A DESCRIPTIVE STUDY OF MATERNAL "NEAR MISSES" AND MATERNAL DEATHS AT THE CHRIS HANI BARAGWANATH ACADEMIC HOSPITAL, SOUTH AFRICA: A RETROSPECTIVE STUDY

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DECLARATION

I, Rachel Hlengani, declare that this research is my own work.
It is being submitted to the Faculty of Health Sciences for the degree of Master of Medicine in Obstetrics and Gynaecology, at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any other degree or examination to this or any other University.

This 26th day of November 2018

DEDICATION

To Ndiene and Vhudihawe

ABSTRACT

Background: Maternal mortality and morbidity are essential components in monitoring level of obstetric care within institutions. Since death from childbirth is uncommon, auditing of maternal morbidity (near miss) which occurs more frequently permits for more lessons to be learnt on pathophysiological processes that can lead to mortality. An in-depth understanding of factors that contributes to both maternal near miss and death, permits identification of areas of weaknesses within the system and can assist with development of policies to improve maternal care.

Objective: To compare causes of maternal deaths and near misses at CHBAH.

Methods: A retrospective study was carried out at CHBAH, including all women who met the criteria for severe maternal outcome between January 2014 and December 2015.

Results: There were 62185 deliveries, and 307 cases of SMO (250 near misses and 57 maternal deaths) during the period of the study. The iMMR was 91.66/100 000 live births and the MNMR was 4.02/1000 live births. The mortality index was 18.57%. Medical disorders, hypertension, obstetric hemorrhage and non-pregnancy related infections were the main causes of death. The common causes of near miss was obstetric hemorrhage followed by puerperal sepsis. The commonest identification criteria of near miss was massive blood transfusion followed by ventilation not for anaesthetic reasons.

Conclusion:
This study showed hypertension, hemorrhage in gynaecology, venous-thromboembolism, medical disorders were more likely to be causes of death than near misses. Obstetric hemorrhage and puerperal sepsis were more likely to be the causes of near misses than causes of death. An important factor associated with death was no antenatal care.

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LIST OF ABBREVIATIONS

AIDS	Acquired Immuno-deficiency syndrome
ANC	Antenatal care
APH	Antepartum hemorrhage
ART	Antiretroviral therapy
CD4	Cluster of differentiation 4
CHBAH	Chris Hani Baragwanath Academic Hospital
CNS	Central nervous system
CPR	Cardio-pulmonary resuscitation
CTPA	Computed tomography pulmonary angiography
CXR	Chest x-ray
ECG	Electrocardiography
ECHO	Echocardiogram
FiO2	Fraction of inspired oxygen
GA	Gestational age
Hb	Haemoglobin
HIV	Human immunodeficiency virus
ICU	Intensive Care Units
iMMR	Institutional maternal mortality ratio
INR	International normalized ratio
LB	Live birth
LOC	Loss of consciousness
MD	Maternal death
MDG	Millennium development goals
MI	Mortality Index
MMR	Maternal mortality rate
MNMR	Maternal near miss ratio
MOU	Midwife Obstetrics Units
NCCEMD	National Committee for Confidential Enquiries into Maternal Deaths
NM	Near miss
NPRI	Non pregnancy related infections
RR	Respiratory rate

PAC	Pretoria Academic Complex
PaO2	Partial pressure of inspired oxygen
PPH	Postpartum hemorrhage
pTT	Partial thromboplastin time
PTLC	Potentially life threatening conditions
SA	South Africa
SDG	Sustainable Development Goals
SMO	Severe maternal outcome
SMOR	Severe maternal outcome ratio
SO2	Saturation of oxygen
TB	Tuberculosis
UEC	Urea, electrolytes, creatinine
UK	United Kingdom
VTE	Venous thrombo-embolism
WHO	World Health Organization

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CHAPTER 1

1. 1 INTRODUCTION

Every hour about 33 women worldwide die due to complications of pregnancy and childbirth, amounting to 289 000 women annually.[1] Almost 99% of these deaths occur in developing countries, thus within areas of low-resource settings and many of these could have been prevented.[1, 2] Despite the high maternal mortality ratios in developing countries, the occurrence of maternal deaths is uncommon in some institutions within these countries.[3] Maternal mortality is also low in developed countries.[1]

Detailed analysis of the determinants and risk factors associated with maternal mortality that are locally important may be determined by analyzing maternal morbidity. Maternal morbidity, commonly referred to as "near miss events" are more frequent, and therefore has gained popularity as an indicator of the quality of obstetric care.[1-3] Near miss cases and maternal deaths (MDs) together are referred to as severe maternal outcome (SMO).[2]

In 2007, the World Health Organization (WHO) established a technical working group comprising of obstetricians, midwives , epidemiologists and public health care professionals to develop a standard definition and uniform identification criteria for maternal near miss cases globally.[1,3]

In 2000, the United Nations established eight International Development Goals, with the aim of improving health systems globally. The fifth development was to improve maternal health – with two main areas: reduction of Maternal Mortality Ratio (MMR) by 75% and achieving universal access to reproductive health by the year 2015.[4]

In an attempt to reduce maternal mortality in South Africa (SA), SA made maternal death notification obligatory in 1997. This led to the establishment of the National Committee for Confidential Enquiries into Maternal Deaths (NCCEMD) which assesses each death and assigns the possible cause and states whether the death was avoidable or not.[5] The NCCEMD thereafter recommends possible ways of avoiding and reducing the probable

causes of these deaths. By 2015, SA still had not reached the MDGs target goal. MDGs have since been replaced by Sustainable Development Goals (SDGs).[6]

In SA, specific policy and guidelines have been put forward to examine and manage an obstetric ill patient, however there is no formal reporting of maternal near misses. This study is a comparison of women with a near miss and women who have died at a tertiary hospital in Gauteng.

1.2 LITERATURE REVIEW

1.2.1 Definition of Severe Maternal Outcome

Maternal mortality is defined as the death of a woman occurring during pregnancy or puerperium from any cause related to or aggravated by the pregnancy or its management. Maternal mortality is one of the health indicators which shows the greatest gap between developed and developing countries and remains a global concern.[1, 2]
Maternal mortality rate (MMR) represents the obstetric risk associated with each pregnancy and its one of the measures that is now being used to assess the quality of the health care system.[3]

Severe acute maternal morbidity commonly known as maternal near miss is defined "as a woman who survived severe life-threatening obstetric condition that occurred during pregnancy, labour or within 42 days after delivery". These are women who may have died if urgent medical interventions and proper hospital care was not given.[2, 3]

Methods of identifying what defines a near miss are summarized into following categories;

a) By defining clinical scenarios related to a specific disease (e.g. hypertensive disorder).
b) By illustrating a specific intervention required to remedy the event (e.g. admission to intensive care unit).
c) By defining organ system dysfunction (e.g. respiratory distress syndrome).

Table 1.1 WHO maternal near miss criteria[1]

Clinical criteria	Laboratory criteria	Management criteria
Acute cyanosis	SO_2 <90% for >60 minutes	Continuous use of vasoactive drugs
Oliguria unresponsive to fluids or diuretics	LOC with glucosuria and ketoacidosis	Puerperal hysterectomy due to infection or hemorrhage
Jaundice with Pre-eclampsia	Bilirubin > 6.0mg/dl	Transfusion of > 5 red pack cells
Respiratory Rate > 40 - <6 /min	PaO2/FiO2 < 200 mmHg	Dialysis for acute kidney failure
LOC and Stroke	pH < 7.1	Cardio-pulmonary resuscitation
Gasping Shock	Acute thrombocytopenia Platelets < 50 000	Intubation for > 60 minutes unrelated to anesthesia
Total paralysis	Lactate > 5	
Coagulation disorders	Creatinine >3.5mg/dl	

***LOC: loss of consciousness.* PaO2: partial pressure arterial oxygen. *FiO2: fraction of inspired oxygen. *pH: potential of Hydrogen**

As previously stated, MDs are few in categorical numbers as compared to near miss events, as such, in recent years this concept has attracted more interest because of its potential value as a supplementary maternal outcome measure to maternal mortality. Auditing of near miss events has the following advantages: [2, 3]

1. The increased number of near misses allows for more lessons to be learnt as compared to evaluating maternal deaths.
2. Maternal mortality and near miss usually share the same pathophysiological pathways, thus making it easier to learn from the latter.
3. Of importance is that both the health care workers and the patients can be interviewed independently on care offered and received respectively.
4. Differences in causes of maternal morbidity and maternal mortality may also show areas where an appropriate intervention has prevented death.

1.2.2 Severe maternal outcome and Sustainable Development Goals

By 2015 substantial improvement had been achieved globally in increasing life expectancy and reducing life time risk associated with child and maternal mortality and morbidity. However, the burden of severe maternal outcomes still remains high in South Africa and other developing countries. By 2015, only half of the women in developing countries had

access to health care, including minimal number of visits of antenatal clinic, skilled birth attendance and family planning.[6]
According to the United Nations Report on the MDGs 2015, between 1990 and 2015 the global maternal mortality had decreased by 45%.[4]

Since the MDGs goals had lapsed at the end of 2015, they have since been replaced by the Sustainable Development Goals (SDGs). The SDGs have 17 goals which are categorized into five areas: people, planet, prosperity peace and partnership. Of the 17 goals, only goal number 3 directly addresses health problems, including maternal and perinatal health concerns. Goal number 3 of the SDGs is to "ensure healthy lives and promote well-being for all at all ages". The aim is to reduce by the year 2030, the global MMR to less than 70 per 100 000 live births from the current rate of 210 per 100 000 live births according to the recent UNFPA report.[6]

1.2.3 The sequelae of severe maternal outcome

It can be expected that for each maternal mortality, there is a large number of women who survive but who will suffer from lifelong incapacitating disabilities. Long term adverse effects encountered by women with near misses include chronic anemias, genital prolapse and urinary incontinence, perineal tears and fistulas. Some of the women also suffer from depression amongst some of the disabilities related to maternal morbidity.[7]

In instances where the woman does not survive these complications, not only will her offspring and family suffer, but the community and society suffers as well. The long term consequences include financial instability, loss of supervision with resultant loss of education and increased mortality in her offspring. In an attempt to bridge the financial gap, most teenage children become the sole provider with resultant poor school enrollment and high dropout rates.[7-8]

In a study that was done in Matlab, Bangladesh from 1983 to 1987, it was made clear that children of age 0-9 years whose household experienced a loss of a mother were most likely to die than those who lost their fathers. Most of the deaths affected those children who were under one year, and female children were likely to die compared to male children.[7]

Between September 2011 and March 2012 Pande et al did an analysis on the consequences of maternal death in rural Kenya. It was found that more than three- quarters of the deceased women had more responsibilities within their families when healthy. After their deaths, these responsibilities fell primarily on the immediate and extended families. Most children had to be taken care of by their grandmothers.[7]

1.2.4 The Obstetric Population

Factors increasing the risk of pregnancy complications beyond the normal level of anticipated risk during pregnancy may be present in woman's past medical history long before she is pregnant. The women may also develop complications antenatally, in labour or in the postnatal period. Therefore, it is important to classify the obstetric population into low and high risk groups.[2, 5] This classification helps with providing focused antenatal care, thereby preventing poor outcomes (See Fig 1).

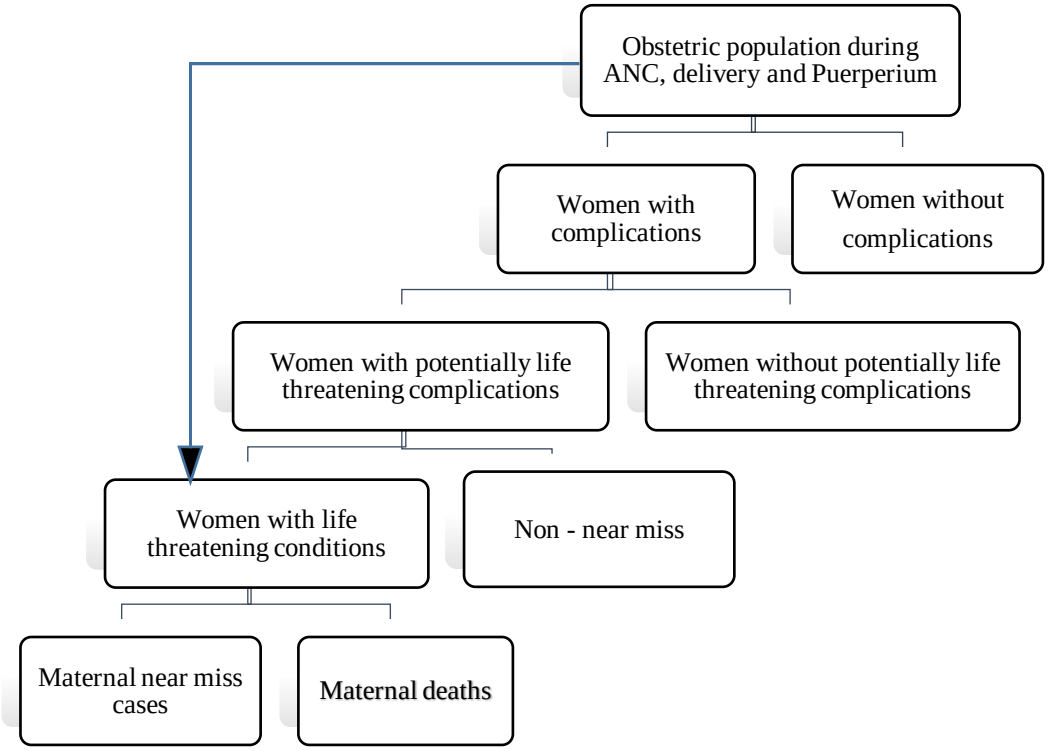

Fig. 1.1 The obstetric population[2]

1.2.5. The Role of Antenatal Care in preventing poor maternal outcomes

Antenatal care (ANC) is a cornerstone for a healthy pregnancy, labour and better maternal and fetal outcome. A further purpose of ANC is that of providing opportunities in preventing, diagnosing and treating conditions that can predispose a women to life threatening complications during pregnancy and /or parturition.[9]

Despite the widespread availability of free ANC services, late and infrequent antenatal clinic attendance still remains a major concern. Survey data from Sub-Saharan Africa indicate that most women only start attending antenatal clinic after their first trimester and do not achieve the number of antenatal clinic visits as recommended by WHO.[9] In some cases the delay in antenatal care may lead to a delay in detection of conditions that may arise during pregnancy and have a potential to increase the MMR.[9, 10]

In line with WHO research that maternal mortality and morbidity is closely related to avoidable causes, the department of health SA is now encouraging women to book early and to be seen eight times during their gravid period.[11]

In a more recent case control study, 2014 conducted in a tertiary hospital in Kenya it was found that poor ANC attendance is related to an increase in MMR. They further concluded that frequent antenatal clinic visits provides opportunities for identifying risk factors for eclampsia and other underlying conditions.[12] David et al also supports the educational role of antenatal clinic attendance in reducing severe maternal outcomes.[13]

Bergsjo et al highlighted that ANC alone cannot prevent SMO, he emphasized that an integrated level of medical care needs to exist for prevention of poor outcomes.[14]

A study that was done in Pretoria Academic Complex also brought forth issues related to ante-natal clinic visits. However they found that 60% of women who had a hypertensive crisis were booked but the hypertensive emergencies were not detected on time. This was closely related to the WHO protocol that they were following. Their study was performed in 2013 to 2014 when the number of recommended antenatal clinic visits was four. They then concluded that the current WHO protocol for ANC within their institution should be revised, so that women can be followed up more frequently.[15] The DOH has adopted the eight visits model in 2016.

1.2.6 Maternal age as a risk factor for poor maternal outcome

Parturition at extremes of ages is highly associated with adverse maternal and perinatal outcomes. Childbirth at young age, that is, less than 18 years, is a global concern to midwives and obstetricians. Maternal complications associated with teenage pregnancy include pre-eclampsia, eclampsia, anaemia and puerperal infections.[16, 17] As to why teenage mothers have higher rate of obstetric complications remains a topic for debate. Some studies site the young gynaecologic pelvis as an area of concern[16], and others studies emphasize demographic factors like low-socioeconomic status unmarried status and low level of education as serious contributing factors to these poor outcomes.[16, 17, 18]

Women who are above the age of 35, often have pre- existing medical conditions that increases their life time risk of developing complications during pregnancy.[19, 20]
These women unfortunately succumb to complications in pregnancy as they lack the physiological reserve as compared to younger patients.[20]

A multi-country study conducted in 29 countries in Asia, Africa, Middle East and Latin America, in 359 health facilities, illustrated that advanced maternal age increases the risk of maternal and perinatal poor outcomes.[19]
A cohort study in the United Kingdom that was carried out between 2003 and 2009 also came up with same conclusion that older women are more likely to suffer from co-existing diseases with resultant increased chance of poor outcomes.[20]

1.2.6 Obstetric related risk factors

1. Grand-multiparity:

The association between parity and SMO, has been well documented, where high parity was associated with increased mortality and morbidity.[20, 21] This finding is mostly seen in developing countries. Developed countries have lower MMR when compared to low socio-economic countries, as they have better access to contraception, ANC and adequate facilities that allows for safer delivery. In other studies they cited that high pregnancy numbers and short inter-pregnancy interval were associated with poor outcomes as a result of anemia, hypertension, mal-presentation and postpartum hemorrhage due to uterine atony and rupture.[21]

2. Mode of delivery - caesarean section

The relationship between caesarean delivery and maternal mortality is complicated. Historically caesarean sections were performed to prevent maternal deaths and perinatal deaths, and in recent years they are performed also to prevent maternal and perinatal morbidity. Deaths in women undergoing caesarean section may be a result of complications related to the caesarean section or the indication itself, such as eclampsia. [22]

Repeat caesarean sections are associated with placenta praevia, morbidly adherent placenta, and adhesions which increases the risk of bleeding. Hysterectomy rates also increases in patients delivered by caesarean section.[23] According to the Saving Mothers report (2011-2013), caesarean delivery rate was 23% and over 67% in the private sector. The report showed that the MMR in the public sector was three times higher in women who had operative delivery in comparison to those who had a vaginal delivery and/or assisted delivery.[24] Bleeding at caesarean section accounted for 222 maternal deaths in that period.[5, 24]

Pattinson concluded that incorrect indications for caesarean sections and the dying skills of assisted delivery are some of the contributing factors to increased caesarean section rate.[24]

In a population based case control study that was conducted in eight Brazilian states between 2009-2012, after controlling for indication bias and confounders, it was found that the risk of postpartum maternal death post caesarean delivery was three fold higher compared to vaginal
delivery.[22]

1.2.7 Impact of co-existing medical conditions on maternal outcomes.

Pre-conception care for women with medical disorders is ideally warranted. Although relatively few medical conditions can prevent pregnancy, most of them can complicate it, and can influence the mother's health even after parturition. Therefore preconception care of these women is emphasized.[10]

A study that was done in the UK found that medical co-morbidities increases the life time risk of death during pregnancy. Out of the 135 patients who died in that study population, medical disorders contributed to 49% of the poor outcome.[25]

Pre-existing diabetes and chronic hypertension are common in pregnant women especially in older women and with higher parity.[20] Cleary-Goldman et al illustrated a higher incidence of medical disorders amongst grand-multiparous women.[26] Anemia in pregnancy was also found to be a significant finding in these women with poor outcomes.[27] According to the Saving Mother's report 2011-2013, medical and surgical conditions had more than doubled since 2002-2004. The leading cause of death in this category was cardiac diseases followed by respiratory related conditions. Most of the women who had respiratory problems tested positive for the Human immune deficiency virus (HIV) and had Tuberculosis (TB).[5]

The spectrum of cardiac disease and feto-maternal outcome was assessed in a retrospective study that was done in Pretoria Academic Hospital between January 2002 and December 2005. It was found that nearly 1% of women who delivered at Pretoria Academic Hospital had an underlying cardiac abnormality, mostly as a result of childhood Rheumatic heart disease. Increased morbidity and mortality was strongly associated with patients who developed pulmonary edema.[28]

HIV infection is a major contributing factor to maternal mortality and morbidity.[29, 30]
In many developing countries, women of reproductive age are unknowingly living with HIV, the majority of them only learn of their status during pregnancy. Most of these women are in Sub-Saharan Africa, at an estimated number of more than 12 million.[30]
In 2015, global estimates of HIV/AIDS related maternal deaths were estimated at 1.6%. In Africa, five countries including SA had 10% or more of MDs related to HIV: SA (32%) Swaziland (19%), Botswana (18%), Lesotho (13%) and Mozambique (11%).[4]

In 2013, The National Antenatal Sentinel HIV survey reported an HIV prevalence of 30% amongst pregnant women in SA. The Saving Mothers Report 2011-2013 reported HIV as the most common underlying infection associated with MD. Of the total number of MD, 87% were tested and 65, 3 % were found to be positive.[31]
Maternal deaths in HIV positive women arise from both direct and indirect causes. Non-pregnancy related infections (NPRI) including TB, pneumonia, and meningitis are important causes of morbidity and mortality in these women.[30, 32, 33]

The direct causes of death commonly seen are those related to puerperal sepsis, especially after caesarean delivery.[32,34] These women have a two to ten times increased risk of developing puerperal sepsis and an increased risk of dying due to sepsis as compared to uninfected women.[30,32,34]

Hargrove et al conducted a study in Zimbabwe on Mortality among HIV positive postpartum women with high CD4 count, they concluded that of CD4 count some of the women still had increased mortality.[34] This increased mortality was also influenced by factors such as physiological changes in pregnancy, increased metabolic demands during parturition and poor accessibility to health care.[34]
Buchmann et al found that advanced maternal age and anaemia in pregnancy were also a common finding in HIV infected pregnant women and contributed significantly to poor outcomes of these mothers.[29]

1.2.8 Avoidable factors in the prevention of severe maternal outcome

When reviewing women with SMO, it is of paramount importance to look at avoidable factors that might have contributed to the unpleasant outcome. These factors determines whether a woman will have accessibility to the necessary care to save her life. These factors include patient related challenges, health worker and health system related obstacles.[13, 35]
In 1994, Thaddeus and Maine came up with a stepwise model that simplifies reasons why women get delayed in accessing treatment. They divided this model into following categories: [36]

- Delay in making decision to seek appropriate care due to:
  - Poor understanding and inability to recognize complications and when to seek for help.
  - Reluctance to seek help influenced by previous treatment by health care worker.
  - Cultural beliefs also plays a role in some communities, where traditional healers are still preferred to western medicine. [36]

- Delay in reaching appropriate care facilities:

- Factors that have been implicated, include distances between community health centers and hospitals, availability of transport and geographical and/or poor roads conditions.[13, 36]

- Delay in receiving adequate care at place of referral:
- Once the patient has reached the place of care, it has been illustrated that more challenges can still be encountered.
- In most developing countries the hospitals are over- crowded, with minimal number of health care workers who are also poorly motivated due to being over worked.
- Other contributing factors, include lack of medical supplies and availability of blood products.[36]

According to the Saving Mothers Report 2011-2013, there has been a decline in maternal deaths in SA. However 60% of the deaths were preventable and these were related to poor quality of care at antenatal clinic level, during labour and within the puerperium. After that review, the NCCEMD decided to continue with the previous recommendation. The previous recommendations were related to HIV, obstetric hemorrhage and complications of hypertension that contributed significantly to MDs. Challenges within the health system were also emphasized as part of preventable factors contributing to MDs. However to further strengthen the previous recommendation, they also emphasized community involvement as part of the strategies to reduce MDs.[5]

1.2.9 Trends in Maternal Mortality and Morbidity

The number of women who died each year from complications of pregnancy and childbirth has declined from 523 000 in 1990 to 289 000 in 2013 worldwide. This reflects a downward trend of 45% in the global maternal mortality ratio: from 380 deaths to 210 deaths per 100 000 live births.[4,37] Quoted figures shows that most deaths occur in developing countries, reflecting inequalities in access to health services and highlights the gap between the rich and poor. In Africa the numbers are still unacceptably high, with sub-Saharan Africa taking the lead at 510 deaths per 100 000 live births with a lifetime risk of maternal deaths of 1:38. Table 1.2 below, illustrates changes in maternal mortality in specific areas between 1990 and 2013.

Table 1.2 Maternal mortality in specific regions: 1990 – 2015 [4]

Region	1990		2015	
	MMR	MD	MMR	MD
World	380	523 000	216	303000
Developed regions	26	3900	12	1700
Developing regions	430	519 000	239	302 000
Sub-Saharan Africa	990	222 000	546	201 000
United Kingdom	10	80	9	74
South Africa	150	1600	140	1500
Botswana	360	170	170	83
Mozambique	1300	8000	480	4800
India	556	152000	174	45000
Nigeria	1350	57000	814	58000

***MD: maternal deaths *MMR: maternal mortality ratio**

According to the Confidential Enquiries into maternal deaths in SA the mortality ratio decreased from 176/100 000 births in 2008-2010 to 154/100 000 births in 2011-2013. South Africa still has a long way to go in achieving the international commitment to decrease maternal mortality to 70 deaths per 100 000 live births.[4, 6]

Table 1.3 Trends in iMMR per province 2011-2013(South Africa)[5]

Province	**Maternal deaths**	**Live Births**	**iMMR**
Eastern Cape	593	362 313	163.67
Free State	281	144 373	194.63
Gauteng	849	613 725	138.34
KwaZulu Natal	964	563 446	171.09
Limpopo	750	381 034	196.83
Mpumalanga	399	227 304	175.54
North West	292	173 037	168.75
Northern Cape	110	63 752	172.54
Western Cape	214	281 602	75.99
South Africa	**4452**	**2 812 597**	**154.06**

***iMMR: institutional maternal mortality ratio**

The prevalence of maternal near miss is now being documented in many hospitals. Irrespective of the WHO standardization of the definition of a maternal "near miss", there still exists a wide variation in defining maternal near miss in developing and developed countries. This can be attributed to disparities between low and high socioeconomic circumstances and availability of resources including high care dependency areas.[38, 39, 40]

The criteria used to define near misses influences the rates. A recent systematic review, showed a higher prevalence rate for near misses when disease specific criterion was used (with a rate of between 0.6-14.98). The prevalence of near misses when organ based and management based criteria was used, was between 0.14 - 0.92 and 0.04 -4.54 respectively. Irrespective of the criteria used to determine the rates of near misses, the rates were higher in low and middle income countries than in high income countries.[41]

1.2.10 Causes of maternal mortality and morbidity

More recently the WHO provided estimates of maternal deaths globally. The analysis revealed that 75 % of complications were due to: hemorrhage (with more than two thirds classified as postpartum hemorrhage), puerperal sepsis, and hypertensive disorders (including pre-eclampsia and eclampsia) and unsafe abortions. [37]

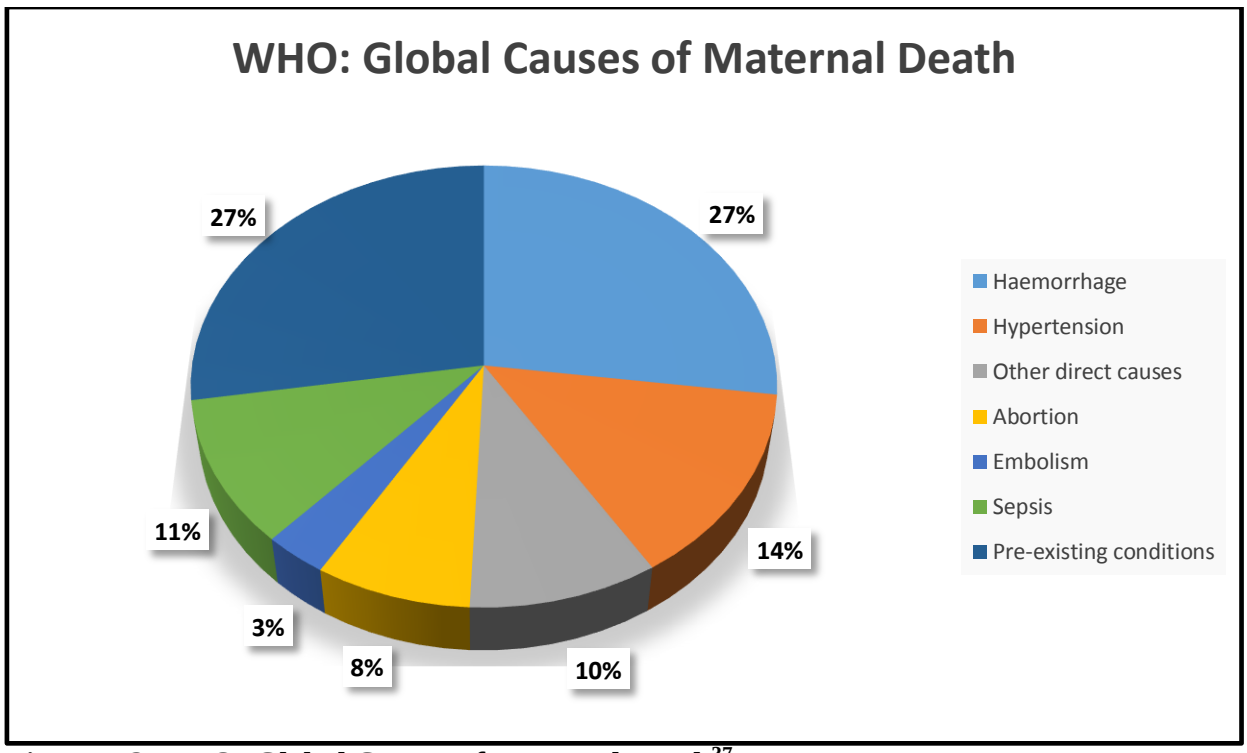

Figure 1.2 WHO: Global Causes of Maternal Death[37]

According to Saving Mothers Report, recent data shows that the leading causes of mortality in SA are as follows:

- Direct causes: Obstetrics hemorrhages (including bleeding at caesarean section), hypertension and pregnancy related infections.
- Indirect causes: NPRI including HIV and its complications, other medical and surgical conditions.[5]

Table 1.4 Causes of Maternal Death SA (2011-2013) [5]

Cause of death	Year: 2011-2013
Direct	49.7%
Obstetric hemorrhage	15.8%
Hypertension	14.8%
Pregnancy related sepsis	5.2.%
Miscarriage	4.3%
Ectopic pregnancy-	2.4%
Anaesthetic Complications	2.4%
Embolism	2.4%
Acute collapse	2.5%
Hyperemesis gravidarum	0.1%
Indirect	46.1%
NPRI	34.7%
Medical and surgical disorders	11.4%
Unknown	4.2%

According to this latest report, complications related to hypertensive disorder and sepsis had dropped, however an increasing trend was seen with obstetric hemorrhage and early pregnancy loss. Although there was a significant drop in deaths due to NPRI, this group still remained the largest category. The decreasing trend in women dying from NPRI could be attributed to the increase in roll out of anti-retroviral therapy (ART).[5]

Maternal death is by far the worst maternal outcome, with recent increased global focus on maternal morbidity, more studies are being done to assess maternal near miss as a surrogate to maternal deaths.[20, 38, 41]

Table 1.5 summarizes some of the studies that were reviewed for this research, hemorrhage was found as a common cause of near miss. The study setting in these studies was taken as it was in the publications**.**

Table 1.5 Summary of near miss studies according to criteria used

Study/year	Country	Study setting	Criteria Used	Common causes of near miss
Mantel[42] 1998	South Africa	Tertiary	Organ systems dysfunction	Hemorrhage/ hypertension/ sepsis
Basket [43] 1998	Canada	Tertiary	Management based	Hypertension/ hemorrhage/sepsis
Gebrehiwot[44] 2011-2012	Ethiopia	Regional	Facility based	Obstructed labour/Hemorrhage
Norhayati[45] 2014	Malaysia	Tertiary	WHO	Hemorrhage
Roopa[46] 2014	India	Tertiary	WHO	Hemorrhage
Nakimuli[47] 2014	Uganda	Referral	WHO	Preeclampsia/Hemorrhage
Kalisa[48] 2014	Rwanda	Maternity ward	Facility based	Hemorrhage/ hypertension
Jayaratnam[49] 2014-2015	Australia	Provincial	WHO modified	Pre-eclampsia/Hemorrhage
Soma-Pillay[50] 2016	South Africa	Tertiary	WHO	Hemorrhage/hypertension
Liyew [51] 2016	Ethiopia	Referral	WHO based	Preeclampsia/incomplete abortion

The causes of near miss differ widely according to geographical distribution. In developing countries approximately one percent of the pregnant women suffer from near misses and only 0.25 % percent of pregnant women in developed countries will suffer from such poor outcome. These rates were found when organ based criteria were used in identifying near miss cases.[41]

Obstetrics hemorrhage, hypertensive disorders, sepsis and obstructed labour are the common causes of maternal near misses in developing countries. Other contributing factors include anaemia in pregnancy.[38, 41]

Fillipi et al conducted a study in Benin, Morocco and Cote d'lvoire, it was found that near miss events are a common occurrence in some African hospitals. Near misses cases were found to be 15 times more when compared to deaths, the near miss/ death ratio ranged from a ratio of 9:1 to 108:1. The common causes of near miss cases in this study were hemorrhage and hypertensive diseases of pregnancy, with sepsis as the least common cause.[52]

An in depth review of all maternal near misses and MDs in an Ethiopian facility that occurred between May 2011 and October 2012, also concluded that hypertensive disorders and obstetric hemorrhage were a frequent occurrence in women with SMO. Obstructed labor and sepsis were also relatively common.[44]

There are few studies on maternal near misses within South African institutions. Recently a study at Pretoria Academic Complex assessing the spectrum of severe maternal outcomes was conducted from the 1st August 2013 to July 2014. They found that the most common underlying conditions were severe pre-eclampsia and obstetric hemorrhage.[50]
A cross-sectional study was conducted at Chris Hani Baragwanath Academic Hospital (CHBAH) to determine the causes of maternal mortality and estimate the MMR in greater Soweto. The study reviewed maternal deaths from 1997 to 2012, there were 479 deaths in that study period. The iMMR was 139/100 000 LB in 2004 and had decreased to 86/100 000 LB in 2012. The most common cause of MDs was NPRI such as HIV, followed by hypertensive diseases and obstetric haemorrhage.[29]

In the UK, sepsis was the leading cause of maternal deaths. Indeed, according to a case study that was conducted between 2011 to 2012 it was found that sepsis is increasing in frequency. In this study 365 women with sepsis were identified, of these women 18% had septic shock and survived.[53] Alongside sepsis, medical comorbidities were associated with direct obstetric mortalities in other developed countries [25,53]

1.3 The research problem.

The MMR at CHBAH and in several institutions in SA has indicated a decreased trend. One of the main reason for this downward trend is the introduction of ART in all pregnant women. Other factors such as blood availability, a multi- disciplinary team with intensivist, cardiologists, internists and anaesthetists may also be contributing to the decreased MMR**,** however an increase in the number of women with "near misses" has been observed. The causes of near misses need to be established.

1.4 Justification

CHBAH is a tertiary hospital with the largest maternity department in Johannesburg, serving the greater Soweto area and also provides referral services for surrounding district hospitals. However, it still lacks a dedicated intensive obstetric care unit. In doing a study

of this nature, it may help identify areas with deficiencies within our maternity department, and also permits the developments and/or amendment of protocols. This may provide relevant information to policy makers in order to provided strategies to reduce severe maternal outcomes.

1.5 The objectives of the study

The main aim of this study was to compare causes of maternal deaths and maternal near misses at CHBAH between January 2014 and December 2015.

The specific objectives were:

- To describe all women with a severe maternal morbidity or mortality at CHBAH (demographic features, ANC factors/ labour factors/ postpartum course)
- To describe the causes of maternal deaths
- To describe the causes of maternal near misses
- To compare the causes of maternal deaths and near miss.

CHAPTER 2

2. 1 METHODOLOGY

2.1.1 Study setting and population

Soweto has a population of more than 1.5 million people and 50% of these are women.[54] CHBAH is a tertiary hospital which serves the Soweto area in the southwestern parts of the city of Johannesburg. CHBAH was a referral hospital for seven Midwifery Obstetrical Units initially and after April 2014, three of the seven referred to Bheki Mlangeni district hospital. Bheki Mlangeni refers level 2 and level 3 patients to CHBAH.

CHBAH is also a referral center for Sebokeng hospital and Thelle Moegoerane which are regional hospitals. Referrals to CHBAH from these hospitals is uncommon and are mainly for specialized services like obstetric cardiology and obstetric endocrinology. Referral from the North West Province are also for specialized services.

About 5% of births at CHBAH occur in women referred from such areas (according to departmental statistics in 2012). Therefore, women from Greater Soweto make up about 95% of hospital births.

The study population included all maternal deaths and women who were classified as having had a Near miss seen at CHBAH from January 2014 to December 2015.

2.1.2 Study design

This was a cross-sectional retrospective- study of women who had died or who were classified as a near miss.

2.1.3 Sample size

A sample size was not calculated, all cases managed during the study period were included.

2.1.4 Inclusion criteria

- All pregnant women (up to 42 days post-delivery) who died between January 2014 and December 2015.
- All pregnant women (up to 42 days post-delivery) who met the institutional criteria for being a near miss from January 2014 to December 2015

2.1.5 Exclusion criteria

- All women without complications.

2.1.6 Variables that are recorded in the database

2.1.6.1 Explanatory variables:

- Age.
- Parity.
- Gravidity.
- Gestational age at booking.
- Antenatal attendance.
    - Number of visits.
    - Late booking: booking at gestational of more than 20 weeks.
    - ANC location.
- Booking bloods.
    - Haemoglobin, HIV, RPR, Rh.
- HIV (if positive)
    - CD4 count.
    - ART (yes/no)
- Antenatal risk assessment
- Co-morbidities
    - Hypertension: hypertension diagnosed before 20 weeks of pregnancy.
    - Diabetes: pre-gestational diabetes.
    - Asthma.
    - Epilepsy.
    - Cardiac disease.
    - Others.
- Previous obstetrics history.
    - Hypertension.
    - Antepartum hemorrhage.
    - Postpartum hemorrhage.
    - Previous caesarean section.

- Timing of referral.
  - ANC.
  - First stage of labour.
  - Second stage of labor
  - Third stage of labour.
  - Puerperium.
- Mode of delivery
  - Normal vaginal delivery.
  - Assisted vaginal delivery.
  - Caesarean section.
- Complications during delivery
  - Induction of labour.
  - Augmentation of labour.
  - Prolonged rupture of membranes.
  - Preterm labour.
  - Failed assisted delivery.
- Patient related factors.
  - Delay in seeking help.
  - Infrequent ANC attendance (less than 4 ANC visits).
  - Late ANC booker (booked after 20 weeks).
  - Declined medical / surgical help.
- Health worker related factors (as documented in patient file).
  - Inappropriate initial assessment (e.g. missed diagnosis of uterine rupture).
  - Delay in assessment.
  - Delay in receiving appropriate care
  - Monitoring problems (no use of partograms/ delays in reviewing patients).
  - Substandard care (included cases with inappropriate initial diagnosis and care thereafter).
- System related factors.
  - Availability of ambulance.
  - Availability of theatre (prolonged waiting period of more than 1 hour).
  - Availability of ICU.
  - Availability of blood products.

- Complications
    - Respiratory dysfunction : based on clinical findings/ CXR findings/ CTPA or VQ scan findings
    - Cardiovascular dysfunction: based on clinical findings/ECG findings and ECHO findings
    - Sepsis: clinical findings and blood findings
    - Disseminated Intravascular coagulopathy: based on clinical and blood findings
    - CNS dysfunction: based on clinical findings and CT findings
    - Multi-organ failure: involvement of one organ or more

2.1.6.2 Outcome variables:

- Maternal Death (MD): death of a woman while pregnant or within 42 days of delivery -cause as determined at departmental mortality and morbidity meeting.
- Maternal mortality ratio (MMR): the number of maternal deaths per 100 000 live births.
- Live births (LB) refers to birth of an offspring which shows evidence of life.
- Maternal Near Miss (MNM) refers to a woman who nearly died but survived pregnancy- related complications during pregnancy, childbirth and within puerperium.
- Near miss criteria (facility based criteria used).
    - Massive blood transfusion.
    - Relook laparotomy.
    - Ruptured uterus.
    - Renal dialysis.
    - ICU admission.
    - Ventilation not for anaesthetics reason.
- Cause of the near miss refers primary cause of chain of events that lead to a life-threatening complications as determined by the researcher.
- Maternal near miss ratio (MNMR) refers to the number of maternal near-miss cases per 1000 live births.
- Maternal near-miss mortality ratio refers to the ratio of MD to that of MNM.
- Severe Maternal Outcome Ratio (SMOR) refers to the number of MD and MNM

- Mortality Index (MI) refers to the number of maternal deaths divided by no of women with severe maternal outcome expressed as a percentage.

2.2 Data Collection and Sources

Near miss cases were retrospectively identified. The maternity admissions books, theatre register, Intensive Care Unit register, labour ward register, and High Care Area registers were scrutinized for women with potentially life threatening conditions (PTLC). Women whose admission diagnosis met the defined criteria and those with possibilities of having a PTLC were retrieved. Where the theatre register noted a procedure longer than 90 minutes, these files were also retrieved so that we did not miss any cases. . Overall 800 files were retrieved from the obstetrics filing department for review. Maternal deaths files were obtained from the HOD's office where they are kept. An in-depth review of each case was carried out.

For each case, data was entered on to a data sheet that was developed for the purpose of the study. Study data were collected and managed using REDCap electronic data capture tools hosted at the University of Witwatersrand. Data was then exported Stata 14 (StataCorp, 4905 Lakeway Drive College Station, Texas 77845 USA) for analysis.
The study data sheet is attached as Appendix A.

2.3 Data Analysis

All categorical variables were described using frequencies and percentages. Continuous variables were described using means with SD and median with IQR and ranges. Comparisons of categorical variables was made using the Chi- squared or Fisher's exact test. Continuous variables were compared using the t-test or Kruskal-Wallis tests. A p-value of <0.05 was considered to be significant.
The denominator for the iMMR, MNM rates and SMO rates was made using the live-birth data for CHBAH, Bhekhi Mlangeni, Chiawelo MOU, Stretford MOU, Lillian- Ngoyi (MOU), Mofolo MOU, Zola MOU, Lenasia South MOU, Iterileng. Hospital statistics show that referrals from regional hospitals accounted for 5% of births and approximately more than 1% of births are home births. We did not include the live-births from regional hospitals that refer to CHBAH.

2.4 Ethics

Acceptable ethical protocols and patient confidentiality was maintained throughout the study.

The study was approved by Human Research Ethics Committee (Medical) for the University of the Witwatersrand and permission to access patients" files was granted by the CEO of CHBAH. These are attached as Appendices B and C.

2.5 Funding

The study was funded by the researcher.

CHAPTER 3

3.1 RESULTS

The first section of this chapter will outline the way the cases were identified. The subsequent sections will describe the causes of deaths, followed by a description of the causes of near miss. A comparison of antenatal factors, comorbidities and pregnancy related complications, labour factors and interventions offered between women who died and women who had a near miss will then be made.

The flow diagram below explains the collection of the cases.

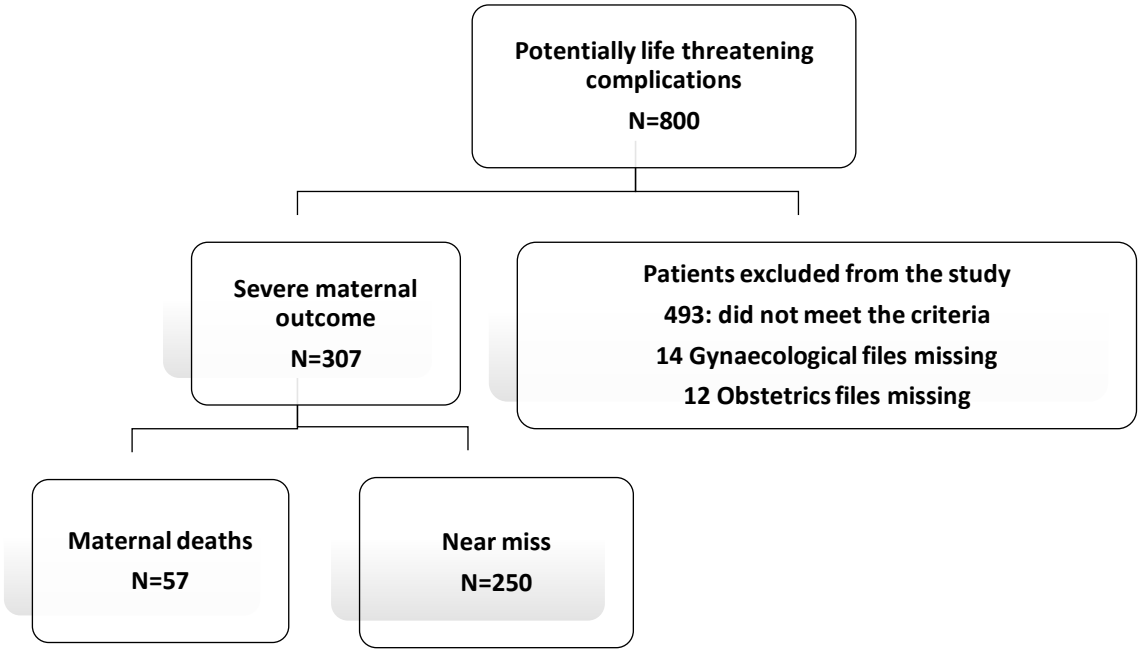

Figure 3.1 Flow diagram showing included and excluded study population

3.2 STUDY POPULATION

There were 307 severe maternal outcomes (57 maternal deaths and 250 near misses) between January 2014 and December 2015. The total live-birth rate for CHBAH, Bheki Mlangeni and the 7 MOU's that directly refer to us was 62 185. The iMMR was 91.66/100 000 live births.

The mortality index was 18.57%. The maternal near miss ratio was 4.02 per 1000 live births, whereas the SMO ratio was 4.93 per 1000 live births.

3.2.1 Maternal deaths and Near misses

The causes of death in order of frequency were medical disorders (n=13; 22.81%), complications of hypertension in pregnancy (n=12; 21.05%), obstetric hemorrhage (n=9; 15.79%) and non-pregnancy related infection mainly HIV (n=9; 15.79%) contributed equally to MDs. The latter were followed by puerperal sepsis (n=7; 12%), gynae-related bleeding (n=5; 8.77%) and venous thrombo embolic events (n=2; 5%)

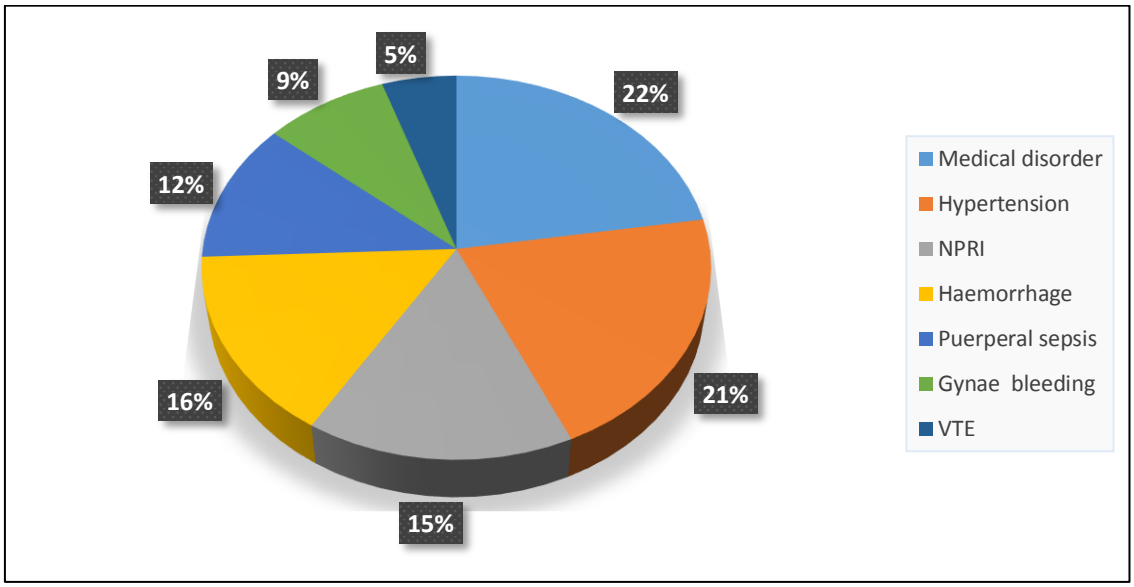

Figure 3.2 Causes of maternal deaths at Chris Hani Baragwanath Academic Hospital

The commonest criteria used to identify near miss cases in this study was massive blood transfusion followed by ventilation not related to an anesthetic reason. In this study, the number of units of red cell concentrate received by patients to qualify as a near miss was 4 within the first 24 hours of onset of near miss event. We had more than 10% of patients who had a ruptured uterus and renal dialysis as an identification criterion. The number of near misses according to identification criteria are tabulated in the following table.

Table 3.1 A Description of the types of near misses

Reason for Near miss	
Massive blood transfusion.	122 (48.80%)
Re-look laparotomy	82 (32.80%)
Ruptured uterus	15(6%)
Hysterectomy	59(23.60%)
Renal dialysis	12(4.80%)
ICU admission	83(33.20%)
Ventilation	114(45.60%)

The number does not add up to the total number of near misses because some women will have had more than one near miss criteria.

In this study the main cause of maternal near miss was obstetric hemorrhage followed by puerperal sepsis. Comparison of the causes of near miss and maternal deaths is illustrated in table 3.2.

Table 3.2 Comparison of the causes of near misses and maternal death

Diagnosis	**Maternal deaths n=57**	**Near Misses n=250**	**p-values**
Direct Obstetrics causes			
Hypertensive disorders	n=12 **iMMR(19.29)**	n=32	0.11 ***
Chronic Hypertension	1(1, 75%)	2(0.80%)	
Pre-eclampsia	3(5.26%)	13(5.20%)	
Eclampsia	8(14.04%)	17(6.80%)	
Obstetric Hemorrhage	n= 9 **iMMR(14.47)**	n=138	0.00 **
Atonic uterus	5(8.77%)	46(18.4%)	
Abruptio placentae	3(5.26%)	33(13.2%)	
Other PPH[8]	1(1.75%)	57(22.8%)	
Gynaecological related bleeding	5(8.77%) **iMMR(8.04)**	2(0.80%)	0.00**
Puerperal sepsis	7(12.28%) **iMMR (11.25)**	44(17.6%)	0.00**
Indirect Obstetrics causes			
VTE [8]	3(5.26%) **iMMR(4.82)**	0	Not calculated
Medical disorders	n=13 **iMMR(20.91))**	n=32	0.05***
Cardiac disorders	6(10.53%)	18(7.20%)	
Diabetes	1(1.75%)	3(1.20%)	
Other medical disorders	6(10.35%)	11(4.40%)	
NPRI [8]	9(15.79%) **iMMR(14.47)**	2(0.80%)	0.00 **
Anesthetic related	0	2(0.80%)	0.00 **

Other PPH*(uterine rupture and bleeding at caesarean section) VTE* (venous thrombo-embolism) NPRI (non-pregnancy related infections)
Fishers Exact Chi-squared*****

3.2.2 Antenatal factors

The table 3.3 below, summarizes the antennal factor for the entire population and then compares the variable in women who had died versus those that had a near miss.

Table 3.3 A comparison of antenatal factors between maternal near miss and maternal deaths

Antenatal Factor¥	**Near miss n=250 (81.43%)**	**Death n=57 (18.57%**	**p-value**
Median age 30 [(IQR 25-35); 15-51]	30 [(IQR=25-35); 15-45]	29[(IQR 25-35); 17-51]	0.64*
Median parity 1 [(IQR 0-2); 0-7]	1 [(IQR 0-2); 0-7]	1[(IQR 0-2); 0-7]	0.86*
Median Gravidity 2.5[(IQR 1-4);1-7]	2 [(IQR 2-3); 1-7]	3 [(IQR 1-4); 1-7]	0.64*
Booked Status			
Unbooked n=28 (10.45%)	10(4.61%)	18 (35.29%)	0.00**
Booked n=240 (89.55%)	207 (95.39%)	33 (64.71%)	
Median number of ANC visits 4[(IQR=3-5; range- 1-10)]	4 [(IQR 3-5); -1-10)]	3 (2-4; 1-8)	0.16*
Place of ANC attendance (n= 233 women)			
Midwife care n=135 (57.94%)	110(55.00%)	25(75.76%)	0.04**
Hospital-based care n=96 (41.20%)	88(44.00%)	8(24.24%	
Private care n=2(0.86%)	2 (1.00)	0 (0.00%)	
Antenatal risk assessment (n=236)			
Low risk n=91 (38.56%)	78 (38.42%)	13 (39.39%)	0.91***
High risk n=145(61.44%)	125(61.58%)	20 (60.61 %%)	
Supplements at ANC (if booked)			
Received supplements n= 223 (83.96%)	190 (88.48%)	33 (64.71%)	1.00**
Did not received supplements n=5 (2.19%)	5 (2.56%)	0	
Median GA= 20 [(IQR=14-25; range= 3-40)]	20 [(IQR 15-250); -3-40]	20 [(IQR 14-230) ;5-33]	0.68*
Blood results at booking			
Median Haemoglobin n= 11.45 [(IQR=2-12.5) range 5.3-16.7)]	11.4[(IQR10.2-12.4);5.30-16.70]	11.6[(IQR10-12.80); 8.60-15]	0.84*
RPR result n=289 (94.14%)			
RPR positive n=9 (3.11%)	7 (2.89%)	2 (4.26%)	0.64**
Rh status n=288 (93.81%)			
Rh negative n=9 (3.11%)	7 (2.89%)	2 (4.26%)	0.64**

¥the total population *Kruskall-WallisFishers Exact***Chi-squared**

3.2.3 HIV status

The HIV status was known in 290 (94.46%) women. Women who died were more likely to be HIV positive or had an unknown HIV result. The median CD4 count was 295 cells per cubic millimeter (cells/µL) (IQR=192-516; range=19-1411). The CD4 count was known in 99 (84.62%) of the HIV infected women. Thirteen women had not been using ART. We did not know about ART usage in eight (6.84%) patients. The difference in HIV status and HIV related factors are shown in table 3.4.

Table 3.4 A comparison of HIV related factors in women with a near miss and women who died.

HIV related factors	Near Miss n=250	Death n=57	p-value
HIV negative n=173 (59.66%)	152 (60.80%)	21 (36.84%)	0.00**
HIV positive n=117(40.34%)	89 (35.60%)	28 (49.12%)	
HIV unknown n=17 (5.54%)	9 (3.60%)	8(14.04%)	
Median CD4= 295(cells/µL) (IQR 192-516; 19-1411)	303 (192-500; 27-1411)	278.5 (178-536; 19-718)	0.76*
Use of ART n= 108 women			
Using ART n= 96 (87.96%)	77 (88.51%)	18 (85.71%)	0.71**
Not using ART n=13 (12.04)	10 (11.49%)	3 (14.29%)	

***Kruskall-Wallis **Fischers' exact test**

3.2.4 Previous Obstetric History

There were 18 (5.86%) women with a history of hypertension in a previous pregnancy, six (1.95%) with a previous antepartum hemorrhage (APH), two (0.65%) with a postpartum hemorrhage (PPH) and 71 (23.13%) with a previous caesarean section. There was no statistically significant difference for a previous APH, or hypertension in the two groups. More women had a history of a previous caesarean section in the women who had a near miss than in the women who died: 64 (25.60%) vs seven (12.28%); (p=0.036).

3.2.5 Referrals

Table 3.5 below shows the time in pregnancy that the women were referred. There were more women who died that were referred in the antenatal period (not in labour). There were 21(6.84%) women who were self-referred and there was no statistically significant difference in those who were a near miss and in those who died 19 (7.60%); 2(3.51%) p-value =0.39

Table 3.5 A comparison of the time in pregnancy that the referral occurred between Near Miss and Maternal Deaths

Referral in pregnancy	**Near miss n= 250**	**Death n=57**	**p-value**
Time in pregnancy when referred n=301			
ANC	122 (49.39%)	38 (70.37%)	0.01**
1st stage of labour	76 (30.77%)	5 (9.26%)	
2nd stage of labour	3 (1.21%)	0 (0%)	
3rd stage of labour	3 (1.21%)	1 (1.85%)	
Puerperium	43 (17.41%)	10 (18.52%)	

Fischer's exact**

3.2.6 Delivery

There were 282 (91.86%) women who were delivered, 199 (70.57%) were delivered by caesarean section and 83 (29.43%) were delivered vaginally. Amongst the assisted vaginal deliveries there were three vacuums and one forceps delivery. There were two women with a failed assisted delivery and both of these were in the near miss group. Four women had laparotomies for extra-uterine pregnancy, seven were ectopic pregnancies and five were undelivered. In addition, they were two women who had hysterotomy, one woman who had surgical termination of pregnancy and six other women who had evacuation for incomplete miscarriages. Mode of delivery was statistically significantly different in the women who had a near miss and the women who died as shown in Table 3.6. The labor related factors were only relevant in 282 pregnancies.

Table 3.6 A comparison of labour-related factors in women who had a near miss and in women who died

	Near miss	Death	p-value
Mode of delivery(n=282)			
Vaginal delivery n=83(29.43%)	64 (26.23%)	19 (50%)	0.00 **
Caesarean section n=199(70.57%)	180 (73.77%)	19 (50%)	
Labour related factors (n=282)			
IOL n=30(10.64%)	25 (10.42%)	5 (14.71%)	0.39 **
Prolonged labour n=25(8.14%)	24 (9.60%)	1 (1.75%)	0.59 **
Augmentation of labor n= 27 (9.57%)	23 (9.20%)	4 (7.02%)	0.78 **
Prolonged ROM membranes n=10 (3.55%)	9(3.60%)	1 (1.75%)	0.70**
Failed assisted delivery n=2 (0.71%)	2 (0.80%)	0 (0.00%)	1.00 **
Preterm Labour n=14 (4.96%)	11 (4.40%)	3 (5.26%)	0.73 **
Neonatal outcome(n=286)			
Live- births n=215(75.17%)	191 (77.33%)	24 (61.54%)	0.03**
IUFD n=71(24.83%)	56 (22.67%)	15 (38.46%)	

Fishers Exact**

3.2.7 Co-morbidities and complications

The co-morbidities and complications discussed below were not always the primary cause of death or near miss and are therefore different from the causes of the event listed at the beginning of this chapter. The cause of death may have been listed as a NPRI in a woman who also had an abruption or retained products of conception.

Medical disorders

There were 81 (26.38%) women who had hypertension and its complications. Table 3.7 shows the difference between women who had a near miss and women who died and who were hypertensive. There were -two (0.65%) women with diabetes, four (1.30%) with epilepsy, four (1.30%) with asthma, and 20 (6.51%) with a cardiac disorder. There was no statistically significant difference in these co-morbidities between women who had a near miss and those who died. Women with cardio-pulmonary failure were more likely to die and this was statistically different as illustrated in Table 3.7.

Hemorrhage: There were 54 (17.59%) of women with an abruptio placentae. Abruptio placenta was a cause of near miss in 33 patients and a cause of deaths in three patients as a primary factor as shown in table 3.7. In the remaining 18 patients, abruptio placentae occurred, but the cause of the event is listed as another cause.

Retained products of conception accounted for 34 (22.58%) cases of PPH, perineal tears for four cases (2.58%), uterine atony for 81 (52.26%) and 36 were not specified (23.23%). There were five women with placenta praevia.

Table 3.7 A comparison between co-morbidities and pregnancy related complications in women with a near miss and in women who died

	Near Miss	Death	P value
Hypertensive disorders in pregnancy			
Chronic Hypertension n=17 (5.76%)	14 (5.60%)	3 (5.26%)	1.00 **
Pre-eclampsia n=39 (13.22%)	36 (14.40%)	3 (5.26%)	0.08 **
Eclampsia n=25 (8.47%)	18 (7.20%)	7 (12.28%)	0.28 **
Hemorrhage related complications			
Abruptio Placentae n= 54 (17.59%)	47 (18.80%)	7 12.28%)	0.33**
PPH: n=155 (50.49%)	144 (57.60%)	11 (19.38%)	0.00 ***
Other conditions			
Sepsis n=82(26.71%)	68 (27.20%)	14(24.56%)	1.00 **
Respiratory dysfunction n=75 (24.43%)	53 (21.20%)	22 (38.60%)	0.01 ***
Cardiovascular dysfunction n=45 (14.66%)	28 (11.20%)	17 (29.82%)	0.00 ***
DIC n= 22 (7.17%)	17 (6.88%)	5 (8.77%)	0.57**
Liver dysfunction n=11 (3.58%)	3 (1.20%)	8 (14.04%)	0.00 **
Renal dysfunction n=36 (11.73%	24 (9.60%)	12 (21.05%)	0.02*
Cerebral dysfunction n=37 (12.05%)	24 (9.60%)	13 (22.81%)	0.01*
Multi- organ dysfunction n=58 (18.89%)	39 (15.60%)	19 (33.33%)	0.00**

Kruskall-Wallis* Fishers Exact Chi-squared*****

3.2.8 Interventions

The number of women who had to have a blood transfusion (more than four units over 24 hours), who were admitted to HCA/ICU, who had a hysterectomy, renal dialysis, or were ventilated is shown in the table 3.8 below.

Table 3.8 A comparison of the Interventions needed in women with near miss and deaths

	Near miss	Death	P-value
Blood transfusion n=210 (68.40%)	182 (72.80%)	28 (49.12%)	0.00***
Admission HCA/ICU n=93 (30.29%)	87(34.80%)	6(10.53%)	0.00 **
Hysterectomy n=69 (22.48%)	61 (24.40%)	8 (14.04%)	0.11 **
Re-look laparotomy n=85(27.69%))	79(31.60%)	6(10.53%)	0.00**
Renal dialysis n=14 (4.56%)	13 (5.20%)	1 (1.75%)	0.48 **
Ventilation n=150 (48.86%)	111 (44.40%)	39 (68.42%)	0.00 ***

Kruskall-Wallis* Fishers Exact Chi-squared *****

3.2.9 Delays in receiving care

3.2.9.1 Patient related factors

There were 160 women with patient related factors as illustrated in table 3.9 below. There was one woman (0.63%) who initially declined medical/ surgical therapy who died.

Table 3.9 A comparison of Patient related factors

	Near miss	Death	P-value
Delay in seeking help n= 62	37(23.13 %)	25(15.63%)	0.09 ***
Infrequent ANC n=35	30(18.75%)	5(3.13%)	0.00 **
Late ANC booker n= 34	27(16.88%)	7(4.12 %)	0.00**
No ANC n=28	10(6.25%)	18(11.25%)	0.11***

Fishers Exact Chi-squared*****

3.2.9.2 Health worker related factors

There was inappropriate initial assessment in 10 (3.26%) women. A delay in initial assessment in 11(3.58%) women and incorrect diagnosis in five (1.63%) women. Overall

substandard management was a factor in 49(15.96%) women. Poor monitoring was found in 11(3.58%) women. Delays in women receiving appropriate management was a common factor in 136 (44.30%) women. See Table 3.9 for an illustration of health worker related factors.

Table 3.10 A comparison of health worker related factors

	Near miss	**Death**	**P-value**
Inappropriate initial assessment n= 10 (3.26%)	8 (3.20%)	2 (3.51%)	1.00**
Delay in assessment n= 11 (3.58%)	11 (4.40%)	0	0.23 **
Incorrect diagnosis n=5 (1.63%)	5 (2.00%)	0	0.59 **
Substandard management n=49 (15.96%)	40 (16.00%)	9 (15.79%)	1.00 **
Monitoring problems n=11(3.58%)	9 (3.60%)	2 (3.51%)	1.00 **
Delays in receiving appropriate care n=136 (44.30%)	112 (44.80%)	24 (42.11%)	0.71 ***

Fishers Exact Chi-squared**

3.2.9.3 Health system related factors

There was a problem with ambulances in the transport of 19 (6.19%) women, a shortage of staff in the care of 12(3.91%) women, theatre was not immediately available in 80(26.06%), and a shortage of blood/ blood products in 11 (3.58%), and ICU was not available in 53(17.26%) cases. See results in table 3.11

Table 3.11 Health System related factors

	Near miss n= 151	Death n=24	P-value
Availability of ambulances n=19 (6.19%)	13 (5.20%)	6 (10.53%)	0.14 **
Staff shortage n=12 (3.91%)	11 (4.40%)	1 (1.75%)	0.70 **
Availability of Theatre n=80 (26.06%)	77(30.80%)	3(5.26%)	0.00 **
Blood/blood products n=11 (3.58%)	10 (4.00%)	1 (1.75%)	0.70 **
Availability of ICU n=53 (17.26%)	40(16.00%)	13(22.81%)	0.24 **

Fishers Exact**

3.2.10 Blood results at the time of event

The mean haemoglobin was 7.12 (±2.29) and the median was 7 (5.40-8.50; 2.20-16). The mean platelet count was 155.68 (±114.80) and the median was 129 (73-202; 3-707), there were 161 women with PI results: mean-1.68 (±1.54), the median was 1.22 (1.09-1.55; 0.80-10). Women who had a pTT result were 125 and the mean was 48.37 (±22.43), the median was 43.20 (36.60-56.30; 0.86-134).

Table 3.12 Blood results at time of event

	Near miss	Death	P-value
Lowest haemoglobin (mean)(g/dL)	7.07 (±2.18)	7.36 (±2.71)	0.45****
Lowest platelets (mean) (150-350 X 10^9 / L)	155.32 (±108.31)	157.33 (±142.50)	0.92****
Highest INR	1.49 (±1.25)	2.42 (±2.22)	0.00*
Highest pTT(seconds)	44.03 (±18.02)	63.40 (±29.24)	0.00****
Mean urea (mmol/L) n=288 6.09 (±5.45),	5.22 (±4.19)	10.24 (±8.24)	0.00****
Median urea(mmol/L) n=288 -4.20(2.70-7.10; 0.50-38)	3.80 (2.60-6.30; 0.50-27.60)	7.70 (44-13.50; 1.60-38)	0.00*
Mean creatinine (µmol/L) n=288 121.32 (±131.33)	106.02 (±112.39)	194.14 (±182.70)	0.00****
Median creatinine (µmol/L) n=288 76 (54-126.50; 4.10-1042)	72 (51-105; 4.10-797)	129 (89-230; 44-1042)	0.00*
Mean pH n=286 7.25 (±0.16)	n=240 7.29 (±0.12)	n=46 7.08 (±0.24)	0.00****
Median pH n=286 7.27 (7.20-7.35; 6.59-7.62)	n= 240 7.30(7.23-7.36; 6.65-7.62)	n=46 pH 7.10 (6.89-7.24; 6.59-7.54)	0.00*
Mean Base Excess (mEq/L) n=280 16.47 (±11.57)	n=234 17.30 (±12.16)	n=46 12.23 (±6.52)	0.00****
Median Base excess(mEq/L) n=280 15.90 (13.50-18.35; 0.90-158)	n=234 16.40 (14.10-18.70; 0.90 - 156)	n=46 11.60 (6.90-15.80; 3.10-28.20)	0.00 *
Mean Lactate (mmol/L) n=260 4.25 (±4.57)	n=219 3.38 (±3.67)	n=41 8.86(±6.01)	0.00 ****
Median Lactate (mmol/L) n=260 2.65 (1.50-5.05; -8.40-33)	n= 219 2.20 (1.40-4.20; -8.40- 33)	n=41 3.50(3.50-13.20 ; 0.70-23)	0.00*

Kruskall-wallis* Fishers Exact Chi-squared T-test*****

CHAPTER 4

4.1 Discussion

The prevalence of maternal near miss and deaths is now being documented in many hospitals. Auditing of maternal deaths and near miss serves as a guide in assessing the standard and quality of care that's being provided within institutions.[42,43,45] Our study also showed that indeed maternal deaths are just 'the tip of an iceberg", there exists a large number of women who survived these PTLC. The near-miss/death ratio was 4.4:1 and was nearly comparable with what is quoted in literature.[55] Since near misses are more common and often share similar characteristics with MDs, they can be used as a guide to implement protocols and improve obstetric care.

Ours was a study set out to describe and compare women with maternal near miss and those who died. The study showed that women who were managed at CHBAH frequently had SMO.

Severe Maternal Outcome Ratio

The SMO ratio in our study was 4.93/1000 live births. Our finding was lower than SMO ratios described in other studies from developing and developed countries. [48, 49,55,56] In a recent prospective cohort study by Kalisa et al done in a rural Rwandan hospital, the SMO ratio was found to be 24.8/ live births almost similar to what was described in a study done in Mozambique by David E et al with an SMO ratio of 22.7.[13, 48]

The observed SMO ratio was slightly lower to what was found in a local study by P Soma-Pillay et al.[50] They found a SMO ratio of 5.1/1000 LB with a mortality index of 14%. A recent descriptive study in a tertiary care center in India, also described a higher SMO ratio of 6/1000 live births.[56]

Our MI was 18.57%, this was higher than that described in the Pretoria Academic Complex and in one rural Rwandan hospital. [48, 50]

Maternal Death and Maternal Mortality ratio

In the current study we found that medical disorders contributed more to MDs. This was followed by hypertension in pregnancy and obstetrics hemorrhage. This differed from most

studies in African countries where obstetric hemorrhages and hypertensive related disorders were found to be the frequent cause of MDs. [13, 38, 40, 50]

Our results showed that women were more likely to survive from obstetric hemorrhage as compared to hypertension. We would speculate that this is because women with hemorrhage may have been healthier and therefore better able to cope with the acute effects of hemorrhage, whereas hypertension leads to other organ dysfunction. We were not able to do any further analyses to see whether this was indeed the reason for the difference.

In the previous NCCEMD 2011-2013 assessment, hemorrhage was identified as the second most important contributor to MD. There was a lot of emphasis including training on control of hemorrhage which may have contributed to the fact that women were more likely to survive hemorrhage than hypertension.

The iMMR was 91.66/100 000 live births, this was calculated using estimated numbers of patients delivered in our referral MOUs and patients delivered at CHBAH. This is lower than the SA MMR that was published in Saving Mothers report 2011-2013 which showed MMR of 154.06/100 000 live births.[5] Our MMR was lower than what was found in other developing countries.[48, 56] According to WHO trends in maternal mortality from 1990 to 2013 illustrated that MMR was 14 times higher in developing countries as compared to developed countries.[4]

Another study in the same hospital which looked at the iMMR , in 2011/2012 found a lower iMMR of 86/100 000, this iMMR was higher than what was found reported at the Pretoria Academic Complex in 2013/14.[29] However compared to other developing countries such as Mozambique, India and Brazil, our iMMR was lower. A recent retrospective analysis in a tertiary care in India illustrated an iMMR of 580/100 000 live births. The Mozambican and Brazilian study described a MMR of 254/100 000 live births and 260/100 000 live births respectively.[13, 46]

The wide disparity in trends of MMR between developing and developed countries is due to lack of resources in developing countries.[38]

We found that there was a decline in iMMR in patients with HIV-related complications. A previous study in CHBAH by Buchmann et al had shown that NPRI was the leading cause of death between 1997 and 2012.[29] This downward trend in HIV related deaths may be attributed to changes in eligibility criteria to initiate ART early in pregnant women.[5] In 2012, on World AIDS day all pregnant women and breastfeeding women became eligible to initiate ART irrespective of CD4 count. Another contributing factor to the decreasing HIV-related mortality, could have been due to an increased awareness and screening of opportunistic infections especially TB.[5] A recent systematic review concluded that indeed, the use of ART is associated with decreased maternal mortality in HIV-infected women.[57]

We found that more women who died were HIV positive compared to those who survived life threatening complications in our study. Comparable findings were found in the Pretoria Academic Complex study where, they had an HIV rate of 19.9% for their study population, 23.10% women were near misses and 36.80% women died. [50] In our study 35% of the near misses were HIV positive and 49.12% of women who died had also tested positive for HIV. In our study 15.79% of the study population died secondary to a NPRI. According to Savings mother report 2011-13, 34, 70% of all avoidable MDs were related to NPRI.[5] Several other studies also showed that HIV/AIDS is a significant contributing factor of both direct and indirect causes of MDs, especially in areas of low-socio economic status including sub-Saharan Africa.[27, 32, 33]

Near misses

The maternal near miss ratio (MNMR) in this study was 4.02/1000 live births. This was lower than MNMR described in other developing countries.[13,47,48,51] The reported MNMR in India in 2012 was 7.56/1000 live births, and was 20/1000 live births in a Mozambican study done in 2014.[13, 56] A recent study in Ethiopia, that was conducted in 2015 to 2016 illustrated a MNMR of 8.01/1000 live births.[51]

The MNMR reported in some developed countries was low at 4.8/1000 live births.[49] In some of the developing countries including Africa, Asia and Latin America, the range of near misses were 0.05-14.98, 0.02-5.07 and 0.34-4.93 respectively.[41]

This differences affirms that the availability and accessibility of maternal health care services is still a concern in low socio-economic countries. Lack of uniformity and

consistency in identification of near miss cases is also a contributory factor in wide variations on findings.[38, 41, 58]
In some countries the interventions used in the management of women with severe complications are not available, such as ICU and dialysis. When these interventions are used as the defining criteria for a near miss, it makes it difficult to compare near misses between different settings.[41, 58]

A prospective observational study of maternal near miss in a tertiary maternity unit in Australia described a NMR of 4.8/1000 live births. In this 12-month study, they had 40 women with potentially life threatening conditions (PTLC) and only 10 cases fitted their definition of a "true" near miss.[49]

The identification criteria of near miss that was frequently observed in the study was blood transfusion and prolonged ventilation not for anaesthetic reason. The current study identified hemorrhage, sepsis, hypertension followed by medical disorders as the most frequent causes of near miss events. This finding is comparable with findings from other studies in developing countries.[44,46,61] Developed countries reported hemorrhage and sepsis as the most frequent cause of SMO in their studies.[25,49,53]

Norhayati et al found blood transfusion as a frequent near miss criteria. However in their study they also found that ICU admission was a second near miss criteria.[45] In our study we had a considerable number of patients who required ICU admissions, but were not admitted in ICU due to lack of ICU beds.
Sepsis was a frequent cause of maternal near miss in our study. Studies in other developing countries found hemorrhage as the other frequent cause.[47,52] Countries such as Mozambique, Rwanda and Ethiopia found hypertensive conditions including eclampsia as a second common cause of maternal near miss.[13,48,51] Studies done in rural India also demonstrated obstetric hemorrhage as a common cause of maternal near miss.

However this finding is not surprising, according to WHO, puerperal sepsis is now the third most common cause of maternal deaths, with caesarean section being recognized as the most important risk factor for postpartum infection.[59]

Lack of theatre space was a common factor contributing to women with prolonged obstructed labour in this study. Other studies also found anaemia and obstructed labour as significant contributors to women with near misses.[38, 51, 52]
The route of delivery was statistically significantly different between NMs and MDs, with more women who delivered by caesarean section dying. According to NEMMCD, bleeding at CS was still a challenge in SA accounting for one third of maternal deaths in 2011-2013.[5]

A study at CHBAH found seventeen cases of maternal deaths had complications related to bleeding at caesarean section in January 2013 to December 2014. In this study they also highlighted availability of theatre space as an additional causative role.[60]
A cross-sectional study done at a regional and one tertiary hospital in Dar es Salaam, Tanzania between February and June 2012 also found that the occurrence of NMs and MDs is strongly associated with CS complications. They highlighted that more women were likely to die than survive these PLTC associated with caesarean delivery.[61]

The present study also showed that there is a statistically significant association between ANC attendance and maternal deaths. Mothers who did not attend antenatal care during pregnancy were most likely to die than those who had proper antenatal care. This is also due to missed opportunities to allow early detection, prevention and management of pre-existing conditions and management of obstetric problems that could have started during pregnancy.

A case control study conducted in a tertiary hospital in Kenya, between January 2004 and March 2011 by Yego et al also highlighted that poor ANC attendance is associated with poor outcomes.[12]
According to Bergsjo, the evidence of ANC attendance as an independent effective way of preventing SMO remains a debatable issue. However if coupled with good intrapartum care, the results are more desirable.[14]

According to Saving Mothers Report 2011-2013, they found that 17.6% of women who died had no ANC attendance and 6.5% had infrequent ANC visits.[5] A seventeen year review that was done in North-Central Nigeria highlighted that unbooked mothers tend to have increased risk of dying compared to booked mothers.[62]

Timely management of obstetric related emergencies plays a role in decreasing SMO. According to Thaddeus and Maine, the maternal outcome can be influenced by delayed appropriate care.[36]
In our study we found that phase three delays (i.e. lack of theatre space and availability of ICU beds) were closely related to the chance of woman dying or surviving these PTLC.

Availability of theatre was highlighted as a significant contributor to SMO.
Similar findings were found in the Mozambican study conducted in 2008, phase three delays were frequent. More than one fourth of their study population had delayed treatment, availability of theatre and blood products were also found to be a serious concern.[13]

According to NCCEMD health worker related emergency management of cases was a significant avoidable cause of maternal deaths. This was seen at all levels of care, from primary level to tertiary level. [5] As stated by the Saving mothers report 2011-2013, anaesthetic related deaths was a major contributing factor[5], such was not a finding in our study. It could be that CHBAH has a consultant on site 24 hours.

In this study there was no difference in the age between women who died and woman who had a near miss. The same applied to parity and gravidity, there was no difference between women who died and women who survived PTLC. However, that does not imply that age, parity and gravidity are not associated with SMO. Age and parity/gravidity of a woman has been found as a common risk factor for the development of SMO in other studies.[13, 20, 21, 26]
According to latest report on Saving Mothers 2011-2013, women who died were in the age groups between 25- 40, deaths in this women were due to NPRI.[5]

4.2 Strength of the study

To our knowledge, this is the first analysis comparing maternal deaths and near miss in SA, we managed to highlight the trends of the common causes and other factors associated with SMO.
All maternal deaths are discussed in Mortality meetings and the most likely cause of death is given. All these files are kept in HODs office and are available.
The large number of patients delivered in our hospital allowed us to demonstrate the spectrum of conditions encountered in our setting.

4.3 Limitations

This was a retrospective study, with possible missing data.

Poor documentation of near miss patients was found in some files.

Retrieving of files was difficult, some files were missing especially for gynaecological patients. Women with near miss in early pregnancy were not fairly represented in the study. Antenatal notes and delivery records were unavailable in some patients who were referred from peripheral hospitals.

4.4 Recommendations

Based on this study the possible measures that can be taken to prevent SMO are:

- Strict triaging systems

  There must be a readily available ambulance/hospital transport at CHBAH maternity ward to transport low risk laboring patients to MOUs.
- Strengthening of already available protocols and implementation of new protocols in management of obstetric hemorrhage, and auditing the effectiveness of these protocols.

- Staffing issues and availability of theatre space and ICU
  - The staff to patient ratio needs to be evaluated.
  - We also recommend the availability of on-site Obstetric consultant to help with decision making and assist in management of challenging cases.
  - CHBAH is one of the biggest hospitals in Africa, however it still lacks an obstetrics dedicated ICU, and we recommend that provision be made for an Obstetric ICU.
  - We also recommend provision of additional Obstetric theatres.

- Recommendations for further research.
  - To prospectively review Near misses in the way that MD are reviewed.- with MDT
  - To understand the effects of Near misses on Mothers, families and the community

4.5 Conclusion

This study showed that maternal deaths and maternal near misses are common. The five most common causes of maternal deaths in SA that is hemorrhage, hypertension, medical disorders, NPRI and sepsis were also the most common causes of near misses, however the order was different with medical disorder being the most common cause of maternal deaths and hemorrhage the most common cause of maternal near misses.

There was no difference in the association with hypertension and the outcome. There was no difference in the association with medical disorders with the outcome. This suggests that the pathway from these conditions to severe maternal outcomes leaves little room to intervene. It is possible that prenatal care rather than antenatal care may make a difference in women with existing medical conditions in this setting.

Identifying and being vigilant in the care of women with hypertension and medical disorders is warranted. Other factors associated with maternal deaths were no antenatal care and HIV infection.

The evaluation of the causes of both may be used to direct care. Auditing and analyzing maternal deaths and near miss concurrently allows for an evaluation of a continuum of care. The aim should be to prevent near misses in order to reduce maternal deaths.

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APPENDICES

APPENDIX A: DATA SHEET

1	**Age**		
2	**Parity**		
3	**Gravidity**		
4	**ANC attendance (Booked)**	Yes	
		No	
		Unknown	
4.1	**If yes, number of ANC visits**		
4.2	**ANC location**	Primary	
		District	
		CHBAH	
		Private	
		Unknown	
5	**Gestational age at booking**		
6	**Booking bloods**		
6.1	**Haemoglobin at booking**	Supplements given	y / n
6.2	**RPR**	Positive/ Negative/Unknown	
6.3	**Rhesus**	Positive/Negative	
6.4	**HIV Status**		
		Positive	
		Negative	
		Unknown	
		If +, latest CD4 count On ARVs or not	y / n
7.	**Blood pressure (mmHg) at booking**		
8	**Previous obstetrics history**	None	
		Hypertensive diseases	
		Antepartum hemorrhage(APH)	
		Postpartum hemorrhage(PPH)	
		Gestational diabetes	
		Other	
9	**Pre-existing medical disorders**	None	

		Hypertension Cardiac diseases		
		Diabetes		
		Asthma		
		Epilepsy		
		Other		
10	**Maternal risk status (At booking)**	High		
		Low		
11	**11.1 Time of referral**	ANC		
		In Labour	First stage	
			Second stage	
			Third stage	
		Puerperium		
	11.2 Reason of referral			
12	**Near miss development**	CHBAH Other hospital		
13	**Mode of delivery**	NVD		
		Caesarea section		
		Assisted delivery	Vacuum	
			Forceps	
14	**Induction of labour** **If yes, reason for IOL**	YES	NO	
15	**Birth attendant**	Unknown		
		Midwife		
		Medical officer		
		Registrar		
		Specialist		
16	**Complications during labour**	Prolonged ROM		y/n
		Prolonged labour		y/n
		Duration of labour		

		First stage	
		Second stage	
		Third stage	
		Augmentation of labour	
		Abruptio placentae Uterine rupture	
		Perineal tears	
		Retained products of conception	
17	**Neonatal Outcome**	Stillborn	
		Alive	
		Ectopic	
		Miscarriage	
18	**Complications post delivery**	Uterine atony	
		Other PPH	
		Gynae-related bleeding	
		DIC	
		Sepsis	
		Renal dysfunction	
		Respiratory dysfunction	
		dysfunction	
		Multi-organ dysfunction	
19	**Interventions**	Relook laparotomy	
		Hysterectomy	
		Blood transfusion	
		High care/ ICU admission	
		Renal dialysis	
		Ventilation	
20	**Contributing circumstances to the event**	Delays in receiving appropriate care	
		Availability of staff	
		Availability of theatre	
		Availability of blood	
21	**Blood result at time of event**	Worst Hb	
		Worst UEC	
		Worst PI/PTT	

		Worst Platelet count		
		Worst blood gas		
22	**Other special investigations**	Chest x-ray Findings		
		Cardiac Echo Findings		
		CTPA Findings		
		CT Brain Findings		
		Ultrasound Findings		
		Other investigations		
23	**Event : Near-miss**	**Criteria for near miss**		
		Blood transfusion>4 units/24hrs		
		Relook laparotomy		
		Ruptured uterus		
		Hysterectomy		
		Renal dialysis		
		Intensive care admissions		
		Ventilation not for anesthetic reason		
24. **24.1**	**Event : Death** **Direct causes**	HPT disorder	PET	
			Eclampsia	
			Chronic HPT	
		Haemorrhage	Abortion	
			Placenta abruption	
			Uterine atony	
			Uterine rupture	
			Other PPH	
		Puerperal sepsis		
		Venous thrombo-embolism		
24.2	**Indirect causes**	Cardiac disease		
		Diabetes		
		Anaesthetic related		
		Non-pregnancy related infections		
		Other medical disorders		

APPENDIX B CHBAH APPROVAL LETTER TO CONDUCT RESEARCH

GAUTENG PROVINCE
HEALTH
REPUBLIC OF SOUTH AFRICA

MEDICAL ADVISORY COMMITTI
CHRIS HANI BARAGWANATH ACADEMIC HOSPITA

PERMISSION TO CONDUCT RESEARCH

Date: 16 March 2016

TITLE OF PROJECT: A descriptive study of maternal "near misses" and maternal deaths at the Chris Han Baragwanath Academic Hospital, South Africa: A retrospective study.

UNIVERSITY: Witwatersrand

Principal Investigator: R Hlengani

Department: Obstetrics and Gynaecology

Supervisor (If relevant): Y Adams

Permission Head Department (where research conducted): Yes

Date of start of proposed study: March 2016
Date of completion of data collection: Dec 2017

The Medical Advisory Committee recommends that the said research be conducted at Chris Hani Baragwanath Hospital. The CEO /management of Chris Hani Baragwanath Hospital is accordingly informed and the study is subject to:-

- Permission having been granted by the Human Research Ethics Committee of the University of the Witwatersrand.
- the Hospital will not incur extra costs as a result of the research being conducted on its patients within the hospital
- the MAC will be informed of any serious adverse events as soon as they occur
- permission is granted for the duration of the Ethics Committee approval.

.....
Recommended
(On behalf of the MAC)
Date: 16 March 2016

.....
Approved/Not Approved
Hospital Management
Date: 20/03/16

APPENDIX C ETHICS CLEARANCE CERTIFICATE

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

R14/49 Dr Rachel Hlengani

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)

CLEARANCE CERTIFICATE NO. M160223

NAME: (Principal Investigator)	Dr Rachel Hlengani
DEPARTMENT:	Obstetrics and Gynaecology Chris Hani Baragwanath Academic Hospital Rahima Moosa Mother and Child Hospital
PROJECT TITLE:	A descriptive study of maternal "near misses" and maternal deaths at the Chris Hani Baragwanath Academic Hospital, South Africa: A Restrospective Study
DATE CONSIDERED:	26/02/2016
DECISION:	Approved unconditionally
CONDITIONS:	
SUPERVISOR:	Prof Yasmin Adam
APPROVED BY:	Doctor CB Penny, Chairperson, HREC (Medical)
DATE OF APPROVAL:	13/05/2016

This clearance certificate is valid for 5 years from date of approval. Extension may be applied for.

DECLARATION OF INVESTIGATORS

To be completed in duplicate and **ONE COPY** returned to the Research Office Secretary in Room 301, Third Floor, Faculty of Health Sciences, Phillip Tobias Building, 29 Princess of Wales Terrace, Parktown, 2193, University of the Witwatersrand. I/we fully understand the conditions under which I am/we are authorized to carry out the above-mentioned research and I/we undertake to ensure compliance with these conditions. Should any departure be contemplated, from the research protocol as approved, I/we undertake to resubmit the application to the Committee. **I agree to submit a yearly progress report**. The date for annual re-certification will be one year after the date of convened meeting where the study was initially reviewed. In this case, the study was initially reviewed in **February** and will therefore be due in the month of **February** each year. Unreported changes to the application may invalidate the clearance given by the HREC (Medical).

Principal Investigator Signature

Date 26/11/2018

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES

APPENDIX D TURNITIN REPORT

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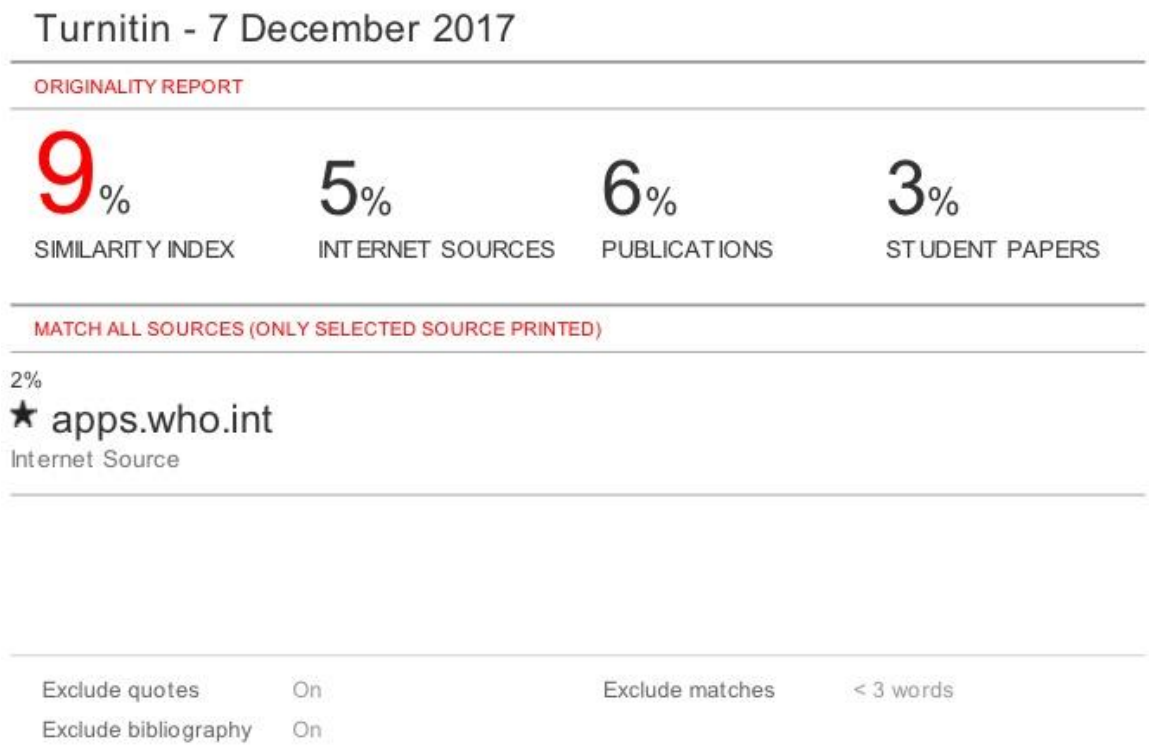

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