INVESTIGATION OF RISK FACTORS FOR SEVERE MATERNAL MORBIDITY AND PROGRESSION TO MORTALITY

A CASE CONTROL AND FOLLOW UP STUDY IN MULAGO HOSPITAL COMPLEX UGANDA

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ABSTRACT

Maternal morbidity is physical ill health related to pregnancy and childbirth or any maternal complication during pregnancy, labour and puerperium. Severe maternal morbidity is a life-threatening obstetric complication. The importance of severe maternal morbidity is that it precedes maternal mortality and is therefore critical in the understanding of the factors that influence maternal mortality.

The overall aim of the study was to investigate risk factors associated with severe maternal morbidity and progression to maternal mortality in Mulago hospital, Kampala, Uganda. The study had two stages: Stage 1 was an unmatched case-control study of severe maternal morbidity and Stage 2 was a follow-up of all cases from Stage 1 to discharge or death.

A total of 499 cases of severe maternal morbidity and 500 controls (women with normal deliveries and no severe maternal morbidity) were studied. Both the cases and controls were interviewed to obtain information on socio demographic factors, previous obstetric outcomes and present obstetric performance. Information on obstetric management was extracted from clinical notes. All cases and controls were tested for HIV, syphilis and haemoglobin level. A total of 39 of the 499 severe maternal morbidity cases died.

The causes of SMM were severe pre eclampsia (25%), severe dystocia (31%) Post partum haemorrhage (19%), ante partum haemorrhage (14%) puerperal sepsis (5%) and medical diseases (6%). The main risk factors for severe maternal morbidity were low socio economic class, long distance from home to Mulago hospital, having specific medical conditions, having to request permission to attend health unit, having a long interval since the last birth, HIV positive status and poor quality of care during antenatal and delivery. Further details, plus separate analyses of specific causes of SMM (eclampsia, post partum haemorrhage, severe dystocia and ante partum haemorrhage) are presented. Determinants of progression to maternal death included low socio economic class, factors associated with management of labour, and HIV/AIDS.

The main conclusion from this work is that improvements in the social and economic status of women, the level of HIV in the community, and the quality of care offered

during pregnancy will reduce the burden of severe maternal morbidity and mortality in Kampala, Uganda. It is likely that these results can be generalised to other areas of sub-Saharan Africa and usefully integrated into Safe-Motherhood Programs there.

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CHAPTER ONE: INTRODUCTION, RATIONALE, AND OBJECTIVES OF THE STUDY

1.1 SEVERE MATERNAL MORBIDITY

Maternal morbidity is defined by the World Health Organization (WHO) as ill health in a woman who has been pregnant (regardless of the site or duration of pregnancy) from any cause related to or aggravated by the pregnancy or its management, but not from accidental or incidental causes[1]. Such morbidity may occur any time and continue beyond reproductive years. The term severe maternal morbidity (SMM) is used when the morbidity is a life threatening obstetric complication related to child bearing. Some authors have called "near-miss" morbidity in that the women only just narrowly death.

Maternal mortality has been used as a standard measure of the success of obstetric interventions. However, there are few cases in developed countries which make it difficult to formulate guidelines on small numbers. SMM has been suggested as an alternative measure. The study of SMM has the advantage that cases are more common and can be interviewed about risk factors or circumstances that occurred before the episode of SMM. This interview can offer a better understanding of the causes of maternal mortality[2-4].

Documentation of events that take place when a patient develops SMM can be used to measure the quality of care offered and in addition monitor the quality of service delivery, within an institution[5,6]. Relatively little epidemiological work has been conducted on the determinants of SMM, especially in developing countries, but factors found to predispose women to SMM are low socio economic stratus, lack of empowerment, lack of accessibility to health care facilities and past and current obstetric performance[3,4,6,7].

MATERNAL MORTALITY

Approximately 529,000 women die as result of childbirth each year worldwide [8,9]. Over 90% of these deaths occur in Africa and Asia and the majority are preventable[8,9].

The different levels of maternal mortality between developing and developed countries have been attributed to differences in the accessibility and type of care offered to

parturient mothers. While it is true that accessibility to health care is a problem in developing countries, the care offered in health units once the patient is there may not be optimal[10]. That is why WHO has been designing appropriate technologies for developing countries to use in order to prevent the rising numbers of maternal deaths[10]. Quality of care factors play a big role in the progression of SMM to maternal mortality[5,6,11]. The type of care offered in hospitals, especially intensive medical care, is very important in saving a woman's life and there by reducing on maternal mortality.

1.2 THE UGANDAN SITUATION

1.2.1 Severe Maternal Morbidity and Maternal Mortality in Uganda

Uganda is one of the countries with high maternal mortality in Africa with over 10,000 deaths per year[9]. The national maternal mortality ratio (MMR) is estimated as 504 per 100,000 live births[12]. This high maternal mortality has been partly attributed to economic turmoil the country has gone through and the impact of HIV/AIDS[13-15]. Because of high maternal mortality, SMM is also expected to be high too.

The incidence and causes of maternal morbidity in Uganda have not been well documented but a small study conducted in Mulago hospital show a similar pattern of rates and causes to that found in other developing countries[16]. Results from one study of referred near-miss cases in Mulago hospital showed the main causes as: haemorrhage, severe dystocia and eclampsia[7]. Since the introduction of the safe motherhood programme in Uganda over a decade ago, there has been no significant decline in maternal mortality. This calls for more innovative measures to be put in place.

1.2.2 HIV in Uganda

HIV in Uganda was first reported in late1984 from the southern part of Uganda in the district of Masaka.[17] It started from a fish-landing site called Kasensero and the disease was thought to have come from Tanzania. The virus caused severe emaciation and hence became to be known as "slim". From this time the prevalence of the disease increased and by the early 1990's had encompassed the whole country.[17,18]

Data from HIV surveillance from sentinel antenatal sites, which are reliable and cover selected sites across the whole country, show that there is downward trend in HIV prevalence country-wide with a current average of 6%[18]. The decline in incidence has

been attributed to Uganda's openness about HIV, and encouraging change of behaviour and condom use[19]. In Uganda as a whole 33% of the deliveries are to adolescents [20] and this is the group with high HIV prevalence[17]. suggesting that the morbidity and mortality associated with HIV is likely to be large and urgently needs to be estimated.

The growing demand on health systems is being underscored by the exploding tuberculosis epidemic in most countries with HIV. TB is becoming one of the major indirect causes of maternal deaths: in Uganda it contributed 10.1% compared to that in Zambia of 25%[14,21-23].

In a study of risk factors for maternal deaths in 1995 in Mulago hospital, Kampala, HIV was estimated to contribute to 40% of the maternal deaths[14]. The contribution of HIV to maternal mortality was assumed clinically but not confirmed using serology. In a small study conducted within Mulago hospital the prevalence of HIV-positivity was found to be 52.3% among maternal deaths compared to 15.2% in those who did not die[22]. This study, however, did not in identify whether HIV contributed to death or was an incidental finding and no study has been carried out on mothers with SMM. Generally, the information of HIV and its overall contribution to SMM and mortality as a direct or indirect cause is not well established.

1.3 RATIONALE OF THE STUDY

SMM and mortality are of major public health importance in Uganda and the world in general. The majority of studies on SMM to date have dwelt more on classification and audit[2,24,25]. Relatively few studies have investigated aetiological factors, and very little has been done with respect to the identification of individual and hospital-based risk factors for SMM in Africa, especially in Uganda. Additionally, factors that put a woman with SMM at risk of death have not been examined epidemiologically. The role of HIV in SMM cases and the progression to maternal mortality is of particular interest. Results from this study will contribute to strategies aimed at reduction of maternal morbidity and mortality in Mulago hospital, Kampala, and Uganda in general. The results will hopefully be incorporated in the safe motherhood program.

1.4 AIMS AND OBJECTIVES

The overall aim of the study was to investigate the risk factors associated with maternal mortality and SMM at Mulago hospital, Kampala, Uganda. Knowledge of risk factors

will facilitate the identification and prediction of those at risk of SMM and, in turn, help prevent both SMM and mortality. The intention is to incorporate the results into the national safe motherhood programme in order to improve maternal health and reduce the burden of disease associated with maternal morbidity and mortality.

Specific objectives were:

a. To determine the risk factors for SMM in women who deliver in Mulago Hospital, Kampala.
b. To investigate the factors that put a woman with SMM at risk of death.
c. To determine the contribution of HIV infection to SMM and progression to mortality.

1.5 STRUCTURE OF THE THESIS

This thesis presents the first African study to explore the risk factors for SMM and progression to mortality in a defined geographical setting. Chapter two reviews the definitions used in the selection of SMM cases world-wide and critically reviews the epidemiological literature associated with it. Chapter three defines maternal mortality, its causes and the factors that influence progression of SMM to maternal mortality. Chapter four describes the methods used in carrying out this study. Chapter five presents the results of the study of SMM and the individual causes of SMM. Chapter six presents the results of the study of progression from SMM to death. Chapter seven discusses the results and chapter eight provides an overview, discusses the strengths and limitations of the study, and offers recommendations for the way forward.

CHAPTER TWO: REVIEW OF THE LITERATURE ON SEVERE MATERNAL MORBIDITY

2.1 INTRODUCTION

Maternal morbidity is the physical ill health of a woman during pregnancy, childbirth and the post partum period. Maternal morbidity has a broad spectrum covering minor ill health to life-threatening obstetric complications. Direct obstetric morbidity results from complications due to the pregnant state, from interventions, incorrect treatment, omissions, or from the chain of events resulting from them. Indirect morbidity results from a previously existing condition or disease, which was aggravated by physiological effects of pregnancy. Such morbidity may occur any time and continue beyond reproductive years.

The main direct causes of SMM are haemorrhage, obstructed labour and ruptured uterus, hypertension and infection. These contribute approximately 80% of the causes of SMM and mortality [9]. The indirect causes contribute 20% and the main conditions are anaemia, existing medical conditions and HIV/AIDS[9].

For a long time most countries have concentrated their efforts on the Confidential Inquiry into the causes and prevention of maternal deaths and little has been done on the inquiry of SMM. Most studies of SMM have examined self-reported morbidity, audit of cases in the hospital, or validation of self reported SMM episodes in the community. Little has been done with respect to the identification of etiological and quality of care risk factors for SMM in Africa, particularly in Uganda.

2.2 DEFINITION OF SMM

A number of terms have been used to describe complications of pregnancy for example critically ill patients, life threatening complications and SMM, the latter being used here. While the definition of maternal mortality is clear, what constitutes SMM varies by place, institution and investigator, with different definitions to suit the circumstances. Although obstetric complications are presented as an alternative to maternal mortality, maternal death is easy to measure because of its definite end point. By contrast, maternal morbidity is a measure between two extremes of good health and maternal death.

Three sets of criteria have been used in the definition of SMM:

1. *Management based*: These criteria depend on the management of the cases of severe morbidity. The management-based criteria include admission to an intensive care unit (ICU), delivery by caesarean section, hysterectomy, blood transfusion and anaesthetic accident. Admission to ICU has been used in developed countries because of the assumption that only severe cases are admitted to intensive care units[25,26]. This criterion is simple to use and it is easy to collect information. The only disadvantage is that the criteria for admission to intensive care unit may vary from country to country, depending on hospital capacity and location of the ICU[25]. The use of this criterion is limited in developing countries because ICU facilities are few and are located away from maternity units. Other management-based criteria include having caesarean section, hysterectomy, or depend on the amount of blood transfused and anaesthetic accidents or complications[2,27,28]. These are prone to problems, for example in South Africa where hypovolaemia will require at least five units of packed cells or blood but the patient may not receive it: the threshold for blood transfusion is high but volume of blood given is low. Also in countries where there is a chronic shortage of blood (like Uganda) this criterion will not work. Another disadvantage of these criteria is that they usually use laboratory investigations which can be expensive and inaccessible to a number of developing countries.

2. *Clinical signs and symptoms*: This set of criteria use clinical signs and symptoms generally built on obstetric complications, focusing on major causes of maternal mortality such as haemorrhage, sepsis and hypertension. These are easy to use and interpret. In developing countries where there are few facilities for ICU, shortage of blood and inadequate laboratory investigation capability, this criterion may be the most appropriate. The criteria depend on the consensus of the hospital or unit on the broad definition of cases of SMM. The main problem with this definition is comparison of cases across the world for example post partum haemorrhage (PPH) in a European setting has been defined as blood loss of 1500mls or more[29], or blood loss of 1000mls or more in UK[30] and in Benin as signs of shock[31]. The use of these criteria needs global standardisation by WHO for easy use and generalisability of results.

3. *Organ- or system-based*: The third set of criteria comprises an organ- or system-based definition which depends on the identification of organ or system dysfunction or failure. This definition depends on, for example, the fact that bleeding must cause vascular hypovolaemia and renal failure, or that sepsis leads to circulatory failure or respiratory failure, and eclampsia will lead to cerebro-vascular accident and brain dysfunction or renal failure, liver failure or coagulation failure[2,32]. The dysfunction of an organ or system selects a specific end point which is very good for identification. But if prompt management is given the end point may not be reached.

In general any of the above criteria can be used well in developed countries where there are facilities for management of these conditions but have big pitfalls in developing countries where many factors influence pregnancy outcome.

2.3 INCIDENCE OF SMM

WHO estimates that every year 529,000 women die from pregnancy related causes and 80-99% cases occur in developing countries[9]. In real terms 90% of these maternal deaths occur in Asia and Sub Saharan Africa [9]. WHO also estimates that for every maternal death there are 16.5 pregnancy related morbidities worldwide. This estimate was based on a small study carried out in a rural community in India in the 1980s and it may no longer be accurate[33]. Each year an estimated 20 million women suffer acute obstetric morbidity worldwide[9].

The reported incidence of SMM in UK for the years 1990-2001 was estimated to between 0.05% and 1.9% of all deliveries[2,25,30,32,34]. The differences in these reported rates have been attributed to the different definitions used for SMM, the facilities available and type of care offered in the institution. In Maryland State in USA a study carried out between 1984 and 1997 on risk factors for ICU admissions found 1,023 women having been admitted to ICU out of 822,591 deliveries, making the rate of 0.12%[35]. This figure compares well with the findings in the UK. [25,30,32]. The results from USA are more representative than the UK because it was population based and yet the UK is mainly hospital based studies. Similarly in France, a study of a French administrative region using the ICU criteria found a rate of 0.36 %[36].

In developing countries the situation is very different and estimates for the ratio of maternal morbidity to mortality have been put it at 105 morbidities per maternal death, making WHO estimates of 16.5 morbidities to one mortality appear a significant under estimate[37]. In a community study interviewing 3,600 rural and urban women in south India, an estimated 41% of pregnant women had reported at least one morbid condition and 15% had experienced severe morbidity. The commonest causes of morbidity were haemorrhage and convulsions (eclampsia) in the post partum period[38]. In South Africa, a study to test the application of clinical definitions of severe acute maternal morbidity identified 147 women with SMM and 30 maternal deaths among 13,429 deliveries, which gives an SMM rate of 5.2% and a ratio of maternal death to SMM of 1:5[2]. This SMM incidence is much higher than that reported in developed countries.

A community study of direct obstetric causes of SMM in six West African countries (Burkina Faso, Ivory Coast, Mali, Mauritania, Niger and Senegal) found the overall incidence to be 6.2% but varied from city to city with the lowest at Bamako in Mali of 3.1% and the highest in Senegal of 9.1%[39] Similar studies of incidence of SMM found an estimate of 8% of deliveries in Benin[31], 6.5% of deliveries in Niger [39]. These estimates are, however, difficult to compare directly because of differences in the methods of data collection. The West African study was a community based prospective cohort study whereas those from Benin and Niger were hospital based. Hospital based studies may not provide reliable estimates for incidence in the population. Another possible reason for differences in incidence from these studies could have been due to differences in the definitions used for "near-miss".

The major causes of SMM in these studies were haemorrhage, sepsis, dystocia and eclampsia[2,7,31,39,40]. In a Kenyan study, a cohort of 4,768 pregnant women followed for four years estimated 17.4% of the women experienced at least one morbid condition during pregnancy[41]. However, this study was a follow up of children, and morbidity of women was collected incidentally and therefore not likely to provide a very reliable estimate of maternal morbidity.

In Uganda the magnitude of morbidity is not known but a small hospital based study carried out in Mulago Hospital found the rate of morbidity for a six-month period in 1999 was 6.1% and the ratio of maternal morbidity to mortality was 8 to 1[16]. The morbidity rate in Uganda was very low compared to other African countries most likely

because some morbidity was not measured and the clinical definitions used were varied.

2.4 RISK FACTORS FOR SMM

Maternal mortality can be prevented in over 90% of cases[42]. Most of the maternal deaths occur during labour and in the immediate post partum period. The effective identification of factors that predispose a pregnant woman to complication, and preventing a complication from resulting in maternal death, is the major thrust in preventing maternal mortality[43].

The primary obstetric factors that cause SMM can occur in the antenatal period, intra and post partum and puerperium. Some of the underlying factors to these primary causes of SMM start during childhood. Maternal under-nutrition and hard physical work predispose both the mother and foetus to increased morbidity and mortality[44]. Under-nutrition leads to poor development of pelvis predisposing to dystocia and its complications, and also causes anaemia which is a predisposing factor for SMM. Hard physical work strains the woman and leads to lack of adequate rest predisposing her to eclampsia[45].

A number of studies in developed countries have looked into factors that predispose women to SMM. In a cohort study of 33,251 women in Tennessee State in USA, the risk predictors for prolonged hospital stay were infection, hypertension-related complications and haemorrhage, regardless of mode of delivery. After adjusting for cofounders the risk factors for SMM in relation to vaginal delivery was only ethnicity and not related to young age[46]. Multiparity was a risk factor for haemorrhage only[46].

In another study done in Maryland USA, risk factors associated with ICU admission were caesarean section, pregnancy-induced hypertension/eclampsia, and PPH[35]. Using multivariate analysis, risk factors for admission to ICU were age more than 35 years, black ethnicity, referral from another hospital, but not marital status[35]. Similar findings have been reported in UK[34]. In a study of ICU admissions in Royal Victoria and Jewish General Hospital in UK the frequency of admissions to ICU was 0.3 per 100 live births and the characteristics of admitted women were young age, multiparity, preterm delivery and admission post partum. The causes of their admissions were haemorrhage, hypertension, medical disease and infection[47]. However, all these studies are hospital based and care has to taken in with interpretation of results since there may

be variation in the levels of quality of care available in ICU and the selection criteria for admission to ICU.

A study of women who delivered in hospital in Gujarat, India found that a haemoglobin level below 11g/dl, lack of antenatal care, primigravidity, age more than 35, and those delivering babies with weight less than 2.5 kilograms, were associated with morbidity[48]. A low parity was associated with less morbidity[48]. In Senegal, in a study comparing maternal morbidity and mortality in two urban areas (this was part of the six country study in West Africa) the level of training and skill of health workers was proportional to level of monitoring and recording of morbidity[27]. The provision of antenatal care and management of morbidity depended on the level of training and skill of the provider.

A study done to investigate quality of care factors determining admission to ICU in a large hospital in UK, found that sub-optimal care was a cause of SMM. The quality of care problems identified were failure of the organisation, lack of knowledge by health workers, failure to appreciate clinical urgency of the complications, lack of support supervision by seniors, and failure to seek advice[5]. This study suggested that quality of care is very important in preventing SMM and mortality.

Risk factors for each individual cause of SMM are considered in the following sections.

2.5 PRE-ECLAMPSIA AND ECLAMPSIA

2.5.1 Definition

Severe pre-eclampsia is a rare but potentially life threatening condition that must be diagnosed and treated promptly. Pre-eclampsia is defined as pregnancy induced hypertension which causes a multisystem disorder, characterised by hypertension and proteinuria[49,50]. The hypertension considered sufficient to make a diagnosis of pre-eclampsia is systolic blood pressure of 140mmHg or higher and a diastolic of 90mmHg or higher, in addition to significant proteinuria of urinary excretion of 0.3g or higher in a twenty four hour urine specimen or approximately equal to 2+ on urinary dipstick[49,51]. The Magpie trial (Magnesium sulphate for prevention of eclampsia) used a multisystem disorder, hypertension and proteinuria to diagnose pre-eclampsia; while the Australasian Society for the Study of Hypertension in Pregnancy (ASSAHP) used the Magpie

definition and twenty or more weeks of gestation[49,51-53].

Table 2.1: Definition of pre-eclampsia and eclampsia used in various trials

Criteria of diagnosis	Characteristics
Pre-eclampsia (Magpie trial definition)	• Pregnancy • Multisystem disorder of pregnancy • Proteinuria
Pre-eclampsia (ASSHP)	• Hypertension after 20 weeks • Proteinuria>300mg/24hours • Renal insufficiency • Liver disease • Neurological problems • Haematological disturbances • Foetal growth restriction
Severe pre-eclampsia (Magpie trial)	• Diastolic BP >110mmhg • Systolic BP >170mmhg on two separate measurements • Proteinuria 3+ OR • Diastolic BP >100mmhg • Systolic >150 mmhg • Two or more signs /symptoms: severe headaches, epigastric pain, blurred vision, hyperreflexia.
Eclampsia (Collaborative trial)	• Occurrence of one or more convulsions with syndrome of pre-eclampsia

Magpie = Magnesium sulphate for prevention of eclampsia.

ASSHP = Australasian society of the study of hypertension in pregnancy

Source Martin Lew et al (2003)[54] Emergency Medicine 15 page 362

Pre-eclampsia can also occur before twenty weeks of pregnancy in conditions such as multiple pregnancies, hydatidiform mole, foetal triploidy, antiphospholipid syndrome, essential hypertension and renal disease[55,56]. Severe pre-eclampsia is pregnancy induced hypertension with a diastolic blood pressure of 110mmHg or more and systolic blood pressure of 160 mmHg or more on two separate measurements at least four hours apart with a proteinuria of 3+ (see table above). Eclampsia is the occurrence of one or more convulsions associated with the syndrome of pre-eclampsia [49].

2.5.2 Pathophysiology of pre-eclampsia and eclampsia

Pre-eclampsia is thought to be due to abnormal placentation which means the presence of the placenta is necessary for pre-eclampsia to occur. It also occurs in extra-uterine or abdominal pregnancy, and in pregnancies without a foetus such as hyditiforme mole, as long as there is presence of placental tissue[57]. The other cause is thought to be the failure of remodelling of the maternal spiral arteries which take place in the first and second trimester of normal pregnancy secondary to trophoblastic invasion. Failure of second wave invasion of the trophoblast leads to abnormal placental trophoblastic infiltration of the uterine spiral arteries, leading to failure of the spiral arteries to transform to dilated flaccid tubes which are supposed to be four times the original diameter of spiral vessels. The failure of the dilation of spiral vessels leads to poor perfusion of the placenta resulting in utero placental ischemia which is responsible for pre-eclampsia[54,56,58,59]. The reduced perfusion to the placenta is associated with increased sensitivity of blood vessels to any pressor agents, with endothelial damage leading to activation of the coagulation cascade resulting in maternal micro thrombi formation and loss of fluid in the intravascular compartment. In pre-eclampsia it is also thought that there is an increased production of superoxide anion which may inactivate nitric oxide leading to reduced relaxation and increased vasoconstriction. This is supported by the observation of low levels of serum antioxidant status in pre-eclampsia and eclampsia[60]. The above factors cannot be the only causes of pre-eclampsia since women who deliver growth restricted babies have reduced placental perfusion and yet not all pre eclamptic women get growth restricted foetus. Other factors which are likely to play a role in the causation of pre-eclampsia include genetic, environmental and behavioural factors which interact with reduced perfusion of placenta and endothelial activation[57,61]. The long term consequences of pre-eclampsia to the mother and baby are not well known, although there are suggestions to the effect that these mothers have increased insulin resistance, altered endothelial function and atherogenic lipid profile later in life when compared to women who had healthy pregnancies[62].

Eclampsia is characterised by convulsions, with hypertension and proteinuria during pregnancy or in post partum period. It occurs in 1 of 200 patients with pre-eclampsia and sometimes fatal if untreated[50,56]. Life threatening complications occur in up to a third of patients with eclampsia and involve multiple organs and systems[54,63]. The main complications of eclampsia are abruption placentae, HELLP syndrome (haemolysis, elevated liver enzymes, and low platelet count), coagulation failure resulting in PPH,

intra cerebral haemorrhage, cardio pulmonary failure, and renal failure. HELLP syndrome is more of an indicator of the severity of the disease than a complication and can sometimes occur without eclampsia. All these complications contribute immensely to SMM and mortality[64].

2.5.3 Incidence and risk factors for pre-eclampsia and eclampsia

Pre-eclampsia affects 2-10% of pregnant women worldwide[54,57] and eclampsia 0.03-0.05%[54]. The reported incidence of eclampsia in the Western world is between 1 in 2000 to 1 in 3000 deliveries (0.03 to 0.05%)[65]. In Africa pre-eclampsia complicates 4-20 % of pregnancies[66]. The reported incidences of eclampsia in India, Kenya and Tanzania is between 0.1-0.2 per 100 deliveries[67] and in Benin 1% [31,39], Niger 2.0% and Zaria Nigeria 2.3%[68]. Part of the explanation for these wide differences may be due to differences in the study methods and possibly the definitions used. All the African studies are hospital based and the incidence depended on the type of hospital, e.g. whether it was referral hospital, and on the selection of women who used the hospital facilities. Therefore, when comparing the incidences we have to be cautious when making conclusions because these incidences may not be a true reflection of occurrence of eclampsia at the population level in these countries.

It is estimated that worldwide 13% of maternal mortality is caused by hypertensive disorders of pregnancy[8] but this figure is much higher in developing countries where the estimates are between 22-35% in Latin America countries and 20-80% in Africa.[57,64,69] The reported incidences of eclampsia in Africa and Latin America are from the review papers which have used mainly information from hospital based studies. This explains the wide range of reported incidence but also highlights the un reliability of hospital based studies in providing the incidences of this diseases. The morbidity and mortality as result of eclampsia increases with increasing age of patients and development of hypertension at an early gestational age[70].

The disease commonly affects primigravidae and women with pre-existing hypertension, or diabetes mellitus, or those with thrombophillies such as antiphospholipid syndrome. In addition, obstetric conditions which increase placental size such as multiple pregnancy and hyditiforme moles predispose to pre-eclampsia probably through the relative decrease in placental blood flow[58].

A number of risk factors for pre-eclampsia have been reported but epidemiological

studies using multivariate analysis have reported age of more than 34 years, obesity in pregnancy, body mass index of more than 24.2kg/m^2, primiparity and urinary tract infection as the main independent risk factors[69,71]. In other studies age below 19 years has been reported as a risk factor for pre-eclampsia but this may be confounded by nulliparity because the two factors are highly correlated[64,69,70].

Paternity change in multiparous women has been found to be associated with pre-eclampsia and women getting pregnant with new partners behave like nulliparous women[72-75]. Another factor associated with pre-eclampsia and eclampsia is a long birth interval of more than four years since the previous birth. The reason for is not well known but may be related to paternity change[76].

In Mexico, low socio economic status of women, primiparity and high pregnancy weight doubled the risk of pre-eclampsia and eclampsia[77]. In Africa low socio economic class and lack of antenatal care attendance have been reported to be risk factor for eclampsia.

A study in Australia found that working women had a higher risk of developing pre-eclampsia and eclampsia compared to non working women[78]. This may be related to the work stress but no study has yet demonstrated a relationship between specific types of job and eclampsia. This finding may be also associated with older primiparity. Cigarettes smoking has been shown to be associated with 30-40% decrease in the risk of pre-eclampsia but this benefit is cancelled by the negative effect of smoking on foetal growth and placental abruption[79]. Studies on risk factors for eclampsia carried out in the USA and UK have shown a higher prevalence of eclampsia among black women compared to white women and mortality was also higher in the black group[70,80,81]. The reason for this was not clear but may be related to social exclusion of black women and their unsatisfactory health seeking behaviour.

A case control study carried out in Herman hospital in Texas USA reported older age (but not young age) and primigravidity were the major risk factors for eclampsia after controlling for antenatal care[82]. The major flaw of this study was the small sample size due to the rarity of eclampsia in Texas, and possible information bias due the method of data extraction from medical records. Another study in USA using data from the Centre for Disease Control, reported that the predictors for eclampsia mortality were age above 35 and black ethnicity[70].

Another study of women in Bethesda in USA, using data from the collaborative perinatal project, found a high risk of recurrence among women who had hypertension in their first pregnancy[83]. The problem with this study was that it investigated women in their first and second pregnancies only so the results cannot be generalised to higher parity groups. However similar findings have been reported else where[84,85]. In Singapore a study to assess the incidence and epidemiological factors for eclampsia found headache as a predictor for eclampsia, along with age below 25 and above 34 and Indian ethnicity[86]. The use of headache as a predictor is, however, subjective and unlikely to be reliable in clinical practice.

Two studies have reported nausea and vomiting, epigastric pain, elevated liver enzymes, serum uric acid above 7.8mg/dl and urine protein of 4+ by dip stick as predictors of eclampsia[87,88]. However other studies have shown that use of serum uric acid levels are not a good predictor for eclampsia[79,89]. A urine protein of 2+ can be used to screen women with borderline pre-eclampsia and confirm the diagnosis of pre-eclampsia although the test has a high degree of false negatives[79]. The platelet life span is much shorter in pre-eclampsia, especially when complicated with intra uterine growth retardation. But the distribution of platelets in pre-eclamptic and normotensive women overlap so much that the counts may not be a good predictor for early detection of pre-eclampsia in low risk women[79].

The modern use of uterine artery Doppler as a screening test for pre-eclampsia has shown encouraging results for the obstetrician and patients in that an abnormal Doppler result increases the likelihood of pre-eclampsia diagnosis by six times[79]. This test is specific but the major draw back is expense and is not used routinely for screening[79]. The problem with laboratory based investigations is that there is no single test which can be used to predict pre-eclampsia. Most of these laboratory tests cannot be used in Africa because of lack of the capacity to carry out these investigations. The simple urine test for protein is used because it is cheap, but it is not very accurate due to many false positives and only diagnoses an established pre-eclampsia.

2.6 POST PARTUM HAEMORRHAGE

2.6.1 Definition

Post-partum haemorrhage (PPH) is the main cause of maternal death world wide, especially in developing countries[90-92]. This complication remains the most challenging in obstetric practice. Prevention and early detection or recognition with prompt management is key to reducing morbidity and mortality due to PPH[90,91,93]. PPH is described as primary when it occurs within twenty fours of delivery of the baby and secondary when it occurs after twenty fours of delivery of the baby.

The definition of post partum haemorrhage depends on the amount of blood loss (500mls or more) but clinical estimation of blood loss is inaccurate and little consideration is given to women with low haemoglobin[93,94]. The 500ml cut off point is arbitrary because the mean loss of blood in a vaginal delivery and caesarean section is 500 ml and 1000 ml respectively[95]. An alternative definition is a change of 10% in the haematocrit, but this must be assessed retrospectively[91,96]. This means that you have to know the haemoglobin level before delivery and not every patient has ante partum haematocrit. This method is useful in assessing the management process of the third stage for the purpose of recommendations and research; but for practicing midwives or doctors is not helpful for clinical management.

The definition of PPH remains a subjective clinical assessment that includes any amount of blood loss that threatens a woman's heamodynamic stability. It remains subjective because some women will be compromised with a loss of relatively small amount of blood, including women with anaemia, hypertension and those with small stature.

2.6.2 Clinical features of PPH

PPH presents as excessive vaginal bleeding and the main causes are uterine atony (over 80% of cases)[97]. The other causes are retained placenta or placental fragments, tears in the genital tract including ruptured uterus and coagulation failure[91,96,98,99]. Uterine inversion although rare also causes PPH. The bleeding due to coagulation failure can be massive and complicated to manage.

2.6.3 Incidence and risk factors for PPH

PPH affects about 5-15% of women after child birth.[91,96,99]. Major PPH, or loss of more than 1000mls of blood, occurs in 5% of deliveries[97].

A number of risk factors have been reported to be associated with PPH, but epidemiological studies have reduced on the traditional risk factors. In a USA study, using a criterion of ten units of haematocrit or more, the PPH rate was found to be 2.8% in vaginal deliveries and after regression analysis only prolonged third stage of labour, pre-eclampsia, previous PPH, twin pregnancy and arrest of descent of presenting part were the predictors of PPH[96]. Stone et al analysing parturient women in UK and using a definition of 1000mls loss of blood for PPH, found a rate of 1.3% and risk factors included placenta abruptio, placenta praevia, multiple pregnancy and obesity, but not multiparity[100]. Factors associated with management were retained placenta and induced labour.

In Zimbabwe, using a criterion of loss of more than 600mls of blood, the study identified low parity, advanced maternal age and antenatal hospitalisation for anaemia as risk factors for PPH. There was a moderate correlation between poor obstetric history and PPH. Multiparity was not a risk factor[101]. In Nigeria, an incidence of 4.5% was found for PPH with risk factors of age more than 35 years and grand multiparity[102]. Multiparity is associated with fibrosis of uterine muscles which predisposes the uterus to uterine atony or failure of uterus to contract causing PPH. This phenomenon seems to be associated more with increasing age than multiparity. Another study in Nigeria found that prolonged second and third stages of labour and non use of oxytocics, were the main risk factors for PPH[103]. Although these two studies were based in similar settings - referral hospitals in Nigeria- the difference in the findings may result from the difference methodologies: the first study was a review of past cases using medical notes, where the cases were defined by visual estimation of blood loss; the second was a case-control study where cases were more accurately assessed using actual blood volume (collected blood) as well as visual estimation of blood loss using linen and swabs. Although the risk of non-use of oxytocics in third stage management has been reported, there are women who still prefer physiological management of the third stage (i.e. allows placenta to naturally separate and delivered). Retained placenta is a major cause of PPH and is associated with history of recurrence and previous caesarean section[104]. In Australia, while studying foetal macrosomia among Chinese migrants, Westerway et al found that foetal weight of more than 3.5kilogrames was associated with PPH[105]. Placenta praevia, abruptio placenta and hypertension have been also identified as risk factors

for PPH[95,106].

The quality of care a woman receives while in labour plays a role in the risk of PPH. A study in the management of PPH in UK found considerable variation in management. Problematic areas included delay in identifying cases of PPH and late involvement of senior staff in management, both of which contributed to morbidity [107]. Similarly, a survey of quality of care in three French regions found that sub standard care contributed to the risk of PPH[108]. In Africa, and Uganda in particular, neglected care leading to obstructed labour, delivery at home or with TBAs, and failures in the referral system predispose women to PPH[23]. In Nigeria there was an association found between PPH and the level of training of delivery attendants, with births attended by doctors less at risk of PPH.[102]. It has been urged that however good the health facilities are, unless women come to use them, morbidity and mortality cannot be reduced. In addition, delays by primary health staff to refer patients will increase the maternal morbidity and mortality due to PPH[104].

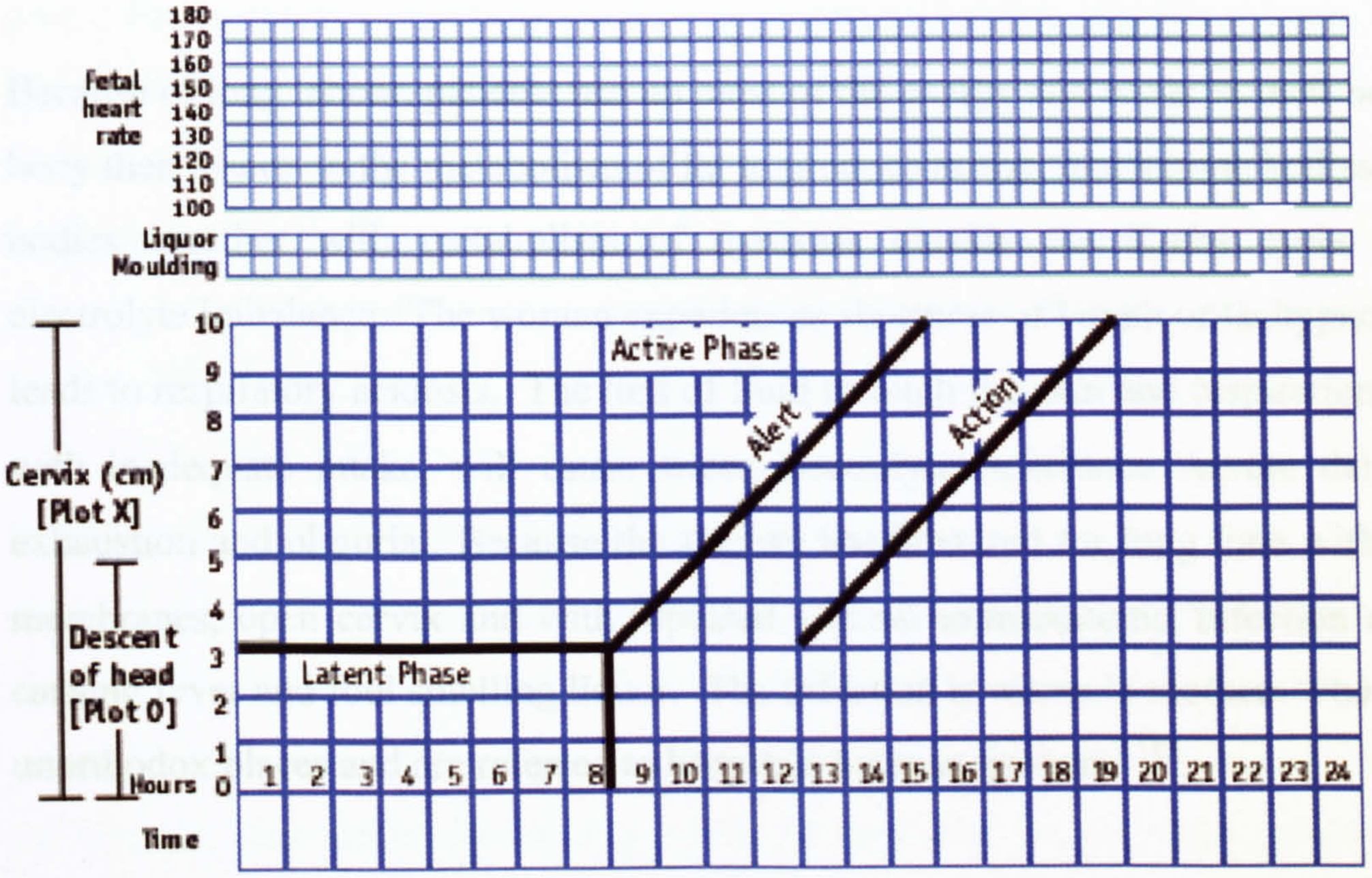
2.7 OBSTRUCTED LABOUR

2.7.1 Definition

Labour is the physiological process through which the uterus expels a foetus to the outside world. Labour is characterised by increased myometrial activity leading to regular uterine contractions, effacement and dilation of the cervix, and ultimately expulsion of the foetus.

Dystocia is used to describe difficult or abnormal labour[109]. The terms prolonged and obstructed labour is often used interchangeably in the international literature. WHO defines prolonged labour as active labour lasting more than 12 hours in spite of good uterine contractions and cervical dilation. Other authors have suggested 24 hours to include primigravidae who usually have longer labours than multigravidae[110]. The length of labour depends on the health status and parity of woman. Primigravidae and women with abnormal foetal presentation take longer time. The type of clinical management offered to a woman by the health providers can also determine the length of labour.

WHO recommends the use of a partograph in monitoring of labour[111]. The partograph was started by Philpot in Zimbabwe as a tool for monitoring labour (see diagram below).



The partograph collects information on the progression of labour which can be used to recognise abnormalities and alert staffs to take appropriate action. The partograph is designed in such way that it can be used by all cadres of staff in all types of health units. Obstructed labour is a major cause of direct obstetric morbidity in Africa and poses a big public health problem. Among mothers who survive these complications, 40% suffer long term morbidity[42,112] due to puerperal sepsis and its complications, and or vesico or recto vaginal fistula which can cause psychosocial distress and divorce.

2.7.2 Clinical features of obstructed labour

In obstructed labour, the progress of labour is impaired by mechanical barriers in the birth canal and is defined as failure of descent of the presenting part despite good uterine contractions[113,114]. The causes of obstructed labour are classified as "passage", "passenger" and "powers". Passage problems include contracted pelvis, abnormal masses in the reproductive canal such as uterine fibroids and ovarian cysts; abnormal placental presentation, cervical dystocia and tight perineum. Passenger problems include a big baby, malpresentation such as breech and brow or congenital abnormalities in the baby. The causes of obstructed labour may overlap for example in a cephalo pelvic disproportion and a big baby. Most of the causes of obstructed are diagnosed during labour except abnormalities of the foetus and contracted pelvis which

should be detectable during pregnancy. However the lack of antenatal ultrasound in developing countries means the abnormalities such as hydrocephalus, or twins, are not picked until labour.

Because of long labour, patients use up most of the energy and water in their body. The body then resorts to the metabolism of fat to produce energy and ketone bodies. Ketone bodies together with metabolism of pyruvate outside the Krebs cycle result in electrolyte imbalance. The woman experiences shortness of breath or tachypnoea which leads to respiratory acidosis. The loss of fluid through the skin and respiration, coupled with inadequate intake, will cause water electrolyte imbalance, severe dehydration, exhaustion and oliguria. Because the woman has laboured for long time with ruptured membranes, open cervix and with repeated vaginal examinations, infection can set in causing fever and foul smelling liquor. The infection is worse in mothers who labour in unorthodox places and are referred to hospitals for management[7,115].

The water and electrolyte imbalance in the mother can cause foetal distress. The strong uterine contractions reduce the oxygen supply to the foetus because of diminished intervals between contractions, resulting in foetal hypoxia. Similarly, uterine contractions compress the foetal head onto the pubic bones leading to grade three moulding of scalp bones with a risk of compression of the brain which can lead to cerebral damage and later death. The surviving baby may suffer cerebral palsy.

The strong uterine contractions force the foetus onto the obstruction, causing the upper segment to pull on the lower segment of uterus which can result in a "bandl's ring" or a band of muscle between the lower segment and upper segment. In primigravidae the over stretching will cause the uterus to have gradual decrease in strength and frequency of uterine contractions (hypotonia), but in multigravidae the contractions tend to continue until the lower segment thins and rupture may result. Strong uterine contractions force the presenting part of the foetus to apply pressure on the urethra and bladder against the pelvic bones which can result in urinary retention and full bladder. Further pressure on bladder can lead to obstruction of the blood supply to the bladder which may cause necrosis, and later desloughing, leading to vesico vaginal fistula. Similarly, pressure on the rectum can lead to recto vaginal fistula and pressure on the sacral plexus may lead to paralysis of the sciatic nerve resulting in foot drop or other neurological problems.

Mothers who survive severe obstructed labour may also suffer from long term morbidities such as pelvic infection, infertility, ectopic pregnancy and chronic pelvic pain. The formation of fistula leads to total loss of bladder or bowel control or both. This has both physical and social problems in that the woman becomes socially excluded in the community. These fistulas do not heal by themselves and require surgical treatment. Expertise in this treatment in Africa is limited, which increases the misery of these patients because the community considers this an incurable condition[68,116].

2.7.3 Incidence and risk factors for obstructed labour

Prolonged labour, or obstructed labour, accounts for 8% of maternal deaths world-wide[117]. In Nigeria it contributes 0.4-7.0%[118]. It is responsible for most of the primary caesarean sections carried out both in developing and developed countries. In Uganda, like other developing countries, because of the high proportion of adolescent pregnancy and under nutrition this condition is not uncommon[20,119]. In Uganda obstructed labour occurs in about 15 % of deliveries in Mulago hospital[23] Dystocia was found to contribute 2.0% of cases of SMM in Zaria Nigeria[68], 4.5% in Benin[31] and 0.1 in Niger[40,120]. Obstructed labour is complicated by uterine rupture and puerperal sepsis which are, in turn, associated with SMM and mortality[119,121,122]. The complications can be prevented through a combination of adequate antenatal care, monitoring of labour using a partograph, availability of emergency obstetric care and an efficient referral system[122].

One major predictor for obstructed labour is the height of the woman. Generally a height of 150cm or less is a risk factor for obstructed labour and such women need special attention during antenatal and labour. The critical height of 150cm needs to be tailored to individual communities because a number of studies have reported different cut off points[123,124]. The "old tale" of our midwives that a short woman and small size shoe is a predictor of operative delivery was confirmed by Kennedy et al that women with smaller feet tended to have more operative deliveries and the operative deliveries decreased with the increasing size of the foot[125,126]. These criteria may be inappropriate to use in developed countries but appropriate for use in developing countries where resources are scarce.

The other predictor which has been used in antenatal clinics is the clinical assessment of the pelvis at 36 weeks of pregnancy in primigravidae. This requires the women to attend an antenatal clinic that gloves are available for the pelvic assessment, and that staff have clinical experience in assessing the pelvis. The drawback of this is the large patients to midwife (or doctor) ratio and also the lack of gloves and staff commitment carry the examination. The other drawback is that a number of women attending antenatal will not accept pelvic assessment because it is invasive, and also some who accept the examination when are told about delivery by caesarean section may not come for it. However, it is thought that in low resourced countries the use of anthropometric measurements and pelvic assessment will screen the majority of the women likely to have obstructed labour[68,127].

In developed countries obstructed labour is almost non existent because of good social services and excellent medical care, but in developing countries it is still a major problem because of poor social infrastructure and poor medical services. In Uganda the general belief that every woman should deliver vaginally has contributed to the low use of maternal health services[128]. Such beliefs contribute to the delay of women to seek medical attention, as alluded to in the three delays contributing to maternal mortality[129]. Womens' attitude towards attending antenatal clinic in developing countries is influenced by socio-cultural factors which oppose orthodox antenatal care and hospital deliveries. This attitude has been shown to play a major role among the Hausa and Fulani communities in Nigeria[116]. The low educational status of the women helps enhance these attitudes and maternal deaths due to obstructed labour were high in this group[116].

Management of labour in health units should be make use of a partograph but few units in developing countries use this tool, despite its availability. In a study carried out in the Dominican Republic looking at quality of care in health units, a partograph was being used in only 40% of its units[130]. The Uganda demographic health survey found incredibly low use of partograph of less than 5% [12]. The low use has been attributed to low morale of staff, large number of patients and sometimes lack of the graph paper and knowledge[130]. This indicates that detection of poor progress of labour is later than it need be and referrals are thus delayed. Also when patients arrive at the referral centre there are further delays to initiate appropriate treatment. This is due to delay of staff response, or lack of staff, shortage of essential drugs and expendables, shortage of blood

and busy theatres. These delays have been reported in Dominican Republic[130]. It has been suggested that the waiting time from diagnosis to operative emergency delivery should be less than 30 minutes[131,132]. Even in developed countries few centres have managed to achieve this standard and some centres have extended it to 45-60 minutes[131,132]. The delay for operative delivery is much longer in developing countries which make obstructed labour more severe, increasing both maternal and perinatal morbidity and mortality.

2.8 RUPTURED UTERUS

2.8 1 Definition

Ruptured uterus (a torn uterus) is the most devastating complication of obstructed labour to both the mother and the foetus[133,134]. When the obstruction is not relieved in time, it will end in a ruptured uterus. In primigravidae the uterus will usually stop contracting and will not rupture, although some primigravidae have ruptured their uterus[135]. Uterine rupture can be spontaneous (when there is no predisposing factor), traumatic (as a result of oxytocic induction of labour, internal podalic version, or rupture of scarred uterus following previous caesarean section or myomectomy)[136]. Some authors have reported spontaneous rupture as the most common[137,138] but others have reported rupture of scarred uterus as the most common[139]. The debate about the relative contribution of spontaneous and scar-induced rupture of the uterus has been ongoing for some time, and there is still no clear-cut answer as to which is the most common type of ruptured uterus. However with increasing caesarean section rates in developing countries and sub optimal maternity care, rupture due to scarred uterus will be prominent [140].

2.8.2 Clinical features of ruptured uterus

Rupture of the uterus in a typical obstructed labour is due to excessive contraction of the upper uterine muscles resulting in stretching and thinning of the lower segment muscles. As the contraction of the uterine muscles continues to force the foetus through the obstruction, it exerts pressure on the thin lower uterine segment resulting in rupture. A previous caesarean section in the lower segment acts as a point of weakness and when there is sufficient degree of obstruction the scar will give way (scar dehiscence). The rupture can occur in the anterior, posterior or antero or postero lateral part of the uterus. Uterine rupture can be recognised during labour using clinical symptoms and signs. The symptoms of rhythmic pains of contractions are replaced by continuous abdominal pain with reduced or absent foetal movements. Studies examining the foetal heart rate

pattern prior to uterine rupture have been reported as the best predictor of uterine rupture. The foetal heart undergoes prolonged deceleration to less than 90 beats per minute that exceeds 1 minute without return to baseline. Prolonged deceleration alone or when proceeded by severe or variable deceleration of foetal heart was diagnostic of uterine rupture in over 70% of cases. This deceleration may be followed by terminal bradycardia and foetal death[141]. This method is very reliable and practical in situations where there is continuous foetal monitoring during labour. However such monitoring is very rare in developing countries where the majority of ruptured uterus occur.

2.8.3 Incidence and risk factors of ruptured uterus

The incidence of ruptured uterus varies from country to country and is more common where maternal health is poor[136,142-144]. The incidence varies from 1 in 157 deliveries to 1 in 865 deliveries[145-148]. Other studies have reported a lower incidence in developing countries of around 1 in 1000 (0.1%) deliveries or less with the majority occurring in women with a previous scar[149].

The predisposing factors for ruptured uterus are maternal, including prolonged labour due to contracted pelvis, cephalo pelvic disproportion, or abnormal growths in the genital tract such as fibroids and ovarian cysts or previous operations on the uterus. Foetal factors are malpresentation or malposition of the foetus, big baby and abnormalities of the foetus such as hydrocephalus and hydropis foetalis. The mode of delivery such as vacuum extraction or forceps delivery or use of fundal pressure during breech delivery can also lead to uterine rupture. Induction or augmentation of labour using oxytocics has been shown to predispose a woman to ruptured uterus[133,141]. In one study, women on oxytocics were three times more likely to develop uterine rupture compared to those who were not[133] and in another study it was four and half times more likely[141]. In a population study of uterine rupture among women who delivered under the care of an obstetrician, or a family doctor in consultation with an obstetrician, in the province of Nova Scotia in Canada, augmentation and induction of labour contributed to 43% of complete rupture of the uterus and 40% of dehiscence of trial of scar[149]. Other predictors of uterine rupture are age and parity which may be a result of uterine muscle scaring leading to weakening of uterine wall muscles and resulting in rupture during childbirth[136,150].

The risk of uterine rupture in women with a previous scar compared to women without

previous scar was 2.8 to 3.7 times as high[151]. The incidence of scar dehiscence was estimated as 0.043 % of deliveries in Dublin and 0.16% of deliveries in Washington USA[149].

With the increasing rate of caesarean sections in developing countries and inadequate accessibility of emergence obstetric care, the rates of rupture of scarred uterus may be on the rise[136,140,142]. Repeat caesarean sections in Africa will significantly increase the burden on the maternal health services available[136,152], compromising the quality of maternity care and in turn increasing maternal morbidity and mortality.

2.9 ANTEPARTUM HAEMORRHAGE

2.9.1 Definition

Ante partum haemorrhage (APH) is an obstetric condition characterised by bleeding from the genital tract that occurs during pregnancy from the time when the foetus is considered viable to delivery of the baby. The WHO now considers viability of the foetus to start from the gestational age of twenty four weeks because of better facilities for support for foetal viability. So the definition of APH has changed from bleeding from 28 weeks of gestation to delivery of baby, to bleeding from twenty four weeks[153].

The major causes of APH are placental in origin and the most common causes are abruptio placenta and placenta praevia. Other causes of bleeding are vasa praevia, local vaginal and cervical lesions and bleeding of undetermined origin. Local causes of APH contribute 5% and rarely make any significant effect on pregnancy unless it is cervical cancer [153]. APH complicates 2-5% of pregnancies worldwide[153].

In developed countries maternal mortality due to APH has decreased tremendously over the last 50 years. In the UK only four maternal deaths due to ante partum haemorrhage: (one abruptio and three placenta praevia) were reported by a relatively recent confidential inquiry[154]. In developing countries maternal mortality due to APH is still high because of prevalent anaemia, inadequate access to maternal health care, and shortage of blood. The confidential inquiry into maternal deaths in UK highlighted the issue of quality of care. Maternal morbidity and mortality due to APH is linked with inadequate resuscitation of the mother, inexperienced junior medical staff, delays in seeking assistance from experienced doctors and senior staff failing to respond quickly to calls[154].

This condition can become life threatening in a very short period and therefore needs prompt intervention. Placenta praevia can be diagnosed by routine ultrasound examination and magnetic resonance imaging which is advantageous for early treatment. But these facilities are not easily accessible in developing countries. It is therefore important that the risk factors for severe APH are investigated so that they can be used to prevent and manage these conditions, in turn reducing maternal morbidity and mortality due to APH.

2.9.2 Clinical features of placenta praevia

Placenta praevia is the implantation of the placenta entirely or in part in the lower segment of the uterus. Four grades of placenta praevia are recognised: grade one is when the placenta encroaches on the lower segment but lower edge does not reach the internal os, grade two is when the lower end of placenta reaches internal os but does not cover it, in grade three the placenta covers the internal os asymmetrically and in grade four the placenta closes internal os symmetrically[155]. Placenta praevia is now classified as minor and major. Minor placenta praevia is when the placenta does not reach the internal os and major is when the placenta touches or covers internal os. Placenta praevia presents with vaginal bleeding which is not painful after twenty four weeks gestation and before delivery of the baby[113]. The bleeding is usually mild and recurrent but sometimes can be massive and life threatening.

2.9.3 Incidence and risk factors for placenta praevia

The incidence of placenta praevia is 3-5 per 1000 pregnancies worldwide and is increasing because of rising caesarean section rate[153,155-157]. The incidence of low lying placenta is much higher at 20 weeks than at 36 weeks and above because as the upper segment enlarges and the lower segment is formed and the placenta moves with the upper segment.

The major risk factor for placenta praevia is previous caesarean section delivery and the risk increases with the increasing number of caesarean sections. The incidence has been reported as 2% after one previous caesarean section, 4.1% after two and 22% after three[155]. Similarly, patterns of increased risk have been observed with dilation and curettage, evacuation of uterus and myomectomy[154,157].

Placenta praevia is more common in older and multiparous women[154,157,158]. The reason

for this is not clear but it may be associated with ageing of the vasculature of the uterus which causes placental hypertrophy and enlargement, hence increasing the likelihood of encroaching on lower segment[158].

The spacing of children is also associated with risk of placenta praevia. In a study carried out among Norwegian women it was found that spacing of more than four years was associated with increased risk of placenta praevia. This was associated with involuntary infertility which could be linked to other factors of placenta praevia such as scarring of the uterus or poor vasculature of the uterus associated with increasing age[158]. The sex of a baby has been reported to be associated with placenta praevia, with a higher risk for male babies[158-160]. The reason for this is not known but it could be linked to maternal hormones or prematurity. Premature rupture of membranes occurs more commonly in women pregnant with male babies and placenta praevia is also more common in premature pregnancies than mature pregnancies.

Recurrence of placenta praevia has been reported and is thought to be linked to defective decidual vascularisation which is similar to the explanation for previous placenta praevia, coupled with previous delivery by caesarean section[158,159]. Placenta abruptio is also reported to be associated with placenta praevia and vice versa. In Norway a doubling of risk was found for placenta praevia among women who had had abruptio placenta and this may have been due to shared aetiology. Both abnormal placentation and smoking have been attributed to abruptio placenta and placenta praevia[159]. Poor invasion of the placenta in the lower segment is also associated with placental abruptio.

Obstetric conditions like multiple pregnancies which have large placentas usually encroach on the lower segment of uterus causing placenta praevia though one study has disputed this[156].

Management of placenta praevia depends on gestational age and the general condition of the woman. If the gestational age is 37 weeks and above immediate delivery is recommended. But if gestational age is below 37 weeks and the bleeding does not compromise the general condition of the mother, conservative management can be offered. However, if the bleeding is significant and the general condition of the woman is compromised immediate delivery is recommended.

Preventing maternal morbidity and mortality in this condition depends on how fast you intervene to manage the haemorrhage. Management of massive haemorrhage needs a well organised management protocol in maternity units. Antenatal supplement of iron and folate ensures that the woman is able to tolerate a mild to moderate blood loss. There should be enough blood to correct the loss, and doctors and anaesthetists should be available to deliver the woman when need arises. In developing countries where few women attend antenatal care, and where there is shortage of blood for transfusion and delays in operative delivery due to lack of doctors or anaesthetists, the risk of SMM and mortality due to placenta praevia is high.

2.9.4 Clinical features of abruptio placenta

Placental abruption is the premature separation of a normally sited placenta from the uterine wall before delivery. Abruptio placenta is initiated by haemorrhage into the decidua basalis from small abnormal uterine arterial blood vessels forming a small haematoma which may be self limiting or may continue to dissect through the decidual layers causing a split of the decidua. The decidual haematoma may remain within the deciduas or may also extravasate into the myometrium producing a couvelair uterus, (bleeding into uterine muscles), or cross placental membranes into the liquor. It may also dissect down toward the cervix manifesting as vaginal bleeding. The expanding haematoma may lead to compression of intervillous space resulting in reduced surface area for placental oxygenation. Reduced placental oxygenation compromises the foetal oxygenation. Foetal death will occur if 50% or more of placental surface area is reduced.

The cause of abruptio placenta is unknown but hypotheses suggest placental or vascular abnormalities. Abnormal placentation, vascular malformations and increased fragility of vessels predispose to haematoma formation, leading to abruptio placenta[154].
Haematoma formation with increased bleeding may precipitate disseminated intravascular coagulopathy (DIC). This hypercoagulable state is maintained by the release of thromboplastic materials into the circulation. The thromboplastic materials in blood circulation cause the formation of more haematoma or clots. The clot is broken down to micro thrombi, precipitating further formation of clot or thrombi. This process uses up most coagulation factors causing coagulation failure resulting in bleeding from different organs and surfaces with PPH being the most serious.

Treatment of abruptio placenta is individualised depending on evaluation of each clinical scenario. A trial of labour and a vaginal delivery is recommended as long the maternal and foetal pair can tolerate the process but there should be close monitoring. Placental abruptio which is severe enough to cause the demise of the foetus in the third trimester is an obstetrical emergency and delivery should be affected to halt onset of disseminated intravascular coagulation (DIC). DIC will occur within one or two hours of complete abruptio placenta. Serial maternal coagulation studies should be carried out and blood and its component should be given whenever necessary. The management of this condition needs specialised staff if the maternal and perinatal mortality associated with this condition is to be minimised, but in developing countries such specialised people are few.

2.9.5 Incidence and risk factors for abruptio placenta

Abruptio placenta occurs in 0.8 to1.0% of all pregnancies[161-164] and 1.2% of twin pregnancies world wide[165]. Abruptio is a major cause of third trimester haemorrhage and perinatal death. The high maternal morbidity and mortality is due to severe haemorrhage which follows this complication.

Maternal hypertension, especially pre-eclampsia and eclampsia is a major risk factor for abruptio placenta[161-163,166,167]. In patients with severe pre-eclampsia Anatha et al found a relative risk of 3.8 for placental abruptio and 2.8 for women with chronic hypertension with superimposed pre-eclampsia[161].have an increased risk of intra uterine growth retardation (IUGR) and hence higher perinatal mortality[165,166,168]. Foetuses that are small for gestational age are at risk of abruption placenta but since IUGR takes time to develop, this observation suggests that the pathology starts early in pregnancy[161]. Abruptio placenta has been found to be an independent risk factor for perinatal death[167,169]. In another study previous second trimester bleeding, vertex presentation and placenta praevia were found to be risk factors for an abruption placenta[167]. Low educational status and not cohabiting with the father of the expected infant has been reported to be associated with abruptio placenta but these findings may be confounded by factors like smoking, nutritional status and age. Maternal age and parity have been linked to abruptio placenta but recent studies have suggested increasing abruptio placenta with increasing parity only up to the age of 30. The highest link was seen in parity of 3 and age below 20 after adjusting for confounders[166]. There was also an

elevated risk in multiple pregnancies when compared to singletons[170] and the difference was attributed to placental under perfusion due to either smoking or hypertensive disorders in multiple pregnancies. The other possible reasons could be hydramnios, pre term labour and premature rupture of membranes.

Chorioamnionitis is an independent risk factor for abruptio placenta[171]. Idiopathic elevated serum alpha foeto maternal protein has been found among women with abruptio placenta[166,172]. The role of alpha feto protein in abruptio placenta is still being investigated but if the association is confirmed this may be useful in early prediction of women at risk.

2.10 PUERPERAL SEPSIS

2.10.1 Definition

Puerperal infection occurs after childbirth because the mother's genital tract has a large raw surface area which can become infected. Infection may be limited to the cavity and wall of the uterus, the fallopian tubes, or it may spread beyond to cause peritonitis and septicaemia. Serious infections are rare in normal labour provided there has been no undue interference or interventions.

2.10.2 Incidence and risk factors for puerperal sepsis

The prevalence of puerperal sepsis in developed countries is low at around 0.6 per 100,000 births but in developing countries is more than 1000 times this risk[173,174]. The reported incidence in Nigeria was 1.7% [175], Mulago 1.2% [16] and Burkina Faso 0.5%[40]. These latter incidences are from cross-sectional hospital-based studies and may not represent the true incidence of the country because the women who use national referral hospitals are likely to be different from women in the general population. It is thus difficult to compare these estimates directly. Puerperal sepsis causes up to 8% of maternal deaths and 15% of intensive care admission worldwide[8,173]. In addition, severe maternal infections such as chorioamnionitis can cause cerebral palsy in children.

Risk factors for puerperal sepsis include caesarean section, chorioamnionitis, and premature rupture of membranes, repeated vaginal examination and instrumental delivery[175-177]. However, less than 10% of women who deliver vaginally develop puerperal infection even when the pregnancy is complicated by premature rupture of membranes[174]. Caesarean section was associated with 13 fold increased risk among

asymptomatic women in developing endometritis in University of Texas [177] and trebling risk in Helsinki, Finland[176]. Other factors which have been associated with puerperal infection are extreme reproductive age, anaemia and low socio economic class and sexually transmitted infections[175,178]. Factors such as retained products of conceptus, obstructed labour, prolonged rupture of membranes and medical diseases especially HIV/AIDS are the leading predisposing factors for puerperal sepsis in developing countries[175,179,180]. In women with reduced resistance due to HIV, puerperal sepsis may progress to septicaemia and may be further complicated by septic shock and possibly death.

Puerperal infection can be complicated by peritonitis, pelvic abscess, burst abdomen and septic shock which put a woman at risk of death. To prevent death, interventions with correct antibiotics and possibly laparotomy are the life saving procedures. This should be supported by blood and pus samples taken for culture and drug sensitivity tests conducted before antibiotic therapy. The type and choice of antibiotic treatment is important in saving the woman's life and also cutting on costs of hospital stays. However, in most developing countries there are few options for antibiotic choice and some laboratory back up is uncommon, leading to women who survive severe episode of sepsis ending up with infertility, ectopic pregnancy and chronic pelvic pain.

2.11 MATERNAL MEDICAL DISEASES

Co-existing medical diseases contribute about 10% of all causes of maternal mortality worldwide and are therefore a major cause of SMM[8]. The maternal medical conditions which cause SMM and mortality include chronic anaemia, cardiac diseases, diabetes mellitus, pulmonary infections and renal diseases[113,181]. With the advent of HIV the co-existing medical conditions contribution to morbidity and mortality have accelerated due to opportunistic infections of HIV/AIDS sufferers. Tuberculosis (TB) is the main cause of morbidity and mortality as a result of HIV/AIDS. In South African states with high rates of HIV, TB has become one the leading cause of indirect cause of maternal morbidity and mortality[21,182]. Other conditions associated with HIV/AIDS are Cryptococcus and bacterial meningitis, pneumocystis carinaii and Kaposi's sarcoma.

Pulmonary oedema is the accumulation of fluid in pulmonary interstitial spaces and alveoli which prevents adequate diffusion of both oxygen and carbon dioxide. The predisposing factors are pre-eclampsia or eclampsia, use of tocolytic therapy, severe

puerperal infection or any other septicaemia condition, cardiac diseases and iatrogenic fluid overload[183]. Pulmonary oedema commonly occurs in the post partum period due to mobilization of fluids combined by 30% decrease of colloid osmotic pressure[183]. This condition is associated with risk of maternal and perinatal morbidity and mortality.

2.11.1 Maternal anaemia

WHO defines anaemia as haemoglobin of less than 11 grams per decilitre[184]. In developing countries a haemoglobin level of below 10 grams per decilitre is defined as anaemia. The physiological changes in pregnancy of increased plasma volume (by 50%) and red blood cell mass (of 18-25%) cause a haemodilution resulting in physiological anaemia. This increases the prevalence of anaemia in pregnancy[185].

The prevalence of anaemia in sub Saharan Africa is estimated to be over 50% among pregnant women[184]. The prevalence of anaemia among antenatal mothers was more than 90% in Malawi[186], 54% in Ghana[187], 80% in India[188], 48% in Uganda, (Kalisoke 1985) and 76% in Kenya[189]. Anaemia in all these countries was associated with *Plasmodium falciparum* malaria especially in primigravidae and adolescents. In addition, in Malawi anaemia was three times more common among unmarried mothers than married ones[190]. The causes of anaemia are iron deficiency (in over 90% of cases)[185-187], malaria, folic acid deficiency, sickle cell and HIV/AIDS[184]. Nutritional deficiency thus accounts for most anaemia even in malaria areas[191].

The effects of anaemia in pregnancy are low birth weight, preterm delivery, intra uterine foetal death, abortion and PPH. Maternal mortality due to anaemia ranges from 27 per 100,000 live births in India to 194 per 100,000 live births in Pakistan and is the leading indirect cause of maternal death in developing countries.[192]. This indicates that anaemia related SMM is very high. In Siaya, Kenya, Hb of 6g/dl and below compared to those with Hb 7-8g/dl found the mortality rate was over eight times higher in those of Hb six or less compared to those with Hb 7-8 g per decilitre[193]and its contribution to observed mortality was 30% with or without blood transfusion.

2.11.2 Maternal cardiac disease

The incidence of cardiac disease varies from country to country depending on the affluence of the nation and has an estimated prevalence of 0.3-3.5% in pregnant women[181]. Cardiac diseases including congestive cardiac failure due to chronic anaemia

have been the main cause of indirect maternal morbidity and mortality worldwide[180,181,192,194] but with the advent of HIV/AIDS the pattern has changed. With improved management of congenital cardiac lesions in developed countries, more cardiac patients are risking pregnancy. In developing countries the majority of cardiac cases have rheumatic heart diseases and very few have congenital heart defects or other cardiomyopathies. Physiological adaptation during pregnancy can potentially worsen the prognosis of women with cardiac disease.

The major problem with cardiac diseases in pregnancy is diagnosis of the disease condition in asymptomatic patients. This means that cardiac patients will present with complications such as congestive cardiac failure, arrhythmia or stroke. The predictors for developing unfavourable cardiac event are: previous history of cardiac failure or cyanosis, systemic ventricular dysfunction and development of hypertension[181,195]. The conditions that put a woman with cardiac disease at risk of SMM and mortality are bacterial endocarditis, pulmonary hypertension, severe anaemia and coarctation of aorta complicated by marfan's syndrome with aortic involvement[195,196].

2.11.3 Maternal diabetes mellitus

The management of diabetes mellitus in pregnancy still presents a lot of challenges to obstetricians, physician and neonatologists. It is even more challenging in developing countries where these cases are managed by medical officers with inadequate laboratory facilities. Risk factors for diabetes mellitus include maternal obesity and familial history of diabetes mellitus[197]. With use of insulin the morbidity and mortality in the mother and foetus has reduced tremendously. However, poorly controlled glucose levels will result in foeto maternal complications such as hypoglycaemia or hyperglycaemia which leads to diabetic keto acidosis. Development of conditions such as hypertension, hydramnios and foetal macrosomia complicate the management of diabetes mellitus and predispose to maternal and neonatal morbidity[197]. Hypertension and superimposed pre-eclampsia, abruptio placenta and hydramnios are complications of diabetes mellitus and these complications can predispose to PPH. Foetal macrosomia is usually associated with vaginal delivery complications, PPH; foetal trauma, hypoglycaemia and respiratory distress syndrome.

2.11.4 Other medical diseases

Other medical conditions include chronic renal diseases, infections and endocrine

conditions. Chronic renal diseases are usually silent and present in advanced stage. Chronic renal disease can cause recurrent abortion, premature delivery and hypertension. An advanced disease is also associated with reduced fertility. Maternal risk is linked to degree of renal insufficiency, which in turn associated with hypertension. Loss of protein in the urine causes nephrotic oedema. Pre-eclampsia super imposes on hypertension in 25-30% of cases, predisposing a woman to SMM and mortality. Endocrine conditions are a rare cause of SMM.

Syphilis in pregnancy causes abortion, intra uterine growth restriction, intra uterine death, premature labour and congenital syphilis[198]. Syphilis and HIV are both sexually transmitted diseases and can co exist and lead to maternal morbidity. HIV can be a symptomatic or symptomatic. Patients present with generalised lymphodenopathy, body rash and signs and symptoms of opportunistic infections. The opportunistic infections include monilia infections, chest infection especially pneumocystis carinaii, and tuberculosis. HIV in pregnancy predisposes women to infectious morbidity and mortality, and risks are greater with low CD4 cell counts[199],[200]. It has also been reported that HIV is associated with increased risk of PPH[200].

CHAPTER THREE: REVIEW OF THE LITERATURE ON PROGRESSION FROM SEVERE MATERNAL MORBIDITY TO MATERNAL MORTALITY

3.1 DEFINITION AND MAGNITUDE OF MATERNAL MORTALITY

The death of a woman during pregnancy or childbirth is a tragedy for the family and the nation. Pregnancy and childbirth kill an estimated 529,000 women each year worldwide and 98% of these deaths occur in the developing world[8]. Over 99% of these deaths are preventable.

A maternal death is defined by the World Health Organisation (WHO) as a death of a woman while pregnant or within 42 days of termination of pregnancy irrespective of the duration and site of the pregnancy, from any cause related to, or aggravated by, the pregnancy or its management but not from accidental or incidental causes[1]. A late maternal death is defined as death of a woman who has been pregnant from direct or indirect obstetric causes more than 42 days, but less than one year, after termination of pregnancy. The causes of maternal death can be considered under two main categories: direct and indirect. Direct refers to those resulting from complications of the pregnant state, labour and the puerperium, or from interventions, omissions, incorrect treatment or any chain of events resulting from any of the above. Indirect obstetric causes of death are those resulting from previous existing conditions that developed during pregnancy and were aggravated by the physiological effects of pregnancy. This classification system is useful but requires detailed medical information: for the majority of maternal deaths in developing countries such details are not available and the cause cannot easily be established. This can lead to under-reporting of maternal deaths.

Maternal mortality in developed countries has reduced to less than 20 per 100,000 live births and in the UK the maternal mortality ratio (MMR) is 12.2 per 100,000[9]. However, in developing countries the MMR is estimated to be as high as 1,000 per 100,000 live births[8,42]. The MMR for Uganda as a whole was estimated by the demographic health survey to be 504 per 100,000 in 2001[12] and for Mulago Hospital, Kampala, the figure was 729 per 100,000 in 2000[23]

The disparity between the levels of maternal mortality in developed and developing countries is attributed mainly to socio differences especially related to poverty and the status of women[42,201]. There is now increasing evidence that lack of access to optimal maternity care in obstetric emergencies is the main contributory factor to maternal mortality in developing countries[11]. This was demonstrated when analysing the differences in the reduction of maternal mortality in the UK and Sweden: Improved economic performance in UK was not associated with a rapid decline of MMR, while improved maternity care in Sweden was associated with a rapid decrease of MMR[11]. The standards of maternity care were the main determinants of reduction of maternal mortality in Sweden and later in UK[202]. Maternal mortality started reducing in the UK when the National Health Service was introduced and accessibility improved irrespective of social class. This suggests that universal access to comprehensive maternity care in the developing world could reduce maternal mortality. However in most parts of Africa, where there is only one midwife for every 15,000 deliveries, the level of obstetric care is very low and maternal mortality very high[203]. In Uganda the midwife to births ratio is estimated to be 1 to 700 per year and the doctor to population ratio is 1 to 18,700 per year[204]. With these alarming statistics the provision of comprehensive maternity care is poor and this explains the high levels of maternal mortality in Africa, and Uganda in particular.

In 1987 the Safe Motherhood initiative was started with the aim of halving maternal mortality by the year 2000 and then by 75% by the year 2015[205]. Despite all the efforts, maternal mortality has continued to rise and the current figures for sub-Saharan Africa as estimated by WHO/UNICEF is about 1,000 deaths per 100,000 live births, and Uganda specifically is 880 per 100,000[8,42]. The reason for such persistent alarming rates could be due to the quality of emergency obstetric care provided.

The majority of maternal deaths worldwide are attributed to direct obstetric causes, such as haemorrhage (24%), obstructed labour (8%), eclampsia (12%), unsafe abortion (13%), sepsis (15%), and other causes such as ectopic pregnancy, embolism and complication of anaesthesia (8%)[8]. Indirect factors explain 20% of maternal deaths worldwide and these include anaemia, malaria, heart disease and HIV/AIDS complications.

In Uganda the causes of maternal death mirror the world pattern, and two sets of data from Kampala estimate that 22% of deaths are explained by haemorrhage, 20% by sepsis, 3% by eclampsia, 15% by unsafe abortion, 35% by complication of HIV/AIDS and 5% by other causes[14,23,206]. If these estimates are representative of the country as whole, indirect causes of maternal mortality resulting from HIV/AIDS may be a very important cause of maternal mortality in Uganda.

Haemorrhage is the major cause of death and has a high case fatality rate worldwide with range of 5-15% of cases dying of the condition[94]. In the UK haemorrhage due to ante partum haemorrhage caused four maternal deaths according to the latest confidential inquiry[154,207]. In Nigeria the estimated case fatality due to haemorrhage ranges from 0.9% to 11.5%[102].

Eclampsia is a severe disease associated with high maternal and perinatal mortality. Maternal deaths are a result of cerebral haemorrhage, cardio pulmonary failure, renal and liver failure and post partum haemorrhage. The case fatality in hospitals in developing countries varies from 5 to 30%[64,208-210]. The deaths have been reduced due to the use of anticonvulsants and anti hypertensive drugs.

The proportion of maternal deaths due to obstructed labour varies from 10-30% in developing countries[13,68]. The case fatality varies from 0.4-34% in developing countries depending on whether the hospital is referral or not, and the type of care offered[117,118,211]. Ruptured uterus case fatality also varies by country with India reporting 10.5%[137], Kenya 4.2%[136], Ethiopia 11.1%[144]and Uganda 11%[146]. High mortality for cases of ruptured uterus is measure of the quality of services available in that hospital[136].

The majority of puerperal sepsis maternal deaths follow obstructed labour and its complications. The advent of HIV has increased the complications due to puerperal sepsis. Case fatalities for puerperal sepsis can be quite high especially in developing countries where there are unsafe abortions, unsafe delivery and lack of suitable antibiotic for treatment[199,212]. This was also demonstrated[96] using data from Scotland where the proportion of cases who died following puerperal sepsis was 1 in 200 compared to 1 in 300 for eclampsia, 1 in 3000 for haemorrhage and 1 in 38,000 for dystocia[213]. In Benin the case fatality for puerperal sepsis was 21%[31].

3.2 HIV/AIDS IN RELATION TO MATERNAL MORTALITY AND MORBIDITY

It was estimated that 45 million people in the world would be HIV-positive by the end of 2003, and in sub Saharan Africa that number would be 29.4 million[214]. In Uganda it is estimated that about 1.5 million people have been infected with HIV. UNAIDS estimates that this epidemic has increased the burden of disease by 15%, on top of the original burden the countries already had.

HIV/AIDS has added a cruel burden on women in sub Saharan Africa. HIV is one of the most devastating pandemics in human history as it afflicts those in their most productive years. In sub Saharan Africa, AIDS has become one of the leading causes of pregnancy related death. Studies from Malawi, South Africa and Zimbabwe show that mortality during pregnancy or within six weeks post partum may have doubled during these years of HIV/AIDS pandemic, obliterating the gains which had been made in controlling maternal mortality[215]. Studies have shown 2-5 fold increased risks of dying during pregnancy and post partum for HIV infected women compared to uninfected women[22,182,216].

AIDS related mortality in Zambia and South Africa has become one of the leading causes of maternal mortality[21,217]. Similar results have been reported in Kampala where indirect causes of maternal mortality were the leading causes of death in the 1990s[13,14]. In Mulago hospital maternal mortality rose from 95 per 100,000 live births in 1972 to 628 per 100,000 in 2001. This rise has been attributed to economic breakdown during the political unrest and turbulent years of the seventies and eighties leading to under-funding of health services, along with the rise of HIV/AIDS[13-15,218].

The increase in maternal deaths in countries affected by the HIV pandemic has led to questions whether HIV progression during pregnancy is accelerated, resulting in maternal death, or is just a reflection of the coexistence of this cause of death among women of reproductive age. HIV/AIDS can increase pregnancy related morbidity in many ways: First by suppressing immunity by depleting the CD4 cells or T helper lymphocytes which play a major role in cell mediated immunity, predisposing the woman to opportunistic infections or community infections[219]. Secondly, HIV can put a pregnant woman at a risk of infections, especially chorioamnionitis, puerperal infection

and urinary tract infections increasing her risk of death[220-222]. Another factor may be the effect of HIV on health systems affecting access to quality of obstetric care services. The burden the disease puts on reproductive health services is enormous and provision of essential care may be compromised, especially in terms of drugs that treat opportunistic infections. It is possible that HIV may be incidental during pregnancy, with pregnant or recently delivered women having the same risk of death as the HIV women who are in reproductive age.

Epidemiological studies from developed countries have up to now failed to demonstrate the progression of the HIV disease during pregnancy or the period following the pregnancy[200,223-227]. A Meta analysis which was carried out on studies of HIV progression during pregnancy from published papers found that the odds ratio for HIV progression to AIDS in all studies was 1.41 (95%CI 0.85-2.33) and in developing countries was 3.71 (95% CI 1.82-7.75). The odds ratio for death was 1.80 (95% CI 0.99-3.33)[228]. This preposition has been rejected in later studies carried out among American cohorts[223] and a French cohort. The differences between the European and developing country populations was is that most of the European women were asymptomatic compared to those in developing countries who were in advanced disease. The outcome of women during pregnancy with HIV depends on the WHO stage of HIV and the CD4 cell count. Asymptomatic women seem to have a better outcome compared to symptomatic women[22,227].

The predictors for progression of HIV during pregnancy are the degree of anaemia, age more than 35 years and lymphopenia at sero conversion[225]. The laboratory predictors were CD4 cell count below 200/microliter, anaemia, and hypoalbuminaemia[229,230]. HIV RNA values were found to be good predictors of mortality: RNA values of 5,000-50,000 and greater than 50,000 copies per ml were strong predictors of death[230]. In the European studies there were no predictors for progression of HIV during pregnancy when patients were matched for CD4 cells and age[223,227,231,232].

Mode of delivery may predispose pregnant women with HIV to maternal complications. Emergency caesarean section has been reported to be associated with increased post partum morbidity such as endometritis, wound infection and pneumonia[233]. The morbidities associated with operative delivery were more severe and sometimes fatal in

those patients with advanced AIDS disease or those with low CD4 cell counts compared to women with asymptomatic HIV[220,234].

The effect of HIV in the critically ill is not well-studied and as far as I know only one study in Ireland has examined its effect. In this study there was lower prevalence of infection in HIV positive women than non HIV positive women, and there were higher frequencies of complications in HIV negative groups as compared to the HIV positive[235]. Thus this study did not find HIV as a risk factor for severe morbidity[235]. However, this study did not report CD4 cell count and viral RNA copies in blood circulation despite the importance of these factors in the outcome of HIV critically ill obstetric patients during childbirth.

3.3 QUALITY OF CARE AND MATERNAL MORTALITY

It is known that delay in receiving care is crucial in the survival of the woman with morbidity[236,237]. Maternal mortality reduction has focused mainly on three delays:

- The delay of the woman to seek medical care.
- Delay to reach first referral facility
- Delay in actually receiving care at the health facility[129].

Accessibility of women to maternity services has been advocated by WHO. This means women in the community should be mobilised and sensitized for safe motherhood programmes. Following the sensitization, health units should offer quality care to women who attend the maternity services. The patients referred to referral hospitals should get treatment that can save them from severe morbidity and mortality. WHO has a set of clinical standards for practice in health units and hospitals, and these include management protocols for different obstetric conditions[238,239]. Each country is expected to make appropriate treatment guidelines to be used in their health institutions. Uganda has these guidelines but unfortunately these are not routinely used for a number of reasons such as shortage of staff, drugs and equipment. The process of providing treatment and monitoring of patients with SMM in particular in an environment with few or no intensive care units is likely to play an important role in the progression of SMM to maternal mortality. The delay in receiving care is critical in the survival of the women with SMM[5,10,236,240]. Quality of care factors usually identified in hospitals are delay to recognise an emergency condition, delay in starting treatment, poor judgement of the patients condition, late

involvement of the senior staff in case management, institutional deficiencies and staff attitude[217,241-243]. Institutional deficiencies have been reported to be responsible for majority of maternal deaths in Sri Lanka[242]. Similar findings have been reported in South Africa and Tanzania[217,244]. Senior staff participation in the management of emergency cases sometimes comes too late to save the patients. This has been highlighted in the confidential inquiry of maternal deaths in the UK[245] and South Africa[217] In France SMM due to PPH was at risk of death when there was no 24 hour anaesthetist and obstetrician on duty[108]. Another study investigating quality of care factors before admission to ICU in a large hospital in UK identified sub-optimal care as major cause of severe morbidity. The care problems identified were failure of organisation, lack of knowledge by health workers, failure to appreciate clinical urgency, lack of supervision and failure to seek advice[5]. This study suggests that quality-of-care issues are very important aspects of prevention of SMM and mortality.

In developing countries like Uganda, where 24 hour coverage is not strictly adhered to, shortage of staff at certain times of the day puts women at risk of death. This was highlighted in the study of maternal mortality in Kampala hospitals[246]. Shortage of staff and poor pays result in poor performance of staff and directly affects the outcome of patients, as has led to delays in attending to patients when they arrive with an emergency. This has been reported in some developing countries[130,247,248]. Management of patients during the labour period is important in detecting any warning signs for maternal morbidity. The partograph is a recommended tool for monitoring of women in labour and low prevalence of use suggests inadequate monitoring of patients. Low levels of patient monitoring have been reported to be associated with high maternal mortality[217,248].

The number of emergencies sent to a referral hospital depends on the capability of the neighbouring units in their provision of emergency obstetric care. When health units cannot offer emergency obstetric care they refer their patients to referral hospitals which can overwhelm it. It can lead to over-crowding and monitoring of patients becomes difficult because, for example, some patients are lying on the floor. This has been observed in Kenya[249] The large numbers of patients with morbidity results in many emergency cases needing emergency operative deliveries. The waiting time for operative delivery should be is less than 30 minutes[131] but a large case load often results in delay. The long waiting periods predisposes patients with morbidity to SMM and

mortality, as has been reported in Dominican Republic[130]and Sri Lanka[242]. Also, the large numbers of patients need expendables to be available both in the labour ward and the theatres, and yet these are usually in short supply. The availability of drugs is related to the numbers of patients and amount of money allocated to them. With budgetary constrains in most developing countries, there is shortage of essential drugs which are necessary for the survival of the patients. The lack of intravenous fluids and anaesthetic drugs also cause delay of operative deliveries. The shortage of drugs thus predisposes patients to SMM and mortality, as reported in East and West African countries[241,247].

The advent of HIV has led to increased wastage of blood as a proportion donated blood is found positive. The blood banks suffer from chronic shortage of blood leading to increased waiting time for operation and transfusion. It is not uncommon for surgeons to carry out operations without adequate blood supplies, putting women at further risk of maternal morbidity[241].

CHAPTER FOUR: METHODS

The Aims and Objectives of the study are presented in Chapter one.

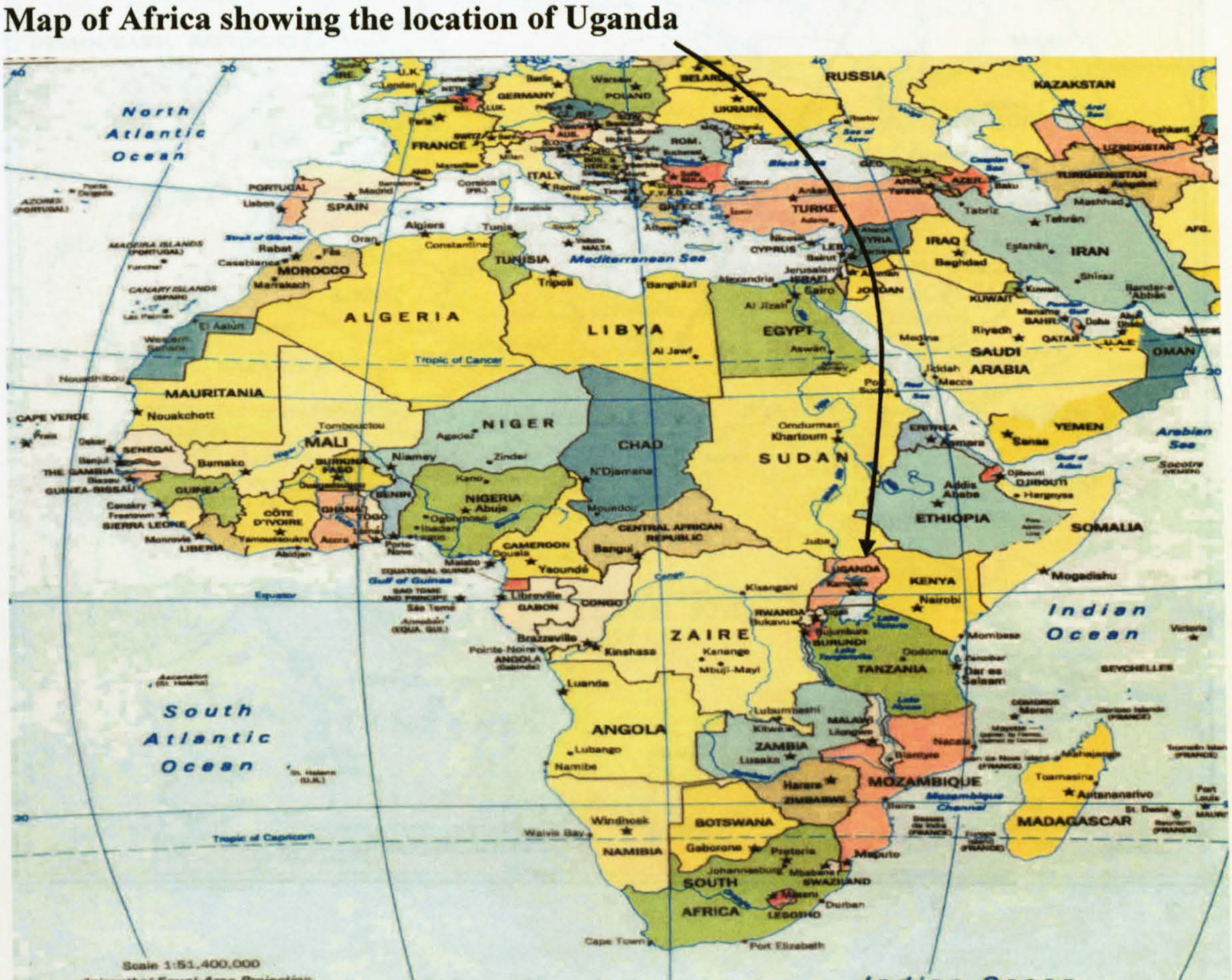
4.1 STUDY DESIGN

The study had a two-stage design. Stage 1 was a prospective unmatched case-control study for risk factors for SMM. Stage 2 was a follow-up study of cases to investigate factors that put a woman with SMM at risk of progressing to maternal mortality.

4.2 STUDY SITE

The study was carried out in Uganda. Uganda is situated in the eastern part of Africa.

Map of Africa showing the location of Uganda



It lies astride the equator with a total surface area of 241,039 square kilometres. Uganda's population was estimated at 24.6 million by the end of 2003 with 52% of this being female. The rural and urban population is 86% and 14% respectively[12]. The

annual population growth rate is 3.2%. The life expectancy at birth is 48 years in females and 45 in males[12]. The total fertility rate is 6.9 and contraceptive prevalence is estimated to be 23%[12]. Uganda is one of the poorest countries in the world with an estimated gross national product of 300 US dollars per capita per annum and only 12% is spent on health[250].

Map of Uganda showing the location of Mulago hospital complex in Kampala

The specific study site was Mulago Hospital, which is situated in the city of Kampala, Uganda. Mulago Hospital complex is a national referral and teaching hospital. It also acts as district hospital for Kampala City Council.

Kampala city has a population of about two million people[250] It covers an area of 250

square miles .Kampala City hosts the capital of Uganda. Kampala is a city of hills where you find most middle and above middle socio economic classes. The surrounding lower-lying areas are mainly populated by lower income people. This is the pattern in the whole Kampala city. It has a heterogeneous ethnicity. The majority ethnic group is Baganda contributing 63%, others are Banyankole, Bakiga, Batoro, Banyoro, Basoga, Bagisu, Iteso, Langi, Acholi and those tribes from West Nile part of Uganda[250]. The people have all levels of educational and economic status ranging from the lowest to the highest in the country. The majority of women in Kampala have middle and low level educational and economic status. About 30% of women in Kampala are involved in professional job and small scale commerce and the majority are peasant or full time house wives[250]. The 15 kilometre radius area used in this study covers the urban and peri urban areas of Kampala city and excludes rural areas.

Mulago hospital has three labour wards: one for private paying patients only, and the other two for general patients (Old Mulago labour ward handling apparently low risk deliveries and run by midwives and the New Mulago ward handling both normal and complicated deliveries). Any pregnant woman in Kampala city is able to attend Mulago hospital for antenatal care and delivery. She is able to attend for delivery even if she did not attend the hospital before birth. The maternity services in these two labour wards are free to all. However there are sometimes shortages of essential drugs and expendables experienced by the hospital. Alternative places for delivery of women living in Kampala city are three Non-Governmental (private, paying) hospitals and 15 health centres with maternity care. The health centres provide basic maternity care, with midwives only.

Most women who develop complications in and around Kampala city (15 Km radius) are referred and managed in New Mulago labour ward. These women will include those who had planned their delivery to be at Mulago as well as those who did not. Women who develop complications after twenty fours post partum are admitted to 5A Annex ward which is an emergency gynaecological ward. Mulago hospital has a twelve-bed intensive care unit, shared between the labour ward and other departments, and is situated in the department of anaesthesia. Admission to this unit is very competitive and the services are free except for renal dialysis. This means that most of severe maternal morbidity cases are managed in the labour ward. The hospital (all the three labour wards) delivered 22,927 women in 2002[23]. Over one third of deliveries

(36%) are to those age below 20 years (adolescents), and the mean parity of women delivering in Mulago is 4.6[23].

It has been estimated that 94% of all pregnant women in Uganda attend one or more antenatal visits, but only 37% deliver in hospital or health units [12]. The Kampala birth survey studied all post partum women who delivered in August and September 1999 and followed them for six weeks. The survey found that 96% of all pregnant women in the city of Kampala had attended antenatal care and 80% delivered in health units (43% in hospitals and 37% in other health units[251].

In one small study carried out in Mulago hospital in 1998 to determine the prevalence of morbidity among the women who delivered in this hospital, 6.1 per 100 deliveries and 7.9 morbidities per maternal death were recorded[16]. In 2001, 148 women died of pregnancy related complications in Mulago hospital, making a maternal mortality ratio of 628 per 100,000 live births. This ratio was lower than that for 2000 which was 729 per 100, 000 live births. Both the ratios are far higher than that of the national estimate of 504 per 100,000 live births[23,205].

The national HIV prevalence from antenatal sentinel centres throughout Uganda the sites was 6.4% in 2002 and in Mulago hospital the prevalence was at 8.2%[12,18].

4.3 ORGANISATION OF THE FIELD WORK

Before the start of field work I obtained ethical approval for the study from Mulago Hospital, the Uganda National Council of Science and Technology, and the LSHTM.

I recruited two study midwives, one laboratory technician, a pathologist, a microbiologist and one obstetrician who assisted me in data collection. I enlisted the service of one runner who transported specimens to the laboratory and collected results. These staff were trained and monitored (see pilot study 4.4 below).

Meetings of the study team were held every fortnight for the first eight weeks and then every month for the rest of the study period. These meetings were to check on progress of study and answer any queries raised.

During the study the pathologist carried out the post mortems and was attended by me or my assistant. He wrote a post mortem report which was put on file and sent back to

me for clinical note extraction.

4.4 PILOT STUDY

The pilot study was carried out between 25th October and 11th November 2001. The overall objective of the pilot was to test the study methods and logistics of data collection. Specific objectives were:

1. To test the diagnostic criteria for selecting SMM cases.
2. To translate the diagnostic criteria into operational definitions for SMM.
3. To determine whether the sample size calculated could be achieved.
4. To conduct interviews of cases and controls in order to assess the feasibility and acceptability of the questionnaire.
5. To test the feasibility of the laboratory investigations and data exchange.
6. To test the clinical record abstraction method.

4.4.1 Planning meetings

A half-day meeting was held with obstetricians and gynaecologists within the Department. I presented my draft case selection criteria for discussion. A consensus on criteria was achieved and a final document for selection of cases was drawn up. A second half-day meeting was held with all key players taking part in the study. Each person's role was defined and the day-to-day running of the study was explained including: the procedure for selecting cases and controls; carrying out interviews; taking off blood specimens; transport of specimens; examination of specimens; and record keeping. Asking for consent from patients, HIV pre- and post- test counselling, and ways of communicating with the research team was also discussed.

4.4.2 Sensitization of staff

The purpose and procedures of the study was explained to all ward staff to sensitize them to the study and to explain to them what to expect. It was explained to them that their co-operation was essential for the success of the study.

4.4.3 Selection and interview of pilot subjects

Ten cases and ten controls were recruited. I observed the selection of cases and

controls, interviews, and taking off blood. I verified the practicability of application of the selection criteria and verified their use and implementation by the assistant PI. Together we examined the cases, carried out data extraction from clinical files and followed up laboratory investigation processes. Analysis of the ten cases and controls was performed and the following corrections were made to the questionnaire: increasing some options for questions, dropping some questions because they were not relevant, and re-phrasing some questions.

Some logistic changes were made, such as recruiting a runner to deliver all specimens to the laboratory and collecting results. Blood for screening for HIV was taken to a larger clinical research centre outside the hospital because it also had facilities carry out CD4 cell counts. We also requested an assistant pathologist to be part of the team in case the senior pathologist was not available to carry a post mortems. We included the ten pilot cases in the main study database due to shortage of case numbers.

4.5 STAGE ONE: CASE CONTROL STUDY OF SEVERE MATERNAL MORBIDITY

4.5.1 Study population

The study population was women of 24 or more weeks of gestation who delivered infants at Mulago hospital or arrived in puerperium between 15th November 2001 and 30th November 2002 and who lived within a radius of 15 kilometres from the hospital.

4.5.2 Definition of cases

All cases were recruited after admission to the labour suite of New Mulago hospital and 5A Annex ward. Cases of SMM were women who developed severe obstetric complications during pregnancy from 24 weeks of gestation to end of puerperium. Gestation was ascertained by weeks of amenorrhoea, clinical examination and whenever possible by ultrasound scan.

Development of selection criteria

The selection criteria were developed in the following way. Firstly, Medline was searched using the words: severe maternal morbidity, obstetric intensive care admission, near miss, HELLP syndrome, eclampsia, obstructed labour, ruptured uterus, post partum haemorrhage, abruptio placenta, placenta praevia, puerperal sepsis and medical diseases such as anaemia, cardio pulmonary failure, coma and renal failure. Those conditions that were difficult to diagnose , such as amniotic embolism, were excluded.

Next, these published criteria were presented to a team of obstetricians and

gynaecologists from Mulago hospital. Eạch criterion was evaluated and agreed by the obstetric team. Key changes to the published criteria were the inclusion of some clinically-based and routinely measured events in Mulago hospital. The main changes were the amount of blood transfused, which was put at two units taking in consideration the shortage of blood, and two units of intravenous fluids for the same reason. For obstructed labour the presence of bandl's ring and maternal distress to dehydration was emphasized. For cardiac and lung diseases it was agreed that there must be clinical evidence of cardio pulmonary failure requiring resuscitation with oxygen.

The following text lists the criteria as developed above:

Severe pre-eclampsia

The cases for severe hypertension had the following:

- Hypertension of equal or more than 160/110 mmhg on two occasions at least four hours a part, and
- Urine protein of 2 + on dipstick.

Plus any two or more of the following:

- Epigastric pain or right upper quadrant pain or tenderness,
- Visual disturbances (flashing of light or blurring of vision),
- Severe headache,
- Oliguria defined as urinary out put of less than 100 mls during any four hour period of admission,
- Pulmonary oedema clinically diagnosed,
- An episode of jaundice diagnosed clinically.

Eclampsia

This was classified as:

- Hypertension indicated by blood pressure of equal or more than 140/90mmhg, with
- Convulsion or generalised fit during pregnancy or in first seven days post partum.

Plus any two or more the following:

- Urine protein of 2+ dipstick,

- Increased aminotransferase of more than or equal to 40 U/I,
- Serum uric acid of 6.0 mg or greater per dl.

Post partum haemorrhage

This was classified as vaginal bleeding post partum of more than 500mls with any two of the following:

- An episode of shock with a systolic blood pressure of equal to or less than 90mmhg and a pulse rate of 100/min small volume or more,
- An intravenous therapy of two or more units of blood,
- An intravenous therapy of fluids of two or more litres.

OR had one of the following emergency operations:

- Evacuation of the uterus,
- Manual removal of the placenta,
- Cervical repair,
- Laparotomy for hysterectomy or ligation of pelvic major vessels.

Obstructed labour

This was characterised by failure of descent of the presenting part despite strong uterine contractions because of mechanical obstruction due to either cephalo pelvic disproportion or soft tissue, or an abnormal presentation or lie. Additionally at least one of the following needed to be present:

- Maternal distress characterised by dehydration, temperature of 38°C and restlessness,
- Uterine signs of obstruction characterised by hypotonia of uterus in primigravidae and hypertonic uterus or bandl's ring,
- Genital tract signs of obstruction as defined by infected liquor and vulva oedema or urinary haematuria.

Ruptured uterus

All cases diagnosed with ruptured uterus were recruited as cases of SMM.

Placenta praevia

This was classified as:

- Vaginal bleeding which is painless before delivery, with
- An episode of shock with a systolic blood pressure of equal to or less than 90mmhg and a pulse rate of 100 or more beats per min and of small volume.

Additionally, one or more of the following was necessary:

- An intravenous therapy of two or more units of blood,
- An intravenous therapy of fluids of two or more litres.

Abruptio placenta

Was characterised by the following:

- Vaginal bleeding or concealed bleeding,
- Abdominal pain and abdominal tenderness,
- An episode of shock with a systolic blood pressure of equal or less than 90mmhg and a pulse rate of 100 or more beats per minute and of small volume, and
- Retro placental clot at delivery of placenta.

With any one of the following:

- An intravenous therapy of two or more units of blood,
- An intravenous therapy of fluids of two or more litres.

Puerperal sepsis

This was infection in current pregnancy, or recent pregnancy, with infection arising from genital tract characterised by:

- Temperature of 38.5°C or more, or less than 36°C,
- Evidence of shock with systolic blood pressure of less than 90mmhg and pulse rate of more than 100 beats per minute in absence other causes of hypotension,
- White cell count of more than $15x10^9$ /L, and
- Positive swab culture.

With any one of the following:

- Acute alteration of mental state characterised by confusion or restlessness,
- An episode of oliguria defined as urine output of less than 100mls in 4 hours,
- Clinical jaundice,

- Uterine evacuation,
- Laparotomy for pelvic abscess.

Maternal anaemia

This was characterised by haemoglobin level less than 7 grams per decilitre with any two or more of the following:

- Diagnosed with heart failure,
- Diagnosed to have haemolysis as evidenced by worsening pallor and jaundice,
- Blood transfusion of two or more units of blood within 24 hours,
- Sickle cell crisis.

Maternal cardiac disease

This was characterised by confirmed (diagnosed) cardiac heart lesion (pathology) with any one or more of the following:

- Diagnosed with being in heart failure,
- Fever of 38.0°C or more,
- Blood pressure of more than 130/90mmhg,
- Episode of jaundice,
- Petichael haemorrhages.

Maternal pulmonary disease

This was characterised by evidence from clinical and chest x-ray of lung disease with acute respiratory failure needing oxygen with or without fever of 38°C or more.

Maternal meningitis

This was characterised by fever of 38°C, severe headache, neck stiffness and positive kerning's sign with or without comma or coma only.

4.5.3 Selection and recruitment of cases

All cases matching one or more of the criteria outlined above (and living within 15 km form the hospital) were included in the study. The cases were selected on a daily basis as they arose. One study midwife was based in the labour suite during the day to identify the cases and notify the PI for verification. The doctors and staff working in the labour suite would also notify the study midwife on duty in the labour suite, or the principal investigator (PI) or his assistant, either by sending a person or by phone about

a case in the labour ward. The PI or assistant checked the labour suite from time-to-time to identify any SMM cases admitted and to verify whether the identified cases satisfied the selection criteria. Figure 4.1 illustrates the selection of cases.

Recruited cases were told about the study and asked to give consent. Most of the cases were too sick to give consent or be interviewed, and the husband, spouse, or the first relative were given information about the study and requested to give consent. The patients were asked for consent later when their conditions improved. For those whose condition did not improve we used the information from the spouse or relative and case records.

4.5.4 Eligibility of controls

Controls were selected from the study population of women of 24 or more weeks of gestation who delivered infants at Mulago hospital or in puerperium between 15th November 2001 and 30th November 2002 and who lived within a radius of 15 kilometres from the hospital. Controls must have had a normal vaginal delivery to a singleton live baby, not had an episiotomy or tear of more than first degree, and the blood loss should have been normal.

4.5.5 Selection and recruitment of controls

The controls were selected on a daily basis during the time of study. Controls were unmatched and the aim was to obtain the same number of controls as cases. Two controls were selected daily by the study midwife. Every mid morning except Sunday a list of women who had had normal deliveries (as defined in 4.5.4 above) was used to choose two women to join the study. The two were selected randomly from the list using computer generated numbers. The selected women were told about the purpose of the study and, if they agreed to take part, the midwife used a checklist to ensure that they satisfied the selection criteria. Those who refused to join the study or did not satisfy the selection criteria were dropped and another woman, or women, selected. Figure 4.1 illustrates the selection of controls.

Control women were told about the study and also given an information sheet about the study to read. The information sheets were in English and local dialect (Luganda). Those who could not read English were given the translated version of information sheet. For those who did not know how to read, the study midwife read the information

sheet to them in the local dialect. They were told about the laboratory investigations which were carried out. They were specifically counselled on voluntary testing for HIV. They were told about the option to know, or not to know, their HIV status. Those who accepted to know their results were given post HIV test counselling. They were then asked to give a written consent.

4.5.6 Data collection

Each case and control was assigned a unique study number.

Interview of cases and controls using questionnaire

The cases or the proxy and controls were interviewed using a pre-coded questionnaire (see Appendix A, Questionnaire A). Questions covered items of information on socio demographic factors, family social history, medical and surgical history, past obstetric performance and present obstetric outcomes. For those who are admitted when too sick, in a coma, or died soon after recruitment, the interview was conducted with the husband or the first relative. However those who recovered were interviewed before or on day of discharge.

A typical interview session in labour ward

Note abstraction from medical records

The following data was extracted from medical records for cases and controls by me or my assistant. Items of information included:

- Medical history,
- Clinical examination and management records,

- Follow up records of patients until discharge or death,
- Causes of morbidity and outcomes(cases only),
- Admission to intensive care records (cases only).

The data were recorded on the questionnaire.

4.5.7 Laboratory investigations

Taking blood specimens for laboratory investigations

After the interview 10 mls of blood was taken off from the cubital area using a vacutainer under sterile procedure for laboratory investigations. Eight mls was put in the purple sequestreen bottles for HIV and syphilis testing and 2 mls put in red sequestreen bottles for full haemogramme. The bottles were labelled with the study number and taken to the laboratory with request forms. The following investigations were performed.

Human immunodeficiency virus test

The HIV screening test was carried out on daily basis on all cases and controls using Determine test (Abbott Laboratories, Abbott Park, IL). This was an immunochromatographic test for qualitative detection of HIV-1/2. The test was performed by applying 50ul of serum to the test pad at the bottom of the strip. The sample then migrates, reconstitutes and mixes with the selenium colloid antigen conjugate. The mixture then continues to migrate through a sold phase until it reaches immobilized recombinant antigens and synthetic peptides in the patient window site. If antibodies to HIV are present, a red line forms in the patient window. If the antibodies to HIV 1/2 are absent, the antigen selenium colloid will flow past the patient window, and no red line is formed. The results of the strip were interpreted visually. A procedural control window is included on each strip where red line forms to ensure quality control of individual strips.

Among the cases those whose HIV test was positive their blood was further analysed for CD4 and CD8 cell counts. The CD4 cell counts were carried out using a flow cytometer (cyflow^{R}). This test was carried out within 48 hours of getting the sample from patients. The flow cytometer used volumetric absolute counting using

immunolabelling of the cells to obtain the absolute count of CD4 and CD8.

Syphilis test

The disease syphilis is caused by a spirochaete *Trepanema Pallidum.* This is a sexually transmitted infection but can also be transmitted through blood transfusion with infected blood.

The tests used include VDRL carbon antigen and TPHA for confirmation from Biotech laboratories. The VDRL carbon antigen is a modified form of VDRL antigen containing micro particulate carbon to enhance visual reading of results. The reagent, non trepaonemal antigen, consists of cardiolipin lecithin which will flocculate when exposed to patient serum containing reagin found in syphilitic patients. The test is read microscopically. The tests which are reactive are further exposed to TPHA which uses preserved avian erythrocytes coated with antigens of *Trepanema pallidum.* When mixed with patients' serum which contains reagin there is haemoagglutination.

Complete blood count

We used a coulter ^{R} MAXM automated haematology counter from Beckman coulter. The instrument measured the white blood cell count and its differential, red blood cell count, haemoglobin concentration, haematocrit, mean corpuscular volume, and mean corpuscular haemoglobin concentration and platelet count. Those cases with haemoglobin level less than 10 grams per decilitre had a blood film to study the blood picture.

Specific tests for diagnosis of SMM

Specific investigations were done on certain cases to confirm the diagnoses. For severe hypertension and eclampsia blood was taken to assess serum uric acid and aspartate aminotransferase. Urine was tested for protein. In puerperal sepsis a high vaginal swab or abdominal swab was taken for culture and sensitivity.

4.5.8 Daily follow up of cases and controls

The controls were checked before they were discharged (usually the day after delivery) by a midwife. At discharge they were given post HIV counselling test and those who wanted to know their HIV status were told. Those who were anaemic or had syphilis were treated.

The cases were checked daily until discharge or death. The midwife checked on the general condition of patients, talking to relatives and checking ward reports on the performance of the patient and reported the findings to the PI or assistant. The PI or assistant did not carry out this follow-up of cases because it could have influenced on the management of patients.

On the day of discharge, the cases who had not been interviewed because of they were too sick were interviewed. They were given post HIV test counselling and those who wanted to know their HIV status were told. Those who were anaemic or had syphilis were treated. The files were collected and information on quality of care was extracted by the PI and filled in the questionnaire.

For the cases that progressed to death a post mortem was requested and carried out by the pathology team to confirm the cause of death. The post mortem findings and patients' case notes were given back to the PI for extraction of information on management of patients and final causes of death.

4.6 STAGE TWO: FOLLOW-UP STUDY OF SEVERE MATERNAL MORBIDITY CASES

4.6.1 Study population

All women recruited as cases of SMM into the first (case-control) stage were followed up until discharge from hospital or death (See 4.5.8).

4.6.2 Definition of outcome

The outcome definition was maternal death.

4.6.3 Data collection

One obstetrician was trained to assist in data extraction from the clinical notes. At discharge or death information on the clinical management of the severe morbidity cases was extracted from the files using an extension of the Stage 1 (case-control) questionnaire (Appendix A Questionnaire B). The following information was extracted from the files:

- Waiting time for operation,

- Causes of delay to have operative delivery,
- Time of examination of patient by obstetrician on duty,
- Times of monitoring of vital signs of patients,
- Frequency of checking for vaginal bleeding,
- Availability of drugs and blood when needed,
- Post mortem results.

4.7 SAMPLE SIZE AND POWER

4.7.1 Stage 1: Case-control study

Sample size was calculated prior to the conducting the study using the estimated number of deliveries in Mulago hospital for the year 1999. In that year there were around 20,000 deliveries and 157 maternal deaths (7.9 per 1,000 deliveries)[252]. Since the study was restricted to women who lived within 15 kilometres from the hospital, the estimated number of deliveries was 60-70% of the total deliveries, making the estimated number of eligible deliveries 13,000. Maternal mortality was likely to be associated with distance from hospital (increasing risk the further away the woman lives), so to allow for the exclusion of women living over 15 kilometres from the hospital, a more conservative estimate of maternal mortality of 5.5 per 1,000 live births was used in these calculations, which is similar to the recent population estimate of 5.06 per 1,000 live births for the whole country of Uganda in 1995[204].

Thus, around 72 maternal deaths in an estimated 13,000 deliveries among women living within 15 kilometres from Mulago hospital were expected in one year. Using the results of a small study done in Mulago[16] and a West African study on SMM[39], the expected ratio of SMM to mortality was estimated to be 7:1. Thus with an estimated 72 maternal deaths among eligible women, approximately of 500 cases of SMM (all causes) could be recruited in one year in Mulago hospital.

With 500 cases and an equal number of controls, and taking a risk factor with prevalence of 30% in the population (such as nulliparity), the case-control study was estimated to have over 99% power to detect odds ratio of 2 and 85% power to detect odds ratio of 1.5 at the level of 5% of significance (see table 4.1A). For a risk factor such as HIV infection, which has an estimated prevalence in the population of a round 12%, the case-control study would have 95% and 55% power to detect odds ratio of 2

and 1.5 respectively.

For individual causes of SMM the estimated numbers of cases were calculated from the prevalence reported in West Africa[39] and in a small Mulago study[16]. An average was calculated and used in the calculations (Table 4.1B). For cases with haemorrhage the estimated number was 143 cases. With 500 controls there was good power to detect a doubling of risk or higher (table 4.1C) over a range of exposure prevalence. The estimated number of cases with eclampsia was only 65 cases, and with 500 controls, the study would have limited power to detect a doubling of risk (table 4.1D).

4.7.2 Stage 2: Follow up study

As described above the expected number of maternal deaths was 72 over the study period. A study with 72 maternal deaths and 428 survivors would have good power to detect an odds ratio of 3.0 and above (table 4.2) over the range of exposure prevalence expected.

4.8 DATA PROCESSING AND ANALYSIS

4.8.1 Data processing

My role in data processing is described in appendix D. The data collected was checked, coded and double entered using Epi-Info software. The data was cleaned and transferred to Stata 8 where it was merged.

4.8.2 Definition of outcomes for case-control study

Cases were assigned a primary diagnosis, e.g. eclampsia or haemorrhage, and secondary diagnoses, as appropriate. The primary outcome was all-cause SMM and for this all women identified and recruited as cases were used and compared to the control women. Secondary outcomes were defined as:

- Severe pre eclampsia and eclampsia,
- Post partum haemorrhage,
- Obstructed labour,
- Ruptured uterus,
- Abruptio placenta,
- Placenta praevia.

For each secondary outcome the relevant subset of cases was compared with all controls. When categorising women as cases both primary and secondary diagnoses were taken into account, and thus women could be considered cases for more than one secondary outcome.

4.8.3 Definition of exposures for case-control study

The main exposures of interest were the socio demographic characteristics, social and family history, past obstetric history, and present obstetric performance and laboratory results. The majority of variables were pre-coded on the questionnaire (see Appendix A). Others required coding as follows:

- Age of patients was grouped as below 20, 20-29, 30-34 and 35 or more years,
- Distance from Mulago was grouped as five kilometres and under, more than five and less than ten kilometres, and between ten and fifteen kilometres,
- Tribe was grouped as Bantu and Nilotics,
- Educational level was grouped according to the educational system in Uganda of nil, primary, secondary and post secondary,
- Spouse and patient's jobs were grouped as employed and peasants (not paid),
- Parity was grouped as primiparous, 2-5 and more than 5,
- Birth interval was grouped as less than 36 months, 37-60 months and more than 60 months,
- Birth weight was grouped as below 2500, 2500-3500 and more than 3500 grams.

A hierarchy of exposures was developed to compare variables which may act at the same level. Variables were grouped together if they were thought to measure similar exposures:

The first level included *socio demographic exposures* (variables in brackets were thought to be highly correlated and thus not independent):

1. Variables measuring distance from hospital and nearest health unit (distance from Mulago to home and distance to the nearest health centre),
2. Marital status (Married and living together),
3. Social grouping (Tribe and religion),
4. Socio economic class (type of house, utilities in the house, educational level, patient's job, husband's job, ownership of house, paying for health services),

5. Requesting permission (asking for permission before visiting health unit, who gives permission).

The second level was *Social, Family and Medical History*:

1. Familial diseases (Hypertension, Diabetes mellitus and epilepsy in family or self),
2. Social behaviour (Drinking of alcohol, smoking).

At the next level were variables associated with *previous obstetric performance*:

1. Abortion,
2. Bleeding during pregnancy,
3. Bleeding in labour,
4. Hypertension during pregnancy,
5. Prolonged labour,
6. Stillborn baby,
7. Delivery by instruments (Caesarean section, vacuum extraction, forceps delivery),
8. Postpartum haemorrhage,
9. Retained placenta,
10. Blood transfusion.

At the next level were variables associated with *present obstetric performance*:

1. Parity,
2. Birth spacing,
3. Antenatal attendance (booking time, number of visits, response to vaginal bleeding during pregnancy),
4. Antenatal diagnosis of hypertension and anaemia,
5. Referral,
6. Length of labour,
7. Mode of delivery,
8. Birth weight and sex of baby.

At the final level were variables associated with *laboratory investigations:*

1. HIV test,
2. Syphilis,

3. Complete blood count.

4.8.4 Analysis of case-control study

Univariate analysis

Distributions of each exposure (number, percentage) were presented for cases and controls. Odds ratios were calculated and Chi-squared tests used to test the statistical significance.

Logistic regression

Logistic regression was used to establish the strength of association between exposure variables and SMM. Logistic regression uses the log odds ratio and all associations are presented as odds ratio with corresponding 95% confidence intervals. Odds ratios of greater than one represents an increased risk of SMM in that exposure compared to the baseline category. The significance of an association between an exposure factor and SMM was assessed using the likelihood ratio test[253]. The baseline level was usually the exposure level with the highest number of cases and controls.

The objective of the study was to assess the independent contribution of exposure variables to SMM. Multiple logistic regression analysis was performed to identify independent exposure variables after controlling for other risk factors and potential confounders. Multiple logistic regressions is an analysis that takes into account a number of variables simultaneously, describing most efficiently the association between the exposures of interest and the disease[254].

A conceptual framework was used to identify variables within the hierarchical relationship of exposure risk factors described in 4.8.3 above.

For socio demographic variables, which were grouped together according to the type of exposure, e.g. exposures measuring socioeconomic class, each factor within the group was tested using the likelihood ratio test to identify which explained the most variation. This would then be the chosen exposure variable to represent that group. Some factors which were not statistically significant but which were thought to be important in the conceptual framework were included in the final set of exposure variables representing socio demographic characteristics.

The multivariate modelling was an iterative process. Selection of variables into the initial multivariate model was based on a p-value of <0.25 obtained from bivariate analyses, as recommended by Hosmer and Lamesho[255]. Variables with such p-values were included in the analysis because, although the variable may be only weakly associated with the outcome by itself, it may become an important predictor of an outcome when taken together with other variables. Variables were taken out of the initial multivariate model one by one, and significance in the presence of all other variables in the model was assessed using the likelihood ratio test. Variables with a p-value of <0.1 were left in the model, and the model was then refitted. This process was repeated until all variables left in the model were either statistically significant at the 95% level or were considered too epidemiologically important to leave out.

The process of hierarchical selection and logistic regression was repeated for subsets of individual causes of SMM.

4.8.5 Analysis of Stage 2: Follow up study

Analysis of stage two followed the same pattern as stage one, the case-control study. The only difference was that the "cases" were those SMM patients who died and the "controls" were the SMM patients who survived. In the hierarchical analysis the quality of care exposure variables were included in this part of analysis. The quality of care factors were:

1. Availability of blood,
2. Use prophylactic antibiotics,
3. Availability of drugs(magnesium sulphate and antibiotics),
4. Coverage of labour ward by obstetricians on duty,
5. Monitoring of patients,
6. Time spent waiting for operation,
7. Causes of delay of operation.

4.9 Ethics and informed consent

Permission was sought and granted from the ethical committees of London school of Hygiene and Tropical Medicine, Mulago Hospital and the Uganda national council of science and technology. Study participants were told about the study and written consent obtained. The patients were given voluntary counselling before being tested for HIV and a post HIV counselling session before being given the HIV results. For those

who were too sick to consent for HIV testing their husband or first relative consented for them and the patient's consent was sought after recovery or at discharge. For those who died consent was requested from the husband or first relative.

Table 4.1 Calculations of sample size and power prior to conducting the study:

STAGE 1 Case-control study

A. Power for all causes of SMM

For 500 cases and 500 controls the power was as follows:

Prevalence of exposure	ODDS RATIO OF SMM					
	1.5	2.0	2.5	3.0	3.5	4.0
30% (e.g. nulliparity)	>84%	>99.5%	100%	100%	100%	100%
12% (e.g. HIV)	57%	97.5%	99.5%	100%	100%	100%

B. Estimated number of specific cases of SMM

Cause of severe morbidity	Expected percentage of causes of SMM among total deliveries		Estimate used for sample size calculation	Estimated number of individual cause of SMM
	Mulago 1999	Burkina Faso 1999		
Haemorrhage	1.44	0.80	1.10	(13,000x1.10) =143
Sepsis	1.24	0.50	0.80	(13,000x0.80)=104
Eclampsia	0.33	0.64	0.50	(13,000x0.50)=65
Dystocia	0.31	1.98	0.70	(13,000x0.70)=91
Anaemia	0.42	-	0.42	(13,000x0.42)=55
Other				42

C. Power for specific cause of SMM: Haemorrhage

For 143 cases and 500 controls the power is as follows:

Prevalence of exposure	ODDS RATIO HAEMORRHAGE					
	1.5	2.0	2.5	3.0	3.5	4.0
30% (e.g. nulliparity)	>50%	>93%	99.5%	>99.5%	100%	100%
12% (e.g. HIV)	30.5%	75%	94%	99%	100%	100%

D. Power for specific cause SMM: Eclampsia

For 65 cases and 500 controls the power is as follows:

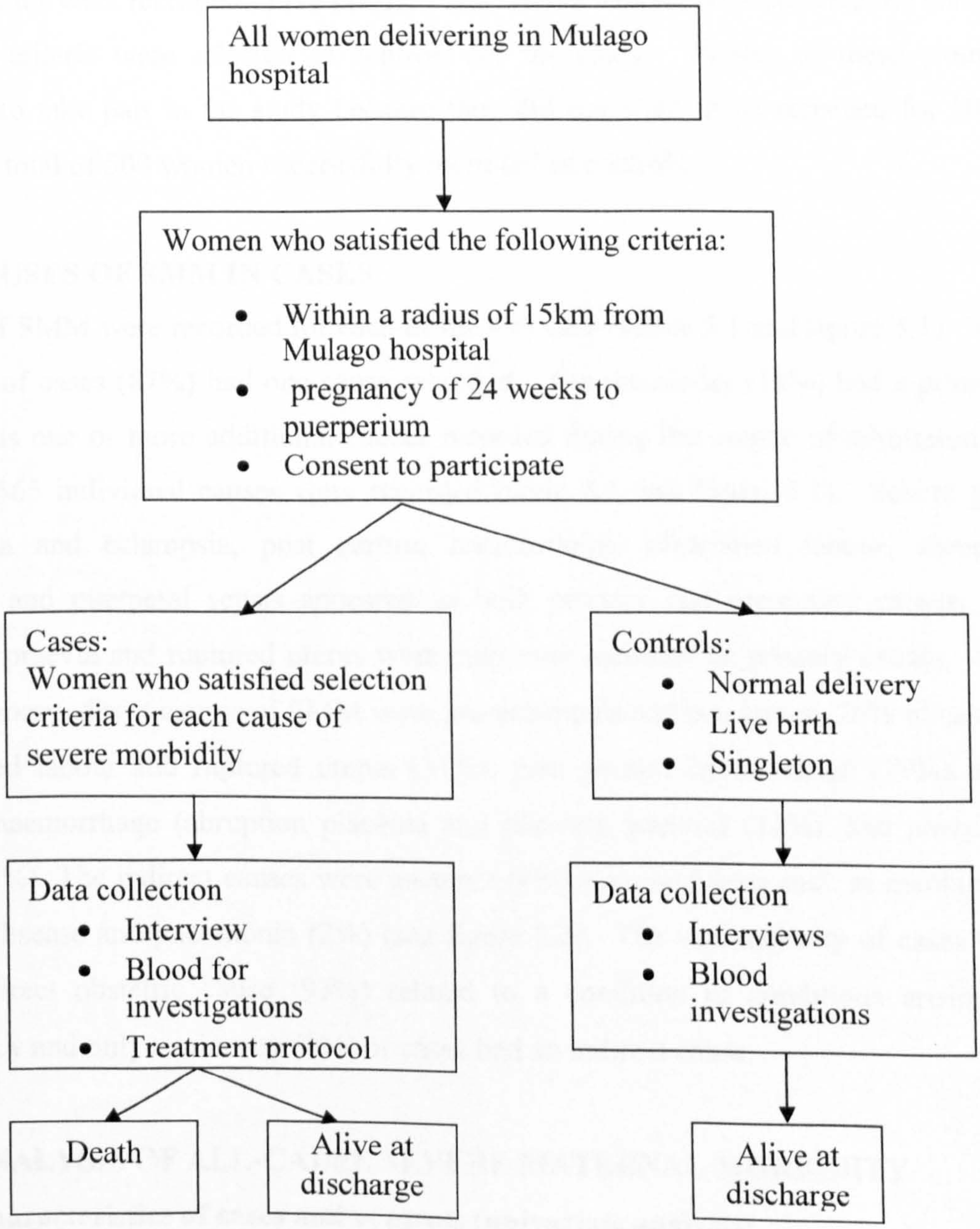
Prevalence of exposure	ODDS RATIO ECLAMPSIA					
	1.5	2.0	2.5	3.0	3.5	4.0
30% (e.g. nulliparity)	>28%	>69%	91%	>98.5%	99.6%	100%
12% (e.g. HIV)	37.0%	69.5%	88.4%	96%	98.7%	99.5%

Table 4.2 Calculations of sample size and power prior to conducting the study: STAGE 2 Follow-up study

For 72 maternal deaths and 428 survivors the power is as follows:

Prevalence of exposure	ODDS RATIO MATERNAL MORTALITY					
	1.5	2.0	2.5	3.0	3.5	4.0
50% e.g. Failure to get blood in 50% cases	49%	69%	96%	100%	100%	100%
10% e.g. Failure to get blood in 10% cases	23%	64%	88.4%	91%	99%	100%

Figure 4.1 Summary of recruitment of study participants



CHAPTER FIVE: RESULTS FROM STAGE 1 CASE-CONTROL STUDY OF SEVERE MATERNAL MORBIDITY

Cases were recruited over a twelve and a half month period from 15th November 2001 to 30th November 2002. During this period Mulago hospital delivered a total of 22,827 women and the caesarean section rate was 14.9%. There were 22,059 live births. The hospital had a total of 843 SMM patients recorded and there were 61 maternal deaths.

5.1 RECRUITMENT OF CASES AND CONTROLS

A total of 499 women satisfied the selection criteria as cases for the study and all these eligible cases were recruited. Five hundred and twelve women who satisfied the control selection criteria were selected as controls for the study. Twelve of these women declined to take part in the study because they did not want to be screened for HIV, leaving a total of 500 women successfully recruited as controls.

5.2 CAUSES OF SMM IN CASES

Causes of SMM were recorded for each of the 499 cases (table 5.1 and figure 5.1). The majority of cases (87%) had one cause recorded. The remainder (13%) had a primary cause plus one or more additional causes recorded during the course of admission. A total of 565 individual causes were recorded (table 5.1 and figure 5.1). Severe pre-eclampsia and eclampsia, post partum haemorrhage, obstructed labour, abruptio placenta and puerperal sepsis appeared as both primary and secondary causes, but placenta praevia and ruptured uterus were only ever recorded as primary causes. The main primary direct causes of SMM were pre-eclampsia and eclampsia (25% of cases), obstructed labour and ruptured uterus (31%), post partum haemorrhage (19%), ante partum haemorrhage (abruption placenta and placenta praevia) (14%), and puerperal sepsis (5%). The indirect causes were anaemia (4%) and conditions such as meningitis, cardiac disease and pneumonia (2%) (see figure 5.2). The vast majority of cases thus had a direct obstetric cause (93%) related to a condition or conditions arising in pregnancy and only a minority (7%) of cases had an indirect cause.

5.3 ANALYSIS OF ALL-CAUSE SEVERE MATERNAL MORBIDITY

5.3.1 Characteristics of cases and controls (univariate analysis)

Table 5.2 describes the characteristics of all SMM (499 cases) and normal deliveries (500 controls).

Socio demographic characteristics (table 5.2i)

The majority of the controls (82%) lived within a radius of 5 kilometres from Mulago hospital compared to just under half the cases, and only a small proportion of the controls (2.2%) lived more than 10 kilometres from Mulago hospital in contrast to 15% of cases (table 5.2i) (crude OR for over 10 km compared to <= 5km =11.6, 95% CI 6. to 22.3). The mean distance in kilometres from home to hospital for controls was 4.2 (SD 2.5) km compared to the mean distance for cases of 6.7 (SD 3.66) km (P <0.001). A similar pattern was seen for the distance from home to the nearest health unit (crude OR = 12.2, 95% CI 6.5 to 24.4).

Both cases and controls were young compared to maternities in developed world, with 30% below the age of twenty years. The mean age for the controls was 23.4 (SD = 5.7 years) which was similar to the mean age of cases of 23.4 (SD = 4years, P>0.05). The vast majority (80%) of both cases and controls were below the age of 30 years. A similar proportion of cases and controls (81% and 85% respectively) were either married or lived as married. The educational level of both cases and controls was low, with 60% having no, or only primary, education. The mean years spent in school for cases was 7.6 (SD = 2 years) and for controls 7.4 (SD = 2.6 years) (P>0.18). Only 6% of cases and with 3% of controls had spent more than 12 years in school. The low educational status was reflected in the type of jobs the cases and controls had: Over 70% of both the cases and controls were peasants. However, 6% cases compared with 3% controls had professional jobs (crude OR professional compared with peasant = 2.5, 95% CI 1.3 to 4.6).

Around two-thirds of both cases and controls were Anglicans or Catholics, but the proportion of Muslims was lower in cases (26%) than in controls (32%). Tribes in Uganda are categorized into two major groups using language and place of origin. The Bantu (Baganda, Basoga, Bagisu, Banyankole, Banyoro and Batoro) are tribes from the Southern and Western part of Uganda and Nilotics are tribes from the North and North Eastern Uganda. A higher proportion of cases (14%) than controls (9%) were Nilotics (crude OR = 1.6; 95% CI 1.1 to 2.5).

Overall, the controls lived in better housing than the cases, with 83% living in plastered brick houses with iron or tiled roofs compared to 51% of the cases. Fourteen percent of cases and 3% of controls lived in poor quality houses of mud with or without iron roof (crude OR for poor housing versus better housing = 7.9, 95% CI 4.3 to 14.2).

A higher proportion of cases (33%) compared to controls (9%) asked for permission before they could attend a health facility (crude OR = 4.7, 95% CI 3.3 to 6.7). Among those who asked for permission, more than 80% of both the cases and controls asked permission from their spouses and less than 20% from their parents or parents in law. The financial contribution to health care was mostly made by the spouse and patient together (84% in cases and 80% in controls). The other contributors were the patient's parents and relatives or the spouse's parents or relatives (crude OR for others paying = 2.9, 95% CI 1.9 to 4.2).

Social, family and medical history characteristics (table 5.2ii)

Approximately one fifth of cases (21%) drank alcohol compared to over one quarter (27%) of controls (crude OR = 0.7, 95% CI 0.5-0.9). Those who drank alcohol had less than 14 units of alcohol per week. Smoking in Ugandan women is rare and as shown in this study group: Less than 0.5% of cases and controls reported smoking. The reported prevalence of familial hypertension and diabetes mellitus was similar in both the cases and controls: around 40% for hypertension and 12% for diabetes mellitus. Existing hypertension was reported in 23 cases (5%) but only 2 controls (0.4%) (crude OR = 12.0, 95% CI 2.8 to 51.3).

Past obstetric performance (table 5.2iii)

Three hundred and fourteen cases (63%) and 350 controls (70%) were multiparous (table 5.2iv). A previous history of evacuation or dilation of uterus was carried out on 7% cases and 4% controls (crude OR = 1.8, 95% CI 1.2 to 4.5). Also a higher proportion of cases had one or more caesarean section in a previous pregnancy (19%) compared to controls (4.0%) (crude OR = 5.4, 95% CI 2.9 to 10.2). About 10% cases and 7% controls had had a stillbirth in a previous pregnancy (crude OR = 1.6, 95% CI 0.9 to 2.9) and 16 cases (5%) and 4 controls (1%) had been transfused in their previous pregnancies (crude OR = 4.7, 95% CI 1.4 to 16.6). Fifteen percent of cases and 11% of the controls had bleeding in a previous pregnancy (crude OR = 1.5, 95% CI 1.0 to 2.5).

Characteristics of current pregnancy (table 5.2iv)

The mean parity of the controls was 2.8 (SD = 0.81) compared to 2.6 (SD = 0.76) for cases. About a third of cases and controls were primiparous (crude OR = 1.3, 95% CI 1.0 to 1.7), and 17% cases and 23% controls were grand multiparous (parity>5). About 50% of SMM cases occurred in what was thought to be safe parity of two to five.

In multigravida the interval between the last born and current pregnancy was longer in cases than controls. Twenty percent of cases reported an interval of more than 60 months compared to 12% of controls (crude OR = 1.8, 95% CI 1.1 to 2.8). The majority of cases and controls attended antenatal care but a high proportion of cases (12%) compared to controls (3%) never attended (crude OR = 4.5, 95% CI 2.5 to 8.4). Although antenatal care attendance was high, 60% of controls and 55% of cases had had less than four antenatal visits. A third of both the cases and controls who attended antenatal care booked in the third trimester. When the cases and controls were asked about what they would do if they suffered vaginal bleeding during pregnancy, three quarters of cases but nearly all controls knew that they should go to hospital immediately (crude OR for not knowing compared to knowing = 8.7, 95% 5.3 to 14.3).

As expected, significantly higher proportions of cases than controls were diagnosed with hypertension (crude OR = 16.9, 95% CI 7.7 to 36.9), anaemia (crude OR = 5.0, 95% CI 1.7 to 14.7), and vaginal bleeding during pregnancy (crude OR = 4.8, 95% CI 1.4 to 16.7).

Mulago hospital is a referral hospital and received 53% of cases compared to 17% of the controls as referred patients (crude OR for being referred patient = 5.5, 95% CI 4.1 to 7.4). The reasons for referral in controls are shown in table 4 of appendix C. The use of a partograph was uncommon in both the cases (7%) and controls (9%) (crude OR for use = 0.8, 95% CI 0.5 to 1.3). The majority of cases had longer first stage of labour (crude OR for > 18 hours = 2.7, 95% CI 1.6 to 4.6) and third stages of labour (crude OR for > 25 minutes = 18.4, 95% CI 3.8 to 89.6) compared to controls.

Only 36% of cases had spontaneous vaginal delivery compared to 100% of controls. The remaining cases were delivered by caesarean section (51.5%), laparotomy (11.2%) and vacuum (1.2%). Babies born to cases were more likely to be of low birth weight

than babies born to controls. (crude OR =5.9, 95% CI 3.8 to 8.8). A lower proportion of cases were given oxytocics soon after delivery (91%) than controls (98%) (crude OR for not receiving oxytocics = 5.7, 95% CI 2.9 to 11.1).

Laboratory results (table 5.2v)

The HIV test was positive in 14% of cases and 9% of the controls (crude OR = 1.7, 95% CI 1.1 to 2.5). The reactive syphilis test was positive for a similar proportion of both cases and controls (9%). Approximately 60% of cases and 15% of controls were found to be anaemic (crude OR for haemoglobin less than 10 mg/dl = 8.4, 95% CI 6.3 to 11.4). However, the mean corpuscular haemoglobin concentration (MCHC) was below 33.0 g/dl in 87% cases and 83% controls, suggesting significant level iron deficiency anaemia. Thirty one percent of cases and 11% controls had a low platelet count (crude OR for <150 10^9/l =3.6, 95% CI 2.6 to 5.1).

5.3.2 Adjusted analyses

Factors found to be of importance in univariate analyses (table 5.2) were entered into a multivariate regression model using the methods described in section 4. Age was included in this model so as to be consistent with other studies. Table 5.3 presents a summary of the adjusted odds ratios for factors found to be independently statistically significantly related to the outcome. The factors used for adjustment are presented as footnotes.

The further away the patient lived from the hospital the higher the risk of developing SMM (adj. OR >5-10km compared to <=5km = 2.6, 95% CI 1.8 to 3.7 and OR >10km compared to <=5km = 7.3, 95% CI 3.6 to 14.5). Having a professional job was also associated with increased risk (adj. OR for professional job compared to peasant = 2.5, CI 1.3 to 5.0). Socio economic status as assessed by the type of house patients lived in was related to risk: Women who lived in brick, not plastered and iron roofed houses (adj. OR = 3.3, 95% CI 2.3 to 4.7), and those who lived in mud and with or without iron roofed houses (adj. OR = 4.5, 95% CI 2.3 to 8.7) were at an increased risk of SMM compared to those who lived in brick, plastered and iron or tiled roofed houses.

Women who depended on financial support from their relatives for up-keep in hospital compared to those who paid for themselves or by their spouse had an increased risk of developing SMM (adj. OR = 5.0, 95% CI 2.9 to 9.8). Similarly, those who asked for

permission to attend hospital were at a higher risk of developing SMM compared to those who did not (adj. OR = 3.3, 95% CI 2.2 to 4.9).

Chronic hypertension before current pregnancy was a very strong independent risk factor for developing SMM (adj. OR = 11.8, 95% CI 2.6 to 54.4). A history of having had an evacuation and/or dilation and curettage of the uterus was associated with a doubling of risk (adj. OR = 2.0, 95% CI 1.2 to 3.9), and women who had had a previous delivery by caesarean section compared to those who had only ever delivered vaginally had more than five times the risk of developing SMM (adj. OR = 5.6, 95% CI 3.0 to 10.4).

Nulliparous women had one and a half times the risk of parous women (adj OR = 1.6, 95% CI 1.1 to 2.3) and women with a long interval since the last birth had more than a doubling of risk (adj. OR = 2.6, 95% CI 1.5 to 4.9). Women who never attended antenatal care had four times the risk of developing SMM compared to women who did attend antenatally (adj. OR = 4.0, 95% CI 2.1 to 7.8) and those who had antenatal care but whose blood pressure was not checked at all had an increased risk compared to women whose blood pressure was checked (adj. OR = 2.6, 95% CI 1.1 to 6.1) during antenatal visits. Hypertension, and anaemia diagnosed during pregnancy were, not surprisingly, associated with being a case (adj. OR hypertension = 12.3, 95% CI 6.0 to 25.2, adj. OR anaemia = 4.4, 95% CI 1.3 to 14.4), as was premature rupture of membranes (adj. OR = 2.3, 95% CI 1.7 to 3.3) and admission to hospital during pregnancy (adj OR = 1.9, 95% CI 1, 1 to 3, 2). Women who did not know what to do if they bled during pregnancy were at increased risk of SMM compared to women who did know that they needed to seek urgent medical attention (adj. OR = 12.7, 95% CI 7.4 to 22.0). Women on trial of scar (adj OR=3.4, 95% CI 1.8 to 6.9) and induced or augmented labour (adj 24.5, 95% CI 9.1 to 99.6) had significantly associated elevated risks. Lack of receipt of oxytocics soon after delivery (adj. OR = 3.1, 95% CI 1.4 to 6.4), and prolonged third stage (adj. OR = 22.6, 95% CI 3.6 to 120.6) were also significantly associated with increased risk. Cases were much more likely than controls to be delivered by a doctor than a midwife (adj. OR = 196.1, 95% CI 96.1 to 396.9). SMM was associated with delivery of a low birth weight (<2500gm) infant (adj. OR = 5.1, 95% CI 3.3 to 8.1) and haemoglobin below 10g/dl (adj. OR 7.8, 95% CI 5.6 to 10.5).

Women who were tested HIV positive had a higher risk of developing SMM than women who were HIV negative (adj. OR = 1.6, 95% CI 1.0 to 2.5).

The risk of SMM was associated with being a referred patient (adj. OR = 6.4, 95% CI 4.5 to 9.1). To investigate possible selection bias associated with referral, further analysis was conducted on the subset of 236 cases and 416 controls who were **not** referred. The results are presented in tables 1 to 4 in Appendix C and as a column in the summary table 5.10. Overall, the pattern of results was similar to that for all cases (see summary table 5.10), although a greater proportion of non-referred cases had had a previous caesarean section (adj. OR = 12.1, 95% 5.7 to 25.9) and had bleeding during the current pregnancy (adj. OR = 7.1, 95% CI 1.7 to 35.1).

5.4 ANALYSIS OF SEVERE PRE-ECLAMPSIA AND ECLAMPSIA

Severe pre-eclampsia and eclampsia was recorded as a primary or secondary cause of SMM in 143 women. There were sixty two cases (43.4%) with eclampsia and eighty one cases (56.6%) with severe pre-eclampsia. Severe pre-eclampsia and eclampsia cases were delivered by spontaneous vaginal delivery (52.4%), caesarean section (46.9%) and vacuum extraction (0.7%). These cases were compared with the 500 control normal deliveries using similar methods to those used for all cases. Table B1 in Appendix B presents the univariate results, which will not be described in detail here.

Adjusted analyses

Table 5.4 presents a summary of the adjusted odds ratios for factors found to be statistically significantly related to the outcome. The factors used for adjustment are presented as footnotes in table 5.4. Factors found to be independently associated with the risk of severe pre-eclampsia and eclampsia after appropriate adjustment were, for the most part, similar to those found for risk of all SMM (table 5.3). But existing hypertension (adj. OR = 26.9, 95% 4.3 to 170.4) and delivery of a low birth weight baby (adj. OR = 23.5, 95% CI 10.4 to 52.7) produced stronger associations than for all cases (see summary comparison table 5.10).

Risk factors specific to pre-eclampsia and eclampsia, and not found for all cases analysed together, were family history of hypertension (adj. OR = 1.9, 95% CI 1.2 to 2.9), history of hypertension in a previous pregnancy (adj. OR = 2.6, 95% CI 1.0 to 6.6), previous history of abortion (adj. OR = 2.6, 95% CI 1.3 to 5.1), and delivering a male

baby (adj. OR = 1.5, 95% CI 1.0 to 2.3) (table 5.4 and 5.10).

Factors which were not found to be independently significantly associated with risk of pre-eclampsia and eclampsia, but were found to be risk factors for all cases, included bleeding in labour (adj. OR = 4.5, 95% CI 0.9 to 12.1.), prolonged third stage (adj. OR = 3.8, 95% CI 0.4 to 38.4), not being given oxytocics (adj. OR = 4.1, 95% CI 0.9 to 16.7), and being HIV positive (adj. OR = 0.7, 95 % CI 0.3 to 1.4) (see summary table 5.10). The lack of association between risk of pre-eclampsia and eclampsia and factors related to labour may be explained by the fact that 46.9% of these cases were delivered by caesarean section. In addition, some of these analyses involved small numbers and hence lacked power to detect statistically significant effects.

5.5 ANALYSIS OF POST PARTUM HAEMORRHAGE

One hundred and six cases had severe post partum haemorrhage (PPH) as a primary or secondary diagnosis of SMM. The specific causes of PPH were: uterine atony (45.0%), tears in the genital tract (22%), coagulation failure (16%), and retained placenta (7%). These 106 cases were delivered by: spontaneous vaginal delivery (70.8%), vacuum extraction (4.7%), caesarean section (14.2%) and laparotomy (10.3%). These cases were compared to the 500 control normal deliveries using the method as that used for all cases. Table B2 in Appendix B presents the results of the univariate analyses.

Adjusted analyses

Table 5.5 presents a summary of the adjusted odds ratios for factors found to be statistically significantly related to the outcome, with factors used for adjustment presented as footnotes. The pattern of results was similar to that found for all cases and only the notable differences will be described.

Women with PPH were more likely to have a previous history of PPH (adj. OR = 3.6, 95% CI 1.1 to 11.8) than all cases. Not unexpectedly, bleeding during labour (adj. OR = 31.5, 95% CI 10.6 to 93.3) and hospital admission during present pregnancy (adj. OR = 2.7, 5% CI 1.2 to 6.5) also produced stronger associations than for all cases (see summary comparison table 5.10). Also, a higher proportion of PPH cases than all cases did not know what to do if there was bleeding during pregnancy (adj. OR = 17.3, 95% CI 7.5 to 39.0). Risk of PPH was very strong for women with prolonged third stage of labour (adj. OR = 49.1, 95% CI 18.8 to 342.8) and a high proportion of women with

PPH had haemoglobin levels below 10 grams/dl (adj. OR = 17.3, 95% CI 9.5 to 31.7).

Factors which were not found to be significantly associated with risk of PPH, but were found to be risk factors for all cases, included professional employment (adj. OR = 1.9, 95% CI 0.7 to 5.4), nulliparity (adj. OR = 1.2, 95% CI 0.7 to 1.9) and premature rupture of membranes (adj. OR = 1.3, 95% CI 0.8 to 2.1). In each of these examples, however, the direction of the effect was similar to that for all cases and the lack of statistical significance may be a result of small numbers and low power. Surprisingly, for previous evacuation and/or dilatation and curettage of the uterus (adj. OR = 0.5, 95% CI 0.2 to 1.2), the (non statistically significant) effect was in the opposite direction to that for all cases (negative association rather than positive association) (see summary table 5.10).

5.6 ANALYSIS OF OBSTRUCTED LABOUR

One hundred and eight cases had obstructed labour as a primary or secondary cause of SMM. Figure 5.4 presents more detail on the causes of the obstructed labour: cephalo pelvic disproportion (59%), big baby (22%), transverse lie (9%), mento posterior (face) (5%), brow (3%) and hydrocephalus (2%). The majority of these 108 women were delivered by caesarean section (94%), vacuum extraction (2%), destructive operation (2%), and one hysterectomy (0.8%) was performed because the uterus was necrotic and could not be salvaged. The mean waiting time for operative delivery was 221.6 (SD = 3.7) hours with a range of 30 to 960 minutes. Forty percent of cases waited for two or less hours, which was the expected waiting time for operation in Mulago hospital. The shortest hospital stay was less than 24 hours for 2% of cases, between 2-9 days for 75%, and 10 to 30 days for 23% of patients. The mean stay in hospital was 9.6 (SD = 5.3 days). At discharge three (2.8%) patients had developed vesico vaginal fistula.

These 108 cases of obstructed labour were compared with the 500 controls of normal deliveries, and the characteristics presented in Table B3 in Appendix B (univariate analysis).

Adjusted analyses

Adjusted analyses were performed using the same method as that used for the analysis of all cases and the results presented in table 5.6 with adjustment factors shown as footnotes. Significant factors associated with increased risk were similar to those found

for all cases, including: longer distance from home to hospital, low quality housing, requiring permission to attend hospital, being unable to pay for hospital upkeep, existing hypertension, previous caesarean section, long birth interval, lack of knowledge of what to do if bleeding in pregnancy, being a referred patient, and having haemoglobin below 10 grams/dl. Nulliparity (adj. OR = 3.2, 95% CI 1.6 to 6.3), premature rupture of membranes (adj 11.3, 95% CI 6.4 to 20.0) and delivery of a male infant (adj. OR = 2.3, 95% CI 3.8 to 10.8) showed stronger associations with risk of obstructed labour than with all cases (see table 5.10). Lack of antenatal care (adj. OR = 1.7, 95% CI 0.5 to 5.0) and HIV positivity (adj. OR = 1.3, 95% CI 0.7 to 2.7) did not reach statistical significance, but the direction of associations was similar to that for all cases.

5.7 ANALYSIS OF RUPTURED UTERUS

Fifty two women suffered a ruptured uterus. The causes were: cephalo pelvic disproportion (33%), previous scar (37%), malpresentation of foetus (15%), big baby (10%), retained second twin (4%), and hydrocephalus (1%). Two women presented with post partum rupture of uterus. There was no ruptured uterus due to oxytocin induction or augmentation. Six (12%) patients had ruptured uterus involving the bladder.

The treatments offered were sub total hysterectomy in 44 (85%), repair of uterus and bilateral tubal ligation in 5(10%), and repair of uterus only for 3 (6%). The mean waiting time for operation after diagnosis was 202.4 minutes, the shortest being 60 minutes and the longest 840 minutes. The mean operating time was 70 minutes and the range was 45 to 120 minutes.

The length of stay of these patients in hospital ranged from less than twenty hours to 30 days. The mean length of stay was 9.7 (SD = 3.7) days. Two (4%) patients stayed for less than twenty fours because they died of hypovolaemic shock due to haemorrhage. Twenty one (40%) patients had puerperal infection post operatively which resulted in prolonged hospital stay. One (2%) patient had developed vesico vaginal fistula at discharge.

Out of 52 cases of ruptured uterus three died (case fatality 6%), two of hypovolaemic shock and third one of uraemic shock following a second operation with a urologist to relieve the ligated ureters on third day after first operation. Twenty four (46%) babies

born were live births and twenty eight (54%) were still births.

Characteristics of the 52 cases of ruptured uterus and the 500 controls are shown in table B4, Appendix B.

Adjusted analyses

As previously, adjusted analyses were performed using the same method as that used for the analysis of all cases. Table 5.7 presents a summary of the adjusted odds ratios for factors found to be statistically significantly related to the outcome, with factors used for adjustment presented as footnotes.

The pattern of results was similar to that found for all cases and only the notable differences will be described. In contrast to the findings for all cases, and specific causes discussed thus far, being young (<20 years) (adj. OR = 0.1, 95% CI 0.1 to 0.4) and nulliparous (adj. OR = 0.1, 95% CI 0.1 to 0.5) was found to be protective for ruptured uterus. Also, being of the Nilotics rather than Bantu tribe doubled risk (adj. OR = 2.4, 95% CI 1.0 to 5.4). For parous women, previous caesarean section was a very strong risk factor for ruptured uterus in the current pregnancy (adj. OR = 22.3, 95% CI 9.2 to 54.2). As expected, bleeding during labour (adj. OR = 27.9, 95% CI 9.6 to 81.3) and low haemoglobin level (<10 grams/dl) (adj. OR = 20.2, 95% CI 9.3 to 43.7) were also very strongly associated with ruptured uterus. Cases with ruptured uterus were more likely than all SMM cases, and controls, to deliver a large baby (>3500 grams) (adj. OR = 2.4, 95% CI 1.2 to 4.7). Notably, HIV positive women had more than 3 times the risk of developing ruptured uterus than HIV negative women (adj. OR = 3.2, 95% CI 1.5 to 7.2).

5.8 ANALYSIS OF PLACENTA PRAEVIA

There were 36 cases of placenta praevia: 80% major placenta praevia and 20% minor. All the minor placenta praevia were of type 2. The characteristics of these 36 cases were compared to the 500 controls, and the results presented in Table B5, Appendix B (univariate analyses).

Adjusted analyses

Adjusted analyses were performed using the same method as that used for the analysis of all cases and the results presented in table 5.8 with adjustment factors shown as

footnotes. This analysis was limited by the small number of cases, and wide confidence intervals, but it was possible to detect some differences in the results compared to all cases (see comparison table 5.10). Women with placenta praevia were found to be much more likely than controls (and all cases) to be living more than 10km from Mulago hospital (adj. OR = 21.4, 95% CI 7.4 to 63.7). Also, for parous women, previous caesarean section was a stronger risk factor for placenta praevia than for all cases, and controls (adj. OR = 19.9, 95% CI 6.4 to 61.7). Previous history of evacuation was strongly associated with placenta praevia (adj. OR = 3.6, 95% CI 1.1 to 12.5). Not unexpectedly bleeding during current pregnancy (adj. OR = 9.9, 95% CI 1.3 to 77.8) was also strongly associated with placenta praevia. Women with placenta praevia were highly likely to deliver a low birth weight baby (adj. OR = 18.9, 95% CI 7.1 to 50.3).

5.9 ANALYSIS OF ABRUPTIO PLACENTA

Abruptio placenta was recorded as a primary or secondary cause of SMM in 45 women. The characteristics of these 45 cases and the 500 controls are shown in table B6 in Appendix B (univariate analysis).

Adjusted analyses

Adjusted analyses were performed using the same method as that used for the analysis of all cases and the results presented in table 5.9 with adjustment factors shown as footnotes. Like placenta praevia described above (section 5.8), this analysis was limited by the small number of cases, and consequent wide confidence intervals, but it was possible to detect some differences in the results compared to all cases and other specific causes of SMM (see comparison table 5.10). As for all cases, long distance from home to Mulago hospital, low quality housing, and requesting permission to attend hospital were associated with increased risk (table 5.9, 5.10). Existing hypertension (adj. OR = 56.8, 95% CI 9.0 to 358.5) was a very strong risk factor, and parous women who had experienced a previous stillbirth (adj. OR = 3.1, CI 95% 1.1 to 9.1) or a previous caesarean section (adj. OR = 7.3, 95% CI 1.8 to 29.7) had increased risk of abruptio placenta. Not surprisingly, bleeding during pregnancy (adj. OR = 26.7, 95% CI 8.6 to 85.4) and bleeding during labour (adj. OR = 18.2, 95% CI 3.8 to 88.4) were clearly associated with being a case, as was being diagnosed with hypertension during pregnancy (adj. OR = 22.7, 95% CI 7.4 to 69.7). Nearly half of all infants delivered to cases were of low birth weight (adj. OR = 24.6, 95% CI 9.2 to 65.9). Somewhat surprisingly, cases were more likely than controls to deliver male babies (adj OR = 1.9,

95% CI 1.0 to 3.8). Being HIV positive was not found to be associated with risk (adj. OR = 1.0, 95% CI 0.3 to 2.9) (table 5.10). A high proportion of women with abruptio placenta (80%) had a haemoglobin level below 10grams/dl (adj. OR = 35.5, 95% CI 13.6 to 92.6).

Table 5.1 Primary and secondary causes of severe maternal morbidity in cases

Cause of SMM	Primary n (%)	Primary and secondary cause n (%)
Severe pre-eclampsia and eclampsia	125(25.1)	143(25.3)
Post partum haemorrhage	95(19.0)	106(18.8)
Obstructed labour	102(20.5)	108(19.1)
Ruptured uterus	52(10.4)	52(9.2)
Abruptio placenta	33(6.6)	45(8.0)
Placenta praevia	36(7.2)	36(6.4)
Puerperal sepsis	25(5.0)	34(6.0)
Anaemia	20(4.0)	25(4.4)
Other medical conditions	11(2.2)	16(2.8)
Total	**499(100)**	**565(100)**

Table 5.2 Characteristics of all SMM cases and controls

(i) Socio-demographic characteristics

Characteristic	Stratum	Cases N (%)		Controls N (%)		Crude odds ratio (95% CI)		P value
Distance from home to Mulago (km)	0-5	246	(49.3)	408	(81.6)	1.0	(-)	
	6-10	176	(35.3)	81	(16.2)	3.6	(2.7-4.9)	0.00
	11-15	77	(15.3)	11	(2.2)	11.6	(6.1-22.3)	
Distance to nearest health unit (km)	0-5	408	(81.8)	491	(98.2)	1.0	(-)	
	>5	91	(18.2)	9	(1.8)	12.2	(6.1-24.4)	0.00
Age (years)	14-19	145	(29.1)	155	(31.0)	0.9	(0.7-1.3)	
	20-29	282	(56.5)	262	(52.4)	1.0	(-)	
	30-35	50	(10.0)	52	(10.4)	0.7	(0.4-1.2)	0.45
	35+	22	(4.4)	31	(6.2)	0.8	(0.6-1.4)	
Marital status	Married	405	(81.2)	425	(85.0)	1.0	(-)	
	Single	94	(18.8)	75	(15.0)	1.3	(0.9-1.8)	0.12
Tribe	Bantu	428	(85.8)	454	(90.8)	1.0	(-)	
	Nilotics	71	(14.2)	46	(9.2)	1.6	(1.1-2.5)	0.01
Religion	Protestant	164	(32.9)	141	(28.2)	1.0	(-)	
	Catholic	165	(33.1)	173	(34.6)	0.8	(0.6-1.2)	
	Muslim	127	(25.5)	160	(32.0)	0.7	(0.5-0.9)	0.03
	Seven day	11	(2.2)	5	(1.0)	1.9	(0.6-5.6)	
	Saved	32	(6.4)	21	(4.2)	1.3	(0.7-2.4)	
Education level of patient	No schooling	25	(5.0)	22	(5.0)	1.2	(0.1-2.2)	
	Primary	266	(53.3)	277	(55.4)	1.0	(0.8-1.3)	0.18
	Secondary	180	(36.1)	186	(37.2)	1.0	(-)	
	College	28	(5.6)	15	(3.0)	1.9	(1.0-2.2)	
Patients job	Commerce	111	(22.2)	114	(22.8)	1.0	(0.8-1.4)	
	Professional	32	(6.4)	14	(2.8)	2.4	(1.3-4.6)	0.02
	Peasant	356	(71.3)	372	(74.4)	1.0	(-)	
Spouse job	Commerce	233	(46.7)	205	(41.0)	1.0	(-)	
	Professional	82	(16.4)	106	(21.2)	0.7	(0.5-1.0)	0.08
	Peasant	184	(36.9)	189	(37.8)	0.9	(0.7-1.1)	
Type of house *	Brick, cemented	258	(51.7)	417	(83.4)	1.0	(-)	
	Brick only	173	(34.7)	69	(13.8)	4.1	(2.9-5.6)	0.00
	Mud only	68	(13.6)	14	(2.8)	7.9	(4.3-14.2)	
Facility in house	Electricity and water	183	(36.7)	261	(52.2)	1.0	(-)	
	Electricity or water only	149	(29.8)	140	(28.0)	1.5	(1.1-2.0)	0.00
	Neither	167	(33.5)	99	(19.8)	2.4	(1.8-3.3)	
Need to request permission to visit Health Unit/hospital	Yes	163	(32.7)	47	(9.4)	4.7	(3.3-6.7)	
	No	336	(67.3)	453	(90.6)	1.0	(-)	0.00
Who gives permission to attend Health Unit/hospital	Spouse	138	(84.3)	42	(88.5)	1.0	(-)	
	Other	25	(15.7)	05	(11.5)	1.4	(1.0-2.2)	0.08
Who pays for treatment	Self and spouse	400	(80.2)	460	(92.0)	1.0	(-)	
	Others	99	(15.8)	40	(8.0)	2.9	(1.9-4.2)	0.00

*Brick, cemented: brick, well cemented house and floor with iron roof or tiles
Brick only: brick, not cemented floor and walls and iron roof
Mud only: Mud walls and floor with iron roof

(ii) Social, family and medical history characteristics

Characteristic	Stratum	Cases		Controls		Odds ratio		P value
		N	(%)	N	(%)	(95% CI)		
Taking alcohol	Yes	105	(21.0)	137	(27.4)	0.7	(0.5-0.9)	0.02
	No	394	(79.0)	363	(72.6)	1.0	(-)	
Smoking	Yes	3	(0.6)	11	(2.20)	0.3	(0.2-2.4)	0.75
	No	496	(99.4)	489	(97.8)	1.0	(-)	
Family hypertension	Yes	196	(39.3)	194	(38.8)	1.0	(0.8-1.3)	0.87
	No	303	(60.7)	306	(61.2)	1.0	(-)	
Family diabetes mellitus	Yes	63	(12.6)	62	(12.4)	1.1	(0.2-1.4)	0.75
	No	436	(87.4)	437	(87.6)	1.0	(-)	
Hypertension (self)	Yes	23	(4.6)	2	(0.4)	12.0	(2.8-51.3)	0.00
	No	476	(95.4)	498	(95.6)	1.0	(-)	
Use of contraceptives	Yes	201	(40.3)	219	(43.8)	1.0	(-)	
	No	298	(59.7)	281	(56.2)	1.2	(0.9-1.5)	0.26

(iii) Past obstetric performance *

Variable	Stratum	Cases		Controls		Odds ratio		P value
		N	(%)	N	(%)	(95% CI)		
Previous abortion	Yes	44	(14.0)	43	(12.3)	1.1	(0.7-1.9)	0.50
	No	270	(86.0)	307	(87.7)	1.0	(-)	
Previous evacuation of uterus and curettage (all women)	Yes	35	(7.0)	20	(4.0)	1.8	(1.2-4.5)	0.00
	No	464	(93.0)	480	(96.0)	1.0	(-)	
Bleeding in previous pregnancy	Yes	48	(15.3)	37	10.6	1.5	(1.0-2.5)	0.07
	No	266	(84.7)	313	(89.4)	1.0	(-)	
Bleeding in labour	Yes	33	(10.5)	37	(10.6)	1.0	(0.6-1.6)	0.99
	No	281	(89.5)	313	(89.6)	1.0	(-)	
Labour lasting more than 18hrs	Yes	54	(17.2)	77	(22.0)	0.7	(0.5-1.1)	0.12
	No	260	(82.8)	273	(78.0)	1.0	(-)	
Still birth	Yes	35	(10.1)	25	(7.1)	1.6	(0.9-2.9)	0.07
	No	279	(88.9)	325	(92.9)	1.0	(-)	
Previous caesarean section	Yes	61	(19.4)	15	(4.0)	5.4	(2.9-10.2)	0.00
	No	253	(80.6)	335	(96.0)	1.0	(-)	
Vacuum or forceps	Yes	6	(1.9)	5	(1.4)	1.4	(0.4-5.1)	0.62
	No	308	(98.1)	345	(98.6)	1.0	(-)	
Post partum haemorrhage	Yes	17	(5.4)	14	(4.0)	1.4	(0.6-3.0)	0.38
	No	297	(94.6)	336	(96.0)	1.0	(-)	
Retained placenta	Yes	8	(5.5)	9	(12.6)	1.0	(0.3-2.9)	0.98
	No	306	(94.5)	342	(97.4)	1.0	(-)	
Hypertension in pregnancy	Yes	23	(7.4)	19	(5.4)	1.4	(0.7-2.7)	0.31
	No	291	(93.3)	331	(94.6)	1.0	(-)	
Blood transfusion During pregnancy	Yes	16	(5.1)	4	(1.1)	4.7	(1.4-16.6)	0.00
	No	298	(94.9)	346	(98.9)	1.0	(-)	

* Women with previous pregnancies only

(iv) Characteristics and outcome of the current pregnancy

Variable	Stratum	Cases		Controls		Odds ratio (95% CI)		P value
		N	(%)	N	(%)			
Parity	1	185	(37.1)	150	(30.0)	1.3	(1.0-1.7)	0.02
	2-4	227	(45.5)	237	(47.4)	1.0	(-)	
	5-14	87	(17.4)	113	(22.6)	0.8	(0.4-0.9)	
Birth spacing	1-36	173	(55.0)	216	(61.9)	1.0	(-)	
In months*	37-60	81	(25.9)	91	(26.0)	1.1	(0.8-1.6)	0.05
	>60	60	(19.1)	43	(12.1)	1.8	(1.1-2.8)	
Attended antenatal care	Yes	438	(87.8)	485	(97.0)	1.0	(-)	
	No	61	(12.2)	15	(3.0)	4.5	(2.5-8.0)	0.00
Booking time for antenatal (weeks)	<28	297	(68.6)	332	(68.6)	1.0	(-)	
	28-36	137	(31.4)	153	(31.4)	1.0	(0.1-1.3)	0.99
Number of antenatal visits	4+	197	(45.0)	195	(40.1)	1.0	(-)	
	<4	240	(55.0)	291	(59.9)	1.2	(0.9-1.6)	0.13
Having blood pressure checked during antenatal	No	103	(24.0)	93	(19.2)	2.7	(1.7-7.6)	0.02
	Yes	325	(76.0)	392	(80.8)	1.0	(-)	
Response to vaginal bleeding during pregnancy	Go to hospital	371	(74.5)	481	(96.2)	1.0	(-)	
	Don't know	128	(25.5)	19	(3.8)	8.7	(5.3-14..3)	0.00
Bleeding during this pregnancy	Yes	14	(2.8)	3	(0.6)	4.8	(1.4-16.7)	0.01
	No	485	(97.2)	497	(99.4)	1.0	(-)	
Hypertension in this pregnancy	Yes	93	(18.6)	7	(1.4)	16.9	(7.7-36.9)	0.00
	No	406	(81.4)	493	(98.6)	1.0	(-)	
Anaemia in this pregnancy	Yes	20	(4.0)	4	(0.8)	5.0	(1.7-14.7)	0.00
	No	479	(96.0)	496	(99.2)	1.0	(-)	
Loss of weight during pregnancy	Yes	50	(10.0)	34	(6.8)	1.5	(1.0-2.4)	0.06
	No	449	(90.0)	466	(93.2)	1.0	(-)	
Admission during pregnancy	Yes	50	(10.0)	37	(7.4)	1.4	(0.9-2.2)	0.14
	No	449	(92.6)	463	(92.6)	1.0		
Referral from other centres	Yes	263	(52.7)	84	(16.8)	5.5	(4.1-7.4)	0.00
	No	236	(47.3)	416	(83.2)	1.0	(-)	
Premature rupture of membranes	Yes	174	(34.9)	111	(22.3)	1.9	(1.4-2.5)	0.00
	No	324	(65.1)	386	(77.7)	1.0	(-)	
	Missing	1						
Bleeding in labour	Yes	98	(19.5)	6	(1.20)	20.1	(8.4-51.4)	0.00
	No	400	(80.5)	493	(98.8)	1.0	(-)	
Use of partograph	Yes	35	(8.2)	44	(8.8)	1.0	(-)	0.32
	No	394	(91.8)	456	(91.2)	0.8	(0.5-1.3)	
	Missing	5						
Type of labour	Normal	330	(76.0)	481	(96.2)	1.0	(-)	0.00
	Trial of scar	34	(7.8)	15	(3.0)	3.3	(1.7-6.5)	
	Augment/induced	70	(16.2)	4	(0.8)	25.5	(8.9-82.9)	
Length of first stage in hours	=<18hours	317	(72.7)	435	(87.2)	1.0	(-)	
	>18	117	(27.3)	65	(12.8)	2.7	(1.61-4.63)	0.00
	No labour	65						
Length of third stage in minutes.**	=<25	401	(88.3)	497	(99.4)	1.0	(-)	
	>25	54	(11.7)	03	(0.6)	18.4	3.8 -89.6	0.00

Variable	Stratum	Cases		Controls		Odds ratio (95% CI)		P value
		N	(%)	N	(%)			
Mode of delivery	Spont vag	180	(36.1)	500	(100)			
	Vacuum	6	(1.2)	0	(-)			
	Caesarean section	257	(51.5)	0	(-)			
	Laparotomy	56	(11.2)	0	(-)			
Sex of baby	Female	233	(47.4)	252	(50.2)	1.0	(-)	
	Male	259	(52.0)	248	(49.6)	1.1	(0.8-1.5)	0.33
	Missing	7						
Birth weight in kilograms	< 2500	121	(25.6)	13	(2.6)	5.9	(3.9-8.8)	0.00
	2500-3500	246	(52.0)	317	(63.4)	1.0	(-)	
	>3500	106	(22.4)	170	(34.0)	1.0	(0.7-1.4)	
	Missing	9						
Level of delivery attendant	Midwife	125	(25.6)	482	(96.4)	1.0	(-)	
	Doctor	344	(71.1)	18	(3.6)	73.7	(43.1 - 127.6)	0.00
	TBA	19	(3.3)	0	(0)	-		
Given Oxytocics **	Yes	408	(90.7)	489	(97.8)	1.0	(-)	
	No	44	(9.8)	11	(2.2)	5.7	(2.9-11.1)	0.00

* Multiparous women only ** ruptured uterus with hysterectomy excluded

(v) Laboratory results

Variable	Stratum	Cases		Controls		Odds ratio (95% CI)		P value
		N	(%)	N	(%)			
HIV status	Negative	429	(86.0)	455	(91.0)	1.0	(-)	
	Positive	70	(14.0)	45	(9.0)	1.7	(1.1-2.5)	0.01
Syphilis	Negative	456	(91.4)	454	(90.8)	1.0	(-)	
	Positive	43	(8.6)	46	(9.2)	0.9	(0.6-1.4)	0.75
Haemoglobin gm/dl	<10	298	(59.8)	75	(15.0)	8.4	(6.3-11.4)	
	=>10	201	(40.3)	425	(85.0)	1.0	(-)	0.00
Mean corpuscular haemoglobin concentration in g/dl	<33.0	436	(87.4)	412	(82.4)	1.5	(1.0-2.1)	0.03
	>33.0	63	(12.6)	88	(17.4)	1.0	(-)	
Platelets $x10^9/l$	<150	152	(30.5)	52	(10.8)	3.6	(2.6-5.1)	0.00
	=>150	347	(69.5)	448	(89.2)	1.0	(-)	

Table 5.3 Risk factors for Severe Maternal Morbidity

Variable	Stratum	Cases N (%)	Controls N (%)	Crude odds ratio (95% CI)	Adjusted odds ratio (95% CI)	P value
Distance from home to Mulago (km)	<+5	246 (49.3)	408(81.6)	1.0(-)	1.0 (-)	0.00
	>5-10	176 (35.3)	81(16.2)	3.6 (2.7-4.9)	2.6 (1.8- 3.7)[a]	
	>10-15	77 (15.3)	11(2.2)	11.6 (6.1- 22.3)	7.3 (3.6 -14.5)[a]	
Distance to nearest health unit (km)	<=5	408 (81.8)	491 (98.2)	1.0 (-)	1.0 (-)	0.00
	>5	91 (18.2)	9(1.8)	15.4 (5.5- 42.7)	6.2 (2.31-20.9)[a]	
Patients job	Commerce	111 (22.2)	114 (22.8)	1.0 (0.8 - 1.4)	1.0 (0.7 - 1.4)[a]	0.02
	Professional	32 (6.4)	14 (2.8)	2.4 (12.5 - 4.6)	2.5 (1.3 – 5.0)[a]	
	Peasant	356 (71.4)	372 (74.4)	1.0 (-)	1.0 (-)	
Type of house	Brick, plastered	258 (51.7)	417 (83.4)	1.0 (-)	1.0 (-)	0.00
	Brick only	173(34.7)	69 (13.8)	4.1 (2.9 - 55.7)	3.3 (2.3 - 4.7)[a]	
	Mud only	68 (13.6)	14(2.8)	7.9 (4.3 - 14.2)	4.5 (2.3 - 8.7)[a]	
Need to request for permission to visit HU	Yes	163(32.7)	47(9.4)	4.7 (3.3 - 6.7)	3.3 (2.2 - 4.9)[a]	0.00
	No	336 (67.3)	453 (90.6)	1.0 (-)	1.0 (-)	
Who pays for treatment	Self and spouse	420 (84.2)	460 (92.0)	1.0 (-)	1.0 (-)	0.00
	Other	79 (15.8)	40 (8.0)	3.3(19.8- 5.6)	5.0 (2.9 - 9.8)[a]	
Admission during pregnancy	Yes	50(10.0)	37(7.4)	1.4(0.9-2.2)	1.9(1.1-3.2)[a]	0.03
	No	449(90.0)	463(92.6)	1.0(-)	1.0(-)	
Previous evacuation of uterus or curettage	Yes	35 (7.0)	20 (4.0)	1.8 (1.2 - 4.5)	2.0 (1.2 - 3.9)[a]	0.01
	No	464 (93.0)	480 (96.0)	1.0 (-)	1.0 (-)	
Hypertension (self)	Yes	23 (4.6)	2 (0.4)	12.0 (2.8- 51.3)	11.8 (2.6 - 54.4)[a]	0.02
	No	476(95.4)	498 (99.6)	1.0 (-)	1.0 (-)	
Previous caesarean section (women with previous pregnancies only)	Yes	61 (19.4)	15 (4.0)	5.6(2.9 - 10.2)	5.6(3.0 - 10.4)[b]	0.00
	No	253 (80.6)	335(96.0)	1.0 (-)	1.0 (-)	
Birth spacing in months (women with previous pregnancies only)	1-36	173 (55.0)	216 (61.9)	1.0 (-)	1.0 (-)	0.01
	37-60	81 (25.9)	91 (26.0)	1.1 (0.8 - 1.6)	1.1 (0.7 - 1.7)[c]	
	>60	60(19.1)	43 (12.1)	1.8 (11.1 - 2.8)	2.6 (1.5 - 4.9)[c]	
Number of pregnancy	1	185(37.1)	150(30.0)	1.3 (1.0-1.7)	1.6(1.1-2.3)[c]	0.00
	2-4	227(45.5)	237(47.4)	1.0 (-)	(-)	
	3-14	87(17.4)	113(22.6)	0.8 (0.6-1.1)	0.6 (0.3-1.0)[c]	
Antennal care attendance	Yes	438 (87.8)	485 (97.0)	1.0 (-)	(-)	0.00
	No	61 (12.2)	15(3.0)	4.5 (2.5 - 8.1)	4.0 (2.1 - 7.8)[c]	
Having blood pressure checked during antenatal	Yes	325(76)	39 (80.8)	2.7(1.7 - 7.6)	2.6(1.1 - 6.1)[c]	0.04
	No	103 (24)	93 (19.2)	1.0 (-)	1.0(-)	
Response to vaginal bleeding during pregnancy	Go to hospital	371 (74.3)	481 (96.2)	1.0 (-)	1.0 (-)	0.00
	Don't know	128 (25.7)	19 (3.8)	8.7 (5.3 - 14.3)	12.7(7.4 - 22.0)[c]	
Having hypertension in this pregnancy	Yes	93 (18.6)	7 (1.4)	14.7 (7.6-28.4)	12.3(6.0-25.2)[c]	0.00
	No	406 (81.4)	493(98.6)	1.0 (-)	1.0 (-)	
Having anaemia in pregnancy	Yes	20(4.0)	4 (0.8)	4.9(1.7-14.7)	4.4(1.3-14.4)[c]	0.00
	No	479(96.0)	496(99.2)	1.0 (-)	1.0 (-)	
Referral from other health units	Yes	263(52.7)	84(16.8)	5.5 (4.1-7.4)	6.4(4.5-9.1)[c]	0.00
	No	236 (47.3)	416(83.2)	1.0 (-)	1.0 (-)	
Premature rupture of membranes	Yes	174(34.9)	111 (22.3)	1.9(1.4-2.5)	2.3 (1.7- 3.3)[c]	0.01
	No	324(65.1)	386 (77.7)	1.0 (-)	1.0 (-)	
Bleeding in labour	Yes	98 (19.5)	6(1.20)	20.1 (8.4-51.4)	7.0 (2.3-16.0)[c]	0.00
	No	400(80.6)	493(98.8)	1.0 (-)	1.0 (-)	

Variable	Stratum	Cases N (%)	Controls N (%)	Crude odds ratio (95% CI)	Adjusted odds ratio (95% CI)	P value
Type of labour	Normal	330(76.0)	481(96.2)	1.0(-)	1.0(-)	0.00
	Trial of scar	34(7.8)	15(3.0)	3.3 (1.7-6.5)	3.4 (1.8-6.9)	
	Augment/induced	70(16.2)	4(0.8)	25.5 (8.9-82.9)	25.5 (89.1-86.4)	
Length of third stage in minutes.	=<25	401(88.3)	497(99.4)	1.0 (-)	1.0 (-)	0.00
	>25	54(11.7)	03(0.6)	18.4 (3.8-89.6)	22.6 (3.9-120.7)[c]	
Level of delivery attendant	Midwife	124 (24.0)	484(96.8)	1.0 (-)	1.0 (-)	
	Doctor	356 (70.9)	16(3.2)	111.0 (60.4-03.9)	196.1 (96.9- 396.9)[c]	0.00
	TBA	16 (2.0)	0 (0)			
Given oxytocics	Yes	408 (90.7)	489 (97.8)	1.0 (-)	1.0 (-)	
	No	44 (9.3)	11(2.2)	5.7 (2.9 - 11.1)	3.1 (1.4 - 6.4)c	0.00
Birth weight In kilograms	< 2500	121(25.6)	13(2.6)	5.9 (3.9 - 8.1)	5.1 (3.3-8.1)c	0.00
	2500-3500	246(52.0)	317(63.4)	1.0 (-)	1.0 (-)	
	>3500	106(22.4)	170(34.0)	1.0(0.7 - 1.4)	1.1 (0.7-1.6)[c]	
HIV	Negative	429(86.0)	455(91.0)	1.0 (-)	1.0 (-)	
	Positive	70 (14.0)	45 (9.0)	1.7 (1.1-2.5)	1.6 (1.0- 2.5)[c]	0.04
Haemoglobin gm/dl	<10	298(59.8)	75(15.0)	1.0 (-)	1.0 (-)	
	=>10	201 (40.3)	425(85.0)	8.4 (6.3- 11.4)	7.8 (5.6-10.5)[c]	0.00

a: Adjusted for age, distance from home to hospital, patients job, type of house she lived in, requesting for permission to attend health unit or hospital, person paying for hospital upkeep and taking of alcohol

b: Adjusted as in (a) plus previous evacuation or dilation and curettage, and chronic hypertension.

c: Adjusted as in (b) plus delivery by caesarean section.

Table 5.4 Risk factors for severe pre-eclampsia and eclampsia

Variable	Stratum	Cases N (%)	Controls N (%)	Crude odds ratio (95% CI)	Adjusted odds ratio (95% CI)	P value
Distance from home to Mulago in (km)	0-5	55 (38.5)	333 (66.0)	1.0(-)	1.0(-)	
	5.1-10	57 (39.9)	139 (27.8)	2.5 (1.6-3.8)	1.8 (1.1-2.9)[a]	0.00
	>10	31(21.6)	28 (5.6)	6.7(3.7-12.0)	3.8 (1.9- 7.7)[a]	
Patients job	Commerce	24 (16.9)	104(22.8)	1.3(0.8-2.1)	1.9(1.0- 3.7)[a]	0.00
	Professional	17(11.8)	14(2.8)	5.7(2.5-13.1)	8.3(3.0-23.1)[a]	
	Peasant	102(71.3)	372(74.4)	1.0(-)	1.0(-)	
Type of house	Brick, plastered	78(54.5)	417 (83.4)	1.0(-)	1.0(-)	
	Brick only	48(33.6)	69(13.8)	3.7(2.4-5.9)	4.5(2.7-7.5)[a]	0.00
	Mud only	17(11.8)	14(2.8)	6.5(3.1-13.9)	7.6 (3.9-26.9)[a]	
Requesting for permission to visit HU	Yes	46 (32.2)	47(9.4)	4.6(2.9-7.3)	3.1(1.7-5.3)[a]	0.00
	No	97(67.8)	453 (90.6)	1.0 (-)	1.0(-)	
Who pays for treatment	Self and spouse	110(77.5)	460(92.0)	1.0(-)	1.0(-)	
	Others	33(22.5)	40(8.0)	4.4(2.6-7.3)	5.6(2.5-12.6)[a]	0.00
Family hypertension	Yes	75(52.5)	194(38.8)	1.7(1.2- 2.5)	1.9(1.2- 2.9)[a]	0.00
	No	68(47.5)	306(61.2)	1.0(-)	1.0(-)	
Existing hypertension	Yes	11(7.7)	2(0.4)	20.8(4.5- 94.8)	26.9(4.3-170.4)[a]	0.00
	No	132(92.3)	498(99.6)	1.0(-)	1.0(-)	
Previous hypertension in pregnancy	Yes	10(11.9)	19(5.4)	1.9(0.9-4.2)	2.6(1.0-6.6)[b]	
	No	74(88.1)	331(94.6)	1.0(-)	1.0(-)	0.05
Previous abortion	Yes	21(25.0)	43 (12.3)	1.9(1.0-3.2)	2.6(1.3- 5.1)[b]	0.00
	No	63(75.0)	307(87.7)	1.0(-)	1.0(-)	
Previous caesarean	Yes	11(13.1)	15(4.0)	3.4(1.48.2)	3.8(1.6-9.1)[b]	0.00
	No	73(86.9)	335(96.0)	1.0(-)	(-)	
Number of pregnancy	1	59(41.2)	150(30.0)	1.5(1.0-2.1)	2.2(1.2-4.3)[c]	0.02
	2-5	74(51.8)	237(47.4)	1.0(-)	1.0(-)	
	>5	10(7.0)	113(22.6)	0.5(0.3-1.0)	0.4(0.1- 1.0)[c]	
Birth spacing in months	<37	39(46.4)	216 (61.9)	1.0(-)	1.0(-)	0.00
	37-60	22(26.3)	91(26.0)	1.4(0.7- 2.6)	1.1(0.4-2.9)[c]	
	>60	22(26.3)	43(12.1)	2.91(1.5- 5.8)	8.3(2.6-26.4)[c]	
Antenatal care	Yes	128(89.5)	485(97.0)	1.0(-)	1.0(-)	
	No	15(10.5)	15(3.0)	3.8(1.8- 8.0)	3.4(1.4-8.5)[c]	0.00
Booking time for antenatal (weeks)	<28	91 (71.6)	332(68.6)	1.0 (-)	1.0(-)	0.05
	28-36	37(28.4)	153(31.4)	0.3(0.2-0.7)	0.4(0.2- 1.0)[c]	
Having hypertension during pregnancy	Yes	71(52.6)	7(9.0)	77.7(34.2- 176.1)	81.8(32.9- 203.5)[c]	0.00
	No	64(47.4)	490(88.5)	1.0(-)	1.0(-)	
Having blood pressure checked during antenatal	No	21(14.7)	93(19.2)	2.2(1.1-4.5)	2.5(1.2-5.2)[c]	0.00
	Yes	121(85.3)	392(80.8)	1.0(-)	1.0(-)	
Admission to hospital	Yes	20(14.0)	31(6.2)	2.5 (1.4- 4.5)	3.1 (1.5-6.4)[c]	0.00
	No	123(86.0)	469(93.8)	1.0(-)	1.0(-)	
Referral	Yes	63(44.1)	84(16.8)	3.9(2.6-5.8)	5.2(3.0-8.9)[c]	0.00
	No	80(55.9)	416(83.2)	1.0(-)	1.0(-)	
Sex	Male	86(6.1)	248(49.6)	1.5(1.0-2.2)	1.5(1.0-2.3)[c]	
	Female	57(39.9)	252(50.4)	1.0(-)	1.0(-)	0.05
Birth weight in grams	<2500	67(46.9)	317(63.4)	22.9(11.9-44.1)	23.5(10.4-52.7)[c]	
	2500-3500	63(40.0)	13(3.0)	1.0 (-)	1.0(-)	0.00
	>3500	13(9.1)	170(34.0)	0.3(0.2-0.7)	0.3(0.2-0.7)[c]	

Variable	Stratum	Cases N (%)	Controls N (%)	Crude odds ratio (95% CI)	Adjusted odds ratio (95% CI)	P value
Haemoglobin in g/decilitre	<10	49(34.3)	75(15.0)	3.0(1.9-45.1)	2.7(1.6- 4.4)[c]	0.00
	=>10	94(65.3)	425(85.0)	1.0 (-)	1.0(-)	
Platelets	<150	51(35.7)	54(10.8)	4.6(2.9- 7.1)	4.5(2.7-7.7)[c]	0.00
	=>150	92(64.3)	446(89.2)	1.0(-)	1.0(-)	

a: Adjusted for distance from home to Mulago hospital, patients job, type of house they were living in, person paying for treatment, age, asking for permission and family hypertension.

b: Adjusted as in (a) plus existing hypertension

c: Adjusted as in (b) plus previous scar and abortion

Table 5.5 Risk factors for post partum haemorrhage

Variable	Stratum	Cases N (%)	Controls N (%)	Crude odds ratio (95% CI)	Adjusted odds ratio (95% CI)	P value
Distance from home to Mulago in (km)	0-5	53 (50.5)	333 (66.0)	1.0 (.)	1.0 (-)	
	5.1-10	37 (34.3)	139 (27.8)	3.4 (2.1 - 5.5)	2.0 (1.0- 3.7)[a]	0.00
	>10	16(15.2)	28 (5.6)	7.7(3.7-14.5)	4.8 (1.9- 7.7)[a]	
Type of house	Brick, plastered	44(41.5)	417 (83.4)	1.0 (-)	1.0 (-)	
	Brick only	51(48.1)	69(13.8)	6.9 (4.3- 11.1)	5.3 (3.0- 9.2)[a]	0.00
	Mud only	11(10.4)	14(2.8)	7.5 (3.2-17.4)	3.3 (1.1-9.9)[a]	
Requesting for permission to visit HU	Yes	30(28.6)	47(9.4)	4.4(2.7- 7.4)	3.2(1.7-9.2)[a]	0.00
	No	76(71.4)	453 (90.6)	1.0(-)	1.0(-)	
Who pays for treatment	Self and spouse	84(80.0)	460(92.0)	1.0(-)	1.0(-)	
	Others	22(20.1)	40(8.0)	2.8(1.6-5.0)	3.6(1.8-7.2)[a]	0.00
Existing hypertension	Yes	4(3.8)	2(0.4)	9.8(1.8- 54.0)	9.3 (1.7- 51.7)[a]	0.01
	No	102(96.2)	498(99.6)	1.0 (-)	1.0(-)	
Previous PPH	Yes	6(8.7)	14(4.0)	2.1 (0.8- 5.6)	3.6 (1.1- 11.8)[b]	0.03
	No	63(91.3)	336(96.0)	1.0 (-)	1.0(-)	
Previous caesarean	Yes	15(21.7)	15(4.0)	6.2 (2.6-12.4)	7.5 (3.5-14.3)[b]	0.00
	No	54(78.3)	335(96.0)	1.0 (-)	1.0(-)	
Birth spacing in months	<37	37 (53.2)	216(61.9)	1.0 (-)	(-)	0.00
	37-60	14(21.0)	91(26.0)	0.9 (0.5- 1.9)	1.3(0.6 - 3.0)[c]	
	>60	18(25.8)	43(12.1)	1.5(1.2- 5.0)	5.2(2.1- 13.0)[c]	
Antenatal care	Yes	92(86.8)	485(97.0)	4.9(2.9- 10.5)	4.7(1.8- 12.4)[c]	
	No	14(13.2)	15(3.0)	1.0(-)	1.0(-)	0.00
Bleeding in labour	Yes	21(19.8)	6(1.2)	20.3(8.0-51.8)	31.5(10.6 -93.3)[c]	0.00
	No	85(80.2)	493(98.2)	1.0(-)	1.0(-)	
Type of labour	Normal	68(64.4)	496(99.2)	1.0(-)	1.0(-)	0.00
	Induced/augmented	38(35.8)	4(0.8)	17.1(4.3-67.5)	18.4(3.6-93.5)[c]	
Having hypertension during pregnancy	Yes	10(9.7)	7(9.0)	7.5(2.8- 20.2)	3.1(1.0- 10.5)[c]	0.01
	No	93(90.3)	490(88.5)	1.0(-)	1.0(-)	
Having anaemia in pregnancy	Yes	5(4.7)	4(0.8)	6.4(1.4-27.7)	6.1(1.1-35.4)[c]	0.05
	No	101(95.3)	496(99.2)	1.0(-)	1.0(-)	
Admission to hospital	Yes	10(9.4)	31(6.2)	1.6(0.8-3.3)	2.7(1.2-6.5)[c]	0.02
	No	96(90.6)	469(93.8)	1.0(-)	1.0(-)	
Referral	Yes	59(55.7)	111(22.3)	6.1(3.97- 9.7)	6.5(3.8-11.2)[c]	0.00
	No	47(44.3)	386(77.7)	1.0(-)	1.0(-)	
Length of third stage in minutes	<26	82 (79.3)	494(98.8)	1.0(-)	1.0(-)	0.00
	>25	22(20.7)	6(1.2)	28.3(6.6 - 78.9)	49.1(8.8-342.8)[c]	
	Missing	2				
Level of delivery attendant	Midwife	51(48.1)	482(96.4)	1.0(-)	1.0(-)	0.00
	Doctor	49(46.2)	18(3.6)	34.9(17.4-70.2)	65.6(26.8-	
	TBA	6(5.7)	0		267.9)[c]	
Birth weight in grams	<2500	13(12.8)	317(63.4)	5.1(2.2- 11.4)	6.1(2.2 - 16.7)[c]	
	2500-3500	63(62.4)	13(3.0)	1.0 (-)	1.0(-)	0.00
	>3500	25(24.8)	170(34.0)	0.7(0.4- 1.2)	0.8(0.4- 1.4)[c]	
Given Oxytocics	Yes	84(80.8)	489(97.8)	1.0(-)	1.0(-)	0.00
	No	20(19.2)	11(2.2)	11.0(4.8-23.3)	12.2(5.0-21.3)[c]	
	Missing	2				
Haemoglobin level in g/decal	<10	79(76.6)	75(15.0)	17.5(10.5-8.9)	17.3(9.5-31.7)[c]	0.00
	=>10	25(24.0)	425(85.0)	1.0(-)	1.0(-)	

Variable	Stratum	Cases N (%)	Controls N (%)	Crude odds ratio (95% CI)	Adjusted odds ratio (95% CI)	P value
Platelets	<150	70(66.0)	54(10.8)	4.3(2.6- 6.9)	4.2(2.3- 7.6)[c]	0.00
	=>150	36(34.0)	446(89.2)	1.0(-)	1.0(-)	

a: Adjusted for distance from home to Mulago hospital, patients job, type of house they were living in, person paying for treatment, age, asking for permission and family hypertension.

b: Adjusted as in (a) plus existing hypertension

c: Adjusted as in (b) plus previous scar and previous PPH.

Table 5.6 Risk factors for obstructed labour

Variable	Stratum	Cases N (%)	Controls N (%)	Crude odds ratio (95 % CI)	Adjusted odds ratio (95% CI)	P value
Distance from home to Mulago in (km)	0-5	34(31.5)	333 (66.0)	1.0(-)	1.0(-)	
	>5-10	45(41.7)	139 (27.8)	3.2(1.9- 5.2)	2.2(1.3- 3.9)[a]	0.00
	>10-15	29(26.9)	28 (5.6)	10.1(5.4-19.0)	6.7(2.6-17.1)[a]	
Distance to nearest health unit	0-5	95 (88.0)	491(98.2)	1.0(-)	1.0(-)	0.00
	6-15	13(12.0)	9(1.8)	7.5(3.1- 18.0)	5.5(1.2 -24.5)[a]	
Type of house	Brick, plastered	59(54.6)	417(83.4)	1.0(-)	1.0(-)	
	Brick only	38(35.2)	69(13.8)	3.6(1.1 - 11.6)	2.9(1.7- 5.0)[a]	0.00
	Mud only	11(10.2)	2.8(5.55)	5.6(2.4- 12.8)	3.1(1.2 - 8.0)[a]	
Requesting for permission to visit HU	Yes	25(23.2)	47(9.4)	3.2(1.6- 6.4)	2.2(1.1 -4.1)[a]	0.01
	No	83 (76.9)	453(90.6)	1.0(-)	1.0(-)	
Who pays for treatment	Self and spouse	85 (78.7)	460(92.0)	1.0(-)	1.0(-)	0.02
	Other	31(21.3)	40(8.0)	2.9(1.7 -5.2)	2.3(1.2 -4.4)[a]	
Previous caesarean	Yes	8 (16.0)	15(4.3)	4.5(1.8- 13.9)	4.7(2.0-14.8)[b]	0.00
	No	42(84.0)	335(95.7)	1.0(-)	1.0(-)	
Number of pregnancy	1	58(39.8)	150(30.0)	2.5(1.6 -3.8)	3.2(1.6-6.3)[c]	
	2-5	43(53.7)	272(54.4)	1.0(-)	1.0(-)	0.00
	6-14	7(6.5)	78(15.6)	0.6(0.3 - 1.3)	0.5(0.2 - 1.3)[c]	
Birth spacing In months	1-36	21 (42.3)	195(61.9)	1.0(-)	1.0(-)	0.01
	>36	29(57.7)	120(38.1)	2.1(1.2 – 4.0)	2.8(1.4 - 5.7)[c]	
Referral	Yes	77(71.3)	84(16.8)	2.2(1.3-3.6)	11.5(7.0-19.7)[c]	0.00
	No	31(28.7)	416(83.2)	1.0(-)	1.0(-)	
Premature rupture of membranes	Yes	76(70.4)	111(22.3)	8.3(5.2- 13.1)	11.3(6.4 – 20.0)[c]	0.00
	No	32(29.6)	386(77.7)	1.0(-)	1.0(-)	
Length of first stage of labour in hours	=<18	16(14.8)	435(87.2)	1.0 (-)	1.0(-)	
	>18	92(85.2)	65(12.8)	5.6(2.4-13.0)	3.3(1.1- 10.2)[c]	0.05
Sex of baby	Female	35(32.4)	252(50.4)	1.0 (-)	1.0(-)	
	Male	73(67.6)	248(49.6)	2.1 (1.4- 3.8)	2.3(1.3- 4.0)[c]	0.00
Haemoglobin gm/dl	<10	49(45.4)	75(15.0)	6.8(4.3- 10.7)	6.4(3.8- 10.8)[c]	0.00
	=>10	59(54.6)	425(85.0)	1.0 (-)	1.0(-)	

a: Adjusted for distance from home to Mulago hospital, patients job, type of house they were living in, person paying for treatment, age, asking for permission and family hypertension.

b: Adjusted as in (a) plus existing hypertension

c: Adjusted as in (b) plus previous scar and previous PPH.

Table 5.7 Risk factors for ruptured uterus

Variable	Stratum	Cases N (%)	Controls N (%)	Crude odds ratio (95% CI)	Adjusted odds ratio (95% CI)	P value
Distance from home to Mulago in (km)	0-5	18(34.6)	333(66.0)	1.0(-)	1.0(-)	0.00
	6-10	22(44.3)	139(27.8)	2.9(1.5- 5.6)	2.0(1.0- 4.2)[a]	
	11-15	12(23.0)	28(5.6)	8.6(3.8- 19.3)	6.7(2.1- 21.2)[a]	
Age	14-19	5(9.6)	155(31.0)	0.1(0.0-0.4)	0.1(0.0-0.4)[a]	0.00
	20-29	36(69.2)	262(52.4)	1.0(-)	1.0(-)	
	30+	11(21.2)	83(16.6)	0.9(0.6-1.9)	0.8(0.4-1.8)[a]	
Tribe	Bantu	42 (80.8)	454(90.8)	1.0(-)	1.0(-)	0.01
	others	10(19.2)	46(9.2)	2.4(1.1 -5.0)	2.4(1.0- 5.4)[a]	
Type of house	Brick, plastered	30 (57.7)	417(82.6)	1.0(-)	1.0(-)	0.05
	Brick only	16(30.8)	69(14.6)	3.6(1.1- 11.6)	2.5(1.2- 7.1)[a]	
	Mud only	6(11.5)	14(2.8)	2.6(1.4- 5.3)	2.0(0.5- 7.4)[a]	
Requesting for permission to visit HU	Yes	15(28.8)	47(9.4)	1.0(-)	2.5(1.2- 5.4)[a]	0.02
	No	37(71.2)	453(90.6)	3.2(1.6- 3.2)	1.0(-)	
Who pays for treatment	Self and spouse	47(90.3)	460(92.0)	1.0 (-)	2.2(1.1- 4.3)[a]	0.01
	Others	5(9.7)	40(8.0)	1.8(0.8- 4.2)	1.0(-)	
Previous labour lasting more than 18hrs	Yes	14(31.1)	77(22.0)	2.0(1.0- 3.8)	2.3(1.5 - 4.9)[b]	0.07
	No	31(68.9)	273(78.0)	1.0 (-)	1.0(-)	
Previous caesarean Section	Yes	19 (41.3)	15(1.0)	18.6(7.7- 40.9)	22.3(9.2- 54.2)[b]	0.00
	No	27(58.7)	355(99.0)	1.0 (-)	1.0(-)	
Number of pregnancy	1	7 (13.5)	150(30.0)	0.3(0.1- 0.7)	0.1(0.1 -0.5)[c]	0.00
	2-5	39(75.0)	272(54.4)	1.0 (-)	1.0(-)	
	6-14	6(11.5)	78(15.6)	0.52(0.21- 1.27)	0.6(0.3- 1.3)[c]	
Birth spacing in months	1-36	27 (59.6)	216(61.9)	1.0 (-)	1.0(-)	0.02
	37-60	8(17.0)	91(26.0)	0.7(0.3- 1.6)	0.9(0.4-2.0)[c]	
	More than 60	11(23.4)	43(12.1)	2.0 (0.9- 4.4)	3.4(1.4- 8.1)[c]	
Antennal care attendance	Yes	47(90.4)	485(97.0)	1.0(-)	1.0(-)	0.00
	No	5 (9.6)	15(3.0)	3.4(1.2- 9.7)	4.7(1.6-13.7)[c]	
Response to vaginal bleeding	Go to hosp	40 (76.9)	481(96.2)	1.0 (-)	1.0(-)	0.00
	Don't know	12 (23.1)	19(3.2)	7.6(2.2- 29.6)	7.3(2.9- 18.3)[c]	
Referral	Yes	27 (51.9)	84(16.8)	5.1(2.9- 9.3)	3.4 (1.8- 6.8)[c]	0.00
	No	25(48.9)	416(83.2)	1.0(-)	1.0(-)	
Bleeding in labour	Yes	20 (38.5)	6(1.2)	49.8(18.7- 98.4)	27.9(10.6-120.3)[c]	0.00
	No	32(61.5)	493(98.8)	1.0(-)	1.0(-)	
Length of labour first stage in hours	<=18	12(23.1)	435(87.2)	1.0(-)	1.0(-)	0.00
	>18	40(76.9)	65(12.8)	22.2(10.6-47.6)	32.1(4.6-165.4)[c]	
Birth weight in grams	< 2500	3 (5.9)	35(7.0)	1.1(0.3-3.7)	1.7(0.46- 6.0)[c]	0.05
	2500-3500	28(54.9)	350(70.0)	1.0 (-)	1.0(-)	
	>3500	20(39.2)	115(23.0)	2.2(1.2- 4.0)	2.4(1.2-4.7)[c]	
HIV	Negative	42 (80.8)	455(91.0)	1.0 (-)	1.0(-)	0.02
	Positive	10(19.2)	45(9.0)	2.4(1.1- 4.2)	3.2(1.5-7.2)[c]	
Haemoglobin gm/dl	<10	12 (23.1)	75(15.0)	19.4 (9.7-38.5)	20.2(9.3- 43.7)[c]	0.00
	=>10	40 (76.9)	425(85.0)	1.0(-)	1.0(-)	

a: Adjusted for age, type of house, the type of transport used, the distance from home to Mulago hospital, permission to attend health unit, and person paying for hospital upkeep.

b: Adjusted as in (a) plus existing hypertension.

c: Adjusted as in (b) plus previous delivery by caesarean section.

Table 5.8 Risk factors placenta praevia

Variable	Stratum	Cases N (%)	Controls N (%)	Crude odds ratio (95% CI)	Adjusted odds ratio (95% CI)	P value
Distance from home to Mulago in km	0-5	12 (33.3)	333(66.6)	1.0(-)	1.0(-)	
	6-10	11(30.6)	139(27.8)	2.2(0.9 - 5.4)	2.4(1.0- 5.7)[a]	0.00
	11-15	13 (36.1)	28(5.6)	12.9(5.4-30.9)	21.4(7.4 - 63.7)[a]	
Patients job	Employed	16 (45.5)	128(25.6)	2.6(1.3 - 5.2)	2.3(1.0- 5.2)[a]	0.05
	Peasant	20(55.5)	372(74.0)	1.0 (-)	1.0(-)	
Requesting for permission to visit HU	Yes	11(30.6)	47(9.4)	5.4(2.6 -11.5)	3.2(1.3- 7.5)[a]	0.00
	No	25 (69.4)	453(90.6)	1.0(-)	1.0(-)	
Evacuation of uterus (all patients)	Yes	5(13.9)	20(4.0)	3.9(1.4 - 11.1)	3.6(1.1- 12.5)[a]	0.04
	No	32(86.1)	480(96.0)	1.0(-)	1.0(-)	
Previous caesarean section	Yes	10 (27.8)	15(4.3)	12.4 (5.8, 30.5)	19.9(6.4- 61.7)[b]	0.00
	No	19(72.2)	335(95.7)	1.0(-)	1.0(-)	
Bleeding during this pregnancy	Yes	6 (16.7)	3(0.6)	26.7(6.1 - 117.0)	9.9(1.3-77.8)[b]	0.00
	No	30(83.3)	497(99.4)	1.0 (-)	1.0(-)	
Response to vaginal bleeding during pregnancy	Go to hospital	29(80.8)	481(96.2)	1.0(-)	1.0(-)	0.00
	Don't know	7(19.4)	19(3.8)	6.1(2.4 – 15.7)	7.3(2.4- 22.0)[c]	
Birth weight in grams	< 2500	14(38.9)	13(2.6)	21.3(8.6 - 52.8)	18.9 (7.1 - 50.3)[c]	0.00
	2500-3500	16(44.4)	317(64.3)	1.0(-)	1.0(-)	
	>3500	6(16.7)	170(34.0)	0.7(0.2- 1.2)	0.5 (0.1 -1.9)[c]	
Haemoglobin in gm/dl	<10	7(19.4)	75(15.0)	23.5(9.9 - 55.5)	32.2(10.8- 96.0)[c]	0.00
	>9.99	29(80.6)	425(85.0)	1.0(-)	1.0(-)	

a: Adjusted for age, distance from home to hospital, patient's job, and asking for permission to visit a hospital.

b: Adjusted as in (a) plus evacuation of uterus.

c: Adjusted as in (b) plus previous caesarean section.

Table 5.9 Risk factors for abruptio placenta

Variable	Stratum	Cases N (%)	Controls N (%)	Crude odds ratio (95% CI)	Adjusted odds ratio (95% CI)	P value
Distance from home to Mulago in km	0-5	14(31.1)	333(66.6)	1.0(-)	1.0(-)	0.00
	6-10	21(46.7)	139(27.6)	3.1(1.8-7.3)	2.7(1.3-5.7)[a]	
	11-15	10 (22.2)	28(5.6)	8.5 (3.5-20.9)	4.3(1.6- 11.4)[a]	
Type of house	Brick, plastered	20 (43.5)	417(83.4)	1.0(-)	1.0(-)	0.00
	Brick only	17(37.0)	69(13.8)	5.1(2.6 - 10.3)	3.7(1.8-7.8)[a]	
	Mud only	9(19.0)	14(2.8)	13.4(5.17-34.7)	10.5(3.8-29.2)[a]	
Requesting for permission to visit HU	Yes	14(31.1)	47(9.4)	3.4(1.65- 7.01)	2.3(1.0- 5.2)[a]	0.02
	No	31 (68.9)	458(90.6)	1.0(-)	1.0(-)	
Taking alcohol	Yes	6 (13.3)	137(27.4)	0.4(0.2- 0.9)	0.3(0.1-0.9)[a]	0.03
	No	39(86.7)	368(72.6)	1.0(-)	1.0(-)	
Hypertension (self)	Yes	6 (13.3)	2(0.4)	38.3(7.5- 196.1)	56.8(9.0- 358.5)[a]	0.00
	No	39(86.9)	498(99.6)	1.0(-)	1.0(-)	
Previous still birth	Yes	6 (15.6)	26(7.4)	2.8(1.1- 7.0)	3.1(1.1- 9.1)[b]	0.04
	No	27(84.4)	324(92.6)	1.0(-)	1.0(-)	
Previous caesarean	Yes	7 (8.7)	15(4.3)	6.0(2.0- 17.1)	7.3(1.8-29.7)[b]	0.00
	No	26(81.3)	335(95.7)	1.0(-)	1.0(-)	
Antennal care attendance	Yes	39(86.7)	485(97.0)	1.0(-)	6.5 (2.0-21.2)[c]	0.00
	No	6(13.7)	15(3.0)	6.2(1.8- 13.5)	1.0(-)	
Bleeding during this pregnancy	Yes	6(15.3)	3(0.6)	25.5(6.1 - 105.9)	26.7 (8.6- 85.4)[c]	0.00
	No	39(86.7)	497(99.4)	1.0(-)	1.0(-)	
Having hypertension in this pregnancy	Yes	16(35.0)	10(5.6)	22.5(11.6 - 84.6)	22.7(7.4- 69.7)[c]	0.00
	No	29(64.4)	490(94.4)	1.0 (-)	1.0(-)	
Referral	Yes	27(60.0)	84(16.8)	7.4(3.9, 14.1)	7.0(3.4 - 14.5)[c]	0.00
	No	18(40.0)	416(83.2)	1.0(-)	1.0(-)	
Bleeding in labour	Yes	34 (75.6)	6(1.2)	254.0(88.6- 728.4)	18.2(3.8- 88.4)[c]	0.00
	No	11(24.4)	493(98.8)	1.0 (-)	1.0(-)	
Sex of baby	Male	32(71.1)	252(50.2)	2.2(1.2-4.9)	1.9(1.0-3.8)[c]	0.05
	Female	13(28.9)	248(49.6)	1.0(-)	1.0(-)	
Birth weight in grams	< 2500	21 (46.7)	13(2.6)	30.1(12.9-70.2)	24.6(9.2- 65.9)[c]	0.00
	2500-3500	17(37.8)	317(63.4)	1.0(-)	1.0(-)	
	>3500	7(15.6)	170(34.0)	0.8(0.3- 1.9)	0.6(0.4 -2.4)[c]	
Haemoglobin gm/dl	<10	36(80.0)	75(15.0)	22.67(10.5- 49.0)	35.5(13.6- 92.6)[c]	
	=>10	9(20.0)	425(85.0)	1.0 (-)	1.0(-)	
Platelets	<150	19(41.3)	54(10.8)	11.7(6.1- 22.5)	8.6(4.2- 17.6)[c]	0.00
	>=150	27(58.7)	446(89.2)	1.0(-)	1.0(-)	

a: Adjusted for age, distance from home to Mulago, type of house and asking for permission to attend health unit.

b: Adjusted as in (a) plus hypertension.

c: Adjusted as in (b) plus previous delivery by caesarean section and previous still birth.

Table 5.10 Summary table for adjusted odds ratio (95% confidence intervals) for all SMM, non referrals and individual causes

Variable	SMM	Non referrals SMM	Eclampsia	PPH	Obstructed labour	Ruptured uterus	Placenta praevia	Abruptio placenta
Long distance from home to Mulago	**7.3(1.8-3.7)**	**7.0(2.8-17.6)**	**3.8(1.9-7.7)**	**4.8(1.9-7.7)**	**6.7(2.6-17.1)**	**6.7(2.1-21.2)**	**21.4(7.4-63.7)**	**4.3(1.6-11.4)**
Age <20	1.2(0.8-1.6)	0.9(0.6-1.4)	1.2(0.7-1.9)	0.8(0.4-1.4)	1.2(0.2-1.1)	**0.1(0.0-0.4)**	0.7(0.3-2.4)	0.9(0.4-2.2)
Nilotics versus Bantu	1.3(0.8-2.0)	1.0(0.5-1.8)	1.4(0.5-3.8)	0.8(0.3-2.4)	1.1(0.4-3.3)	**2.4(1.0-5.4)**	0.6(0.1-2.0)	1.6(0.7-4.2)
Professional versus peasants	**2.5(1.3-5.0)**	**2.5(1.0-11.8)**	**8.3(3.0-23.1)**	2.2(0.9-9.1)	1.4(0.3-6.0)	1.5(0.7-3.9)	**2.3(1.0-5.2)**	1.0(0.5-1.8)
Low quality house	**4.5(2.3-8.7)**	**3.5(2.3-19.6)**	**7.6(3.9-26.9)**	**3.3(1.1-9.9)**	**3.1(1.2-8.0)**	**2.5(1.2-5.4)**	-	**3.7(1.8-7.8)**
Requesting for permission to visit health unit	**3.3(2.2-4.9)**	**3.6(2.1-6.3)**	**3.1(1.7-5.3)**	**3.2(1.7-9.2)**	**2.2(1.1-4.1)**	**2.5(1.2-5.4)**	**3.2(1.3-7.5)**	**2.3(1.0-5.2)**
Un able to pay for hospital upkeep	**5.0(2.9-9.8)**	**2.2(1.2-4.1)**	**5.6(2.5-12.6)**	**3.6(1.8-7.2)**	**2.3(1.2-4.4)**	**2.2(1.1-4.3)**	0.8(0.3-3.9)	2.5(0.9-21.6)
Has family history of hypertension	1.1(0.9-1.6)	1.4(1.0-2.1)	**1.9(1.2-2.9)**	1.3(0.4-2.2)	2.9(0.9-8.2)	1.2(0.6-2.4)	0.6(0.3-1.3)	1.1(0.5-2.1)
Hypertension (self)	**11.8(2.6-54.4)**	**11.6(1.7-80.1)**	**26.9(4.3-170.4)**	**9.3(1.7-51.7)**	1.3(0.5-3.0)-	-	10.0(0.8-125.4)	**56.8(9.0-358.5)**
Previous evacuation / dilation and curettage	**2.0(1.2-3.9)**	2.1(0.9-5.0)	-	0.4(0.2-1.1)	1.1(0.4-10.5)	2.2(0.3-16.5)	**3.6(1.1-12.5)**	1.1(0.3-8.3)
Previous history of abortion	0.9(0.6-1.6)	**1.3(0.7-2.6)**	**2.6(1.3-5.1)**	1.3(0.0.5-3.0)	0.3(0.1-1.3)	1.1(0.4-3.3)	1.0(0.3-3.8)	1.7(0.2-5.4)
Previous delivery of still birth	1.2(0.6-2.1)	1.0(0.4-2.1)	1.7(0.8-3.4)		1.1(0.4-3.3)	1.2(0.4-3.9)	-	**3.1(1.1-9.1)**
Previous history of hypertension in pregnancy	1.2(0.6-2.6)	1.9(0.7-4.5)	**2.6(1.0-6.6)**	2.1(0.9-8.6)	0.8(0.2-3.7)	-	-	-
Previous delivery by caesarean section	**5.6(3.0-10.4)**	**12.1(5.7-25.9)**	**3.8(1.6-9.1)**	**7.5(3.5-14.3)**	**4.7(2.0-14.8)**	**22.3(9.2-54.2)**	**19.9(6.4-61.7)**	**7.3(1.8-29.7)**
Having history of PPH	1.3(0.5-3.2)	2.1(0.7-5.8)	0.7(0.1-3.8)	**3.6(1.1-11.8)**	1.0(0.2-3.5)	1.0(0.1-8.8)	0.9(0.1-7.8)	2.4(0.7-8.8)
Birth spacing of more than 60 months	**2.6(1.5-4.9)**	**3.4(1.4-8.0)**	**8.3(2.6-26.4)**	**5.2(2.1-13.0)**	**2.8(1.4-5.7)**	**3.4(1.4-8.1)**	0.8(0.3-2.4)	3.0(0.9-10.6)
Nulliparity	**1.6(1.1-2.3)**	**2.0(1.1-3.6)**	**2.2(1.2-4.3)**	1.4(0.8-2.3)	**3.2(1.6-6.3)**	**0.1(0.1-0.5)**	0.6(0.2-2.0)	0.5(0.0-18.2)
Grand multiparity	0.6(0.3-1.0)	0.9(0.5-1.7)	**0.4(0.1-1.0)**	0.6(0.4-1.7)	0.5(0.2-1.3)	0.6(0.3-1.3)	0.4(0.1-1.2)	0.8(0.2-2.9)

Variable	SMM	Non referrals SMM	Eclampsia	PPH	Obstructed labour	Ruptured uterus	Placenta praevia	Abruptio placenta
No antenatal care	**4.0(2.1-7.8)**	**5.6(2.5-12.5)**	**3.4(1.4-8.5)**	**4.7(1.8-12.4)**	1.8(0.8-5.2)	**4.7(1.6-13.7)**	2.7(0.5-15.1)	**6.5(2.0-21.2)**
Blood pressure not checked during antenatal	**2.6(1.1-6.1)**	**2.6(1.1 - 6.1)**	**2.5(1.2-5.2)**	0.9(0.5-1.4)	-	-	-	-
Didn't know what to do when she bleeds during pregnancy	**12.7(7.4-22.0)**	**8.6(3.6-20.2)**	**10.8(5.8-24.0)**	**17.3(7.5-39.0)**	**13.2(6.1-28.4)**	**7.3(2.9-18.3)**	**6.1(2.4-15.7)**	-
Diagnosed with hypertension during antenatal	**12.3(6.0-25.2)**	**11.3(5.9-22.3)**	**81.8(32.9-203.5)**	**3.1(1.0-10.5)**	-	2.9(0.6-14.7)	3.6(0.5-27.5)	**22.7(7.4-69.7)**
Diagnosed with anaemia during antenatal	**4.4(1.3-14.4)**	**4.6(1.4-14.6)**	-	**6.1(1.1-35.4)**	-	-	-	-
Referral	**6.4(4.5-9.1)**	N/A	**5.2(3.0-8.9)**	**6.5(3.8-11.2)**	**2.7(1.9-5.6)**	**3.4(1.8-6.8)**	**2.8(1.1-7.4)**	**7.0(3.4-14.5)**
Bleeding during pregnancy	2.8(0.7-9.5)	**7.1(1.7-35.1)**	1.9(0.3-12.0)	3.4(0.7-17.8)	-	-	**19.9(1.3-77.8)**	**26.7(8.6-85.4)**
Admitted during pregnancy	**1.9(1.1-3.2)**	**2.1(1.0-4.9)**	**3.1(1.5-6.4)**	**2.7(1.2-6.5)**	-			-
Premature rupture of membranes	**2.3(1.7-3.3)**	**2.9(1.8-4.9)**	-	1.4(0.9- 2.8)	**11.3(6.4-20.0)**	**4.6(2.1-9.9)**	-	-
Trial of scar	**3.4(1.8-6.9)**	**5.5(2.6-11.5)**	-	-	-	-	-	-
Bleeding in labour	**7.0(2.3-16.0)**	**2.3(1.2-7.2)**		**31.5(10.6-93.3)**	5.4(0.9-16.3)	**27.9(9.6-81.3)**		**18.2(3.8-88.4)**
Labour lasting more than 18 hours	3.4(0.9-13.4)	2.7(0.9-5.3)	2.8(0.9-9.0)	0.7(0.4-1.3)	**3.3(1.1-10.2)**	-	-	-
Prolonged third stage	**22.6(3.9-120.7)**	**11.2(2.1-61.1)**	4.1(0.2-114.6)	**49.1(18.8-342.8)**	-	-	-	-
Not given oxytocics	**3.1(1.4-6.4)**	**2.8(1.0-8.3)**	4.8(0.9-17.5)	**12.2(5.0-21.3)**	-	-	-	-
Delivered low birth weight	**5.1(3.3-8.1)**	**4.5(2.4-8.8)**	**23.5(10.4-52.7)**	**6.1(2.2-16.7)**	-	1.7(0.5-6.0)	**18.9(7.1-50.3)**	**24.6(9.2-65.9)**
Delivered baby >3500 grams	1.2(0.8-1.7)	1.3(0.7-2.2)	**0.3(0.2-0.7)**	0.8(0.4-1.4)	1.4(0.9-2.3)	**2.4(1.2-4.7)**	0.3(0.1-18.2)	1.0(0.2-2.9)
Delivered male baby	1.2(0.9-1.6)	1.2(0.7-1.4)	**1.5(1.0-2.3)**	1.2(0.8-2.1)	**2.3(3.8-10.8)**	1.1(0.7-2.1)	1.0(0.3-2.9)	**1.9(1.0-3.8)**
HIV positive	**1.6(1.0-2.5)**	1.9(1.0-4.0)	0.5(0.2-1.2)	1.5(0.8-3.2)	1.6(0.7-3.5)	**3.2(1.5-7.2)**	1.6(0.3-7.5)	0.8(0.2-2.9)
Haemoglobin below 10grams/dl	**7.8(5.6-10.5)**	**6.6(4.0-10.9)**	**2.7(1.6-4.4)**	**17.3(9.5-31.7)**	**6.4(3.8-10.8)**	**20.2(9.3-43.7)**	**32.2(10.8-96.0)**	**35.5(13.6-92.6)**
Platelets below $150x10^9/l$	**3.1(2.0-4.8)**	**2.5(1.4-4.5)**	**4.5(2.7-7.7)**	**4.2(2.3-7.6)**	-	-	1.3(0.4-4.1)	**8.6(4.2-17.6)**

Figure 5.1 Distribution of a total of 565 recorded causes of severe maternal morbidity in 499 cases

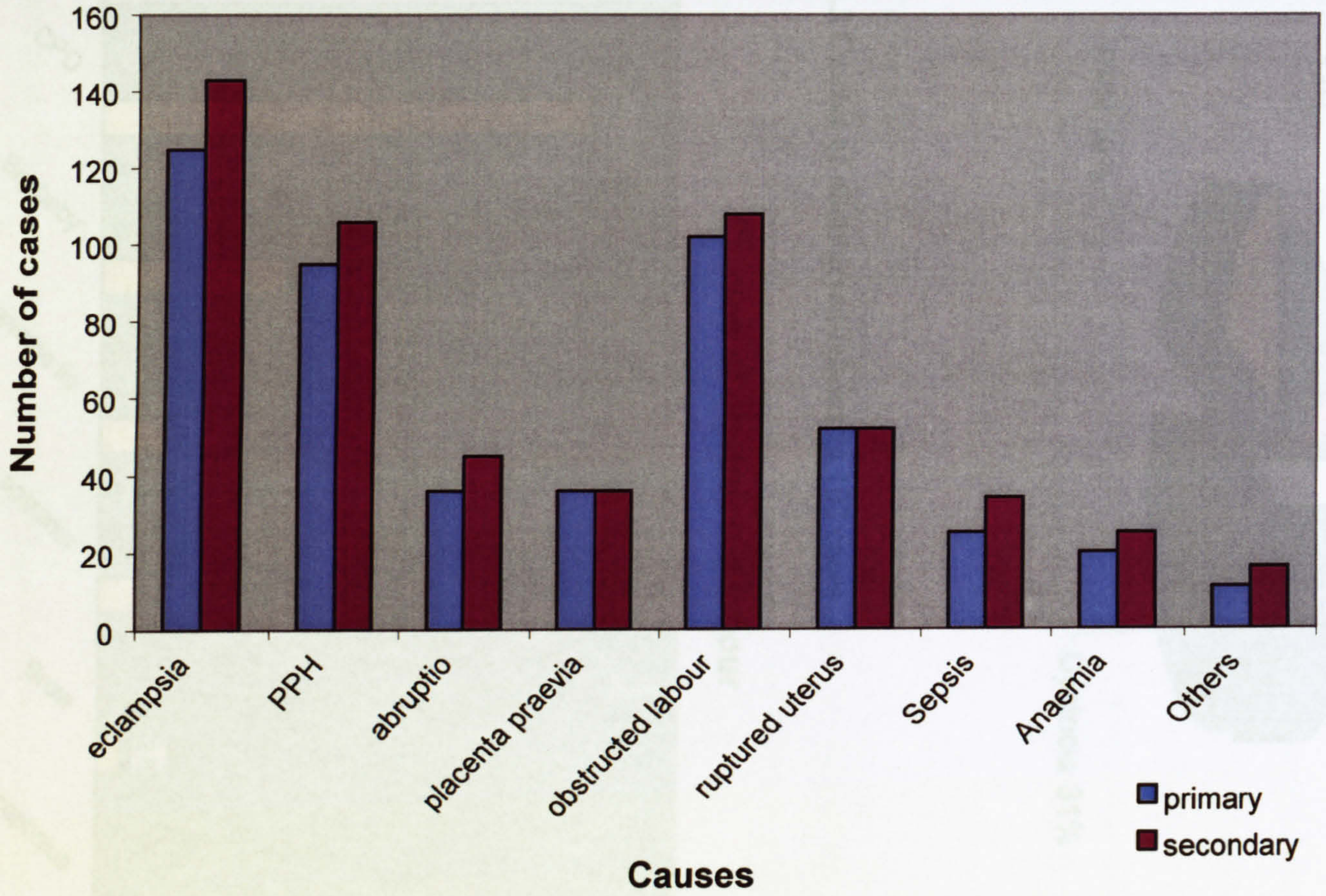


Figure 5.2 Primary causes (%) of SMM in 499 cases

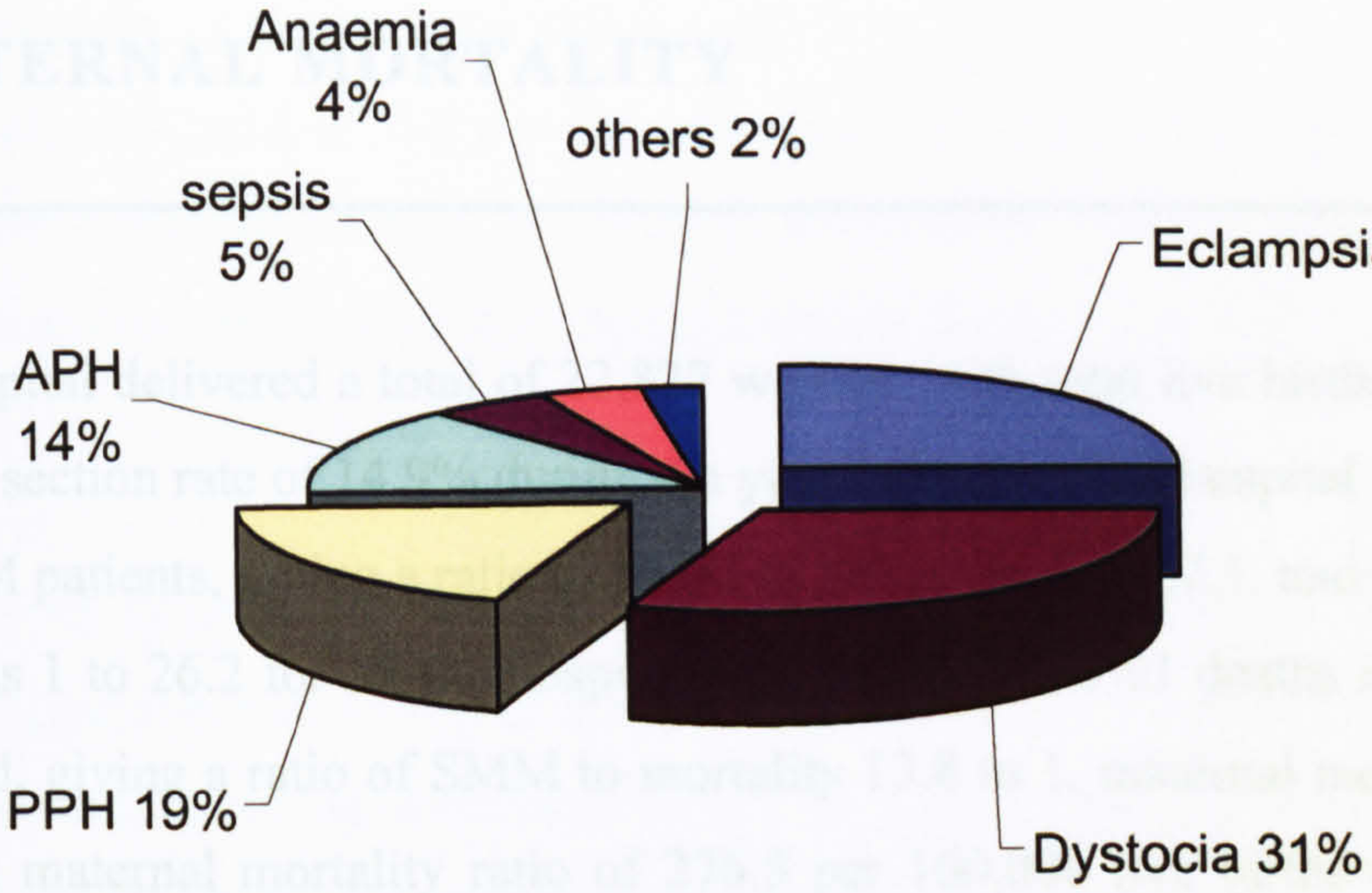
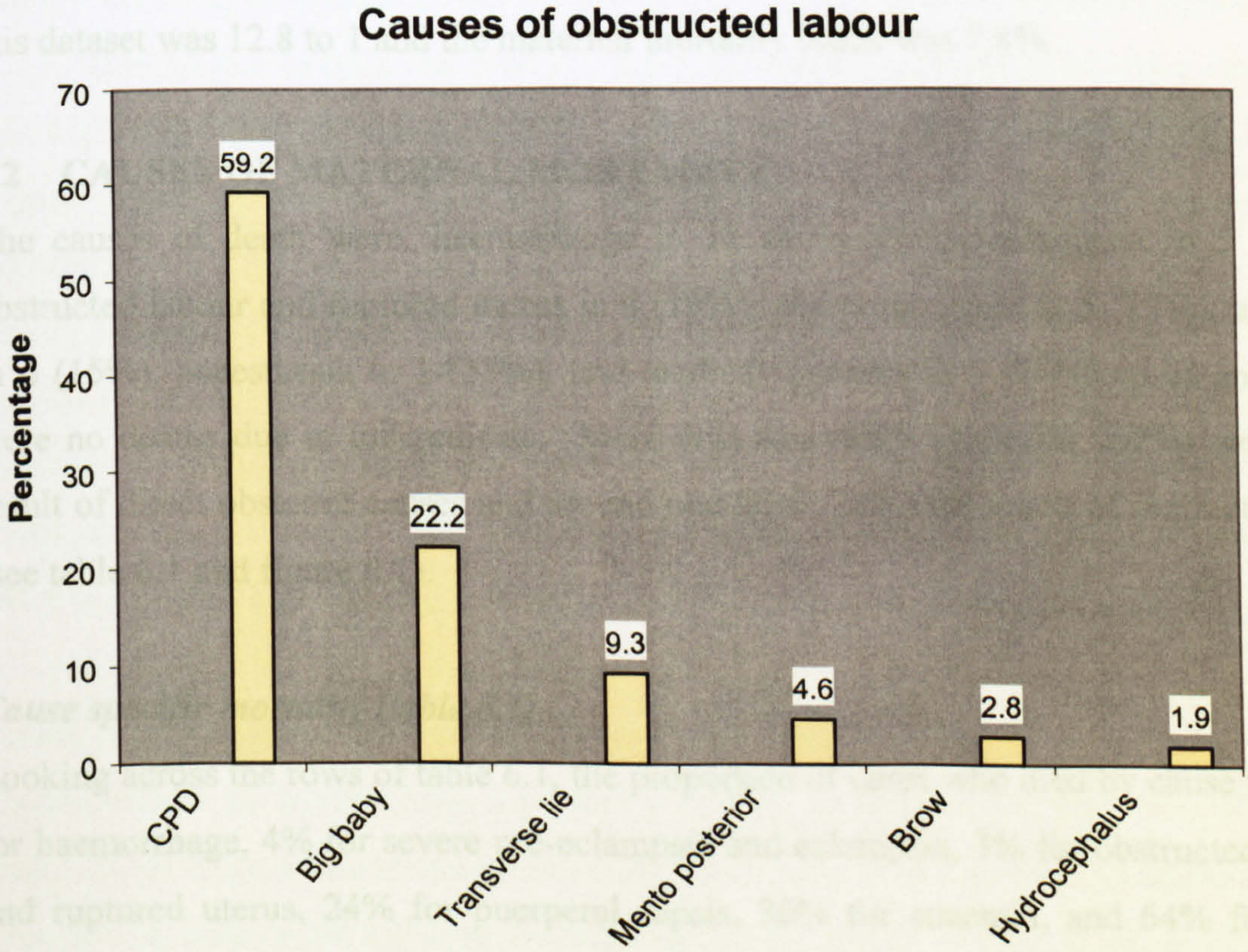


Figure 5.3 Causes of obstructed labour in 102 cases



CHAPTER SIX: RESULTS FROM STAGE 2 - STUDY OF PROGRESSION FROM SEVERE MATERNAL MORBIDITY TO MATERNAL MORTALITY

Mulago hospital delivered a total of 22,827 women, with total live births of 22,059 and a caesarean section rate of 14.9% during the year of study. The hospital recorded a total of 843 SMM patients, giving a ratio of SMM to deliveries 1 to 27.1, and a ratio of SMM to live births 1 to 26.2 for all the hospital data. There were 61 deaths in total over the study period, giving a ratio of SMM to mortality 13.8 to 1, maternal mortality index of 7.2% and a maternal mortality ratio of 276.5 per 100,000 live births for the hospital data.

6.1 NUMBERS IN STUDY

The study followed up 499 severe morbidity cases recruited as part of the case- control study. Of these, 460 survived and 39 died. The ratio of SMM to maternal mortality in this dataset was 12.8 to 1 and the maternal mortality index was 7.8%.

6.2 CAUSES OF MATERNAL MORTALITY

The causes of death were: haemorrhage in 12 cases (31%); eclampsia in 5 (13%); obstructed labour and ruptured uterus in 4 (10%); puerperal sepsis in 5 (13%); anaemia in 6 (15%); anaesthesia in 1 (23%); and medical diseases in 6 (15%) cases and there were no deaths due to tuberculosis. More than two thirds of deaths (69%) were as a result of direct obstetric causes and around one third (31%) the result of indirect causes (see table 6.1 and figure 6.1).

Cause specific mortality (table 6.1)

Looking across the rows of table 6.1, the proportion of cases who died by cause was 7% for haemorrhage, 4% for severe pre-eclampsia and eclampsia, 3% for obstructed labour and ruptured uterus, 24% for puerperal sepsis, 30% for anaemia, and 64% for other medical diseases.

6.3 CHARACTERISTICS OF WOMEN IN THE STUDY (univariate analysis)

Table 6.2 describes the characteristics of women with SMM who died (n=39) and those

who did not die (n=460).

Socio demographic characteristics (table 6.2i)

Approximately one third of the women who died and one half of those who survived lived less than 6 kilometres from the Mulago hospital, but 26% of those who died and 14% of the survivors lived more than ten kilometres away (crude OR = 2.9, 95% CI 1.2 to 7.0).

The majority of women who died were between the ages of 20 and 29 years (77%), compared to just over half (55%) of the survivors. About 90% of women who died and 85% of those who survived were aged below 30 years. Overall, the mean age for the survivors was 22.3 (SD=2.3 years) and was similar to those who died was 23.6 (SD = 4.7 years).

The educational level was similar, with 95% of those who died and 92% of survivors spending twelve or less years in school. A lower proportion of women who died were employed (13%) compared to 70% of survivors (crude for peasant versus employed OR = 0.3, 95% CI 0.1 to 0.9). In contrast, the proportion of spouses who were employed was higher for women who died (82%) than for women who survived (79%), but not significantly so (crude OR = 0.8, 95% CI 0.3 to 2.3). There was no clear evidence for a difference in the type of housing for the two groups of women (crude OR for the lowest quality housing = 0.5, 95% CI 0.1 to 1.7). A higher proportion of women who died needed to ask for permission to attend the health unit (51%) compared to women who survived (31%) (crude OR = 2.4, 95% 1.2 to 4.5) but the proportion of women who relied on others to pay for medical treatment differ significantly in both groups (crude OR = 0.7, 95% CI 0.3 to 1.8).

Social, family and medical history characteristics (table 6.2ii)

Three-quarters of women who died had a history of familial hypertension compared with 52% of those who survived (crude OR = 2.7, 95% CI 1.2 to 6.0). In addition, those who had a history of existing hypertension was higher (10%) in those who died compared to those who survived (4%) (crude OR = 2.7, 95% CI 0.9 to 8.2). Admission to hospital at any time in during the present pregnancy was more common in women who died (18%) compared to women who did not die (9%) (crude OR = 2.6, 95% CI 1.1 to 5.9).

Past obstetric performance (table 6.2iii)

The proportions of subjects with a history of previous abortion were similar in groups, 14% in those who died and 14% in the survivors. Similarly, there were no significant differences in the proportions of women who died and women who survived with respect to other adverse obstetric events, including bleeding, stillbirth, long labour, hypertension or blood transfusion. However, some of these analyses were based on very small numbers of deaths. The proportion of women who delivered by caesarean section in previous pregnancy was 24% in those who died and 22% in survivors (crude OR = 1.6, 95% CI 0.7 to 4.0).

Characteristics of the current pregnancy (table 6.2iv)

A lower proportion of women who died (28%) compared to survivors (38%) were nulliparous (crude OR = 0.4, 95% CI 0.2 to 0.9) or grand multipara (8% of women who died and 18% of survivors (crude OR = 0.2, 95% CI 0.0 to 1.0). The majority of women who died (64%) were gravidae two to five.

Antenatal clinic attendance was more common in those who survived (90%) than those who died (56%) (crude OR = 5.9, 95 %CI 3.0 to 11.9) and when women were asked what they would do if they had vaginal bleeding during pregnancy, about half (49%) cases and (24%) controls did not know what to do (crude OR = 2.9, 95% CI 1.2 to 7.0). The proportion of referrals was similar for those who died (49%) and those who survived (51%) (crude OR = 0.8, 95% CI 0.4 to 1.6). The proportion of deliveries by laparotomy was higher in those who died (16%) compared to those who did not die (11%) (crude OR = 1.1, 95% CI 0.4 to 3.2). A high proportion of women who died delivered male babies (75%) compared to those who survived (51%) (crude OR = 2.9, 95% CI 1.3 to 6.3).

Type of care received while on ward (Quality of care factors table 6.2v)

One third of women who died did not get oxytocics after delivery compared to only 9% of survivors (crude OR = 4.8, 95% CI 2.1 to 11.6). Senior obstetricians cover the labour ward on twenty four hour basis. The obstetrician on duty reviewed 62% of women who died and 68% women who survived within one hour of diagnosis of the complication and there was no statistical difference between these two proportions (P> 0.39). The proportion of patients who were reviewed by an obstetrician six hours or more after

diagnosis of the complication was 28% of women who died and 13% women who survived (P< 0.011).

Patients who had operative delivery waited on average 245 minutes with a range of 20 to 860 minutes. One quarter of women who died compared to approaching one half of women who did not die were delivered within two or less hours after the decision to operate had been made. Sixteen percent of deaths compared to 7% survivors waited for more than ten hours for operation (crude OR = 4.1, 95% CI 0.9 to 18.3). The length of the operation was similar in both groups with a mean time of one hour. It was not uncommon for the hospital to run out of drugs such as magnesium sulphate, antibiotics, intravenous fluids and blood. Sixty four percent of women who died compared to 10% of survivors did not receive blood when most needed due to shortage (crude OR = 13.9, 95% CI 7.9 to 33.6), and one quarter of deaths compared to 5% of survivors had to rely on relatives to buy drugs because of hospital shortage (crude OR = 7.1, 95% CI 3.0 to 17.1). Monitoring of patients after diagnosis of SMM was one of the most important requirements of the management. The monitoring carried out was of blood pressure, pulse, respiratory rates and vaginal bleeding. A higher proportion of women who died were monitored less than six times (13%) compared to those who did not die (8%) (crude OR for monitoring <6 times compared to 6 to 13 times = 6.5, 95% CI 1.4 to 30.6). Similarly, a low frequency of vaginal monitoring (less than 4 times in 24 hours) compared to more frequent monitoring (greater than 8 times in 24 hours) was more common in women who died than in women who survived (crude OR = 6.5, 95% CI 1.4 to 30.1).

Laboratory results (table 6.2vi)

The HIV test was positive in 39% of the women who died and 12% of the women who survived (crude OR = 4.6, 95% CI 2.2 to 9.3). Also CD4 cell count of less than 200 per 10^9/litre in HIV positive patients was more frequent in those who died (80%) compared to those who survived (46%) (crude OR = 4.8, 95% CI1.2 to 18.9). Thirteen percent of women who died where syphilis test positive compared to 8% of survivors (Crude OR = 1.7, 95% CI 0.5 to 4.7). Seventy four percent of deaths and 59% survivors had a haemoglobin level of less than 10g/dl (crude OR = 2.1, 95% CI 0.9 to 4.6).

6.4 ADJUSTED ANALYSES

Factors found to be of importance in univariate analyses (table 6.2) were entered into a

multivariate regression model using the methods described in Chapter 4. Age was included in this model so as to be consistent with other studies. Table 6.3 presents a summary of the adjusted odds ratios for factors found to be independently statistically significantly related to risk of death. The factors used for adjustment are presented as footnotes. Cause of morbidity was included as an extra adjustment factor in a second series of analyses, the results also presented in table 6.3 (final column).

Puerperal sepsis and medical disease was associated with three times and eleven times higher risk of death respectively than post partum haemorrhage (adj. OR = 3.4, 95% CI 1.0 to 11.2 and OR = 11.3, 95% CI 2.7 to 46.6 respectively). The further the severe morbidity patient lived a way from the hospital the higher the risk of progressing to maternal mortality: Women who lived between more than 10 and 15 kilometres had more than treble the risk of death compared to those who lived five or less kilometres from the hospital (adj. OR 3.1, 95% CI 1.0 to 9.3). Being employed was a protective factor (adj. for employed versus peasant OR = 0.2, 95% CI 0.1 to 0.7) and having to ask for permission to visit the hospital or health unit was associated with a trebling of risk (adj. OR = 3.2, 95% CI 1.4 to 7.0). A previous history of admission to hospital for any medical reason increased the risk of progressing to maternal mortality (adj. OR = 3.8, 95% CI 1.1 to 10.5) as did previous delivery by caesarean section (adj. OR = 2.7, 95% CI 1.0 to 7.8).

Women who did not attend antenatal care and who did not know what to do if vaginal bleeding occurred had higher risks of dying than women who did attend and who did know that they needed to seek medical advice (adj. OR = 4.0, 95% CI 1.3 to 9.2 and adj. OR = 4.3, 95% CI 1.2 to 7.0, respectively). Patients who were diagnosed with anaemia during the antenatal period had more than seven times the risk of progressing to maternal mortality compared with women who did not have anaemia (adj. OR = 6.7, 95% 1.4 to 31.3).

Not getting oxytocics soon after delivery of the baby was associated with a four fold increased risk of death compared to those who did receive them (adj. OR = 4.0, 95% CI 1.7 to 9.7). Patients who delivered male babies also had a four times the risk of progressing to maternal mortality compared to those who delivered female babies (adj. OR = 4.0, 95% CI 1.6 to 10.1).

When patients developed an SMM complication and were not seen by the obstetrician on duty within six hours of diagnosis there was an increased risk of death. (adj. OR = 2.2, 95% CI 1.1 to 4.6). Fifty eight percent of severe morbidity patients had operative deliveries. Those who waited for operative delivery for ten or more hours had an increased risk compared to those who waited for under two hours (adj. OR = 4.6, 95% CI 1.1 to 39.6). Lack of an essential drug or blood at a time when it was needed was also associated with an increased risk of progressing to maternal mortality (adj. OR = 3.6, 95% CI 1.1 to 11.3 and adj. OR = 10.1, 95% CI 94.2 to 24.3). Women whose pulse and blood pressure was monitored infrequently post partum had increased risk of mortality compared to those who were monitored more often (adj OR for monitoring less than six times compared to more than 13 times = 5.6, 95% CI 1.2 to 25.7). Similarly, mortality was dramatically higher for women who were monitored infrequently for vaginal bleeding in the first 24 hours following delivery (adj OR for monitoring less than 4 times compared to monitoring more than 9 times = 27.3, 95% CI 4.1 to 182.6).

Mortality was five times higher in HIV positive women compared to HIV negative women (adj. OR = 5.1, 95% CI 2.0 to 12.8). Similarly, HIV positive patients with CD4 cell counts less than $200x10^9$ per litre had almost six times the risk of death compared to HIV positive women with CD4 cell counts at or above $200x10^9$ per litre (adj. OR = 5.9, 95% CI 2.5 to 72.1). Further analysis of excluding puerperal sepsis and medical condition in the multivariate model reduced the odds ratio of HIV (adj. without puerperal sepsis and medical disease cases OR = 3.8, 95% CI 0.9 to 12.5).

When cause of mortality was included in the models the adjusted odds ratios were generally similar to those discussed above (see last column of table 6.3). The exception to this was the result for vaginal monitoring of patients where the risk of progressing to mortality reduced from more than 27 times increased risk for monitoring less than 4 times in 24 hours (compared to monitoring more than 9 times) to four times increased risk (adj. OR = 3.9, 95% CI 1.2 to 12.5). This decrease in effect reflects the fact that women with bleeding are more likely to be checked vaginally, and adjusting for cause of morbidity made suitable allowance for this.

Causes of delay for operation

Two hundred and seventy eight women with SMM, 25 who died and 259 who did not,

had an operation during delivery (see table 6.2). Of these, 20 (79.9%) of the women who died, and 187 (55%) of the women who survived, waited more than two hours to have the operation. The most common cause of the delay for operation was a busy theatre due to other obstetric emergencies, which was reported for 60% of the survivors and 45% of the deaths (table 6.4). The noticeable difference in reason for operative dealt in the women who died compared to the women who survived was shortage of blood (23% of the women who died and 6% of women who survived).

Table 6.1 Cause of severe maternal morbidity and mortality in study

Primary cause of SMM	SMM Cases		Deaths		Case fatality rate (%)
	N	(%)	N	(%)	
Severe pre-eclampsia and eclampsia	125	(25.1)	5	(12.8)	4.0
Post partum haemorrhage	95	(19.0)	12	(30.6)	7.3
Abruptio placenta	33	(6.6)			
Placenta praevia	36	(7.2)			
Obstructed labour	102	(20.4)	4	(10.3)	2.6
Ruptured uterus	52	(10.4)			
Puerperal sepsis	25	(5.0)	5	(12.8)	20.0
Anaemia	20	(4.0)	6	(15.3)	30.0
Others medical diseases	11*	(2.2)	7 +	(17.9)	63.6
Total	**499**	**(100)**	**39**	**(100)**	**8%**

* Medical conditions: Cardiac disease (3), Meningitis (2), Pneumonia (3), pulmonary embolus (2) and Cerebral malaria (1)

\+ Medical conditions: Pulmonary embolus (2), Broncho pneumonia (2), Meningitis (2) and Cardiac disease (1)

Table 6.2 Characteristics of women with SMM who died and women with SMM who survived

(i) Socio-demographic characteristics

Characteristic	Stratum	Deaths N (%)		Survivors N (%)		Crude odds ratio (95% CI)		P value
Distance from home to Mulago (km)	0-5	12	(30.8)	324	(50.9)	1.0	(-)	
	6-10	17	(43.6)	159	(34.6)	2.1	(1.0-4.5)	0.03
	11-15	10	(25.6)	67	(14.6)	2.9	(1.2-7.0)	
Distance to nearest health unit (km)	0-5	5	(12.8)	152	(33.0)	1.0	(-)	0.00
	>5	34	(87.2)	308	(67.0)	3.4	(1.2- 10.0)	
Age (years)	14-19	5	(12.8)	140	(30.4)	0.3	(0.1-0.8)	
	20-29	30	(76.9)	252	(54.8)	1.0	(-)	0.16
	30+	4	(10.2)	68	(14.8)	0.4	(0.1-1.5)	
Marital status	Married	35	(89.7)	370	(80.4)	1.0	(-)	0.16
	Single	4	(10.3)	90	(19.6)	0.5	(0.2-1.4)	
Tribe	Bantu	35	(89.7)	393	(85.4)	1.0	(-)	0.44
	Nilotics	4	(10.3)	67	(14.6)	0.7	(0.2- 2.0)	
Religion	Protestant	13	(33.3)	151	(32.8)	0.8	(0.4-1.9)	
	Catholic	16	(41.0)	149	(32.4)	1.0	(-)	
	Muslim	8	(20.5)	119	(25.9)	0.6	(0.2-1.6)	0.73
	Seven day	0	(0.0)	11	(2.4)	-	-	
	Saved	2	(5.1)	30	(6.5)	0.6	(0.1-3.1)	
Education level of patient	No schooling	1	(2.6)	24	(5.2)	0.7	(0.1-6.1)	0.52
	Primary	25	(64.0)	241	(52.4)	1.6	(0.1- 5.6)	
	Secondary	11	(28.2)	169	(36.7)	1.0	(-)	
	College	2	(5.1)	35	(7.6)	1.2	(0.6-7.0)	
Patients job	Employed	5	(12.8)	320	(69.6)	0.3	(0.1-0.9)	0.01
	Peasant	34	(87.2)	140	(30.4)	1.0	(-)	
Spouse job	Employed	32	(82.1)	365	(79.3)	1.0	(-)	
	Peasant	7	(17.9)	95	(20.7)	0.8	(0.3-2.3)	
Type of house	Brick plastered	22	(56.4)	236	(51.3)	1.0	(-)	
	Brick only	14	(35.9)	159	(34.6)	0.9	(0.5-1.9)	0.45
	Mud only	3	(7.7)	65	(14.1)	0.5	(0.1-1.7)	
Facility in house	Electricity and piped water	18	(46.2)	158	(34.3)	1.0	(-)	0.0
	Water or electricity only	18	(46.2)	137	(29.8)	1.2	(0.6-2.4)	0
	Neither	3	(7.6)	165	(35.9)	0.2	(0.0-0.5)	
Need to request permission to visit Health Unit/hospital	Yes	19	(48.7)	317	(68.9)	2.4	(1.2-4.5)	0.00
	No	20	(51.3)	143	(31.1)	1.0	(-)	
Who gives permission to attend Health Unit/ hospital	Spouse	17	(81.0)	267	(84.2)	1.0	(-)	0.66
	Other	4	(19.0)	50	(15.8)	1.3	(0.4- 4.0)	
Who pays for treatment	Self and spouse	33	(74.6)	367	(79.8)	1.0	(-)	0.6
	Others	6	(25.4)	93	(20.2)	0.7	(0.3-1.8)	7

(iv) Characteristics and outcome of the current pregnancy

Variable	Stratum	Deaths N	(%)	Survivors N	(%)	Odds ratio (95% CI)		P value
Number of pregnancy	1	11	(28.2)	174	(37.8)	0.4	(0.2-0.9)	0.02
	2-4	25	(64.1)	202	(43.9)	1.0	(-)	
	5-14	3	(7.7)	84	(18.3)	0.2	(0.0-1.0)	
Birth spacing in months*	1-36	21	(75.9)	152	(53.3)	1.0	(-)	
	>36	8	(24.1)	133	(46.7)	0.3	(0.1-0.8)	0.00
Attended antenatal care	Yes	22	(56.4)	416	(90.4)	1.0	(-)	
	No	17	(43.6)	44	(9.6)	5.9	(3.0-11.9)	0.00
Booking time for antenatal (weeks)	<28	18	(81.8)	279137	(67.1)	1.00	(-)	
	28-36	4	(19.2)		(30.9)	1.2	(0.6-2.7)	0.64
Number of antenatal visits	4+	11	(40.7)	186	(47.1)	1.0	(-)	
	<4	16	(59.3)	220	(52.9)	1.2	(0.6-2.7)	0.64
Response to vaginal bleeding during pregnancy	Go to hospital	20	(51.3)	351	(76.5)	1.0	(-)	
	Don't know	19	(48.6)	109	(23.5)	2.9	(1.2-7.0)	0.02
Bleeding during this pregnancy	Yes	2	(5.1)	12	(2.6)	2.0	(1.0-3.5)	0.06
	No	37	(94.1)	448	(97.4)	1.0	(-)	
Hypertension in this pregnancy	Yes	3	(7.7)	89	(19.3)	0.2	(0.1- 0.9)	0.01
	No	36	(92.3)	371	(80.7)	1.0	(-)	
Anaemia in this pregnancy	Yes	8	(20.5)	12	(2.6)	6.7	(2.7-16.8)	0.01
	No	31	(79.5)	448	(97.4)	1.0	(-)	
Loss of weight During pregnancy	Yes	8	(20.5)	45	(9.8)	2.4	(1.0-5.5)	0.06
	No	31	(79.5)	418	(90.9)	1.0	(-)	
Referral from other centres	Yes	19	(48.7)	244	(53.0)	0.8	(0.4-1.6)	0.60
	No	20	(51.3)	216	(47.0)	1.0	(-)	
Premature rupture of membranes	Yes	10	(25.6)	164	(35.7)	0.6	(0.3-1.3)	0.21
	No	29	(74.4)	295	(64.3)	1.0	(-)	
Bleeding in labour	Yes	7	(18.0)	91	(19.6)	0.9	(0.2-6.4)	0.89
	No	32	(82.0)	369	(80.2)	1.0	(-)	
Type of labour	Normal	19	(52.8)	228	(50.2)	1.0	(-)	
	Augmented or induced	17	(47.2)	226	(48.8)	0.9	(0.5-1.8)	0.77
Use of partograph	Yes	5	(13.2)	30	(6.6)	1.0	(-)	
	No	33	(86.8)	426	(93.4)	0.5	(0.2-1.5)	0.13
	Missing	1		4				
Mode of delivery	SVD	18	(47.4)	160	(34.8)	1.0	(-)	
	Vacuum	1	(2.6)	5	(1.1)	1.8	(0.2-14.1)	0.09
	Caesarean	13	(34.2)	244	(53.2)	0.5	(0.2-1.0)	
	Laparotomy	6	(15.8)	50	(10.9)	1.1	(0.4-3.2)	
	Undelivered	1		1				
Sex of baby	Female	9	(25.0)	223	(49.1)	1.0	(-)	
	Male	27	(75.0)	231	(50.9)	2.9	(1.3-6.3)	0.01
	Missing	2		7				
Birth weight In kilograms	< 2500	8	(19.4)	117	(25.8)	0.5	(0.2-1.3)	0.17
	2500-3500	25	(69.4)	231	(51.2)	1.0	(-)	
	>3500	4	(11.1)	105	(23.0)	0.4	(0.1-1.0)	0.06
	Missing	2		7				

Variable	Stratum	Deaths		Survivors		Odds ratio		P value
		N	(%)	N	(%)	(95% CI)		
Level of delivery attendant	Midwife	12	(31.5)	113	(24.9)	1.0	(-)	
	Doctor	24	(63.2)	323	(71.3)	0.6	(0.3-1.3)	0.32
	TBA	2	(5.2)	17	(3.8)	1.3	(0.3-6.6)	
	Missing	1		1				

* For women with at least one previous pregnancy

(v) Quality of care factors

Characteristic	Stratum	Deaths		Survivors		Crude odds ratio		P value
		N	(%)	N	(%)	(95% CI)		
Given oxytocics*	Yes	26	(70.3)	37733	(91.4)	1.00	(-)	
	No	11	(29.7)		(8.6)	4.8	(2.1-11.6)	0.00
Use of prophylactic antibiotics	Yes	19	(26.6)	130	(29.3)	1.0	(-)	0.93
	No	25	(71.4)	314	(70.7)	1.0	(0.5-2.3)	
Patient seen by senior within 1hr	Yes	24	(61.5)	311	(67.6)	1.0	(-)	
	No	15	(38.5)	149	(32.4)	1.4	(0.7 - 2.7)	0.39
Patient seen by senior within 6hrs	Yes	28	(71.8)	402	(87.5)	1.0	(-)	
	No	11	(28.1)	58	(12.5)	2.8	(1.3-5.8)	0.01
Waiting for operation in minutes +	1-120	5	(26.3)	150	(44.5)	1.0	(-)	
	121-600	11	(57.9)	165	(49.0)	2.0	(0.8-5.9)	0.07
	601+	9	(15.8)	22	(6.5)	4.1	(0.9-18.3)	
Time taken operating in minutes +	<60	15	(75.0)	285	(86.9)	1.0	(-)	
	>60	5	(25.0)	43	(13.1)	2.2	(0.8-6.4)	0.14
Delay to operate +	Yes	20	(80.0)	187	(54.1)	3.2	(1.1-10.0)	0.1
	No	5	(20.0)	150	(45.9)	1.0	(-)	
Shortage of blood or its products	Yes	25	(64.0)	45	(9.8)	13.9	(7.9-33.6)	0.00
	No	14	(35.9)	415	(90.2)	1.0	(-)	
Shortage of drugs	Yes	10	(25.7)	21	(4.6)	7.1	(3.0-17.1)	0.00
Relative to buy	No	29	(74.3)	432	(95.4)	1.0	(-)	
Number of times monitored: blood pressure pulse, respiratory rate in 24 hrs	<6	5	(12.8)	35	(7.6)	6.5	(1.4-30.6)	0.02
	6-13	28	(71.8)	198	(43.0)	3.4	(-)	
	>13	6	(15.3)	227	(49.3)	1.0	(1.1-12.0)	
Number of times monitored: vaginal bleeding First 24hrs	<4	5	(12.8)	33	(7.4)	6.5	(1.4-30.1)	0.02
	5-8	28	(71.8)	253	(56.00	3.4	(1.1-12.0)	
	>8	6	(15.3)	165	(36.6)	1.0	(-)	

* Hysterectomy for ruptured uterus excluded

+ In those requiring operation

(vi) Laboratory Results

Variable	Stratum	Deaths		Survivors		Odds ratio		P value
		N	(%)	N	(%)	(95%CI)		
HIV status	Negative	24	(61.5)	405	(88.0)	1.0	(-)	
	Positive	15	(38.5)	55	(12.0)	4.6	(2.2-9.3)	0.00
CD cell count *	<200	12	(80.0)	25	(45.5)	4.8	(1.2-18.9)	0.03
	=>200	3	(20.0)	30	(54.5)	1.0	(-)	
Syphilis	Negative	34	(87.2)	422	(91.7)	1.0	(-)	
	Positive	5	(12.8)	38	(8.3)	1.7	(0.5-4.7)	0.33
Haemoglobin	<10	29	(74.4)	269	(58.5)	2.1	(0.9-4.6)	0.05
Gm/dl	=>10	10	(25.6)	191	(41.5)	1.0	(-)	
Platelets	<150	18	(46.1)	134	(29.1)	2.1	(1.0-4.2)	0.02
	=>150	21	(53.9)	326	(70.9)	1.0	(-)	

* In HIV positive women

Table 6.3 Risk factors for progression from SMM to maternal mortality

Variable	Stratum	Deaths N (%)	Survivors N (%)	Crude odds ratio (95% CI)	Adjusted odds ratio (95% CI)	Adjusted including all causes of mortality in model [d]	P value
Causes of maternal morbidity and mortality	Haemorrhage	12(30.8)	152(33.0)	1.00	1.0(-)		
	Eclampsia	5(12..8)	120(26.1)	0.5(0.2-1.4)	0.4(0.1-1.3)[a]		0.00
	Dystocia	4(0.2)	150(38.5)	0.4(0.1-1.2)	0.4(0.1-1.3)[a]		
	Sepsis	6(15.4)	19(4.1)	4.7(1.5-14.3)	3.4(1.0-11.2)[a]		
	Anaemia	6(15.4)	14(3.4)	4.2(1.4-12.6)	2.9(0.9-9.2)[a]		
	Other medical	6(15.4)	5(1.1)	12.5(3.4-45.1)	11.3(2.7-46.6)[a]		
Distance from home to Mulago	0-5	12(30.8)	152(33.0)	1.0	1.0(-)	1.0(-)	0.00
	5.1-10	17(43.6)	201(43.7)	2.1(1.0-4.1)	2.0(0.8- 5.00)[a]	1.5(0.7-3.5)	
	>10	10(25.6)	107(23.3)	2.9(1.2 - 7.0)	3.1(1.0 -9.3)[a]	2.9(1.0-5.5)	
Patients job	Employed	5 (12.8)	320(69.6)	0.3(0.1-0.9)	0.2 (0.1- 0.7)[a]	0.2 (0.0-0.7)	0.00
	Peasant/nil	34(87.2)	140(30.4)	1.0(-)	1.0(-)	1.0(-)	
Requesting permission to visit HU	Yes	19(48.7)	317(68.9)	2.4(1.2, 4.5)	3.2(1.4 -7.0)[a]	2.6 (1.2-5.8)	0.00
	No	20(51.3)	143(31.1)	1.0(-)	1.0 (-)	1.0(-)	
Admission to hospital	Yes	8 (18.0)	42(8.7)	2.6(1.1- 5.9)	3.8(1.1- 10.5)[a]	2.5(1.0-6.6)	0.01
	No	31(82.0)	418(91.3)	1.0(-)	1.0(-)	1.0(-)	
Previous delivery by caesarean section	Yes	7(18.0)	64(13.9)	1.6(0.7-3.9)	2.7(1.0 - 7.8)[b]	2.0(0.8-5.4)	0.06
	No	32(82.0)	396(86.1)	1.0(-)	1.0(-)	1.0(-)	
Birth spacing in months [1]	1-36	21(75.9)	152(53.3)	1.0(-)	1.0(-)	1.0(-)	0.05
	>36	8(24.1)	133(46.7)	0.3(0.1 - 0.8)	0.4(0.1- 1.0)[c]	0.3(0.1-1.2)	
Antennal care attendance	Yes	22(56.4)	416(90.4)	1.0(-)	4.0(1.3- 9.2)[c]	3.9(1.7-9.1)	0.00
	No	17(43.6)	44(9.6)	5.9(3.0- 11.9)	1.0 (-)	1.0(-)	
Response to vaginal bleeding during antenatal	Go hospital	20(51.3)	351(76.5)	1.0(-)	1.0(-)	1.0(-)	
	Don't know	19(48.6)	109(23.5)	2.9(1.2 - 7.0)	4.3(1.2- 7.0)[c]	3.2(1.4-7.0)	0.00
Anaemia in antenatal	Yes	8(20.5)	17(3.7)	6.7(2.7-16.8)	6.7(1.4-31.3)[c]	6.2(2.4-32.1)	0.02
	No	31(79.5)	443(96.3)	1.0(-)	1.0(-)	1.0(-)	
Bleeding during this pregnancy	Yes	2 (5.1)	12(2.6)	2.0(1.0 -3.5)	5.9(1.0- 33.4)[c]	3.2(0.6-17.3)	0.04
	No	37(94.1)	448(97.4)	1.0(-)	1.0 (-)	1.0(-)	
Sex of baby	Female	9(25.0)	223(49.1)	1.0(-)	1.0(-)	1.0(-)	0.00
	Male	27(75.0)	231(50.9)	2.9(1.3-6.3)	4.0(1.6 - 10.1)[c]	4.5(1.6-11.7)	
Given oxytocics	Yes	26(70.3)	377(91.4)	1.0(-)	1.0 (-)	1.0(-)	0.00
	No	11(29.7)	33(8.6)	4.8(2.1-11.6)	4.0(1.7- 9.7)[c]	4.0(1.5-10.9)	
Patient seen by senior within 6hrs	Yes	28(71.8)	402(87.5)	1.0(-)	2.2(1.1- 4.6)[c]	3.7(1.5-9.2)	0.05
	No	11(28.1)	58(12.5)	2.8(1.3, 5.8)	1.0 (-)	1.0(-)	
Waiting for operation in minutes [2]	1-120	5(26.3)	150(44.5)	1.0(-)	1.0 (-)	1.0(-)	
	121-600	11(57.9)	165(49.0)	2.0(0.7 - 5.9)	2.1(0.8- 9.0)[c]	2.4(0.7-8.4)	0.05
	601+	9(22.0)	22(6.5)	4.1 (0.9- 18.3)	4.6(1.1 - 39.6)[c]	5.8(2.3-109.2)	
Shortage of blood	Yes	25(64.0)	45(9.9)	5.5(2.7-10.9)	10.1(4.2-24.3)[c]	10.1(4.2-24.3)	0.00
	No	14(35.9)	411(90.1)	1.0(-)	1.0(-)	1.0(-)	
Shortage of drugs Relative to buy	Yes	10(25.7)	21(4.6)	7.1(3.0-17.1)	3.6(1.1- 11.3)[c]	2.9(1.0-9.3)	0.00
	No	29(74.3)	432(95.4)	1.0(-)	1.0 (-)	1.0(-)	
Number of times monitored: blood pressure/pulse post partum	6-13	28(71.8)	222(49.1)	3.4(1.1-12.0)	3.1(12-10.9)[c]	3.8(1.1-13.0)	0.00
	>13	6(15.4)	196(43.4)	1.0(-)	1.0 (-)	1.0(-)	
	<6	5(12.8)	34(7.5)	6.5(1.4 - 30.6)	5.6(1.2-25.7)[c]	5.6(1.2-25.7)	
Number of times	4-8	28(71.8)	253(56.0)	3.4(1.1 -12.0)	16.2(3.6- 73.0)[c]	13.1(0.7-14.5)	0.00

(ii) Social, family and medical history characteristics

Characteristic	Stratum	Deaths N (%)		Survivors N (%)		Odds ratio (95% CI)		P value
Family hypertension	Yes	29	(74.4)	240	(52.2)	2.7	(1.2-6.0)	0.00
	No	10	(25.6)	220	(47.9)	1.0	(-)	
Family diabetes mellitus	Yes	9	(23.1)	54	(11.7)	1.8	(0.6-5.3)	0.31
	No	30	(76.9)	406	(88.3)	1.0	(-)	
Hypertension (self)	Yes	4	(10.3)	19	(4.1)	2.7	(0.9-8.2)	0.09
	No	35	(89.7)	441	(95.9)	1.0	(-)	
Admission to hospital	Yes	8	(18.0)	42	(8.7)	2.6	(1.1-5.9)	0.03
	No	31	(82.0)	418	(91.3)	1.0	(-)	
Use of contraception	Yes	13	(33.3)	188	(40.9)	1.0	(-)	0.12
	No	26	(66.7)	272	(59.1)	1.4	(0.7- 2.9)	

(iii) Past obstetric performance

Variable	Stratum	Deaths N (%)		Survivors N	%	Odds ratio (95% CI)		P value
Previous abortion	Yes	4	(13.8)	40	(14.0)	1.2	(0.4-3.6)	0.74
	No	25	(86.2)	246	(86.0)	1.0	(-)	
Bleeding in previous pregnancy	Yes	3	(10.3)	45	(15.7)	0.8	(0.2-2.6)	0.70
	No	26	(89.7)	241	(84.3)	1.0	(-)	
Bleeding in labour	Yes	2	(6.9)	31	(10.8)	0.8	(0.2-3.4)	0.69
	No	27	(93.1)	255	(89.2)	1.0	(-)	
Labour lasting more than 18hrs	Yes	5	(17.2)	49	(17.1)	1.2	(0.5-3.3)	0.68
	No	24	(82.8)	237	(82.9)	1.0	(-)	
Still birth	Yes	5	(17.2)	30	(10.5)	2.1	(0.8-5.6)	0.15
	No	24	(82.8)	256	(89.5)	1.0	(-)	
Previous caesarean section	Yes	7	(24.1)	64	(22.4)	1.6	(0.7-4.0)	0.28
	No	22	(75.9)	222	(77.6)	1.0	(-)	
Hypertension in pregnancy	Yes	4	(13.8)	19	(6.6)	2.7	(0.9-8.2)	0.09
	No	25	(86.2)	267	(93.4)	1.0	(-)	
Blood transfusion during pregnancy	Yes	1	(3.4)	15	(5.2)	0.8	(0.1-6.1)	0.23
	No	28	(96.6)	271	(94.8)	1.0	(-)	

* women with previous pregnancies only

Variable	Stratum	Deaths N (%)	Survivors N (%)	Crude odds ratio (95% CI)	Adjusted odds ratio (95% CI)	Adjusted including all causes of mortality in model [d]	P value
monitored: vaginal bleeding First 24 hours	>9	6(15.4)	165(36.6)	1.0(-)	1.0 (-)	1.0(-)	
	<4	5(12.87)	33(7.4)	6.45(1.40- 30.06)	27.3(4.1- 182.6)[c]	3.9(1.2-12.5)	
HIV status	Negative	24(61.5)	405(88.0)	1.0 (-)	(1.0)	1.0(-)	0.00
	Positive	15(38.5)	55(12.0)	4.60(2.18, 9.30)	5.1(2.0- 12.8)[c] 5.8(2.1-12.9)[e]	4.1(1.7-11.4)	
CD cell count [3]	<200	12(80.0)	25(45.5)	4.8(1.22,18.93)	5.9(2.5, 72.1)[c]	4.8(1.00- 63.2)	0.00
	>200	3(20.0)	30 (54.5)	1.0(-)	1.0 (-)	1.0(-)	
Haemoglobin in gm/dl	<10	29(74.4)	269(58.5)	2.06(0.94, 4.64)	2.6(1.1- 6.4)[c]	2.9(1.0-9.7)	0.03
	=>10	10(25.6)	191(41.5)	1.0(-)	1.0 (-)	1.0(-)	

a: Adjusted for: distance from home to Mulago, patient's job, requesting for permission and previous delivery by caesarean section.

b: Adjusted for: distance from home to Mulago, patients job, requesting for permission and previous delivery by caesarean section and admission to hospital.

c: Adjusted for: distance from home to Mulago, patients job, requesting for permission and previous delivery by caesarean section, admission to hospital, birth spacing, parity, antenatal care, hypertension, anaemia, bleeding and sex of baby.

d: Adjusted in c plus causes of SMM.

e: Adjusted as in d plus sexually transmitted infections and mode of delivery

1 In those with at least one previous pregnancy

2 In those requiring operation

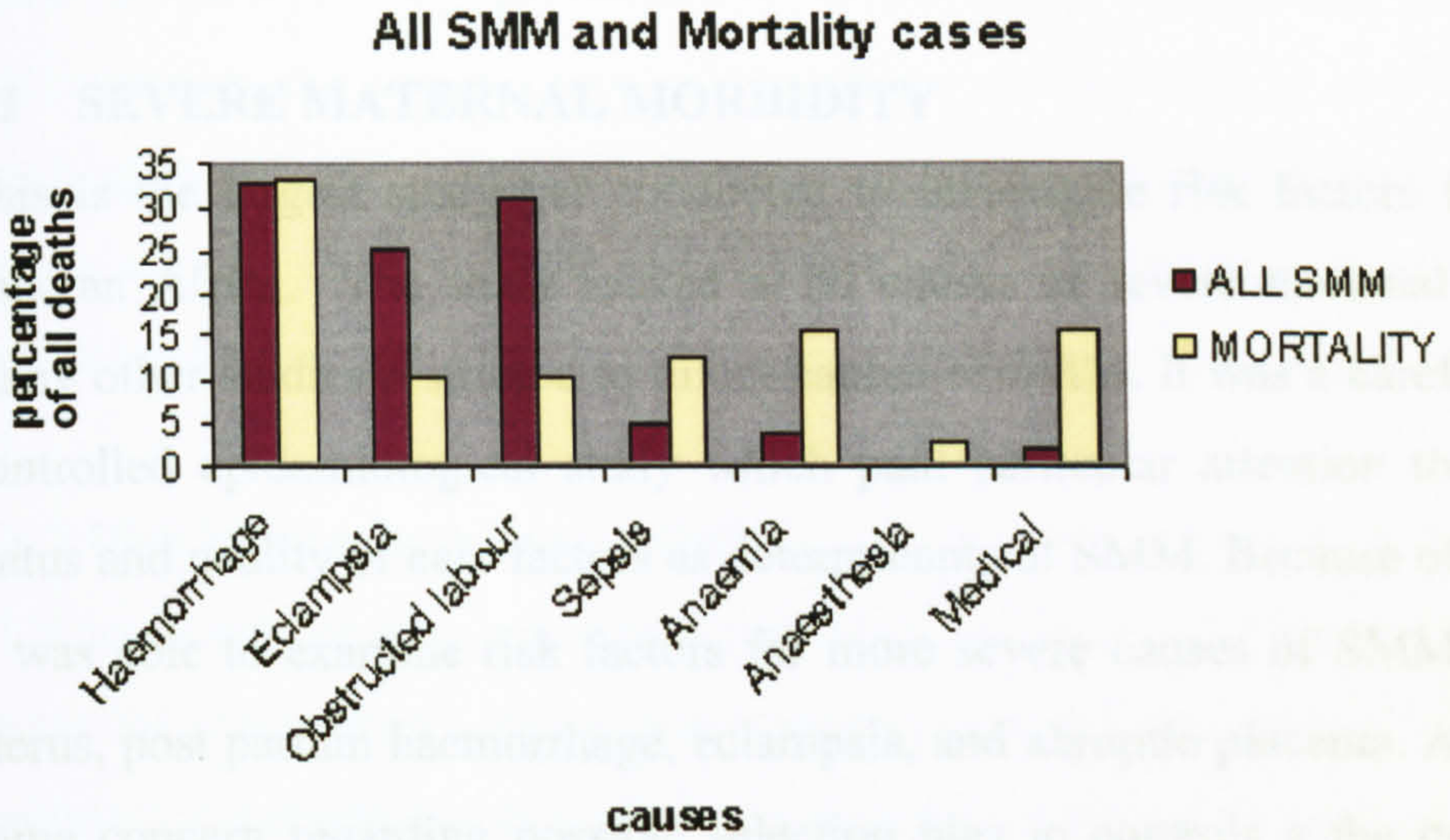
3 In HIV positive women

Table 6.4 Causes of delay for 207 women* who waited more than two hours for a caesarean section

Cause of delay of operation*	SMM cases who survived		SMM cases who died		Total causes of delay	
	N	(%)	N	(%)	N	(%)
Busy theatre	131	(60.0)	10	(45.5)	141	(58.1)
Delay by doctors	38	(17.4)	4	(18.2)	42	(17.5)
Delay of anaesthetist	15	(6.9)	1	(4.5)	16	(6.7)
Shortage of expendables	16	(7.0)	0	(-)	16	(6.7)
Delay of nursing staff	6	(2.6)	0	(-)	6	(2.5)
Lack of blood	8	(3.5)	5	(22.7)	13	(5.4)
Lack of instruments	2	(0.9)	0	(-)	2	(0.8)
Sterilization failure	1	(0.4)	1	(4.5)	2	(0.8)
Patient refused to consent	1	(0.4)	1	(4.5)	2	(0.8)
Total	218	(100)	22	(100)	240	(100)

* Same patient may appear twice in the table as more than one cause could have been reported

Figure 6.1 Relative distribution of severe maternal morbidity and mortality



CHAPTER SEVEN: DISCUSSION

7.1 SEVERE MATERNAL MORBIDITY

This is the largest study yet conducted to investigate risk factors for SMM in sub-Saharan Africa. The study looked at all causes of severe maternal morbidity unlike many other studies restricted to direct causes of SMM. It was a carefully designed and controlled epidemiological study which paid particular attention to the role of HIV status and quality of care factors as determinants of SMM. Because of the study setting, it was able to examine risk factors for more severe causes of SMM such as ruptured uterus, post partum haemorrhage, eclampsia, and abruptio placenta. Although there was some concern regarding possible selection bias in controls a the design stage of the study, the prevalence of HIV positivity in controls was similar to that of the general population of Kampala, providing strong evidence that the controls were representative of the population.

This study confirmed most of the known risk factors for SMM which have been reported in the literature, again indicating a thorough and high-quality study. It also identified new risk factors which have not been reported in the literature before. The study confirmed the role of HIV in SMM and progression to maternal mortality.

7.1.1 Causes of SMM

Ninety three percent of the SMM cases in this study had direct obstetric causes and 7% indirect. Obstetric haemorrhage overall (33%) was the main cause of SMM in this study, as it was in Mulago hospital overall over the study period. This is the pattern in most low-income countries[39,256], but is in contrast to developed countries where the leading morbidity is hypertensive diseases[24,25,29].

Hypertensive diseases were more prevalent here than the previously reported contribution of less than 10% of SMM cases in the hospital[23,252]. This increase may be related to the large number of primigravidae who delivered at the hospital over the study period. This apparent increase of hypertensive disease in Uganda is similar to reported trends in South Africa and Zimbabwe where the leading cause of SMM is now hypertensive disease[2,3,6,248]. The high proportion of cases in our study with obstructed labour and ruptured uterus suggests that the quality of maternal care was low. Indeed,

low quality of care was evident in the infrequent use of a partograph for monitoring patients: less than 10% of study participants were monitored in this way. Only 5% of cases had puerperal sepsis as a primary cause, which was a lower proportion than was anticipated at the design stage of the study. This could be due to early treatment resulting in reduction of the number of cases presenting with a severe episode. Another reason may be that over 80% of the women in Kampala deliver in health units under skilled attendants with knowledge of aseptic conditions[251].

7.1.2 Risk factors for all cause SMM

This study did not find age, either younger than 20 or older than thirty four, was a risk factor for severe morbidity, as had been reported in other studies[34,35,257]. However the majority of patients in this study had a mean age of 23, and over 80% of both the cases and controls were below the age of thirty years which limited the power of the study to detect older age effects.

The study found that the further away the patients lived, the higher the risk of developing SMM. A lower proportion of cases (81%) compared to controls (98%) lived five or less kilometres from a health unit, which is the WHO requirement for good accessibility to health services[258]. Since the majority of patients fulfilled the WHO requirement of access to health services, we would expect fewer maternal complications. Referral from other health units was associated with an increased risk of developing SMM. This finding was similar to that for a study of referred patients in Mulago hospital as a whole, which showed a large proportion of "near-miss" cases were referrals[7]. Similar results have also been reported in Nigeria and Guinea[115,259]. Referral was a strong risk factor most probably because of time delays and the process of transferring patients being harmful, especially in circumstances where there is no ambulance service. Because of the importance of referral as a risk factor, the analyses were repeated using non-referred women only. The pattern of results was not greatly altered by this restriction, indicating the independent effect of the other determinants of SMM in this study. The general issue of bias, and the possible effects of bias on the results of this study, will be discussed in Chapter 8.

Women who reported professional jobs had an increased risk of developing SMM compared to women who classified themselves as peasants. This somewhat counter-intuitive finding may relate to increased stress and lack of adequate rest[79]. Or it may

indicate a degree of selection bias, as these women recognized the importance of coming to hospital. Socio economic status was mainly assessed using housing type. Those of lower social economic status (living in mud or brick houses with iron roofs) had 3 to 4 times the risk of SMM after adjustment for confounding factors compared to those of higher socio-economic level (who lived in plastered brick houses with iron or tiled roofed houses). Low socio-economic class and poverty have been reported to be important underlying factors in both SMM and maternal mortality[34,201,260]. Women who said that they needed to ask for permission (from their husband or other family members) before attending a health unit or hospital had increased risk of developing SMM compared to those who did not need to ask for permission. This suggests that when a complication (signs and symptoms) occurs the woman cannot make a decision to attend a health unit until the spouse or family member gives permission, resulting in delay. Requesting permission is also a manifestation of women's poverty because they depend financially on their spouses. Indeed, patients who depended on others for financial support while they were in hospital had increased risk of developing SMM after controlling for confounders. Poverty has been reported to be associated with SMM and mortality in both developed and developing countries[34,260,261]. Poverty is associated with poor nutrition, low education status and low or non use of antenatal care.

With regards previous reproductive history, gravid patients with a history of having had an evacuation and dilation and curettage had twice the risk of SMM compared to those who did not. This finding has not been reported in the literature to date and may be explained by the fact that previous history of evacuation or dilation and curettage is associated with adverse obstetric events such as ante partum haemorrhage. Women with a poor obstetric history are at increased risk of an adverse event in the current pregnancy. Parous women who had delivered by caesarean section in a previous delivery also had higher risk of developing SMM compared to those who had only ever delivered vaginally. In a similar argument to that presented for previous abortion and/or evacuation of the uterus, previous caesarean section may simply be a marker for previous morbidity. Or it could be a measure of the quality of obstetric performance in Mulago hospital in that timely intervention was not offered to these women when need arose and they ended up with severe complications. Indeed, women on trial of scar had thrice the risk of developing SMM. The other explanation could be the desire for vaginal delivery among African women such that those with a previous scar will delay attending medical care in an attempt to avoid a repeat caesarean[68,128,142].

Chronic hypertension, as well as hypertension in previous pregnancies, was associated with a considerably increased risk of developing SMM. Chronic hypertension has been found to be an important risk factor for SMM in studies carried out in USA, UK and South Africa[6,34,35]. Previous history of admission to hospital for medical (non-obstetric) reasons during pregnancy was associated with an increased risk of SMM. Admission was most probably for pre-existing hypertension, urinary tract infection or anaemia, which can predispose women to SMM. This has been observed in the UK[34].

A very long interval since the last pregnancy ended (more than five years) was associated with an increased risk of developing SMM, but analyses comparing birth intervals of less than 18 months with those between 18 and 36 months did not reveal any statistically significant variation in risk (results not presented in analysis). This suggests that frequent births are not associated with SMM, a finding reported in other studies[262,263]. The reason for the effect of long birth interval on SMM is not clear but previous studies have shown an association between birth intervals of more than 4 years and the risk of pre-eclampsia and eclampsia[69,76]. In addition, a prolonged birth interval of more than 5 years could be associated with development of uterine fibroids among Africans [264] which can predispose to malposition of foetus resulting in obstructed labour or cause reduced blood supply to the placenta leading to ante partum haemorrhage.

The mean parity in both cases and controls was 2.6 (SD = 0.8), with a range of 1 to 14. Nulliparity but not high parity was associated with the risk of developing SMM after adjusting for confounders. High parity has been reported to be associated with risk of maternal mortality in developing countries [265]and an association with SMM was expected, but not demonstrated in this study. The morbidity and mortality risk due to high parity may be a measure of the risk associated with advanced age (over 34 years), and we did not have a large number of study subjects within this age group in our study.

Overall, antenatal care attendance was high in cases (88%) and in controls (97%) and was similar to the national figure of 94%[12]. But the patients who did not attend antenatal care at all had, as expected, increased risk of developing SMM after controlling for confounding factors compared to those who attended at least once. This confirmed what other research studies have found[266]. Although the attendance was relatively high, a third of cases and controls booked for antenatal care in the third

trimester, and in both cases and controls over 55% of women attended less than four times. An antenatal attendance of less than 4 times is considered inadequate by WHO standards which recommend at least 4 visits spread over the 3 trimesters[267]. Thus, although there was a high level antenatal care attendance overall, patient observation over the course of the pregnancy was not adequate for staff to detect abnormalities. In addition, the quality of antenatal care was limited: among patients who attended antenatal clinic almost one quarter of cases compared to almost one tenth of the controls did not have their blood pressure checked. This was associated with a clear increased risk of developing SMM. Failure to measure blood pressure when a woman attends antenatal clinic is a serious omission and demonstrates inadequacies in antenatal care provision.

When study participants were asked what they would do if they developed vaginal bleeding in their current pregnancy one quarter of cases did not know what to do compared to 4% of the controls. Bleeding during pregnancy is one of the most serious signs/symptom which pregnant women should recognize and act on by seeking medical attention immediately. Knowledge about what a woman should do when she bleeds during pregnancy tests not only whether a woman has attended antenatal clinics, but also whether the health education messages given during such visits were understood. A higher proportion of cases than controls failed to absorb the message regardless of whether they attended antenatal care.

Anaemia during pregnancy was associated with a clear increase in risk. Anaemia in pregnant women has been estimated to be about 40-80% in developing countries[185,268] and the levels are known to be associated with, and aggravated by, the degree of malaria infection[186,187,189]. Several studies have reported an association between anaemia and risk of maternal morbidity and mortality in Africa[269,270]. We found a haemoglobin level of less than 10 grams per decilitre was a risk factor for SMM. A limitation of this result is that all the control samples were taken after delivery, but a proportion of case samples were taken during delivery, making it difficult to disentangle the role of bleeding during delivery and antenatal anaemia.

During labour, premature rupture of membranes (membranes ruptured before start of labour) increased risk of SMM. This is explained by the fact that premature rupture of membranes is associated with chorioamnionitis, which in turn is an underlying cause of

abruptio placenta and puerperal infection[162,176]. Premature rupture of membranes is also associated with cephalo pelvic disproportion and abnormal presentation of the foetus which put a woman at risk of developing SMM if intervention to deliver her was not provided in time.

Bleeding during labour as expected was clearly associated with increased risk of SMM. Bleeding during labour is a serious warning sign which needs evaluation and appropriate management. With good monitoring of labour SMM could be avoided by prompt management. This result suggests that there was inadequate monitoring of patients or delay in reaching hospital or offering appropriate treatment.

Active management of the third stage is the recommended practice that has been shown to prevent post partum haemorrhage.[98]. Normal third stage should last not more than 30 minutes because the risk of post partum haemorrhage increases with a time[271]. Study participants whose third stage lasted more than 25 minutes had a remarkably high risk of SMM. In addition, women who did not receive oxytocics soon after delivery of their babies had higher risks of developing SMM compared to women who did receive it. This confirms an earlier finding that administering oxytocics soon after delivery of the baby reduces the incidence of PPH[99,106]. The reason for not getting oxytocin may be due to shortage of syringes, lack of the drugs, or lack of staff knowledge.

Having SMM resulted in higher risks of delivery of low birth weight babies (babies weighing less than 2500 grams). This finding relates to the fact that low birth weight is associated with pre-eclampsia, ante partum haemorrhage and medical disease[172]. Low birth weight also results from premature termination of pregnancy due to the severity of SMM.

In our study sample the test for Syphilis was positive in 9% of both cases and controls. This is within the reported prevalence estimated between 4-15% among pregnant women in Sub Saharan Africa[198,272-274]. Syphilis was not associated with the risk to SMM.

HIV in sub Saharan Africa has claimed many lives including pregnant women. HIV prevalence rates in Uganda have reduced from 30% in the early 1990's to 8% in urban

areas and 4% in rural areas with an overall average of 6.5% in the early 2000s[18]. Fourteen percent of cases and 9% controls tested HIV positive in this study: HIV positivity was associated with twice the risk of developing SMM. HIV infected women have a degree of immunodeficiency and are thus expected to have significant increase of morbidity when compared to the HIV negative women. Reported conditions associated with HIV include chorioamnionitis, puerperal sepsis, ante partum haemorrhage, post partum haemorrhage and chronic anaemia[199,200]. One study in Ireland reported no influence of HIV on the clinical course of critically ill obstetric patients[235]. The type of care women receive during pregnancy and delivery and the stage of HIV disease may account for the difference in this result and the findings of our study. Other studies have shown that pregnancy does not influence the progression of the HIV disease[223,231]. Studies from Rwanda reported increased risks of post operative complications among HIV positive mothers compared to HIV negative mothers[275]. It is thought that post partum morbidity is determined by maternal CD4 lymphocyte count and stage of maternal HIV disease[233]. The HIV positive patients in Mulago hospital only received niverapine peripartum to prevent vertical transmission of HIV. No woman was on antiretroviral treatment for HIV/AIDS in the study pre-partum.

In conclusion, the main risk factors identified for all types of SMM were residential distance from hospital, low socioeconomic status of women, lack of empowerment, history of hypertension and previous adverse events in pregnancy, being referred, type of care offered to women during pregnancy and delivery, and HIV status. The improvement of maternal care offered to women during the antenatal period and delivery, coupled with an improved referral system, could potentially reduce the burden of SMM in Kampala. Prevention of HIV transmission will also reduce SMM. In the community, mobilization of women for safe motherhood, improvement of social status of women and empowerment of women economically are likely to contribute to the reduction of SMM.

This study has confirmed the following risk factors previously reported in the literature:

- Residential distance from health unit
- Nulliparity
- Pre-existing medical conditions
- Low socio economic class and low social status

- Non attendance of antenatal care
- Referred from another health unit during labour
- Admission prior to delivery for medical reasons.

This study did not confirm the following findings previously reported in the literature:

- High parity as a risk factor for SMM
- Young and older mothers being at increased risk of SMM.

This study reports the following new associations not previously reported in the literature:

- Birth spacing of more than five years was associated with an increased risk of SMM
- HIV positivity was associated with an increased risk of SMM
- Previous delivery by caesarean section was associated with an increased risk of SMM
- Previous uterine evacuation was associated with an increased risk of SMM
- Lack of knowledge of what to do when bleeding starts during pregnancy was associated with increased risk of SMM.

7.2 RISK FACTORS FOR INDIVIDUAL CAUSES OF SMM

7.2.1 Risk factors for severe pre-eclampsia and eclampsia

Severe pre-eclampsia and eclampsia are potentially life threatening conditions. The management aims at reduction of high blood pressure, preventing and controlling convulsions and ultimately termination of pregnancy. Severe pre-eclampsia and eclampsia contributed 25% as primary causes of SMM.

In this study the characteristics of these cases were compared the characteristics of the controls in a separate case-control analysis. Living a further way from the hospital, being a referred patient, lack of knowledge about what to do if there was bleeding in pregnancy, and low socio-economic and social status were significant risk factors for eclampsia and severe pre-eclampsia, and for all SMM cases as described in 7.1.2. Poor socio economic status and poverty may lead to a lack of some essential dietary elements

such as vitamin E and other antioxidants. These micronutrients have been postulated to decrease the production of monocyte tumour necrosis factor alpha which is likely to play a role in athrogenic events and is a potent endothelial activating factor playing a role in the pathogenesis of pre-eclampsia[276]. The relationship between pre-eclampsia and maternal age has been described as J shaped where hypertension is raised in the young ages, decreases, and then begins to rise above age of thirty four years[69]. Maternal age (young or old) was not found to be risk factor for severe pre-eclampsia and eclampsia in this study although other studies have reported it[77,79]. This may have been because of majority women delivered in Mulago hospital were below thirty years.

Women who were employed had increased risk of developing pre-eclampsia and eclampsia compared to peasant women after controlling for potential confounders such as age, and professionals had the highest risk within the employed group. Similar results were reported from the Mexico where working women had twice the risk of pre-eclampsia compared to non-employed women[77]. Two other studies, from Australia, showed similar associations between working and pre-eclampsia[78 77,277,278]. It has been suggested that the association between pre-eclampsia and working during pregnancy is related to strain and different levels of physical activity at work but not to socio economic status Ugandan women who participate in commercial and professional work probably did not get enough time to rest and this may predispose them to pre-eclampsia.

Family history of hypertension doubled the risk of developing pregnancy induced hypertension. Familial hypertension may be associated with pre-eclampsia because pre-eclampsia could be the first manifestation of later development of chronic hypertension[50]. And, perhaps not surprisingly, study women with pre-existing chronic hypertension had a very high risk of pre-eclampsia and eclampsia compared to those without. This confirms findings from recent studies that both familial hypertension and chronic hypertension are risk factors for pre-eclampsia and eclampsia[51,65,69,73]. Similarly, the current study confirmed previous reports of increased risk associated with a history of pregnancy-induced hypertension[45,55,71,79]. In addition, previous history of admission to hospital for medical (non-obstetric) reasons during pregnancy was associated with a trebling of the risk. Admission was most probably for pre-existing hypertension or urinary tract infection which can predispose a woman to pregnancy induced hypertension.

Women with a previous history of abortion had an increased risk of developing pre-eclampsia or eclampsia. Previous studies have reported that women who have had abortion are at risk of pre-eclampsia when the next pregnancy is not with the same partner[278]. Any pregnancy following an abortion or term pregnancy with the same partner is thought to be protective because of the immune theory of pre-eclampsia which suggests that second invasion of trophoblast is protective[71,278,279]. Many studies have reported nulliparity as a risk factor for severe pre-eclampsia[45,54,74,82,280,281] and this study confirmed the finding. How the mother reacts to the first invasion of the trophoblast or placenta will determine the risk of pre-eclampsia. Failure of the normal invasion of trophoblastic cells leads to mal-adaptation of the spiral arterioles thought to be related to the causation of pre-eclampsia[56]. The protective effect of multiparity which disappears on change of paternity have lead some authors to suggest that it is primipaternity, rather than primigravidity, which is a risk factor for pre-eclampsia[282] Results from a Norwegian population study have confirmed the role of paternity in the determination of pre-eclampsia[72]. We did not ask about paternity in our questionnaire and were thus unable to examine the change of partner. Indeed, grand multiparity was found to be protective for developing severe pre-eclampsia. Because grand multiparity is associated with increasing age, it was expected to be associated with increased risk for pre-eclampsia but this was not observed. In our study majority of the patients were below thirty years which suggests age rather than grand multiparity is a risk factor for pre-eclampsia.

We found that pregnancies with a long birth interval of over 5 years had over 8 fold greater risk of developing severe pre-eclampsia compared to pregnancies with birth intervals of thirty six or less weeks. The reason for this association is not known but could be due factors such as sub fecundity and other risk factors associated with paternal change which may act together to predispose to pre-eclampsia[76,283].

Women who had no antenatal care had a higher risk of developing severe pre-eclampsia. Antenatal care is an important component of maternity care which screens women who are at risk or have developed pre-eclampsia so that they can be managed early to prevent complications. Effectiveness of the screening of the women depends on the quality of antenatal care, the booking time and the number of visits by the patients. Among those who did attend antenatal care, there was evidence that cases had their blood pressure checked less often than controls over the course of the pregnancy, a

serious omission in antenatal care. The hypertensive mothers would have had signs and symptoms suggestive of hypertension and could therefore have been identified and managed to prevent the development of severe pre-eclampsia or eclampsia.

Once diagnosed, women with pre-eclampsia should ideally be followed up using uric acid levels which are good predictors of severity of established pre-eclampsia. Delivery can then be carried out at an appropriate time to prevent further complications. Measurement of serum uric acid and creatinine levels are limited in developing countries because of cost, and are not used routinely in Mulago hospital. Urinary protein measurement as used in Mulago is cheap and readily available but picks up cases late and has false negatives[79]. With inadequate laboratory facilities to monitor the progress of pre-eclampsia, as is the case in developing countries, many women will end up with severe maternal and perinatal morbidity.

Women with pre-eclampsia and eclampsia delivered a significantly higher proportion of male babies compared to women without these conditions. The explanations for this in not clear but similar results were reported by Basso and Olsen[283]. Other studies however have found no statistical difference in total testosterone and free estriol values between women with pre-eclampsia and those without suggesting that sex of foetus does not play a role in causation of the pre-eclampsia[284].

Hypertension in pregnancy causes intra uterine foetal growth restriction. However not all pre-eclamptic mothers deliver growth restricted babies, and the effect depends on the initiation of the disease. Pre-eclampsia is more severe when it starts early in pregnancy but has minimal effect on the foetus when it starts late pregnancy[45]. In this study low birth weight babies were much more likely to be delivered by women with severe pre-eclampsia and eclampsia, indicating that the disease was initiated early in pregnancy or that there was premature termination of pregnancy as result of severity of disease.

This study did not find a statistically significant association between HIV and risk of severe pre-eclampsia and eclampsia. In our study we must note that the numbers were small and so the study lacked power to detect a statistical significant difference even it had been present, so we must be cautious about concluding no effect.

The platelet life span is shorter in pregnancy induced hypertension especially when

complicated by growth restriction of the foetus. This study found a greater risk of thrombocytopenia (less than 150 x 10^9 per litre) in women with severe pre-eclampsia and eclampsia. Fifteen (10%) of cases had platelet counts less than 100 x 10^9 cells per litre and were complicated with HELLP syndrome. However the distribution of platelets among women with hypertension and those without overlap too much for platelet count to be used as a predictor for severe pre-eclampsia.

In conclusion, this study found the main risk factors for severe pre-eclampsia and eclampsia were: residing further away from hospital, being referred, being a professional woman, having familial or co existing hypertension, nulliparity, birth interval of more than five years, previous abortion, and delivery of male babies. Prevention of this disease will depend on quality of care offered to women during antenatal and labour and support of laboratory investigations.

In summary this study has confirmed the following as risk factors for severe pre-eclampsia already reported in literature:

- Nulliparity
- Stress of job
- Antenatal care
- Chronic and familial hypertension
- Previous hypertension in pregnancy
- Birth interval of more than four years
- Male babies
- Low socio economic status.
- Being a referral patient

The study found the following as risk factors not previously reported in the literature:

- Previous abortion.

7.2.2 Risk factors for post partum haemorrhage

Post partum haemorrhage (PPH) is the leading causes of maternal morbidity and mortality in developing countries[8]. It contributed 19% of primary causes of SMM in this study.

The background to the PPH cases were uterine atony (45%), retained placenta or

placental tissue (16%), coagulation failure (16%) and genital tract tears (15%). Uterine atony is a common cause of PPH due to high parity and age-related changes which take place in the uterine connective tissue and muscles resulting in reduced contractility and retraction of uterine muscles after delivery. Other contributory factors to uterine atony are prolonged labour, over-distension of the uterus in multiple pregnancy and hydramnios, non use of oxytocics soon after delivery and anaesthesia[102,285]. In industrialized countries induction of labour, operative delivery and epidural anaesthesia are major risk factors for PPH[107].

Women who lived further away from Mulago hospital, in poor quality housing, being unable to pay for hospital upkeep, and needing to ask for permission to visit a health unit or hospital had increased risks of PPH after adjusting for confounders, results which were similar to those described for all SMM cases (7.1.2.). Asking for permission causes delay of the mother to reach health unit/hospital but also may encourage them to deliver at home and present to hospital with PPH. This is further reinforced by the low socio economic status of the women which hinder women from using health facilities because of failure to afford transport and cultural beliefs that encourage them to deliver at home[128,286].

Patients with chronic hypertension had a greater risk of developing PPH compared to those without. Hypertension predisposes to pre-eclampsia and abruptio placenta which are also risk factors for PPH[91,99,106]. Women with a past obstetric history of PPH had a higher risk of developing severe PPH after controlling for confounders. This was similar to Hall's finding of a 3 fold increase among patients with previous history of PPH[287]. In Zimbabwe there was moderate association of previous history of PPH with risk for PPH[101]. Previous history of PPH seems to be a good predictor of subsequent PPH, but the limitation is validation of the reported history of PPH[288].

Women who delivered by caesarean section in their previous pregnancy had a much higher risk of developing PPH after adjusting for confounders. When previous scar was further adjusted for mode of delivery the effect persisted. This was similar to Coombs findings, although the effect of previous scar disappeared after controlling for induction of labour[96]. The explanation for previous scar being a risk factor is possibly related to recurrent factors such as previous ante partum haemorrhage and hypertension which are underlying risk factors for PPH. It may also be related to prolonged labour and its

complications resulting in PPH.

Birth intervals of more than five years increased the risk of PPH after adjusting for confounders. Previous work has shown that prolonged birth interval may be associated with increasing age and low parity, both of which have been reported to be associated with PPH[101,239]. However, our estimate was adjusted for parity so that is not a likely explanation in these data. Long birth interval is associated with conditions such as pre-eclampsia and ante partum haemorrhage which are known risk factors for PPH[113].

Patients who did not attend antenatal care had increased risk of developing PPH. Studies have reported a strong relationship between lack of antenatal care and PPH[13,285], but one study in Nigeria showed no relationship between lack of antenatal care and risk for PPH[102]. The association between lack of antenatal care and PPH is related to management: women at risk of PPH are offered advice on where to deliver, and doctors prepare for these women by taking blood for haemoglobin level and grouping. When they arrive in labour blood is booked and a drip set up in anticipation of bleeding. But women without identifiable risk factors also get PPH, so delivery attendants need to have the skill and knowledge to manage these conditions if the morbidity, and associated mortality, is to be prevented. Women who lack knowledge about what to do if there was bleeding in pregnancy had increased risk of developing PPH. Previous work has reported that ante partum haemorrhage which usually presents with bleeding is a risk factor for PPH[107].

Bleeding in labour, as expected, was associated with a much greater risk of developing severe PPH. This was because the majority of women who bleed during labour are likely to have ante partum haemorrhage or ruptured uterus which are risk factors for PPH[98,107]. Women who bleed during labour should be managed in anticipation of PPH. Patients diagnosed with hypertension during pregnancy were also at greater risk of PPH. Hypertension is associated with disseminated intravascular coagulation which predisposes patients to PPH due to coagulation failure[95].

Referred patients to Mulago hospital had higher risk of developing severe PPH. This is explained by the fact that some women labour out of hospital and only come to Mulago when they have failed to deliver and have complications or have delivered at home and have a retained placenta. Similar results have been reported in previous studies from

Mulago and elsewhere[7,285]. Women who had induced or augmented labour had a markedly increased risk developing PPH, as has been reported in other studies[95,107].

Women who did not get oxytocics soon after delivery had increased risk of developing PPH. The majority of these patients were referred to Mulago after delivery. The recommended management of third stage is by active management: utero tonics are to be given at delivery of the anterior shoulder of foetus or within one minute of delivery of baby, followed by delivery of placenta by controlled cord traction. Conservative management allows the placenta to be delivered physiologically by waiting for placental separation then delivery with or without administration of utero tonics. Active management of third stage has been demonstrated to reduce on the incidence of PPH[95,107,271]. The loss of blood is minimal within the first 30 minutes, but the increases three fold for longer third stages[271]. In our study those who stayed in the third stage for 25 or more minutes were at very high risk of PPH compared to those who spent less than 25 minutes after adjusting for confounders. Other studies have shown that prolonged third stage predisposes to PPH[95,101,103,107].

The patients delivered by a doctor had markedly increased risk of PPH compared to those delivered by midwives. This may be partly explained by the fact that patients delivered by doctors were women who are were already at risk of PPH, or attended hospital with existing PPH. However a study in Nigeria showed reduction of PPH in women delivered by doctors[102].

Women with PPH delivered a higher proportion of babies weighing less than 2500 grams compared to women without SMM. This was because conditions that cause low birth weight also cause PPH. PPH was not found to be associated with the delivery of big babies in this study, although some studies have reported increased incidence of PPH due to big babies as result of over distension of the uterus, which affects the contractility and retraction of the uterine muscles[95,102].

In conclusion, risk factors for PPH were found to be residential distance from hospital, being referred, and low socio economic status of women, existing hypertension and anaemia, past history of PPH, lack of antenatal care and management of third stage of labour. Proper management of labour using skilled attendants at delivery and use of oxytocics during the third stage remains the hall mark in the prevention of PPH.

In summary, this study confirmed the following as risk factors for PPH already reported in the literature:

- Low socio economic class
- Lack of antenatal care
- Being referred patient
- Prolonged third stage
- Hypertension
- Induction or augmentation of labour
- Previous history of PPH.

The study found the following risk factors for PPH not previously reported in the literature:

- Previous delivery by caesarean section
- Lack of knowledge of what to do when bleeding occurs in pregnancy
- Birth spacing of more than five years.

7.2.3 Risk factors for obstructed labour

Obstructed labour and its consequences was the most frequent sub group of SMM in this study. This complication is a life threatening obstetric emergency but when recognized early and managed by caesarean section usually carries few or no complications.

Women who lived further away from Mulago hospital, in poor quality housing, being unable to pay for hospital upkeep, who did not know what to do if bleeding in pregnancy, and who needed to ask for permission to visit a health unit or hospital had increased risks of severe obstructed labour after adjusting for confounders. Low socio economic class has been reported as a risk for obstructed labour[13,117,118,217,289]. The majority of our patients lived within five kilometres from the nearest health unit and therefore the risk of obstructed labour should be minimal if the units had comprehensive maternity services and a functional referral system. In order to reduce maternal morbidity and mortality due to obstructed labour, a referral system should have a transport component to transfer patients to referral hospitals in order to reduce the delay[290]. Indeed women who were referred had eleven fold risk for developing obstructed labour. Sometimes, even when the referral system is working, if the midwife

or delivery attendant does not make a decision to refer a patient promptly, the patient will remain at risk of obstructed labour.

The vast majority (91%) of women with obstructed labour were below the age of thirty years compared to 83% of controls. Although a young age was a statistically significant factor for obstructed labour in the univariate analysis, the effect disappeared after adjusting for confounders. In Gombe hospital in Sokoto Nigeria age below thirty years was associated with increased risk of obstructed labour[211]. Other work in developing countries has indicated that under-nutrition may cause poor development of pelvises[44] and this, coupled with pregnancies in teenagers who are still growing, put them at risk of obstructed labour if their labour is not well managed[44,118,135,211,289]. We found that primigravidae had increased risk of developing severe obstructed labour compared to multigravidae. The majority of the primigravidae were teenagers who are expected to be at higher risk of cephalo pelvic disproportion, as reported in Nigeria[117,118,211].

Parous patients who had delivered by caesarean section in a previous pregnancy had increased risk of developing severe obstructed labour compared to those who had only previously delivered vaginally. This suggests the existence of a recurrent cause of obstructed labour, but that timely delivery was not offered in the current pregnancy.

Another explanation may be the desire for vaginal delivery among African women. As mentioned previously, they tend to avoid a repeat caesarean section by labouring at home and only turn up in hospital when vaginal delivery has failed. Similar observations have been reported in Nigeria and Uganda[128,142,207]. This risk, then, should be interpreted cautiously because it may be a measure of health seeking behaviour of the women (in that they delayed to come to hospital) or quality of care (in that the intervention to deliver was delayed) rather than a direct effect of previous delivery by caesarean section.

Although some studies have reported lack of antenatal care as a risk factor for obstructed labour[117,289]. We did not find a statistically significant association in this study. The effect estimate, however, was above one, and the lack of significance may be related to lack of power resulting from the small number of cases.

Monitoring of labour using a partograph was low in both cases (11%) and controls (9%)

in this study, suggesting there was poor monitoring of labour which resulted in failure to detect prolonged labour. If obstructed labour is not terminated in time it will progress to severe obstructed labour. The mean waiting time for a patient to have caesarean section from diagnosis to operation should be less than 30 minutes[131] but in this study the average waiting time for caesarean section was 211 minutes (3.5 hours). Only 46 (43%) of the patients with obstructed labour were operated on within two or less hours of diagnosis, which was the target of the hospital, and only 3 (3%) met the international standard of having caesarean section done in less 30 minutes. The reason for the long waiting times was a busy operating theatre (with other obstetric emergencies) and delays by staff. A similar finding of busy theatre not coping with obstetric emergencies has been reported in Dominican Republic[130].

Parous women with birth intervals of more than 36 months had higher risks of developing severe obstructed labour after adjusting for confounders. The reason for this was not clear but may be associated with previous obstructed labour which recurred. It is also possible that the effect of a previous delivery was traumatic and resulted in a longer waiting time to next pregnancy[291]. Women who presented with premature rupture of membranes had much higher risk of developing severe obstructed labour. Cephalo pelvic disproportion, malpresentation, malposition and abnormal lie are associated with premature rupture of membranes and these conditions predispose to obstructed labour[109].

As expected, patients who laboured for more than 18 hours were more likely to develop severe obstructed labour compared to those who did not. The mean length of labour in cases of obstructed labour was 25.2 (SD = 16.2 hours) and this was in excess of the suggested 24 hours which indicate that a woman's life may be in danger. Obstructed labour was associated with the delivery of male babies which are likely to be heavier than the female babies[292].

In conclusion, risk of severe obstructed labour was associated with residential distance from hospital, referral, low socio economic status of women, nulliparity and the type of care offered during labour. Monitoring of labour using a partograph is key to preventing obstructed labour.

In summary, this study confirmed the following risk factors for obstructed labour

previously reported in the literature:

- Low socio economic class
- Living further a way from hospital
- Asking for permission
- Referral
- Parity
- Prolonged labour.

The study found the following risk factors not previously reported in the literature:

- Birth spacing of more than 36 months
- Previous caesarean section scar
- Delivery of a male baby.

7.2.4 Risk factors for ruptured uterus

Uterine rupture is one of the most dangerous obstetric emergencies which have serious consequences for the mother and foetus. It is one of the main causes of maternal death in sub-Saharan Africa[136]. Uterine rupture is a catastrophic event to a woman because she may loose her future fertility due to hysterectomy or repair of uterus with bilateral tubal ligation[293].

Ruptured uterus contributed 10% of the primary causes of SMM in this study. The background causes were: cephalo pelvic disproportion (33%), previous scar (37%), malpresentation of the foetus (15%), big baby (10%) and others (5%). This pattern was similar to studies in other developing countries[136,148,175,294]. The treatment offered was subtotal hysterectomy (85%), repair of uterus and bilateral tubal ligation (10%) and repair of uterus only (4%). Scar dehiscence with no other complication is better managed by uterine repair. Hysterectomy cases performed better post operatively than those whose uteruses were repaired. Six (12%) of patients had uterine rupture involving the bladder. This was similar to that reported in Ethiopia and Nigeria[142,295]. The main worry with offering subtotal hysterectomy in Uganda is the risk of developing cancer of cervix later in life.

Women who lived further away from Mulago hospital, in poor quality housing, being unable to pay for hospital upkeep, who did not know what to do if bleeding started, and who had to ask for permission to visit a health unit or hospital had increased risks of ruptured uterus after adjusting for confounders, similar results to those described for all

SMM cases (7.1.2.). Low socio economic status has been reported previously as a risk factor for ruptured uterus [68,136,142].

Teenage women had a lower risk of developing ruptured uterus as did nulliparous women. Other studies have reported similar findings[136,145,146]. It is known that when mechanical obstruction to labour occurs in primiparous women uterine contractions gradually weaken and stop without uterine rupture, but in multigravidae contractions are more likely to continue until delivery or rupture of uterus[296].

Uganda has two major tribal groupings: the Bantu who are the majority and the Nilotics. The Nilotics had an increased risk of developing ruptured uterus compared to the Bantu. Most of the Nilotics are displaced persons due to civil war in their region and have come to live in Kampala. As result of civil war it is possible that some women could have had fracture of the pelvis or lower limbs resulting in cephalopelvic disproportion and predisposing them to uterine rupture. There also could be poor health seeking behaviour of these women and a strong desire for vaginal delivery.

We found that women with a history of previous labour lasting more than 18 hours had a higher risk of ruptured uterus after adjusting for confounders. This was likely to be associated with previous scar because women labouring for more than 18 hours were more likely to have been delivered by caesarean section. The main draw-back with such information is the recall and measurement bias of number of hours in labour. Our finding of a strong association between previous scar and ruptured uterus was similar to that found by several other studies[134,139,143,148,297]. Some authors have demonstrated increased risk of rupture with increasing number of caesarean sections. The risk of uterine rupture in relation to previous scar varies from country to country, type and site of uterine scar (either in upper segment or lower segment, transverse or vertical scar) and post-operative outcome of the mother. It has been reported that post operative fever increases the risk of scar dehiscence by 4 times in the next trial of labour[141,217].

Birth spacing of more than 5years was associated with an increased of ruptured uterus compared to birth intervals of 36 or less months. The possible explanation for this could be a result of the women's health seeking behaviour of attempting vaginal delivery at home and coming to hospital when delivery has failed. It is also possible that there was delay of operative delivery resulting in ruptured uterus.

Lack of antenatal attendance was a clear risk factor for ruptured uterus. A similar result has been reported in studies in Kenya[136], Ethiopia[144], Sudan[140] and in Nigeria[142]. However, over 50% cases of ruptured uterus were referred to Mulago hospital and referral was associated with risk. These patients laboured outside the hospital and when they had failed they were referred, or self referred, to Mulago. Similar findings have been reported from Mbale regional hospital in Uganda.[297], in Ethiopia[144] and in Ghana[298]. These results suggest that there was low quality of care in peripheral maternity units and that referred patients may have suffered undue delay to Mulago hospital, possibly because of lack of transport.

Women with ruptured uterus were more likely to deliver babies weighing more than 3500 grams. Big babies cause obstructed labour when delivery is not terminated in time to prevent rupture[296].

HIV positive women had increased risk of uterine rupture. There were 10 cases of ruptured uterus who were HIV positive and 4 of these had previous scar. It is possible that these 4 cases were asymptomatic HIV in a previous delivery by caesarean section and had poor uterine wound healing due to sub clinical infection. This could not be investigated further in this study as we did not have information of the patient's previous HIV status. This finding needs to be urgently investigated further.

In conclusion, risk factors for ruptured uterus were found to be residential distance for the hospital, referral, and poor socio economic status, previous scar, type of care offered during pregnancy and labour, and HIV. Early diagnosis and management of prolonged labour are likely to reduce the risk of ruptured uterus.

In summary this study confirmed the following risk factors for ruptured uterus as previously reported in literature:

- Previous caesarean section
- Low socio economic status
- Lack of antenatal care
- Multiparity
- Referral
- Older age

- Birth weight more than 3500 grams.

This study identified the following risk factors not previously reported in the literature:

- Birth interval of more than five years
- HIV positive status
- Nilotics group of tribes in Uganda.

7.2.5 Risk factors for placenta praevia

Placenta praevia is a major cause of obstetric haemorrhage in the third trimester and is associated with severe maternal complications and adverse perinatal outcomes. Placenta praevia is very important because the condition can become life threatening within a short period and if not managed promptly mortality due to this condition is very high.

Distance of residence from Mulago hospital and asking for permission before attending a health unit or hospital were risk factors for developing severe ante partum haemorrhage due to placenta praevia. As mentioned above, this condition is life threatening and occurs within a short time. If patients have to travel a long way or have to ask for permission to attend hospital valuable time will be lost. Referred patients were also an increased risk, probably also because of crucial time delays.

Many studies have reported an association of placenta praevia with increasing age and high parity[157,158,299]. There was some evidence from our data that younger women and nulliparous women had lower risks but the results were not statistically significant: we had very few numbers of women in the strata to test this adequately.

Women who were employed had a higher risk of placenta praevia after adjusting for confounders compared to peasant women. As mentioned in a previous section (7.2.1) employed women may spend less time resting, predisposing them to haemorrhage since bed rest is one way of managing placenta praevia. No study as far as I know has ever reported an association between socio economic factors and risk of placenta praevia.

A history of evacuation and or dilation and curettage of the uterus was associated with an increased risk, as has been reported previously[157,158,299,300]. Evacuation is related to a history of abortion but abortion was a not found to be a risk factor in this study.

Evacuation is associated with scarring of the uterus leading to under-perfusion which may predispose to placenta praevia. Scarring of the uterus has been reported as a risk factor for placenta accreta in other studies[157,158,301].

Patients who had previous delivery by caesarean section were at increased risk of placenta praevia after adjusting for confounders compared to those who did not, a finding which has been reported in the literature previously[158,299]. A meta analysis of over 170,000 pregnant women found a dose-related risk of placenta praevia with increasing number of caesarean section deliveries[301]. The reason for this finding is thought to be damage and scarring of the uterus during caesarean section predisposing to low implantation of the placenta. Another explanation is the attraction and adherence of the placenta to the caesarean section scar[301-305]. Scarring of the uterus may also retard the physiological development of the lower uterine segment and interfere with the placental migration within the upper segment as the pregnancy grows. The history of evacuation of the uterus may be acting in the same way as previous scar on the uterus[299,301]. Recently, manual removal of placenta has been reported to be a risk factor for placenta praevia, a finding also thought to act through scarring of uterus[157].

When women were asked what they should do when bleeding starts during pregnancy, a higher proportion of cases than controls did not know that they needed to seek urgent medical attention. Bleeding in the present pregnancy was associated with an increased risk of placenta praevia. This was likely to be due threatened abortion or early presentation of placenta praevia. Vaginal bleeding due to placenta praevia is likely to occur when the lower segment of the uterus begins to form at thirty two weeks of pregnancy.

Eleven percent of cases compared to 3% of controls did not attend antenatal care. After adjusting for confounders the effect of lack of antenatal care on the risk of severe placenta praevia disappeared. Antenatal care would be effective if there was a routine ultrasound examination on all women who attended, or at least all those who have vaginal bleeding to identify cases with placenta praevia and plan for their management. The cost and maintenance of ultra sound machines may be too much for developing countries for it to be routine.

Women with placenta praevia were much more likely than controls to deliver low birth

weight babies. This may be largely explained as severe haemorrhage leading to premature delivery, but chronic hypoxia due to placenta praevia may also cause intra uterine growth retardation[158].

In conclusion, the study identified risk factors for major placenta praevia as residing further away from Mulago hospital, being referred, and previous evacuation of the uterus or dilation and curettage, previous scar, recurrent bleeding and having employment. Prevention of severe haemorrhage due to placenta praevia is by use of ultrasound for at-risk patients in the antenatal period and offering prompt treatment when necessary.

In summary this study confirmed the following risk factors as reported previously in the literature:

- Previous history of evacuation
- Previous history of caesarean section
- Being referred patient
- Vaginal bleeding during pregnancy.

This study identified the following risk factors not previously reported in the literature:

- Having some employment.

7.2.6 Risk factors for abruptio placenta

Abruptio placenta is known to be an important cause of SMM and mortality worldwide. It is associated with high perinatal morbidity and mortality. Abruptio placenta contributed 7% of primary causes of SMM.

Women who lived further away from Mulago hospital, in poor quality housing, being unable to pay for hospital upkeep, and needing to ask for permission to visit a health unit or hospital had increased risks of severe abruptio placenta after adjusting for confounders. Poor education has been reported to be risk factor for abruptio placenta[163,165,172] but in this study no strong effect of education was observed after adjusting for other markers of socio-economic status.

Teenage pregnancy has been reported to be associated with abruptio placenta[172] as has

advanced age[163,165,166]. These trends were not demonstrated in this study but, again, the number of cases was small and the power of the study to detect small effects was low.

We found that women who had a stillbirth in a previous delivery had an increased risk of abruptio placenta. This is likely to be a measure of recurrence of abruptio placenta because the majority of women in Mulago hospital who develop severe abruptio placenta ended up with stillbirth. Previous abruptio placenta had been reported as a risk factor in the literature[306]. Patients who delivered by caesarean section in their previous pregnancy had greater risk of developing abruptio placenta after adjusting for confounders. A previous study of history of delivery by caesarean section did not show an association with abruptio placenta[163]. Our finding may suggest similar aetiology of abruptio placenta and placenta praevia.

Women diagnosed with chronic hypertension or hypertension during pregnancy had very much higher risks of abruptio placenta compared to women who did not. This is in agreement with previous reports of hypertension as a risk factor for abruptio placenta[163,165,166,172]. The patho physiology of hypertension and abruptio placenta is still not well understood. However, in a study which evaluated 445 patients with severe pre-eclampsia and eclampsia, the severity of blood pressure elevation and proteinuria was not predictive of abruptio placenta, suggesting a more complex aetiology of abruptio placenta than a simple casual link with hypertensive disorder[307].

Women who did not attend antenatal care had a higher risk of developing abruptio placenta. This is despite the fact that diagnosis of abruptio placenta in the antenatal clinic is difficult, even with use of ultrasound[166]. Not surprisingly, patients who presented with repeated vaginal bleeding of small amounts of blood during the present pregnancy had a very high risk of developing severe abruptio placenta. These are the type of patients would benefit from ultrasound[166]. As expected patients who presented with vaginal bleeding during labour had much higher risks. Interestingly, a previous study has found that although 65-80% of abruptio placenta present with vaginal bleeding, 20-35% is concealed[308]. These cases would not be picked up on simple examination or questioning about vaginal bleeding.

Delivery of a male baby was more common in cases than controls, a finding which has been reported previously[163,166,167,169,172]. The explanation may be related to the

association between pre-eclampsia and male babies. Women with severe abruptio placenta were highly likely to deliver low birth weight infants through premature delivery, an observation previously reported by Katherine et al[166]. The still birth rate for the case was 52%. This was very high but within the estimated perinatal mortality in abruptio placenta of 4.4% to 67.3% reported by previous studies[166]. The incidence of stillbirth is associated with the degree of separation of placenta with separation exceeding 50% making mortality is inevitable[308].

In conclusion, the risk factors identified for abruption placenta were residing further away from Mulago hospital, referral, hypertension, recurrent vaginal bleeding, previous delivery with caesarean section, lack of antenatal care and low socio economic status. Prevention of severe abruptio placenta is by offering prompt management when abruption occurs.

In summary, this study confirmed the following risk factors for abruptio placenta previously reported in the literature:

- Low socio economic status
- Recurrence
- Hypertension
- Being a referred patient
- Vaginal bleeding during labour
- Lack of antenatal care
- Further away the patient lived from Mulago hospital.
- Delivery of male babies

The study found the following risk factors not previously reported in the literature:

- Repeated vaginal bleeding during pregnancy
- Previous caesarean section
- Previous still birth.

7.3 PROGRESSION FROM SEVERE MATERNAL MORBIDITY TO MORTALITY

7.3.1 Ratio of SMM cases and deaths

The ratio of SMM to mortality was 12.8 to 1, which was similar to the ratio reported by the hospital during the study period of 12.7 to 1. The ratio was similar to that reported

in Benin of 12:1[31], and in Nigeria of 10:1[309], but higher than that reported in India of 7:1[310] and in South Africa of 5:1[2]. Higher ratios have been reported in Jamaica 25:1[311]. The difference in the reported ratios was due to differences in the definitions used in selecting the SMM cases and the quality of care the cases received. The better the quality of care received the fewer deaths and the higher the ratio of SMM to mortality[2,36,248].

7.3.2 Causes of maternal mortality and case fatality

The distribution of death by cause was similar to that reported before in Uganda [23] and other studies in sub Saharan Africa[8,39,136,209]. The relatively higher proportion of deaths due to haemorrhage may be due to shortage of blood and the quality of care the cases received. This will be discussed further in section 7.3.3 below. A high proportion of women with puerperal sepsis and medical diseases died compared to other causes of mortality and this was similar to findings from West Africa[39] and Scotland[213]. The high proportion of deaths in puerperal sepsis cases may be related to HIV/AIDS and quality of care offered in the hospital. This will also be discussed in the next section.

7.3.3 Risk factors for progression to maternal mortality

Age was not found to be related to risk of death in SMM. This finding was in contrast to previous findings of young age being associated with death in Uganda[23,312] and older ages also being linked to death following SMM elsewhere[248]. However, the study had very little power to investigate age as only 5 women who died were under 20, and only 4 were over 30 years.

Living more than ten kilometres, compared to under 5 kilometres, from Mulago hospital was a clear risk factor for death. It may be that these women took longer to reach hospital following development of obstetric complications and arrived in hospital in a critical condition which was difficult to salvage[7,115,313,314]. Another factor possibly related to delay was that some women had to ask for permission before attending a health unit or hospital. Asking for permission is a manifestation of lack of empowerment of Ugandan woman whereby they cannot make an independent decision. We have shown here that this is significantly associated with risk of death following SMM. As an example, one woman in this study was unable to make a decision, and refused a caesarean section, until the husband came and consented; by which time she had ruptured her uterus.

Employment was associated with a lower risk of death. Employed women have better education, are more likely to attend antenatal clinic, and are most probably empowered, resulting in a lower risk of progressing to maternal mortality. Low educational status, poverty and lack of empowerment of women have been reported to be associated with maternal mortality in previous studies[201,312,315,316].

Admission to hospital during the pregnancy for any condition other than pregnancy was associated with a higher risk of death. These were women admitted for medical conditions such as malaria, hypertension, urinary tract infection and anaemia and these results provide evidence that these medical conditions predisposed women with SMM to progress to death. Further evidence for this comes from the case fatality mortality where over 55% of SMM cases attributed to medical conditions died.

Our data showed that women who reported a previous caesarean section had a higher risk of death, although the result was of borderline statistical significance. Any delay in delivering patients with previous scar will put them at risk of morbidity and mortality because the uterus can rupture. Delay may result from the recognized desire of patients to deliver vaginally and late attendance in order to avoid a repeat section. Additionally, the hospital may have delayed offering operative delivery. In Mulago hospital, the mean waiting time for operative delivery was 245 minutes (4 hours) because of busy theatre; hence patients with a previous scar carried high risk of mortality. This is discussed further in section 7.3.4.

Multigravida women with birth interval of more than 36 months since the last delivery had a reduced risk of dying compared to those with lower birth intervals. Longer birth intervals may have enabled women to rest and recover from previous pregnancy[217]. Further analysis of the data comparing women whose previous birth interval was 14 or less months compared to 24-36 months showed no increased risk of progression to maternal mortality (results not shown in analysis). This suggests that very frequent births do not predispose women to maternal mortality, as has been noted in a previous study[262], although the statistical power of our analysis was limited.

Women who did not attend antenatal clinics had increased risk of death. Hopefully, women who attend antenatal care are screened for obstetric risk factors, managed, and

given advice where to deliver. For antenatal care to be effective patients should book in the first trimester and attend regularly as prescribed by the health provider, but of those who did attend, about 60% of those who died and 55% of those who survived booked in third trimester. About the same proportion attended fewer than 4 times. This type of antenatal care does not give a health worker enough time to screen the patients for possible risk factors. Furthermore, regarding the quality of antenatal care provided, 9% of those who died compared to 6% of those who survived had attended antenatal but had never had their blood pressure checked at all. This suggests that the quality of antenatal care was low, possibly due to lack of equipment and or shortage of staff. In a review carried out on effectiveness of antenatal care in a number of countries, in the UK 15% of women who had a previous history PPH were not identified and in Java one in four of women with a previous stillbirth were not identified by trained health workers, which calls in question the quality and effectiveness of antenatal care offered.[317].

Bleeding during pregnancy is a sign of an obstetric emergency which needs to be evaluated and appropriate management offered. It is known that early reporting to hospital with vaginal bleeding can reduce on the risk of dying from haemorrhage[113]. This study found that lack of knowledge about what to do if there was vaginal bleeding during the pregnancy was related to increased risk of death. Cases diagnosed with anaemia in pregnancy had an increased risk of dying compared to cases who did not have anaemia. This finding is similar to previous reports of anaemia being a known cause of maternal mortality in developing countries[270,318]. Patients with haemoglobin of less than 10 grams per decilitre had 3 times the risk of progressing to maternal mortality compared to those with haemoglobin above 9g/dl after adjusting for confounders. This finding is complicated by the fact that the haemoglobin level was measured in some patients post delivery and therefore it is difficult to disentangle from antenatal anaemia. The high rate of anaemia brings in question whether these women received haematinics during antenatal visits and, if they did, whether the compliance to taking the drugs was high. Also, it is possible they received haematinics but because majority came in the third trimester there was not enough time for the haematinics to have an impact on the haemoglobin level. The anaemia finding may also be confounded by underlying factors such as nutritional status which was not measured.

The women who delivered male babies had higher risk of death. This finding is most probably related to the fact that male babies are bigger than female babies[292,319] and could have predisposed to severe dystocia. In addition, male babies have been linked to

increased risk of severe pre-eclampsia and eclampsia, and abruptio placenta. However, the mechanism whereby the sex of the baby in a woman who has SMM can influence the risk of death is not entirely clear.

7.3.4 Type of care offered for SMM patients

The partograph has been shown to be an efficient tool in monitoring labour and in identifying women who need obstetric interventions. Patographs were used in 13% of those patients who died compared to 7% of those who survived. The generally low use of the partograph suggests that monitoring of patients was not adequate. Although Patographs may not have been used on critically sick patients because they needed special observations or because they did not labour, low usage could have been due to poor patient to staff ratio, low morale among staff or lack of knowledge regarding its use.

The majority of SMM patients were delivered by doctors, as expected, but 2 cases (5%) who died and 17 cases (4%) who did not die were delivered by TBAs. These numbers were too few to allow meaningful statistical analyses, but the finding it is of potential importance. Most of the SMM patients delivered by TBAs were patients who came in with PPH and puerperal sepsis post delivery. TBAs in Uganda still play a role in delivering mothers but the major concern is can they recognize signs of danger and refer the patients to hospital for further management on time? One study in Senegal comparing women who delivered by trained TBAs and professional midwives showed that maternal mortality was higher in TBA-assisted deliveries compared to midwife assisted deliveries and it was postulated that the midwives were able to detect and refer more complications than TBAs[27].

Patients who did not get oxytocics soon after delivery of their baby had higher risk of progressing to maternal mortality compared to those who did. It is known that the use of oxytocics soon after delivery prevents PPH[99,320].

Mulago hospital labour ward is managed on a 24 hour basis by a team of two obstetricians (Consultant and senior registrar), 4 senior house officers (registrars), four junior house officers and a team of midwives. The patients who developed SMM, or were referred with this condition, and not seen by the obstetrician on duty within 6 hours of diagnosis of the severe morbidity condition had higher risks of death compared

to those who were seen within 2 hours. The time of day when a patient is admitted or develops a severe complication may be important: Patients who developed complications between midnight and early morning were less likely to be seen by the obstetrician because they do not stay in hospital through the night and when called some do not turn up because of lack of transport. Another explanation may be the low morale among the obstetricians because of low pay, driving them to attend private practice when they are supposed to be in hospital. The old practice of carrying out labour ward rounds every 6 hours also contributed to delays. The consultant obstetrician on duty is crucial because the SHO needs him or her for decision making or management of the patients at a critical time. If they were not available this may predispose the woman with SMM to progress to maternal mortality.

Overall, 52% of the SMM patients were delivered by caesarean section: 34% of the patients who died and 53% of the patients who survived. It has been recommended that the waiting time for operative delivery (time from decision making to time of operation) in emergency caesarean section should be at less than 30 minutes[131,132]. As mentioned previously the mean waiting time for operation in this study was 4 hours 5 minutes with a range of 20 to 860 minutes. The patients who waited for more than 10 hours had 5 times the risk of progressing to death compared to those who waited for less than 2 hours. The reasons for long waiting times for operation (more than 2 hours) were: busy obstetric theatre with emergencies (58%), delay by doctors (18%), delay by anaesthetist (7%), lack of expendables and failure of sterilization (8%) and lack of blood (5%). The hospital was overwhelmed by obstetric emergencies that needed to be delivered but the theatre had only 2 operating tables to handle both obstetric and gynaecological conditions. The large numbers of emergencies was because neighbouring health facilities did not have capacity to handle emergency caesarean section. The other 3 NGO hospitals are paying hospitals. This resulted in large numbers of patients being referred to the Mulago hospital. Similar demand caused by obstetric emergencies has been reported in Dominican Republic[130]. The hospital was in process of addressing this problem by renovating and turning part of labour ward into a theatre and hopefully reducing waiting times.

The large numbers of emergencies over stretches the resources of the hospital which is under funded by government, leading to shortages of expendables and instruments. Staff delays were due to the morning audit meeting which lasted at least 45 minutes

daily, followed by handing over rounds in the labour ward lasting at least 1 hour. The other cause of delay was in the evenings when staff handed over to the night staff, more especially in theatre where it involved counting of instruments. The anaesthetists were understaffed and had only 2 shifts in 24 hours and change over in the evening caused a lot of delays for operation because of late arrival of the night anaesthetist. In France it has been found that lack of 24 hour anaesthetists was associated with maternal mortality due to PPH[108]. The delays and shortages of staff and lack of equipment and drugs, experienced in Mulago hospital put women at risk of mortality. This was also reported in a study carried out in Dakar Senegal which found the type of staff on duty, and the equipment available at the time of admission of a patient, were predictors of survival[321]. Similar findings have been reported in other Kampala hospitals[206].

Monitoring critically ill patients was crucial, especially in Mulago hospital where intensive care facilities are limited. The hospital has only one 12-bed intensive care unit. This meant that most of the critically ill patients were nursed in the labour ward, increasing the demands on staff in an already under-staffed unit. The study analysed patient monitoring in the first 24 following diagnosis of a SMM condition. Those whose blood pressure, pulse, and respiration were monitored less than 13 times had increased risk of dying compared to those who were monitored more than thirteen times. Of course, less monitoring in the women who died may be explained by the fact of death itself, but it is unlikely to explain the whole effect. The monitoring of blood pressure, pulse and respiration for very ill patients generally was every 15 minutes. This is less frequent than in places with good facilities where there would have been continuous monitoring.

Lack of regular and frequent monitoring of vaginal bleeding was also associated with risk of death. In a normal delivery, using a partograph, vaginal bleeding should be checked every half hour for first 4 hours and those with PPH checked on more frequently for at least 24 hours. A lower proportion of women who died were checked for vaginal bleeding more than 8 times in the first 24 hours following diagnosis of SMM than cases who survived.

One of the causes of delay of operation was lack of blood for transfusion and perhaps not surprisingly, we found that patients who needed blood for transfusion, but where it was unavailable, had high risk of death. Lack of blood has been reported as one of the

factors that have increased the maternal mortality in Mulago hospital since the advent of HIV in early 1980s[7,15,23] The shortage has been made worse by the high HIV prevalence in Uganda in that a high proportion of donated blood needs to be discarded. Similar shortage of blood and its effect on maternal deaths has been reported in Nakuru provisional general hospital in Kenya[322].

Puerperal sepsis contributed about 6% of the maternal deaths in this study. Puerperal sepsis can be reduced by having skilled delivery attendants and carrying out delivery in a clean, aseptic environment[323]. We found that those patients who needed specific antibiotics, or magnesium sulphate for managing their condition, but did not receive them because they were not available, were more likely to progress to mortality than patients who either did not need medication or needed them and received them promptly. When the hospital did not have the required drugs, relatives were asked to buy them, especially antibiotics and magnesium sulphate. This delayed the required treatment or resulted in failure to obtain the required treatment. The budgetary constrain of the hospital was responsible for this situation.

Three patients died due to poor surgical skills and lack of supervision by the obstetricians on duty. The 2 patients who had a window on the uterus post operatively raises questions about the supervision of the post graduate students (SHO) by the consultants on duty. If there was adequate supervision and consultation these deaths could have been prevented. One woman had her ureters ligated during hysterectomy and this also demonstrates inadequate skills. However, in this latter case, the delay of urologist to intervene led to woman's death. These 3 cases demonstrate lack of adequate knowledge and skill of the surgeons who carried out the operations and failure of the consultant on duty to provide support supervision. It also shows weakness in communications across the teams on duty in the hospital in general.

7.3.5 HIV and progression to maternal mortality

Since the advent of HIV in Uganda and sub Saharan Africa in general, mortality due to the HIV/AIDS has continued to rise. HIV has been attributed to the rising numbers of maternal deaths[182,215]. This study found HIV positive women with SMM had 5 times the risk of progressing to death compared to HIV negative women with SMM. When we adjusted for the cause of death the point estimate for HIV decreased, indicating that some of the causes may be more strongly related to HIV than others. The risk of death

following ruptured uterus showed the strongest association with HIV. Further analysis showed that when puerperal sepsis and medical conditions were removed from the multivariate model, the estimate decreased, suggesting that the risk of dying associated with HIV may also act through these conditions. Majority of women with medical condition could have had HIV related conditions. The majority of those HIV positive patients who died also had CD4 cell counts below 200, and a CD4 Cell count below 200 was highly significantly associated with risk of death. However, 3 HIV positive patients with CD4 cells above 200 died due post partum haemorrhage. HIV has been reported to increase the risk for PPH in critically ill obstetric patients who are HIV negative[200]. The results of this study confirm what other studies in sub Saharan Africa that have shown: HIV predisposes pregnant women to mortality. The uniqueness of this study is that it has demonstrated that critically ill obstetric patients who are HIV positive are at increased risk of death compared to critically ill patients who are HIV negative. This study did not investigate patients with tuberculosis, which is a major cause of mortality in HIV/AIDS, because of the selection criteria used. Our odds ratio of progression to maternal mortality was higher than the reported odds of 1.80(95% CI 0.99-3.33) for HIV positive in maternal deaths compared to the general population in fairly recent met analysis[228] but similar to results of population based studies from Uganda[216]. One study in Ireland which investigated the role of HIV in SMM, showed no effect of HIV on outcome of SMM cases. [235] The difference between the Irish study and this study may be due to the type of care offered, and stage of HIV/AIDS in the study patients. The asymptomatic HIV cases have a better outcome. All our patients were not HAART but some of them had received the niverapine peripartum to prevent transmission of HIV by the mother to the child. The peripartum dose may not have affected the link between HIV and progression to maternal mortality, but it has been reported that the patients on HAART were at lower risk of death[230].

In conclusion, the risk factors for progression to maternal mortality were low socio economic class, distance from home to Mulago, type of care offered, organization of health system and HIV. Improvement of quality of care in the period during antenatal and labour and reorganization of management of labour ward and theatre is likely to reduce maternal mortality. The control of HIV will also reduce the burden of maternal mortality. Long term strategies to improve women's education, incomes and empowerment are also expected to reduce maternal mortality.

In summary, this study has confirmed the following risk factors for progression to maternal mortality as reported in literature:

- Lack of antenatal care
- Distance from hospital
- Low socio economic class
- Delay to reach hospital
- Treatment deficiency
- Shortage of blood
- HIV (general risk for maternal mortality)
- Lack or delay of senior support
- Inadequate monitoring of patients.

This study found the following risk factors for progression to death from SMM not previously reported in the literature:

- Lack of blood
- HIV status (specially within SMM patients)
- Delay of operative delivery.

CHAPTER EIGHT: LIMITATIONS, CONCLUSIONS, AND RECOMMENDATIONS

This is the largest study yet conducted to investigate risk factors for SMM and progression to maternal mortality in sub-Saharan Africa. It paid particular attention to the role of HIV status and quality of care factors as determinants of SMM and maternal death. The results have been reported and discussed in previous chapters, and before moving on to the conclusions and recommendations emerging from this work the limitations of the study need to be addressed.

8.1 LIMITATIONS

8.1.1 Statistical Power

During the design phase of the study we predicted that a sample size of 500 cases and 500 controls would provide the case-control study with very good power to detect at least a doubling of risk associated with most risk factors if such associations existed in the population. Since we were able to achieve these numbers (albeit taking a little longer than the estimated 12 months) we are confident that the case-control study of all cause SMM was well powered. The individual causes of SMM achieved a reasonable sample sizes in 4 of the 9 primary causes: eclampsia and pre-eclampsia; post-partum haemorrhage; obstructed labour and ruptured uterus. Although individual analyses were conducted for ante partum haemorrhage and placenta praevia, the small numbers limited their statistical power, as was pointed out in the discussion. For puerperal sepsis and anaemia the numbers were too small (25 or less) to allow meaningful analyses to be carried out.

Regarding Stage 2, the study of progression from SMM to death, the study ended up with fewer deaths (39) than anticipated at the design stage of the study (72). These analyses thus had less power than originally predicted. However, we considered that the estimated 80% power we had to detect an odds ratio of 3.5 or more over the range of exposures was reasonable and the analyses were conducted, keeping in mind the less-than-ideal power when interpreting the results.

8.1.2 Bias

The potential for selection bias in Stage 1 of the study was recognised at the design

stage. Since Mulago hospital is a referral hospital we expected that SMM cases would come from a wider geographical area than controls. The controls may thus not have been representative of the population from which the cases originated, resulting in selection bias with respect to exposure distribution. In order to limit this bias we restricted the study area for both cases and controls: they had to live 15 or less kilometres from Mulago hospital. The fact that residential distance from the hospital emerged as a consistent risk factor in the study despite this restriction emphasises the importance of our original decision to limit the study population to 15km.

Referral also emerged as an important risk factor for SMM, raising the possibility that referred patients (who tended to be cases) may be fundamentally different from non-referred patients with regards other exposures, introducing a form of selection bias. In fact, when we compared the results for all cases and controls with that for only non-referred cases and controls there were no clear differences in the pattern of risk factors, indicating the absence of major selection bias associated with referral. However, referral is clearly a risk factor for SMM (after adjustment for distance) and the explanation may be the time taken for patients to travel from health unit to Mulago hospital. Unfortunately time was not measured, largely because of difficulties in recalling time by the patients.

Once they appeared in the hospital, selection bias of cases was minimised by using trained midwives and using selection criteria and processes which had been tested in the pilot study. In addition, the selection and recruitment of controls was highly regulated. The selection of cases and controls was certified by the principal investigator or his assistant on daily basis before they were included in the study. For stage 2, the mortality study, all SMM cases who died, and all SMM cases who survived until discharge, were included in the analysis. It is recognised that SMM cases who died after hospital discharge would have been misclassified as "survivors" in this study. However, this misclassification would most likely have tended to move the estimates of effect (of exposures) towards the null.

Information biases arising during the interviews of patients must also be considered, especially for those very sick patients where the interview was by "proxy" with the first relative or the spouse. Hopefully information bias was kept to a minimum by careful training of interviewers, and by interviewing the survivors at time of discharge. But for

the SMM patients who died, there remains the possibility of exposure misclassification. In order to limit the possibility of both differential and non-differential (random) error the author used the antenatal record information whenever available to check information and fill in missing information from proxy respondents.

Another possible source of information bias was data extraction from clinical notes. In some records observations or procedures may have been carried out but not recorded, possibly because they were considered "routine". Since the study depended on recorded information this could have resulted in misclassification of these exposures. However, since observations and procedures are more likely to be recorded for cases than for controls, any effect of missing data would have attenuated the effects found, rather than giving spurious results. Since we have interesting findings linking quality of care, or the lack of it, to increased risk of outcome, we can be reasonably confident that these results were not simply the result of recording errors.

Recall by study participants of other exposures, such as age and previous obstetric history, could have been a problem especially among multi parous women. Whether this was different in the cases than the controls, leading to biased estimates, is difficult to estimate. However, even if it was present it is unlikely to explain the major pattern of results reported here.

8.1.3 Confounding

This study was as comprehensive as possible and many social and economic factors were asked about as well as obstetric and medical details of previous pregnancies. However, potential confounding factors such as nutritional status, stature, height and weight were not measured and it must be recognised that there may be some uncontrolled confounding in this study. Having said that, the author does not consider this a major limitation since most factors previously reported in the literature were included.

During the adjustments for confounders I took into consideration the factors that existed before pregnancy such as socio demographic and economic factors, social and family history, existing medical conditions and past obstetric performance. All analyses were adjusted for these pre pregnancy factors only. This was because I was conscious that further adjustment with factors acting during pregnancy and delivery may interfere with

my understanding of factors in the causal pathways and could lead to over adjustment.

8.2 CONCLUSIONS

Factors that predispose women to SMM and progression to mortality are not only obstetric but interlinked with social, economic and gender factors. These factors act together and are responsible for the high maternal mortality found in many parts of the developing world.[128,180,324]. This means that the reduction of maternal mortality and morbidity is complex and needs programs that address issues like poverty, nutrition, education of the girl child, improvement of communication, empowerment of women and quality of care in health institutions. These programs need government and political commitment, money, and mobilisation and sensitization of the people for it to have effect on maternal mortality.

A holistic approach to addressing SMM and maternal mortality using both obstetric and community factors will yield better and sustainable results. Obstetric and hospital based factors are amenable to change and this is where the emphasis has to be put whilst long-term programs that address socio economic and cultural factors are implemented.

8.2.1 Distance and transport factors

The further away the patients lived from Mulago hospital the greater the risk of SMM and progression to maternal mortality. As with referral, distance is probably a proxy for time and is associated with the difficulty in affording transport to Mulago hospital. This matter was made worse by lack of ambulance services for the referred patients from the health units.

8.2.2 Socio-economic factors

From this study it is evident that low socio economic class (poverty) as demonstrated by people living in low quality houses (mud and brick only) were risk factors for SMM overall, all primary causes of SMM, and progression to maternal mortality. The level of poverty in society affects maternal mortality and consequently SMM in that women will not be able to afford to educate their children, afford the cost of health services, or transport to hospital. Poverty also leads to not having enough food to eat and living in a poor health environment such as slums in this study. All these factors have an effect on SMM and mortality and have been reported elsewhere[261,324-326].

Poverty is linked to poor nutrition which can cause women to have poorly developed pelvises and, together with adolescent pregnancy, predisposes to obstructed labour and ruptured uterus. Poverty was also exhibited by patients who depended on relatives for financial help. Lack of personal finance makes patients less able to afford transport to hospitals or health units leading to non attendance or poor compliance of antenatal care and later delay in reporting to hospital for delivery. In addition, it may encourage women to deliver at home, as has been reported in Nigeria[309].

The women who had jobs were at increased risk of SMM, and this I thought may be due to lack of adequate rest. However, employment among women with SMM was protective for progression to maternal mortality. This may be the result of ability to afford to buy drugs in circumstances where drugs were unavailable, or that the women attended hospital in good time for adequate treatment.

8.2.3 Gender issues

Women who needed to ask for permission from their spouses or relatives before attending hospital were at higher risk of SMM and progression to maternal mortality. This finding is a reflection of the lack of empowerment of women in important decision making processes. Lack of empowerment is associated with low education status, poverty, and cultural beliefs that a husband is the decision maker[116,128,205,309,327]. In this study almost all the women spent twelve or less years in school and about one third were peasants. Low levels of education, poverty and traditional beliefs predispose women to delays in seeking medical attention and strengthen their resolve in delivering at home[116]. Furthermore, traditional birth practices and beliefs are that pregnancy is a test of endurance of a woman and maternal death is a sad, but normal, event in Ugandan communities[128]. Such traditional beliefs lead to use of primary health care units and the referral hospital, including when complications have occurred, only as a last resort. Such traditional beliefs may also explain why the Nilotics compared to Bantu tribes were at higher risk of ruptured uterus. Men should be encouraged to be more supportive of their wives and look at them as partners rather than baby factories, and should be encouraged to take control of their family rather than allow relatives to dictate to them what is good for them and their wives.

8.2.4 Medical factors

Admissions to hospital for medical reasons, having chronic hypertension, and having

anaemia and hypertension during pregnancy, were predictors for SMM and progression to maternal mortality. These findings were similar to those reported in UK and South Africa[2,34]. These are patients who should have benefited from antenatal care and medical management, but clearly did not.

8.2.5 Age, parity and birth interval

Adolescent pregnancy has been reported in other studies as a major cause of maternal morbidity and mortality because of abortion related complications, dystocia and eclampsia in sub Saharan Africa[13,42]. However this was not demonstrated in this study. Adolescents, or age below 20 years, were in fact protective in ruptured uterus, although this effect is difficult to disentangle from nulliparity. Age above 34 has been reported to be a predictor of SMM and maternal mortality[2,34]; again, this study did not demonstrate this effect because the majority of women who delivered in Mulago were below the age of 30 years.

Primigravidae was a predictor for SMM and this was driven by increased risk for severe pre-eclampsia and eclampsia and severe dystocia. In Uganda grand multiparity (GMP) or parity above 5 usually occurred by the age of thirty. GMP was not a predictor for SMM and progression to maternal mortality in this study but was associated with reduced risk of severe pre-eclampsia. There are conflicting submissions about grand multiparity: that it is not a risk factor for maternal morbidity and mortality[328,329] and that is it[330,331]. Clearly the influence of GMP on risk is related to the type and quality of care available.

A long birth interval of more than 5 years was found to be a determinant of SMM and its primary causes such as eclampsia and pre-eclampsia, PPH and dystocia. The explanation is not clear but may be due to the women's health seeking behaviour or the type of care these patients received. However there may be some underlying factors causing this phenomenon which need further investigation. As expected, birth intervals of more than 3 years were protective for progression to maternal mortality, emphasising importance of family planning in prevention of maternal mortality. [332].

8.2.6 Quality of care

Good quality care offered to women when pregnant and during labour can prevent the majority of complications associated with childbirth. We found evidence that sub-

optimal care predisposed to SMM and mortality. Although over 90% of the study women attended antenatal care, the booking time was late (on average 25 weeks) and over 50% attended less than four times. Late booking for antenatal care, coupled with few visits, perhaps does not give the provider time and opportunity to manage pregnancy complications or to refer, appropriately. This may be a reflection of the health seeking behaviour of women as alluded in traditional beliefs and practice [128] or poor screening during antenatal care as demonstrated by non-measurement of blood pressure in over 20% of the women. Non measurement of blood pressure may also be reflection of staff shortage or lack of equipment in health facilities.

The use of a partograph was low suggesting that monitoring of labour was poor. Monitoring of labour is important because impending complications can be identified and managed early to avert severe maternal morbidity. For example patients who had vaginal bleeding or prolonged labour would have been identified and managed. Similarly patients who were monitored less were at higher risk of progressing to maternal mortality. The low levels of monitoring may be associated with shortage of staff, inadequate staff knowledge, or poor staff morale[130]. Lack of intensive care facilities has been found in previous studies to be associated with progression from SMM to maternal mortality[2]. However, monitoring of patients in the wards could be improved by addressing the patient to midwife ratio. Unfortunately in Mulago hospital there is over-crowding in the labour ward with some patients sleeping under the beds, making monitoring of patients extremely difficult. Similar results were reported in Kenyatta hospital Kenya[249].

Previous caesarean section scar was a predictor for SMM and all its primary causes but not for progression to maternal mortality (although the numbers of cases were few). Previous scar is, of course, an indicator of previous morbidity. With adequate care patients with previous scar should not develop SMM: clearly in this hospital those on trial of scar did not getting timely intervention when the need arose. Also, delays of such patients reaching hospital (for both deliberate and logistical reasons) and delays in operative delivery once they arrived, added to the problem and highlights the significance of the importance of timely treatment to avoid SMM.

Prolonged third stage and non use of oxytocics was predictive of SMM and progression to maternal mortality, especially for PPH. The role of a skilled attendant delivery is

very important in avoiding morbidity and mortality associated with this condition since a good proportion of women who develop PPH have no warning signs.

We found that delays of specialists to review SMM cases increased risk of death. The consultants should see patients more regularly and be available for consultation when needed. The cases that had surgical problems leading to death may be the tip of the ice berg in that a number of patients admitted to the labour ward may spend many hours before being reviewed by a consultant. This causes delay in decision making and consequently delay in getting the right treatment to avoid death. Our results suggest that the supervision by consultants of SHOs may have been inadequate and may indeed be affecting the training of obstetricians as evidenced by the surgical errors which resulted in mortality. However, the surgical problems encountered could also be treated as adverse events in the management of patients[333,334]. Interdisciplinary communication was not functioning efficiently as evidenced by a woman with ligated ureters who died due to uraemia. In the organisation of the hospital, emergency teams on duty should be able to consult across other teams in the hospital so that such delays, and errors, are avoided.

Drugs in Mulago Hospital are, in theory, free and available to patients. But in some instances drugs such as antibiotics and magnesium sulphate were not available. When these shortages occurred, patients or their relatives were asked to buy the drugs, or were given a less effective alternative. Shortage of drugs put women at risk of death, especially those with severe pre-eclampsia and eclampsia and sepsis. A drug such as magnesium sulphate is critical in the management of eclampsia and is so cheap that it should always be available. Shortage of this drug in particular suggests that the planning and supply of drugs and equipment to the labour ward is far from adequate. Shortage of blood for transfusion was also associated with mortality following diagnosis of SMM. Blood shortages in Uganda have been exacerbated by HIV and similar shortages have been observed in Nakuru provisional hospital in Kenya[322].

8.2.7 HIV and AIDS

This study found out that HIV positivity was a predictor for SMM. The specific type of SMM associated with HIV status was ruptured uterus and this may be related to the healing of caesarean section scar in asymptomatic HIV women in a previous delivery. This is a new observation which needs further investigation.

The study confirmed that critically ill patients who were HIV positive had an increased risk of progressing to maternal death, a finding which has been reported elsewhere.[13,200,215,216,248] The increase in pregnancy related mortality in populations affected by HIV could be due either to pregnancy induced acceleration of HIV disease or simply the result of coexistence of the HIV disease amongst women in reproductive age taking its toll. Maternal death as result of HIV seen in sub Saharan Africa has put into question the quality of care offered in hospitals as well as poverty among the women, nutritional deficiencies and the prevalence of HIV related disease in the general population. The increased burden that HIV places on medical services in developing countries has lead to over-stretching of the resources available for health care and compromises in the quality of care. This has resulted in shortage of hospital beds, drugs, blood and staff. The effect of some of these quality of care factors on maternal mortality have been identified, and quantified, in this study.

8.2.8 Implication of the study to safe motherhood

The aim of this study was to identify the risk factors that predispose a woman to SMM and progression to maternal mortality so that these factors can be used to screen and predict women at risk in the antenatal period and labour. The aim is to be able to offer appropriate management in order to reduce maternal mortality. However, statements from WHO say that every pregnant woman is at risk of a maternal complication and thus risk assessment or screening does not work[335]. In developing countries, where access to maternity care and resources are limited, risk assessment still has a role to play, especially in setting priority for management of patients. If the 94% pregnant women who attend antenatally in Uganda could deliver in maternity clinics, priority setting would be necessary because of the large numbers versus the available facilities. Advocacy for women to deliver in health units is top on the agenda of safe motherhood, but whether developing countries can cope with this influx is in doubt. In Uganda about 40%[12] and in Kampala about 80%[251], women deliver in health facilities but the type of care offered is generally low quality. Staff numbers are limited and those that are working have reduced morale since equipment and resources are scarce. Only 12% of GNP is spent on health[250] so it is perhaps not surprising that SMM and maternal mortality remain a major problem in Uganda, and sub Saharan Africa overall.

The decision making processes of women need to be addressed at the community level,

along with traditional birth practices and beliefs, in order to reduce the delay of women seeking medical services. The participation of the men as partners in reproductive health will go along way in addressing this issue. The current movement towards universal primary education in Uganda is one step forward in addressing decision making processes for women but this must be accompanied by improvement of the lives and incomes of women.

While over 90% of both cases and controls lived five kilometres or less from a health unit, lack of ambulance services to transport patients from these health units to hospitals is a major draw-back. The majority of women with morbidity who were referred to Mulago hospital used public transport and this must have resulted in delay. Well-functioning maternity units can contribute to the reduction of maternal mortality when the referral system has one or more working ambulances.

Besides the delay in reaching hospital, we found that patients faced further delays while waiting for operative delivery and appropriate consents. Ideally, peripheral health units should be able to offer emergency obstetric care instead of referring most of their cases to Mulago hospital. This calls on government and Kampala city council to upgrade both staff and equipment in these units. This would cut down on transport delays and also over-crowding and expenditure so that Mulago could function efficiently as a national referral centre.

The advent of HIV in sub Saharan Africa was another curse to the poor population. This study has demonstrated increase risk of SMM and mortality as result of HIV. The situation is made worse by lack of drugs including antibiotics and anti retroviral and shortages of blood for transfusion. The prevention of HIV, along with adequate management of existing cases, will hopefully reduce the extra deaths in pregnancy attributed to HIV.

In conclusion, the findings from this study suggest that the most urgent factors to be addressed in order to reduce SMM and maternal mortality are: mobilisation and sensitization women for safe motherhood, prevention and management of HIV, and the provision of quality care to parturient women.

8.3 RECOMMENDATIONS

8.3.1 Further research: extending the study

- Further research is needed to follow up the SMM cases who survive to evaluate the effect of morbidity on health. The progression and outcome of any following pregnancy would be particularly important. The length of follow up would depend on the amount of research funding available, but should be at least one year following delivery.
- The role of HIV needs to be further evaluated, especially regarding the role in rupture of uterus, previous scar and eclampsia.
- A study of quality of care in Mulago hospital is necessary to quantify its magnitude and effect on maternal and perinatal morbidity and mortality. The study should first develop practical, reproducible and nationally agreed tools for measurement of quality of care in Mulago hospital and Uganda in general.
- Intervention studies that address social, cultural and religious factors influencing decision making by women need to be put in place. Such programs will aim at changing women's decision making processes and discourage traditional beliefs and birth practices that are harmful. This intervention should also address the role of the spouses in reproductive health.
- An intervention study to assess the impact of stocking blood for blood transfusion in labour wards on maternal mortality in Mulago hospital is recommended.
- A pilot intervention study to offer support supervision to neighbouring health units in the provision of comprehensive obstetric care would be useful. The effect of this intervention on the number and outcome of SMM patients attending Mulago hospital, and the impact on the type of care offered in Mulago, would be assessed.
- More research is needed to study the effect of anaemia on SMM and maternal mortality, in particular the role of HIV in the causation of anaemia in pregnancy.

8.3.2 Policy issues

***Economic*:** Low socio economic class was a predictor for both SMM and progression to maternal mortality.

- The government should put in place programs that are aimed at alleviating poverty. Programs such universal education for all school children and rural finance schemes for women to take credit and start income-generating activities are recommended.
- At the village level government should finance societies that co-ordinate the

buying and selling of local produce to enable village people to receive adequate payment for their goods.

Decision making: Decision making was one of the main predictors of SMM and maternal mortality. Empowerment of women is a significant component in addressing SMM and mortality.

- Education of the girl child should be promoted as this will improve the status of women in society, improve decision making, and reduce adolescent pregnancy rates.
- At the community level, women should be encouraged to organise into groups where they can learn about reproductive health issues: about their bodies, sex, pregnancy and delivery and universal rights for women regarding reproductive health and other rights in general.
- Sensitize and involve men to play a big role in reproductive health matters.

***Distance and referral*:** The further way a woman lived the higher the risk of SMM and progression to maternal mortality.

- Kampala city council, with assistance from government and NGOS, should put in place an ambulance service to transfer patients form health centres to referral hospitals.
- The government, in collaboration with Kampala city council, should upgrade some health units so that they can offer comprehensive obstetric services in order to reduce congestion in Mulago hospital.

***Antenatal care*:** Lack of antenatal care was predictor for SMM and progression to maternal mortality:

- Staffing of antenatal clinics should be in proportion to the number of patients they serve so that they can offer quality care. Staff should be regularly updated on current concepts of management of women in antenatal clinics.

***Management of patients in labour*:** The type of care offered to patients in the labour ward was a predictor of SMM and progression to maternal mortality.

- Monitoring of patients in labour should be by use of a partograph. The hospital should employ more staff to ensure the staff-to-patient ratio is adequate to facilitate the use of the partograph. Staff should be given refresher courses on its

use.

- The Intensive Care Unit should be expanded to accommodate more obstetric cases.
- Programmes to develop and implement treatment guidelines for managing obstetric cases in the labour ward should be initiated.
- Consultants should be on duty in the labour ward for the full 24 hours and actively participate in the management of patients.
- Consultation across emergency teams on duty in different disciplines should be improved and strengthened.
- The hospital should create another theatre in the labour ward to handle the large numbers of emergencies and reduce on waiting time for operation.
- The level of anaesthetist staffing should be improved so that they can work an 8 hour shift instead of 12 and hence be available to handle emergencies.
- The government should increase on the funding of the hospital so that more drugs and equipment can be bought.
- The blood bank should organise more blood donor exercises to collect more blood and should prioritise the labour ward in its blood allocation.

8.3.3 Political Issues

Government level:

- Politically formulate and enhance policies that promote safe motherhood at government and community levels.
- Increase funding to health institutions especially Mulago hospital complex.
- Continue supporting and promoting programs which reduce and prevent HIV spread.
- Incorporate of some of the risk factors identified in safe mother hood programmes.

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APPENDIX A: QUESTIONNAIRES

Questionnaire A

Please fill in the appropriate responses by ticking or filling in the required information

Interviewer's initials:	☐☐
Date and time of interview: *Date:* *Time (24 hr clock):*	☐☐/☐☐/☐☐☐☐ ☐☐ ☐☐
Study number:	☐☐☐☐☐
Who is being interviewed – the patient herself, or a representative? *1 = The patient herself* *2 = The patient's husband or partner* *3 = The patient's mother, sister or close female relative* *4 = other (please specify here): _____* *9 = Not known*	☐
I am first going to ask some general questions about you (/your wife/etc)	
1. How old are you? *(Age in years; if patient/patient's represenative does not know, estimate and tick box)*	☐☐
2. Where do you live? _____	
3. What is the distance from your home to this hospital in kilometres? *(Distance from hospital in km; Not known = 99)*	☐☐
4. What is the distance from your home to the nearest Health Unit in kilometres? *(Distance from health unit in km; Not known = 99)*	☐☐
5. What is your tribe? *1 = Ganda* *2 = Nkole* *3 = Soga* *4 = Nyarwanda* *5 = Acholi* *6 = Teso* *7 = Gisu* *8 = Other (please specify here): _____* *99 = Not known*	☐
6. What is your religion? *1 = Protestant* *2 = Catholic* *3 = Muslim* *4 = 7th Day Adventist* *5 = Other (please specify here): _____* *9 = Not known*	☐
7. Have you ever been to school? *1 = Yes* *2 = No (➔ skip to question 10)* *9 = Not known*	☐
8. For how many years did you attend school? *(No. of years of schooling; Not known = 99)*	☐☐
9. What is the highest level of school attended? *1 = Primary* *2 = Secondary* *3 = College / University* *9 = Not known*	☐

10. What is your job? *1 = Commerce* *2 = Agriculture* *3 = Artisan* *4 = Professional* *5 = Peasant* *9 = Not known*	☐
11. Are you currently married or in stable union, single, separated, divorced or widowed? *1 = Married/stable union* *2 = Single* *3 = Separated* *4 = Divorced* *5 = Widowed* *6 = Other (please specify here): _____* *9 = Not known* *(→ skip to question 13 if not married or in a stable union)*	☐
12. Are you living under the same roof as your husband or partner? *1 = Yes* *2 = No* *9 = Not known*	☐
13. What is your husband or partner's job? *1 = Commerce* *2 = Agriculture* *3 = Artisan* *4 = Professional* *5 = Peasant* *6 = Does not have paid employment* *9 = Not known*	☐
14. What is the highest level of school attended by your husband or partner? *1 = No formal education* *2 = Primary* *3 = Secondary* *4 = College /University* *9 = Not known*	☐
15. Who is the owner of the house you live in? *1 = You and husband/partner* *2 = Husband or partner* *3 = You* *4 = Parents / husband's (partner's) parents* *5 = Landlord (renting)* *9 = Not known*	☐
16. What type of house do you live in? *1 = Mud with or without iron roof* *2 = Brick, not plastered and iron roof* *3 = Brick, plastered and iron roof* *4 = Brick, plastered and tiled roof* *5 = Other (please specify here): _____* *9 = Not known*	☐
17. What facilities does the house you live in have? *1 = Electricity in house and tap water or bore hole* *2 = Electricity and piped water in house* *3 = Tap water or bore hole only* *4 = Electricity only* *5 = No electricity or tap or piped water* *9 = Not known*	☐
18. What type of transport did you use when coming to hospital? *1 = Came on foot* *2 = Bicycle* *3 = Motor bicycle* *4 = Public vehicle* *5 = Personal car* *6 = Ambulance* *9 = Not known*	☐
19. Do you ask for permission to visit health care unit or hospital when you have a health problem? *1 = Yes*	☐

2 = No (➜ skip to question 21) *9 = Not known*	
20. From whom do you ask permission? *1 = Husband or partner* *2 = Mother-in-law* *3 = Your parents* *4 = Other (please specify here): _____* *9 = Not known*	☐
21. Who pays for health care for pregnancy and delivery in your household? *1 = Self and husband/partner* *2 = Husband or partner* *3 = You* *4 = Parents / husband's (partner's) parents* *5 = Other (please specify here): _____* *9 = Not known*	☐
Now I am going to ask about all your previous pregnancies	
22. How many pregnancies have you carried in total? *(No. of pregnancies; Not known = 99)* ***If no previous pregnancies (i.e. this is their first pregnancy) ➜ skip to question ...***	☐☐
23. When did you have each pregnancy?	**1st** ☐☐ **Month** ☐☐☐☐ **Year** **2nd** ☐☐ **Month** ☐☐☐☐ **Year** **3rd** ☐☐ **Month** ☐☐☐☐ **Year** **4th** ☐☐ **Month** ☐☐☐☐ **Year** **5th** ☐☐ **Month** ☐☐☐☐ **Year** **6th** ☐☐ **Month** ☐☐☐☐ **Year** **7th** ☐☐ **Month** ☐☐☐☐ **Year** **8th** ☐☐ **Month** ☐☐☐☐ **Year** ***(add more on back page if necessary)***
24. Were any of your pregnancies multiple pregnancies? *Put a code for each pregnancy:* *1 = No, singleton* *2 = Yes, twin* *3 = Yes, triplet* *4 = Yes, higher number of babies* *9 = Not known*	**1st** ☐ **2nd** ☐ **3rd** ☐ **4th** ☐ **5th** ☐ **6th** ☐ **7th** ☐ **8th** ☐ ***(add more on back page if necessary)***

25. How did each of your previous pregnancies end?

(You may need to explain the outcomes)

Put a code for each pregnancy:

1 = live born baby or babies
2 = stillborn baby or babies
3 = Miscarriage
4 = Planned termination of pregnancy
5 = Ectopic pregnancy
7 = Hydatidiform mole
8 = Other (please specify here): _____
99 = Not known

1st ☐
2nd ☐
3rd ☐
4th ☐
5th ☐
6th ☐
7th ☐
8th ☐

(add more on back page if necessary)

26. Did you have to have an operation or other procedure during the delivery of any of your pregnancies?

(You may have to explain what is meant by this)

1 = Yes (→ ask which pregnancies, and what was done)
2 = No (→ skip to question ...)
9 = Not known

Procedures:

1 = Caesarean section
2 = Vacuum extraction
3 = Forceps delivery
4 = Repair of uterus
5 = Other (please specify here): _____
9 = Not known

	1, 2, 7 or 9	Procedure
1st	☐	☐
2nd	☐	☐
3rd	☐	☐
4th	☐	☐
5th	☐	☐
6th	☐	☐
7th	☐	☐
8th	☐	☐

(add more on back page if necessary)

27. Do you know why you had to have this operation/operations or procedure/procedures?

(Write reasons below for each pregnancy, labelling the reason with the pregnancy number)

_____

_____

_____

_____

99 = Not known

Have you had any of the following problems during <u>any</u> of your previous pregnancies, i.e. during the pregnancy, delivery or in the time following the delivery?

28. Bleeding during the pregnancy?

1 = Yes
2 = No
9 = Not known

1st ☐
2nd ☐
3rd ☐
4th ☐
5th ☐
6th ☐
7th ☐
8th ☐

(add more on back page if necessary)

29. Bleeding during labour? *1 = Yes* *2 = No* *9 = Not known*	1st ☐ 2nd ☐ 3rd ☐ 4th ☐ 5th ☐ 6th ☐ 7th ☐ 8th ☐ *(add more on back page if necessary)*
30. Excessive bleeding after delivery? *1 = Yes* *2 = No* *9 = Not known*	1st ☐ 2nd ☐ 3rd ☐ 4th ☐ 5th ☐ 6th ☐ 7th ☐ 8th ☐ *(add more on back page if necessary)*
31. Delay of placenta to come out for more than 60 minutes after delivery? *1 = Yes* *2 = No* *9 = Not known*	1st ☐ 2nd ☐ 3rd ☐ 4th ☐ 5th ☐ 6th ☐ 7th ☐ 8th ☐ *(add more on back page if necessary)*

32. Labour lasting more than 18 hours? *1 = Yes* *2 = No* *9 = Not known*	1st ☐ 2nd ☐ 3rd ☐ 4th ☐ 5th ☐ 6th ☐ 7th ☐ 8th ☐ *(add more on back page if necessary)*
33. High blood pressure? *1 = Yes* *2 = No* *9 = Not known*	1st ☐ 2nd ☐ 3rd ☐ 4th ☐ 5th ☐ 6th ☐ 7th ☐ 8th ☐ *(add more on back page if necessary)*
34. Pus discharge from your vagina during pregnancy or after delivery? *1 = Yes* *2 = No* *9 = Not known*	1st ☐ 2nd ☐ 3rd ☐ 4th ☐ 5th ☐ 6th ☐ 7th ☐ 8th ☐ *(add more on back page if necessary)*

35. Blood transfusion?
1 = Yes
2 = No
9 = Not known

1st ☐
2nd ☐
3rd ☐
4th ☐
5th ☐
6th ☐
7th ☐
8th ☐

(add more on back page if necessary)

36. Admission to hospital?
1 = Yes (→ ask which pregnancies, and why they were admitted – write answers below)
2 = No
9 = Not known

Reason for admission (label each reason with the relevant pregnancy number):

_____
_____
_____
_____
_____
_____

1,2 or 9 **??ICD10 code**

1st ☐
2nd ☐
3rd ☐
4th ☐
5th ☐
6th ☐
7th ☐
8th ☐

(add more on back page if necessary)

Now I am going to ask about your current pregnancy

37. Did you plan for this pregnancy?
1 = Yes
2 = No
9 = Not known

☐

38. How old is your last born?
(Put age in years and months)

☐☐ Years ☐☐ Months

39. Do you remember when your had your last normal menstrual period?
(Put date, or 01/01/2025 if cannot remember date)

☐☐/☐☐/☐☐☐☐

40. What was the expected delivery date?
(Put date, or 01/01/2025 if cannot remember date)

☐☐/☐☐/☐☐☐☐

41. How many weeks of ammenorrhoea is she now?

☐☐

42. During this pregnancy did you attend antenatal check up?
1 = Yes
2 = No (→ skip to question 44)
9 = Not known

☐

43. How many times did you go for antenatal check up?
1 = One to three
2 = Four or more
9 = Not known

☐

44. How many months was the pregnancy when you went for the first antenatal check up?
1 = Less than four months
2 = Between four and seven months
3 = More than seven months

☐

9 = Not known	
45. During your antenatal period: *(you need to explain the condition and confirm from records)* **i) Were you told you have hypertension?** *1 = Yes* *2 = No* *9 = Not known* **ii) Did You have vaginal bleeding during this pregnancy?** *1 = Yes* *2 = No* *9 = Not known* **iii) Were you told you had anaemia or lack of blood?** *1 = Yes* *2 = No* *9 = Not known* **iv) Did you have water coming out your vagina? (Pre term rupture of membranes)** *1 = Yes* *2 = No* *9 = Not known*	☐ ☐ ☐ ☐
46. Were you admitted during this pregnacy? (The reason for admission was medical disease such as UTI, hypertension, malaria, Anaemia) *1 = Yes* *2 = No*	☐
47. Have you had any of the following complications during this pregnancy: **i) Abnormal vaginal discharge?** *1 = Yes, 2 = No , 9 = Not known* **ii) Blurring of vision?** *1 = Yes, 2 = No , 9 = Not known* **iii) Painful and frequent urination?** *1 = Yes, 2 = No , 9 = Not known* **iv) Frequent fevers?** *1 = Yes, 2 = No , 9 = Not known* **v) Cough lasting a month or more?** *1 = Yes, 2 = No , 9 = Not known* **vi) Loss of weight?** *1 = Yes, 2 = No , 9 = Not known* **vii) Body rash?** *1 = Yes, 2 = No , 9 = Not known* **viii) Swelling of the body?** *1 = Yes, 2 = No , 9 = Not known* **ix) Epigastric pain?** *1 = Yes, 2 = No , 9 = Not known* **x) Excessive weight gain?** *1 = Yes, 2 = No , 9 = Not known* **xi) Severe headache?** *1 = Yes, 2 = No , 9 = Not known* **xii) The baby stopped moving?** *1 = Yes, 2 = No , 9 = Not known* **xiii) Other (please give details)** *1 = Yes, 2 = No , 9 = Not known* _____ _____	☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐
Now I am going to ask you questions about diseases of the reproductive system, and about contraception	
48. Have you ever had any of the following infections in the last one year? *(You need to explain the symptoms of the STI)* **i) Gonorrhoea?** *1 = Yes, 2 = No , 9 = Not known* **ii) Syphilis?** *1 = Yes, 2 = No , 9 = Not known* **iii) Chlamydia?** *1 = Yes, 2 = No , 9 = Not known* **iv) Bacterial vaginosis?** *1 = Yes, 2 = No , 9 = Not known* **v) Candidiasis (thrush)?** *1 = Yes, 2 = No , 9 = Not known*	☐ ☐ ☐ ☐ ☐ ☐ ☐

vi) Chancroid? *1 = Yes, 2 = No , 9 = Not known*

vii) Other sexually transmitted infection (please give details)
1 = Yes, 2 = No , 9 = Not known

_____

_____

49. Have you ever had any of the following operations on your reproductive system?
(You may need to describe what these are)

i) Evacuation? *1 = Yes, 2 = No , 9 = Not known*

ii) Dilatation and curettage ("D and C") *1= Yes, 2 =No, 9= Not known*

iii) Myomectomy? *1 = Yes, 2 = No , 9 = Not known*

iv) Operation on cervix? *1 = Yes, 2 = No , 9 = Not known*

v) Repair of the uterus? *1 = Yes, 2 = No , 9 = Not known*

vi) Other operation on your reproductive system (please give details) *1 = Yes, 2 = No , 9 = Not known*

_____

_____

50. Which contraceptive method did you last use in the six months before becoming pregnant this time?

1 = Permanent
2 = Injection depo
3 = Norplant
4 = Intrauterine contraceptive device
5 = Condom
6 = Spermicides
7 = Oral contraceptive pills
8 = Rhythm
9 = Vaginal jellies
10 = Emergency contraception
11 = Other
12 = None
99 = Not known

This section is on medical and surgical conditions	
51. Have you ever been told that you have any of these medical conditions? **i) Essential hypertension** *Yes=1, No=2, Not known=9* **ii) Chronic hypertension** *Yes=1, No=2, Not known =9* **iii) Renal disease** *Yes=1, No=2, Not known =9* **iv) Sickle cell disease** *Yes=1, No=2, Not known =9* **v) Herpes zoster** *Yes=1, No=2, Not known =9* **vi) Tuberculosis** *Yes=1, No=2, Not known =9* **vii) Diabetes mellitus** *Yes=1, No=2, Not known =9* **viii) Bronchial Asthma** *Yes=1, No=2, Not known=9* **ix) Cardiac Disease** *Yes=1, No=2, Not known =9* **x) Others** **State** _____	☐☐☐☐☐☐☐☐☐
52. Have you ever had fractures of the lower limbs, spine or pelvis? *Yes=1, No=2, Not known =9*	☐
53. Have you ever been given blood? *Yes=1, No=2*	☐
54. What was the reason for blood transfusion? *Bleeding during pregnancy = 1* *Lack of blood = 2* *Don't know = 99* *Other* State _____	☐
This section is about your family and social history	
55. Do you take alcohol? *Yes=1 No=2 (If no go to no 57)*	☐
56. How much alcohol do you take per week? *1=<10* *2=11-14* *3=15-21* *4=>21*	☐
57. Do you smoke? *Yes=1 No=2 (If no go to no 59)*	☐
58. How many sticks of cigarettes per day?	☐☐
59. Do you have any of your relatives who have the following conditions? **i) Hypertension** *Yes = 1, No = 2, Not known = 99* **ii) Diabetes mellitus** *Yes = 1, No = 2, Not known = 99* **iii) Sickle cell disease** *Yes = 1, No = 2, Not known = 99* **iv) Epilepsy** *Yes = 1, No = 2, Not known = 99* **v) Other** **State** _____	☐☐☐☐☐
This section is about labour and delivery	
60. This is about your referral. **i) Were you referred?** *Yes = 1, No = 2 (If not referred go to no 60)* **ii) State the reason for referral:** _____ _____	☐

61. Did your membranes rupture before getting labour pains? That is you have draining of water from your vagina *Yes = 1, No = 2 (If no skip no 62)*	☐
62. If yes how many hours ago before delivery?	☐☐☐☐☐
63. Did you have vaginal bleeding before delivery? *Yes = 1, No = 2 (If no go to no 64)*	☐
63. If yes how much blood did she loose in mil litres?	☐☐☐☐☐
At the end of No 64 go ahead and take blood. ***This section is on clinical examination. This is for abstraction from the clinical notes.***	
The following questions refer to the time of at recruitment. **64. State general condition of the patient (see appendix4)** *1 = poor* *2 = fair* *3 = good*	☐
65. State degree of pallor *1 = mild* *2 = moderate* *3 = severe*	☐
66. Does she have jaundice? *Yes = 1, No = 2*	☐
67. State the degree of oedema *1 = mild* *2 = moderate* *3 = severe/gross* *4 = Nil*	☐
68. In the cardio vascular system *1. Pulse* *2. BP* *3. Murmurs Yes = 1, No = 2*	☐☐☐ ☐☐☐☐☐☐☐
69. In respiratory system *1. Respiratory rate* *2. Added sounds: Yes = 1, No = 2* *3. Consolidation: Yes = 1, No = 2*	☐ ☐☐☐☐☐
70. In central nervous system *1. Coma: Yes = 1, No = 2* *2. Neck stiff: Yes = 1, No = 2* *3. Kerning's : Yes = 1, No = 2*	☐☐ ☐ ☐ ☐
Obstetrical examination at recruitment	
71. Fundal height estimation in centimetres if not delivered	☐☐
72. What was the presentation of foetus? *1 = cephalic* *2 = breech* *3 = shoulder* *4 = brow* *5 = face* *6= other* *State* _____	☐
73. What was the foetal heart rate?	☐☐☐☐☐
74. What was the lie of foetus? *1 = longitudinal* *2 = transverse* *3 = oblique*	☐

75. State any abnormalities observed or elicited on abdominal examination

1 = tenderness
2 = Bandl's ring
3 = easily palpable foetus
4 = others
State _____

☐
☐

Vaginal examination findings

76. What was the appearance of external genitalia

1 = normal
2 = tears
3 = oedematous
4 = other
*State*_____

☐

77. Describe the discharge

1 = blood
2 = pus or infected liquor
4 = mucoid blood stained (show)

☐

78. State the presenting part

1 = cephalic
2 = brow
3 = face
4 = shoulder
5 = breech

☐

79. What was the mode of delivery?

1 = spontaneous vertex delivery
2 = assisted breech delivery
3 = Caesarean section
4 = vacuum
5 = forceps
6 = laparotomy

*Other state*_____

1st ☐ **2nd** ☐

80. State the indication of caesarean section or laparotomy or instrumental delivery.

_____

_____

81. What type of labour was it

1 = normal labour
2 = trial of labour
3 = trial of scar
4 = induction of labour
5 = Augmented labour

☐☐☐☐☐

82.

a) What is/was the out come of baby

i) Sex: Male =1, Female =2 ☐

ii) Weight ☐☐☐☐☐

iii) Apgar Score ☐☐

iv) Still birth: Fresh=1, Macerated=2 **(*if twins fill in 82b too*)** ☐

82.

b) For second twin delivery
What is/was the out come of delivery

i) Sex: Male =1, Female =2 ☐

ii) Weight ☐☐☐☐☐

iii) Apgar Score ☐☐

iv) Still birth: Fresh=1, Macerated=2 ☐

83. What was the total blood loss during third stage in millilitres	☐☐☐☐☐
84. State total length of labour in hours *1. First stage in hours* *2. Second stage in hours* *3. Third stage in minutes*	☐☐☐☐☐ ☐☐☐☐☐ ☐☐☐☐☐
This section is about the post partum period	
85. Has the placenta been delivered? *Yes = 1, No = 2 (if no go to 90)*	☐
86. Is the placenta complete? *Yes = 1, No = 2*	☐
87. If the whole or part of placenta was retained, How was it removed? *1 = Manual removal of placenta* *2 = Evacuation* *3 = Hysterectomy* *Other State* _____ _____	☐
88. Did she get post partum haemorrhage? *Yes = 1, No = 2*	☐
89. State the cause of post partum haemorrhage. *1 = Vaginal tear* *2 = Cervical tear* *3 = Episiotomy site* *4 = Uterine tear* *5 = Uterine atony* *6 = Coagulation failure* *Other State* _____ _____	☐
90. Does the patient have fever during the puerperium? *Yes = 1, No = 2*	☐
91. Does the patient have foul smelling/pus like lochia? *Yes = 1, No = 2*	☐
92. Was she operated on in puerperium? *Yes = 1, No = 2* *If no go to no 96*	☐
93. Which operation was done? *1= Laparotomy* *2 = Colpotomy* *3 = Closure of burst abdomen* *4 = Evacuation* *Other State* _____ _____	☐
94. What was the indication of of operation in puerperium? **State** _____ _____	
95. Admission to intensive care unit. **i)** Was she admitted to intensive care unit? *Yes=1, No=2* **ii)** Number of days in ICU in days	☐ ☐☐☐☐☐
96. State the final diagnosis of patient at discharge: _____ _____	
97. Describe the state on patient at discharge *1 = fair* *2 = dead (Continue with the abstraction)*	☐
98. State total stay in hospital in days	☐☐☐☐☐

99. State the cause of death _____ _____	☐☐☐☐☐
100. Was post mortem done? *Yes = 1, No = 2*	☐
101. What is the cause of death from post mortem? _____ _____	

Questionnaire B

This questionnaire is on quality of care

Interviewer's initials:	☐☐
Date and time of interview: *Date:* *Time (24 hr clock):*	☐☐/☐☐/☐☐☐☐ ☐☐ ☐☐
Study number:	☐☐☐☐☐
1. Did she attend antenatal care? *Yes = 1, No = 2 (if no go to number 3)*	☐
2. Did you attend health talks during antenatal clinics? *Yes = 1, No = 2*	☐
3. Did she have the following tests done during antenatal? **i) Syphilis** *Yes = 1, No = 2* **ii) Haemoglobin level** *Yes = 1, No = 2* **iii) Urinalysis** *Yes = 1, No = 2*	☐ ☐ ☐
4. Was her blood pressure checked during antenatal period? *1 = Never checked* *2 = Less than four times* *3 = More than four times*	☐
Question 5 and 6: Ask the patient at discharge. **5. State what you should do when you get vaginal bleeding during antenatal period.** *1 = I don't know* *2 = Go to hospital immediately*	☐
6. Did you get tetanus immunisation during antenatal period? *Yes = 1, No = 2*	☐
7. Were you given an injection ergometrine soon after delivery of your baby? *Explain this to her.* *Yes = 1, No = 2, Not known = 9*	☐
8. Was the labour monitored using a partograph? *Yes=1, No =2*	☐
9. How many times was she observed after diagnosis of severe maternal morbidity complication in the first 24 hours? *i. BLOOD PRESSURE/PULSE/RESPIRATORY* *ii. VAGINAL BLEEDING POST DELIVERY*	☐☐☐☐☐ ☐☐☐☐☐

10. Was she given prophylactic antibiotics during labour? *Yes = 1, No = 2*	☐
11. What is the level of training of delivery attendant? *1 = Midwife* *2 = Clinical officer* *3 = Intern Doctor* *4 = Doctor/SHO* *5 = Specialist* *6 = TBA* *7 = None*	☐
12. State time of diagnosis of operative delivery	☐☐☐☐☐
13. State time of start of operation?	☐☐☐☐☐
14. How long was the waiting time in hours?	☐☐☐☐☐
15. How long was the operation in minutes?	☐☐☐☐☐
16. Was there any delay in doing the operation? *Yes=1, No =2*	☐
17. If yes state the reason of delay *1 = Delay of nursing staff* *2 = Delay of doctors* *3 = Delay of anaesthetist* *4 = Lack or shortage of instruments.* *5 = Power failure* *6 = Failure of sterilisation* *7 = Lack of expendables* *8 = Theatre was busy with obstetric emergency*	1st ☐ 2nd ☐
18. Did the doctor call his/her senior when faced with complications? *Yes = 1, No = 2*	☐
19. **i) When the senior was called did he/she come to give support to the junior?** *Yes=1 No =2* **ii) If no state the reason for not coming** _____ _____ _____	☐
20. When this patient was admitted/diagnosed with severe maternal morbidity condition was she seen by the senior (Obstetrician) six or more hours of diagnosis? *Yes = 1, No = 2*	☐
21. When the severe morbidity patient was admitted/ diagnosed did senior (Obstetrician) see her one or less hours of admission? *Yes = 1, No = 2*	☐
22. *<u>This to be answered by PI or Assistant</u>* **i) Were relevant laboratory investigations carried out?** *Yes = 1, No = 2* **ii) Are the results available?** *Yes = 1, No = 2, Some = 3*	☐
23. **i) Did she get the right treatment within thirty minutes of diagnosis of severe maternal morbidity condition?** *Yes = 1, No = 2* **ii) Did she get blood for transfusion when she needed it?** *Yes = 1, No = 2* **iii) Was she given definitive antibiotic for treatment of her condition?** *Yes = 1, No = 2* **iv) Was magnesium sulphate available for treatment of her condition?** *Yes = 1, No = 2*	☐ ☐ ☐ ☐
24. Were relatives asked to buy drugs for patients' treatment? *Yes = 1, No = 2, Not known*	☐
Criteria to assess clinical performance for severe maternal morbidity	

GENERAL ACTIONS TAKEN	
25. Was the patient's complete history documented in clinical notes? **i) Identification of patient** *Yes = 1, No = 2* **ii) Present obstetric history** *Yes = 1, No = 2* **iii) Past obstetric history** *Yes = 1, No = 2* **iv) Reason for referral** *Yes = 1, No = 2* **v) Gynaecological history** *Yes = 1, No = 2* **vi) Medical history** *Yes = 1, No = 2*	☐ ☐ ☐ ☐ ☐ ☐
26. Clinical Examination **Full clinical state of patient at admission.** *Yes = 1, No = 2* *You need to go to relevant section for that morbidity.*	☐
This section is for post ante partum haemorrhage	
THE ACTIONS TAKEN	
27. Management of patient. Were the following done? **i) Intravenous access achieved** *Yes = 1, No = 2* **ii) Patient's Haemoglobin or haematocrit was carried out** *Yes = 1, No = 2* **iii) Typing blood and cross matching was carried out** *Yes = 1, No = 2* **iv) Coagulation test performed** *Yes = 1, No = 2* **v) Crystalloid/colloids were infused until X-matched blood is available** *Yes = 1, No = 2* **vi) Clinical monitoring of patients was done every quarter an hour for at least twelve hours was carried out to detect deterioration of the patient.** *Yes = 1, No = 2* **vii) Urine out put monitored hourly** *Yes = 1, No = 2* **viii) Experienced staffs were involved in the management of life threatening condition within ten minutes of admission** *Yes = 1, No = 2* **ix) Theatre available within thirty minutes of diagnosis** *Yes = 1, No = 2* **x) Coagulation test performed** *Yes = 1, No = 2*	☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐
This is on actions taken on eclampsia	

28. Were the following management offered to the patient?	
i) Treatment or prophylaxis for seizures was with magnesium sulphate *Yes = 1, No = 2*	☐
ii) Anti hypertensive was given to the patients within two hours of diagnosis *Yes = 1, No = 2*	☐
iii) Respiratory rate and tendon reflexes were monitored when magnesium sulphate was in use *Yes = 1, No = 2*	☐
iv) Ante partum and post partum fluid chart were maintained *Yes = 1, No = 2*	☐
v) Haematological and renal investigations should be done at least once (bleeding, clotting time, platelet count and urine albumin) *Yes = 1, No = 2*	☐
vi) Delivery was achieved within twelve hours *Yes = 1, No = 2*	☐
vii) Monitor urine out put, pulse, blood pressure carried out for at least 48 hours after delivery *Yes = 1, No = 2*	☐

This section is on post partum haemorrhage	
29. In the management of patient were the following carried out?	
i) Intravenous access achieved *Yes = 1, No = 2*	☐
ii) Patient's Haemoglobin or haematocrit should be checked *Yes = 1, No = 2*	☐
iii) Typing blood and cross matching *Yes = 1, No = 2*	☐
iv) Coagulation test performed *Yes = 1, No = 2*	☐
v) Crystalloid/colloids were infused until x-matched blood is available *Yes = 1, No = 2*	☐
vi) Clinical monitoring of patients done every quarter an hour for at least two hours was carried out to detect deterioration of patient *Yes = 1, No = 2*	☐
vii) Urine out put should be measured hourly *Yes = 1, No = 2*	☐
viii) Experienced staff should be involved in the management of life threatening condition within ten minutes of admission *Yes = 1, No = 2*	☐
ix) Theatre available within thirty minutes of need *Yes = 1, No = 2*	☐
x) Coagulation test performed *Yes = 1, No = 2*	☐
xi) Oxytocics are used *Yes = 1, No = 2*	☐

Criteria to assess clinical performance for obstructed labour	
ACTIONS TAKEN. Were the following actions carried out?	**RESPONSE**
30.	
i) Resuscitation of patient was carried out *Yes = 1, No = 2*	☐
ii) Typing and cross matching of blood done *Yes = 1, No = 2*	☐
iii) Delivery o f the foetus carried out within two hours of diagnosis *Yes = 1, No = 2*	☐
iv) Urinary bladder should be drained and rested *Yes = 1, No = 2*	☐
v) Broad-spectrum antibiotics given *Yes = 1, No = 2*	☐

This section is on ruptured uterus and actions taken

31. Were the following actions carried out?

i) **Resuscitation of patient was done** *Yes = 1, No = 2* ☐

ii) **Typing and cross matching of blood carried out** *Yes = 1, No = 2* ☐

iii) **Emergency surgery performed within two hours of diagnosis** *Yes = 1, No = 2* ☐

iv) **Urinary bladder drained and rested** *Yes = 1, No = 2* ☐

v) **Broad-spectrum antibiotics given** *Yes = 1, No = 2* ☐

vi) **Clinical monitoring of patients done every quarter an hour for at least two hours should be carried out to detect deterioration of patient** *Yes = 1, No = 2* ☐

This section is for puerperal sepsis

i) **Resuscitation of patients was done** *Yes = 1, No = 2* ☐

ii) **Typing and cross matching of blood was carried out** *Yes = 1, No = 2* ☐

iii) **Clinical monitoring of patient done every half hour for at leasst twenty four hours to detect detoriation of patient?** *Yes = 1, No = 2* ☐

iv) **Broad spectrum antibiotics were given** *Yes = 1, No = 2* ☐

v) **Was culture and sensitivity of swab carried out within 24 hours of admission?** *Yes = 1, No = 2* ☐

vi) **Was any surgery carried out on this patient?** *Yes = 1, No = 2* ☐

Fill in all laboratory results here

Study number: ☐☐☐☐☐

32. Haematological tests:

a) Hb Level _____

b) Mean corpuscular volume _____

MCHC _____

Blood Film _____

_____

_____

c) Platelet count _____

d) Other _____

_____

_____

33. HIV screening test _____

a) CD 4 _____

b) CD8 _____

34. Syphilis test _____

35. Liver function tests

a) Serum glutamate-oxalate transaminase (SGOT) _____

b) Serum glutamate pyruvate transaminase (SGPT) _____

c) Lactate dehydrogenase (LDH) _____

36. Renal function tests

a) Urine Protein _____

b) Serum Uric level _____

c) Serum creatinine _____

37. i) Pus culture. (State the site .....)

a) Bacteria cultured _____

b) Antibiotic sensitivity _____

ii) Sputum culture.

a) Bacteria cultured _____

b) Antibiotic sensitivity _____

iii) Blood culture

a) Bacteria cultured _____

b) Antibiotic sensitivity _____

_____

APPENDIX B: UNIVARIATE TABLES FOR SPECIFIC CAUSES OF SEVERE MATERNAL MORBIDITY

Table B1 Characteristics of severe pre eclampsia and eclampsia cases and controls

(i) Socio-demographic characteristics

Characteristic	Stratum	Cases		Controls		Crude odds ratio (95% CI)		P Value
		N	(%)	N	(%)			
Distance from home to Mulago (km)	0-5	55	(38.5)	408	(81.6)	1.0	(-)	
	6-10	57	(39.9)	81	(16.2)	2.5	(1.6-3.8)	0.00
	11-15	31	(21.6)	11	(2.2)	6.7	(3.7-12.0)	
Distance to nearest health unit in (km)	0-5	113	(81.8)	491	(98.2)	1.0	(-)	
	>5	30	(18.2)	9	(1.8)	14.5	(6.7-31.4)	0.00
Age in years	14-19	49	(34.3)	155	(31.0)	1.1	(0.7-1.6)	
	20-29	78	(54.5)	262	(52.4)	1.0	(-)	
	30-35	10	(7.0)	52	(10.4)	0.7	(0.3-1.3)	0.32
	35+	6	(4.2)	31	(6.2)	0.7	(0.3-1.6)	
Marital status	Married	112	(78.3)	425	(85.0)	1.0	(-)	
	Single	31	(21.7)	75	(15.0)	1.6	(1.0-2.5)	0.05
Tribe	Bantu	135	(94.4)	454	(90.8)	1.0	(-)	
	Nilotics	8	(5.6)	46	(9.2)	0.6	(0.3-1.3)	0.17
Religion	Protestant	44	(30.8)	141	(28.2)	1.0	(-)	
	Catholic	50	(35.0)	173	(34.6)	0.9	(0.6-1.5)	0.10
	Muslim	38	(26.6)	160	(32.0)	0.8	(0.5-1.2)	
	Seven day	2	(1.4)	5	(1.0)	1.3	(0.2-6.8)	
	Saved	9	(6.3)	21	(4.2)	1.4	(0.6-3.2)	
Education level of patient	Primary and nil	74	(51.8)	299	(59.8)	0.9	(0.6-1.3)	
	Secondary	54	(37.8)	186	(37.2)	1.0	(-)	0.00
	College	15	(10.5)	15	(3.0)	3.4	(1.3-7.1)	
Patients job	Commerce	24	(16.9)	114	(22.8)	1.3	(0.8-2.1)	
	Professional	17	(11.7)	14	(2.8)	5.7	(2.4-13.1)	
	Peasant	102	(71.3)	372	(74.4)	1.0	(-)	0.00
Spouse job	Commerce	24	(16.9)	205	(41.0)	1.0	(-)	
	Professional	17	(11.7)	106	(21.2)	1.2	(0.8-1.9)	0.31
	Peasant	102	(71.3)	189	(37.8)	0.8	(0.4-1.3)	
Type of house	Brick, plastered	78	(53.2)	417	(83.4)	1.0	(-)	
	Brick only	48	(33.6)	69	(13.8)	3.8	(2.4-5.9)	0.00
	Mud only	17	(11.8)	14	(2.8)	6.5	(3.1-13.9)	
Facility in house	Electricity and piped water	56	(39.2)	261	(52.2)	1.00	(-)	
	Electricity or Tap water	40	(28.0)	140	(28.0)	0.6	(0.3-1.0)	0.00
	Neither	47	(32.8)	99	(19.8)	2.9	(2.0-4.5)	
Need to Request permission to visit Health Unit/hospital	Yes	46	(32.2)	47	(9.4)	4.6	(2.9-7.4)	0.00
	No	97	(67.8)	453	(90.6)	1.0	(-)	
Who gives permission to attend Health Unit/hospital	Spouse	84	(84.7)	401	(88.5)	1.0	(-)	
	Other	13	(15.3)	52	(11.5)	1.4	(0.8-2.6)	0.23
Who pays for treatment	Self and spouse	110	(77.5)	403	(80.6)	1.0	(-)	
	Others	33	(22.5)	97	(19.4)	4.4	(2.6-7.3)	0.00

(ii) Social, family and medical history characteristics

Characteristic	Stratum	Cases		Controls		Odds ratio (95% CI)		P Value
		N	(%)	N	(%)			
Taking alcohol	Yes	27	(18.9)	137	(27.4)	0.6	(0.4-1.0)	0.04
	No	116	(81.1)	363	(72.6)	1.0	(-)	
Smoking	Yes	0	-	11	(2.20)	-	-	-
	No	143	(47.5)	489	(97.8)			

Family hypertension	Yes	75	(52.5)	194	(38.8)	1.7	(1.6-3.3)	0.00
	No	68	(47.5)	306	(61.2)	1.0	(-)	
Family diabetes mellitus	Yes	11	(7.7)	62	(12.4)	1.6	(1.0-2.6)	0.00
	No	132	(92.3)	437	(87.6)	1.0	(-)	
Hypertension (self)	Yes	11	(7.7)	2	(0.4)	20.8	(4.5-94.8)	0.00
	No	132	(92.3)	498	(95.6)	1.0	(-)	
Admission to hospital	Yes	20	(14.0)	31	(6.2)	2.5	(1.4-4.5)	0.00
	No	123	(86.0)	469	(93.8)	1.0	(-)	
Use of contraception	Yes	20	(14.0)	219	(43.8)	1.0	(-)	0.00
	No	123	(86.0)	281	(56.2)	2.5	(1.4-4.5)	

(iii) Past obstetric performance*

Variable	Stratum	Cases		Controls		Odds ratio		P
		N	(%)	N	(%)	95% CI)		Value
Previous abortion	Yes	21	(25.0)	43	(12.3)	1.9	(1.0-3.4)	
	No	63	(75.0)	307	(87.7)	1.0	(-)	0.03
Bleeding in previous pregnancy	Yes	20	(23.8)	37	10.6	2.0	(1.1-3.6)	0.02
	No	64	(76.2)	313	(89.4)	1.0	(-)	
Bleeding in labour	Yes	15	(17.9)	37	(10.6)	1.5	(0.8-2.8)	0.23
	No	69	(82.1)	313	(89.6)	1.0	(-)	
Labour lasting more than 18hrs	Yes	5	(6.0)	77	(22.0)	0.2	(0.1-0.5)	0.00
	No	79	(94.0)	273	(78.0)	1.0	(-)	
Still birth	Yes	15	(17.9)	25	(7.1)	1.7	(0.8-3.4)	0.07
	No	69	(82.1)	325	(92.9)	1.0	(-)	
Previous caesarean section	Yes	11	(13.1)	15	(4.0)	3.4	(1.4-8.2)	0.00
	No	73	(86.9)	335	(96.0)	1.0	(-)	
Vacuum or forceps	Yes	1	(1.2)	5	(1.4)	0.7	(0.1-6.0)	0.74
	No	83	(98.8)	345	(98.6)	1.0	(-)	
Post partum haemorrhage	Yes	2	(2.4)	14	(4.0)	0.5	(0.1-2.2)	0.35
	No	82	(97.6)	336	(96.0)	1.0	(-)	
Retained placenta	Yes	3	(3.6)	9	(12.6)	1.2	(0.3-4.5)	0.82
	No	81	(96.4)	342	(97.4)	1.0	(-)	
Hypertension in pregnancy	Yes	10	(11.9)	19	(5.4)	1.9	(0.9-4.2)	0.74
	No	74	(88.1)	331	(94.6)	1.0	(-)	
Blood transfusion During pregnancy	Yes	06	(7.1)	4	(1.1)	5.4	(1.5-19.5)	0.01
	No	78	(92.9)	346	(98.9)	1.0	(-)	

* Women with previous pregnancies only

(iv) Characteristics and outcome of the current pregnancy

Variable	Stratum	Cases		Controls		Odds ratio		P
		N	(%)	N	(%)	(95% CI)		Value
Number of pregnancy	1	59	(41.2)	150	(30.0)	1.5	(1.0-2.1)	0.06
	2-4	74	(51.8)	237	(47.4)	1.0	(-)	
	5-14	10	(7.0)	113	(22.6)	0.5	(0.3-1.0)	
Birth spacing in months*	1-36	39	(46.4)	216	(61.9)	1.0	(-)	
	37-60	22	(26.3)	91	(26.0)	1.4	(0.7-2.6)	
	>60	22	(26.3)	43	(12.1)	2.9	(1.5-5.8)	0.02
Attended Antenatal care	Yes	128	(89.5)	485	(97.0)	1.0	(-)	
	No	15	(10.5)	15	(3.0)	3.8	(1.8- 8.0)	0.00
Booking time for antenatal (weeks)	<28	91	(71.6)	332	(68.6)	1.0	(-)	
	28-36	37	(28.4)	153	(31.4)	0.3	(0.2 -0.7)	0.00
Number of antenatal visits	4+	71	(55.9)	195	(40.1)	1.0	(-)	
	<4	57	(44.6)	291	(59.9)	1.2	(0.8-1.7)	0.42
Having blood pressure checked during antenatal	No	21	(14.7)	93	(19.2)	2.2	(1.1-4.5)	0.00
	Yes	121	(85.3)	392	(80.8)	1.0	(-)	
Response to vaginal bleeding during pregnancy	Go to hospital	11033	(76.9)	481	(96.2)	1.0	(-)	
	Don't know		(23.1)	19	(3.8)	7.6	(4.2-13.9)	0.00
Bleeding during this pregnancy	Yes	3	(2.1)	3	(0.6)	3.4	(0.7-17.8)	0.01
	No	140	(97.9)	497	(99.4)	1.0	(-)	
Hypertension in this pregnancy	Yes	71	(52.6)	7	(1.4)	77.7	(34.2-176.1)	0.00
	No	64	(47.4)	493	(98.6)	1.0	(-)	
Anaemia in this pregnancy	Yes	1	(0.7)	4	(0.8)	0.9	(0.1-7.0)	0.91
	No	142	(99.3)	496	(99.2)	1.0	(-)	
Referral from other centres	Yes	63	(44.1)	84	(16.8)	3.9	(2.6-5.8)	0.00
	No	80	(55.9)	416	(83.2)	1.0	(-)	
Length of first stage in hours	=<18hours	139	(97.2)	435	(87.2)	1.0	(-)	0.00
	>18	1	(0.7)	65	(12.8)	0.1	(0.0-0.3)	
	no labour	2	(1.4)					
Sex of baby	Female	86	(60.1)	248	(50.2)	1.0	(1.0-2.2)	0.04
	Male	57	(39.9)	252	(49.6)	1.5	(-)	
Birth weight in grams	< 2500	67	(46.9)	13	(2.6)	22.9	(11.9-44.1)	0.00
	2500-3500	63	(44.0)	317	(63.4)	1.0	(-)	
	>3500	13	(9.1)	170	(34.0)	0.9	(0.2-0.7)	

* For women with at least one previous pregnancy

(v) Laboratory Results

Variable	Stratum	Cases		Controls		Odds ratio		P
		N	(%)	N	(%)	(95% CI)		Value
HIV status	Negative	134	93.7	455	(91.0)	1.00	(-)	
	Positive	9	6.3	45	(9.0)	0.7	(0.3-1.4)	0.31
Syphilis	Negative	135	94.4	454	(90.8)	1.0	(-)	
	Positive	8	5.6	46	(9.2)	0.6	(0.3-1.3)	0.17
Haemoglobin grams/decilitre	<10	49	34.3	75	(15.0)	3.0	(1.9-45.1)	
	=>10	94	65.3	425	(85.0)	1.0	(-)	0.00
Platelets x 10^9/litre	<150	51	35.7	52	(10.8)	4.6	(2.9-7.1)	0.00
	=>150	92	64.3	448	(89.2)	1.0	(-)	

Table B2. Characteristics of post partum haemorrhage cases and controls

(i) Socio-demographic characteristics

Characteristic	Stratum	Cases		Controls		Crude odds ratio (95% CI)		P Value
		N	(%)	N	(%)			
Distance from home to Mulago (km)	0-5	54	(50.5)	408	(81.6)	1.0	(-)	
	6-10	36	(34.3)	81	(16.2)	3.4	(2.1-5.5)	0.00
	11-15	16	(15.2)	11	(2.2)	11.2	(4.9-25.4)	
Distance to nearest health unit (km)	0-5	87	(82.1)	491	(98.2)	1.0	(-)	
	>5	19	(17.9)	9	(1.8)	17.5	(5.6-54.9)	0.00
Age (years)	14-19	32	(30.2)	155	(31.0)	0.9	(0.6-1.5)	
	20-29	58	(54.7)	262	(52.4)	1.0	(-)	0.94
	30+	16	(15.1)	83	(16.6)	1.0	(0.4-2.0)	
Marital status	Married	87	(82.5)	425	(85.0)	1.0	(-)	
	Single	19	(17.9)	75	(15.0)	1.3	(0.7-2.2)	0.31
Tribe	Bantu	94	(88.7)	454	(90.8)	1.0	(-)	
	Nilotics	12	(11.3)	46	(9.2)	1.3	(0.6-2.6)	0.50
Religion	Protestant	40	(35.9)	141	(28.2)	1.0	(-)	
	Catholic	32	(31.1)	173	(34.6)	0.7	(0.4-1.2)	
	Muslim	24	(22.6)	160	(32.0)	0.6	(0.3- 1.0)	0.08
	Other	10	(9.4)	26	(5.2)	1.2	(0.5-2.8)	
Education level of patient	No schooling	6	(5.7)	22	(4.4)	1.4	(0.5-3.7)	
	Primary	58	(54.7)	277	(55.4)	2.1	(0.8-5.7)	
	Secondary	36	(34.0)	186	(37.2)	1.0	(-)	0.64
	College	6	(5.7)	15	(3.0)	1.1	(0.7-1.7)	
Patients job	Commerce	28	(26.4)	114	(22.8)	1.3	(0.8-2.2)	
	Professional	06	(5.7)	14	(2.8)	1.9	(0.7-5.4)	0.31
	Peasant	72	(67.9)	372	(74.4)	1.0	(-)	
Spouse job	Commerce	64	(62.1)	205	(41.0)	1.0	(-)	
	Professional	24	(21.4)	106	(21.2)	1.0	(0.6-1.8)	0.44
	Peasant	18	(16.5)	189	(37.8)	0.7	(0.4-1.3)	
Type of house	Brick, plastered	44	(41.5)	417	(83.4)	1.0	(-)	
	Brick only	51	(48.1)	69	(13.8)	6.9	(4.3-11.1)	0.00
	Mud only	11	(10.4)	14	(2.8)	7.5	(3.2-17.4)	
Need to request permission to visit Health Unit/hospital	Yes	30	(28.6)	47	(9.4)	3.8	(2.3-6.4)	
	No	76	(71.4)	453	(90.6)	1.0	(-)	0.00
Who gives permission to attend Health Unit/hospital	Spouse	25	(82.9)	42	(88.5)	1.0	(-)	
	Other	05	(17.1)	05	(11.5)	1.7	(0.4-7.4)	0.44
Who pays for treatment	Self and spouse	84	(80.0)	403	(80.6)	1.0	(-)	
	Others	21	(20.0)	97	(19.4)	1.0	(2.7-7.4)	0.00

(ii) Social, family and medical history characteristics

Characteristic	Stratum	Cases		Controls		Odds ratio (95% CI)		P Value
		N	(%)	N	(%)			
Taking alcohol	Yes	23	(21.7)	137	(27.4)	0.7	(0.4-1.2)	0.22
	No	83	(72.6)	363	(72.6)	1.0	(-)	
Smoking	Yes	1	(0.9)	11	(2.20)	0.4	(0.1-3.3)	0.41
	No	105	(99.1)	489	(97.8)	1.0	(-)	
Family hypertension	Yes	47	(44.3)	194	(38.8)	1.4	(0.1-2.1)	0.07
	No	59	(55.7)	306	(61.2)	1.0	(-)	
Hypertension (self)	Yes	4	(3.8)	2	(0.4)	9.8	(1.8-54.0)	0.00
	No	102	(96.2)	498	(95.6)	1.0	(-)	
Use of contraception	Yes	39	(43.8)	219	(43.8)	1.0	(-)	
	No	67	(63.2)	281	(56.2)	1.3	(0.9-2.1)	0.10

(iii) Past obstetric performance*

Variable	Stratum	Cases		Controls		Odds ratio (95% CI)		P Value
		N	(%)	N	(%)			
Previous abortion	Yes	9	(13.1)	43	(12.3)	1.0	(0.1-2.1)	0.97
	No	60	(86.9)	307	(87.7)	1.0	(-)	
Bleeding in previous pregnancy	Yes	10	(14.5)	37	(10.6)	1.3	(0.6-2.7)	0.49
	No	59	(85.5)	313	(89.4)	1.0	(-)	
Bleeding in labour	Yes	6	(8.7)	37	(10.6)	0.8	(0.3-1.8)	0.53
	No	63	(91.3)	313	(89.6)	1.0	(-)	
Labour lasting more than 18hrs	Yes	12	(17.4)	77	(22.0)	0.7	(0.4-1.3)	0.43
	No	57	(82.6)	273	(78.0)	1.0	(-)	
Previous caesarean section	Yes	15	(21.7)	15	(4.0)	6.2	(2.6-12.4)	0.00
	No	54	(78.3)	335	(96.0)	1.0	(-)	
Post partum haemorrhage	Yes	6	(8.7)	14	(4.0)	2.1	(0.8-5.6)	0.14
	No	63	(91.3)	336	(96.0)	1.0	(-)	
Retained placenta	Yes	3	(4.3)	9	(12.6)	0.5	(0.4- 6.0)	0.67
	No	66	(95.6)	342	(97.4)	1.0	(-)	
Hypertension in pregnancy	Yes	7	(10.1)	19	(5.4)	1.8	(0.7-4.4)	0.21
	No	62	(89.9)	331	(94.6)	1.0	(-)	

* Women with previous pregnancies only

(iv) Characteristics and outcome of the current pregnancy

Variable	Stratum	Cases		Controls		Odds ratio		P
		N	(%)	N	(%)	(95% CI)		Value
Number of pregnancy	1	37	(34.9)	150	(30.0)	1.2	(0.7-1.9)	0.40
	2-4	57	(53.8)	237	(47.4)	1.0	(-)	
	5-14	12	(11.3)	113	(22.6)	0.7	(0.4-1.4)	
Birth spacing	1-36	37	(53.2)	216	(61.9)	1.0	(-)	
In months (in	37-60	14	(21.0)	91	(26.0)	0.9	(0.5-1.9)	0.03
multigravida)	>60	18	(25.8)	43	(12.1)	2.5	(1.2-5.0)	
Attended Antenatal	Yes	92	(86.8)	485	(97.0)	1.0	(-)	0.00
care	No	14	(13.2)	15	(3.0)	4.9	(2.9-10.5)	
Booking time for	<28	58	(63.0)	332	(68.6)	1.0	(-)	0.23
antenatal (weeks)	28-36	34	(37.0)	153	(31.4)	1.3	(0.8-2.1)	
Having blood pressure	No	83	(78.3)	93	(19.2)	1.0	(-)	0.31
checked during	Yes	23	(21.7)	392	(80.8)	0.8	0.4-1.3)	
antenatal								
Response to vaginal	Go to hospital	82	(77.4)	481	(96.2)	1.0	(-)	0.00
bleeding during	Don't know	24	(22.6)	19	(3.8)	7.4	(3.9-14.1)	
pregnancy								
Bleeding during this	Yes	4	(3.8)	3	(0.6)	6.5	(1.4-29.5)	0.03
pregnancy	No	102	(96.2)	497	(99.4)	1.0	(-)	
Hypertension in this	Yes	10	(9.4)	7	(1.4)	7.5	(2.8-9.7)	0.00
pregnancy	No	96	(90.6)	493	(98.6)	1.0	(-)	
Anaemia in this	Yes	5	(4.7)	4	(0.8)	6.1	(1.4-27.4)	0.00
pregnancy	No	101	(95.3)	496	(99.2)	1.0	(-)	
Admission to hospital	Yes	10	(90.6)	469	(93.8)	1.6	(0.7-3.3)	
	No	96	(9.4)	31	(6.2)	1.0	(-)	0.25
Referral from other	Yes	59	(55.7)	84	(16.8)	6.1	(4.0-9.7)	0.00
centres	No	47	(44.3)	416	(83.2)	1.0	(-)	
Premature rupture of	Yes	3	(2.8)	111	(22.3)	1.3	(0.8-2.1)	0.27
membranes	No	103	(97.2)	386	(77.7)	1.0	(-)	
Bleeding in labour	Yes	21	(19.8)	6	(1.2)	20.3	(8.0-51.8)	0.00
	No	85	(80.2)	493	(98.8)	1.0	(-)	
Type of labour	Normal	68	(64.2)	496	(99.2)	1.0	(-)	
	Induced or augmented	38	(35.8)	4	(0.8)	69.2	(20.7-240.6)	0.00
Use of partograph	Yes	11	(10.4)	44	(8.8)	1.0	(-)	
	No	95	(89.6)	456	(91.2)	1.2	(0.6-2.4)	0.61
Length of first stage	<=18 hours	13	(12.3)	77	(22.0)	1.0	(-)	0.03
	>18hours	93	(87.7)	273	(78.0)	0.6	(0.3-1.0)	
Length of third stage in	<26	84	(79.2)	494	(98.8)	1.0	(-)	
minutes	>25	22	(20.8)	6	(1.2)	28.3	(6.6-78.9)	0.00
Sex of baby	Female	58	(54.7)	252	(50.2)	1.0	(-)	
	Male	48	(45.3)	248	(49.6)	0.8	(0.5-1.2)	0.34
Birth weight	< 2500	13	(12.8)	13	(2.6)	5.0	(2.2-11.4)	
In kilograms	2500-3500	63	(62.4)	317	(63.4)	1.0	(-)	0.00
	>3500	25	(24.8)	170	(34.0)	0.7	(0.4-1.2)	
	missing	5						
Level of delivery	Midwife	51	48.1	482	(96.4)	1.0	(-)	0.00
attendant	Doctor	49	46.2	18	(3.6)	34.9	(17.4-70.2)	
	TBA	6	5.7	0	(0)			
Given Oxytocics	Yes	85	(80.2)	489	(97.8)	1.0	(-)	
	No	21	(19.8)	11	(2.2)	11.0	(4.8-23.3)	0.00

(v) Laboratory Results

Variable	Stratum	Cases		Controls		Odds ratio (95% CI)		P Value
		N	(%)	N	(%)			
HIV status	Negative	93	(87.7)	455	(91.0)	1.0	(-)	
	Positive	13	(12.3)	45	(9.0)	1.4	(0.7-2.7)	0.30
Syphilis	Negative	98	(87.7)	454	(90.8)	1.0	(-)	0.59
	Positive	8	(12.3)	46	(9.2)	0.8	(0.4-1.8)	
Haemoglobin	<10	79	(74.5)	75	(15.0)	17.4	(10.5-28.9)	0.00
gm/dl	=>10	27	(25.5)	425	(85.0)	1.0	(-)	
Platelets $1x10^9$/litre	<150	70	(66.0)	52	(10.8)	4.3	(2.6-6.9)	0.00
	=>150	36	(34.0)	448	(89.2)	1.0	(-)	

Table B3 Characteristics of obstructed labour cases and controls

(i) Socio-demographic characteristics

Characteristic	Stratum	Cases		Controls		Crude odds ratio (95% CI)		P Value
		N	(%)	N	(%)			
Distance from home to Mulago (km)	0-5	34	(31.5)	408	(81.6)	1.0	(-)	
	6-10	45	(41.7)	81	(16.2)	3.2	(1.9-5.2)	
	11-15	29	(26.9)	11	(2.2)	10.1	(5.4-19.0)	0.00
Distance to nearest health unit (km)	0-5	95	(88.0)	491	(98.2)	1.0	(-)	
	>5	13	(12.0)	9	(1.8)	7.5	(3.1-18.0)	0.00
Age (years)	14-19	41	(38.0)	155	(31.0)	1.2	(0.8-1.9)	0.00
	20-29	58	(53.7)	262	(52.4)	1.0	(-)	
	30-35	5	(4.6)	52	(10.4)	0.4	(0.2-1.1)	
	35+	4	(3.7)	31	(6.2)	0.6	(0.19-1.71)	
Marital status	Married	87	(80.6)	425	(85.0)	1.0	(-)	
	Single	21	(19.5)	75	(15.0)	1.4	(0.8-2.3)	0.27
Tribe	Bantu	42	(80.8)	454	(90.8)	1.0	(-)	
	Nilotics	10	(19.2)	46	(9.2)	2.4	(1.1-5.0)	0.03
Religion	Protestant	35	(32.4)	141	(28.2)	1.0	(-)	
	Catholic	36	(33.3)	173	(34.6)	0.8	(0.5-1.4)	0.57
	Muslim	30	(27.8)	160	(32.0)	0.8	(0.4-1.3)	
	Other	7	(6.5)	261	(5.2)	1.3	(0.5-3.4)	
Education level of patient	No schooling	5	(9.6)	22	(5.0)	0.3	(0.0-1.7)	
	Primary	13	(25.0)	277	(55.4)	1.2	(0.8-1.9)	0.19
	Secondary	23	(44.2)	186	(37.2)	1.0	(-)	
	College	1	(1.9)	15	(3.0)	0.7	(0.4-4.5)	
Patients job	Employed	32	(29.6)	128	(25.6)	1.1	(0.3-3.6)	0.99
	Peasant	76	(70.4)	372	(74.4)	1.0	(-)	
Spouse job	Commerce	71	(65.7)	205	(41.0)	1.0	(-)	0.09
	Professional	12	(11.1)	106	(21.2)	0.5	(0.3- 1.0)	
	Peasant	25	(23.2)	189	(37.8)	1.0	(0.6-1.7)	
Type of house	Brick, plastered	59	(54.6)	417	(83.4)	1.0	(-)	
	Brick only	38	(35.2)	69	(13.8)	3.6	(1.1-11.6)	0.00
	Mud only	11	(10.2)	14	(2.8)	5.6	(2.4-12.8)	
Facility in house	Electricity and piped water	44	(40.7)	261	(52.2)	1.0	(-)	0.00
	Electricity or piped water	47	(43.5)	140	(28.0)	1.7	(1.0-3.1)	
	Neither	27	(25.0)	99	(19.8)	2.1	(1.2-3.0)	
Need to request permission to visit Health Unit/hospital	Yes	25	(23.2)	47	(9.4)	3.2	(1.6-6.4)	
	No	83	(76.9)	453	(90.6)	1.0	(-)	0.00
Who gives permission to attend Health Unit/hospital	Spouse	20	(83.5)	41	(88.5)	1.0	(-)	
	Other	05	(16.5)	06	(11.5)	1.5	(0.8-2.9)	0.20
Who pays for treatment	Self and spouse	85	(78.7)	403	(80.6)	1.0	(.)	
	Others	23	(21.3)	97	(19.4)	2.9	(1.7-5.2)	0.00

(ii) Social, family and medical history

Characteristic	Stratum	Cases		Controls		Odds ratio (95% CI)		P Value
		N	(%)	N	(%)			
Taking alcohol	Yes	28	(25.9)	137	(27.4)	0.9	(0.6-1.5)	0.75
	No	80	(74.1)	363	(72.6)	1.0	(-)	
Smoking	Yes	3	(2.8)	11	(2.20)	0.8	(0.5-1.2)	0.12
	No	105	(97.2)	489	(97.8)	1.0	(-)	
Family hypertension	Yes	5	(4.6)	194	(38.8)	2.8	(0.8-7.1)	0.49
	No	103	(95.4)	306	(61.2)	1.0	(-)	
Family diabetes mellitus	Yes	42	(38.9)	62	(12.4)	1.0	(0.8-1.9)	0.35
	No	66	(61.1)	437	(87.6)	1.2	(-)	
Hypertension (self)	Yes	4	(3.9)	2	(0.4)	9.6	(1.7-33.0)	0.01
	No	104	(96.1)	498	(95.6)	1.0	(-)	
Use of contraception	Yes	7	(6.5)	219	(43.8)	1.1	(0.5-2.4)	0.23
	No	101	(93.5)	281	(56.2)	1.0	(-)	

(iii) Past obstetric performance *

Variable	Stratum	Cases		Controls		Odds ratio (95% CI)		P Value
		N	(%)	N	(%)			
Previous abortion	Yes	4	(8.0)	43	(12.3)	0.4	(0.1-1.2)	0.09
	No	46	(92.0)	307	(87.7)	1.0	(-)	
Previous evacuation of uterus/dc (all women)	Yes	4	(3.7)	20	(4.0)	0.7	(0.2-2.5)	0.54
	No	104	(96.3)	480	(96.0)	1.0	(-)	
Bleeding in previous pregnancy	Yes	5	(10.0)	37	10.6	0.6	(0.2-1.6)	0.31
	No	45	990.0)	313	(89.4)	1.0	(.)	
Bleeding in labour	Yes	4	(8.0)	37	(10.6)	0.5	(0.1-1.4)	0.17
	No	46	(92.0)	313	(89.6)	1.0	(-)	
Labour lasting more than 18hrs	Yes	12	(24.0)	77	(22.0)	0.7	(0.4-1.3)	0.25
	No	38	(76.0)	273	(78.0)	1.0	(-)	
Still birth	Yes	5	(10.0)	25	(7.1)	0.9	(0.3-2.4)	0.81
	No	45	990.0)	325	(92.9)	1.0	(-)	
Previous caesarean section	Yes	8	(16.0)	15	(4.0)	4.5	(2.0-11.9)	0.00
	No	42	(84.0)	335	(96.0)	1.0	(-)	
Vacuum + forceps	Yes	2	(4.0)	5	(1.4)	1.9	(0.4-9.8)	0.46
	No	48	(96.0)	345	(98.6)	1.0	(-)	
Post partum haemorrhage	Yes	3	(6.0)	14	(4.0)	1.0	(0.3-3.5)	0.10
	No	47	(94.0)	336	(96.0)	1.0	(-)	

* Women with previous pregnancies only

(iv) Characteristics and outcome of the current pregnancy

Variable	Stratum	Cases		Controls		Odds ratio (95% CI)		P Value
		N	(%)	N	(%)			
Number of pregnancy	1	58	(39.8)	150	(30.0)	2.5	(1.6-3.8)	
	2-4	43	(53.7)	237	(47.4)	1.0	(-)	0.00
	5-14	7	(6.5)	113	(22.6)	0.6	(0.3-1.3)	
Birth spacing in months*	1-36	21	(42.3)	216	(61.9)	1.0	(-)	
	37-60	29	(57.7)	91	(26.0)	2.1	(1.2-4.0)	0.02
	>60	-		43	(12.1)			
Attended Antenatal care	Yes	102	(94.4)	485	(97.0)	1.0	(-)	
	No	6	(5.6)	15	(3.0)	1.7	(0.7-5.0)	0.19
Booking time for antenatal (weeks)	<28	66	(64.7)	332	(68.6)	1.0	(-)	
	28-36	36	(35.3)	153	(31.4)	0.3	(0.2-1.1)	0.06
Response to vaginal bleeding during pregnancy	Go to hospital	79	(73.2)	481	(96.2)	1.0	(-)	0.00
	Don't know	29	(26.8)	19	(3.8)	9.3	(5.0-17.4)	
Referral from other centres	Yes	31	(28.7)	84	(16.8)	2.6	(1.3-3.6)	0.00
	No	77	(71.3)	416	(83.2)	1.0	(-)	
Premature rupture of membranes	Yes	76	(70.4)	111	(22.3)	8.3	(5.2-13.1)	0.00
	No	32	(29.6)	386	(77.7)	1.0	(-)	
Bleeding in labour	Yes	6	(5.6)	6	(1.2)	4.9	(1.5-15.3)	0.00
	No	102	(94.4)	493	(98.8)	1.0	(-)	
Length of first stage	<=18	16	(14.8)	43565	(87.2)	1.0	(-)	
	>18	92	(85.2)		(12.8)	5.6	(2.4-13.0)	0.00
Use of partograph	Yes	12	(11.1)	44	(8.8)	1.0	(-)	
	No	96	(88.9)	456	(91.2)	0.8	0.4-1.5	0.45
Sex of baby	Female	35	(32.4)	252	(50.2)	1.0	(-)	
	Male	73	(67.6)	248	(49.6)	2.1	(1.4-3.8)	0.00
Birth weight in kilograms	< 2500	9	(8.4)	13	(2.6)	3.3	(1.3-8.3)	0.04
	2500-3500	59	(54.6)	317	(63.4)	1.0	(-)	
	>3500	40	(37.0)	170	(34.0)	1.3	(0.9-2.0)	

* For women with at least one previous pregnancy

(v) Laboratory Results

Variable	Stratum	Cases		Controls		Odds ratio (95% CI)		P Value
		N	(%)	N	(%)			
HIV status	Negative	95	(88.0)	455	(91.0)	1.0	(-)	
	Positive	13	(12.0)	45	(9.0)	1.3	(0.7-2.7)	0.33
Syphilis	Negative	99	(91.7)	454	(90.8)	1.0	(-)	0.78
	Positive	9	(8.3)	46	(9.2)	0.9	(0.4-1.9)	
Haemoglobin gm/dl	<10	49	(45.4)	75	(15.0)	6.8	(4.3-10.7)	0.00
	=>10	59	(54.6)	425	(85.0)	1.0	(-)	

Table B4 Characteristics of cases of ruptured uterus and controls

(i) Socio-demographic characteristics

Characteristic	Stratum	Cases		Controls		Crude odds ratio (95% CI)		P Value
		N	(%)	N	(%)			
Distance from home to Mulago (km)	0-5	18	(34.6)	408	(81.6)	1.0	(-)	
	6-10	22	(44.3)	81	(16.2)	2.9	(1.5-5.6)	0.00
	11-15	12	(23.0)	11	(2.2)	8.6	(3.8-19.3)	
Distance to nearest health unit (km)	0-5	46	(88.5)	491	(98.2)	1.0	(-)	
	>5	06	(11.5)	9	(1.8)	8.3	(3.0-23.3)	0.00
Age (years)	14-19	5	(9.6)	155	(31.0)	0.1	(0.0-0.4)	0.00
	20-29	36	(69.2)	262	(52.4)	1.0	(-)	
	30+	11	(21.2)	83	(16.6)	0.9	(0.6-1.9)	
Marital status	Married	47	(90.4)	425	(85.0)	1.0	(-)	
	Single	5	(9.6)	75	(15.0)	0.6	(0.2-1.5)	0.28
Tribe	Bantu	42	(80.8)	454	(90.8)	1.0	(-)	
	Nilotics	10	(19.2)	46	(9.2)	2.4	(1.1- 5.0)	0.00
Religion	Protestant	14	(26.9)	141	(28.2)	1.0	(-)	
	Catholic	20	(38.5)	173	(34.6)	1.2	(0.6-2.5)	
	Muslim	13	(25.0)	160	(32.0)	0.8	(0.4-1.8)	0.82
	Seven day	2	(3.8)	5	(1.0)	4.0	(0.7-22.7)	
	Saved	3	(6.8)	21	(4.2)	1.4	(0.4-5.4)	
Education level of patient	No schooling	5	(9.6)	22	(5.0)	0.8	(0.4-1.4)	0.24
	Primary	25	(48.0)	277	(55.4)	1.0	(-)	
	Secondary	22	(42.3)	186	(37.2)	1.9	(0.7-5.6)	
	College	0	(-)	15	(3.0)			
Patients job	Employed	10	(19.2)	128372	(25.6)	1.0	(-)	
	Peasant	42	(81.8)		(74.4)	1.2	(0.6-2.6)	0.07
Spouse job	Commerce	9	(17.0)	205	(41.0)	1.0	(-)	
	Professional	10	(18.9)	106	(21.2)	0.6	(0.1-5.0)	
	Peasant	23	(64.1)	189	(37.8)	0.7	(0.1-5.2)	0.89
Type of house	Brick, plastered	30	(57.7)	417	(83.4)	1.0	(-)	
	Brick only	16	(30.8)	69	(13.8)	3.6	(1.1-11.6)	
	Mud only	6	(11.5)	14	(2.8)	2.8	(1.4-5.3)	0.00
Need to request permission to visit Health Unit/hospital	Yes	15	(28.8)	47	(9.4)	3.2	(1.6-3.2)	0.00
	No	37	(71.2)	453	(90.6)	1.0	(-)	
Who gives permission to attend Health Unit/hospital	Spouse	13	(92.1)	42	(88.5)	1.0	(-)	
	Other	2	(7.9)	05	(11.5)	0.4	(0.1-1.8)	0.26
Who pays for treatment	Self and spouse	47	(90.3)	403	(80.6)	1.0	(-)	
	Others	5	(9.7)	97	(19.4)	1.8	(0.8-4.2)	0.07

(ii) Social, family and medical history

Characteristic	Stratum	Cases		Controls		Odds ratio (95% CI)		P Value
		N	(%)	N	(%)			
Taking alcohol	Yes	12	(23.1)	137	(27.4)	0.8	(0.4-1.5)	0.46
	No	40	(76.9)	363	(72.6)	1.0	(-)	
Family hypertension	Yes	19	(36.5)	194	(38.8)	0.9	(0.5-1.6)	0.74
	No	33	(63.5)	306	(61.2)	1.0	(-)	
Use of contraception	Yes	22	(42.3)	219	(43.8)	1.0	(-)	
	No	30	(57.7)	281	(56.2)	1.1	(0.6- 2.0)	0.21

(iii) Past obstetric performance *

Variable	Stratum	Cases		Controls		Odds ratio (95% CI)		P Value
		N	(%)	N	(%)			
Previous abortion	Yes	4	(8.7)	43	(12.3)	0.9	(0.3-2.5)	0.79
	No	41	(91.3)	307	(87.7)	1.0	(-)	
Previous evacuation of uterus/dc (all women)	Yes	2	(4.4)	20	(4.0)	2.2	(0.3-16.5)	0.46
	No	43	(95.6)	480	(96.0)	1.0	(-)	
Labour lasting more than 18hrs	Yes	14	(31.1)	77	(22.0)	2.0	(1.0-3.8)	0.02
	No	31	(68.9)	273	(78.0)	1.0	(-)	
Still birth	Yes	5	(11.1)	25	(7.1)	0.9	(0.3-2.4)	0.81
	No	40	(88.9)	325	(92.9)	1.0	(-)	
Previous caesarean section	Yes	19	(42.2)	15	(4.0)	18.7	(7.7-40.9)	0.00
	No	26	(57.8)	335	(96.0)	1.0	(-)	

* Women with previous pregnancies only

(iv) Characteristics and outcome of the current pregnancy

Variable	Stratum	Cases		Controls		Odds ratio (95% CI)		P Value
		N	(%)	N	(%)			
Number of pregnancy	1	7	(13.5)	150	(30.0)	0.3	(0.1-0.7)	0.00
	2-4	39	(75.0)	237	(47.4)	1.0	(-)	
	5-14	6	(11.5)	113	(22.6)	0.5	(0.2-1.3)	
Birth spacing in months*	1-36	26	(57.8)	216	(61.9)	1.0	(-)	
	37-60	8	(17.8)	91	(26.0)	0.7	(0.3-1.6)	0.04
	>60	11	(24.4)	43	(12.1)	2.0	(1.0-4.4)	
Attended Antenatal care	Yes	47	(90.4)	485	(97.0)	1.0	(-)	
	No	5	(9.6)	15	(3.0)	3.4	(1.2-9.7)	0.02
Response to vaginal bleeding during pregnancy	Go to hospital	40	(76.9)	481	(96.2)	1.0	(-)	0.00
	Don't know	12	(23.1)	19	(3.8)	7.6	(3.4-16.8)	
Referral from other centres	Yes	27	(51.9)	84	(16.8)	5.1	(2.9-9.3)	0.00
	No	25	(48.1)	416	(83.2)	1.0	(-)	
Bleeding in labour	Yes	20	(38.5)	6	(1.20)	49.8	(18.7-32.4)	0.00
	No	32	(61.5)	493	(98.8)	1.0	(-)	
Use of partograph	Yes	1	(1.9)	44	(8.8)	1.0	(-)	0.11
	No	51	(98.1)	456	(91.2)	0.2	(0.0-1.5)	
Length of labour first stage in hours	<=18	12	(23.1)	435	(87.2)	1.0	(-)	0.00
	>18	40	(76.9)	65	(12.8)	22.2	(10.6-47.6)	
Sex of baby	Female	25	(48.1)	252	(50.2)	1.0	(-)	
	Male	27	(51.9)	248	(49.6)	1.1	(0.6-1.9)	0.10
Birth weight in kilograms	< 2500	3	(5.9)	13	(2.6)	1.1	(0.3-3.7)	0.02
	2500-3500	28	(54.9)	317	(63.4)	1.0	(-)	
	>3500	20	(39.2)	170	(34.0)	2.2	(1.2-4.0)	

* For women with at least one previous pregnancy

(v) Laboratory Results

Variable	Stratum	Cases		Controls		Odds ratio (95% CI)		P Value
		N	(%)	N	(%)			
HIV status	Negative	42	(80.8)	455	(91.0)	1.0	(-)	
	Positive	10	(19.2)	45	(9.0)	2.4	(1.1-4.2)	0.03
Syphilis	Negative	46	(86.5)	454	(90.8)	1.0	(-)	
	Positive	7	(13.5)	46	(9.2)	1.5	(0.6-3.5)	0.94
Haemoglobin gm/dl	<10	12	(23.1	75	(15.0)	19.4	(9.7-38.5)	0.00
	=>10	40	(76.9)	425	(85.0)	1.0	(-)	

Table B5 Characteristics of cases of ante partum haemorrhage due to placenta praevia and controls

(i) Socio-demographic characteristics

Characteristic	Stratum	Cases		Controls		Crude odds ratio (95% CI)		P Value
		N	(%)	N	(%)			
Distance from home to Mulago (km)	0-5	12	(33.3)	408	(81.6)	1.00	(-)	
	6-10	11	(30.6)	81	(16.2)	2.2	(0.9-5.1)	0.00
	11-15	13	(36.1)	11	(2.2)	12.9	(5.3-30.9)	
Distance to nearest health unit (km)	0-5	28	(77.8)	491	(98.2)	1.0	(-)	
	>5	8	(22.2)	9	(1.8)	15.6	(5.6-43.5)	0.00
Age (years)	14-19	6	(16.7)	155	(31.0)	0.4	(0.1-1.1)	0.06
	20-29	21	(58.3)	262	(52.4)	1.0	(-)	
	30+	9	(25.0)	83	(16.6)	1.5	(0.7-3.3)	
Marital status	Married	31	(86.1)	425	(85.0)	1.0	(-)	
	Single	5	(13.9)	75	(15.0)	0.9	(0.3-0- 2.4)	0.85
Tribe	Bantu	32	(91.6)	454	(90.8)	1.0	(-)	
	Nilotics	4	(8.4)	46	(9.2)	1.4	(0.5-4.0)	0.09
Religion	Protestant	18	(50.0)	141	(28.2)	1.0	(-)	
	Catholic	8	(22.2)	173	(34.6)	0.4	(0.2-1.0)	0.00
	Muslim	5	(13.9)	160	(32.0)	0.3	(0.1-0.8)	
	Seven day	1	(2.8)	5	(1.0)	3.5	(0.6-19.7)	
	Saved	4	(11.1)	21	(4.2)	2.1	(0.7 -6.3)	
Education level of patient	No schooling	1	(2.8)	22	(5.0)	0.7	(0.1-5.7)	
	Primary	19	(52.8)	277	(55.4)	1.1	(0.5-2.2)	0.07
	Secondary	12	(33.3)	186	(37.2)	1.0	(-)	
	College	4	(11.1)	15	(3.0)	4.1	(1.2-14.4)	
Patients job	Employed	16	(45.5)	128	(25.6)	2.6	(-)	
	Non employed	20	(55.5)	372	(74.4)	1.0	(1.3-5.2)	0.01
Spouse job	Commerce	2	(5.6)	205	(41.0)	4.4	(0.8-23.8)	0.08
	Professional	8	(22.2)	106	(21.2)	1.1	(0.5-2.8)	
	Peasant	15	(41.7)	189	(37.8)	1.0	(-)	
		9	(25.0)			1.1	(0.5-2.7)	
		2	(6.6)			0.3	(0.1-1.3)	
Type of house	Brick, plastered	28	(80.0)	417	(83.4)	1.0	(-)	
	Brick only	8	(20.0)	69	(13.8)	1.0	(0.4-2.3)	0.95
	Mud only			14	(2.8)			
Facility in house	Electricity and piped water	23	(63.9)	261	(52.2)	1.0	(-)	0.00
	Electricity or tap only	7	(19.4)	140	(28.0)	1.6	(0.6-3.8)	
	Neither	6	(16.7)	99	(19.8)	7.4	(2.6-21.1)	
Need to request permission to visit Health Unit/hospital	Yes	11	(30.6)	47	(9.4)	5.4	(2.6-11.5)	0.00
	No	25	(69.4)	453	(90.6)	1.0	(-)	
Who gives permission To attend Health Unit/hospital	Spouse	10	(92.0)	42	(88.5)	1.0	(-)	
	Other	1	(2.0)	05	(11.5)	0.7	(0.2-2.9)	0.10
Who pays for treatment	Self and spouse	33	(91.6)	403	(80.6)	1.0	(-)	
	Others	3	(8.4)	97	(19.4)	0.7	(0.3-3.5)	0.94

(ii) Social, family and medical history

Characteristic	Stratum	Cases		Controls		Odds ratio (95% CI)		P value
		N	(%)	N	(%)			
Taking alcohol	Yes	12	(33.3)	137	(27.4)	1.3	(0.6-2.7)	0.44
	No	24	(66.7)	363	(72.6)	1.0	(-)	
Family hypertension	Yes	11	(30.6)	194	(38.8)	0.7	(0.3-1.4)	0.32
	No	25	(69.4)	306	(61.2)	1.0	(-)	
Hypertension (self)	Yes	2	(5.6)	2	(0.4)	7.0	(0.9-80.4	
	No	34	(94.4)	498	(95.6)	1.0	(-)	0.17
Use of contraception	Yes	1	(2.8)	219	(43.8)	7.1	(0.6-80.4)	0.11
	No	35	(97.2)	281	(56.2)	1.0	(-)	

(iii) Past obstetric performance

Variable	Stratum	Cases		Controls		Odds ratio (95% CI)		P value
		N	(%)	N	(%)			
Previous abortion	Yes	4	(13.3)	43	(12.3)	1.4	(0.5-4.1)	0.35
	No	26	(86.7)	307	(87.7)	1.0	(-)	
Previous evacuation of uterus/dc (all women)	Yes	5	(13.9)	20	(4.0)	3.9	(1.4-11.1)	0.01
	No	31	(87.1)	480	(96.0)	1.0	(-)	
Bleeding in previous pregnancy	Yes	3	(27.8)	37	10.6	0.9	(0.2-3.5)	0.92
	No	26	(72.2)	313	(89.4)	1.0	(-)	
Bleeding in labour	Yes	2	(27.8)	37	(10.6)	0.7	(0.1-2.9)	0.53
	No	27	(72.2)	313	(89.6)	1.0	(-)	
Labour lasting more than 18hrs	Yes	4	(13.8)	26	(7.5)	2.0	(0.5-6.9)	0.22
	No	25	(86.2)	324	(92.5)	1.0	(-)	
Previous caesarean section	Yes	10	(27.8)	15	(4.0)	12.4	(5.8-30.4)	0.00
	No	19	(72.2)	335	(96.0)	1.0	(-)	
Vacuum + forceps	Yes	1	(3.4)	5	(1.4)	2.8	(0.3-24.9)	0.40
	No	28	(96.6)	345	(98.6)	1.0	(-)	
Hypertension in pregnancy	Yes	1	(3.4)	19	(5.4)	09	(0.1-7.8)	0.88
	No	28	(96.6)	331	(94.6)	1.0	(-)	

* Women with previous pregnancies only

(iv) Characteristics and outcome of the current pregnancy

Variable	Stratum	Cases		Controls		Odds ratio (95% CI)		P Value
		N	(%)	N	(%)			
Number of pregnancy	1	7	(19.5)	150	(30.0)	0.5	(0.2-1.2)	
	2-4	25	(69.4)	237	(47.4)	1.0	(-)	0.29
	5-14	4	(11.1)	113	(22.6)	0.6	(0.2-1.7)	
Birth spacing in months*	1-36	18	(69.2)	195	(61.9)	1.0	(-)	
	37-60	8	(30.8)	120	(38.1)	0.7	(0.3-1.7)	0.45
Attended Antenatal care	Yes	32	(88.9)	485	(97.0)	1.0	(-)	
	No	4	(11.1)	15	(3.0)	4.0	(1.3-1.7)	0.02
Number of antenatal visits	4+	22	(66.7)	291	(59.9)	1.0	(-)	
	<4	11	(33.3)	195	(40.1)	0.8	(0.4-1.6)	0.45
Response to vaginal bleeding during pregnancy	Go to hospital	29	(80.8)	481	(96.2)	1.0	(-)	
	Don't know	7	(19.4)	19	(3.8)	6.1	(2.4-15.7)	0.00
Bleeding during this pregnancy	Yes	6	(16.7)	3	(0.6)	30.1	(6.3-60.5)	0.00
	No	30	(83.3)	497	(99.4)	1.0	(-)	
Referral from other centres	Yes	13	(30.1)	84	(16.8)	2.8	(1.4-5.7)	0.00
	No	23	(63.9)	416	(83.2)	1.0	(-)	
Sex of baby	Female	20	(55.6)	252	(50.2)	1.0	(-)	
	Male	16	(44.4)	248	(49.6)	0.8	(0.4-1.6)	0.49
Birth weight in kilograms	< 2500	14	(38.9)	13	(2.6)	21.3	(8.6-52.8)	0.00
	2500-3500	16	(44.4)	317	(63.4)	1.0	(-)	
	>3500	6	(16.7)	170	(34.0)	0.7	(0.2-1.8)	

* For women with at least one previous pregnancy

(v) Laboratory Results

Variable	Stratum	Cases		Controls		Odds ratio (95% CI)		P Value
		N	(%)	N	(%)			
HIV status	Negative	33	(91.7)	455	(91.0)	1.0	(-)	
	Positive	3	(8.32)	45	(9.0)	0.9	(0.3-3.1)	0.68
Syphilis	Negative	33	(91.7)	454	(90.8)	1.0	(-)	
	Positive	3	(8.3)	46	(9.2)	0.9	(0.3-3.0)	0.86
Haemoglobin	<10	7	(19.4)	75	(15.0)	23.5	(9.9-55.5)	0.00
gm/dl	=>10	29	(80.6)	425	(85.0)	1.0	(-)	
Platelets	<150	8	(22.2)	52	(10.8)	2.4	(1.0-5.4)	0.04
	=>150	28	(77.8)	448	(89.2)	1.0	(-)	

Table B6 Characteristics of cases of ante partum haemorrhage due to abruptio placenta and controls

(i) Socio demographic characteristics

Characteristic	Stratum	Cases		Controls		Crude odds ratio		P
		N	(%)	N	(%)	(95% CI)		Value
Distance from home to Mulago (km)	0-5	14	(31.1)	408	(81.6)	1.0	(-)	
	6-10	21	(46.7)	81	(16.2)	3.1	(1.8-7.3)	0.00
	11-15	10	(22.2)	11	(2.2)	8.5	(3.5-20.9)	0.00
Distance to nearest health unit (km)	0-5	37	(82.2)	491	(98.2)	1.0	(-)	
	>5	8	(18.2)	9	(1.8)	11.8	(4.3-32.4)	0.00
Age (years)	14-19	9	(20.0)	155	(31.0)	0.7	(0.3-1.5)	0.28
	20-29	25	(55.6)	262	(52.4)	1.0	(-)	
	30+	11	(23.9)	83	(16.6)	1.4	(0.7-2.9)	
Marital status	Married	41	(91.1)	425	(85.0)	1.0	(-)	
	Single	4	(8.9)	75	(15.0)	0.6	(0.2-1.6)	0.27
Education level of patient	No schooling	2	(4.4)	22	(5.0)	0.7	(0.1-5.7)	
	Primary	26	(57.8)	277	(55.4)	1.1	(0.5-1.9)	0.20
	Secondary	16	(35.6)	186	(37.2)	1.0	(-)	
	College	1	(2.2)	15	(3.0)	4.1	(1.2-14.4)	
Patients job	Employed	35	(76.1)	128	(25.6)	1.0	(-)	
	Peasants	11	(23.9)	372	(74.4)	1.15	(0.5-2.3)	0.82
Spouse job	Employed	36	(78.3)	205	(41.0)	1.0	(-)	
	Not employed	10	(21.7)	106	(21.2)	1.1	(0.5-2.3)	
				189	(37.8)			0.82
Type of house	Brick, plastered	20	(43.5)	417	(83.4)	1.0	(-)	0.00
	Brick only	17	(37.0)	69	(13.8)	5.1	(2.6-10.3)	
	Mud only	9	(19.0)	14	(2.8)	13.4	(5.2-34.7)	
Need to request permission to visit Health Unit/hospital	Yes	14	(31.1)	47	(9.4)	3.4	(1.7-7.0)	0.00
	No	31	(68.9)	453	(90.6)	1.0	(-)	
Who gives permission to attend Health Unit/ hospital	Spouse	28	(87.5)	403	(88.5)	1.0	(-)	
	Other	4	(12.5)	52	(11.5)	1.1	(0.4-3.3)	0.85
Who pays for treatment	Self and spouse	40	(87.0)	403	(80.6)	1.0	(-)	
	Others	6	(13.0)	97	(19.4)	1.7	(0.7-4.3)	0.26

(ii) Social, family and medical history

Characteristic	Stratum	Cases		Controls		Odds ratio		P
		N	(%)	N	(%)	(95% CI)		Value
Taking alcohol	Yes	6	(13.3)	137	(27.4)	0.4	(0.2-1.0)	0.04
	No	39	(86.7)	363	(72.6)	1.0	(-)	
Family hypertension	Yes	16	(35.6)	194	(38.8)	1.0	(0.5-1.9)	0.99
	No	25	(55.5)	306	(61.2)	1.0	(-)	
		4	(8.9)					
Hypertension (self)	Yes	22	(48.9)	2	(0.4)	1.0	(0.4-1.5)	0.51
	No	23	(51.1)	498	(95.6)	0.8	(-)	
Use of contraception	Yes	6	(13.3)	219	(43.8)	1.0	(-)	0.00
	No	39	(86.9)	281	(56.2)	5.1	(2.0-13.6)	
							(-)	

(iii) Past obstetric performance *

Variable	Stratum	Cases		Controls		Odds ratio (95% CI)		P Value
		N	(%)	N	(%)			
Previous abortion	Yes	4	(8.9)	43	(12.3)	2.3	(0.6-7.7)	0.12
	No	41	(91.1)	307	(87.7)	1.0	(-)	
Previous evacuation of uterus/dc (all women)	Yes	2	(3.1)	20	(4.0)	0.5	(0.1-2.1)	0.28
	No	31	(96.9)	480	(96.0)	1.0	(-)	
Bleeding in previous pregnancy	Yes	2	(6.2)	37	(10.6)	0.6	(0.1-2.5)	0.43
	No	30	(93.8)	313	(89.4)	1.0	(-)	
Labour lasting more than 18hrs	Yes	4	(12.5)	77	(22.0)	0.5	(0.2-1.6)	0.20
	No	28	(87.5)	273	(78.0)	1.0	(-)	
Still birth	Yes	6	(15.6)	25	(7.1)	2.8	(1.1-7.0)	0.03
	No	27	(84.4)	325	(92.9)	1.0	(-)	
Previous caesarean section	Yes	8	(25.0)	15	(4.0)	5.0	(1.8-13.4)	0.00
	No	24	(75.0)	335	(96.0)	1.0	(-)	
Post partum haemorrhage	Yes	4	(2.5)	14	(4.0)	3.4	(1.0-10.8)	0.03
	No	28	(97.5)	336	(96.0)	1.0	(-)	

* Women with previous pregnancies only

(iv) Characteristics and outcome of the current pregnancy

Variable	Stratum	Cases		Controls		Odds ratio (95% CI)		P Value
		N	(%)	N	(%)			
Parity	1	13	(28.9)	150	(30.0)	0.9	(0.5-1.8)	0.87
	2-4	26	(57.8)	237	(47.4)	1.0	(-)	
	5-14	6	(13.3)	113	(22.6)	0.8	(0.3-2.0)	
Birth spacing in months*	1-36	16	(50.0)	195	(61.9)	1.0	(-)	
	37-60	9	(28.1)	82	(26.0)	1.3	(0.6-3.2)	0.41
	>60	7	(21.9)	38	(12.1)	2.3	(0.9-5.8)	
Attended Antenatal care	Yes	39	(86.7)	485	(97.0)	1.0	(-)	
	No	6	(13.7)	15	(3.0)	4.5	(1.8-13.5)	0.00
Bleeding during this pregnancy	Yes	6	(15.3)	3	(0.6)	25.5	(6.1- 105.8)	0.00
	No	39	(86.7)	497	(99.4)	1.0	(-)	
Hypertension in this pregnancy	Yes	16	(35.0)	7	(1.4)	22.5	(11.63-8.6)	0.00
	No	29	(64.4)	493	(98.6)	1.0	(-)	
Referral from other centres	Yes	27	(60.0)	84	(16.8)	7.4	(3.9-14.1)	0.00
	No	18	(40.0)	416	(83.2)	1.0	(-)	
Premature rupture of membranes	Yes	7	(15.6)	111	(22.3)	0.6	(0.3-1.5)	0.30
	No	38	(84.4)	386	(77.7)	1.0	(-)	
Bleeding in labour	Yes	34	(75.6)	6	(1.20)	254.0	(88.6-728.4)	0.00
	No	11	(24.4)	493	(98.8)	1.0	(-)	
Sex of baby	Male	32	(71.1)	252	(50.2)	2.2	(1.2-4.9)	
	Female	13	(28.9)	248	(49.6)	1.0	(-)	0.00
Birth weight in kilograms	< 2500	21	(46.7)	13	(2.6)	30.1	(12.9-70.2)	0.00
	2500-3500	17	(37.8)	317	(63.4)	1.0	(-)	
	>3500	7	(15.6)	170	(34.0)	0.8	(0.3-1.9)	

* For women with at least one previous pregnancy

(v) Laboratory Results

Variable	Stratum	Cases		Controls		Odds ratio (95% CI)		P value
		N	(%)	N	(%)			
HIV status	Negative	41	(91.1)	455	(91.0)	1.0	(-)	0.98
	Positive	4	(8.9)	45	(9.0)	1.0	(0.3-2.9)	
Syphilis	Negative	41	(91.1)	454	(90.8)	1.0	(-)	
	Positive	4	(8.9)	46	(9.2)	1.0	(0.3-2.8)	0.94
Haemoglobin gm/dl	<10	36	(80.0)	75	(15.0)	22.7	(10.5-49.0)	0.00
	=>10	9	(20.0)	425	(85.0)	1.0	(-)	
Platelets	<150	19	(41.3)	52	(10.8)	11.7	(6.1-22.5)	0.00
	=>150	27	(58.7)	448	(89.2)	1.0	(-)	

APPENDIX C : TABLES RELATING TO REFERRED AND NON-REFERRED CASES

Table C1: The primary causes of all severe maternal morbidity compared to non referrals

Primary cause	Number of referrals n (%)	Number of non referrals n (%)	Total number of all cause SMM n (%)
Severe pre eclampsia and eclampsia	57(45.6)	68(54.4)	125(100)
Post partum haemorrhage	58(61.0)	37(39.0)	95(100)
Obstructed labour	70(68.6)	32(31.4)	102(100)
Ruptured uterus	27(51.9)	25(48.1)	52(100)
Abruptio placenta	19(57.6)	14(42.4)	33(100)
Placenta praevia	10(27.8)	26(72.2)	36(100)
Puerperal sepsis	14(56.0)	11(44.0)	25(100)
Anaemia	6(30.0)	14(70.0)	20(100)
Other medical conditions	4(36.4)	7(63.6)	11(100)
Total	**263**	**236**	**236**

Table C2: Comparing the crude odds ratios of all severe maternal morbidity to those who were not referred to Mulago hospital

(i) Socio-demographic characteristics

Characteristic	Stratum	Crude odds ratio All SMM (95% CI)		P Value	Non referral cases	Non referral crude odds		P Value
Distance from home to Mulago (km)	0-5	1.0	(-)		121(51.3)	1.0	(-)	0.00
	6-10	3.6	(2.7-4.9)	0.00	85(36.0)	3.7	(2.5-5.4)	
	11-15	11.6	(6.1-22.3)		30(12.7)	9.4	(4.3-20.4)	
Distance to nearest health unit (km)	0-5	1.0	(-)		212(89.8)	1.0	(-)	0.00
	5.1-15	12.2	(6.1-24.4)	0.00	24(10.2)	11.7	(4.0-34.1)	
Age (years)	14-19	0.9	(0.7-1.3)		72(30.5)	1.2	(0.8-1.7)	
	20-29	1.0	(-)		127(53.8)	1.0	(-)	
	30-35	0.7	(0.4-1.2)	0.45	28(11.9)	1.0	(0.6-1.9)	0.32
	35+	0.8	(0.6-1.4)		9(3.8)	0.6	(0.3-1.4)	
Marital status	Married	1.0	(-)		195(82.6)	1.0	(-)	0.56
	Single	1.3	(0.9-1.8)	0.12	41(17.4)	1.1	(0.7-1.7)	
Tribe	Bantu	1.0	(-)		209(88.6)	1.0	(-)	
	Other	1.6	(1.1-2.5)	0.01	27(11.4)	1.2	(0.7-2.0)	0.46
Religion	Protestant	1.0	(-)	0.03	77(32.6)	1.0	(-)	
	Catholic	0.8	(0.6-1.2)		75(31.8)	0.7	(0.5-1.2)	
	Muslim	0.7	(0.5-0.9)		66(28.0)	0.7	(0.4-1.2)	0.42
	Seven day	1.9	(0.6-5.6)		3(1.3)	1.1	(0.2-5.2)	
	Saved	1.3	(0.7-2.4)		15(6.4)	1.3	(0.6-2.6)	
Education level of patient	No schooling	1.2	(0.1-2.2)		15(6.4)	0.9	(0.6-1.3)	
	Primary	1.0	(0.8-1.3)	0.18	121(51.3)	1.5	(0.6-3.4)	
	Secondary	1.0	(-)		89(37.7)	1.0	(-)	0.55
	College	1.9	(1.0-2.2)		11(4.6)	1.3	0.6-2.6)	
Patients job	Commerce	1.0	(0.8-1.4)		52(22.0)	0.9	(0.6-1.4)	0.21
	Professional	2.4	(1.3-4.6)	0.02	15(6.4)	2.2	(0.9-5.0)	
	Peasant	1.0	(-)		169(71.6)	1.0	(-)	
Spouse job	Commerce	1.0	(-)		106(44.9)	1.0	(-)	
	Professional	0.7	(0.5-1.0)	0.08	94(39.8)	0.6	(0.4-1.0)	0.16
	Peasant	0.9	(0.7-1.1)		36(15.3)	0.9	(0.6-1.3)	
Type of house *	Brick, cemented	1.0	(-)		117(49.6)	1.0	(-)	0.00
	Brick only	4.1	(2.9-5.6)	0.00	94(39.8)	4.3	(2.4-6.4)	
	Mud only	7.9	(4.3-14.2)		25(10.6)	6.6	(3.2-13.9)	
Facility in house	Electricity and water	1.0	(-)	0.00	65(27.5)	1.0	(-)	0.00
	Electricity or water only	1.5	(1.1-2.0)		84(35.6)	2.0	(1.3-3.0)	
	Neither	2.4	(1.8-3.3)		87(36.9)	3.3	(2.2-4.9)	
Need to request permission to visit Health Unit/ hospital	Yes	4.7	(3.3-6.7)		72(27.1)	5.2	(3.3-8.3)	0.00
	No	1.0	(-)	0.00	164(69.5)	1.0		
Who gives permission to attend Health Unit/ hospital	Spouse	1.0	(-)		64(85.5)	1.0	(-)	0.71
	Other	1.4	(1.0-2.2)	0.08	10(14.5)	1.1	(0.7-1.9)	
Who pays for treatment	Self and spouse	1.0	(-)		193(81.8)	1.0	(-)	
	Others	2.9	(1.9-4.2)	0.00	43(18.2)	2.2	(1.3-3.5)	0.01

*Brick, cemented: brick, well cemented house and floor with iron roof or tiles
Brick only: brick, not cemented floor and walls and iron roof
Mud only: Mud walls and floor with iron roof

(ii) Social, family and medical characteristics

Characteristic	Stratum	Crude Odds ratio All SMM (95% CI)		P value	Non referral cases	Non referral crude odds (95% CI)		P value
Taking alcohol	Yes	0.7	(0.5-0.9)	0.02	50(21.2)	0.7	(0.5-1.0)	0.04
	No	1.0	(-)		186(78.8)	1.0	(-)	
Smoking	Yes	0.3	(0.2-2.4)	0.75	1(0.4)	0.2	(0.0-1.2)	0.12
	No	1.0	(-)		235(99.6)	1.0		
Family hypertension	Yes	1.0	(0.8-1.3)	0.87	10243.2)	1.3	(0.9-1.8)	0.11
	No	1.0	(-)		134(56.8)	1.0		
Family diabetes mellitus	Yes	1.1	(0.2-1.4)	0.75	30(12.7)	1.2	(0.8-2.1)	0.35
	No	1.0	(-)		206(87.3)	1.0	(-)	
Hypertension (self)	Yes	12.0	(2.8-51.3)	0.00	13(5.5)	12.1	(2.7-53.9)	0.00
	No	1.0	(-)		223(94.5)	1.0	(-)	
Use of contraceptives	Yes	1.0	(-)		100(42.3)	1.0	(-)	0.98
	No	1.2	(0.9-1.5)	0.26	136(57.6)	1.0	(0.7-1.4)	

(iii) Past obstetric performance *

Characteristic	Stratum	Crude odds ratio All SMM (95% CI)		P value	Non referral cases	Non referral crude odds (95% CI)		P value
Previous abortion	Yes	1.1	(0.7-1.9)	0.50	25(16.7)	1.4	(0.8-2.4)	
	No	1.0	(-)		125(83.3)	1.0	(-)	0.42
Previous evacuation of uterus and curettage (all women)	Yes	1.8	(1.2-4.5)	0.00	20(13.3)	2.2	(1.1-4.2)	0.02
	No	1.0	(-)		130(8.7)	1.0	(-)	
Bleeding in previous pregnancy	Yes	1.5	(1.0-2.5)	0.07	27(18.0)	1.7	(1.0-3.1)	0.04
	No	1.0	(-)		123(82.0)	1.0	(-)	
Bleeding in labour	Yes	1.0	(0.6-1.6)	0.99	18(12.0)	1.1	(0.6-2.1)	0.66
	No	1.0	(-)		132(88.0)	1.0	(-)	
Labour lasting more than 18hrs	Yes	0.7	(0.5-1.1)	0.12	26(17.3)	0.7	(0.4-1.1)	0.13
	No	1.0	(-)		124(82.7)	1.0	(-)	
Still birth	Yes	1.6	(0.9-2.9)	0.07	16(10.7)	1.2	(0.6-2.3)	0.60
	No	1.0	(-)		134(89.3)	1.0	(-)	
Previous caesarean section	Yes	5.4	(2.9-10.2)	0.00	41(27.3)	5.1	(2.9-8.7)	0.00
	No	1.0	(-)		109(71.7)	1.0	(-)	
Vacuum or forceps	Yes	1.4	(0.4-5.1)	0.62	4(2.7)	1.2	(0.3-4.2)	0.80
	No	1.0	(-)		146(97.3)	1.0	(-)	
Post partum haemorrhage	Yes	1.4	(0.6-3.0)	0.38	12(8.0)	1.8	(0.7-4.1)	0.15
	No	1.0	(-)		138(92.0)	1.0	(-)	
Retained placenta	Yes	1.0	(0.3-2.9)	0.98	6(4.0)	1.2	(0.4-3.4)	0.35
	No	1.0	(-)		144(96.0)	1.0	(-)	
Hypertension in pregnancy	Yes	1.4	(0.7-2.7)	0.31	17(11.3)	2.2	(1.1-4.6)	0.03
	No	1.0	(-)		133(88.7)	1.0	(-)	
Blood transfusion during pregnancy	Yes	4.7	(1.4-16.6)	0.00	9(6.0)	5.4	(1.5-20.34)	0.00
	No	1.0	(-)		141(94.0)	1.0	(-)	

* Women with previous pregnancies only

(iv) Current obstetric performance

Characteristic	Stratum	Crude odds ratio All SMM (95% CI)		P value	Non referral cases	Non referral crude odds (95% CI)		P value
Parity	1	1.3	(1.0-1.7)	0.02	86(36.5)	1.3	(0.9-1.9)	0.10
	2-4	1.0	(-)		102(43.2)	1.0	(-)	
	5-14	0.8	(0.4-0.9)		48(20.3)	0.8	(0.6-1.4)	
Birth spacing in months*	1-36	1.0	(-)		87(57.8)	1.0	(-)	
	37-60	1.1	(0.8-1.6)	0.05	34(23.0)	1.1	(0.6-1.5)	0.07
	>60	1.8	(1.1-2.8)		29(19.2)	1.8	(1.0-3.0)	
Attended Antenatal care	Yes	1.0	(-)		198(83.9)	1.0	(-)	0.00
	No	4.5	(2.5-8.0)	0.00	38(16.1)	6.4	(3.3-12.6)	
Booking time for antenatal (weeks)	<28	1.0	(-)		127(64.1)	1.0	(-)	0.46
	28-36	1.0	(0.1-1.3)	0.99	71(38.9)	1.1	(0.8-1.6)	
Number of antenatal visits	4+	1.0	(-)		79(39.9)	1.0	(-)	0.13
	<4	1.2	(0.9-1.6)	0.13	119(60.1)	1.1	(0.8-1.6)	
Having blood pressure checked during antenatal	No	2.7	(1.7-7.6)	0.02	4(.0)	2.6	(1.6-5.2)	0.00
	Yes	1.0	(-)		194(98.0)	1.0		
Response to vaginal bleeding during pregnancy	Go to hospital	1.0	(-)		180(76.3)	1.0	(-)	0.00
	Don't know	8.7	(5.3-14..3)	0.00	56(23.7)	7.7	(4.3-13.9)	
Bleeding during this pregnancy	Yes	4.8	(1.4-16.7)	0.01	41(17.4)	7.2	(1.5-34.5)	0.00
	No	1.0	(-)		195(82.9)	1.0	(-)	
Hypertension in this pregnancy	Yes	16.9	(7.7-36.9)	0.00	62(27.1)	25.2	(9.9-64.1)	0.00
	No	1.0	(-)		174(72.9)	1.0	(-)	
Anaemia in this pregnancy	Yes	5.0	(1.7-14.7)	0.00	12(5.1)	7.4	(2.1-26.4)	0.00
	No	1.0	(-)		224(94.9)	1.0	(-)	
Loss of weight	Yes	1.5	(1.0-2.4)	0.06	212(89.8)	1.1	(0.3-2.4)	0.14
During pregnancy	No	1.0	(-)		24(10.2)	1..0	(-)	
Admission during pregnancy	Yes	1.4	(0.9-2.2)	0.14	34(14.4)	2.0	(1.2-3.3)	0.00
	No	1.0			202(85.6)	1.0	(-)	
Referral from other centres	Yes	5.5	(4.1-7.4)	0.00		-		
	No	1.0	(-)					
Premature rupture of membranes	Yes	1.9	(1.4-2.5)	0.00	66(28.0)	1.8	(1.3-2.7)	0.00
	No	1.0	(-)		170(72.0)	1.0	(-)	
	missing							
Bleeding in labour	Yes	20.1	(8.4-51.4)	0.00	8(3.4)	21.0	(8.9-49.9)	0.00
	No	1.0	(-)		228(96.6)	1.0	(-)	
Use of partograph	Yes	0.8	(0.5-1.3)	0.32	14(5.9)	0.9	(0.9-1.8	0.80
	No	1.0	(-)		221(94.1)	1.0	(-)	
	missing							
Length of first stage in hours	= <18hours	1.0	(-)		182(88.0)	1.0	(-)	0.00
	>18	2.7	(1.61-4.63)	0.00	25(11.8)	2.6	(1.4-4.4)	
	no labour				29			
Length of third stage in minutes.**	= <25	1.0	(-)		200(92.6)	1.0	(-)	0.00
	>25	18.4	3.8 -89.6	0.00	16(7.4)	17.2	(3.4-82.1)	
Sex of baby	Female	1.0	(-)		115(48.7)	1.0	(-)	0.65
	Male	1.1	(0.8-1.5)	0.33	121(51.3)	1.1	(0.7-1.5)	
	missing							
Birth weight In kilograms	< 2500	5.9	(3.9-8.8)	0.00	76	6.8	(4.2-10.9)	0.00
	2500-3500	1.0	(-)		118	1.0	(-)	
	>3500	1.0	(0.7-1.4)		41	1.2	(4.2-10.9)	
	missing							
Level of delivery attendant	Midwife	1.0	(-)		50(21.7)	1.00	(-)	0.00
	Doctor	111.0	(60.4-203.9)	0.00	161(70.0)	237	(84.0-663.2)	
	TBA	-			19(8.3)			
Given Oxytocics **	Yes	1.0	(-)		174(88.8)	1.0	(-)	0.00
	No	5.7	(2.9-11.1)	0.00	22(11.2)	6.9	(3.0-15.87)	

* Multiparous women only ** ruptured uterus done hysterectomy excluded

(v) Laboratory results

Characteristic	Stratum	Crude odds ratio (95% CI)		P value	Non referral cases	Non referral crude odds (95% CI)		P Value
HIV status	Negative	1.0	(-)		205(86.9)	1.0	(-)	0.05
	Positive	1.7	(1.1-2.5)	0.01	31(13.1)	1.6	(1.0-2.7)	
Syphilis	Negative	1.0	(-)		209(88.6)	1.0	(-)	
	Positive	0.9	(0.6-1.4)	0.75	27(11.4)	1.2	(0.7-1.9)	0.52
Haemoglobin gm/dl	<10	1.0	(-)		134(56.8)	1.0	(-)	0.00
	=>10	8.4	(6.3-11.4)	0.00	102(43.2)	7.7	(5.4-11.3)	
Mean corpuscular haemoglobin concentration in g/dl	<33.0	1.5	(1.0-2.1)	0.03	203(86.0)	1.4	(0.9-10.2)	0.06
	>33.0	1.0	(-)		33(14.0)	1.0	(-)	
Platelets x109/l	<150	3.6	(2.6-5.1)	0.00	659(27.5)	3.0	(2.0-4.6)	0.00
	=>150	1.0	(-)		171(72.5)	1.0	(-)	

Table C3 Distribution of selected factors amongst referrals in severe maternal morbidity cases and controls

Variable	Stratum	Cases		Controls	
		Referrals n (%)	Non referrals n (%)	Referrals n (%)	Non referrals n (%)
Distance	<=5km	82(31.2)	75(31.8)	51(60.7)	282(67.8)
	>5-10	91(34.6)	85(36.0)	16(19.0)	65(15.6)
	>10	47(19.0)	30(12.7)	2(2.4)	9(2.2)
Permission	Yes	91(34.6)	74(30.5)	15(17.9)	32(7.7)
	No	172(65.4)	164(69.5)	69(82.1)	384(92.3)
Paying	Yes	56(21.4)	43(18.2)	2(2.4)	38(9.1)
	No	206(78.6)	193(81.)	82(97.6)	378(90.9)
Housing	Brick, cemented	137(52.1)	121(51.3)	72(85.7)	345(83.0)
	Brick only	83(31.6)	90(38.1)	9(10.7)	60(14.4)
	Mud only	43(16.3)	25(10.6)	3(3.6)	11(2.6)
Parity	Nulliparity	99(37.6)	85(36.0)	35(29.7)	125(30.0)
	2-5	125(47.5)	103(43.6)	47(56.0)	190(45.7)
	>5	39(14.8)	48(20.3)	12(14.3)	101(24.3)
Antenatal care	Yes	231(87.8)	198(83.9)	82(97.6)	404(97.1)
	No	32(12.2)	38(16.1)	2(2.4)	12(2.9)

Table C4 Reason for referral among controls in stage 1 cases control study of SMM

Reason for referral	Numbers %
No delivery facility	4 (4.8)
Nulliparity	12(14.3)
Big baby	16(19.0)
Premature rupture of membranes	10(11.9)
Poor progress	24(26.5)
Breech	3(3.6)
Medical diseases	7(8.3)
History of infertility	5(6.0)
Ante partum haemorrhage	3(3.6)
Total	84(100)

Table C5 Distribution of severe maternal morbidity and progression to mortality by referral

Variable	Stratum	Cases		Controls	
		Referrals n(%)	Non referrals n(%)	Referrals n(%)	Non referrals n (%)
Distance	<=5km	5(26.3)	7(35.0)	120(49.2)	114(52.8)
	>5-10	7(36.8)	10(50.0)	84(34.4)	75(34.7)
	>10	7(36.8)	3(15.0)	40(16.4)	27(12.5)
Permission	Yes	9(47.4)	11(55.0)	82(33.6)	61(28.2)
	No	10(52.6)	9(45.0)	162(66.4)	155(71.8)
Paying	Yes	4(21.1)	2(10.0)	52(21.4)	41(9.0)
	No	15(78.9)	18(90.0)	191(78.6)	175(81.0)
Housing	Brick, cemented	9(47.4)	13(65.0)	128(52.4)	108(50.0)
	Brick only	7(36.8)	7(35.0)	76(31.2)	83(38.4)
	Mud only	3(36.8)	0	40(16.4)	25(11.6)
Parity	Nulliparity	2(10.5)	8(40.0)	97(39.7)	78(36.0)
	2-5	15(79.0)	11(55.0)	110(45.1)	91(42.3)
	>5	2(10.5)	1(5.0)	37(15.2)	47(21.7)
Antenatal care	Yes	9(47.4)	13(65.0)	222(91.0)	185(85.7)
	No	10(52.6)	7(35.0)	10(9.0)	31(14.3)

APPENDIX D : PEOPLE INVOLVED IN THE STUDY

The roles of the people who contributed to this study and the production of the thesis are listed below.

1. Supervisors (Pat Doyle and Noreen Maconochie) and advisory committee (Carine Ronsmans, Jim Todd)

- My supervisor PD was instrumental in guiding me from the beginning of the course to the end. Together with the statistician (NM) was instrumental in conceptualising the study design and guided me in preparation of upgrading document and main thesis. Carine Ronsmans contributed to the study design and the interpretation of the results.
- PD visited me during the field work to see and check on data collection and data entry.
- PD provided advice during the analysis of data and interpretation of results.
- PD read my thesis and assisted me in English grammar
- The advisory committee guided me on the feasibility of the study in the early days and later on how to focus on my study objectives during analysis and write up.

2. Statistical help from Jim Todd

- JD gave me advice on analysis whenever I asked for it, especially when carrying out multivariate analysis.

3. Help with Field Work

Assistant to PI: this was an obstetrician and gynaecologist. He:

- Aided me in ensuring that the cases and controls satisfied the selection criteria.
- Covered me whenever I was not available.

Interviewers: These were two senior midwives. They:

- Interviewed the cases and controls.
- Took off specimens for investigations
- Followed up of case and controls till discharge or death.

Pathologist: He:

- Carried out post mortems for all SMM cases who died.

Laboratory technician: They:

- Carried out all laboratory investigations as requested by PI or assistant PI

Runner

- Was responsible for delivery of specimen to laboratories and carrying back the results.

Data entry clerk: She;

- Carried out first data entry in Uganda.

4. My personal role.

- Played the major role in the conceptualisation of the study design
- Wrote the upgrading document.
- Piloted the study
- Supervised all staff in Uganda who participated in collection of data.
- Supervised first data entry in Uganda.
- Carried out second data entry at London School of Hygiene and Tropical Medicine
- Carried out data cleaning and checking.
- Carried out the data analysis
- Interpreted the results
- Wrote the thesis.
