



**CONTRIBUTION OF POSTPARTUM HAEMORRHAGE TO
MATERNAL DEATH AFTER CAESAREAN SECTION AT CHRIS HANI
BARAGWANATH ACADEMIC HOSPITAL, SOUTH AFRICA FROM
1997 TO 2014**

By DR BYIRINGIRO JEAN PAUL

Registrar in Obstetrics and Gynecology

Supervised by DR FRANK KA

A research report submitted to the Faculty of Health Sciences, University of the Witwatersrand, Johannesburg, in partial fulfilment of the requirements for the degree of Master of Medicine.

Johannesburg,

November, 2018

DECLARATION

I, Jean Paul Byiringiro declare that this research report is my own original work. It is being submitted for the degree of Master of Medicine in Paediatrics and Child Health at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at this or any other university.

Signed:

A handwritten signature in dark ink, appearing to read 'Jean Paul Byiringiro', is written over a horizontal dotted line. The signature is fluid and cursive.

On the 11th day of November 2018

DEDICATION

I dedicate this work to my parents Mr. Kazura Augustine (deceased), Mrs Mukanyangezi Venantie (deceased) and all the other family members who died during the genocide against Tutsi in Rwanda.

I also dedicate it to my lovely wife Marie Grace Mukeshimana and our beloved children Arni Kazura Byiringiro, Lior Henri Byiringiro and Naysa Juru Byiringiro.

To my brother Mr Mazimpaka Jean Marie Vianney.

ACKNOWLEDGEMENTS

Besides my personal efforts, the completion relied on different people and institutions. Without their continuous encouragement and unconditional support, the success of this work would have not been achieved.

Firstly, I would like to express my deepest appreciation to my supervisor to Dr. Frank Karlyn, not only for giving sense to this research topic and accepting to supervise it, but also her incomparable role and guidance through this process of research despite her busy schedule.

I would like also to express my sincere gratitude to Professor Eckhart Buchmann for his constructive advice, knowledge and invaluable time towards the success of this research project.

To my dear family especially my lovely Marie Grace Mukeshimana and our children for the morale support and encouragement.

To the Government of the republic Rwanda, I am forever appreciative for the sponsorship and the continued support rendered during my training that enabled me to accomplish this duty.

To the University of Witwatersrand through the Department of Obstetrics and Gynaecology of the faculty of Health Sciences for acceptance into the programme and unwavering support during the tenure period.

Special regards to Professor Hennie Lombaard, Professor Adam Yasmin and Dr. Lawrence Chauke for their inspiration, ardent and lively academic interest that enabled me to accomplish my studies.

TABLE OF CONTENTS

DECLARATION.....	ii
DEDICATION	iii
ACKNOWLEDGEMENTS	iv
LIST OF TABLES	vii
LIST OF FIGURES.....	viii
ABBREVIATIONS	ix
ABSTRACT	x
1. INTRODUCTION	1
1.1. Definition of Postpartum Haemorrhage	1
1.2. Global Maternal Mortality	2
1.3. Caesarean Section.....	4
1.3.1. Complications of Caesarean Section versus vaginal delivery	4
1.3.2. Rising Caesarean Section Rates	6
1.3.3. Causes of haemorrhage at caesarean section	7
1.3.4. Maternal mortality from haemorrhage at caesarean section	7
1.4. Peri-operative and conservative life-saving measures	8
1.5. Preventive Measures	13
1.6. Maternal deaths related to haemorrhage at caesarean section	13
2. OBJECTIVES AND METHODS.....	15
2.1. Problem statement and justification for the research	15
2.2. Research Question	15
2.3. Research Objectives	15
3. METHODOLOGY	16
3.1. Research Setting.....	16
3.2. Research design and population.....	16
3.3. Sampling procedure and size estimation	16

3.4. Data collection.....	17
3.5. Data analysis.....	17
3.6. Ethical considerations	17
4. RESULTS.....	18
5. DISCUSSION	26
5.2. Research limitations.....	30
5.3. Research strengths.....	30
5.4. Conclusion	30
REFERENCES.....	32
APPENDIX A: DATA COLLECTION SHEET	37
APPENDIX B: ETHICS APPROVAL	44

LIST OF TABLES

Table 1: Estimation of Blood Volume loss by Haemorrhage (5)	2
Table 2: Demographic and clinical data of women who died from haemorrhage at or after caesarean section (n=15).....	19
Table 3: Causes of bleeding in women who died from haemorrhage at or after caesarean section (n=15).....	20
Table 4: Clinical and surgical management at the time of caesarean section (n=15).	20
Table 5: Use of blood products	21
Table 6: Mean blood loss and complications reported during or after caesarean section.....	22
Table 7: Case-by-case summary of all the women who died, including some detail on surgical difficulty and sequence of events	24
Table 8: Comparison of obstetric deaths for each triennium from 2002 up to 2016 .	27

LIST OF FIGURES

Figure 1: Maternal mortality ratio in South Africa 1990-2010	3
Figure 2: B-Lynch technique, showing the anterior view (a & c), as well as the posterior view (b), B-Lynch.....	10
Figure 3: Bakri balloon (A), and the Bakri balloon inserted in a uterus during PPH (B)	11
Figure 4: Uterine artery ligation (A) and a ligated uterine artery during postpartum haemorrhage (B)	12
Figure 5: Procedures performed at relook laparotomy (n=10).....	23
Figure 6: Place of death of women who died from haemorrhage at or after caesarean section.....	23

ABBREVIATIONS

AIDS: Acquired Immune Deficiency Syndrome

BMJ: British Medical Journal

C/S: Caesarean Section

CHBAH: Chris Hani Baragwanath Academic Hospital

CPR: Cardio-pulmonary resuscitation

FD: Fetal distress

FFP: Fresh frozen plasma

HIV: Human Immunodeficiency Virus

ICU: Intensive Care Unit

IIA: Internal Iliac Artery

MDG5: Millennium Development Goal 5

MHCA: Maternity High Care Area

MMR: Maternal Mortality Ratio

NCCEMD: National Committee for the Confidential Enquiries into Maternal Deaths

OH: Obstetric haemorrhage

PPH: Postpartum haemorrhage

SD: Standard deviation

SSA: Sub-Saharan Africa

USA: United States of America

ABSTRACT

Background and objectives

Haemorrhage at and after caesarean section has increasingly become a significant cause of maternal mortality in South Africa. This study was done to determine the frequency and characteristics of maternal mortality from haemorrhage associated with caesarean section at Chris Hani Baragwanath Academic Hospital (CHBAH) from January 1997 to March 2014.

Methods

The maternal record charts, of women who died from haemorrhage at and after caesarean section, were analysed for demographic and clinical and factors from a database of all maternal deaths at CHBAH, spanning the period 1997 to 2014 with permission from the gatekeepers . Haemorrhage deaths associated with the caesarean section, but caused by underlying problems, for example, placental abnormalities and uterine rupture, were excluded as these conditions are independent risk factors for bleeding at caesarean section. Descriptive statistics (means with standard deviations and medians with interquartile ranges) were used to analyse the data.

Results

There were 15 maternal deaths from caesarean section-related haemorrhage. Eleven deaths had caesarean sections at CHBAH, giving a cause-specific case fatality rate of 10.7 per 100 000 caesarean sections. The mean age of the women was 35.6 years. Two women were primigravid. Eight women (53%) had previous caesarean sections, and four were in the second stage of labour. Frequent contributory causes for haemorrhage were uterine atony [the failure of the uterus to contract adequately after the third stage of labour] (80%), broad ligament injury (40%), coagulopathy (40%) and uterine injury (33%). Ten women received blood transfusions, and 11 had hysterectomies, three at the time of caesarean section and eight at relook laparotomies. Difficulty at caesarean section was noted in ten cases.

Conclusion

Haemorrhage from caesarean section, as a cause of death, is less common at CHBAH than in South Africa as a whole. Risk factors for mortality from caesarean

section include advanced maternal age, previous caesarean section and second stage caesarean section. Surgical difficulties and atonic uterus are frequently encountered at caesarean section.

1. INTRODUCTION

1.1. Definition of Postpartum Haemorrhage

Since the culmination of Caesarean Section (C/S) deaths are a result of obstetric haemorrhage the relevant issues pertinent to maternal mortality associated with shall be discussed.

The definition of postpartum hemorrhage (PPH) is still controversial. There is no single, satisfactory definition of PPH thus far. Many definitions based on blood volume loss, haematocrit change, and haemodynamic instability have been proposed.

Based on blood volume loss, PPH has been defined as a blood loss more than 500 ml after vaginal delivery or more than 1000 ml after caesarean section (C/S) (1). The Royal College of Obstetrician and Gynaecologists (RCOG) uses 500 ml of blood loss as the cutoff for defining PPH while 1000 ml of blood loss is used to define severe PPH (2). However, the limitation of this definition, as reported by many other authors, is that blood loss is not accurately or routinely measured and can therefore be underestimated visually by the health care provider, which can lead to a delay in the diagnosis of PPH (3).

Based on haematocrit or haemoglobin change, PPH has been defined as a 10% decrease in postpartum haematocrit level compared to antepartum levels, or the need for blood transfusion. The disadvantage of this definition is that there is no correlation between postpartum haematocrit and acute blood loss. Further, the haematocrit can be altered by the amount of intravenous fluid received previously by the patient and the patient's dehydration status (4, 5).

The other definition of PPH is based on any excessive bleeding that results in symptoms such as pallor, light headedness, weakness, palpitations, diaphoresis, restlessness, confusion, air hunger, syncope and/or signs of hypovolaemia such as hypotension, tachycardia, oliguria, and oxygen saturation less than 95%. PPH is termed "primary" when it occurs within 24 hours post-delivery and "secondary" when it occurs 24 hours to 12 weeks after delivery (6).

In South Africa, based on the monograph of the management of postpartum haemorrhage, PPH is categorized as outline in Table 1 (5).

Table 1: Estimation of Blood Volume loss by Haemorrhage (5)

	Mild	Moderate	Severe
Blood loss	500-1000ml	1000-2000 ml	>2000ml
Systolic Blood pressure	Normal or slight decrease, worse on sitting	Decreased, (80-100 mm Hg)	Marked fall (<80 mm Hg)
Heart rate	Increased < 100	100-120	>120
Breathing	Normal	Mild increase 20-25/min	Increased > 25/min
Conscious level	Normal	Restless	Confused or depressed
Perfusion	Cold peripheries	Cold	Cold and clammy
Urine output*		oliguria	anuria

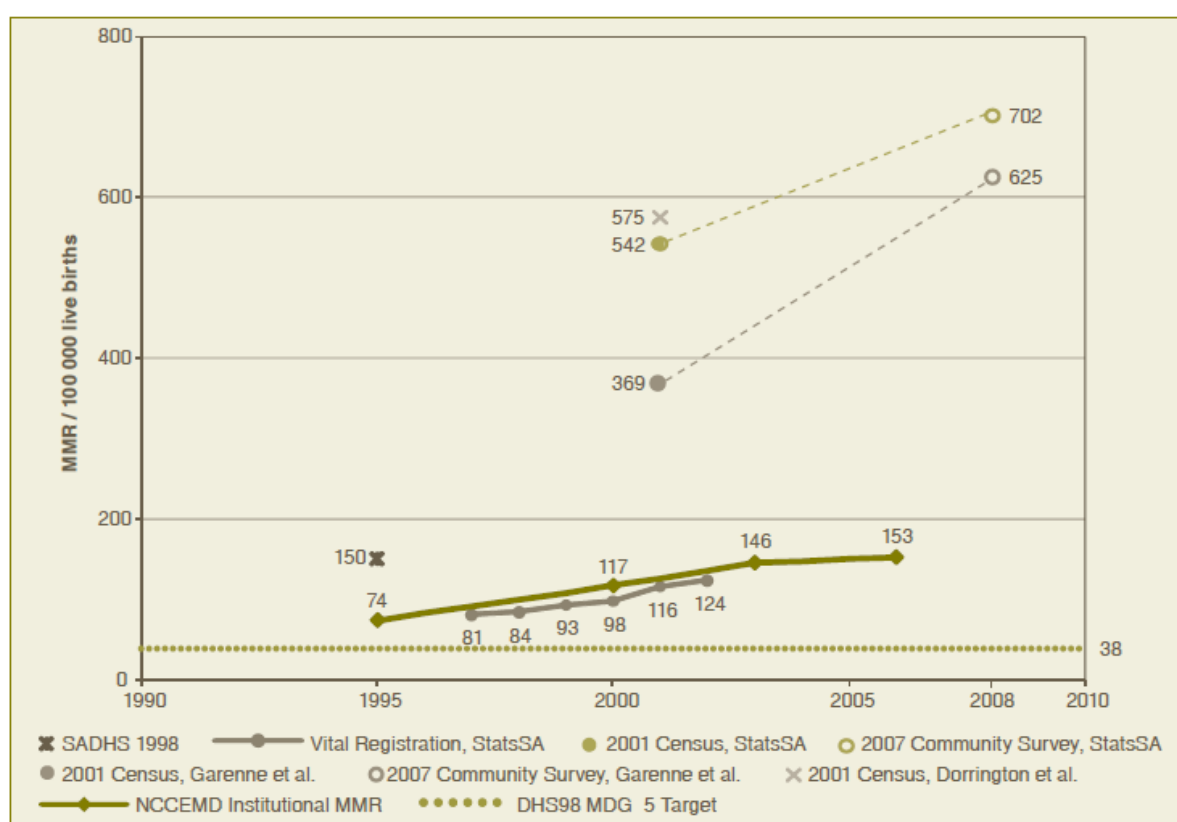
1.2. Global Maternal Mortality

Maternal mortality is a serious public health problem, not restricted to low income countries but globally (1). In 2013, 293 000 women died worldwide following complications of pregnancy (4). According to Kassebaum, there is evidence of wide disparities with respect to maternal deaths especially between developing and developed countries (4). Developing countries bear a disproportionate quantity of maternal deaths, 99% occur in developing countries compared to 1% in developed nations (7, 8). Of note, among the 15 countries with the highest MMRs (500 to 1000 maternal deaths per 100 000 live births), most are in Sub-Saharan Africa (SSA), while most of the 15 countries with the lowest MMRs (less than 5 maternal deaths per 100 000 live births) are in Europe

On the other hand, the causes of maternal mortality vary by geographic region. While complications related to hypertensive disorders and thromboembolic diseases are the most frequent causes of maternal mortality in developed countries, in Africa and Asia, haemorrhage (30.8% to 33.9%) is the leading cause of maternal mortality, followed by hypertensive disorders infectious conditions, particularly related to HIV Human-Immunodeficiency Virus (HIV) and Acquired Immune Deficiency Syndrome (AIDS) (9).

South Africa has not shown a decrease in the MMR by 75% from 1990 to 2015 (10). In SSA, the average annual reduction in maternal deaths has been estimated at about 0.1%, while the lifetime risk of maternal death was 1 in 16, showing that achieving Millennium Development Goals⁵ (MDG)⁵ which is aimed at improving maternal health in countries of SSA is far from being realised.

In South Africa, there has been a rising trend of MMR over time. According to Blaauw and Penn-Kekana (11), the overall MMR in South Africa increased from 150 per 100 000 in 1998 to 625 per 100 000 in 2007, while Mpemba, Kampo (12) reported that the specific maternal mortality rate (MMR) due to postpartum haemorrhage (PPH) from 2008 to 2010 was 24.9 deaths per 100 000 live births in South Africa compared to 18.8 deaths per 100 000 live births in the previous triennium 2005-2007 (12). Figure 1 shows the reported South African MMR using different measures of national data, and within different time periods. The great variation depending on the different methods is remarkable.



Source: National Department of Health, 2002;⁴¹ Statistics South Africa, 2005;⁴⁵ Statistics South Africa, 2010;⁴⁶ Garenne et al., 2008;⁴³ Garenne et al., 2009;⁴⁴ Dorrington et al., 2004;⁴² National Committee on Confidential Enquiries into Maternal Deaths, 2005-2007.¹⁸

Figure 1: Maternal mortality ratio in South Africa 1990-2010

According to the Saving Mothers Report for the triennium 2014-2016, the most 3 frequent causes of maternal mortality in South Africa, in descending order, are non-pregnancy-related infections, hypertensive disease and obstetric hemorrhage.

1.3. Caesarean Section

1.3.1. Complications of Caesarean Section versus vaginal delivery

Caesarean section is the delivery of the fetus through a surgical incision in the abdominal wall and uterus.

The most commonly listed indications for caesarean delivery are:

- Failure to progress during labor
- Non-reassuring fetal status
- Fetal mal-presentation

Other less common indications are abnormal placentation, maternal infection, multiple gestations, fetal bleeding diathesis, cord presentation or prolapse, suspected macrosomia, mechanical obstruction to vaginal birth, and uterine rupture (13).

Caesarean sections involve major abdominal surgery and increase the risk of maternal death four-fold in emergency situations and about three times during elective surgery in a healthy mother and baby (14).

In a cohort of 19 467 women undergoing delivery, 4 837 by C/S and 13 368 vaginally, the rate of PPH in the emergency group was 6.75% significantly greater than the elective caesarean group (4.84%, $P = 0.007$) however the risk of PPH in the elective C/S group was not statistically significant than those that delivered vaginally (15).

Risk factors for PPH after an elective caesarean section included:

- Leiomyomata
- Blood disorders
- Placenta praevia
- Antepartum bleeding; and

- General anaesthesia.

Non-elective caesarean PPH risk factors included:

- Blood disorders,
- Retained placenta,
- Antepartum transfusion,
- Antepartum / intrapartum haemorrhage,
- Placenta praevia,
- General anaesthesia and
- Macrosomia

A prospective, observational study of primary caesarean deliveries conducted at 13 university centers in the USA in 2000 revealed that caesarean delivery in the second stage of labor is associated with higher maternal morbidity than caesarean delivery in the first stage of labor (16) .

Endometritis is the most common infective complication associated with caesarean delivery, with its incidence varying from 5 to 85%, depending upon the patient population surveyed and methods of diagnosis. Also, surgical site infections were identified in 81 (5.0%) of 1,605 women who underwent low transverse caesarean section in a large case-control study of risk factors for surgical site infection conducted in the USA (17).

Haemorrhage is a common and preventable complication of caesarean delivery. It is estimated that the mean blood loss at caesarean delivery is approximately 1000 ml, however estimates of blood loss might not be reliable. In a study done at the University of Alabama in the USA in 2006, approximately three percent of all patients undergoing caesarean delivery required blood transfusions.

Urinary tract or bowel injuries constitute another category of complications associated with caesarean delivery. Urinary and gastrointestinal tract injuries are uncommon, occurring in fewer than 1 percent of pelvic surgical procedures, as revealed by a case-control study conducted in the USA in 2005, that identified 42 bladder injuries among 14,757 caesarean deliveries (18).

In a study by Clark et al. in the USA in 2008, the risk of death caused by or associated with caesarean delivery was estimated at 2 per 100 000 caesarean deliveries, while the corresponding rate was 0.2 per 100 000 vaginal deliveries (19). This demonstrates that caesarean delivery carries a significantly higher risk of complications and death, compared to vaginal delivery.

1.3.2. Rising Caesarean Section Rates

In the absence of standard medical or obstetrical indications, caesarean sections on maternal request have been documented to be on the rise worldwide, although accurate data on this issue is not well known since, clinicians do not always indicate whether the procedure was done on maternal request (20, 21) . In addition, maternal reasons for choosing caesarean section include convenience of scheduled delivery, fear of the labour pain, the process, and complications of labor, previous poor labor experiences, concerns about fetal harm from labor and vaginal birth, and concerns about developing anal or urinary incontinence from labor and vaginal birth (22).

A continuing rise in the rate of caesarean delivery has been reported in many countries during the past decades. An analysis of the increase of caesarean section rates from 1990 to 2014, demonstrated the global rates at 18, 6 %. Higher rates have been described in developing countries and in Latin America and the Caribbean which accounts for 40.5% with Southern America having the highest rate in the world at 42.9% (23, 24). In Africa, the average rate of caesarean section deliveries is 7.3%. The caesarean section rate has increased from 6.7% in 1990 to 19.1% in 2014 worldwide (25).

The following are some of the many factors that may contribute to the increase in caesarean section rates in general:

- Low priority of enhancing women's own abilities to give birth
- Side-effects of common labour interventions
- Failure to offer an informed choice on vaginal birth
- Casual attitudes about surgery, with limited awareness of harms
- Incentives to practice in a manner that suit the obstetrician

In some countries, socioeconomic status and health insurance have been reported to be associated with a rise in caesarean section rates, while in others, clinicians are rewarded based on the number of caesarean section performed, which contributes to the global rise in the rates of caesarean section. In China particularly, a common belief that children delivered by caesarean delivery are destined to be healthier than those born by vaginal delivery, has contributed to the rise of caesarean section rates (26). In South Africa, like in Brazil, research has shown that the increasing rates of caesarean section have been observed in the most affluent population groups, suggesting or confirming that the rates are linked with socio-economic reasons possibly more than medical reasons.

1.3.3. Causes of haemorrhage at caesarean section

While uterine atony is the commonest cause of PPH after vaginal birth (27) , this is unlikely to be the case with caesarean section. Uterine atony may occur with caesarean section as it does after vaginal delivery, but surgical trauma from incisions or lacerations contributes significantly to bleeding. According to a review by Fawcus and Moodley (28) this may be due to the difficult delivery of an impacted head, faulty surgical technique such as poorly sited uterine incision, or difficulties on encountering adhesions, especially in women who have had previous caesarean sections (28). Studies on haemorrhage after caesarean section are few, and do not describe direct surgical causes for haemorrhage at caesarean section. Risk factors have however been shown, and two studies done in the USA, include general anesthesia, fetal macrosomia, preterm birth, pre-eclampsia, clotting defects, a protracted active phase of labour and prolonged second stage of labour (15, 29). A recent study from Ethiopia confirmed the high-risk of haemorrhage requiring hysterectomy when a caesarean section is done in the second stage of labour (30).

1.3.4. Maternal mortality from haemorrhage at caesarean section

Countries in Africa have high rates of caesarean section mortality from haemorrhage. A study of 25 hospitals in Malawi from 1998 to 2002 found a 1.08% mortality rate from caesarean section (31) . Blood loss was the most frequent cause of death; however, a large number of women had serious pre-operative risk factors, such as antepartum haemorrhage, ruptured uterus and anaemia. Specific surgical difficulties were not mentioned. More than half of the caesarean sections (65%) were

performed by paramedics. Of the 85 women who died in that study, 15 died intraoperatively, and 68 died in the postnatal ward.

Even higher mortality rates were reported from a district in Zimbabwe from 1998 to 2000, where the fatality rate after caesarean section was 18/1128 [1.6%] (32). Ten of the 18 deaths resulted from operative haemorrhage, five of them associated with a previous caesarean section. No further clinical details were documented. It is notable that studies reporting haemorrhage at caesarean section do not describe operative details or difficulties; rather, they give risk factors for haemorrhage e.g. second stage of labour, previous caesarean section. Studies are needed to identify specific operative causes of haemorrhage even in the absence of risk factors. Fawcus and Moodley (5) describe some of these causes locally but there is a dearth of these statistics in the international literature.

Audits of maternal deaths have identified avoidable factors related to mortality from haemorrhage-associated with caesarean section. Regarding the situation in South Africa, poor initial assessment, inadequate problem recognition, inadequate monitoring after caesarean section, and failure to follow standard protocols at primary and secondary levels were reported to account for maternal deaths to a large extent (33). Reviewing data from the confidential enquiries into maternal deaths in South Africa, Fawcus et al. identified substandard care in 60% of cases, including failure to secure haemostasis at the caesarean section, non-use of potentially effective treatment such as parenteral ergometrine, failure to perform uterine compression sutures and balloon tamponade, and delays in definitive management such as hysterectomy (5).

1.4. Peri-operative and conservative life-saving measures

The treatment of PPH varies depending on the cause and timing of haemorrhage

As a first-line measure for the control of bleeding from an atonic uterus, whether from caesarean section or vaginal delivery, uterotonics should be employed. These include oxytocin, a physiologically produced hormone secreted by the posterior pituitary gland which causes uterine contraction. This drug, given intra-muscularly in the 3rd stage of labour, can also be administered intravenously as an infusion to effect sustained uterine contraction in the case of PPH.

Ergometrine, a combination of ergotamine and oxytocin, is a potent drug in the treatment of postpartum haemorrhage. However, its use is limited in patients with known cardiac lesions and hypertension.

Prostaglandin F_{2α} is also a uterotonic and is administered intramuscularly into the uterine cornua for the control of postpartum haemorrhage especially at caesarean section under vision.

Misoprostol, a synthetic prostaglandin analogue is also widely used for the prevention and treatment of PPH and can be administered orally or rectally.

These conservative measures are the initial steps taken to control bleeding as they are non-invasive and have a fairly rapid onset of action.

Peri-operative life saving measures during caesarean delivery that may occur before, during or after the surgical intervention

Apart from general measures to deal with bleeding such as fluid resuscitation, uterine massage, direct haemostatic sutures, and uterotonic drugs, various lifesaving interventions have been proposed to address PPH after caesarean delivery. These are listed below.

Uterine compression suture: The most well-known compression suture is the B-Lynch method, where a suture is tied over and around the uterus to keep it contracted as in manual compression (34) . This is a method of external uterine compression. Complications related to uterine compression sutures like erosion and uterine necrosis have been described but are rare (35) . Future reproductive potential is preserved (36) . The B-Lynch stitch is indicated in uterine atony and does not control bleeding associated with placenta accreta neither does it play a role in PPH prevention for subsequent pregnancies. Below are images illustrating the B-Lynch technique, showing the anterior view (a & c), as well as the posterior view (b), B-Lynch.

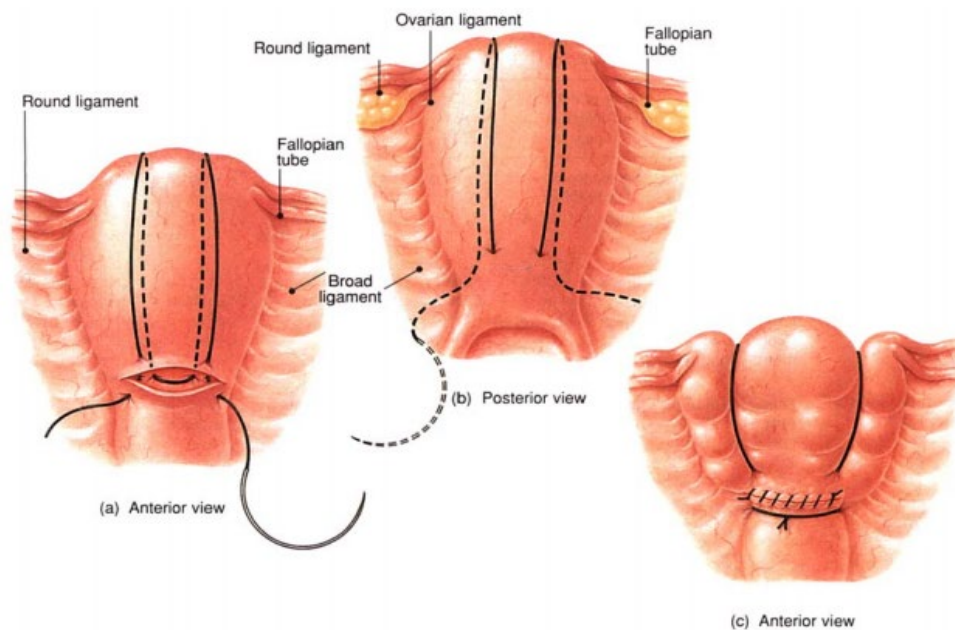


Figure 2: B-Lynch technique, showing the anterior view (a & c), as well as the posterior view (b), B-Lynch.

Balloon tamponade: This technique uses devices like the Bakri balloon or a condom inflated with intravenous crystalloid fluid to tamponade bleeding from the uterine cavity after caesarean or vaginal delivery (37) . Balloon tamponade can be used alone or in combination with compression sutures. When it is used at caesarean section, it has an advantage of the surgeon having direct vision of the uterus (30, 38). Below are images illustrating a Bakri balloon (A), and the Bakri balloon inserted in a uterus during PPH (B)

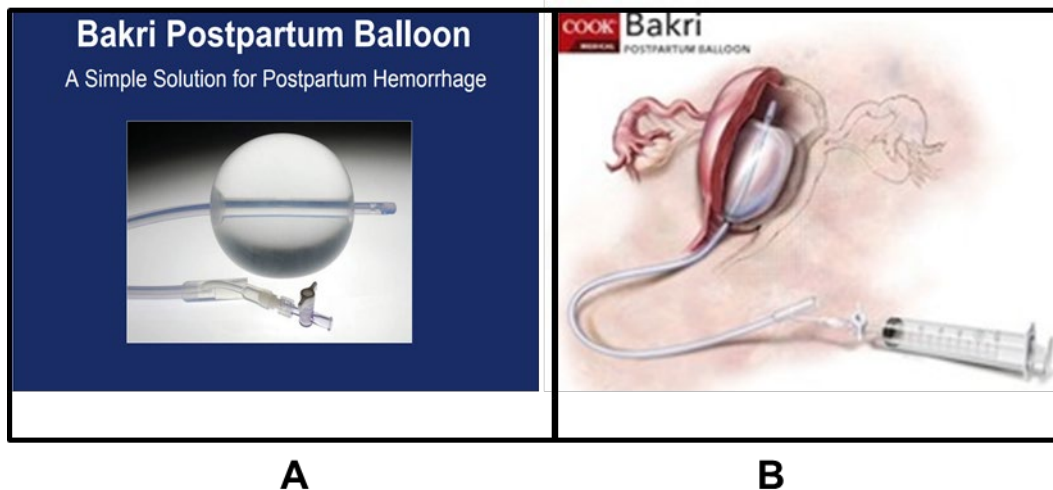


Figure 3: Bakri balloon (A), and the Bakri balloon inserted in a uterus during PPH (B)

Uterine artery ligation: The technique consists of bilateral ligation of the uterine vessels to reduced bleeding from the uterus. This procedure has become a first-line intervention for controlling uterine bleeding at laparotomy (39, 40) . Uterine artery ligation is preferable to internal iliac artery ligation because the uterine arteries are more accessible, rendering the procedure easier, even for inexperienced surgeons. This procedure is mainly indicated for lacerations to uterine or utero-ovarian artery branches. However, it is also used to temporarily decrease bleeding from other causes, such as an atonic uterus, by reducing perfusion pressure to the uterus. In a classic paper in 1994, AbdRabbo showed that stepwise devascularisation of the uterine blood supply, starting with the uterine arteries, can be successful in controlling haemorrhage in over 90% of patients (41). There are no significant serious short- or long-term complications associated with the procedure (42) . Below are images illustrating uterine artery ligation (a) and a ligated uterine artery during postpartum haemorrhage (b), (43).

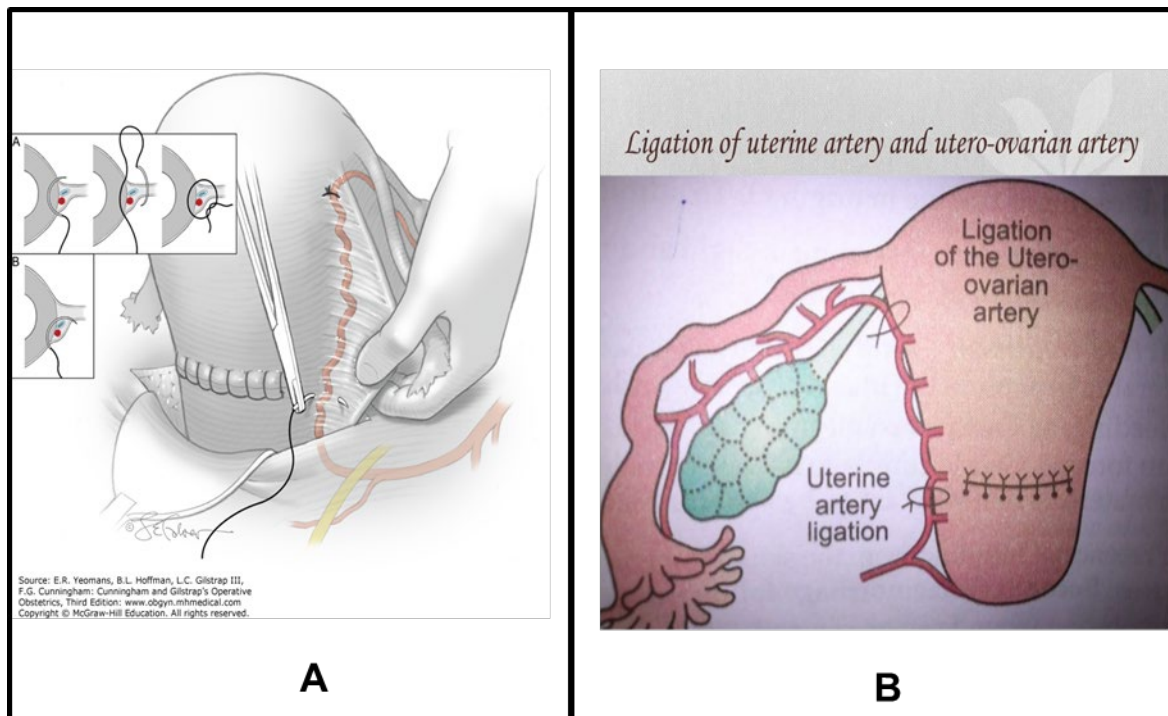


Figure 4: Uterine artery ligation (A) and a ligated uterine artery during postpartum haemorrhage (B)

Internal iliac artery ligation: Bilateral ligation of the internal iliac arteries is used to control uterine bleeding by decreasing the pressure of blood flowing to the uterus (44). This is a difficult technique especially when there is a large uterus, a transverse lower abdominal incision, ongoing haemorrhage, or if the patient is obese. It is best performed by an experienced specialist. For this reason, it is less commonly practiced than uterine compression sutures and uterine artery ligation. However, internal iliac artery ligation is a successful method that can help to avoid emergency obstetric hysterectomy (45).

Hysterectomy: The last resort in the treatment of intractable haemorrhage in uterine atony or severe bleeding from surgical trauma is a hysterectomy. Abnormal placentation or uterine atony are the most common causes of peripartum hysterectomy with each accounting for 30% to 50% of cases (46) .

Temporising measures to prevent the development of haemorrhagic shock are also required, with fluid and transfusion therapy especially if a patient needs to be transferred to a higher care facility while still bleeding. These include uterine tourniquet and aortic compression (47) .

1.5. Preventive Measures

Active management of the third stage of labour, which consists of administration of a prophylactic oxytocin after delivery of the baby, with controlled cord traction and delivery of the placenta, is an important and effective strategy for prevention of PPH. Adequate monitoring in first two hours after delivery, after caesarean section has also been shown to prevent death due to PPH. Ultimately, identifying women who are at risk of PPH, and selection of well-trained birth attendants, can prevent PPH and decrease the rate of maternal death related from this condition. There is a need for improvement of knowledge and clinical skills for resuscitation as well as for surgical techniques and clinical decision-making among health care workers. Further, teamwork and administrative support can play an important role in preventing PPH after caesarean section. The above-mentioned peri-operative life-saving measures, coupled with skills in clinical decision-making are the cornerstone of PPH preventive measures. Of note, the effectiveness of these preventive strategies has been shown in countries that have made considerable progress in attaining the MDG 5 such as Brazil, China and Egypt (48).

1.6. Maternal deaths related to haemorrhage at caesarean section

The targets set in 2014 to reduce maternal mortality from obstetric caused by 20% in 2016 were closely achieved at 19%. Obstetric haemorrhage was still the third most common cause of maternal mortality in South Africa for the 2014 -2016 triennium accounting for 624 of the total deaths. Emergency hysterectomies were performed in 31.7% of deaths from bleeding associated with caesarean delivery. Of concern was the persisting high number of deaths due to bleeding after caesarean delivery. The OH related maternal mortality ratio (MMR) was 22.67/100 000 live births which was less than 244.32 in the 2011-2013 triennium.

As in the 2011-2013 triennium, maternal age over 35 and delivery by C/S were strongly associated with OH; 35% of women who died were over 35 years of age and 62.5% delivered by C/S.

In the 2014-2016 triennium, the major causes of death from haemorrhage:

- Bleeding associated with C/S (34.9%)
- Uterine rupture (15.1%)

- Abruptio placentae (12.9%)
- Uterine atony (9.5%)
- Retained placenta (6.9%)

Saving Mothers report 2014-2016

Maternal deaths from obstetrics haemorrhage related to caesarean delivery:

As can be seen from the above factors and causes of maternal deaths from haemorrhage, C/S is by far the largest contributor.

The majority of deaths from C/S and associated complications occurred at public hospitals; district hospitals, regional hospitals and at tertiary hospitals in ascending order. This may not reflect the level of care where delivery occurred, as many women were referred from district level with bleeding after delivery or CD to a regional or tertiary facility.

Maternal death assessors judged the majority (87.8%) of the obstetric haemorrhage deaths to be possibly or probably avoidable, and 58.8% were thought to be probably avoidable.

Patient related avoidable factors include:

- Late booking and delay in seeking care and the identification of risk factors - 33.8%.

Administrative factors - 66.2%, include:

- Lack of blood and blood products (11.7%)
- Delays in interinstitutional transport (23.7%)
- Delays initiating clinical care due to overburdened services (7.8%)
- Lack of appropriately trained doctors (31%) or nurses (19%), especially at district hospitals.

Health worker-related avoidable factors accounted for 86.3% of assessable deaths at district hospitals, 68.5% at regional hospitals and 53.6% at tertiary hospitals. Analysis of avoidable factors indicates that emphasis needs to be placed on

improving the quality of medical care at district, regional and provincial tertiary hospitals particularly in the provinces with greatest numbers of haemorrhage deaths.

2. OBJECTIVES AND METHODS

2.1. Problem statement and justification for the research

A substantial amount of work has been done to understand the magnitude of the contribution of PPH to maternal deaths attributable to haemorrhage at and after caesarean section in South Africa; however, the likelihood of a surge in direct maternal deaths due to PPH from this cause is imminent. This could be primarily due to the rise in the number of caesarean sections carried out across the country. Little evidence exists to describe the definitive contribution of PPH to maternal deaths over the last two decades at our institution.

2.2. Research Question

What was the contribution of maternal mortality due to post-partum haemorrhage at or after caesarean section at Chris Hani Baragwanath Academic Hospital (CHBAH) between 1997 and 2014, and what were the causes of death?

2.3. Research Objectives

- To estimate the proportion of maternal deaths attributable to haemorrhage at or after caesarean section from 1997 to 2014.
- To describe the demographic and obstetric characteristics of the women who died from bleeding associated with caesarean section during the study period.
- To describe the clinical and surgical management in women who died because of haemorrhage at or after caesarean section.

3. METHODOLOGY

3.1. Research Setting

From 1997 to 2014, CHBAH was the only hospital serving a population of about 1.4 to 1.8 million people in Greater Soweto, Orange Farm and Lenasia areas, to the South-West of Johannesburg. The maternity unit also provided referral services to community health centers in Soweto and to other hospitals in Gauteng province and some hospitals in North-West Province. All maternal deaths at CHBAH from 1997 have been routinely notified to the national confidential enquiries, and the original case notes have been kept in the hospital's Department of Obstetrics and Gynaecology. In 2013 a computerized database of all maternal deaths was created, with causes of death classified as in the Saving Mothers reports.

3.2. Research design and population

This was a retrospective descriptive study. All deaths classified as caused by haemorrhage at or after caesarean section were included, from 1 January 1997 to 31 March 2014 from the database; Women who had more than one contributory cause to the haemorrhage were also included e.g. broad ligament injuries and vaginal tears. Deaths from ruptured uterus and deaths related to caesarean section but caused by placental abnormalities (placental abruption, placenta praevia, placenta accreta) were not included. Our study aimed to describe the number of women in whom the primary cause of death was haemorrhage from caesarean section. Inclusion of women with abnormal placentation would have confounded the primary cause of death. Women referred from other primary and secondary hospitals and who fitted the inclusion criteria were included in the study.

3.3. Sampling procedure and size estimation

The number of women to be included in the study depended on the number of deaths that occurred from 1997 to 2014. All deaths fitting the inclusion criteria were included. The sampling strategy, therefore, was period sample for this time interval, including all cases.

3.4. Data collection

The maternal clinical files were accessed from the database with permission from the gatekeepers by using the cause of death as indicated in the inclusion criteria. Clinical information was gathered and entered onto a specially designed data sheet (Appendix A). The information included demographic, reproductive and clinical characteristics of the women, as well as the circumstances around their caesarean sections, the time and place of death, and the measures taken by the clinical staff to control the bleeding, including drugs used, surgical procedures attempted, and blood transfusions given. In addition, the total numbers of caesarean sections done at CHBAH in the study period were obtained from the records of the Department of Obstetrics and Gynaecology. The cause of death was determined in each case by the researcher.

3.5. Data analysis

Data sheet information was transcribed onto Microsoft Excel software and then imported into Stata statistical software for analysis. All statistical analyses were descriptive. Summary measures included means with standard deviations (mean $\pm$ SD) and proportions presented as percentages. The cause-specific case fatality rate for caesarean section was calculated by dividing the number of deaths from haemorrhage at or after caesarean section by the total number of caesarean sections in the study period.

3.6. Ethical considerations

Access to the database was obtained from the hospital management and the Department of Obstetrics and Gynaecology via signed written documentation. All necessary precautions were taken to ensure that patient's confidentiality was not breached – no identifiers were entered onto the data sheet other than a study number that was kept securely by the researcher. In addition, ethics approval for this study was obtained from the University of the Witwatersrand's Human Research Ethics Committee (Appendix B).

4. RESULTS

From 1997 to March 2014, 102 948 caesarean deliveries were performed at CHBAH. Of those, 15 women died as a consequence of associated haemorrhage at C/S. All 15 of the patient's files were retrieved and reviewed. Eleven of these operations were done at CHBAH, representing an incidence of 10.7 per 100,000 caesarean deliveries. The mean age of the women was 35.6 years. Almost 27 % of study patients were known to be HIV positive, while 26.7% had pregnancy induced hypertension. Although many women had prior pregnancies (86.6%) and caesarean sections (53.3%), none had a recorded history of PPH in the previous pregnancies. Spontaneous labour was reported in 12 out of 15 women, with none receiving augmentation or induction. Clinical notes describing difficult caesarean sections were present for 10 patients (66.7%). Most caesarean sections were done as emergencies (86.7% emergency versus 13.7% elective). Previous cesarean section (40.0%) and fetal distress (26.7%) and were the most frequent indications for caesarean section in Table 2 below.

Among the causes of bleeding, which might have resulted in PPH, uterine atony was the most common (diagnosed in 80% of the patients), followed by an injury to broad ligament and coagulopathy (which were present in 40% each) (Table 2). Four patients had caesarean sections in the second stage of labour.

While oxytocin was noted to be administered in 12 patients (80%), other medication such as ergometrine and misoprostol used 20% (3 patients each) while prostaglandin F2 α has never been administered. As measures of controlling blood loss, immediate hysterectomy was performed in 3 (20%) cases and abdominal packing in 20% of patients. In 13.3%, internal iliac artery ligation was done. In addition, no patients had other surgical management strategies applied, such as balloon tamponade, systematic devascularization or the B-Lynch compression suture (Table 2).

Table 2: Demographic and clinical data of women who died from haemorrhage at or after caesarean section (n=15)

Characteristic (n=15)	Frequency	Percent
Age in years (mean $\pm$ standard deviation)	35.6 $\pm$ 6.7	
15-20	0	0
21-25	0	0
26-30	5	33.3%
31-35	4	26.7%
36-40	1	6.7%
41-45	4	26.7%
>46	1	6.7%
HIV status		
Positive	4	26.7%
Negative	6	40.0%
Not known	5	33.3%
Indication for current caesarean section		
Previous caesarean section	6	40.0%
Foetal distress	4	26.7%
Cephalo-pelvic disproportion	2	13.3%
Breech presentation	1	6.7%
Retained twin	1	6.7%
Poor obstetric history	1	6.7%
Emergency vs. elective caesarean section		
Emergency	13	86.7%
Elective	2	13.3%
Multiple vs. singleton pregnancy		
Multiple	1	6.7%
Singleton	14	93.3%
Pregnancy-induced hypertension		
Yes	4	26.7%
No	11	73.3%
Parity		
0	2	13.3%
1 – 2	8	53.3%
3 and more	5	33.3%

Previous caesarean section		
Yes	8	53.3%
No	7	46.7%
Previous history of PPH		
Yes	0	0.0%
No	15	100.0%

Spontaneous labour was reported in 12 out of 15 women, with none receiving augmentation or induction. Clinical notes describing difficult caesarean sections were present for 10 patients (66.7%).

Table 3: Causes of bleeding in women who died from haemorrhage at or after caesarean section (n=15).

Characteristic	Frequency	Percent
Uterine atony	12	80.0%
Injury to uterine artery	4	26.7%
Injury to broad ligament	6	40.0%
Other uterine injury	5	33.3%
Coagulopathy	6	40.0%
Vaginal injury	3	20%

The total number of women in the study was 15, however it can be seen from the table above that the injuries/causes of haemorrhage were not mutually exclusive. Six women who had massive haemorrhage experienced coagulopathy despite other life-saving measures and this may have been a contributory cause of death.

The women who suffered severe vaginal injury were associated with the second stage of labour.

Table 4: Clinical and surgical management at the time of caesarean section (n=15).

Characteristic (n=15)	
Duration of the caesarean section (minutes)	
Average duration, Mean	58.1
60 min or less, n (%)	7 (46.70)
>60 min, n (%)	4 (26.70)
Not documented, n (%)	4 (26.70)
Ergometrine administration, n (%)	
Yes	12 (80)
No	3 (20)
Prostaglandin F2-alpha use, n (%)	
Not documented	15 (100)
Misoprostol use, n (%)	
Yes	3 (20)
Unknown	12 (80)
Hysterectomy at time of C/S, n (%)	3 (20)
Use of other haemostatic sutures	3 (20)
Internal iliac artery ligation at time of caesarean section	2 (13.30)
Packing of the abdomen at time of caesarean section	3 (20)

Red cell transfusion was used in ten patients (66.7%) and the majority of those (n=7) received more than four units of packed red cells (70%). FFP was transfused in 17 (53.3%) patients (Table 4). Regarding resuscitation measures, CPR was performed in 40% of women (Table 5).

Table 5: Use of blood products

Use of blood products (n=15)	
Red cell transfusion	
Average unit, Mean (SD)	3.6 (SD)
≤ 4, n(%)	3 (20)
≥ 4, n(%)	7 (46.70)
No red cell transfusion	5 (33.30)
Units of fresh frozen plasma (FFP), n(%)	
≤ 4	5 (33.30)

≥ 4	3 (20)
No FFP transfusion	7 (46.70)

Table 6: Attempted resuscitation measures

Attempted resuscitation measures		
Cardio-pulmonary resuscitation (CPR)	n	%
Yes	6	40%
No	8	53.30%
Not known	1	6.70%

The estimated blood loss at caesarean section was 900 ml. However, for almost half the patients (46.7%), the amount of blood lost during or after the operation was not documented.

Of the eight patients who underwent a, relook laparotomy, all had developed coagulopathies and 87.5% had difficult haemostasis. Twenty-five percent developed renal failure. Three patients had two relook laparotomies. Hysterectomies were performed additionally in eight patients (at first or second relook) (Table 6). There were ten relook laparotomies, six done specifically because of bleeding. While hysterectomies were performed in 53.3% cases, internal iliac artery ligation and abdominal packing were done in 26.7% each (Figure 2).

Table 6: Mean blood loss and complications reported during or after caesarean section.

Average blood loss at/during C/S (ml)	Mean: 900	
<1000	5	33.3%
1000 or more	3	20.0%
Not documented	7	46.7%
Complications at or after relook laparotomy	8	53.3%
Difficult haemostasis	7	87.5%
Coagulopathy	8	100%
Renal failure	2	25%
Hypothermia	1	12.5%

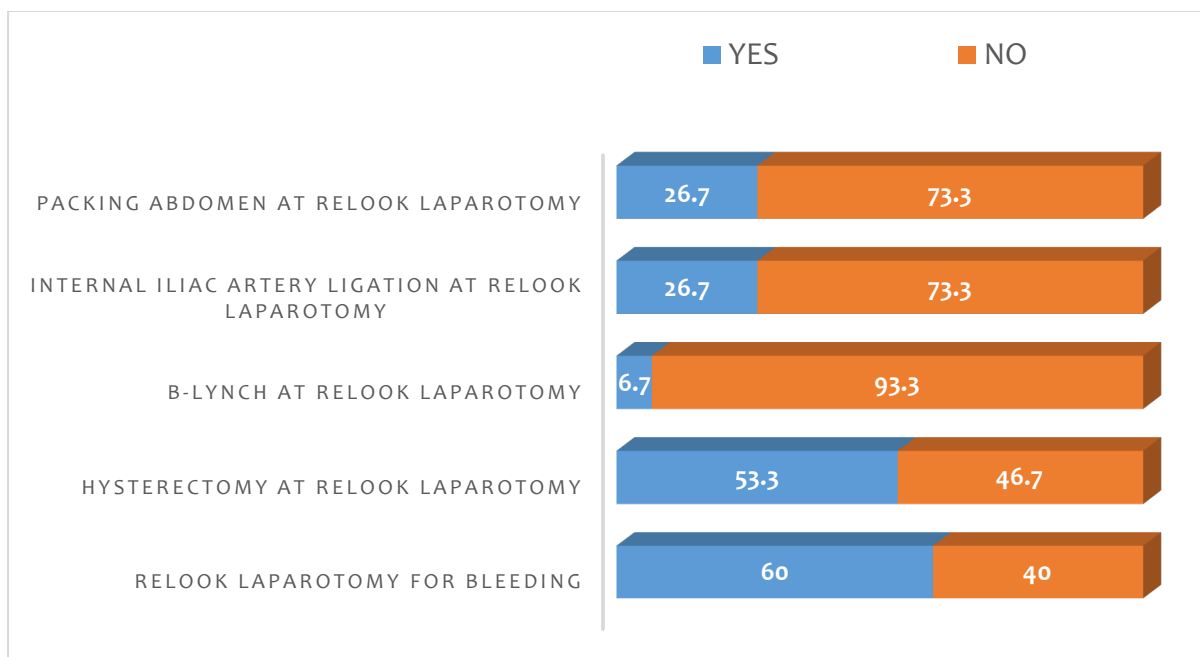


Figure 5: Procedures performed at relook laparotomy (n=10)

Most women (67%) died in the maternity high care area or in the CHBAH multidisciplinary intensive care unit. One died intra-operatively, and one died in the patient waiting area, having been transferred from a district hospital (Figure 3).

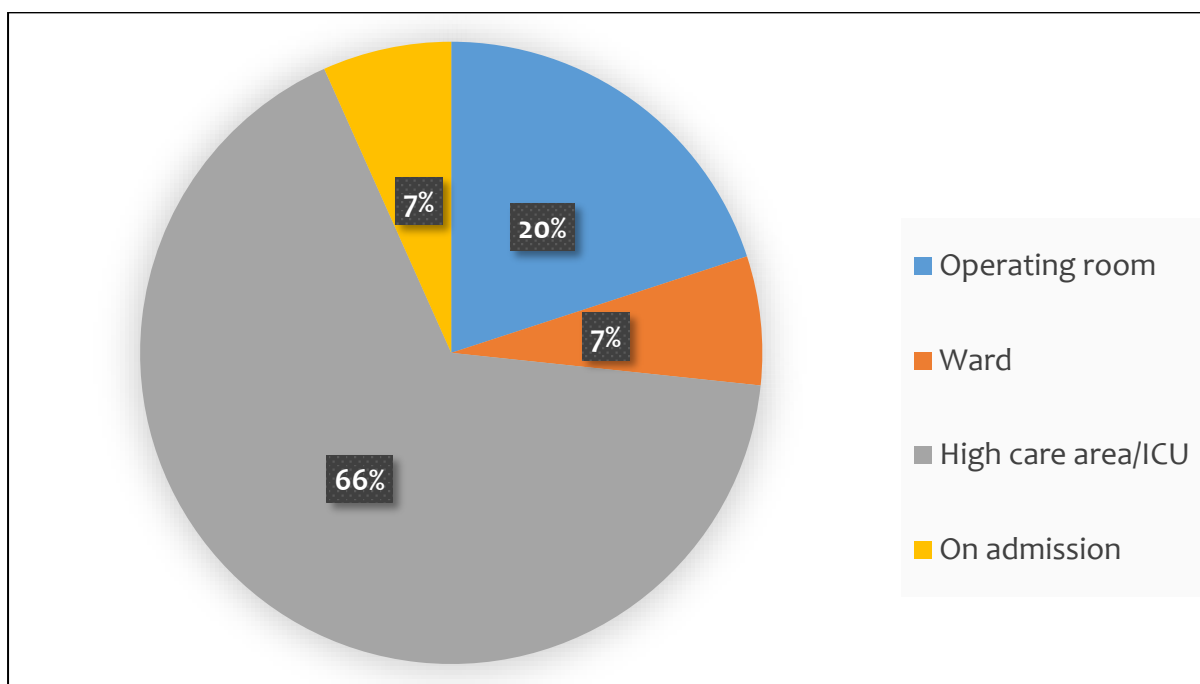


Figure 6: Place of death of women who died from haemorrhage at or after caesarean section.

Table 7: Case-by-case summary of all the women who died, including some detail on surgical difficulty and sequence of events

Year	Age	Parity	Previous CS	Second stage of labour	CS done at CHBAH	Indication for CS	Description
2000	27	1	No	Yes	Yes	Fetal distress	Difficult C/S followed by repeat surgery with hysterectomy, died intra-operatively
2000	37	4	No	No	Yes	Fetal distress	No difficulty at C/S, followed by repeat surgery with hysterectomy, died in ICU
2003	46	6	Yes	No	Yes	Previous CS	Difficult C/S, did an immediate hysterectomy and IIA ligation, died intra-operatively
2005	28	0	No	No	Yes	Fetal distress	No difficulty at C/S, then uterine atony, repeat surgery with hysterectomy, died in MHCA
2005	45	6	No	Yes	Yes	Poor progress	Difficult C/S, did an immediate hysterectomy and IIA ligation, died in ICU
2006	34	1	Yes	Yes	Yes	Previous CS	Difficult C/S and delivery, followed by repeat surgery with hysterectomy and IIA ligation, died in ICU
2007	33	2	Yes	No	No	Previous CS	The difficulty with adhesions did an immediate hysterectomy,

							then transferred to CHBAH, died in ICU
2007	30	1	Yes	No	Yes	Previous CS	The difficulty with adhesions did not do a hysterectomy, died in MHCA
2008	30	2	Yes	No	Yes	Previous CS	The difficulty with adhesions, followed by repeat surgery with hysterectomy and IAA ligation, died in MCA
2009	45	4	Yes	No	Yes	Breech	The difficulty with adhesions, then repeat surgery with the finding of incomplete uterine repair, did a hysterectomy, died in MHCA
2010	43	1	Yes	No	No	Previous CS	No difficulty at C/S, transferred to CHBAH for bleeding, had repeat surgery with hysterectomy and IIA ligation, died in ICU
2012	32	1	No	No	No	Fetal distress	Difficult C/S, transferred to CHBAH for bleeding, died on admission
2012	33	1	Yes	Yes	Yes	Retained twin	The difficulty with adhesions did an immediate hysterectomy, died intra-operatively
2013	30	0	No	No	No	Cephalopelvic disproportion	No difficulty at C/S, then bleeding, transferred to CHBAH, had laparotomy and

							B-Lynch suture, died later in MHCA
2014	42	6	No	No	Yes	Poor obstetric history	No difficulty at C/S collapsed in postnatal ward, an autopsy found atonic uterus filled with blood clot

C/S = caesarean section, ICU=intensive care unit, IIA=internal iliac artery, MHCA=maternity high care area, CHBAH= Chris Hani Baragwanath Academic Hospital

5. DISCUSSION

This retrospective study was conducted to quantify and explain maternal mortality related to bleeding at and after caesarean section at CHBAH, in the absence of major placental pathology or uterine rupture. The incidence (case fatality rate) was 0.01% or 10.7 per 100,000 caesarean deliveries. This may be a slight underestimate because cases of major placental pathology and uterine rupture were excluded from the denominator of total caesarean sections, as these data were not available for the years of the study.

Compared to other reported data, this finding demonstrates that PPH related to caesarean section is an important cause of maternal mortality at CHBAH. In the USA, for instance, the reported case fatality rate of PPH after Caesarean Section has been reported by Clark, Belfort (19) to be 2.2 per 100 000 caesarean deliveries. This rate is much lower than the reported post-caesarean section PPH related case fatality rate in South Africa of 0.042% or 42 deaths per 100 000 Caesarean deliveries and even lower than the frequency reported above for countries such as Malawi and Zimbabwe at 0.62%. It is worth noting that the rates, as described in the present study, occurred in a referral academic setting (CHBAH), an institution where the number of PPH-related deaths would be expected to be low. Indeed, the Fifth Report on Confidential Enquiries into Maternal Deaths in South Africa, reported that only about one-fifth of maternal death due to haemorrhage occurred in tertiary hospitals

while most of the deaths occurred in district and/or regional hospitals during the period of 2005-2007.

The following table demonstrates the trend in OH according to the available data from the 2002 to 2016 triennia from the Saving Mothers Report (38, 49-51).

Comparison of obstetric deaths for each triennium from 2002 up to 2016

Table 8: Comparison of obstetric deaths for each triennium from 2002 up to 2016

Saving Mothers report	Percentage of maternal death related to obstetric haemorrhage	MMR related to obstetric haemorrhage	Maternal death related to Obstetric Haemorrhage after Caesarean section
2002-2004	13%	20.7/100000 live births	-
2005-2007	12,4%	18.8/100000 live births	-
2008-2010	14,1%	24.9/100000 live births	26,2%
2011-2013	15,8%	24.3/100000 live births	32,3%
2014-2016	16,9%	22.6/100000 live births	34,9%

With regard to the causes of haemorrhage, uterine atony was the most commonly recorded cause of PPH, with an overall contribution of 80% of cases in our cohort. Uterine atony has been reported as the most common cause of PPH worldwide. Particularly, the rate of 79% reported by Bateman in 2010 is comparable to those reported in our study. Uterine atony-induced PPH is often responsive to conservative therapy, and does not commonly result in massive blood transfusion, shock or maternal death in developed countries. This calls into question the adequacy and timeous reaction of medical teams attending to women after caesarean section and their management of the third stage of labour (even at caesarean section), as well as adequate monitoring of women in the early post-operative period. Nevertheless, these findings should be interpreted with caution, since, in the present study, the number of women who developed uterine atony, but

on whom appropriate management strategies were undertaken in time to prevent other complications and death, is not known.

In several studies and in the Saving Mothers Reports across most triennia, a recurring trend is the failure of healthcare workers to recognise life-threatening post-partum bleeding. Abnormal post-operative vital signs are not well monitored and the index of suspicion in high-risk patients is not borne in mind. There is also a failure to recognise the ineffectiveness of conservative measures and recourse to relook laparotomy. In district and regional hospitals, faced with life-threatening PPH, inexperienced medical officers should seek help from surgical colleagues who are competent at pelvic surgery including internal iliac artery ligation. Transporting a haemodynamically unstable patient may have fatal consequences as observed in several of the Saving Mothers Reports.

Other risk factors and surgical problems associated with PPH in this study were advanced maternal age, previous caesarean section, hypertensive disorders, and caesarean section in the second stage of labour, coagulopathy, uterine artery injury, injury to the broad ligament, and vaginal injury. All these causes have been cited in the previous literature as potential causes or contributors to PPH (52).

Specifically, advanced age appears a striking cause because, in this series, the mean maternal age of those who died was 35.6 years and one-third of patients were more than 40 years of age. In the present study, 13.3% had no previous deliveries (parity 0), while approximately one third (33.3%), had 3 or more pregnancies. The role of a previous caesarean section is likely to be significant when considering the surgical challenges e.g., distortion of anatomy and friable or scarred tissue.

Oxytocin administration was used to control PPH in at least 80% of the study cases, however, it seemed to have been ineffective, as those cases resulted in persistent bleeding, shock and death. While this drug is readily available and is used widely to treat bleeding due to uterine atony effectively if administered immediately after delivery (53). It is not clear why oxytocin administration did not result in effective control of PPH in the present study.

Delay in timely drug administration, lack of adequate post-partum monitoring and possible other administrative factors such as availability of blood and blood products or lack of well-established protocols may play a role in these outcomes.

Interpretation of clinical management in this study is limited by the absence of a control group of women with caesarean sections who survived, either without bleeding or with severe bleeding (near-misses).

Regarding the estimation of blood loss, the present study confirms a previously reported problem of inaccurate estimation of blood loss during the post-partum period, which is a problem in many health facilities all over the world, but particularly in Africa. Of the 15 cases, information on postpartum blood loss could not be retrieved for almost half of the patients. Moreover, of those on whom data on blood loss were documented, an in-depth analysis showed that the estimated blood loss was likely not in keeping with the severity of the patient's clinical status. For instance, more than 60% of those who had estimations of blood loss documented, of less than 1000 ml, all went into shock and subsequently died.

In the present study only 5 of the 15 cases received a blood transfusion. This omission cannot be justified in a tertiary hospital with emergency blood on hand and a fully functional blood-bank on the premises. The care of the patient intra-operatively is the responsibility of both, the surgeon and anesthetist. The failure to administer blood to a severely unstable patient suggests substandard care.

No data suggested that there were patient-related factors involved in severe haemorrhage. The place of death suggests that almost all survived the initial severe bleeding intra-operatively, with two-thirds of women dying in a high care setting.

In terms of preventing the possible deaths from C/S, healthcare workers need to be proactive. High-risk patients should be referred antenatally to higher centres of care for assessment and management. Further, patients with a history of PPH or C/S, or any of the listed risk factors, should be transferred immediately on presentation in labour. If a delay is anticipated or the C/S must be done at a regional or district hospital, blood and blood products should be acquired, drugs for the conservative management of haemorrhage and mechanisms to tamponade the bleeding, be prepared. Ideally the most senior surgeon should perform the C/S.

Good contemporaneous notes should be documented, stating the drugs given, procedures involved, cause of haemorrhage and other relevant factors. In this study, there were no such notes. As noted in the Saving Mothers Report of 2014-2016, the transfer of unstable patients between institutions is also a cause of death after C/S.

In our study 1 patient demised while awaiting intervention, suggesting she was unstable at or during the time of transfer.

In our study, three hysterectomies were performed at caesarean section. This may be explained by the seniority of the surgeon, further intraoperative injuries etc. However, a specialist consultant is available 24 hours daily, so there are no satisfactory reasons for the delay or failure in performing a hysterectomy. Hysterectomy is a life-saving procedure and recourse should be taken when conservative management and other modalities e.g. the B-Lynch or condom catheter has proved ineffective.

5.2. Research limitations

The retrospective nature of the study as well as the small sample size, make it difficult to establish a definite direction of causal associations between postpartum haemorrhage after caesarean section and risk factors. There is missing data especially from referral hospitals or poor note-keeping at the time or after the event. This included the documentation of administration of drugs, seniority of the surgeon, intra-operative haemostatic measures, estimation of blood loss etc. Because data on other causes of maternal mortality was not accessible to the researcher, it was not possible to estimate the contribution of caesarean section-related haemorrhage as part of the greater problem of obstetric haemorrhage deaths.

5.3. Research strengths

Despite the small sample size of the study, our findings are similar to the trends of the Saving Mothers Report through most of the triennia. Further, the avoidable and administrative factors are similar to those in the SMR. Our study confirms that little progress has been made in the bid to decrease maternal deaths from caesarean section.

5.4. Conclusion

As stated earlier, the incidence of C/S is increasing globally, and deaths from caesarean section locally. There will always be patients who require C/S e.g. women with abnormal placentation, placental abruption etc. Preventing deaths from C/S is not performing them without a dire indication. That requires us to review the way we manage labour, thereby making accurate diagnosis of CPD and other intrapartum complications including slow progress. Recourse to caesarean section should never

be taken lightly. CTGs need to be correctly interpreted and the latest guidelines should be well known as not to make false diagnoses of fetal distress. Skills with instrumental delivery need improvement to eliminate the need for C/S in a woman in the second stage and who fits the criteria for instrumental delivery. Importantly, preparation for an adverse event should be made when performing a high-risk caesarean section. Drugs, fluids and the necessary expertise and equipment should be on hand. The debate remains: are maternal deaths from haemorrhage at C/S avoidable? While the numbers continue to rise, it seems not. As our study has shown with respect to PPH and death, there is no such entity as a routine caesarean section.

REFERENCES

1. Prata N, Gerdt C. Measurement of postpartum blood loss. *Bmj*. 2010;340:c555.
2. Obstetricians RCo, Gynaecologists. Prevention and management of postpartum haemorrhage. Green Top Guideline. 2009;52:1-24.
3. Starrs A, Winikoff B. Misoprostol for postpartum hemorrhage: Moving from evidence to practice. *International Journal of Gynecology & Obstetrics*. 2012;116(1):1-3.
4. Kassebaum NJ, Bertozzi-Villa A, Coggeshall MS, Shackelford KA, Steiner C, Heuton KR, et al. Global, regional, and national levels and causes of maternal mortality during 1990–2013: a systematic analysis for the Global Burden of Disease Study 2013. *The Lancet*. 2014;384(9947):980-1004.
5. Fawcus S, Moodley J. Haemorrhage associated with caesarean section in South Africa: be aware. *SAMJ: South African Medical Journal*. 2011;101(5):306-9.
6. WHO. WHO guidelines for the management of postpartum haemorrhage and retained placenta. Switzerland: World Health Organisation, 2011.
7. Mojekwu JN, Ibekwe U. Maternal mortality in Nigeria: Examination of intervention methods. *International Journal of Humanities and Social Science*. 2012;2(20):135-49.
8. Hogan MC, Foreman KJ, Naghavi M, Ahn SY, Wang M, Makela SM, et al. Maternal mortality for 181 countries, 1980–2008: a systematic analysis of progress towards Millennium Development Goal 5. *The lancet*. 2010;375(9726):1609-23.
9. Ezugwu E, Agu P, Nwoke M, Ezugwu F. Reducing maternal deaths in a low resource setting in Nigeria. *Nigerian Journal of clinical practice*. 2014;17(1):62-6.
10. Blaauw D, Penn-Kekana L. Maternal health: reflections on the Millennium Development Goals. *South African Health Review*. 2010;2010(1):3-28.
11. Blaauw D, Penn-Kekana L. Maternal health. *South African health review*. 2010:3-28.
12. Mpemba F, Kampo S, Zhang X. Towards 2015: post-partum haemorrhage in sub-Saharan Africa still on the rise. *Journal of clinical nursing*. 2014;23(5-6):774-83.
13. Liu X, Lynch C, Cheng W, Landon M. Lowering the high rate of caesarean delivery in China: an experience from Shanghai. *BJOG: An International Journal of Obstetrics & Gynaecology*. 2016;123(10):1620-8.

14. Leth RA, Møller JK, Thomsen RW, Uldbjerg N, Nørgaard M. Risk of selected postpartum infections after cesarean section compared with vaginal birth: a five-year cohort study of 32,468 women. *Acta obstetrica et gynecologica Scandinavica*. 2009;88(9):976-83.
15. Magann EF, Evans S, Hutchinson M, Collins R, Lanneau G, Morrison JC. Postpartum hemorrhage after cesarean delivery: an analysis of risk factors. *Southern medical journal*. 2005;98(7):681-5.
16. Alexander JM, Leveno KJ, Rouse DJ, Landon MB, Gilbert S, Spong CY, et al. Comparison of maternal and infant outcomes from primary cesarean delivery during the second compared with first stage of labor. *Obstetrics & Gynecology*. 2007;109(4):917-21.
17. Rouse DJ, MacPherson C, Landon M, Varner MW, Leveno KJ, Moawad AH, et al. Blood transfusion and cesarean delivery. *Obstetrics & Gynecology*. 2006;108(4):891-7.
18. Phipps MG, Watabe B, Clemons JL, Weitzen S, Myers DL. Risk factors for bladder injury during cesarean delivery. *Obstetrics & Gynecology*. 2005;105(1):156-60.
19. Clark SL, Belfort MA, Dildy GA, Herbst MA, Meyers JA, Hankins GD. Maternal death in the 21st century: causes, prevention, and relationship to cesarean delivery. *American journal of obstetrics and gynecology*. 2008;199(1):36. e1-. e5.
20. Alves B, Sheikh A. Investigating the relationship between affluence and elective caesarean sections. *BJOG: An International Journal of Obstetrics & Gynaecology*. 2005;112(7):994-6.
21. Bettes BA, Coleman VH, Zinberg S, Spong CY, Portnoy B, DeVoto E, et al. Cesarean delivery on maternal request: obstetrician–gynecologists’ knowledge, perception, and practice patterns. *Obstetrics & Gynecology*. 2007;109(1):57-66.
22. Ecker J. Elective cesarean delivery on maternal request. *Jama*. 2013;309(18):1930-6.
23. Gossman GL, Joesch JM, Tanfer K. Trends in maternal request cesarean delivery from 1991 to 2004. *Obstetrics & Gynecology*. 2006;108(6):1506-16.
24. Gibbons L, Belizán JM, Lauer JA, Betrán AP, Merialdi M, Althabe F. The global numbers and costs of additionally needed and unnecessary caesarean sections performed per year: overuse as a barrier to universal coverage. *World health report*. 2010;30:1-31.

25. Betrán AP, Ye J, Moller A-B, Zhang J, Gülmezoglu AM, Torloni MR. The increasing trend in caesarean section rates: global, regional and national estimates: 1990-2014. *PLoS One*. 2016;11(2):e0148343.
26. Declercq ER, Sakala C, Corry MP, Applebaum S, Herrlich A. *Listening to mothers III: Pregnancy and birth*. New York: Childbirth Connection. 2013;2103.
27. Organization WH, Unicef. Trends in maternal mortality: 1990 to 2010: WHO, UNICEF, UNFPA and The World Bank estimates. 2012.
28. Fawcus S, Moodley J. Postpartum haemorrhage associated with caesarean section and caesarean hysterectomy. *Best Practice & Research Clinical Obstetrics & Gynaecology*. 2013;27(2):233-49.
29. Combs CA, Murphy EL, Laros JR. Factors associated with hemorrhage in cesarean deliveries. *Obstetrics and gynecology*. 1991;77(1):77-82.
30. Belay T, Yusuf L, Negash S. A comparative study on first stage versus second stage caesarean section on maternal and perinatal outcome. *Ethiopian medical journal*. 2014;52(1):1-8.
31. Fenton PM, Whitty CJ, Reynolds F. Caesarean section in Malawi: prospective study of early maternal and perinatal mortality. *Bmj*. 2003;327(7415):587.
32. Van Eygen L, Rutgers S. Caesarean section as preferred mode of delivery in term breech presentations is not a realistic option in rural Zimbabwe. *Tropical doctor*. 2008;38(1):36-9.
33. Fawcus S. Practical algorithms for management of postpartum haemorrhage. *A Monograph of the Management of Postpartum Haemorrhage*. 2010:16.
34. Allam M. The B-Lynch and other uterine compression suture techniques. *International Journal of Gynecology & Obstetrics*. 2005;89(3):236-41.
35. Gottlieb AG, Pandipati S, Davis KM, Gibbs RS. Uterine necrosis: a complication of uterine compression sutures. *Obstetrics & Gynecology*. 2008;112(2):429-31.
36. Fuglsang J. Later reproductive health after B-Lynch sutures: a follow-up study after 10 years' clinical use of the B-Lynch suture. *Fertility and sterility*. 2014;101(4):1194-9.
37. Tindell K, Garfinkel R, Abu-Haydar E, Ahn R, Burke T, Conn K, et al. Uterine balloon tamponade for the treatment of postpartum haemorrhage in resource-poor

settings: a systematic review. *BJOG: An International Journal of Obstetrics & Gynaecology*. 2013;120(1):5-14.

38. Deaths NCfCEiM. Saving Mothers 2011-2013: Sixth report on confidential enquiries into maternal deaths in South Africa: Fact sheet Pretoria. National Department of Health; 2015.

39. O'Leary JL, O'Leary JA. Uterine artery ligation in the control of intractable postpartum hemorrhage. *American Journal of Obstetrics & Gynecology*. 1966;94(7):920-4.

40. O'Leary JA. Uterine artery ligation in the control of postcesarean hemorrhage. *The Journal of reproductive medicine*. 1995;40(3):189-93.

41. AbdRabbo SA. Stepwise uterine devascularization: a novel technique for management of uncontrollable postpartum hemorrhage with preservation of the uterus. *American journal of obstetrics and gynecology*. 1994;171(3):694-700.

42. Roman H, Sentilhes L, Cingotti M, Verspyck E, Marpeau L. Uterine devascularization and subsequent major intrauterine synechiae and ovarian failure. *Fertility and sterility*. 2005;83(3):755-7.

43. Yeomans ER, Hoffman BL. *Cunningham and Gilstrap's Operative Obstetrics*: McGraw-Hill Education; 2017.

44. Evans S, McSHANE P. The efficacy of internal iliac artery ligation in obstetric hemorrhage. *Surgery, gynecology & obstetrics*. 1985;160(3):250-3.

45. Clark SL, Phelan JP, Yeh S, Bruce SR, Paul RH. Hypogastric artery ligation for obstetric hemorrhage. *Obstetrics and gynecology*. 1985;66(3):353-6.

46. Glaze S, Ekwilanga P, Roberts G, Lange I, Birch C, Rosengarten A, et al. Peripartum hysterectomy: 1999 to 2006. *Obstetrics & Gynecology*. 2008;111(3):732-8.

47. Taylor A, Sharma M, Tsirkas P, Sardo ADS, Setchell M, Magos A. Reducing blood loss at open myomectomy using triple tourniquets: a randomised controlled trial. *BJOG: An International Journal of Obstetrics & Gynaecology*. 2005;112(3):340-5.

48. Lozano R, Wang H, Foreman KJ, Rajaratnam JK, Naghavi M, Marcus JR, et al. Progress towards Millennium Development Goals 4 and 5 on maternal and child mortality: an updated systematic analysis. *The Lancet*. 2011;378(9797):1139-65.

49. Deaths NCoCEiM. Saving mothers 2005–2007: fourth report on confidential enquiries into maternal deaths in South Africa. Pretoria; 2009.

50. Mothers S. Mothers 2008-2010: Fifth report on the confidential enquiries into maternal deaths in South Africa. Compiled by the national committee for confidential enquiry into maternal deaths Department of Health, Republic of South Africa. 2012.
51. Moodley J, Fawcus S, Pattinson R. Improvements in maternal mortality in South Africa. South African Medical Journal. 2018;108(3):4-8.
52. Mhyre JM, Shilkrut A, Kuklina EV, Callaghan WM, Creanga AA, Kaminsky S, et al. Massive blood transfusion during hospitalization for delivery in New York State, 1998–2007. Obstetrics and gynecology. 2013;122(6):1288.
53. Organization WH. Proportion of births attended by a skilled attendant: 2008 updates. 2008.

APPENDIX A: DATA COLLECTION SHEET

DATA SHEET

A) DEMOGRAPHICS:

- 1) Age.....
- 2) Parity.....
- 3) Booked.....Y/N (No=0/Yes=1)
- 4) HIV.....neg/pos/unknown: **neg = 0; pos=1; unknown=2**
- 5) CD4.....

B) OBSTETRIC HISTORY

Previous caesarean section: y/n **Y=1; N=0** (Prevcs)

Number.....

Indication /s for previous caesarean section: Indpcs

- 1)-previous caesarean section
- 2)-Sterilization
- 3) - Prolonged second stage of labour
- 4)-Fetal distress
- 5)-cephalopelvic disproportion
- 6)-Prolonged latent phase of labour
- 7)-Prolonged active phase of labour
- 8)-Orolonged of second stage of labour
- 9)-Breech presentation
- 10)-Transverse presentation
- 11)-Multiple pregnancy

- 12)-Retained Twin
- 13)-Cord Prolapse
- 14)-Antepartum haemorrhage
- 15)-Eclampsia
- 16)-Failed Induction of Labour
- 17)-Poor Obstetric history

Indication for index (present caesarean section: Index

- 1)-previous caesarean section
- 2) - previous caesarean section + Sterilisation
- 3)-Sterilization
- 4) - Prolonged second stage of labour
- 5)-Fetal distress
- 6)-cephalopelvic disproportion
- 7)-Prolonged latent phase of labour
- 8)-Prolonged active phase of labour
- 9)-Prolonged of second stage of labour
- 10)-Breech presentation
- 11)-Transverse presentation
- 12)-Multiple pregnancy
- 13)-Retained Twin
- 14)-Cord Prolapse
- 15)-Antepartum haemorrhage
- 16)-Eclampsia

17)-Failed Induction of Labour

18)- Poor Obstetric history

Emergency/Elective: **Em = 1** **EL =2** (EmEL)

Previous history of PPH.....**Y/N** **Y=1** **N=0** (Prev PPH)

Multiple /singleton pregnancy.....**Mult=1** **Sing=2** (MulSing)

C) LABOUR:

1)- Induction of labour.....**Y/N** **Y=1** **N=0** IndLab

a) Agents: 1)-Misoprostol

2)-Prandin

3) Artificial rupture of membrane + oxytocin

4)-Mechanical induction of labour (stretch and sweep) ...

5) Not done.....

2)- Spontaneous Labour.....**Y/N** **Y=1** **N=0** (SpoLb)

3)- Augmentation of labour.....**Y/N** (AOL)

4) - Abruptio.....**Y/N** (Abruptio)

5)- Antepartum haemorrhage of unknown origin.....**Y/N** (AHUO)

6)- Placenta praevia(diagnosed).....(Plpraevd)

D) Time patient taken for caesarean section:.....

(Timecs)

E) INTRA-OPERATIVE:

1) Iatrogenic injury to vessels **Y/N** **Y=1** **N=0** (IIVessel)

2) Iatrogenic injury to Uterus **Y/N** (liuterus)

3) Difficult caesarean Section.....(.Difcs)

A) Adhesions Y/N (Adhsions)

B) Thin lower segment with tears Y/N (ThnLS)

C) Difficult delivery Y/N (Difdel)

4) Adherent placenta:

1)-Accreta (Adhplac)

2)-Increta

3)-Percreta

4) Unknown

5) Not

5) Placenta praevia (undiagnosed)...Y/NY =1 N=0 (Plpraevu)

6) Uterine atony Y/N (Utratony)

F) Duration of Caesarean section: 222= unknown (Durcs)

- Approximate blood loss 999=Unknown(Bldlos)

G)Technique used for caesarean section: (Techcs)

1) - The Vertical Classical Uterine incision:

2)-The lower uterine segment incision:

H) Type of Anaestheticused: (Typanest)

1) - General Anaesthesia:

-Regional spinal:-2) Spinal Anaesthesia.....

3) -Epidural Anaesthesia.....

I) CONSERVATIVE MANAGEMENT:

1) Syntocinon infusion Y/N Y =1 N=0 (Syntinfu)

2) Ergometrine Y/N (Ergomrt)

3) Prostaglandin F2 α Y/N (ProstF2)

4) Misoprostol:1)-per os (Misopros)

2)-per rectal

3) not used

J) SURGICAL MANAGEMENT(at time of caesarean section)

1) Hysterectomy... Y/N (Hyst) **Y=1 N=0**

2) B-Lynch stitch... Y/N (Blynch)

3) Devascularisation.....Y/N (Devascul)

4) Other haemostatic sutures....Y/N (Ohsuture)

4) Internal iliac artery ligation....Y/N (IIAligat)

5) Packing of the abdomen...Y/N (Packabd)

6) Balloon tamponade....Y/N (Baltamp)

K) CAUSES OF BLEEDING:

1) Sterilisation...Y/N (Steri) **Y=1 N=0**

2) Uterine atony..Y/N (Utratony)

3) Uterine artery injury..Y/N (Utartinj)

4) Broad ligament injury..Y/N (Bdlgtinj)

5) Placenta accrete...Y.N (Placaccr)

6) Other uterine injury..Y/N (Outerinj)

7) Coagulopathy...Y/N (Coag)

8) Vagina injury..Y/N (vaginj)

L) BLOOD AND BLOOD PRODUCTS:

1) Emergency Blood: Y/N.....Number of units (Emblood)

2) Number of units of Packed red cells: (PRCs)

3) Number of units of Platelets: (PTLS)

4) Number of units of Fresh frozen plasma: (FFPS)

M) UNDERLYING MEDICAL CONDITION:

1) PIH(Pregnancy Induced Hypertension)..Y/N **Y=1 N=0**

2) Chronic Hypertension..Y/N (CHPT)

3) Anaemia in pregnancy..Y/N (Anepreg)

4) HELLP (Hemolysis Elevated Liver enzymes and Low Platelets)..Y/N

5) Anticoagulant therapy...Y/N (Anticoag)

6). ITP (Idiopathic Thrombocytopenia Purpura)..Y/N

7). AIDS (Acquired immune deficiency syndrome)..Y/N

8) Pre-existing infection:...Y/N (Pexstinf)

9)DIC (Disseminated Intravascular Coagulopathy)..Y/N

N) RESUSCITATION ATTEMPTED AT THE TIME OF PPH...Y/N

1) If yes what was done

-Cardiopulmonary resuscitation...(CPR).Y/N

-Drugs given : 1)-Adrenaline (Adrenal) Y/N

2)-Atropine (Atrop) Y/N

2) Relook laparotomy for bleeding..... (RLKLAP) **(Y/N Y=1 N=0)**

-Hysterectomy at relook laparotomy.....(HystRLK) Y/N

-B lynch at relook laparotomy.... (BlyncRLK) Y/N

- IIA ligation at relook laparotomy.... (IIAlgRLK) Y/N
- Packing abdomen at relook laparotomy.... (PacabRLK) Y/N
- 3) Number of relook laparotomies:(NoRLK)..... Y/N
- 4) Complications at relook/ primary surgery:... (Complrlk) Y/N
 - Difficult with hemostasis....(DifHRLK)Y/N
 - Coagulopathy... (CoagRLK).....Y/N
 - Clinical renal failure... (RenalRLK).....Y/N
 - Hypothermia..... (Hypother)..... Y/N

O) PLACE OF DEATH (plcDeath)

- 1) In theatre
- 2) In recovery
- 3) In ward
- 4) In High Care Area
- 5) In Intensive Care Unit
- 6) In admission

P) Summary of the case:

APPENDIX B: ETHICS APPROVAL

Human Research Ethics Committee (Medical)

Research Office Secretariat: Senate House Room SH 10005, 10th floor. Tel +27 (0)11-717-1252
Medical School Secretariat: Medical School Room 10M07, 10th Floor. Tel +27 (0)11-717-2700
Private Bag 3, Wits 2050, www.wits.ac.za. Fax +27 (0)11-717-1265



08 April 2014

Dr Mfenyane

Chief Executive Officer

Chris Hani Baragwanath Academic Hospital

Johannesburg

Dear Dr Mfenyane

CONFIRMATION OF STUDY APPROVAL

Protocol Ref no: M140329

Protocol Title: Contribution of postpartum haemorrhage to maternal death after caesarean section at CHBAH SA 1997-2012

Principal Investigator: Dr Jean Paul Byiringiro

This letter serves to confirm that the Human Research Ethics Committee (Medical) has approved the above mentioned study. In order for a clearance certificate to be issued, the researcher is required to submit written approval to conduct the study in your hospital.

Yours Sincerely,

A handwritten signature in black ink, appearing to read "Zanele Ndlovu", written over a dotted line.

Ms Zanele Ndlovu

Administrative Officer

Human Research Ethics Committee (Medical)

