An Investigation of Blood Transfusion Practices in A Regional Obstetric Hospital with no On-Site Blood Bank

By

Daniel M. Bengesai

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Date of Submission:
Supervisors: Dr TA. Horak
Co-Supervisor: Professor Susan Fawcus
Department of Obstetrics and Gynaecology
University of Cape Town

University of Cape Town

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Declaration

I, Daniel Mishael Bengesai, declare that this dissertation is based on my own work and has not been submitted for any other degree or professional qualification. Where I have used the published work of others, I have made every effort to attribute both in text and in the reference section clearly.

Signed by candidate

DANIEL M BENGESAI

26/09/2022

DATE

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ABBREVIATIONS

AIDS	Acquired Immunodeficiency Syndrome
ANW	Antenatal Ward
CRYO	Cryoprecipitate
C/S	Caesarian Section
FFP	Fresh Frozen Plasma
FDP	Freeze-Dried Plasma
Hb	Haemoglobin
HBV	Hepatitis B virus
HCV	Hepatitis C virus
HIV	Human Immunodeficiency Virus
LMIC	Low-and Middle-Income Countries
MMH	Mowbray Maternity Hospital
NCCMED	National Committee on Confidential Enquiries into Maternal Deaths
OASIS	Obstetric Anal Sphincter Injuries
OH	Obstetric Haemorrhage
PPH	Postpartum Haemorrhage
RBC	Red Blood Concentrate
RBCE	Red blood Concentrate
RCOG	Royal College of Obstetricians and Gynaecologists
SCU	Special Care Unit
SD	Standard Deviation
UN	United Nations
WCBTS	Western Cape Blood Transfusion Services
WCBS	Western Cape Blood Service
WHO	World Health Organisation

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SYNOPSIS

Background

This study aimed to investigate blood transfusion practices in a regional obstetric hospital with no on-site blood bank. Underpinning this research was the argument that principles of evidence-based medicine should apply to blood transfusions in the same way they do to any other clinical practice area. Considering the limited availability of resources (financial, human and blood products) and the ever-increasing and competing needs facing South Africa, the practices surrounding the use of blood and blood products must be audited.

Method

This study used a retrospective descriptive audit approach to collect data on blood transfusion management from Mowbray Maternity Hospital, a Regional Hospital in Metro West, Cape Town, which receives complicated obstetric patients from satellite Midwife Obstetric Units (MOUs) and District Hospitals. In addition, an in-depth folder review of two months was also conducted for 118 women to ascertain the precise obstetric indications and decision-making processes.

Results

During the study period, there were 10030 deliveries, of which 4734 (47, 2%) were caesarean deliveries, 5081(50.7%), were vaginal deliveries, and 215 (2.1%) were assisted deliveries. Only 781women received blood products; thus, the incidence of blood transfusion during this period was 7.8%. Red blood cell concentrate (including emergency red blood cell concentrate) was the most transfused blood product, followed by fresh frozen plasma, cryoprecipitate, and platelets. Approximately 12.6% of the patients received emergency red blood cells, reflecting acute post-partum haemorrhage while cross-matched red blood cell concentrate (RBC), was transfused to 82.2% of the women in the sample. The clinical area was not labelled for 24.1% (n=189) of patients who received blood products. 58% of the blood transfusions were done after hours.

Overall, different transfusion patterns were observed for women who received multiple blood products. The in-depth folder review on 118 patients indicated that the leading cause for blood transfusion was postpartum haemorrhage secondary to uterine atony, which accounted for

38.1 % of the transfusions. The range of the pretransfusion Hb was 4-9g/dl, with a mean of 6.51(SD±0.07), suggesting that all the women who received blood products were anaemic.

Conclusion

Overall, the results from this study indicate that the transfusion of blood products was in line with international practice, where RBC is the most transfused product, followed by FFP other products. Regarding the transfusion rate, although it was higher than in most developed countries, it was much lower than in other low-and medium-income countries. However, while a low rate of PPH and blood transfusion rate is preferable, it also indicates thatphysicians have fewer opportunities to train by self-experience. Therefore, the use of protocolsremains central to effective PPH management and the improvement of the quality of care at MMH, and this should be coupled with routine, retrospective audits, as in the case of this study.

The specific reasons for blood transfusions also need to be explored in more detail so as to improve patient care accordingly. For instance, the fact that a significant proportion of women who received blood products were diagnosed with anaemia reinforces the need for early detection of and treatment of antepartum anaemia as well as increasing the use of parenteral iron.

The results from this study also suggest that data management issues need to be considered, particularly the siloed nature of the data. It is recommended that MMH establish a unified and integrated system for capturing and managing data quality and storage.

An Investigation of Blood Transfusion Practices in A Regional Obstetric Hospital with no On-Site Blood Bank

1. Introduction and Rationale for the Study

Blood transfusion is a lifesaving procedure and an integral part of emergency obstetric care. It is, however, associated with potentially serious health and economic outcomes. The financial burden of blood transfusion is worsened by the number of tests donated blood must undergo to reduce the risk of introducing infections such as HIV, Hepatitis B and C in recipients. [1] In South Africa, blood is itself a scarce commodity, considering that less than 1%of the population donates blood.[2] Research evidence has also shown that errors often occur inthe process of transfusing blood to the correct patients, resulting in potential morbidity and even mortality associated with incompatible blood transfusions.[3, 4] In order to be sustainable, a blood supply system must ensure that there is a sufficient, secure, and long-lasting supply of blood products to meet the population's medical needs. For this, a balance between supply and demand must be maintained.

The study is based on the premise that the principles of evidence-based medicine should apply to blood transfusions in the same way they do to any other area of clinical practice. This, it is assumed, will alleviate some of the problems associated with insufficient and inappropriate use of blood in obstetric emergencies. For instance, there is a tendency never to transfuse fewer than 2 units of red cells, and changing this practice in a London district has led to a considerable reductionin blood expenditure.[5, 6]

Blood transfusion during pregnancy is a common practice worldwide and can occur during the antepartum, intrapartum, and postpartum stages. While obstetric haemorrhage (OH) is the most common reason for blood transfusion, anaemia during pregnancy from a variety of other causes has also been shown to be an indication for transfusion in pregnant women.[7] The South African National Committee on Confidential Enquiries into Maternal Deaths noted that anaemia occurred in approximately 40% of all maternal deaths in South Africa. The reportindicated that 13% of OH related maternal deaths were associated with a ‘lack of blood products’ and showed that 38% of OH deaths occurred at the primary level of care.[8] In SouthAfrica, all tertiary and some regional hospitals have on-site blood banks, whilst mostregional and all district hospitals do not.[9] Instead, they rely on a supply of O negative and O positive red blood cells stored in an on-site refrigerator, as well as fresh dried plasma (FDP) for emergency transfusions. Given this background, medical practitioners working in maternity services must be proficient in

managing the transfusion of blood and blood productsso that this precious resource can be used immediately in the event of an obstetric emergency and judiciously to prevent inappropriate usage.

Mowbray Maternity Hospital (MMH) is a regional hospital with no on-site blood bank and thus keeps ‘emergency’ blood in a refrigerator in Theatre and stores FDP on-site as a pharmacyitem. MMH is, therefore, an appropriate site to investigate the blood transfusion practices in a regional hospital without a blood bank and is the setting of the proposed study.

2. Literature Review

2.1 Introduction

According to Reshma (2019), the first recorded blood transfusion was done by Dr Jean Bapstiste Denys of France in 1667, who transfused sheep's blood on a 15-year-old boy.[10] Years later, Dr Blundel, a British obstetrician putting the discipline of obstetrics and gynaecology at the forefront of innovation, performed the first successful human blood transfusion on a woman with postpartum haemorrhage using her husband's blood. Since then,blood transfusion has become central to clinical practice, particularly in obstetrics, due to the likelihood of blood loss before, during and after birth.

Several medical conditions may occur during pregnancy, thereby predisposing a woman to require blood therapy. These include i) anaemia and ii) haemorrhage, both common in developing countries such as South Africa. While these conditions may differ in severity, failure to transfuse appropriately may lead to maternal morbidity or mortality duringor after pregnancy. The following discussion focuses on these conditions and how they complicate the pregnancy state.

2.2 Anaemia

Anaemia is a common medical condition globally, but more so in the developing world, accounting for 89% of the global burden.[11] According to the World Health Organisation, anaemia in pregnancy refers to haemoglobin (Hb) of less than 11g/dl; however, the classification depends on the trimester during pregnancy.[12] For example, <11g/dl in the first trimester, <10.5g/dl in the second and <10,5g/dl in the third trimester. Anaemia is also classified by the level of severity (Table 2.1). A Hb level of 10.0-10.9 g/dl is considered mild anaemia, while 9.9-7g/dl is classified as moderate. Severe anaemia occurs when the Hb level is between 4-6.9 g/dl, while anything <4 is considered very severe anaemia.[13-14]

Table 2.1 Classification of Anaemia by Hb levels

Severity	Hb in g/dl
Mild	10-10.9
Moderate	7- 9.9
Severe	4-6.9
Very severe	<4

[14] Good Clinical Practice Recommendations for Iron Deficiency Anaemia in Pregnancy

Anaemia can also be classified according to its pathophysiology as either relative or absolute based on the red blood cell mass determination. Relative anaemia is "characterised by a normal total red blood cell mass in an increased plasma volume," while absolute anaemia refers to absolute red cell mass reduction due to reduced red cell production, destruction and or blood loss.[15] In other words, absolute anaemia is related to the volume of the red blood cells. A condition such as pregnancy can cause relative anaemia, while OH can result in absolute anaemia.

During pregnancy, the body produces more blood to help support the baby. There is a plasma volume increase of 40% above baseline by 24 weeks of pregnancy. Cardiac output increases by 30 to 50% due to increased stroke volume in early pregnancy and increased heart rate later in pregnancy. [16] The red cell mass increases by about 18 to 20%, which is comparatively less than the increase in plasma volume, reaching 50 to 60% by 32 weeks gestation, causing physiological dilutional anaemia.[17] Expected haemoglobin levels are 11g/dl in the first trimester, 10,5g/dl during the second/third trimester and 10g/dl post-natal. The increase in plasma volume leading to dilutional anaemia, increased red cell mass, and increased iron transfer to the fetus increases iron demand during pregnancy, which in women with depleted iron stores can lead to iron deficiency anaemia; hence the need for iron supplementation.[18]

There are several causes of anaemia resulting from, amongst others, nutritional factors (e.g. deficiencies in iron, folate, vitamin B12 and proteins), genetic factors (e.g. sickle cell or thalassemia), chronic diseases (e.g. chronic renal failure, blood loss and infectious diseases). Iron deficiency is the most common cause of anaemia worldwide, accounting for up to 75% of cases.[19] Even in developed countries, where dietary iron is readily available, the evidence indicates that iron deficiency remains a significant cause of morbidity, with a high proportion of women becoming anaemic during pregnancy.[20]

The World Health Organisation reports that approximately 40% of pregnant women were anaemic in 2016. However, country-by-country disaggregation shows that the rates ranged from as low as 20% for countries such as Australia to as high as 61% in Togo and 63% in Yemen.[21] In Low- and Middle-Income countries (LMICs), including South Africa, iron deficiency anaemia is the most common cause of anaemia in pregnancy. If the body is not getting enough iron and other nutrients, it will not produce enough red blood cells to support pregnancy adequately. Thus, anaemia during pregnancy affects the mother and the fetus and can lead to subsequent health problems such as reduced birth weight, an increased risk of preterm birth, and anaemia in the infant.[20] For example, a meta-analysis conducted by Figueiredo et al. (2018) revealed that babies born to mothers with maternal anaemia were likelyto have a mean reduction in birth weight of 60,55g.[22] A separate meta-analysis found that maternal anaemia increased the risk of premature birth by a factor of 1.56.[23] Mothers who have anaemia are more likely to experience breathing problems, tiredness, and palpitations. One Sudanese study found that pregnant women with severe anaemia were up to 3.6 times more likely to be at risk of pre-eclampsia, while Anjanappa et al. (2015) found that the risk of intrauterine growth restriction (IUGR) was 3.77 times higher, and low APGAR score at 1 minwas 3.8 times higher for neonates of anaemic women in an Indian hospital.[24,25]

Moreover, Neonatal Intensive Care Unit (NICU) admissions were 2.96 times higher in anaemic mothers than in non-anaemic mothers and babies of anaemic mothers had up to 1.7 times the risk of having alow Apgar score at 1 min. Among anaemic women, the risk of intrauterine fetal death was two times greater than non-anaemic women. All of the above underpins the importance of preventing anaemia before pregnancy and identifying and treating anaemic patients before or early in pregnancy to prevent pregnancy-related complications associated with anaemia. Those at high risk of anaemia, such as women from low socio- economic backgrounds, teenagers, low body mass index (BMI), multiple pregnancies, etc., should be identified and appropriate prophylactic measures instituted prior to pregnancy or asearly as possible in pregnancy.

2.2 Obstetric Haemorrhage

While acknowledging the risks associated with anaemia, obstetric haemorrhage is by far the most common reason for the transfusion of blood and blood products. It is also one of the

leading causes of severe maternal morbidity and mortality globally, being only third to non-pregnancy-related sepsis and hypertensive diseases in pregnancy.[26] Research evidence suggests that obstetric haemorrhage accounts for approximately 24% of maternal deaths annually. Severe bleeding (≥2000 ml) occurs in at least 3–5% of deliveries, while blood product transfusion is required in 0.3–1% of cases globally.[27] These numbers are unevenly distributed, and the LMICs still carry the highest burden of maternal mortality. For example, OH accounts for more than 30% of all maternal deaths in Africa and Asia compared to 3.4% in the United Kingdom and 11.4% in the United States.[28] The Saving Mothers Report (2017-2019) in South Africa indicates that maternal deaths due to OH accounted for 15.8% of deaths, with bleeding at caesarean section being a significant cause of OH and maternal morbidity and mortality.[29] Shabalala and Sebitloane found that severe obstetric haemorrhage occurred in 1.63%, 2.49% and 2.61% of all deliveries in 2009, 2010 and 2011, respectively.[30] While non-pregnancy-related infections such as HIV and AIDS are the leading cause of maternal mortality in sub-Saharan Africa, including South Africa, these are considered indirect causes, making OH the second most common direct cause of maternal death after hypertensive diseases of pregnancy.[29,30]

Severe obstetric haemorrhage results from normal obstetric, surgical, and/or systemic haemostasis failure. Several conditions could predispose women to severe OH.[31] OH can occur in the antepartum or intrapartum stage, where possible causes include placenta praevia, abruptio placenta, uterine rupture and bleeding from local lesions such as cervical carcinoma.[32, 33] OH can also occur postpartum. Postpartum haemorrhage (PPH) is defined as blood loss of 500 ml or more within 24 hours after birth. [34] PPH occurs due to several factors such as uterine atony, retained placenta or products of conception, perineal and cervical lacerations, inverted uterus, as well as following abruptio placenta or placenta praevia, with the former being considered one of the leading causes. [30, 35]

In general, when a woman is in a non-pregnant state, less than 1% of her cardiac output flows through her uterus. This contrasts with the terminal stage of pregnancy, where uterine blood flow accounts for 15% of cardiac output.[15] Uterine atony occurs when the uterus fails to contract after the separation of the placenta. It refers to the inadequate contraction of the ‘corpus uteri myometrial cells post-delivery.[36] In simple terms, uterine atony is the loss of tone in the uterine musculature. When a woman goes into labour, her uterine muscles contract, compressing the blood vessels and reducing the blood flow, setting the stage for local

coagulation at the placental bed to stop bleeding. This is meant to compress blood vessels, encourage placental separation, and increase coagulation, thus preventing haemorrhage. Sometimes, however, the uterus fails to contract after labour, leading to postpartum hemorrahage[37] Several factors can predispose to uterine atony. These include grand multiparity, prolonged or induced labour, fibroid uterus, and uterine overdistention due to polyhydramnios, multiple pregnancies, and macrosomic babies. However, uterine atony can also occur in women who do not have any of these risk factors.

Ineffective uterine contraction is also associated with other conditions, such as retained placenta, placental disorders and coagulopathy.[36] Retained placenta, which occurs in approximately 1–3% of vaginal deliveries, is a relatively common cause of obstetric morbidity.[38] This happens when the placenta fails to separate during the third stage of labour, and if it is not treated in time, it can lead to life-threatening PPH. In the case of placental abruption, the placenta separates from the inner wall before the birth of the baby. Although it is less common than retained placenta, occurring in less than 1% of pregnancies, it is associated with high morbidity and mortality for both mother and baby. PPH in the case of abruptio placenta results predominantly from uterine atony as well as coagulopathy. [39] Placenta praevia (PP) refers to the abnormal position of the placenta in the lower segment of the uterus and is classified as minor or major praevia depending on whether the placental lower edge reaches and/ or covers the internal cervical or not. PPH results from the inability of the thin lower segment to contract as effectively as the rest of the uterus. The incidence of placenta praevia is approximately 3-5 per 1000 pregnancies globally and is on the rise due to the increase in caesarean section rates.[40] Although these placental conditions can lead to emergency caesarean delivery, the excessive bleeding that occurs underpins the importance of management at a tertiary level of care with appropriate personnel and facilities.[35] In South Africa, cesarean-related haemorrhage is considered a leading cause of maternal deaths, accounting for 5.5 deaths for every 10,000 caesarian sections performed, hence the need for experienced care. [41]

In vaginal deliveries, the tissue of the vagina or uterus can be torn during birth leading to bleeding.[42] This is often the case if one gives birth to a macrosomic baby. At times, surgeons can perform an episiotomy at the opening of the vagina to help the baby deliver. [42] Sultan's classification of perineal lacerations classifies Obstetric Anal Sphincter Injuries (OASIS). A

third-degree tear is an injury to the perineum involving the anal sphincter complex, which includes the external and internal anal sphincter (EAS & IAS) and is classified as 3A, 3B and 3C. 3A involves less than 50% EAS, 3B involves greater than 50% of EAS, with 3C involving the IAS, while a fourth-degree tear goes through the anal sphincter all the way to the anal mucosa and rectum. [43]

Whatever the cause of bleeding, it is crucial to recognise that severe bleeding can quickly evolve, leading the woman to become coagulopathic.[30] Therefore, it is important that a comprehensive evaluation of blood loss and its cause, a patient's medical condition, age, and vital signs is conducted to determine whether a transfusion is necessary. In cases where a haematology laboratory is available, a blood biochemical profile can be conducted to help guide the decision as to whether or not a blood transfusion is indicated and how many units to transfuse. Otherwise, transfusion is often formulaic in cases where haematology is not available; for instance, following the fourth unit of RBCs, a transfusion ratio of 2:1:1 of RBC: FFP: PLTS is recommended by the National Committee on Confidential Enquiries into Maternal Deaths.[44] In other words, blood transfusion must be conducted with an "evidence-based approach which balances the expected clinical benefit with the risks associated with the transfusion of blood and blood products." [2]

2.3 Blood Products Used in Obstetric Transfusion

Whole blood is rarely used in clinical practice.[10,45] Rather, the blood is split into its individual components so that each patient requiring blood receives the specific component they require. The typical blood components include i) red blood cells, ii) plasma and iii) platelets. It is also a common practice to use blood derivatives such as granulocytes which are derived from whole blood/platelet-rich plasma.[45] Table 2.2 presents a summary of the blood products used in obstetric transfusion as well as their relevant function.

2.3.1 Red Blood Cells (RBC)

Red blood cell transfusion is one of the most frequently used blood products in obstetric transfusion. This is largely due to the high number of pregnant women with anaemia, mainly iron deficiency anaemia, as well as OH.[45,46] These patients are transfused with red blood cells

to replace the deficiency in their blood by increasing haemoglobin. Therefore, this type of transfusion is indicated to "achieve a fast increase in oxygen supply to tissues, when the concentration of haemoglobin (Hb) is low or when the oxygen-carrying capacity is reduced." It also increases red cell mass and blood volume in patients who have lost blood, as in the case of obstetric haemorrhage. A healthy adult produces approximately 0.25mL/kg of red blood cells daily, while each RBC has a life span of up to 120 days. [46] However, the average life span for transfused RBC is 50-60 days and can be even shorter in the presence of underlying factors that might affect their survival.

2.3.2 Plasma Transfusion

Unlike red blood cell transfusion, plasma transfusion consists of the "non-cellular" parts of the blood.[44] It is used to prevent and treat coagulopathy in patients with active bleeding and to increase plasma proteins that may be deficient in their blood.[46] Blood products often used in plasma transfusion predominantly include fresh frozen plasma (FFP), which is plasma that has undergone viral inactivation with solvent/detergent treatment (S/D FFP) or with methylene blue (MB FFP) or with psoralens (S59).[47] FFP is prepared by separation from whole blood through a process referred to as apheresis. It is then frozen at a designated temperature within eight hours of the collection so as to preserve its clotting ability. Although frozen, this blood product is considered 'fresh' because it was frozen immediately after it was collected. The essential components of FFP are albumin, fibrinogen, albumin other natural coagulants.[48]

Fresh dried plasma (FDP) is an alternative to FFP, which can be used in the resuscitation of haemorrhagic shock in situations where FFP is not readily available. [49] It is a lyophilised form of FFP which can be stored at 4 degrees Celsius, unlike FFP, which must be stored at -20 degrees Celsius. FDP is available as a pharmacy item in South Africa and can be kept on-site, readily available for use.

2.3.4 Platelets

Platelets, also known as thrombocytes, are the smallest cells of the blood, which play an essential role in haemostasis. [50] For instance, when a blood vessel is damaged, platelets rush to the injury site, are bound to Von Willebrand factor and form a plug to keep the blood within the damaged vessel. [51] Several known conditions may cause a low platelet count in pregnancy.

These include gestational thrombocytopenia, which affects, on average, 6-8% of pregnant women and is the most common cause of thrombocytopenia in pregnancy. This is followed by thrombocytopaenia associated with hypertensive conditions in pregnancy, such as gestational hypertension, pre-eclampsia, eclampsia and HELLP Syndrome (Haemolysis, Elevated Liver Enzymes, Low Platelets).[50] Immune thrombocytopenia (ITP) is an autoimmune disease where the body produces antibodies targeted against platelets resulting in autoimmune destruction of platelets leading to thrombocytopenia of varying severity.[45] Other causes of thrombocytopenia in pregnancy include Acute Fatty Liver of Pregnancy (AFLP), Thrombotic Thrombocytopenic Purpura (TTP) and Haemolytic Uraemic syndrome, which, together with HELLP syndrome, may be difficult to differentiate and form a deadly disease triad in pregnancy, with severe morbidity and mortality. [51]

2.3.5 Cryoprecipitate

Cryoprecipitate is a frozen blood product prepared from blood plasma. It is created from fresh frozen plasma thawed to 1-6 degrees, centrifuged, and the precipitate is collected. The components of Cryoprecipitate are fibrinogen, factor VIII, factor XIII and von Willebrand factor. The main indications for use are excessive bleeding with coagulation factor depletion, haemophilia, von Willebrand disease, hypo and afibrinogenemia, disseminated intravascular coagulopathy (DIC), and uraemic bleeding tendency. [52]

Table 2.2 Blood products used in obstetric transfusion.

Blood Product	Red Blood Cells	Fresh Frozen Plasma and Freeze-dried plasma	Platelets	Cryoprecipitate
Function/ Indication	To increase the number of red blood cells after trauma or in anaemic patients	To prevent coagulopathy in patients with active bleeding	To prevent and stop bleeding	To control bleeding in patients whose blood does not clot normally. Recommended when fibrinogen levels are low

2.4. Cross Matched Blood

When preparing an obstetric haemorrhage or anaemic patient for transfusion, there is a need to obtain a blood sample from the patient to obtain cross-matched blood. The first step involves determining the blood type of the patient and the presence or absence of the Rh factor. This is then followed by screening for abnormal antibodies, mainly anti D and anti-Kell. Other abnormal antibodies include anti-Kidd, M, S, S, U and Diego. If the patient is found to have these antibodies, cross-matched blood without these antigens should be given.[35]

However, when emergency blood transfusion is essential in haemorrhagic patient resuscitation, compatibility testing might delay transfusion, leading to mortality. In such cases, group O, Rh-negative and positive blood can be transfused without any compatibility tests.[53] In the case of MMH, the hospital keeps at least 2 O negative and 6 O positive blood units for emergency use.

2.5 Factors affecting the supply and demand for blood and blood products

Several factors affect the supply and demand of blood. The WHO identified four cornerstones of safe and adequate blood transfusions.[18] These include a national system, volunteer donations, blood testing, and avoiding unnecessary transfusions. These factors present significant challenges, especially for LMICs, due to inefficient blood supply structures, blood procurement costs, screening, storage, and inequitable access. In addition, the persistence of the human immunodeficiency virus (HIV) and the recognition of Hepatitis C have affected both the quality and quantity of blood donated.[30]

The WHO recommends that each country have an integrated blood safety and supply system.[21] This includes establishing a "national blood system with well-organised and coordinated blood transfusion services; the collection of blood, plasma and other bloodcomponents from low-risk, regular, voluntary unpaid donors through the strengthening of donation systems; quality-assured screening of all donated blood for transfusion-transmissibleinfections."[21,54]

Most countries have made progress in this regard and have set up integrated blood supply and safety systems in compliance with international standards. Compliance, however, especially in developing countries with a high burden of diseases transmissible through blood transfusion, including HIV, Hepatitis B virus (HBV), and Hepatitis C virus (HCV), also poses an additional cost challenge. In South Africa, this has been worsened by the fact that there has been no significant growth in government expenditure on health since 2013 (Figure 2.1, below). This little-to-no growth in health budget allocation suggests a limitation on health spending, affecting both the availability and patient access to blood, especially in public hospitals, as part of the overall decline in the quality of health.

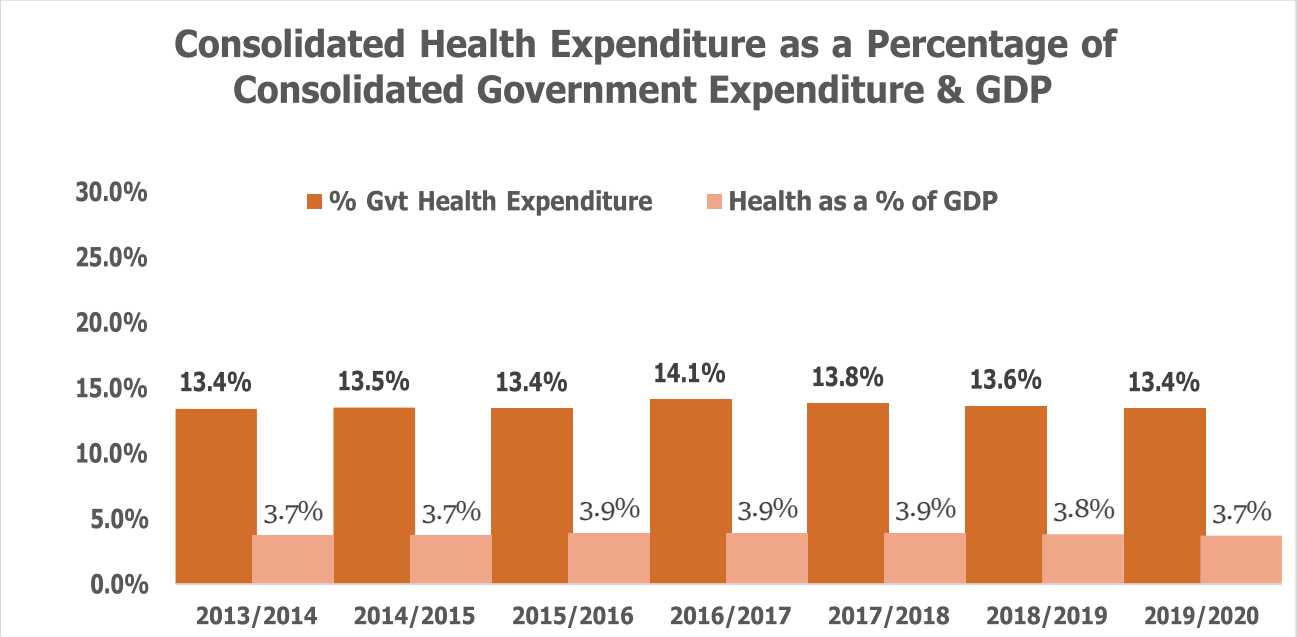


Figure 2.1 Health Expenditure as a Percentage of Government Expenditure and GDP
Source: Estimates of National Expenditure 2017, Estimates of Provincial Revenue and Expenditure 2017 and Budget Review 2017

Timely distribution of blood to hospitals is essential, hence, it is recommended that there should be functional fridges to store emergency blood, especially in trauma and emergency units.[55] However, rural hospitals in South Africa, like in many other parts of sub-Saharan Africa, face poor delivery, storage and distribution of blood. [56] Nonetheless, some countries like Rwanda have adopted an innovative strategy for delivering blood products using drones. This has allowed them to reach the most remote areas. [56] This technology, however, is yet to be adopted

in South Africa, suggesting that blood distribution to remote areas and rural areas with no onsite blood bank remains a challenge.[55]

The WHO also uses the number of blood donations per 1000 population as a proxy for determining the availability of blood in a country. For instance, in 2013, the WHO (2015) recorded that 46 countries in Africa accounted for approximately 5% of the global blood donations, yet Africa is home to approximately 13% of the world's population.[21] In contrast, Europe reported approximately 30% of the global blood donations, while the region is inhabited by about 11% of the global population. Figure 2.2 presents the regional distribution of population and blood donations by WHO region.[21]

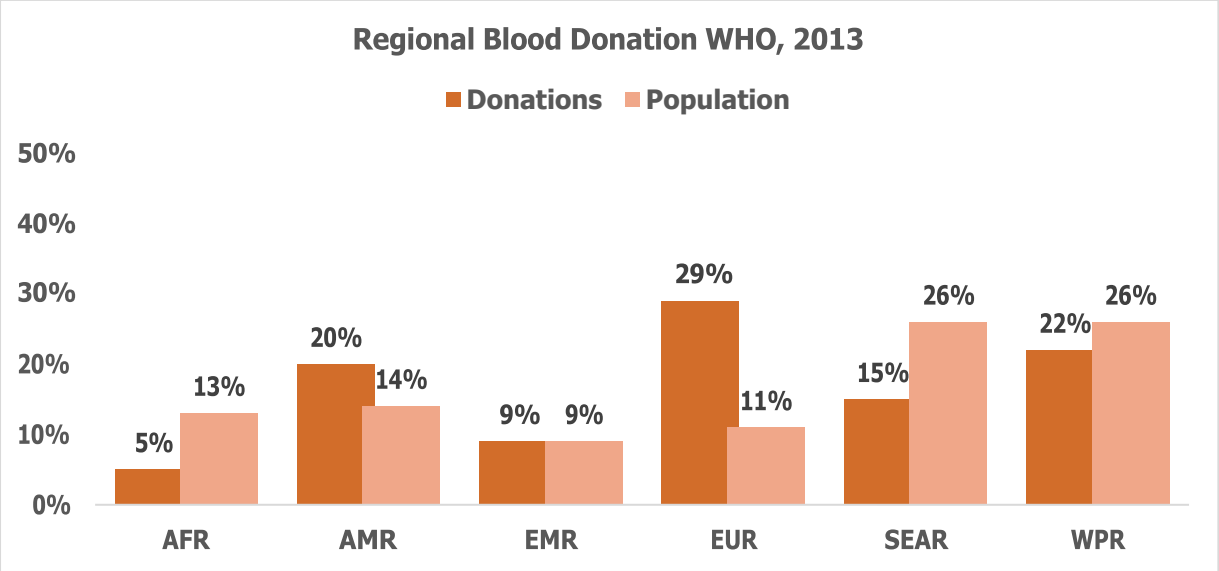


Figure 2.2 Regional Distribution of Population and Blood Donations by WHO Region, 2013

Source: WHO Global status report on blood safety and availability 2015: AFR: African Region; AMR: Region of the Americas; EMR: Eastern Mediterranean Region; EUR: European Region; SEAR: South-East Asia Region; WPR: Western Pacific Region

There is a shortage of donors in South Africa, as only 1% of South Africans donate blood.[2] Yet, thousands of people require blood daily due to either pregnancy or childbirth-related bleeding or as a consequence of the high rates of road traffic accidents and interpersonal violence, including intimate partner violence. This results in an inefficient blood supply chain, with high demand and a low supply. As a result, this makes blood a scarce and highly-priced

commodity, while the shortage of supply has a direct and harmful impact on women with pregnancy and delivery related haemorrhage.[45]

In essence, the limited availability of resources (both financial and of blood products), coupled with the ever-increasing and competing needs facing South Africa, requires careful assessment of need before blood is transfused. Even in cases where blood transfusion indications may be emergent, there is a need to ensure that blood transfusion should be appropriate. It is crucial in the antenatal period to identify patients with anaemia and those at risk of haemorrhage (e.g. grand multiparous patients, major placenta, etc.) so that appropriate prophylactic treatment can be instituted to reduce the need for blood transfusion. Iron supplementation can be administered via the oral or parenteral route for patients with conditions that interfere with oral supplementation. Failure or delay in recognising risk factors that may need to be treated with blood might adversely affect maternal outcomes.[26] In South Africa, a country with high-income inequalities reflected in every aspect of life, including maternal health, ineffective referral and transportation systems escalate the risk associated with obstetric emergencies. Considering this, medical practitioners specialising in obstetrics and gynaecology must be proficient in managing the transfusion of blood and blood products.[26] They should be mindful that successful haemorrhage management relies primarily on timely diagnosis, instituting appropriate treatment quickly, and a multidisciplinary approach to management. In addition, practitioners also need to optimise anaemia in the antenatal period using haematinics or iron transfusion and supplementation. This is supported in the literature, as much research shows that routine iron and folic acid supplementation can reduce the prevalence of iron deficiency anaemia-related morbidity and the need for emergency blood transfusion during pregnancy.[45,46]

2.6 Guidelines for Blood transfusion

Some interventions can avert the risk of PPH by addressing factors that lead to excessive bleeding and appropriately managing the third stage of labour. In addition, adequate iron stores and nutrition before delivery can lessen the consequences of PPH for an individual woman. Guidelines for maternal care globally and in South Africa recommend conducting a full blood count for all pregnant women at the first booking, at 28 weeks and just before delivery.[8,14] This enables women with low Hb levels to receive iron supplementation early in pregnancy or RBC transfusion before delivery in cases of severe anaemia. However, proper anaemia management

is contingent on effective systems for rapid blood review and adequate follow-up to avoid delays in management.

The early detection of excessive bleeding can also improve the outcome of PPH and more so when the woman is in a facility with adequate skills and resources to manage the PPH. However, not all risk factors can be predicted during the antenatal period, with some studies estimating that more than two-thirds of women with PPH have no known risk. [57] Obstetric staff must therefore be able to detect cases of PPH timeously so that appropriate intervention can be instituted.

Proper blood management depends on the correct etiological diagnosis of the cause of bleeding.[54] To guide medical staff, the National Committee on Confidential Enquiries into Maternal Deaths (NCCEMD) has developed some guidelines that should be used to manage OH.[44] These guidelines, which are derived from international guidelines such as the Royal College of Obstetricians and Gynaecologists (RCOG), the World Health Organisation and the Saving Mothers' reports, include information on prevention, diagnosis and management of PPH, with algorithms and practical perspectives. Figure 2.3 presents a flow diagram for managing bleeding after a C-section and normal vaginal delivery (NVD).

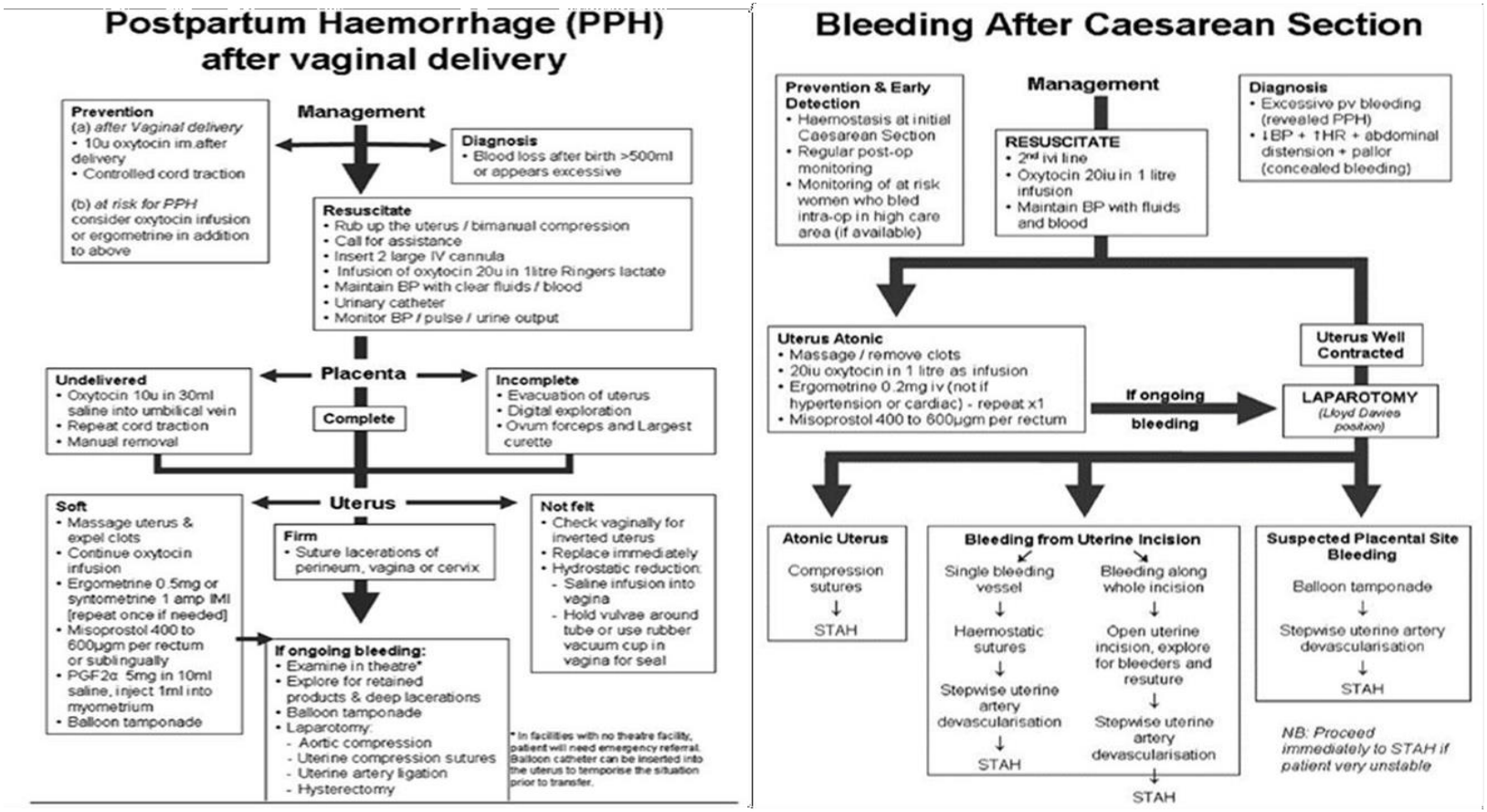


Figure 2.3: Guidelines for PPH after Vaginal Delivery Caesarean Section (NCCEMD, 2016)

Obstetric haemorrhage often requires a massive blood transfusion. Thus, the SANBC and the South African Department of Health (DoH) have developed additional guidelines for managing OH (Figure 2.4). This protocol provides guidelines on situational analysis and decision-making for severe OH. It is important to note that while these algorithms are helpful alone, they are not sufficient to manage PPH. This is because other social competencies are needed to managePPH effectively. These include factors such as teamwork leadership and which might require further training. In addition, competent surgical skills are also required to manage PPH effectively. Intraoperative cell salvage - a safe and resource-saving procedure which involves resupplying the patient with lost haemoglobin is also recommended to manage obstetric haemorrhage.[58] However, at the time of writing this dissertation, MMH did not perform intraoperative cell salvage.

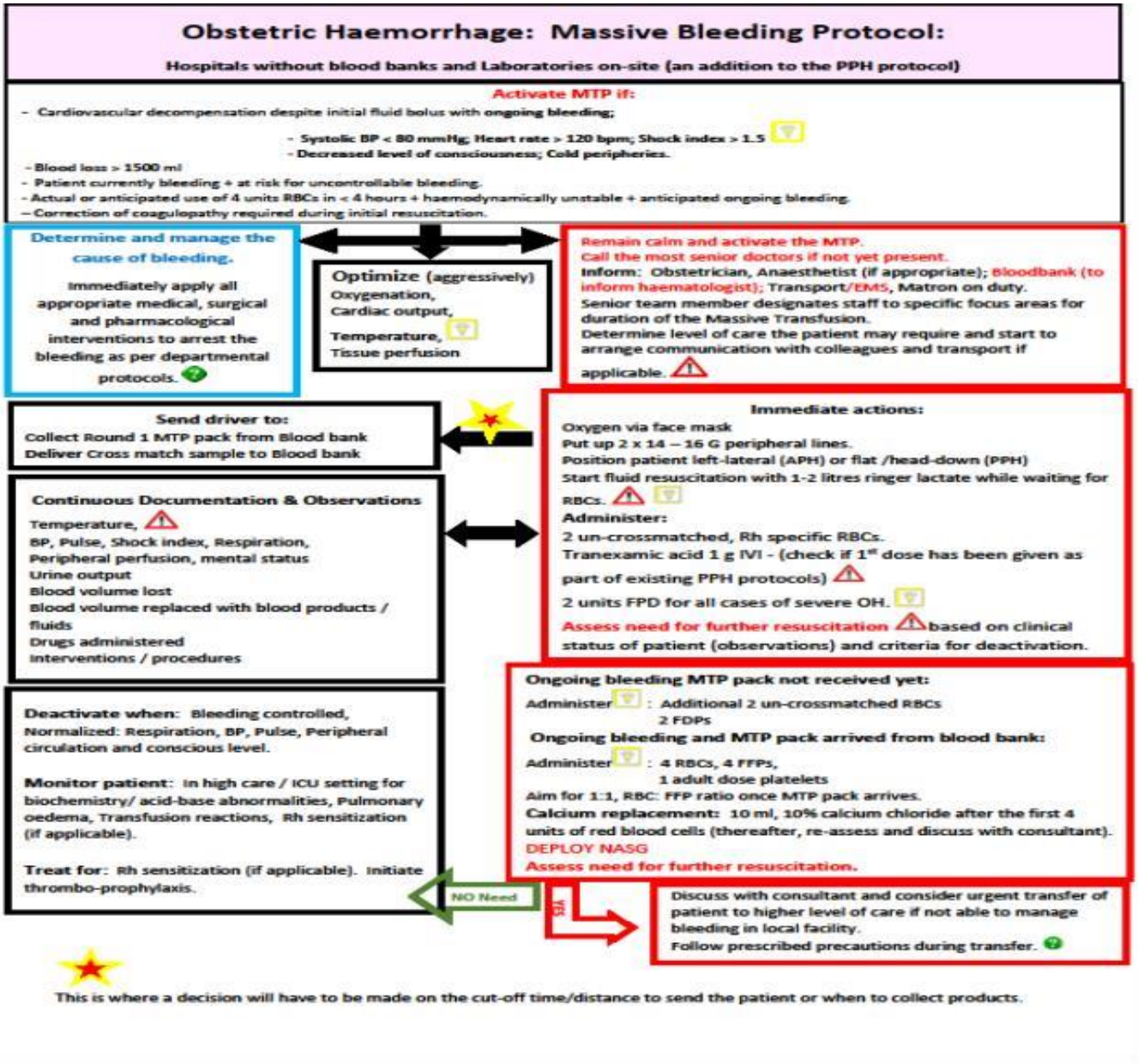


Figure 2.4 Additional Guidelines for Severe PPH (Suggested SANBS/DOH SA Guidance)

2.6 Conclusion

Blood transfusion is a lifesaving procedure. Although the World Health Organisation provides guidelines for the transfusion of blood and blood products, these are not mandatory unless regulated by the medical body in a respective country. The inappropriate use of blood components can have serious consequences resulting in morbidity and even mortality. In addition, blood is a costly commodity. Therefore, there is a need for the use of blood and blood products to be audited so that informed decisions regarding the need for transfusion can be made.

3. Aims and Objectives

The study aims to investigate blood transfusion practices in a regional obstetric hospital with no on-site blood bank.

3.1 Specific objectives

- To describe the amount of blood used per annum and monthly trends in blood product utilisation during the year, 2018.
- To describe the relative proportions of 'emergency blood' transfused compared to cross-matched blood; and use of other blood products.
- To describe the number of units (and range) of red cells transfused per woman.
- To describe the clinical area/ ward from which the blood was ordered.
- To describe the proportion of blood ordered after hours and the amount of blood returned without use.
- To perform an in-depth folder review of two months of a sample of women who received blood products in order to ascertain the precise obstetric indications and decision-making processes

3.2 Research Design

This study used a retrospective descriptive audit approach to collect data on blood transfusion management from Mowbray Maternity Hospital, a Regional Hospital in Metro West, Cape Town, which receives complicated obstetric patients from satellite Midwife Obstetric Units (MOUs) and District Hospitals. In addition, an in-depth folder review of two months was also conducted for 118 women to ascertain the precise obstetric indications and decision-making processes.

3.2.1 Study Setting

The study was conducted at Mowbray Maternity Hospital (MMH), a Regional Hospital in Metro West, Cape Town, which receives complicated obstetric patients from satellite Midwife Obstetric Units (MOUs) and District Hospitals, notably antenatal referrals for anaemia, postpartum for OH and other high-risk patients, such as patients with pre-eclampsia, which is a condition that increases the risk of ante, intra and postpartum haemorrhage and other complications. MMH performs approximately 10 000 deliveries per year, most of which are complicated pregnancies, and is staffed by specialists, registrars, medical officers, and interns. The hospital does not have an on-site blood bank but has a functioning refrigerator in Theatre,

with a supply of six (6) units O positive red blood cells and two (2) units O negative blood. In addition, it stocks fresh, dried plasma as a pharmacy item, with several bottles always available in the Theatre. Blood usage monitoring at MMH was commenced in 2012 by a senior specialist.

3.2.2 Study Population

The study population included all women for whom blood products were transfused in 2018 at Mowbray Maternity Hospital. These were identified via (a) Monthly reports received from the Western Cape Blood Transfusion Services (WCBTS) on blood usage at MMH and (b) the register in Labour Ward/ Theatre, which records the use of 'emergency' blood. In 2019, the WCBTS changed its name to that of the Western Cape Blood Service (WCBS).

a) Data Collection

The blood transfusion reports provide information on the type of blood products ordered and administered, the number of units per woman, the location from where they were ordered (e.g. Antenatal Ward, Labour Ward, Theatre, Special Care Unit), after-hours ordering and returned/ unused products. This data was collated and analysed to obtain the required information. Medical folders were retrieved from the Medical Records Department for the in-depth folder review, and the necessary information was extracted from the folders and entered onto a purpose- designed data collection sheet (Appendix A).

b) Inclusion Criteria

- The study focused on Mowbray Maternity Hospital, a regional hospital in Metro West, Cape Town, which receives complicated obstetric patients from satellite midwifery units and district hospitals.
- The study was limited to 2018, as this was the most recent year for which comprehensive and accurate historical data was available at the time of the study.
- The study subjects were all women who gave birth at Mowbray Maternity during the study period and received blood products such as red cell concentrate (including emergency blood), fresh frozen plasma, cryoprecipitate, and platelets.
- Cases where patient files, records, or documentation were not readily available for an in-depth file review, were excluded from the folder review.

3.3 Data analysis

The analytical method employed in this study was mainly descriptive and involved the use counts, and percentages as well as means and medians. These techniques were carefully used to provide a thorough understanding of the various aspects related to the use of blood products in a clinical setting. These methods offer straightforward and interpretable insights that are applicable to clinical procedures and decision-making.

3.3 Ethical Guidelines

Several ethical guidelines must be followed when conducting research. The Department of Health provides the following guidelines to be followed in clinical research: i) informed consent; ii) balance of harm and benefit; iii) privacy; iv) transparency; v) ethics review; vi) informed consent, and vii) safety and monitoring.[59] Informed consent is concerned with providing the participants with adequate, clear and concise information about the purpose of the research so that their participation is based on a full understanding of the nature of the research. Balancing harm and risk require a risk-benefit analysis of the potential harm to the patient beyond the study's life, while safety and monitoring deal with the prevention, monitoring, and prompt intervention of serious adverse events that might occur. Patients also have the right to privacy; thus, research must protect patient confidentiality at all costs. Before embarking on research, investigators must seek approval from an ethics committee, such as the Research Ethics Committee and the Data and Safety Monitoring Committee in South Africa. The guidelines also indicate that these guidelines will vary depending on the nature of the research. This study adopted a retrospective methodology where patient case records were analysed. This was done as part of an audit/ evaluation to improve the quality of care at MMH. There was no contact with individual patients. As such, individual consent was not required and, therefore, not sought. All data collection was anonymised, and data sheets were kept in a secured place. All information was treated with confidentiality following the Helsinki Declaration.[60] Permission was sought from the Mowbray Maternity Hospital Research Committee, the Department of Obstetrics and Gynaecology Research Committee and the University of Cape Town Ethics Committee (HREC Ref. 801/2019)

4. Results

This section presents the results of the study as outlined in the objectives. The section is structured as follows: First, data on total transfusions administered during the study period will be presented. This includes monthly reports on blood usage at MMH received from the Western Province Blood Transfusion Service (WPBTS) and the data from the Labour Ward and Theatre register, which records the use of 'emergency' blood. The subsequent part of the analysis will focus on the folder review.

4.2 Blood Product Utilisation During the Study Period

During the study period, there were 10 030 deliveries. Of these, 5081 (50.6%) were normal vaginal deliveries, 4731 (47.2) were caesarian section (CS) deliveries, and the remaining 215 (2.2%) were assisted deliveries. Seven hundred and eighty-one (781) of the women who delivered during the study period received blood products. However, given that some of these women received more than one blood product, the sample size for each blood product ranged from 7 for platelets to 729 for red blood cells. In other words, 7 out of 781 received platelets, while 729 out of 781 received red blood cells.

Figure 4.1 below presents a flow diagram for the study sample.

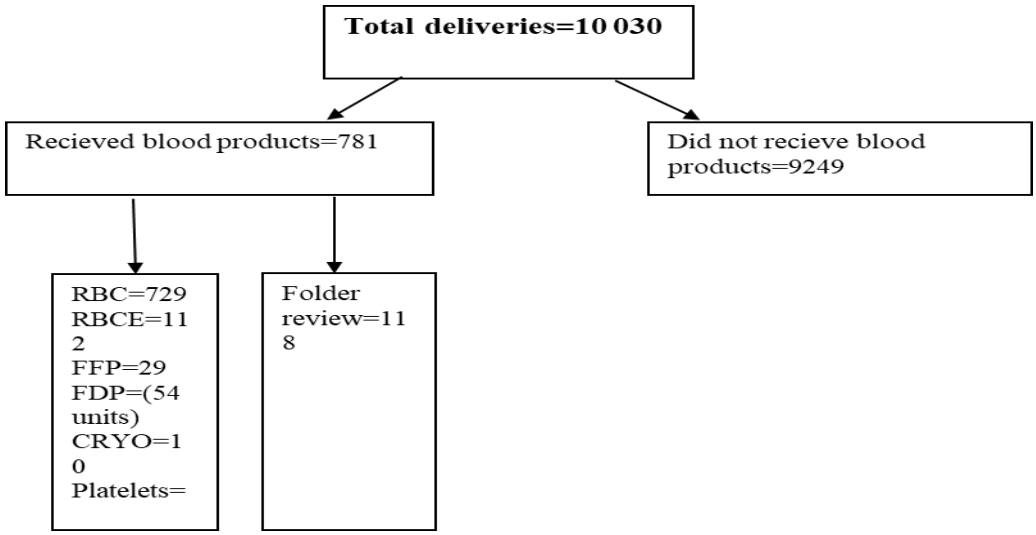


Figure 4.1: The Study Population

4.2.1 Patient Demographics

The demographic characteristics of the patients who received blood at MMH in 2018 are presented in Table 4.1 below. Most of the transfusions were among women aged 25-29 (n=202, 26.1%), followed by the age group 20-24 (n=191, 25.27%)) and age group 30-34 (n=165, 21.7%). Approximately 12% of the patients that received blood transfusions were young teenage mothers (n=87), while about 12% (n=92) of those aged 35-39 also received blood. The least proportion of blood transfusions was among women aged 40 years and above (n=22, 2.9%), mostly reflecting fewer women above 40 years getting pregnant. There were also 22 women (2.8%) whose details, including age, were not captured in the data.

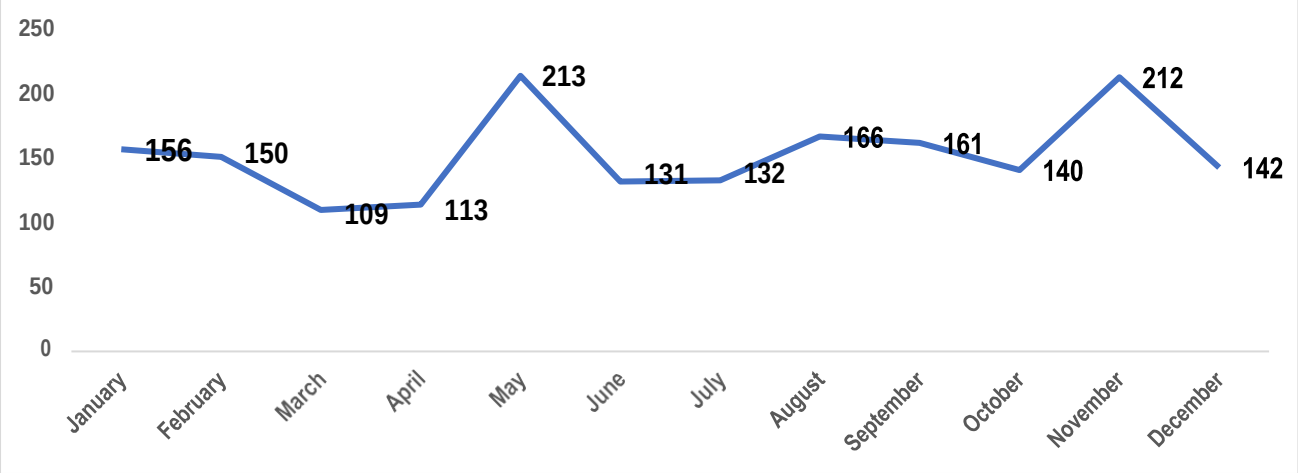
Table 4.1: Demographic Characteristics of the Study Sample

Age group	N	%
Missing	22	2.8
13-19	87	11.5
20-24	191	25.2
25-29	202	26.1
30-34	165	21.7
35-39	92	12.1
40+	22	2.9
Total	**781**	**100**

4.3 Trend Analysis of Blood Product Utilisation in 2018

Figure 4.2 below shows the trends in blood utilisation (in terms of the amount of blood transfused) at Mowbray Maternity Hospital in 2018.

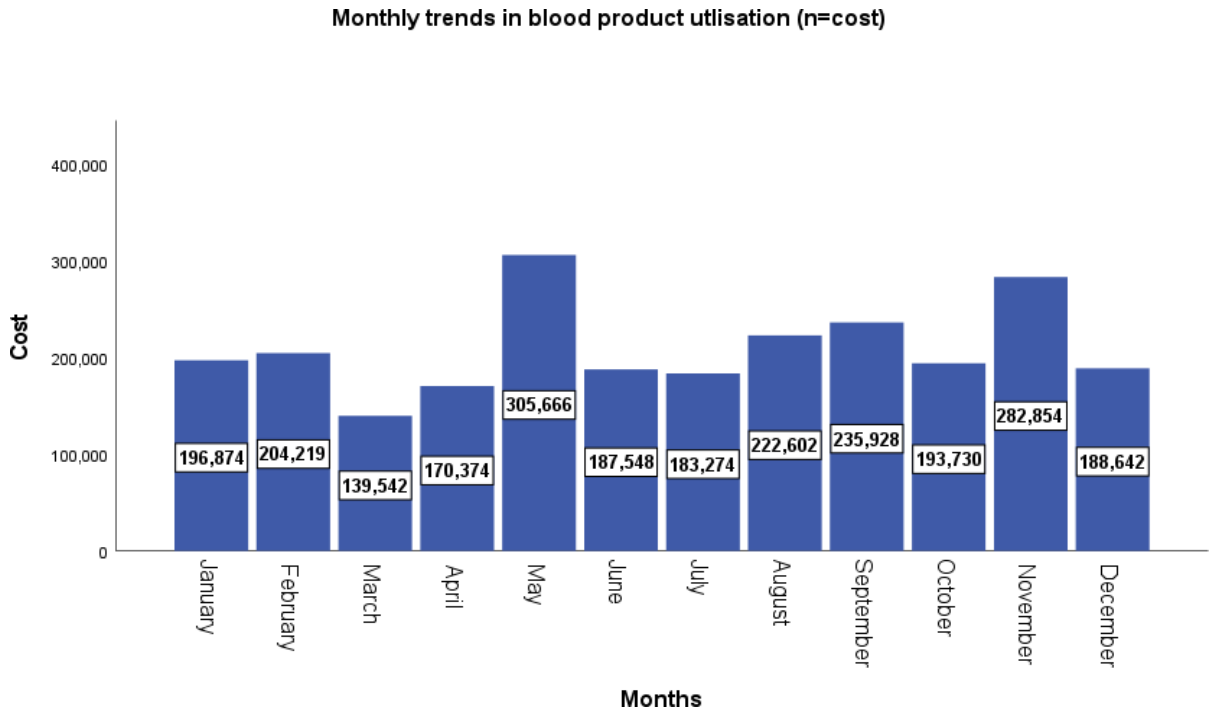
Figure 4.2: Monthly Trends in Blood Utilisation (n = units)



The total number of blood units collected from the study blood bank in 1 year (1st January 2018 to 31st December 2018) was 1771 units, with a monthly average of 152 units. For this study, blood product utilisation for months (January, n = 156 units) and (February, 150 units) were closest to the calculated monthly average. The month of March had the lowest amount of blood units transfused (n=109). The months of May (n=213) and November (n=212) had the most blood transfusions.

Figure 4.3 below presents the trend analysis of the cost of the blood that was transfused in 2018.

Figure 4.3 Trend Analysis of the Cost of Blood Products Utilised During the Study Period (n= amount in rands)



The total cost of the blood that was transfused in 2018 was R2,511,254, with a monthly average of R209,271. Monthly expenditure correlated directly with the amount of blood and blood products transfused. The utilised quantity of blood products showed some seasonal variations: peaks were observed in May, September and November, while fewer units were utilised in February and March. This corresponds with Figure 4.3 above, showing that February and March had the lowest blood transfusions. The months of May, September and November had the highest and above-average units of blood utilised.

Table 4.2 presents data comparing the total deliveries and transfusions. In total, 10030 deliveries were registered at MMH in 2018, suggesting that blood transfusion incidence among obstetric patients was approximately 7.8% (718/10030). Although December had the highest number of deliveries (911), the highest incidence proportion of blood transfusions was in November (9.9%), followed by May (9.6%) and then February (9.0%). March had the lowest incidence of blood transfusions (6.1%).

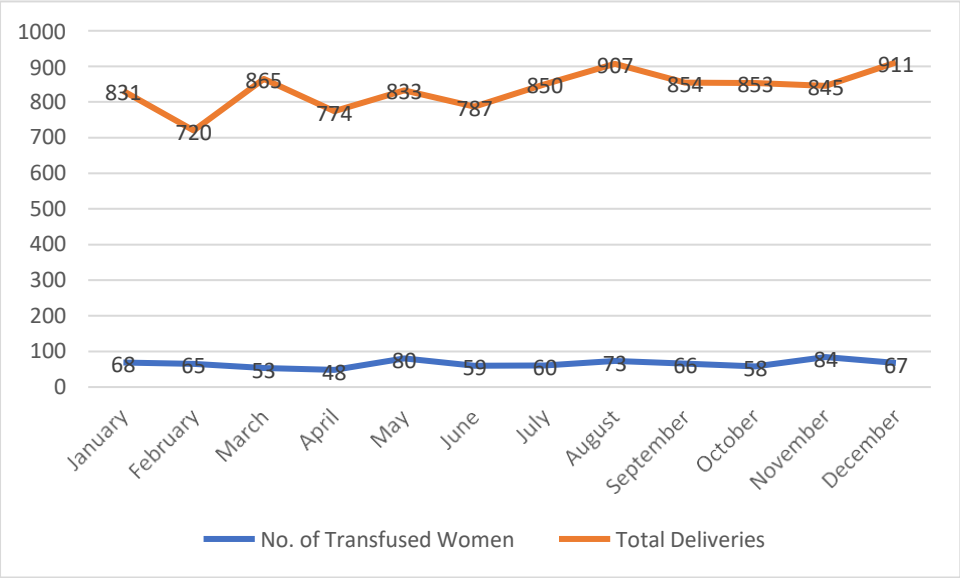
Regarding caesarian (CS) deliveries, there were a total of 4734 deliveries during the study period. When these were compared to the total transfusions, the results show that the rate of transfusion ranged from 13.0% in March to 20.4 in May.

Table 4.2: Women Who Received Blood Products as a Proportion of Total Deliveries

Month	No. of transfused women	Total deliveries	Proportion	Total CS deliveries	Proportion
January	68	831	8.2	388	17.5
February	65	720	9.0	358	18.2
March	53	865	6.1	409	13.0
April	48	774	6.2	361	13.3
May	80	833	9.6	392	20.4
June	59	787	7.5	380	15.5
July	60	850	7.1	390	15.4
August	73	907	8.1	413	17.7
September	66	854	7.7	390	16.9
October	58	853	6.8	429	13.5
November	84	845	9.9	414	20.3
December	67	911	7.4	410	16.3
Total	**781**	**10030**	**7.8**	**4734**	**16.5**

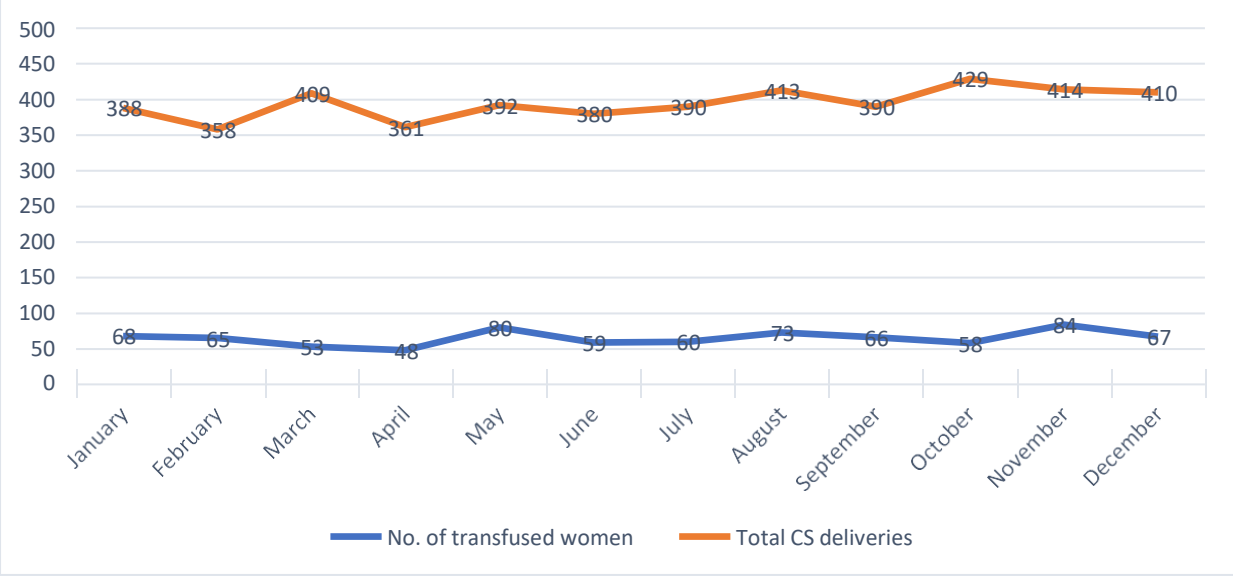
Figures 4.4 and 4.5 below present graphical comparisons of the total deliveries and total transfusions for the entire sample of women who received blood products (Fig. 4.4) and for the sub-sample of those who gave birth through C-section (4.5).

Figure 4.4 Total Deliveries vs Overall Number of Transfusions



For C-section, the graph below indicates that a high number of C-section was not necessarily associated with a high proportion of blood transfusions. For instance, although March had the fifth highest number of women who delivered via C-section, it was the month with the second lowest number of transfusions.

Figure 4.5: Total Number of C-sections vs Overall Number of Transfusions



4.3 Proportions of 'Emergency Blood' Transfused Compared to Cross-Matched Blood; And Use of Other Blood Products

Table 4.3 below presents the descriptive analysis of the blood products that were transfused for all the women included in this study.

A total of 781 women received blood products during the study period. A breakup of the proportion of people transfused with different blood products showed that 729 out of 781 (82.2%) women were transfused with cross-matched Red Blood Concentrate (RBC), making it the product with the highest number of transfusions.

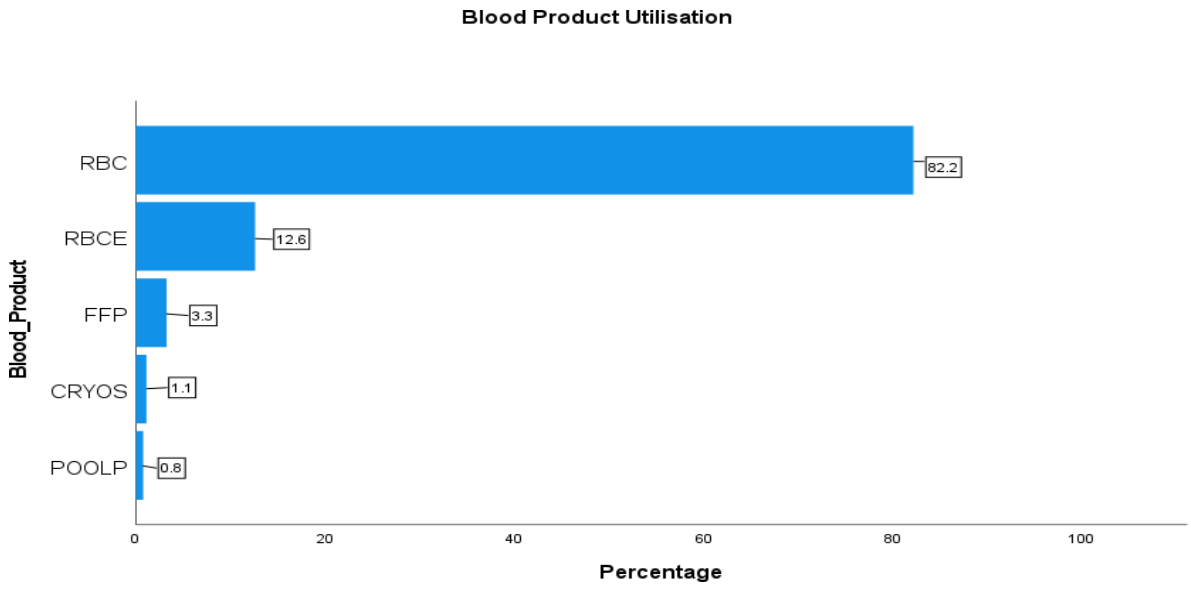
Table 4.3 Relative Proportions of Blood Products Used in 2018 (n=781)

Blood Type	No of blood transfusion	Mean units (range)
RBC	729	1.89 (1-6)
RBC Emergency	112	1.24 (1-3)
Plasma - Fresh Frozen	29	2.0 (1-4)
Plasma- Fresh Dried	54	
Cryoprecipitate 100iu	10	1.2 (1-2)
Pooled Random Donor Platelets	7	1

Emergency RBC accounted for 12.6% of the transfusions, and Fresh Frozen Plasma (FFP) was distributed to approximately 3.3 % of the study sample, Cryoprecipitate (Cryo) 1.1% and Pooled Random Donor Platelets were distributed to less than ≤1% of the sample each. The average transfusion ratio of the 32 women who received other blood products besides RBCs was 2:1 RBC to FFP. Table 4.3 presents the different transfusion patterns found in the data. The mean blood units for RBC were 1.89, RBCE, 1.24 units, FFP, 2.0units, Cryo, 1.2 units and platelets 1 unit. Transfusion of at least four RBC units occurred in approximately 7.8% of transfusions, with FFP occurring in at least 0.2% of the transfusions. The FDP data used for this analysis was not disaggregated by patient details - and only summary statistics were obtained from the Pharmacy department. Therefore, the mean units could not be calculated. Nonetheless, 54 units of FDP were transfused. The months of February (11 units) and May (10 units) had the highest utilisation. The lowest utilisation was in July, where only one unit was transfused, followed by August (2 units) and September and October (3 units each).

Figure 4.6 below presents the graphical evidence of the proportion of transfusions by blood product.

Figure 4.6: Relative Proportions of Blood Products Used in 2018 (N= 781)



Of the 781 patients who received blood products during the study period, 32 received more than one blood component; these ratios are presented in Table 4.4 below. The first column presents the ratios in terms of the different units used, the second column relates to the number of women who received blood products in that particular ratio, and the third column has information on blood product combinations. Of note, data on emergency and cross-matched RBC was combined for this analysis.

Table 4.4 Transfusion Patterns

Ratio	n	Blood Products
2 : 1	4	RBC+FFP
2 : 2	1	RBC+FFP
2 : 3	1	RBC+FFP
3 : 1	1	RBC+FFP
3 : 2	1	RBC+FFP
3 : 3	1	RBC+FFP
4 : 2	4	RBC+FFP
5 : 1	1	RBC+FFP
5 : 2	5	RBC+FFP
6 : 2	2	RBC+FFP
4 : 1	1	RBC+CRYO
2 : 1 : 1	1	RBC+FFP+PLAT
7 : 2 : 1	1	RBC+FFP+PLAT
4 : 1 : 1	1	RBC+FFP+CRYO
4 : 2 : 1	2	RBC+FFP+CRYO
5 : 2 : 2	1	RBC+PLAT+CRYO
6 : 1 : 1	1	RBC+PLAT+CRYO
8 : 1 : 1	1	RBC+PLAT+CRYO
6: 3:1:2	1	RBC+FFP+PLAT+CRYO
6:4 :1:1	1	RBC+FFP+PLAT+CRYO

4.3.1 Red Blood Cell Utilisation

Table 4.5 below presents the descriptive statistics for red blood cell utilisation at Mowbray Maternity Hospital in 2018.

Table 4.5 Red Blood Cell Utilisation (n=729)

Month	No. of women who received RBC	Quantity of units transfused
January	54	107
February	60	116
March	48	90
April	47	99
May	76	164
June	57	111
July	55	118
August	70	152
September	65	136
October	58	124
November	72	168
December	67	134
TOTAL	**729**	**1519 (Mean = 127)**

A total of 729 women were transfused with cross-matched red blood cell concentrate (RBC) in 2018. Cross matched blood accounted for 82.2.3% (n=729 out of 781) of the total transfusions. The total number of RBC units was 1519, with a mean of 1.89 units per patient (Table 4.3). The mean monthly usage of the RBC was 127 units, with a range of 90 units in March to 167 units in November (Table 4.5). The months of May (n=85), November (n=85) and August (77) had the highest number of women who received RBC, corresponding with Figure 4.2, which also showed that these months had the highest amount of blood product utilisation. The month of March also had the least number of women who received red blood cells (n=52).

Table 4.6: Emergency Red Blood Cell Utilisation (n=112)

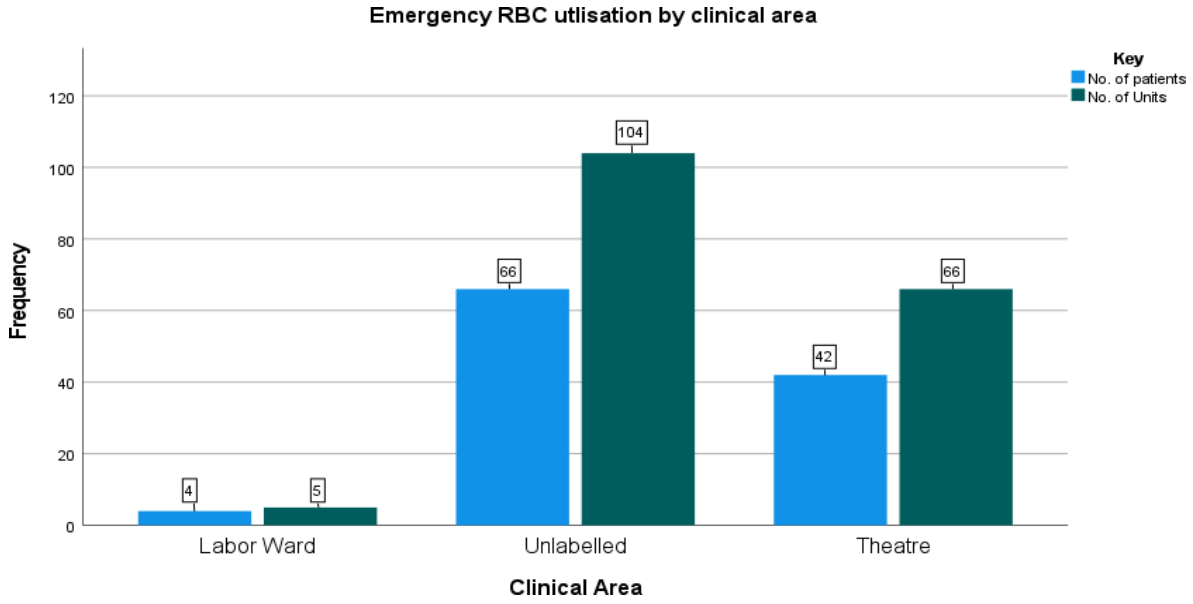
Month	No. of women who received emergency RBC	Total number unit's RBC administered
January	22	36
February	11	18
March	11	17
April	4	5
May	15	26
June	6	9
July	7	12
August	4	5
September	3	7
October	8	9
November	21	31
December	0	0
TOTAL	**112**	**175 (mean=14.6)**

One hundred and twelve (112) women received red blood cells under emergency conditions. The total number of emergency RBC units transfused was 175, with a mean of 1.2 units per patient (Table 4.3). The monthly mean for emergency RBC was 14.6 units, with a minimum range of 0 units for the month of December and a maximum of 36 for January (Table 4.6). The months of January, May and November had the highest amount of emergency RBC transfusions.

4.4 Clinical Area/ Ward from which the Blood was Ordered

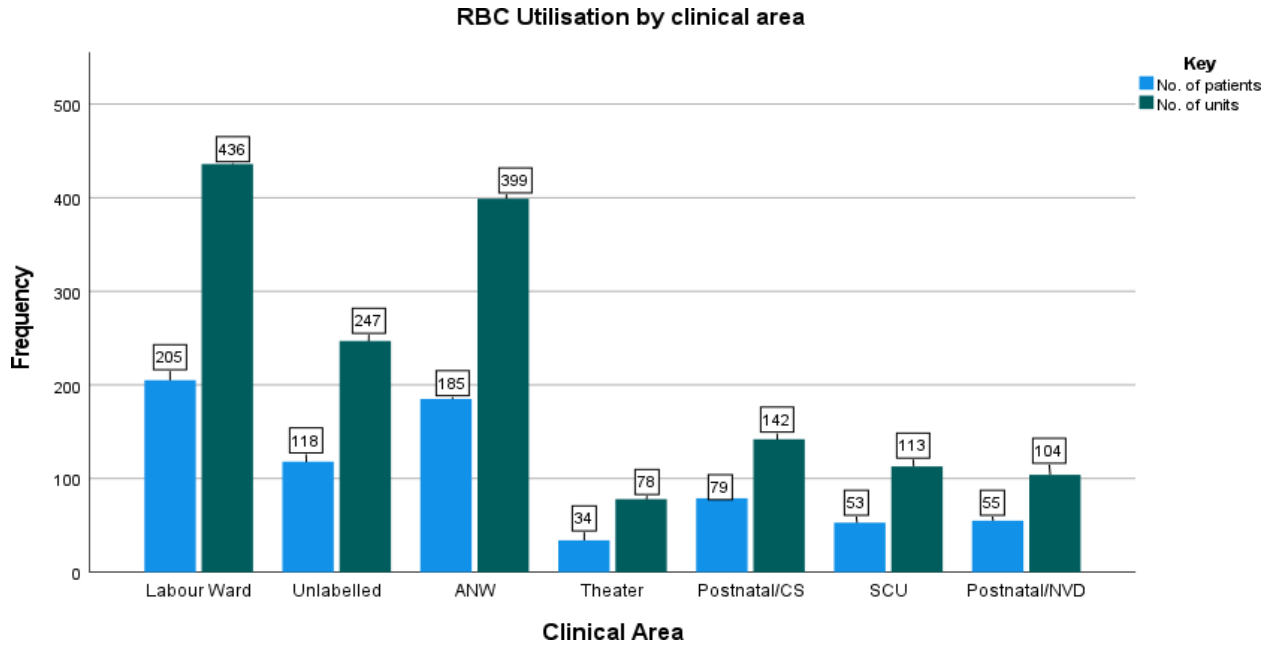
Figures 4.7 - 4.9 show the department or clinical ward from which the blood products described in Table 4.3 were used.

Figure 4.7: Emergency Red Blood Cell Utilisation by Clinical Area



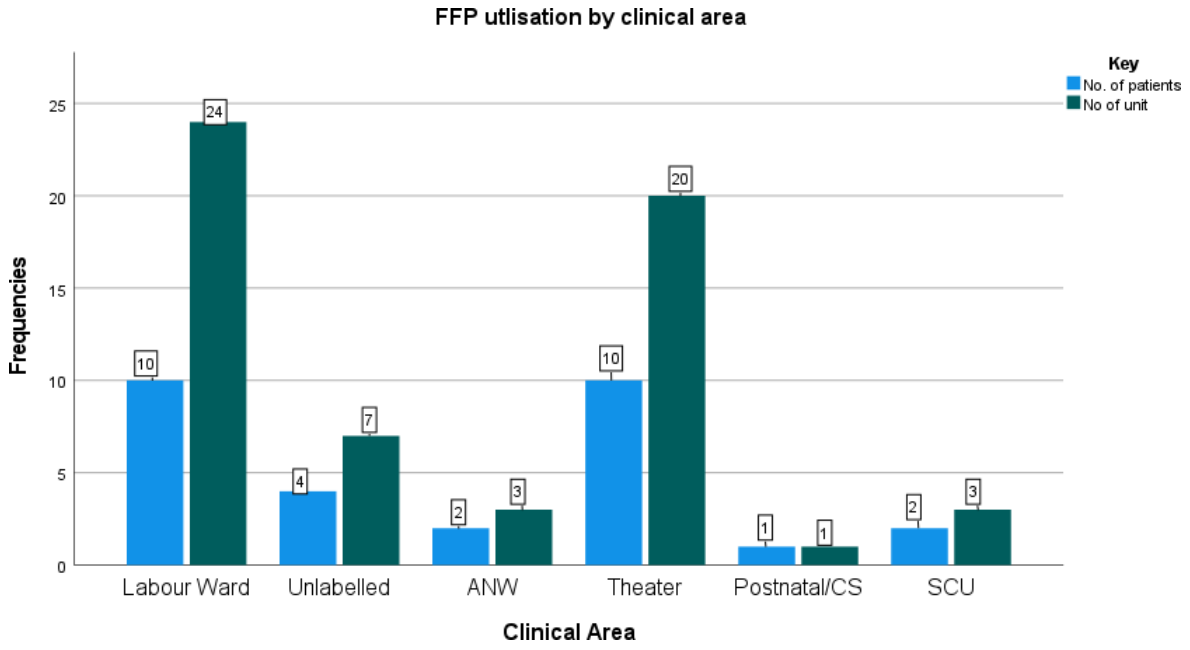
In terms of the ward/ clinical area, the bulk of emergency RBC was used in a clinical department labelled as 'Obstetrics' in the data, although no such ward exists at MMH. Further investigation revealed that the term 'obstetrics' was used when the attending physicians did not indicate the ward they were ordering the blood from on the form. Therefore, it representsblood products utilised by the Obstetric Department, but as the specimens were unlabeled, theycould not be assigned to a specific ward. Nonetheless, a total of 66 women were transfused with 104 units of emergency RBC, accounting for 59% of the total sample who received emergency RBC at MMH in 2018. In 2018, 42 patients received emergency blood in Theatre (66 units), while in the Labour Ward, there were four (4) transfusions of emergency blood (5 units). A further 66 women received emergency blood in 2018 (104 units), but the clinical area was not documented.

Figure 4.8: Red Blood Cell Concentrate Utilisation by Clinical Area



The highest utilisation of red blood cells was in the Labour Ward, where 205 transfusions (436 units) of cross-matched red blood cells accounted for almost 30% of the total RBC transfusions. This was followed by the antenatal ward with 185 transfusions (399 units); 'unlabelled'118 (247 units); post-natal for Caesarian Sections with 79 transfusions (142 units); post-natal for vaginaldelivery with 55 transfusions (104 units), Special Care Unit with 53 transfusions (113 units) and Theatre-34 (78 units). The Special Care Unit at MMH has six beds and caters for critically ill obstetricpatients. It is situated within the antenatal ward to closely monitor high-risk patients for obstetric complications, e.g. OH, preeclamptic patients on MgSO4. Patients who suffer surgicalcomplications or postpartum haemorrhage are also admitted to this ward for closer monitoring once they have been stabilised.

Figure 4.9: Fresh Frozen Plasma Utilisation by Clinical Area



Fresh Frozen Plasma was mainly transfused in the Labour Ward (n=10, 24 units) and the Theatre (n=10, 20 units). The clinical department for four (4) of the FFP transfusions (7 units) was unlabelled, while the Special Care Unit and the Antenatal Ward had two transfusions (3 units) each. Lastly, one Fresh Frozen Plasma transfusion (1 unit) was transfused for caesarean sections in the post- natal ward.

Regarding Cryoprecipitate, five (n=5, 6 units) transfusions were conducted in the Labour Ward, two (2) transfusions each in the Special Care Unit (2 units) and Theatre (3 units). One (1 unit) of the transfusions could not be allocated to a clinical area as the specimen was unlabeled. Platelets were transfused to 3 patients in the Labour Ward (3 units), and two (2) patients each in the Special Care Unit and Theatre. Each of these patients received two (2 units) each. This is shown in Table 4.7.

Table 4.7: Cryoprecipitate and Platelet Use by Clinical Area

	CRYO		*Platelets*	
	No. of transfusions	No. of units	No. of transfusions	No. of units
Labour Ward	5	6	3	3
Unlabelled	1	1		
Theatre	2	3	2	2
SCU	2	2	2	2
Total	10	12	7	7

4.5 In-Depth Folder Review

An in-depth folder review was conducted for two months. In these two months, a total of 301 patients were screened for transfusion. One hundred and twenty-six (126) patients of the 301 received blood transfusions. Eight (8) of the folders were empty; hence, an in- depth analysis of these patients' files could not be done. Eventually, the analysis was done for118 patients.

The in-depth folder review focused on the following topics:

4.5.1 Patient demographics
4.5.2 Timing of transfusion
4.5.3 The proportion of patients who received emergency blood/cross-matched blood
4.5.4 Indications for transfusion
4.5.5 Pre and post-transfusion haemoglobin
4.5.6 The rank of the clinician who ordered blood

4.5.1 Patient Demographics for Folder Review

Table 4.8 below presents the descriptive statistics of the women who received blood

Table 4.8: Descriptive Statistics of the Folder Review Sample

Variable	N	%
Age		
15-19	16	13.6
20-24	21	17.8
25-29	31	26.3
30-34	27	22.9
35-39	17	14.4
40-44	5	4.2
Missing	1	0.8
Gravida		
1	39	33.1
2	30	25.4
3	17	14.4
4+	32	27.1
Para		
1	42	35.6
2	33	28.0
3	18	15.3
4+	25	21.2
Delivery mode		
Caesarean	44	37.3
Vaginal	74	62.7
Blood Loss		
<500ml	13	11.0
≥500ml-<1000ml	66	55.9
≥1000ml-<2500ml	33	28.0
≥2500ml	4	3.4
Missing	2	1.7
Tachycardia PR		
< 110	4	3.4
>110	114	96.6
Birthweight		
≤2500	15	12.7
2501-3000	27	22.9
3001-3500	40	33.9
3501-4000	24	20.3
4001+	12	10.2

A total of 118 patient folders were reviewed for the months of March and May. Sixteen (16, 13.8%) of the women were aged 15-19 years, 20 (17.24%) were aged 20-24 years, 31 (26.7%) 25-29 years, 27 (23.4%), 30-34 years, 17 (14.7%), 35-39 years and 5 (4.3%), 40-44 years. The women were mostly gravidas 1, 2 or 4+ and para 1 or 2. More than half of the women (55.9%) had estimated blood loss between greater than or equal to 500ml, while 28.0% (n=33) had severe blood loss (i.e. blood loss greater than or equal to 1000ml but less than 2500ml). Only 3.4% (n=4) had massive bleeding (blood loss greater than or equal to 2000ml). For 11% (n=13) of the women, a blood loss below 500ml was recorded. Approximately 96.6% (n=114) of the women who received blood had a pulse rate above 110, i.e. were tachycardic. Most women had normal vaginal deliveries (74, 62.7%) and gave birth to babies with birth weights in the range 3001-3500g (40, 33.9%). The mean birth weight was 3175g (SD± 62.5). The total number of births during the two months in which patient folders were reviewed was 1698 (Table 4.2), thus, the transfusion rate for this period was 7,4% (126/1698). This rate is comparable to the entire study period rate of 7.8%. There were 801 C/Sections and 870 vaginaldeliveries during the two months of folder review. The incidence of transfusion for C/Sectionwas 5,5% (44/801), while for vaginal deliveries was 8,5% (74/870). Given that eight folders did not contain clinical notes and could therefore not be allocated, it is possible that these two rates (C/Section and NVD) could be slightly higher than reported in this study.

4.5.2 The Timing of Transfusion

Table 4.9 presents data on the timing of transfusion. Eight (8) women received blood during antenatal, while the remaining 110 were transfused postpartum. The former were diagnosed with antenatal anaemia.

Table 4.9 Timing of transfusion

Antenatal	Postpartum
8	**110**

4.5.3 Emergency Blood Utilisation

Table 4.10 presents the results on emergency blood utilisation among women whose folders were reviewed.

Table 4.10 Emergency Blood Utilisation

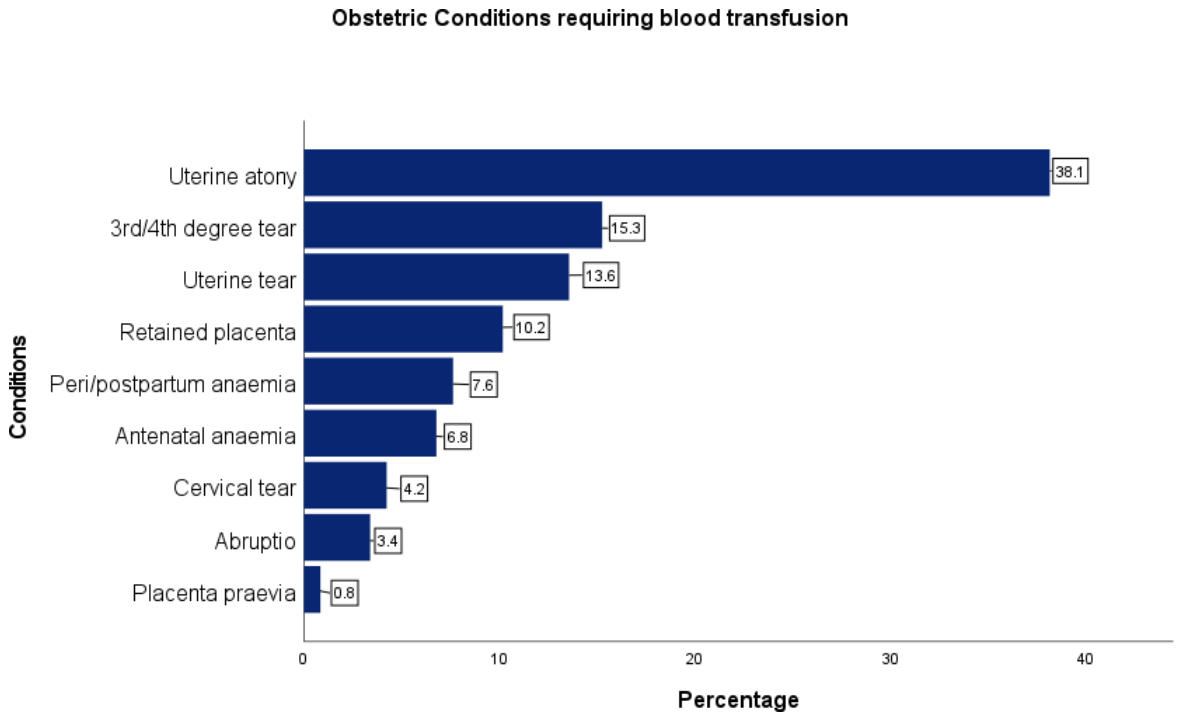
Blood product	RBC	RBCE	FFP	FDP	Platelets	CRYO
Total transfusions	102	16	7	5	3	1

RBC was the main blood product that was transfused in the two months in which folders were reviewed. Only 16 (13.5%) of the patients whose folders were reviewed were indicated as having received emergency blood. However, data from the blood bank (Table 4.6) suggests that 34 patients (11 in March and 15 in May) received emergency blood. This discrepancy is likely due to the missing folders (eight) or errors in data capture. The other blood products were transfused in addition to cross-matched red or emergency red blood cells. On average, women who had severe PPH (blood loss >1500mls) received approximately 2-4 units of RBC with 1 FDP and 2 FFP or RBC and FFP. One patient received one unit each of RBC, FDP, platelets and cryoprecipitate.

4.5.4 Obstetric Indications Requiring Blood Transfusion

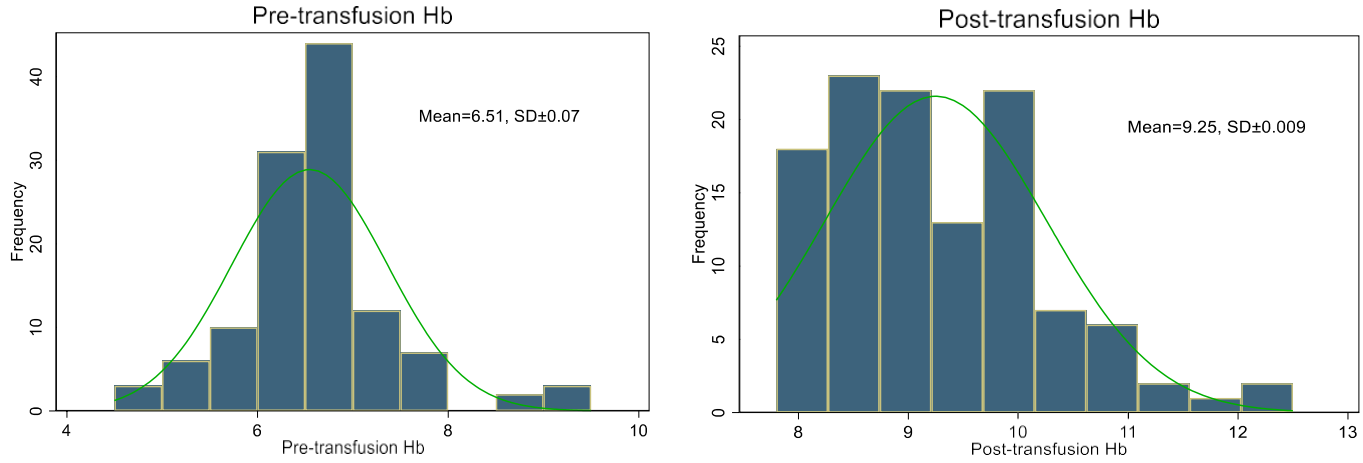
The main indication for transfusion was postpartum haemorrhage, caused by several factors, as shown in Figure 4.10. More than a third of the transfusions were for uterine atony(n=45, 38.1%). The next group of patients who received blood had perineal tears **(**3rd-degree tear, 4th-degree tear, 15.3%, n=18. Approximately 14% (n=17) were diagnosed with symptomatic anaemia, of which eight (8) were diagnosed with antenatal anaemia. For nine (9)of the cases, the available data could not distinguish whether anaemia was diagnosed during orpost labour. Hence, these cases were combined in the analysis.

Figure 4.10. Obstetric Conditions Requiring Blood Transfusion



Generally, pregnant women are at risk of being anaemic, which can be exacerbated by postpartum haemorrhage. For instance, there was a significant difference between the pre-transfusion haemoglobin and the post-transfusion haemoglobin ($p<0.001$) in this study (Figure 4.11). The mean pretransfusion Hb was 6.51 (SD±0.07). The range for the pretransfusion Hb was 4-9. The mean was 9.25 (SD±0.009) for the posttransfusion Hb, and the range was 8-12.5. Therefore, the main reason for transfusion was anaemia. For 17 of the patients, the clinical condition for transfusion was indicated as anaemia, of which 8 had antenatal anaemia, and the other nine had post-partum anaemia. Anaemia on its own is not a complete diagnosis; it is always secondary to an underlying cause, however, we used it as a diagnosis in cases were no cause was indicated for anaemia.

Figure 4.11: Pre and Post-Transfusion Haemoglobin



Complications involving uterine tears at Caesarean section accounted for 13.6% (n=16) and cervical tear post-NVD 4.2% (n=5) of all transfusions in these two months. Placental problems (placenta previa, 1%, n=1), abruptio (3.4%, n=4) and retained placenta (10.2%, n=12) accounted for 15% of the blood transfusions.

4.5.5 Characteristics of Physicians Ordering Blood Transfusion

Of all the 16 patients who received emergency blood in the two months where folders were reviewed, the blood was requested by senior medical staff. In terms of the total sample, 80 (67.8%) of the blood transfusions were ordered by registrars, followed by Community Service Medical Officers (COSMOS) (27, 22.8%). Consultants ordered blood products for only four (4) of the patients, while Medical Officers requested blood for seven (7) patients.

Table 4.11: Seniority of Doctor Requesting Blood

Consultant	Registrar	MO	COSMO
4	80	7	27

4.6 Cancelled /Returned Blood Products

Table 4.12 presents descriptive statistics of the amount of blood returned without use.

Table 4.12: Blood Returned Without Use

Clinical area	Cost	Units
Labour Ward	47969	70
Unlabelled	21322	31
Theatre	4844	7
SCU	6176	9
ANW	13122	19
Postnatal-Caesarean Section	6756	10
Postnatal-NVD	1384	2
Total	**101573**	**148**

One hundred forty-eight (148) blood units were returned without use, of which 145 were red blood cell concentrates, 2 units of fresh frozen plasma and 1-unit platelets. The cost of these blood products was R101 573. This accounted for about 7.5% of the total transfusion orders. The Labour Ward had the highest amount of cancelled blood products, accounting for 47% of the total returned blood. The ward was not labelled for 31 (20.9%) of the cancelled blood units. Nineteen units (12.8%) were returned from the Antenatal Ward, 10 units (6.8%) from the post-natal ward for Caesar, 9 units (6%) Special Care Unit, and 7 units (4.7%) Theatre. The post-natal ward for NVD had the least amount of cancelled blood products (2 units). Fortunately, most of the cancelled/ returned products were returned in reusable condition; hence the cost implications were less than stated, although inevitably, losses were incurred.

4.7 After Hours Orders

Table 4.13: After Hours Orders

Clinical area	Cost (Rands)	Units
Labour	157252	475
Unlabelled	59103	164
ANW	77399	191
Postnatal/C-S	13890	41
Postnatal/NVD	25447	66
SCU	20111	51
Theatre	16032	41
Total	**369234**	**1029**

A total of 1029 units of blood were ordered after hours, accounting for 58% of total blood transfusion requests. In other words, the bulk of blood products that were transfused in 2018 were ordered after hours. After-hours care refers to care provided between 6 pm and 6 am on weekdays, weekends, and public holidays. The total after hours expenditure amounted to R369234,00 for the year 2018.

5.0 Discussion

5.1 Summary of the Results

During the study period, there were 10 030 deliveries. Of these, 4734 (47, 2%) were caesarean deliveries, 5081 (50.7%) were normal vaginal deliveries, and 215 (2.1%) were assisted deliveries. Overall, the results show that 1771 blood units were transfused to 781 women with obstetric haemorrhage or anaemia from other causes; thus, the overall incidence of blood transfusion was 7.8% for all deliveries. The rate is higher than reported in High-Income Countries (HICs) such as Burgundy, France, which averaged 7.3% or Australia, which had a rate of 1.2%. [61, 62] Therate was also higher than the 4% reported at an academic hospital in South Africa but lower than other LMICs settings, e.g. Belgaum, India, which averaged 28.1%, and a tertiary hospital in Nigeria, which reported 12%.[63,64,65] Red blood cell concentrate (including emergency red blood cell concentrate) accounted for most blood products transfused, followed by Fresh Frozen Plasma, Cryoprecipitate, and Platelets. Approximately 60% of the blood was ordered after hours, while 7.5% of the blood products were returned without use. Regarding the folder review, the leading cause for blood transfusion was postpartum haemorrhage secondary to uterine atony, accounting for 38.1% of the transfusions. The range of the pretransfusion Hb was 4-9g/dl, with a mean of 6.51 (SD±0.07), confirming that all the womenwho received blood products were anaemic.

The women who received blood in this study were generally younger (below 30 years), indicating that a significant proportion of women were falling pregnant before they turn 30 years. The mean and median age was 27 years, reflecting the youthful population age structure of South Africa and the fact that younger people are more likely to get pregnant. According to Statistics South Africa, more than 35% of the South African population is between 15 and 34 years.[66] Less than 3% of the women who received blood were above the age of 40, indicating that fewer women with advanced maternal age were getting pregnant dueto the reduced fecundity that comes with age.

5.2 Trends in Blood Utilisation

Understanding the trends in transfusion is needed for health institutions such as Mowbray Maternity Hospital as it helps hospital administrators monitor blood usage and predict future usage. In this study, the results show that 1771 units of blood were transfused in 2018, with a monthly average of 148 units. Although some months had much lower transfusions and some higher than the mean of 148, blood transfusions were generally clustered between 109-207 units. The mean number of blood units transfused ranged from 2 units for red blood cells, fresh frozen plasma, platelets and 1 unit for Cryoprecipitate. The mean number of blood units transfused for patients receiving emergency blood was 1.2. In other words, the practice was to transfuse double units of RBC and FFP and single units for the other blood products. Although the practice of transfusing 2 units of RBC, in general, is comparable with practices in other hospitals in the country, it has also been questioned, especially in cases where there is no active bleeding, leading to the 'Why give 2 when 1 will do?' campaign.[67,68] Blood, just like any other therapeutic agent, has risks and high costs and should be administered at the lowesteffective dose. This approach also results in cost savings without compromising patient safety.
[5,6, 69]

Among trauma patients, the practice of massive transfusion of FFP has become accepted. [70] According to the RCOG, however, the optimum FFP-to-RBC ratio for managing massive bleeding remains unknown, partly due to limited randomised controlled studies.[71] Recommendations from anaesthetic societies are also inconsistent, such as transfusing FFP in at least a 1:3 ratio with RBC (USA); 1:2 (UK) or withholding FFP until 4 units RBC have been administered (UK). [72] The RCOG recommends that 12–15 ml/kg should be administered for every 6 units of red cells during massive PPH.[71] Similarly, in this study, physicians differed in their transfusion thresholds. The ratio of FFP:RBC ranged from 1:2 to 1:5 (Table 4.4). Further research, in particular using in-depth interviews, is needed to understand why physicians used different transfusion thresholds at MMH.

Regarding the cost, blood transfusions for 2018 amounted to approximately 2.5 million Rand, with an average monthly cost of R204 370. The most expensive blood product was Cryoprecipitate 100iu, which cost R7660 per unit. This was followed by pooled random donor platelets, which had an average cost of around R6700.

5.3 Blood Product Utilisation

Given that most of the postpartum bleeding is due to a systemic haemostatic defect, the use of blood components *vis a viz* whole blood is highly recommended in the medical field, and for good reasons.[2] First, splitting the donated blood into components increases the utility of each donation.[73,74] This is because the different blood components can be made available to patients depending on their needs. Additionally, splitting the blood components ensuresthat each blood recipient receives only the component they need.

In this study, blood components such as RBC, Platelets, FFP, FDP and Cryoprecipitate were used during 2018. Red blood cells were the most utilised product accounting for over 80% of the total transfusions. In contrast, only 3% of the patients received Fresh Frozen Plasma, while Platelets and Cryoprecipitate were distributed to less than 1% of the women who received blood at MMH. These proportions reflect how blood is prepared and distributed in South Africa, where on average, 95% of all the collected blood is processed into components. Most of this blood is also distributed as red blood cells. Thus, like in many parts of the world, the use of whole blood in transfusion is very low in South Africa and only done upon special requests from doctors in the case of massive haemorrhage and exchange transfusions.[74]

The use of red blood cell concentrates at MMH is in keeping with global practice. For instance, Matsunaga et al. (2012) found that RBCs were transfused to 85.5% of the patients, while in a study by Chawla et al. (2018), red blood cells were transfused to 79% of the sample.[75,76] It is also estimated that up to 15 million RBC units are transfused in the United States annually, while 85 million are transfused worldwide.[77,78] Red blood cells are integral to blood transfusion therapy. They transport oxygen from the lungs to other parts of the body as well as remove carbon dioxide from organs and tissues through an iron-containing protein called haemoglobin. Therefore, a low red cell blood count, i.e. anaemia, leads to patient morbidity, causing, among other symptoms, shortness of breath, easy fatigability, increased risk of infections and more severe complications such as cardiac failure. In clinical practice, the most common indications for transfusion are either blood loss due to trauma or symptomatic anaemia. In this study, most of the blood loss resulted from obstetric trauma encountered during labour and delivery.

When transfusing blood, the general practice is to conduct blood typing and cross-matching to determine if the donated blood is compatible with the patient. This ensures that patients receive

blood compatible with their specific ABO and RhD status, thus preventing any harmful interactions.[44] In emergency and special circumstances, however, this might not be possible. A patient might be given group-specific blood that is not cross-matched. Group-specific blood ensures quick transfusion of a patient in need in emergent situations. In this study, 112 (12.4%) patients received transfusions of emergency RBC, compared to 729 (82.2%) who received cross-matched red blood cells. In other words, the transfusion practices at MMH are more inclined towards the use of cross-matched blood in keeping with international standards.[78] This is a far safer and cheaper practice and less likely to cause transfusion reactions and the productionof antibodies by immunising the patient.

In general, platelets and Fresh Frozen Plasma (FFP) are the least utilised blood products and must be transfused only when indicated. Platelets are used for patients with clinically significant bleeding and suspected thrombocytopenia, while FFP is used to correct "microvascular bleeding, multiple coagulation factor deficiencies."[73] A single unit of platelets can increase the platelet count by 5000–7000/l. Mercier and Bonnet also recommend the use of platelets and plasma to control acute obstetric haemorrhage.[78] Cryoprecipitate transfusion is also indicated in major haemorrhage at a standard dose of two 5-unit pools, with further transfusion guided by fibrinogen results, aiming for a value above 1,5g/l (normal fibrinogen level is between 2 and 4g/dl).

5.4 Clinical Department Receiving Blood

Regarding the ward/ clinical area from which blood was ordered, the bulk of cross-matched red blood cells were transfused in the Labour Ward (471 units) and Antenatal Ward (386 units). Two hundred and fifty-one (251) units (136 transfusions) could not be allocated to a clinical department as the specimens were not labelled with this information. Emergency blood supply at Mowbray is stored in a fridge in the Theatre Complex. Given that labour, delivery and surgery are the most high-risk times for obstetric haemorrhage, emergency blood is collected from this fridge when indicated and immediately reordered and replaced from the Blood Bank at Groote Schuur Hospital. Fresh frozen plasma was generally given to patients in the Labour Ward (24 units) and Theatre (20 units).

Although transfusing the wrong patient rarely occurs due to strict protocols followed before blood transfusion, e.g. two health professionals identifying blood and blood products to ensure the correct patient is transfused, the chances of transfusing a wrong patient increase if incorrect recording is done on blood bank forms. Not recording clinical areas on blood bank forms was a common error observed in this study, and among other things, it impacts everyday operations and effective data sharing. Consequently, clinicians may under or overestimate transfusion prevalence and compliance with standards of care. [79] Moreover, not indicating the clinical area on a blood bank form can also lead to delays in cases where emergency blood is needed, thus putting the patient's life at risk. Not indicating a clinical area can lead to more blood products being returned, increasing the cost through wastage and repeat testing. Some blood products, e.g. FFP and Platelets, have a short half-life once dispatched; therefore, wastage is significant. It is, therefore, imperative that labelling of blood bank specimens be done withoutfail.

5.5 Obstetric Conditions Requiring Blood Transfusion

To enhance the utility of transfusion, each transfusion must be linked to a clinical condition. In other words, what motivated the clinician to give the transfusion must be clear. This prompted an in-depth folder review for two months. In general, most of the women whose folders were reviewed had a blood loss of ≥500ml - hence, they all could be classified as havingPPH, in line with the NCCMED definition of PPH.[44] Only 11% had a blood loss of less than 500ml. Generally, blood loss is difficult to evaluate, and often visual estimation is the most common and practical way to estimate maternal blood loss, especially whenemergency transfusion is required.[80] Therefore, there is the possibility of misinterpretation ofthe quantity of blood loss. Nonetheless, for 80% of the women in the folder review sample, ablood transfusion was primarily conducted when the patient's Hb level was less than 7g/dL, compliant with current RBC transfusion guidelines.[62] The decision to perform blood transfusions was mainly based on the clinical judgment of the attending Medical Officers or Registrars, as these are the majority of physicians at MMH. Other doctors who ordered transfusions at MMH were Community Service Medical Officers (COSMOs) or Interns. This group of doctors are relatively junior in terms of their medical training and would generally discuss the decision for transfusion with a more senior doctor before ordering the blood. There is a need for ongoing training of these physicians in procedural and technical skills to provide high-quality care to patients. Even qualified surgeons are still expected to study and evaluate new procedures and keep up with current knowledge in the field.

The main condition that led to patients receiving blood transfusion at MMH was postpartum haemorrhage due to uterine atony, uterine tear, and third and fourth-degree tears. Other conditions included placental problems (placenta praevia, abruptio placenta, and retained placenta), and cervical tears at vaginal delivery. These indications have also been documented in prior research.[35,37] Uterine atony is one of the most common causes of postpartum haemorrhage and among the top five maternal mortality causes.[34,36] It is the leading direct cause of maternal mortality in South Africa according to the Saving Mothers report of the triennium of 2017 to 2019.[8] In this study, the folder review revealed that most (23 out of 45, 51%) of the mothers who presented with uterine atony were in the age range 30-44. Some of these women had also undergone more than four deliveries, a factor which is well known to increase the risk of uterine atony and hence PPH, i.e. multiparity.[33, 34-36]

Uterine rupture, another cause of severe OH, is a serious obstetric condition associated with maternal and fetal morbidity and mortality. The early signs of uterine rupture are often nonspecific, making early detection and diagnosis difficult; hence clinicians should havea low threshold for recognising this condition in patients with risk factors, for example, previous C/sections and patients undergoing induction of labour. Usually, from the time of diagnosis to delivery, only 10-30 minutes are available before clinically significantfetal morbidity becomes inevitable.[81] Treatment of uterine rupture is immediate laparotomy with caesarean delivery and, if necessary, a hysterectomy.

Perineal tears (third- and fourth-degree tears) were the second most common cause of PPH. These can occur when the vagina is not stretching enough to accommodate the baby's head or due to episiotomy. Episiotomy, however, should not be performed routinely except under certain conditions, such as fetal distress in the second stage of labour, previous third-degree tears etc.[41,57] Although these conditions can be managed through surgery, the genital trauma they cause can lead to excessive bleeding requiring emergency blood transfusion and subsequent anal incontinence and sexual dysfunction if not adequately repaired.[42]

In this study, the following placental problems were associated with OH, retained placenta, placenta praevia and abruptio placenta, of which the former was more common. Factors that increase the need for transfusion in placenta praevia include antepartum haemorrhage, which may lower the haematocrit.[82] All patients with major placenta praevia require delivery by caesarean section, which in itself is a risk factor for PPH. When the placenta is attached to the lower part of the uterus, it may 'provoke increased and uncontrollable intra-operative haemorrhage necessitating blood transfusion'. Using the Saving Mothers report, Gebhardt et al. (2015) note that in South Africa, some deaths which were classified as uterine atony, abruptio placentae and placenta praevia were actually due to severe bleeding at C-section, hence the need for training in good surgical skills and the need for senior-level staff to perform difficult C/Sections.[41]

For 14% (17 out of 118) of the women whose folders were reviewed, the risk factor for transfusion was classified as anaemia, with the cause of anaemia not indicated. Eight of the transfusions were performed antenatally and nine in the postpartum (or peripartum) period. Generally, anaemia is not a standalone indication for transfusion. Postpartum anaemia can result either from PPH or from normal blood loss occurring in a patient with chronic anaemia at the onset of labour. In some cases, blood loss at delivery is underestimated, and the patient is subsequently found to be anaemia during routine postnatal examination.

PPH can be prevented, and prevention should begin early in the pregnancy for high-risk women. The NCCEMD also provides guidelines on steps that should be followed for c- section and vaginal deliveries as well as management of conditions that predispose women to PPH (Figures 2.4 and 2.5, Chapter 2).[44] These guidelines are devised from international guidelines such as the RCOG, the World Health Organisation, and the Saving Mothers Report.
[8,41, 83, 84, 85]

Prevention includes optimising patient haemoglobin before pregnancy or early in pregnancy, preventing anaemia by giving iron supplementation, and optimising nutrition during the antenatal period and before pregnancy, hence the need for pre-pregnancy counselling. Women with optimal haemoglobin levels are more likely to have a high blood loss tolerance relative to anaemic ones. There is also a need for the early recognition of high-risk patients, for example, those with anaemia, placenta praevia/ accreta, multiparous patients, patients with previous multiple caesarean sections or other previous abdomio- pelvic surgery that increase the risk

of PPH during caesarean section due to abdominal and pelvic adhesions that may complicate surgery. [58, 82]

While some of the risk factors for PPH are known before delivery, PPH also occurs in women with no known risk factors. Therefore, physicians must be on the lookout for possible cases of PPH at every delivery. Available guidelines recommend the active management of the third stage of labour as the most effective strategy for preventing PPH. [44] There is a need for meticulous management of pregnant patients, coupled with timeous diagnosis or identification of risk factors for PPH. Reappraising the patient's vital signs and vaginal flow before leaving the delivery area may also aid in identifying slow, steady bleeding.

To prevent PPH at vaginal delivery, Oxytocin 10 U IM should be given to help the uterus contract, followed by controlled cord traction. The physician should also look for possible risks for bleeding, such as the atonic uterus, lacerations and uterine inversion. In the case of lacerations, rectal examinations should also be conducted to check for anal sphincter and anorectal mucosal injury. In the event of PPH, the physician should rub the uterus and expel clots as recommended in the NCCEMD post-NVD algorithm.[44]

In the case of a C-section, excessive bleeding and resultant complications can be prevented by having senior surgeons in attendance or transferring to specialist care pre-operatively if severe bleeding is anticipated, e.g. placenta praevia or multiple previous abdominopelvic operations. Physicians should be well trained in the medical, mechanical and surgical methods available for the optimal and timeous control of PPH. Medical methods include the use of uterotonics such as oxytocin, syntometrine, ergometrine, and misoprostol, as well as the use of tranexamic acid, which has been shown to be most effective when used within the first hour of haemorrhage, as per the WOMAN TRIAL.[86] Further, mechanical methods such as manual compression and balloon tamponade can be used where indicated, and failing that, surgical methods such as compression sutures, systemic devascularisation and hysterectomy can also be used to control bleeding. Interventional techniques aiming at embolising the uterine arteries can be employed where expertise and facilities are available. [44,83]

The SANBC has also suggested guidelines for massive bleeding. Their protocol includes, among other things, a transfusion package, early detection and repeated monitoring of

haemostasis, as well as intervention algorithms. The transfusion package includes 4 units RBCs, 4 units of FFP and one adult dose platelet is given in a 1:1 ratio for RBC and FFP after thefourth unit of RBC. However, the protocol recommends the transfusion of 2 unmatched RH-specific RBCs or 2 FDP units in emergency cases without waiting for laboratory results. This treatment can be repeated until the bleeding is under control.

From the folder review, women with cases of severe PPH received on average 2-4 units of RBC and 2 units of FFP and 1 Platelet. FDP was generally administered as 1 unit. This is despite the protocol recommending a 1:1 RBC and FFP ratio after the fourth RBC unit and2 units of FDP. This suggests that while care is taken to follow the protocol regarding situation analysis, adherence to the massive transfusion protocol regarding the number of units to transfuse is often at the discretion of the attending physician's clinical judgment. For instance, some patients might already be coagulopathic, in which case FFP or FDP might need to be administered immediately.

5.6 After Hours Orders and Blood Returned Without Use

Stokes et al. (2018) identified three broad categories of administering blood. These include laboratory inputs for typing and issuing blood, nursing inputs for transfusion, and blood wastage.[87] In addition to these costs, patients also have to incur other indirect costs such as hospital stay, doctors' fees etc., making blood transfusion a costly healthcare procedure. Physicians should be aware of this and try to minimise extra costs as much as possible. In this study, approximately 58% of the blood transfusions were administered afterhours. This can be justified in an obstetric environment due to the emergency nature of the situations that require blood transfusion. In cases where transfusion is not emergent, it is recommended that blood transfusion occur during regular working hours to reduce cost. The high volume of after-hours transfusions at MMH might be because it is a referral hospital. Therefore, the possibility of many patients being admitted as emergency cases is veryhigh. This is also worsened by the fact that the hospital has no onsite blood bank. Nonetheless,physicians should evaluate each case first to determine whether or not an after hours transfusionis indicated.

Apart from minimising costs related to after-hours transfusion, there is also a need to audit cancelled blood products. Cancelled blood products result from situations where blood has been cross-matched and ordered but is then returned to the blood bank unused. A clinical scenario where this may happen would be the case of a patient with a placenta previa that requires delivery. As massive obstetric haemorrhage is anticipated, blood should always be available in the theatre for these cases. Should the surgery be uneventful, the blood would be returned to the blood bank unused. The same applies to a patient who presents in Labour Ward with an active antepartum haemorrhage requiring emergency delivery. Blood would be ordered timeously, but should control of the haemorrhage be obtained, the blood would not be required. In both of these situations, the timeous ordering of blood can be lifesaving, and the additional cost of sometimes returning the blood to the blood bank can be justified. At other times, however, blood is ordered based on a fingerpick Hb, and when the venous Hb is taken, the patient's Hb is found to be higher than anticipated.[88] In such cases, the blood is returned to the blood bank. Where clinical situations allow, blood should only be ordered based on formal laboratory haemoglobin levels. When blood needs to be returned to the blood bank, the blood should be retained in a container at a temperature of 1 °C to 10 °C and returned within 24 hours of issue.[74] In this study, approximately 8% of the blood ordered by theclinicians was returned to the blood bank without use. Of this, the Labour Ward accounted for almost half (47%) of the blood returned without use, followed by the blood returned from the unlabeled clinical areas (21%). Given that most emergencies would be admitted to MMH via the Labour Ward, these cancelled products would be appropriate. The NVD postnatal ward had the least returned blood, accounting for only 1%. This is commendable, as it suggests that very little blood was ordered based on finger rick Hb alone.

Several study reports indicated blood product over-ordering practices range from only 5% to 40%. [89] Similarly, statistics from other developing countries reveal that 40% to 70% of transfused patients showed gross over-ordering. Other estimates from South Africa indicate up to 10% of annual blood wastage due to over-ordering. The blood utilisation rate in India was 28%, while in Nigeria, it was 43.6%, and 69.7%, respectively [89-934].

5.7 Limitations of the Study

There are some limitations associated with an audit study that uses secondary data. First, the study is limited to data collected for different purposes and not for the current study. This might affect the data quality since the researcher had no control over the data collection process or documentation. For instance, the data quality could be limited by inadequate documentation at the time of transfusion. The data quality issues observed in this study include accuracy, completeness, and data consistency. Data accuracy relates to error-free records; completeness deals with missing values, while consistency relates to matched values.

Some aspects of data accuracy are easy to measure, for instance, the date of transfusion, the cost of transfusion etc. However, challenges arise when data values are unknown or incorrectly captured. For example, a few transfusion cases were labelled as having been conducted in the antenatal clinic or FFP being transfused in the antenatal ward, both of which are highly unlikely. It is possible that patients were initially assessed in these units and transfused in another ward. Another example of data inaccuracy was when the clinical area for blood transfusion was labelled as 'Obstetrics' when there was no such ward at MMH. This inaccuracy was due to specimens not being labelled and hence allocated to obstetrics. This makes it impossibleto assign a large proportion of the blood orders to a clinical unit and, in turn, limits the audit process, as one cannot know whether, for instance, after-hours orders or cancelled products areappropriate.

The second data quality relating to this study is completeness. There were cases when patients' names, dates of birth or hospital reference number were not captured, making it impossible to find any additional details about these cases. In some cases, the clinical ward was labelled as N/A or just left blank. These cases were combined with those labelled 'Obstetrics' in the analysis.

Another issue that indirectly impacts the data used in this study is that clinical data at MMH is siloed. For instance, data on FDP utilisation is only available in the Pharmacy records, while data on other blood transfusions came from the data on blood transfusions from the blood bank. For this analysis, only the pooled (summary) FDP utilisation statistics were available, which were not disaggregated by clinical area or patient ID. Additionally, data on total deliveries is

managed by a different department. This presents challenges for a researcher related to data access.

A second limitation is that the study was conducted in one secondary hospital in South Africa. This could affect how the findings can be generalised to other regions, given that South Africa is not a homogenous country in terms of socio-economic status, which is reflected in every aspectof life, including health care. There is a need for future studies investigating blood transfusionpractices to include hospitals in the entire province so as to gain a better and more reliable understanding of the transfusion practices. Lastly, the folder review was conducted for two months of the year. This information might not be representative of blood transfusion practices across the entire year.

5.8 Recommendations and Conclusions of the study

OH is a common obstetric emergency that can develop rapidly and unexpectedly. Overall, this study's results suggest that approximately 8% of women who delivered babies received blood products during the study period. Although this rate is higher than in most developed countries, it is comparable to or lower than most LMICs, which reflects good clinical practice at MMH with early detection of at-risk women and prophylactic measures instituted in time to prevent excessive blood transfusion and also good clinical blood transfusion practice at MMH.

Nonetheless, blood loss is often imprecisely estimated during the antepartum and immediate postpartum periods. The possibility of OH underestimation at MMH can also not be ignored. Hence, while a low incidence rate is desirable, it could also mean that OH is being under-recognised. More studies that focus on quantifying blood loss are needed to determine the extent of OH at MMH.

Several measures can be implemented at MMH to minimise blood product wastage. For instance, there is a need to optimise the use of existing guidelines and protocols. The integration of protocols remains central to the effective management of PPH and improving the quality of care at MMH. For instance, guidelines on pre-transfusion anaemia can be enhanced to ensure that appropriate criteria for transfusion are followed. Additionally, it is important that regular

retrospective audits on the use of blood and blood products, as is the case with this study, be undertaken – especially regarding after hours orders and cancelled products. As with any other life-saving protocol, there is a need for periodic review and practice drills of these protocols.

It is also recommended that MMH establish a transfusion committee that will compare transfusion data against transfusion benchmarks. For instance, there is a need to put in measures to ensure that all physicians do not deviate from established guidelines without sound clinical reasoning, and where this is done, the rationale behind the clinical judgement must be established. Such a committee will ensure continuous and evidence-based quality improvement in blood management.

The fact that a significant proportion of women who received blood products (in the folder review) were diagnosed with anaemia, also points to the need for early detection of and treatment of antepartum anaemia. Antenatal care should be strengthened to identify and manage antepartum anaemia, thereby reducing the need for blood transfusions. Other ways of treating postpartum anaemia include using more parenteral iron, which is often recommended when patients are unresponsive to oral therapy. Several parenteral iron products, such as iron dextran, ferric gluconate and iron sucrose, are available. This therapy is currently being promoted at MMH not only to minimise blood product usage but also because of its many advantages over actual blood transfusion.

This study also raises the need to keep accurate patient records for patient management and circulation of information amongst the different teams involved in the patient's treatment or care. In addition to algorithms that help with situational analysis and decision-making, training on other social competencies, such as teamwork and leadership, is needed. Although all health care practitioners should practise these competencies, they are not necessarilyinnate to all physicians and require constant training. In the case of PPH, the team players atMMH will include the blood bank that provides blood products, the drivers, the porters, the Pharmacy for FDP, the nurses who monitor patients' vital signs, and the physicians.

This study revealed an increase in the cost of care for women who have OH and anaemia requiring transfusion compared to those without. This is worsened by the fact that many of the OH cases are handled after hours since MMH is a referral hospital, probably since most of these cases are usually obstetric emergencies.

Finally, MMH could consider investing in data management software to improve patient care. This might take the form of a unified and integrated system for capturing, managing data quality and data storage. Such a system will help prevent some of the disparate inconsistencies found in this study, such as data on clinical areas and pull together currently siloed data. For example, FDP data is only found in the Pharmacy data and not in the database on blood transfusions. However, an integrated data management software system will not solve all the data quality issues. The quality of the original source of data is also key. Issues such as consistent terms/ wording and follow-up on incomplete specimen forms need to be optimised.

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Appendices

Appendix A

Patient ID	D.O.B	Delivery mode	Gravidas	Parity	Timing	Emergency Blood	Indication	Pre-Transfusion Hb	Post transfusion Hb	Symptomatic	Tachycardic PR > 100	Active Vaginal Bleeding	Seniority of Dr Ordering T/F	Reaction	Number of units t/f	Blood loss	Baby wgt