasing by 560,458 cases between 2008 and 2012, respectively (10). Furthermore, congenital syphilis prevalence declined by 39%, seeing a decrease of 225,869 cases in the same period (10). The same study found that 84.6% of syphilis-positive pregnant women went to antenatal care at least once in 2012 (10). The study further looked at maternal syphilis infections by regions. Africa had the largest proportion of maternal syphilis infections, accounting for 63.1% of all maternal infections globally (585,664) and having a prevalence of 1.68 percent (10). It has been established that the increase in maternal syphilis infections was related to poor availability of screening services or availability of syphilis treatment for pregnant women, especially in developing countries (10).

In a study carried out in developing regions of Asia and Latin America (11), it was established that antenatal syphilis screening was cost-effective in reducing syphilis prevalence and increasing maternal syphilis coverage. Syphilis prevalence among pregnant women significantly decreased between 1940 and 1990, according to a systematic review study published in 2016 that looked at epidemiological trends in the disease. This was attributed to the use of penicillin as a therapy (12).

1.2.2. Syphilis screening coverage in pregnancy

WHO provides guidance on managing sexually transmitted illnesses worldwide (10). These include syphilis testing and providing suitable care to pregnant women who have the infection to prevent adverse effects on the unborn child and fetus (9). With limited resources and funding, regular screening of syphilis continues to be difficult in many developing countries. When it comes to routine syphilis screening, Africa faces a significant challenge because funds are allocated to more pressing activities such as HIV and TB (11).

Studies conducted in Africa showed that there was poor maternal syphilis screening coverage in rural areas compared to urban areas (13, 18). Challenges faced by African rural areas are related to poor infrastructure, poor access to health care facilities, poor program activity integration, and lack of patient information on syphilis screening and

treatment history, which lead to poor routine syphilis screening, treatment, and follow-up care (13, 18).

In a study conducted in Papua New Guinea (15), screening of pregnant women during their antenatal visits proved to have a positive outcome for pregnant women, with early treatment and prevention of infection for the fetus (12, 13). The findings in Papua New Guinea were concordant with findings in the study in Ethiopia (14, 16). It was established that the persistence of syphilis in pregnant women was caused by syphilis and HIV coinfections as well as healthcare related challenges like shortage of resources for syphilis testing and poor or lack of antenatal care attendance by pregnant women (15, 16).

To monitor the impact of the implementation of interventions to improve reproductive, adolescent, maternal, and neonatal health, academics from international, regional, and national institutions, UN agencies, civil society organizations, and the World Bank joined forces to launch Countdown 2030. (19). In a 2020 study that aimed to evaluate the performance of countdown 2030 countries, it was reported that of the 81 countries included in the study, only 53 countries (65%) reported their maternal syphilis screening coverage, while 41 countries (51%) reported treatment coverage between 2016 and 2017, respectively (19). A total of 103,648 adverse birth outcomes are predicted to have occurred between 2016 and 2017 in the 81 countries due to gaps in syphilis screening and treatment services, with 41,856 of those adverse birth outcomes occurring as stillbirths among pregnant women attending antenatal care (19).

1.2.3. Maternal syphilis in Africa

According to data from WHO reports on the global syphilis burden, the prevalence of syphilis proved to be high on the African continent (7, 10). Reports on sexual transmitted infections in pregnant women showed that the region of Southern Africa carries the highest burden of syphilis prevalence rate of 6.5% among pregnant women when compared to other African regions, with East Africa at 4.6% and West Africa at 4.0% (17, 18). These results were contrasted with those of other research, which found that the prevalence rate of women infected with syphilis during their pregnancy was

somewhat higher than that of the general population; that it was 4.5% in sub-Saharan Africa, 3.9% in Southern and East Africa, and 3.5% in West and Central Africa (18).

In South Africa, the overall syphilis prevalence in all women 15 – 49 years enrolled in the 2015 ANC HIV survey was 2% (21). The lowest rate of syphilis among women who had used ANC services was 1.6% (95% CI: 1.3% - 2.0%) for pregnant women aged between 15 and 19 years old. For pregnant women aged 20 to 24, 25 to 29, 30 to 34, and 35 to 39, the prevalence of syphilis was about 2%. Pregnant women aged 40 to 44 had the highest reported syphilis prevalence, at 3.2% (95% CI: 2.1% - 4.7%) (21).

Furthermore, findings in the surveys done in 2011 and 2015 showed a provincial increase in syphilis prevalence among pregnant women who attended antenatal care clinic visits (21). Pregnant women with HIV coinfection had the highest syphilis burden among pregnant women in the Northern Cape, KwaZulu-Natal, Limpopo, Mpumalanga, and Free States provinces (21). The results of the surveys revealed that inadequate facility access and late antenatal clinic visits by pregnant women in South Africa were a barrier to early diagnosis and treatment of pregnant women with syphilis infections during their pregnancy (21).

1.2.4. Syphilis screening and associated factors

According to most of the literature reviewed, a lack of or poor routine syphilis screening has negative and adverse effects on pregnant women and anyone else (19, 20). In a study conducted in Rwanda, it was discovered that poor access to public health care, poor infrastructure, shortage of health care personnel and diagnostic tools were the main factors that led to poor syphilis screening of pregnant women, where a proportion of women were even found to have delivered their babies at home without even a single antenatal visit (20).

In another study in Africa, challenges with syphilis screening emanated from pregnant women not being screened during their first antenatal visit, a lack or delay in attending antenatal visits by pregnant women, and a shortage of medical personnel to render antenatal care (4). Another clustered randomized controlled study in Mongolia found that pregnant women who received on-site screening through point of care testing had

a lower incidence of congenital syphilis, were more likely to be screened during the first and third trimesters and received adequate syphilis and partner treatment (17).

In a 2015 case-control study in Ghana, some factors were shown to be related to pregnant women not having their syphilis screening done during antenatal care (22). Failure to screen for syphilis during antenatal care has been linked to pregnant women seeking antenatal care in a private health facility, previous unsuccessful pregnancies, and not getting screened or tested for HIV during the current pregnancy (22). It was also discovered that, in contrast to pregnant women who were attending private health facilities, all pregnant women who visited antenatal care in public facilities received a comprehensive care package inclusive of syphilis screening and treatment (22).

In a 2020 study conducted in Lusaka, Zambia, additional factors preventing pregnant women from receiving syphilis screenings were examined (23). According to the study's conclusions, the main cause for pregnant women getting syphilis tests was patient-related factors. These factors, including pregnant women's marital status and educational attainment, were found to be the main reasons why syphilis screening was not conducted during the first antenatal care visit (23).

1.3. Problem statement

In South Africa, an antenatal HIV seroprevalence survey was conducted across all nine provinces in 2017 (24). This survey collected data on whether enrolled pregnant women had been screened for syphilis using the onsite rapid test and laboratory syphilis testing and reported on overall coverage of testing nationally and by province (24). However, the geospatial, individual, and facility level factors associated with RPR syphilis screening during the first antenatal care visit by pregnant women were not determined during the 2017 antenatal HIV sentinel survey and have not been determined previously (20).

By 2030, the Sustainable Development Goals (SDG) seek to reduce unnecessary new-born and under-five child mortality as well as advance universal access to sexual and reproductive health care (35). Each nation must put into practice maternal syphilis screening as one of the measures to help achieve the SDGs. The national goals for

maternal syphilis screening in South Africa are set at 95%, and it must be ensured that 95% of those who test positive are treated (24).Without determining the geospatial distribution of maternal syphilis screening, the maternal syphilis screening coverage and the factors associated with not screening for syphilis among pregnant women at the provincial and district level, it is not easy for South Africa to reach the 95% syphilis screening targets recommended by WHO towards the goal of syphilis elimination in pregnant women.

1.4. Justification

WHO (10) and SDG (35) established recommendations to support testing and treatment for syphilis among pregnant women throughout their pregnancy term to improve positive pregnancy outcomes and promote maternal and child health. To promptly diagnose and treat syphilis at an early stage of pregnancy, it is required that all pregnant women have a syphilis screening during their first antenatal appointment (10). This study seeks to identify gaps in maternal syphilis testing coverage and screening of pregnant women during their first antenatal visits in public health facilities in South Africa and to propose recommendations for improving maternal syphilis testing and treatment coverage and prevention.

1.5. Research questions

- Did South Africa reach its targeted maternal syphilis screening coverage in 2017?
- What was the 2017 geospatial distribution of maternal syphilis screening coverage in South Africa?
- What individual and population-level factors were associated with not being screened for syphilis in pregnancy?

1.6. Aim

This study aimed to investigate the factors associated with screening for syphilis among pregnant women during antenatal care.

1.7. Objectives

- To assess trends in maternal syphilis screening coverage in South Africa, 2017.
- To determine the 2017 geospatial distribution of maternal syphilis screening coverage in South Africa.
- To determine the 2017 individual and population-level factors associated with not being screened for syphilis in pregnancy in South Africa.

CHAPTER 2. METHODOLOGY

In this chapter, the methods used in this study are described. The chapter presents details of the study design, study setting, and study population. It also provides details on the measured outcome variable, exposure variables, and the data analysis techniques used in this study.

2.1. Study design

The data from the 2017 ANCHSS was used in this study as a secondary data analysis. The primary study involved data collection on HIV and syphilis screening of all pregnant women aged 15–49 years attending public facilities for any antenatal care service during their current pregnancy in South Africa.

2.2. Study Setting

The South African National Department of Health has conducted antenatal surveys for syphilis and HIV every year since 1990. The survey's objective is to provide data over time for epidemiological estimates at the national, provincial, and district levels as well as extrapolation of HIV infections for future projections, informing the planning, implementation, and impact assessment of initiatives for the disease and infection control and prevention of syphilis and HIV/AIDS (24).

The survey's objectives included estimating the distribution of HIV in each district; trends in HIV prevalence at the provincial and national levels; performance on the 90-90-90 Joint United Nations Programme on HIV/AIDS (UNAIDS) indicators; and the uptake of syphilis services based on a review of medical records. Thirty-two thousand seven hundred sixteen (32,716) pregnant women from 1,595 South African public health facilities made up the nationally representative sample for the 2017 antenatal HIV sentinel survey (ANCHSS), whose clinical files were examined and whose blood samples were taken, and testing and screening were conducted (24).

2.3. Description of the primary study

The primary data accessed for this research report was from the linked-anonymous national antenatal HIV seroprevalence survey of 2017. The survey enrolled pregnant women between the ages of 15 – 49 years who visited public health facilities for any antenatal care during the current pregnancy.

2.3.1. Study population and sampling

From 1,595 South African public health facilities, 32,716 pregnant women between the ages of 15 – 49 years participated in the primary study. All 52 districts and the country's nine provinces (the Eastern Cape, Free State, Gauteng, KwaZulu-Natal, Limpopo, Mpumalanga, North West, and Western Cape) were represented by participants.

The survey's sample size was calculated to yield an estimate of the point prevalence of HIV at the district level with a margin of error of 3–5%. Pregnant women were enrolled in the survey using a facility-level consecutive sampling method. A probability proportional to size sampling technique was used to select sentinel sites within each stratum. In this secondary study, secondary data analysis of survey data was performed using a sample of pregnant women who had survey results on maternal syphilis screening during the 2017 antenatal HIV sentinel survey, the survey reported a national maternal syphilis screening coverage of 96.7% in 2017 (24). The secondary data analysis did not include any pregnant women from the 2017 antenatal HIV sentinel survey with missing data on maternal syphilis screening.

2.3.2. Data collection procedures for primary study

The survey was conducted from October 1st through the second week of November 2017. The survey involved a brief interview, a review of medical records, and the collection of blood samples by regular antenatal care nurses. Age, race, education level, marital status, gravidity, parity, type of antenatal visit, and gestational age were the demographic data that were gathered. To estimate the HIV status knowledge, ART coverage, and syphilis screening, the following information was gathered: the frequency of routine HIV testing; the results of routine HIV testing; the frequency of

antiretroviral treatment (ART) use; the length of time since ART initiation; the frequency of ART use in the previous three days; and the frequency of routine syphilis testing.

Each participant provided a blood sample (5 ml), which was then sent to the appropriate National Institute for Communicable Diseases (NICD) and National Health Laboratory Service (NHLS) laboratories for HIV testing. The remaining blood was transferred to the NICD's HIV reference laboratory to conduct tests for recent HIV infection, viral load, and exposure to antiretroviral (ARV) drugs.

2.3.3. Data management procedures for the primary study

A data collection form was used during the survey, which was printed in two copies (one original and one carbon copy), one of which was handed to the data clerk to enter immediately on the antenatal survey web-based DHIS Patient module, while the other was forwarded to the serology laboratory with the specimen (24). Data from the primary study was downloaded from web-DHIS and TrakCare and was stored on a secure server at NICD on password-protected computers with restricted access and with online protection for viruses. During data collection, access to data (i.e., web-DHIS, TrakCare, and downloaded data) was restricted to appropriate surveillance staff, and data training and confidentiality were conducted with the staff. Ownership of the data and provision of data storage, security, and confidentiality were both the NICD responsibilities on behalf of the NDoH.

2.4. Inclusion and exclusion criteria for current study

Inclusion criteria

All consenting pregnant women between the ages of 15 – 49 years who visited an antenatal clinic for the first time or for follow-up visits throughout their current pregnancy were included in the survey for the main study. All pregnant women between the ages of 15 – 49 years who took part in the ANCHSS in 2017 and for whom data on syphilis screening was available were included in the secondary analysis study.

Exclusion criteria

During the primary survey, to avoid duplicate sampling, pregnant women who had previously attended the clinic while the survey was being conducted were excluded. Women who were pregnant and younger than 14 years or older than 50 years were excluded. In the current study, participants who had missing data on syphilis screening were also excluded.

2.5. Description of outcome and exposure variables

2.5.1. Outcome/dependent variable

The outcome variable in this study was maternal syphilis screening. Maternal syphilis screening was classified as "Yes" if it was documented, or "No" and was determined from medical record review of the pregnant woman. The results of the maternal syphilis screening from the RPR test would either be reactive, which is classified in this study as having tested positive for syphilis, or non-reactive, which is classified in this study as having tested negative for syphilis.

2.5.2. Description of variables in this study

Variables	Description and categories
Geographical location	For this variable, facilities were categorized into three categories: "rural", "urban" or "peri-urban".
Type of antenatal visit	This is a categorical variable, measured in the number of clinic visits during the pregnancy term. "First visit" or "follow-up".
Age	Age in this study is a numerical, continuous variable, measured in years. Age groups were generated: 15 – 24 years, 25 – 34 years, and >35years.
Race	This is a categorical and nominal variable; race was classified into two categories: black/African and non-black.
Level of education	This is a categorical and nominal variable, categorized into three categories: “None – Primary”, “Secondary”, and “Tertiary”.
Marital status	Marital status was categorized into three categories: "Single", "Married/living with partner" and "Divorced, Widowed, separated".
Parity	Parity is a numerical and continuous variable, measured in the number of pregnancies carried to viable gestational term. Two categories were generated, "none" and "one or more".
Gravidity	This is a numerical and continuous variable, measured in the number of pregnancies. Two categories were generated; "one" and "more than one".
Gestational age	This is a numerical and continuous variable, measured in weeks. Three categories were generated: first trimester, second trimester, and third trimester.
HIV and ART status	Both HIV and ART status are binary variables. Subsequently, three variables (HIV negative, HIV positive – on ART, and HIV positive – ART not started/unknown) were used to generate a combined outcome variable "HIV & ART status". The variables were categorized as; HIV status (negative or positive), ART ("yes," "no,” and "unknown").

Table 1: *List of baseline socio-demographic and clinical characteristics of participants and their categories*.

2.6. Statistical analysis

2.6.1. Data management

The National Institute for Communicable Diseases (NICD) provided data for this study in Stata® format (Stata Corp, California, USA). The process of data cleaning involved

extracting the study age-group (15 – 49 years) from the dataset and dropping all variables that were not needed for this study's objective. Some of the variables had to be generated and others had to be recoded to do the analysis.

2.6.2. Descriptive statistics

Data cleaning and exploratory analyses were conducted; testing for underlying assumptions was also done. Continuous variables were tested for normality using Shapiro – Wilk test, and when data did not follow a normal distribution, they were presented as median and interquartile range. To ensure external validity and to control for bias, differences between the excluded and included participants were examined using the Pearson chi-squared test.

In this current secondary data analysis, descriptive analysis was weighted to ensure that the study sample is representative of the country's antenatal care attendance. A median and interquartile range were used to present characteristics for continuous variables, whereas frequencies were used to report characteristics for categorical variables. A Pearson chi-squared test was performed to test for an association between different categorical variables and the outcome variable. To present the findings, tables and graphs were used.

2.6.3. Inferential statistics

To account for the study design of the ANCHSS, survey-weighted data analysis was used in all models discussed below. Clustering at the facility level (primary sample unit) and stratification by district were both considered in the weighted analysis.

The association between syphilis screening and explanatory variables was explored using logistic regression. Univariable logistic regression was performed on all explanatory variables listed in section 2.5 against the outcome variable of syphilis screening. Following the univariable analysis, an automatic stepwise regression with forward selection was used for the selection of variables. The probability of entry into the model was set at p-value ≤ 0.2. Age, gravidity, parity, gestational age, HIV and

ART status were variables used in the selection step along with the type of antenatal visit, which was marginally significant in the univariable model. Interaction terms were tested using the adjusted Wald test. All regression analyses were done in a survey mode. A multivariable logistic regression model was fitted as the final model using the selected variables, and the results are presented and subsequently discussed.

2.6.4. Geospatial analysis

The trends of syphilis screening among participants based on their district and province of enrolment were analysed using Arc GIS 10.5.1 (Esri products, California, USA) to generate the thematic maps. Raster spatial data was used to create shape files and maps. The national and district percentages of pregnant women not screened for syphilis were analysed.

2.7. Ethical consideration

The Human Research Ethics Committee (HREC) at the University of the Witwatersrand provided ethical permission for the study, and the ethics waiver certificate is displayed in the list of appendices with protocol number M200339.

CHAPTER 3. RESULTS

The results of the study are presented in this chapter. It contains tables, graphs, and thematic maps, all of which present study participants' characteristics, maternal syphilis screening coverage in South Africa, the 2017 geospatial distribution of the maternal syphilis screening coverage, and the individual and population-level factors associated with not being screened for syphilis in pregnancy. The sequence in which the results are presented in this chapter corresponds to the study objectives.

3.1. Description of study participants

The study population of the participants who were a part of this research is shown in Figure 1 below. The primary study included 32,716 pregnant women from 1,595 South African public health facilities, ranging in age from 15 to 49 years. All nine of South Africa's provinces were represented by participants.

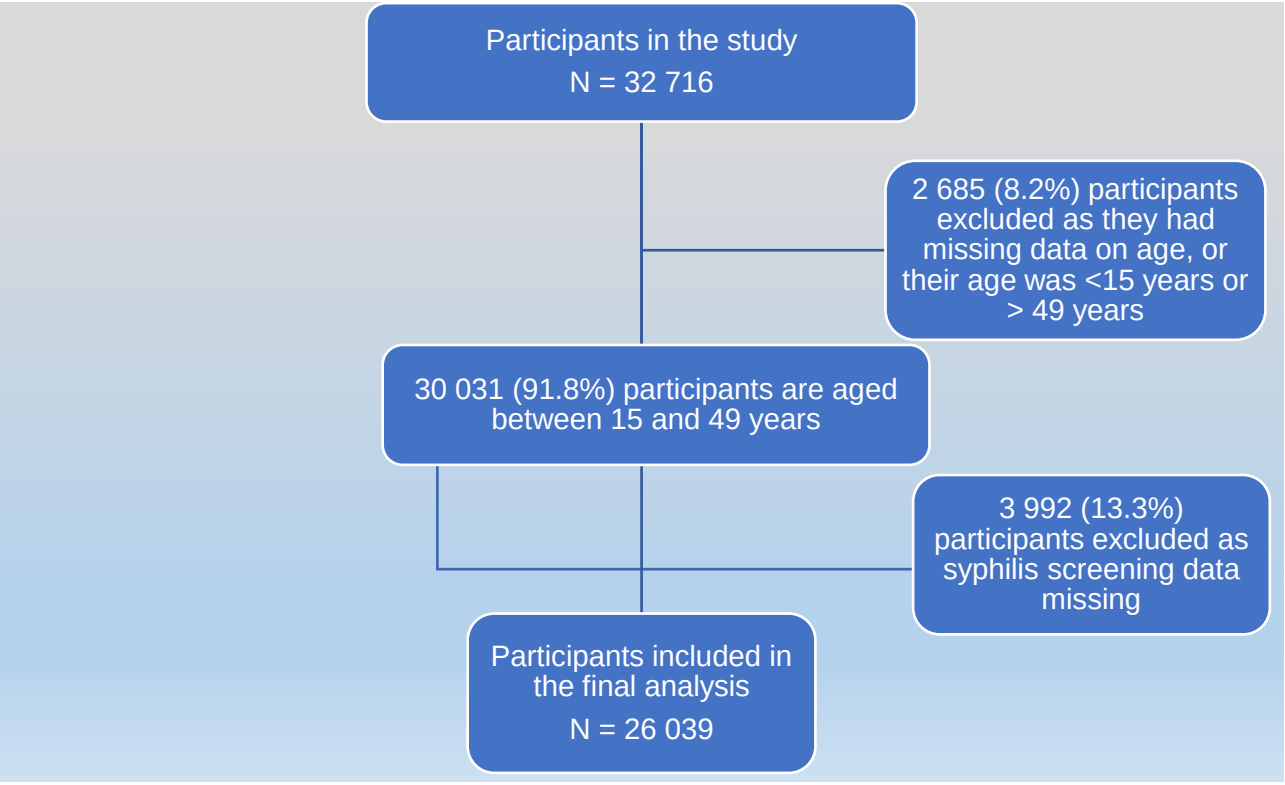


Figure 1: Study participants included in the current study

In this study, 2,685 participants were excluded as they either had missing data on age or their age category was below 15 and above 49 years. Furthermore, when an

analysis was carried out on the 2,685 participants that were excluded, they had missing data on all the variables that were included in the survey. Of the remaining 30,031 participants, 3,992 (13.3%) of the participants were not eligible for the study as they had missing data on syphilis screening. Therefore, the study remained with 26,039 (86.7%) participants who had data on syphilis screening, meaning they were either screened or not screened for syphilis during the survey.

Table 2 below presents the baseline characteristics of the participants in comparison between those eligible for the study and those that were not eligible across all the variables. Apart from those participants who had missing data for each variable, it can be seen from Table 2 below that most participants were eligible for each characteristic. Most characteristics were not linked to being ineligible; however, the participants' single ineligibility factor was associated with a lack of maternal syphilis screening.

Variables	Eligible N = 26029 (86.7%)		Not eligible N = 3992 (13.3%)		Total N = 30031		
	n	(%)	n	(%)	n	(%)	p-value
Age groups:							0.514
15-24 years	11219	(43.1)	1748	(43.8)	12967	(43.2)	
25-34 years	11806	(45.3)	1804	(45.2)	13610	(45.3)	
≥35 years	3014	(11.6)	440	(11)	3454	(11.5)	
Race:							<0.001
Non-Black African	2796	(10.7)	513	(12.9)	3309	(11)	
Black African	22963	(88.2)	3222	(80.7)	26185	(87.2)	
missing	280	(1.1)	257	(6.4)	537	(1.8)	
Level of education:							0.022
None to Primary Level	2729	(10.5)	439	(11.1)	3168	(10.5)	
Secondary Level	19601	(75.3)	2751	(68.9)	22354	(74.4)	
Tertiary Level	3127	(12)	417	(10.4)	3544	(11.8)	
missing	582	(2.2)	385	(9.6)	967	(3.2)	
Marital status:							0.261
Single	18595	(71.4)	2754	(68.9)	21369	(71.1)	
Married/living with partner	6998	(26.9)	978	(24.5)	7976	(26.6)	
Divorced/Widowed/Separate	88	(0.3)	10	(0.3)	98	(0.3)	
missing	358	(1.4)	250	(6.3)	608	(2)	
Province:							<0.001
Eastern Cape	3059	(11.7)	652	(16.3)	3711	(12.4)	
Free State	2161	(8.3)	309	(7.7)	2470	(8.2)	
Gauteng	3737	(14.4)	496	(12.4)	2427	(8.1)	
KwaZulu-Natal	7276	(27.9)	764	(19.1)	4233	(14.1)	
Limpopo	1869	(7.2)	341	(8.5)	2210	(7.4)	
Mpumalanga	2318	(8.9)	337	(8.4)	2655	(8.8)	
North West	1743	(6.7)	333	(8.3)	2076	(6.9)	
Northern Cape	1180	(4.5)	204	(5.1)	1384	(4.6)	
Western Cape	2696	(10.4)	556	(13.9)	3252	(10.8)	
Geographical location:							0.006
Rural	8000	(30.7)	1324	(33.2)	9324	(31)	
Urban	15937	(61.2)	2343	(58.7)	18280	(60.9)	
Peri-Urban	2102	(8.1)	325	(8.1)	2427	(8.1)	
Parity:							0.858
None	9577	(36.8)	1379	(34.5)	10956	(36.5)	
1 or more	16273	(62.5)	2328	(58.3)	18601	(61.9)	
missing	189	(0.7)	285	(7.1)	474	(1.6)	
Gravidity							0.690
1	8634	(33.2)	1255	(31.4)	9889	(32.9)	
More than 1	17274	(66.3)	2474	(62)	19748	(65.6)	
missing	131	(0.5)	263	(6.6)	394	(1.3)	
Type of antenatal visit:							<0.001
Follow-up visit	16295	(62.6)	2184	(54.7)	18479	(61.5)	
First visit	9593	(36.8)	1593	(39.9)	11186	(37.2)	
missing	151	(0.6)	215	(5.4)	366	(1.3)	
Gestational age:							0.014
1-13 weeks	3858	(14.8)	607	(15.2)	4465	(14.8)	
14-27 weeks	11064	(42.5)	1570	(39.3)	12634	(42.1)	

28-40+ weeks	10239	(39.3)	1384	(34.7)	11623	(38.7)	
missing	878	(3.4)	431	(10.8)	1309	(4.4)	
HIV & ART status							<0.001
Negative	17621	(67.7)	2860	(71.6)	20841	(69.3)	
HIV positive – on ART	6954	(26.7)	802	(20.1)	7756	(25.6)	
HIV positive – not started ART	1464	(5.6)	330	(8.3)	1794	(5.1)	

ART= antiretroviral therapy.

Table 2: Baseline characteristics of participants before excluding those not eligible in the study.

3.2. Maternal syphilis screening coverage in South Africa

Table 3 below presents the participants' characteristics and screening coverage of participants according to their individual characteristics. Participants had a 26-year-old median age (IQR: 22 – 31 years). Furthermore, 45.8% of those who participated were between the ages of 25 and 34, with 86.7% being Black African. The majority had completed secondary education (74.6%), were single (70.3%), resided in an urban area (64.8%) and were HIV negative (68.6%). The median age of the pregnant women who were not screened for syphilis was 26 years (IQR: 22 – 30 years), and 45.2% of them were between the ages of 25 and 34 years. In addition, 85.1% were black Africans, had secondary education (74.2%), were single (71.1%), and resided

Variables	**Screened for syphilis N = 25 188 (96.7%)**			**Not screened for syphilis N = 851 (3.3%)**			**Total (N = 26 039)**			**χ2 test (p-value)**
	n	Weighted (%)	95% Confidence interval	n	Weighted (%)	95% confidence interval	n	Weighted (%)	95% confidence interval	
Age (median/IQR)	26 (22 – 31)			26 (22 – 30)			26 (22 – 31)			p <0.001*
Age groups:										
15 – 24 years	10849	(42.2)	41.6 – 42.9	370	(43.4)	40.5 – 46.4	11219	(42.3)	41.6 – 42.9	0.648
25 – 34 years	11423	(45.9)	45.3 – 46.5	383	(45.2)	42.6 – 47.9	11806	(45.8)	45.2 – 46.4	
35+ years	2916	(11.9)	11.6 – 12.3	98	(11.3)	9.71 – 13.2	3014	(11.9)	11.6 – 12.2	
Race:										
Black African	22227	(86.8)	86.6 – 87.6	736	(85.1)	80.4 – 88.7	22963	(86.7)	85.9 – 87.5	0.293
Non-Black African	2687	(12.2)	11.4 - 13	109	(14.3)	10.6 – 18.9	2796	(12.2)	11.5 - 13	
missing	274	(1.1)	0.9 – 1.2	6	(0.6)	0.4 – 1.2	280	(1.1)	0.9 – 1.2	
Level of education:										
None to Primary education	2645	(10.8)	10.2 – 11.4	84	(10.0)	7.61 – 13.2	2729	(10.8)	10.4 – 11.4	0.269
Secondary education	18963	(74.6)	73.8 – 75.4	638	(74.2)	70.7 – 77.4	19601	(74.6)	73.8 – 75.4	
Tertiary education	3012	(12.3)	11.7 - 13	115	(14.3)	11.5 – 17.7	3127	(12.4)	11.8 - 13	
missing	568	(2.3)	2.1 – 2.5	14	(1.5)	0.9 – 2.3	582	(2.3)	2.0 – 2.5	
Marital status:										
Single	17994	(70.3)	69.4 – 71.1	601	(71.1)	70 - 75	18595	(70.3)	69.5 – 71.1	0.444
Married/living with partner	6764	(28.0)	27.2 – 28.8	234	(26.7)	22.9 – 30.8	6998	(28.0)	27.2 – 28.8	
Divorced/Widowed/Separated	83	(0.3)	0.3 – 0.4	5	(0.6)	0.3 – 1.1	88	(0.3)	0.3 – 0.4	
missing	347	(1.4)	1.3 – 1.6	11	(1.7)	1.0 – 2.7	358	(1.4)	1.3 – 1.6	
Geographical location:										
Rural	7736	(27.5)	25.7 – 29.4	264	(29.3)	23.4 - 36	8000	(27.6)	25.8 – 29.4	0.253
Urban	15399	(64.8)	62.7 – 66.7	538	(66.3)	59.1 – 72.8	15937	(64.8)	62.8 – 66.7	
Peri-urban	2053	(7.7)	6.5 – 9.2	49	(4.4)	2.1 – 8.9	2102	(7.6)	6.4 – 9.0	

1. Median IQR; n (%) 3. Pearson Chi-Squared test
2. 95% Confidence interval 4. Adjusted Wald test

in an urban area (66.3%).

ANC= antenatal care; ART= antiretroviral therapy; CI= confidence interval OR= Odds ratio.

Table 3: Demographic characteristics of the pregnant women obtained during antenatal clinic visits according to syphilis screening status.

As presented in table 4 below, in terms of prenatal characteristics, most of those who were not screened had a parity of one or more (62.9%) and gravidity of more than one (67.4%), similar to those who were screened at 63.0% and 66.9%, respectively. Interestingly, of those who were screened, 61.1% were attending a follow-up ANC visit, while 53.5% of those who were not screened were attending their first ANC visit [p-value = <0.001]. The majority of pregnant women not screened were in their second trimester (41.6%) [p-value = <0.001] and were HIV negative (70.7%) [p-value = 0.006].

Variables	**Screened for syphilis N = 25188 (96.7%)**			**Not Screened for syphilis N = 851 (3.3%)**			**Total (N = 26039)**			**χ2 test (p-value)**
	n	Weighted (%)	95% confidence interval	n	Weighted (%)	95% confidence interval	n	Weighted (%)	95% confidence interval	
Parity										
None	9,276	(36.3)	35.7 – 36.8	301	(36.1)	33.4 – 38.9	9,577	(36.3)	35.7 – 36.8	0.520
One or more	15,732	(63.0)	62.5 – 63.6	541	(62.9)	60.3 – 65.4	16,273	(63.0)	62.5 – 63.6	
missing	180	(0.7)	0.6 – 0.8	9	(1.0)	0.5 – 1.9	189	(0.7)	0.6 – 0.9	
Gravidity										
One	8,367	(32.6)	32.1 – 33.2	267	(32.1)	29.7 – 34.7	8,634	(32.6)	32.1 – 33.1	0.891
More than one	16,695	(66.9)	66.4 – 67.4	579	(67.4)	64.8 – 69.8	17,274	(66.9)	66.4 – 67.4	
missing	126	(0.5)	0.4 – 0.6	5	(0.5)	0.2 – 1.2	131	(0.5)	0.4 – 0.6	
Type of antenatal visit:										
First	9,125	(38.3)	37.3 – 39.3	468	(53.5)	48 – 58.9	9,593	(38.8)	37.9 – 39.8	<0.001
Follow up	15,916	(61.1)	60.1 – 62.1	379	(46.2)	40.7 – 51.6	16,295	(60.6)	59.7 – 61.6	
missing	147	(0.6)	0.5 – 0.7	4	(0.3)	0.2 – 0.8	151	(0.6)	0.5 – 0.7	
Gestational age:										
First trimester: 1 – 13 weeks	3,695	(14.9)	14.4 – 15.4	163	(18.6)	16.2 – 21.3	3,858	(15.0)	14.6 – 15.5	<0.001
Second trimester: 14 – 27 weeks	10,703	(42.7)	42.1 – 43.3	361	(41.6)	38.9 – 44.4	11,064	(42.7)	42.1 – 43.3	
Third trimester: 28 – 43 weeks	9,959	(39.1)	38.4 – 39.8	280	(34.3)	30.8 – 38.1	10,239	(39.0)	38.3 – 39.6	
missing	831	(3.3)	3 – 3.5	47	(5.4)	4.1- 7.2	878	(3.3)	3.1 – 3.6	
HIV & ART status										
Negative	17,014	(68.6)	67.9 – 69.2	607	(70.7)	68 -73.3	17,621	(68.6)	68 – 69.3	0.006
Positive – on ART	6,771	(25.7)	25.1 – 26.4	183	(21.9)	19.3 – 24.7	6,954	(25.6)	24.9 – 26.2	
Positive – not started ART/unknown	1,403	(5.7)	5.5 – 6.0	61	(7.4)	5.9 – 9.3	1,464	(5.8)	5.5 – 6.1	

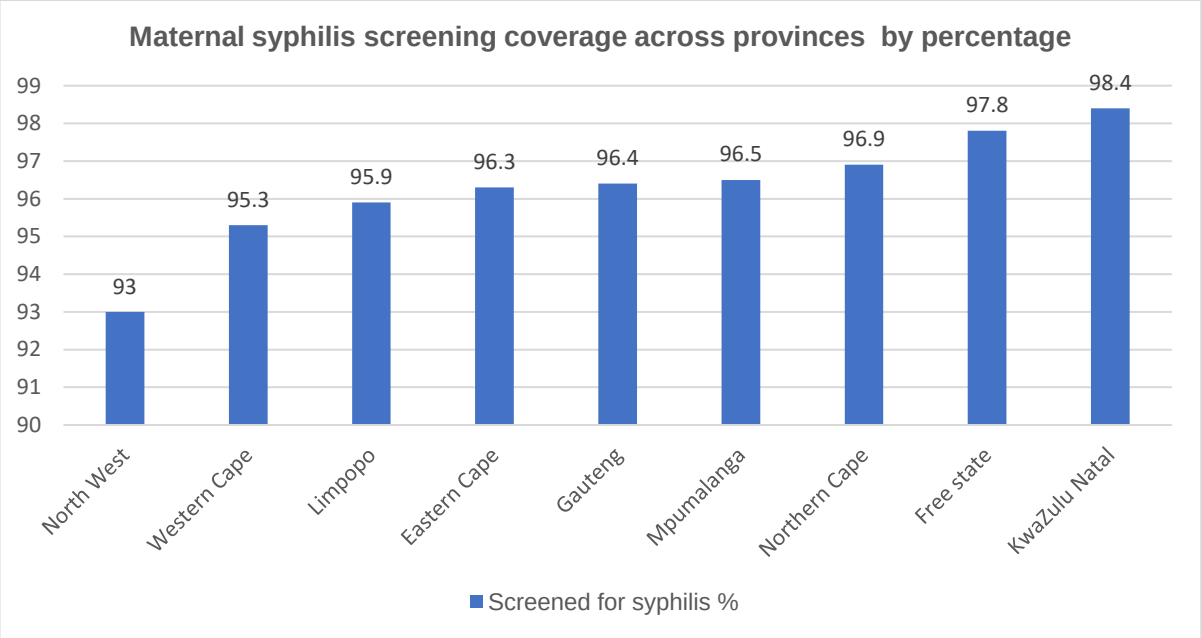
1. Median IQR; n (%) 3. Pearson Chi-Squared test
2. 95% Confidence interval 4. Adjusted Wald test

ANC= antenatal care; ART= antiretroviral therapy; CI= confidence interval OR= Odds ratio.

Table 4: Antenatal characteristics of the pregnant women obtained during antenatal clinic visits according to syphilis screening status.

Figure 2 below presents maternal syphilis screening coverage by province from the 2017 HIV and syphilis seroprevalence South African survey. Overall, of the 26 039 pregnant women included in the analysis, 96.7% (95% CI 96.12 – 97.20) (25 188) were all screened for syphilis during the survey. The 2017 maternal syphilis screening coverage by province was above 90% across all provinces, with KwaZulu-Natal having the highest screening coverage at 98.4% (95% CI 97.49 – 99.01) and North West province having the lowest maternal syphilis screening when compared to all the other provinces at 93% (95% CI 81.70 – 97.51).

Figure 2: Maternal syphilis screening coverage by province in the 2017 survey



3.3. 2017 geospatial distribution of the maternal syphilis screening coverage.

By province, maternal syphilis screening coverage from the 2017 survey is represented in Figure 3. The percentage of pregnant women who were not screened for syphilis was highest in the North West province (7.0%), followed by the Western Cape Province (4.7%) when compared with other provinces.

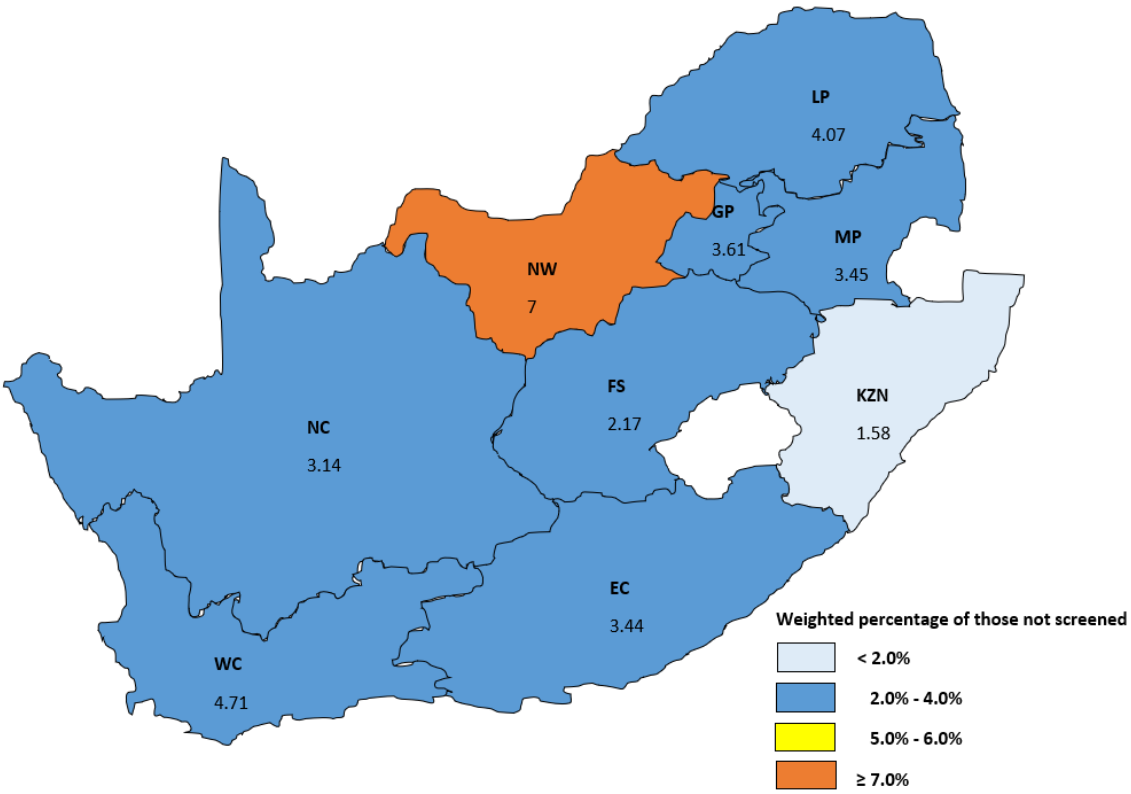


Figure 3: Mapping of maternal syphilis coverage by province in the 2017 survey

The results of the pregnant women who were not screened for syphilis are shown in Figure 4 below, broken down by district. At 11.5%, the Bojanala Platinum district municipality of the North West province had the second-highest percentage of pregnant women who had not been screened for syphilis, while the Overberg district municipality of the Western Cape province had the highest at 12.4% when compared with all the other districts.

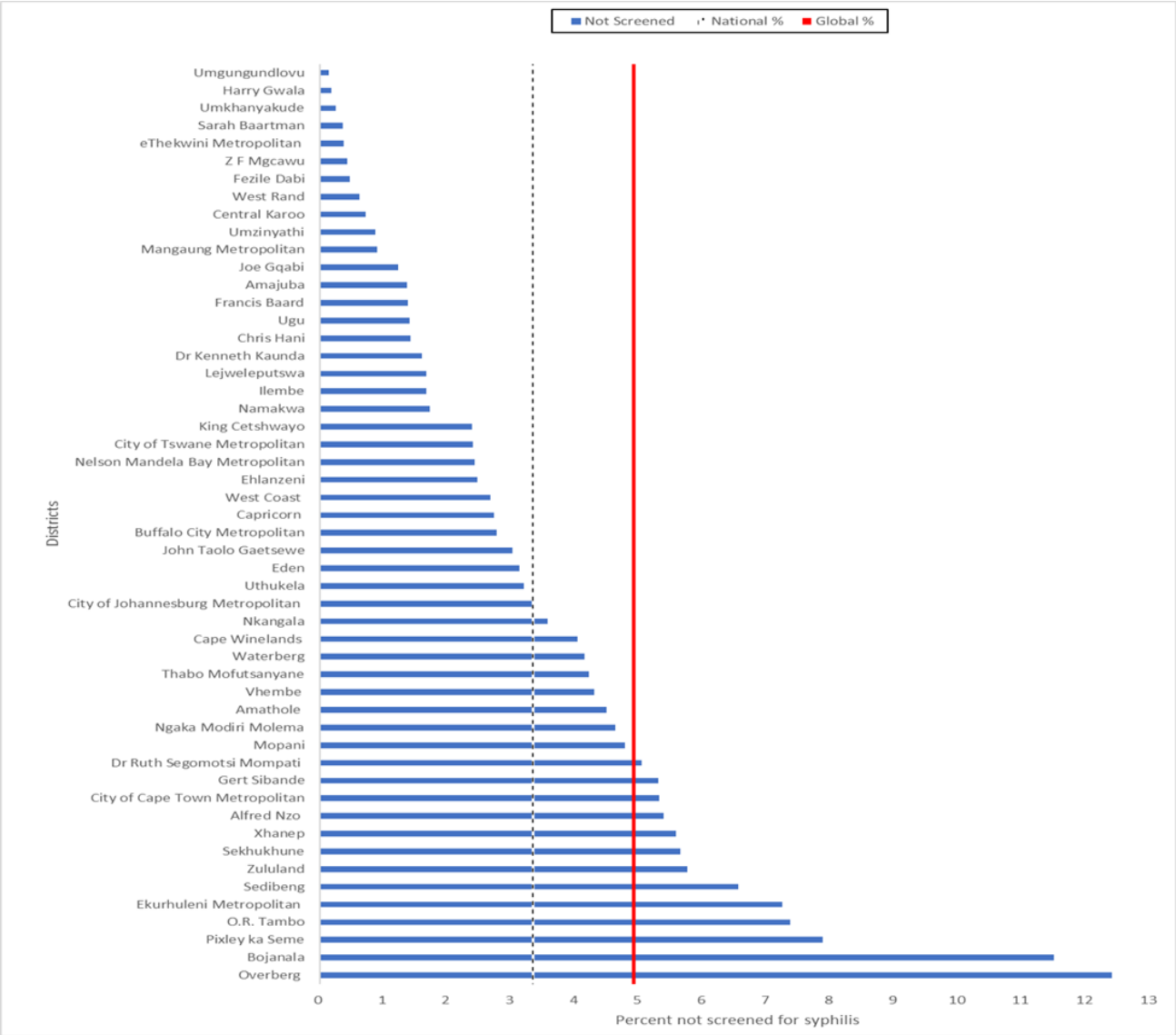


Figure 4: Maternal syphilis screening coverage by district

A significant proportion of pregnant women were not screened for syphilis during antenatal visits, according to our analysis of syphilis screening coverage among pregnant women by districts. Figure 5 shows maternal syphilis screening coverage for the top 5 districts with the greatest proportion of pregnant women who did not receive syphilis screening. The greatest percentage was seen in the Overberg district of the Western Cape, where 12.4% of pregnant women were not screened for syphilis during the survey.

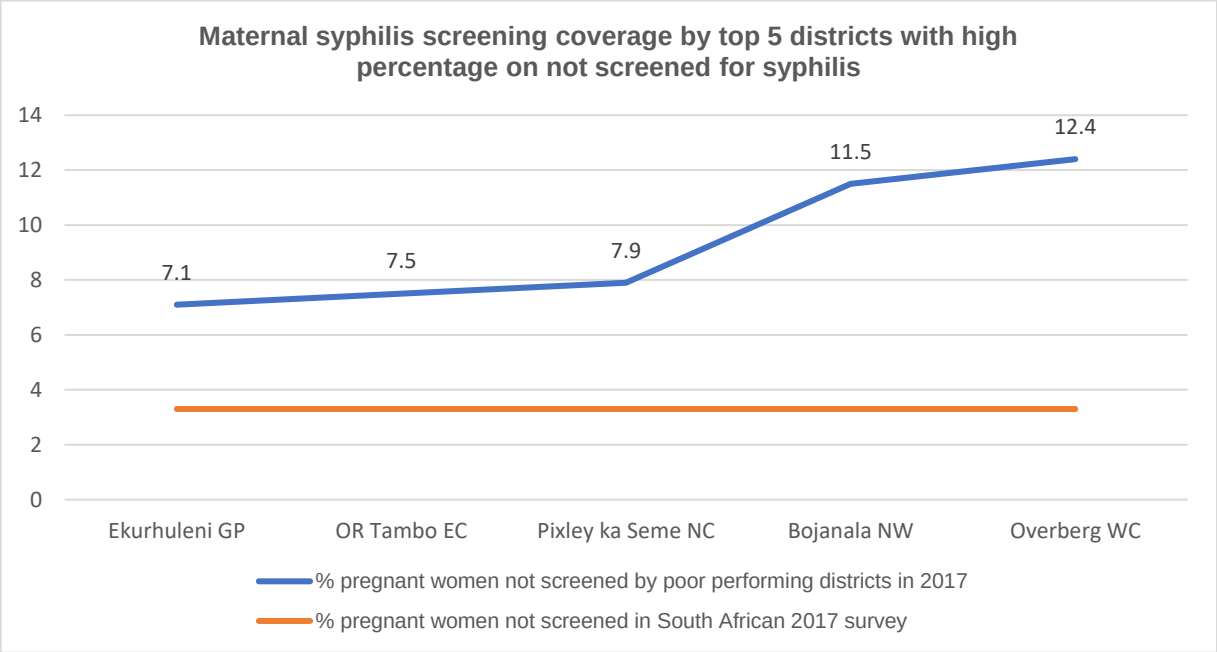


Figure 5: Maternal syphilis screening coverage by top 5 districts with high percentage of pregnant women not screened for syphilis in 2017.

3.4. The individual and population-level factors associated with not being screened for syphilis in pregnancy

Figure 3 above shows the percentage of pregnant women who were not screened for syphilis during the 2017 antenatal survey. We note that North West Province had the highest percentage of pregnant women who were not screened for syphilis, at 7%, while KwaZulu-Natal had the lowest percentage, 1.6%, of pregnant women who were not screened for syphilis during the survey. In a univariate analysis, being divorced, separated, or widowed (unadjusted odds ratio [OR], 1.80; 95% confidence interval [CI], 0.92 to 3.54) was marginally associated with not being screened for syphilis during pregnancy in the 2017 survey when compared to pregnant women who were single. While attending first antenatal visit only (unadjusted OR, 1.85; 95% CI, 1.47 to 2.32) was significantly associated with not being screened for syphilis by pregnant women during antenatal care in the 2017 survey when compared to those pregnant women who were attending follow-up care antenatal visits.

Comparatively, there was a significant association found in pregnant women who only attended their first antenatal care visit and did not receive screening for syphilis when compared to those who attended follow-up antenatal care visits. When compared to pregnant women in KwaZulu Natal who attended follow-up antenatal care visits, pregnant women who resided in Gauteng, Eastern Cape, Mpumalanga, Limpopo, North West, Northern Cape, or Western Cape had increased odds of not being screened for syphilis during their only first antenatal care visit. Pregnant women who only had their first antenatal visit had increased odds of not being screened for syphilis [adjusted OR 1.82 (1.38 – 2.39)] when compared to those who had follow-up visits. Those from the abovementioned provinces have more than twice the increased odds of not being screened for syphilis when compared with those from KwaZulu-Natal. On the contrary, the age of the women, their race, other demographic features, and antenatal characteristics were not independently associated with their not being screened for syphilis. Table 4 below presents the factors.

Characteristic	Weighted % not screened	Crude OR (95% CI)	p-value	Adjusted OR (95% CI)	p-value
Age of woman:					
15-24 years	3.4	1		1	
25-34 years	3.3	0.96 (0.85 – 1.08)	0.504	0.95 (0.82 – 1.10)	0.511
≥35 years	3.1	0.92 (0.76 – 1.12)	0.432	0.87 (0.70 – 1.08)	0.210
Race:					
Non-Black African	3.9	1		1	
Black African	3.2	0.84 (0.59 – 1.19)	0.319	0.94 (0.70 – 1.26)	0.675
Level of education:					
None to Primary education	3.1	1		1	
Secondary education	3.3	1.07 (0.79 – 1.44)	0.673	1.15 (0.85 – 1.54)	0.358
Tertiary education	3.8	1.25 (0.83 – 1.88)	0.292	1.42 (0.97 – 2.09)	0.073
Marital status:					
Single	3.3	1		1	
Married/living with partner	3.2	0.94 (0.76 – 1.16)	0.562	0.86 (0.70 – 1.07)	0.184
Divorced/Widowed/ Separated	5.9	1.80 (0.92 – 3.54)	0.086	1.94 (0.97 – 3.85)	0.060
Province:					
Eastern Cape	3.7	2.37 (1.35 – 4.13)	0.002	2.40 (1.36 – 4.24)	0.003
Free State	2.2	1.38 (0.67 – 2.86)	0.380	1.43 (0.68 – 3.00)	0.348
Gauteng	3.6	2.33 (1.25 – 4.36)	0.008	2.49 (1.28 – 4.84)	0.007
KwaZulu-Natal	1.6	1		1	
Limpopo	4.1	2.64 (1.49 – 4.66)	0.001	2.62 (1.47 – 4.68)	0.001
Mpumalanga	3.5	2.23 (1.15 – 4.31)	0.018	2.34 (1.20 – 4.51)	0.012
North West	7.0	4.69 (1.4 – 15.39)	0.011	5.56 (1.65– 18.69)	0.006
Northern Cape	3.1	2.02 (0.92 – 4.40)	0.079	2.33 (1.04 – 5.26)	0.041
Western Cape	4.7	3.08 (1.67 – 5.66)	<0.001	3.51 (1.88 – 6.55)	<0.001
Location:					
Rural	3.5	1.88 (0.87 – 4.08)	0.110	2.02 (0.86 – 4.75)	0.108
Urban	3.4	1.81 (0.83 – 3.94)	0.136	1.67 (0.74 – 3.75)	0.219
Peri-Urban	1.9	1		1	
Gravidity:					
One	3.3	1		1	
More than one	3.3	1.02 (0.91 – 1.15)	0.695	1.29 (0.98 – 1.69)	0.070
Parity:					
None	3.3	1		1	
One or more	3.3	1.00 (0.89 – 1.13)	0.966	0.82 (0.63 – 1.07)	0.146
Type of antenatal visit:					
Follow up	2.5	1		1	
First	4.6	1.85 (1.47 – 2.32)	<0.001	1.81 (1.38 – 2.38)	<0.001
Gestational age:					
First trimester: 1 – 13 weeks	4.1	1		1	
Second trimester: 14 – 27 weeks	3.2	0.78 (0.67 – 0.91)	0.002	0.96 (0.83 – 1.12)	0.601
Third trimester: 28 – 43 weeks	2.9	0.70 (0.56 – 0.88)	0.002	1.12 (0.91 – 1.38)	0.278
HIV & ART status					
Negative	3.4	1		1	
Positive – on ART	2.8	0.82 (0.70 – 0.97)	0.017	1.03 (0.88 – 1.21)	0.725
Positive – not started ART/unknown	4.2	1.26 (0.98 – 1.61)	0.068	1.13 (0.89 – 1.43)	0.327

ANC= antenatal care; ART= antiretroviral therapy; CI= confidence interval OR= Odds ratio.

Table 5: Factors associated with not being screened for syphilis among pregnant women in the 2017 survey.

CHAPTER 4. DISCUSSION

Discussions of the study's primary findings, its strengths and limitations, its conclusions and recommendations are presented in this chapter. This study assessed the maternal syphilis coverage across the age of the pregnant women included in the study; coverage by provinces; geospatial distribution of maternal syphilis screening; and the factors associated with not being screened for syphilis. The primary findings discovered in this study are that the type of antenatal visit of the pregnant women was associated with not being screened for syphilis.

4.1. Summary of findings.

According to the findings of this study, the maternal syphilis screening coverage in South Africa for 2017 was 96.7% (95% CI 96.12 – 97.20); that is, 25 188 of the participants were screened for syphilis during the 2017 HIV antenatal survey out of 26 039 participants who had a syphilis screening outcome. Furthermore, all the nine provinces achieved a maternal syphilis screening coverage above 90%, with the North West province not reaching the global target of elimination of mother-to-child transmission of syphilis of 95% at the lowest maternal syphilis screening coverage of 93% (95% CI 81.70 – 97.53) when compared with the other eight South African provinces. There were certain districts with large percentages of participants who were not screened (over 5%). In this study, the odds of not being screened for syphilis were higher among pregnant women who attended only their first visit of antenatal care at enrolment and resided in Gauteng, Eastern Cape, Mpumalanga, Limpopo, North West, Northern Cape, or Western Cape provinces when compared to those residing in KwaZulu-Natal province.

4.2. Maternal syphilis screening coverage, individual and population-level factors.

This study has shown the need to intensify maternal syphilis screening. Intensifying syphilis screening during pregnancy, early diagnosis, and treatment of positive pregnant women are important to reducing maternal syphilis and its detrimental effects on childbirth. It is important to note that there should be improvement in hospitals and primary health care facilities in the coverage of antenatal care services, which should

include syphilis screening and testing during pregnancy, treatment of those pregnant women who are syphilis positive, and re-screening of those that initially tested negative for syphilis. Findings from a study in Mongolia (28) concur with the importance of early diagnosis and treatment of pregnant women who are syphilis positive. It was found that in geographical locations and health care facilities where maternal syphilis screening was intensified, there was a reduction in adverse birth outcomes related to maternal syphilis (28).

According to this study, there were differences between provinces and districts in the percentage of pregnant women who underwent syphilis screening. The study's findings about the discrepancies between provincial and district maternal syphilis coverage could be attributed to the provinces' different lack of resources, particularly medical professionals experienced by respective provinces; differences in health facilities; for example, poor health facility infrastructure; and limited health resources, including inadequate supply of syphilis test kits and treatment; poor laboratory results turnaround time; and other provinces' being deeply rural with limited health care facilities within reach for pregnant women. Similar findings were found in a different study (32) that showed that access to obstetric services was not fairly distributed throughout South Africa. The socioeconomic groups and geographic regions with the greatest disparities in access to treatment were noted (32).

Previous studies identified shortages of medical resources, shortages of experienced healthcare personnel, and poor access to health care facilities by pregnant women as major factors in poor maternal syphilis screening and treatment (29, 31). Access to antenatal care services is critical for every pregnant woman to scale up improvement in maternal health as per millennium development goals 2030 (32). It is important for health authorities to strengthen the supply chain of each health care facility and ensure that medical supplies are always in place to cater to the needs of pregnant women. Laboratory services should also be strengthened and be made available in all public health care facilities and should have good turnaround time and timeous availability of patients' results. Geographical areas with great poverty and poor access to medical services should receive more resources.

There was an association in this study between attending only the first antenatal care visit and not getting screened for syphilis among pregnant women, despite the fact that all public health facilities provide free maternal syphilis screening to pregnant women at all types of antenatal care visits. It is quite concerning that pregnant women receiving care at public health facilities are not screened for syphilis at their initial antenatal visit. Although it is noted that shortage of staff and medical resources such as specimen tubes or test kit could be playing a role in poor maternal syphilis screening at first visit, pregnant women and the unborn child benefit from early diagnosis and treatment of syphilis during pregnancy, often during the first antenatal visit (29, 34).

In light of this, the study's findings point to a chance lost to reduce the negative effects of maternal syphilis. This study's findings on inadequate syphilis screening at the initial antenatal visit may be associated with pregnant women's delay in seeking antenatal care; pregnant women unaware of the syphilis screening and not requesting one to be done when the health care practitioner does not offer it; lack of health education about syphilis screening to patients and communities; shortage of syphilis test kits; inadequate laboratory services; shortage of treatment; and poor reporting or recording by health care practitioners.

Previous research studies identified poor health education for pregnant women, poor data collection, late antenatal care booking, and a lack of resources, including insufficient laboratory services, a lack of syphilis test kits, and treatment, as barriers to syphilis screening among pregnant women (22, 28, 29, 33, 34). According to Punguyire et al. (29), pregnant women's readiness to request syphilis screening increased the uptake of maternal syphilis screening in Ghanaian healthcare facilities. To address issues of late antenatal care booking and pregnant women’s insufficient knowledge about maternal syphilis screening, it is crucial to educate the community as well as childbearing women about the importance of antenatal visits during pregnancy and the services rendered during these antenatal visits in health care facilities, as well as the importance of these services. If pregnant women are aware of the risks of syphilis infection for both their health and the health of their unborn children, they may be more likely to request syphilis tests.

To achieve universal maternal syphilis screening coverage and reduce preventable infant deaths and adverse pregnancy outcomes caused by maternal syphilis, it will require ongoing improvements in access to antenatal care services; ensuring that all pregnant women attending ANC are screened and tested; efforts should be increased in testing and treating partners; ensuring availability of treatment for syphilis in health care facilities; and ongoing training of health providers on correct recording and reporting. It is noteworthy that studies that are interested in assessing maternal syphilis screening coverage are limited, as most studies on syphilis base most of their discussions and results on syphilis prevalence and treatment of the general population (26, 27, 29) rather than maternal syphilis screening coverage. Further research is needed on several constituents of maternal syphilis screening and treatment at the facility level for a specific group of patients to identify maternal syphilis screening gaps and population level specific factors causing them.

4.3. Strengths and limitations of the study

This study presents limitations as the data analysed on maternal syphilis screening coverage and factors associated with not screening was from five years ago in a 2017 survey. It is acknowledged that the situation related to maternal syphilis in South Africa may have changed to either an advantage or disadvantage given the emergence of the COVID-19 pandemic. Furthermore, this study is limited to only one maternal syphilis screening and does not assess re-screening of syphilis at the gestational ages of 32 – 34 weeks in women who were previously screened negative for syphilis at booking and might have acquired syphilis during pregnancy.

This study has the limitation of not addressing all the 95-95-95 targets as it only assesses screening for syphilis among pregnant women and not the treatment of those that test positive for syphilis during pregnancy. This does not fully address adverse pregnancy outcomes, as there is no analysis of those pregnant women who had positive syphilis results. The primary survey study surveyed pregnant women between ages 15 – 49 years of age across South Africa in all the nine provinces in 2017. The secondary study has a limitation of generalizability, as drawing broad inferences for the South African population from the data of a survey conducted in the

year 2017 for the year 2022 population might be a challenge. However, this study will give recommendations related to syphilis in pregnant women rather than make broad inferences from 2017 data.

4.4. Conclusions and recommendations

This study has shown a maternal syphilis screening coverage of 96.7% for South Africa in the antenatal HIV sentinel survey conducted in 2017. There was an association between the type of antenatal visit and not being screened for syphilis, which was the main association in this study. Surprisingly, among provinces with a non-screening prevalence of more than 3.3%, being in particular provinces and attending the first antenatal care visit were strongly associated with not screening for syphilis during pregnancy. The poor maternal syphilis screening coverage for pregnant women in their first antenatal visit in this study demonstrates how important it is to have pregnant women report for their first antenatal visit before 20 weeks and develop strategies that will inform community awareness and the quality of health services rendered to pregnant women; and further decrease poor birth outcomes related to maternal syphilis.

Measures to address maternal syphilis screening coverage in provinces and their districts are necessary to address provincial and national negative birth outcomes linked to syphilis among pregnant women in South Africa. Working to resolve concerns with early antenatal booking for pregnant women, treating pregnant women who are syphilis-positive and their partners, and addressing gaps related to lack of resources and healthcare professionals should be prioritized at the sub-district, facility, and community levels. Syphilis screening during pregnancy is crucial, and there must be community-wide awareness campaigns about the disease's impact on pregnant mothers and their unborn children.

It is recommended that healthcare professionals receive ongoing training on managing syphilis in pregnancy, recording maternal syphilis screening during antenatal care, and reporting maternal health data, especially at community health care level, and empower the facilities with important resources for rapid scale-up of early diagnosis of maternal syphilis through screening and treatment of positive pregnant women.

Timeous and regular procurement of test kits and treatment for syphilis and timeous distribution are recommended to prevent unnecessary stockouts, which lead to missed opportunities to screen, test, and render treatment to pregnant women for syphilis and to prevent adverse birth outcomes related to maternal syphilis. Strengthening national laboratory health services to all facilities is crucial to reducing delays in turnaround time of results on syphilis tests done on pregnant women in those provinces that make use of labs for testing of syphilis.

This study supports further studies on factors associated with not screening for syphilis in pregnancy and maternal syphilis screening coverage, which will make use of reliable and authentic diagnostic measures and provide details on the factors and risks associated with not screening for syphilis during pregnancy. We recommend qualitative studies on both pregnant women and healthcare providers to understand barriers to syphilis screening from the patient and health care provider's perspective.

REFERENCES

1. Rowley J, Vander Hoorn S, Korenromp E, Low N, Unemo M, Abu-Raddad LJ, Chico RM, Slomak A, Newman L, Gottlieb S, Thwin SS, Broutet N, Taylor MM, et al. Chlamydia, gonorrhoea, trichomoniasis and syphilis: global prevalence and incidence estimates 2016. Geneva World Health Organisation. 2016

2. Kwiek J, Mwapasa V, Alker A, Muula A, Misiri H, Molyneux M, et al. Socio-demographic characteristics associated with HIV and syphilis seroreactivity among pregnant women in Blantyre, Malawi, 2000-2004. Malawi Med J. 2008 Oct;20(3):80–5.

3. Mullick S. Treatment for syphilis in antenatal care: compliance with the three dose standard treatment regimen. Sex Transm Infect. 2005 Jun;81(3):220–2.

4. Kanyangarara M, Walker N, Boerma T. Gaps in the implementation of antenatal syphilis detection and treatment in health facilities across sub-Saharan Africa. Resch SC, editor. PLoS One. 2018 Jun;13(6):e0198622.

5. Newman L, Rowley J, Hoorn S Vander, Wijesooriya NS, Unemo M, Low N, et al. Global Estimates of the Prevalence and Incidence of Four Curable Sexually Transmitted Infections in 2012 Based on Systematic Review and Global Reporting. PLoS One. 2015;10(12):1–17.

6. Hoque M, Hoque ME, van Hal G, Buckus S. Prevalence, incidence and seroconversion of HIV and Syphilis infections among pregnant women of South Africa. S Afr J Infect Dis. 2021 Nov 24;36(1):296. doi: 10.4102/sajid.v36i1.296. PMID: 34917677; PMCID: PMC8661397.

7. Kwiek JJ, Mwapasa V, Alker AP, Muula AS, Misiri HE, Molyneux ME, et al. MMJ2003-0080.pdf. 2008;20(September):80–5.

8. Volmink J. HIV: mother to child transmission. Clinical evidence. 2003. 785-794 p.

9. Morifi M, Malevu N, Odayan S, McCarthy K, Kufa T. Congenital Syphilis Case Surveillance in South Africa 2017-19: Experience, Challenges and Opportunities. J Trop Pediatr. 2021 Aug 27;67(4):fmab079. doi: 10.1093/tropej/fmab079. PMID:

34490454.

10. Wijesooriya NS, Rochat RW, Kamb ML, Turlapati P, Temmerman M, Broutet N, et al. Global burden of maternal and congenital syphilis in 2008 and 2012: a health systems modelling study. Lancet Glob Heal. 2016 Aug;4(8):e525–33.

11. Tuite A, Fisman D. Go big or go home: Impact of screening coverage on syphilis infection dynamics. Sex Transm Infect. 2016;92(1):49–54.

12. Kenyon CR, Osbak K, Tsoumanis A. The Global Epidemiology of Syphilis in the Past Century – A Systematic Review Based on Antenatal Syphilis Prevalence. PLoS Negl Trop Dis. 2016;10(5):1–23.

13. Kuznik A, Muhumuza C, Komakech H, Marques EMR, Lamorde M. Antenatal syphilis screening using point-of- care testing in low- and middle-income countries in Asia and Latin America: A cost- effectiveness analysis. PLoS One. 2015;10(5):1–9.

14. Kojima N, Klausner JD. An Update on the Global Epidemiology of Syphilis. Curr Epidemiol Reports. 2018;5(1):24–38.

15. Badman SG, Vallely LM, Toliman P, Kariwiga G, Lote B, Pomat W, et al. A novel point-of-care testing strategy for sexually transmitted infections among pregnant women in high-burden settings: Results of a feasibility study in Papua New Guinea. BMC Infect Dis [Internet]. 2016;16(1):1–6. Available from: http://dx.doi.org/10.1186/s12879-016-1573-4

16. Amsalu A, Ferede G, Assegu D. High seroprevalence of syphilis infection among pregnant women in Yiregalem hospital southern Ethiopia. BMC Infect Dis. 2018;18(1):1–6.

17. Shahrook S, Mori R, Ochirbat T, Gomi H. Strategies of testing for syphilis during pregnancy. Cochrane Database Syst Rev. 2014 Oct 29;(10):CD010385. doi: 10.1002/14651858.CD010385.pub2. PMID: 25352226.

18. Rac MWF, Revell PA, Eppes CS. Syphilis during pregnancy: a preventable threat to maternal-fetal health. Am J Obstet Gynecol [Internet]. 2017;216(4):352–63. Available from: http://dx.doi.org/10.1016/j.ajog.2016.11.1052

19. Trivedi S, Taylor M, Kamb ML, Chou D. Evaluating coverage of maternal syphilis screening and treatment within antenatal care to guide service improvements for

prevention of congenital syphilis in *Countdown* 2030 Countries. J Glob Health. 2020 Jun;10(1):010504. doi: 10.7189/jogh.10.010504. PMID: 32280458; PMCID: PMC7138526.

20. Mutagoma M, Balisanga H, Remera E, Gupta N, Samuel S, Riedel DJ, et al. women in Rwanda and correlates of syphilis-HIV co-infection. 2018;28(1):45–53.

21. Madhi SA, Briner C, Maswime S, Mose S, Mlandu P, Chawana R, et al. Causes of stillbirths among women from South Africa: a prospective, observational study. Lancet Glob Heal. 2019;7(4):e503–12.

22. Dassah ET, Adu-Sardokie Y & Mayaud P (2015). Factors associated with failure to screen for syphilis during antenatal care in Ghana: a case control study. BMC infectious diseases 2015. 125(2015).

23. Davis R, Xiong X, Althabe F, Lefante J, Cafferata ML, Mwenechanya M, Mwanakalanga FH, Chomba E, Buekens P et al. Factors associated with HIV and syphilis screening among pregnant women at first antenatal visit in Lusaka, Zambia. 2020. BMC research notes (2020) 13:423.

24. Woldesenbet S, Kufa T, Cheyip M, Ayalew K, Lombard C, Manda S, Nadol P, Barron P, Chirombo B, Igumbor E, Pillay Y, Puren A. Awareness of HIV-positive status and linkage to treatment prior to pregnancy in the "test and treat" era: A national antenatal sentinel survey, 2017, South Africa. PLoS One. 2020 Mar 13;15(3):e0229874. doi: 10.1371/journal.pone.0229874. PMID: 32168356; PMCID: PMC7069609.

25. Dinh TH, Kamb ML, Msimang V, Likibi M, Molebatsi T, Goldman T, Lewis DA. Integration of preventing mother-to-child transmission of HIV and syphilis testing and treatment in antenatal care services in the Northern Cape and Gauteng provinces, South Africa. Sex Transm Dis. 2013 Nov;40(11):846-51. doi: 10.1097/OLQ.0000000000000042. PMID: 24113405; PMCID: PMC6823923.

26. Mullick S, Beksinksa M, Msomi S. Treatment for syphilis in antenatal care: compliance with the three dose standard treatment regimen. Sex Transm Infect. 2005 Jun;81(3):220-2. doi: 10.1136/sti.2004.011999. PMID: 15923289; PMCID: PMC1744982.

27. Kularatne RS, Niit R, Rowley J, Kufa-Chakezha T, Peters RPH, Taylor MM, Johnson LF, Korenromp EL. Adult gonorrhea, chlamydia and syphilis prevalence, incidence, treatment and syndromic case reporting in South Africa: Estimates using the Spectrum-STI model, 1990-2017. PLoS One. 2018 Oct 15;13(10):e0205863. doi: 10.1371/journal.pone.0205863. PMID: 30321236; PMCID: PMC6188893.

28. Munkhuu B, Liabsuetrakul T, Chongsuvivatwong V, Geater A, Janchiv R. Coverage of antenatal syphilis screening and predictors for not being screened in Ulaanbaatar, Mongolia. Sex Transm Dis. 2006 May;33(5):284-8. doi: 10.1097/01.olq.0000194577.71693.c7. PMID: 16641821.

29. Punguyire D, Mahama E, Letsa T, Akweongo P, Sarfo B. Factors associated with syphilis screening uptake among pregnant women in health facilities in Brong Ahafo Region of Ghana. Matern Health Neonatol Perinatol. 2015 Mar 18;1:7. doi: 10.1186/s40748-015-0009-2. PMID: 27057324; PMCID: PMC4823680.

30. Freitas CHSM, Forte FDS, Roncalli AG, Galvão MHR, Coelho AA, Dias SMF. Factors associated with prenatal care and HIV and syphilis testing during pregnancy in primary health care. Rev Saude Publica. 2019 Sep 23;53:76. doi: 10.11606/s1518-8787.2019053001205. PMID: 31553379; PMCID: PMC6752686.

31. Watson-Jones D, Oliff M, Terris-Prestholt F, Changalucha J, Gumodoka B, Mayaud P, Semakafu AM, Kumaranayake L, Gavyole A, Mabey D, Hayes R. Antenatal syphilis screening in sub-Saharan Africa: lessons learned from Tanzania. Trop Med Int Health. 2005 Sep;10(9):934-43. doi: 10.1111/j.1365-3156.2005.01473.x. PMID: 16135202.

32. 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 May 21;12:120. doi: 10.1186/1472-6963-12-120. PMID: 22613037; PMCID: PMC3467180.

33. Stanton C, Abderrahim N, Hill K. An assessment of DHS maternal mortality indicators. Stud Fam Plann. 2000 Jun;31(2):111-23. doi: 10.1111/j.1728-

4465.2000.00111.x. PMID: 10907277.

34. Bocoum FY, Kouanda S, Zarowsky C. Barriers to antenatal syphilis screening in Burkina Faso. Pan Afr Med J. 2014 Jan 18;17 Suppl 1(Suppl 1):12. doi: 10.11694/pamj.supp.2014.17.1.3423. PMID: 24624245; PMCID: PMC3946229.

35. Liu L, Oza S, Hogan D, Chu Y, Perin J, Zhu J, Lawn JE, Cousens S, Mathers C, Black RE. Global, regional, and national causes of under-5 mortality in 2000-15: an updated systematic analysis with implications for the Sustainable Development Goals. Lancet. 2016 Dec 17;388(10063):3027-3035. doi: 10.1016/S0140-6736(16)31593-8. Epub 2016 Nov 11. Erratum in: Lancet. 2017 May 13;389(10082):1884. PMID: 27839855; PMCID: PMC5161777.

36. Congenital syphilis quarterly surveillance report December 2020 Centre for HIV and STIs Notifiable Medical Conditions Surveillance. NICD 2020.

6.0. APPENDICES

Appendix 1: Plagiarism declaration

Plagiarism
Declaration - LT Chau

Appendix 2: Turnitin report signed by supervisor

Final Research report
LT Chauke 1280445 2

Appendix 3: Ethics waiver certificate from the Human Research Ethics Committee of the University of the Witwatersrand.

M200339.pdf

Appendix 4: 2017 HIV antenatal survey ethics approval

HREC
APPROVAL_R14-49_2