FACTORS ASSOCIATED WITH MATERNAL MORTALITY IN SOUTH EAST BOTSWANA

TUDUETSO M. MOKGATLHE

A mini-thesis submitted in partial fulfillment of the requirements for the degree of Masters in Public Health at the School of Public Health,
University of the Western Cape

Supervisor: Professor Ehimario Igumbor

November 2012

FACTORS ASSOCIATED WITH MATERNAL MORTALITY IN SOUTH EAST BOTSWANA

TUDUETSO MOKGATLHE

KEYWORDS

- Maternal mortality
- Maternal death
- Maternal health
- Pregnancy-related death
- Risk factors
- Cause of death
- Case control study
- Quantitative study
- Record review
- Botswana

ACKNOWLEDGEMENTS

This mini-thesis would not have been possible without the contribution of various people and I gratefully appreciate their assistance.

I owe thanks to my supervisor, Professor Ehimario Igumbor for his wise guidance, valuable feedback, support and encouragement throughout this work. Additionally, I would like to thank Ms. Corinne Carolissen and Ms. Janine Kader, for their timely responses to enquiries and helpfulness. I am also grateful for my colleagues at UWC for the moral support.

I must also thank Ms. Thipe and Ms. Kasule from the Ministry of Health. Additionally, I would like to express my gratitude to Princess Marina Hospital and Bamalete Lutheran Hospital for granting me permission to access the required information. At PMH, I would specifically like to thank Dr. Petr and Ms. Moatshe and at BLH, Ms. Sello.

I must also acknowledge the contribution made by members of my family. My husband, Boitshoko for believing in me and encouraging me to apply for this MPH. Our children- Lindile, Sandile, Andile and Khetiwe- for being my inspiration. My mother, Irene and my siblings for cheering me on and for their support. My mother-in-law, Nursey, for babysitting when I needed to travel to Cape Town. Dr. Lucky Mokgatlhe for helping set up the database and his family for babysitting.

Lastly but not least, I thank God for being a guiding light throughout this work and for giving me the strength to keep going until the end.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

Factors Associated with Maternal Mortality in South East Botswana.

T. M. Mokgatlhe

Masters in Public Health Minithesis, School of Public Health, University of the Western Cape

Background: Maternal mortality is a significant public health problem world-wide, as it is an important indicator for the functioning of the health system. The maternal mortality ratio for Botswana is higher than other countries with comparable economic growth, despite impressive access to health services. In order to develop relevant programs and policies to reduce maternal mortality, the factors associated with maternal mortality were studied. The study aimed to describe the maternal and health services factors associated with maternal mortality in South East Botswana.

Methodology: A quantitative case-control study was used to retrospectively review medical records for 71 cases of maternal deaths and 284 controls randomly selected from mothers who delivered in the same year and at the same health facility, in South East Botswana from 2007 to 2009. Information was collected on the maternal and health services characteristics of the cases and controls including age, level of education, marital status, parity, utilization of health facilities that consist of antenatal care (ANC), type of delivery, complications during pregnancy, type of health facility and ANC provider. Data was analyzed using Predictive Analysis Software (PASW) Version 18. Two-sample t- test, Pearson's Chi-square test and the Fisher's exact test were used to test the difference between the proportions of the various categories of variables in cases and controls. Univariate logistic regression analysis was applied to identify the risk factors associated with maternal deaths. A multivariate logistic regression model was estimated to see the joint effects of the identified risk factors for maternal mortality. Hosmer and Lemeshow test was used to test the goodness of fit of the model.

Results: The mean age of the maternal deaths was 28.0 ± 5.3 years and they had taken place at a hospital (100%). A large number of deaths occurred before delivery

(59.0%). The causes of maternal death included both direct (73%) and indirect causes (27%). Direct causes were the leading causes of death and they were abortion (22.5%) and haemorrhage (18.3%). The maternal characteristics associated with maternal mortality were having complications at delivery (OR=20.91), not receiving ANC (OR=6.31) and delivering by caesarean section (OR= 2.66). The health facility characteristics associated with maternal mortality were delivering outside the health facility (OR=14.78), having been referred from another facility (OR=8.62) and delivering at a general hospital (OR=5.91). The data produced a model with good fit that included one maternal risk factor and three health facility risk factors. These were being admitted with preterm labour, delivering at a general hospital or before arrival at the health facility and having been referred from another health facility.

Conclusion: Maternal mortality was associated with both maternal and health facility risk factors. The model developed may be used to identify and manage high-risk women to reduce the number of maternal deaths. It was recommended that, the current system should continue to be monitored and evaluated through the Maternal Mortality Monitoring System (MMMS). Furthermore, the referral and management of complications needs to be strengthened through a multi-sectoral approach.

DECLARATION

I declare that *Factors Associated with Maternal Mortality in South East Botswana* is my own work, that it has not been submitted before for any degree or examination in any other university, and that all the sources I have used or quoted have been indicated and acknowledged as complete references.

Tuduetso M. Mokgatlhe November 2012

Signed: . . . . . .

1.0 CHAPTER ONE: INTRODUCTION

This chapter sets the context of the study by providing background information which includes an overview of the maternal mortality situation worldwide and in Botswana. It also briefly describes the demographic, socio-economic and health services profile of the study area, South East Botswana. Furthermore, the problem statement and the purpose of the study are presented.

1.1. Background Information

Maternal mortality is a worldwide problem which is more pronounced in the developing countries than in the developed countries (Alvarez, Gil, Hernández and Gil, 2009). According to the World Health Organisation (WHO) (2010), in 2008 the maternal mortality ratios (MMR) ranged from 2 maternal deaths per 100,000 live births in Greece to 1400 maternal deaths per 100,000 live births in Afghanistan. High levels of maternal mortality are a health and developmental concern as it is an indicator not only of the health of women but also of the status of the health care system in a country. This is because, a maternal death is a representation of a large number of other women who experience morbidity (WHO, 2004a). This is of importance as most of these deaths are considered preventable (WHO, 2004a).

In 2008 (WHO, 2010), there were approximately 358,000 maternal deaths worldwide, of which 99% were from developing countries and 57% were from sub-Saharan Africa. The report also estimates the MMR for sub-Saharan Africa to be 640 deaths per 100,000 live births, which is 40 times that of Europe (16 deaths per 100,000 live births) and 28 times that of North America (23 deaths per 100,000 live births). Additionally, sub-Saharan Africa has MMRs as high as 1000 and 1200 deaths per 100,000 live births in countries such as Guinea-Bissau and Chad, respectively (WHO, 2010). In Southern Africa, countries such as Angola and

Tanzania also had MMRs as high as 610 and 790 deaths per 100,000 live births, respectively. In Botswana, the MMR was estimated to be 190 deaths per 100,000 live births in 2008, with a range of uncertainty from 84 to 380 deaths per 100,000 (WHO, 2010). The Central Statistics Office (CSO) (2011a) reported an MMR of 163 deaths per 100,000 live births in 2010.

Botswana is a developing country in Southern Africa. It is a landlocked, semi-arid country of 582, 000 square kilometres (Ministry of Finance and Development Planning, 2003). According to the preliminary results of the 2011 census, the population of Botswana was 2, 038, 228 (CSO, 2011b). The population is concentrated in the South Eastern parts due to favourable conditions for agriculture and the location of the country's capital city in this region (Ministry of Finance and Development Planning, 2003).

Botswana has a fast growing economy, and as a result the national government has been able to deliver high level services with respect to health. Primary health care services are delivered through a decentralized system managed by the Ministries of Health (MOH) and Local Government. The former, oversees all hospitals and the latter, is in charge of clinics, health-posts and mobile stops (Ministry of Finance and Development Planning, 2003). This study will assess records from Gaborone, which is a major urban centre and the surrounding rural areas in South East Botswana. The population of this area is 320, 167 (CSO, 2011b). According to the Central Statistics Office (2007), 100% of the population live within 5km of a health facility in Gaborone, and within 15km of a health facility in South East. The information for the study population is summarised in Table 1.1., below. Due to the close proximity of the South East district to Gaborone, some of the population commutes daily to Gaborone for employment and school.

Table 1.1. Demographic, socio-economic and health services information for Gaborone and South East

Information	Gaborone	South East	Reference
Residence	Urban	Rural	
Population	227,333	92,843	Central Statistics Office, 2011b
Unemployment	14.5%	19.8%	Central Statistics Office, 2008
Health facilities	2 hospitals 24 Clinics	1 hospital 10 Clinics 4 Healthposts 36 Mobile stops	Personal communication with K. Baeti, 3 June 2008
Access to health facilities	100% within 5km	66% within 8km 100% within 15km	Central Statistics Office, 2007a
National adult female literacy rate		81.3%	Central Statistics Office, 2007b

1.2. Problem Statement

Botswana is an upper middle income country, whose economic growth has enabled the country to develop a comparably well-functioning health system. Despite the provision of free health care services and access to health facilities, in 2008, the MMR was relatively high at 190 (WHO, 2010 and CSO, 2011a). Although the MMR for Botswana is lower than that for low income countries, it is higher than that of a number of countries in the same income group such as, Mauritius (36 deaths per 100,000 live births) (WHO, 2010). There is a need to determine the leading causes of maternal mortality and the factors (maternal and health services) associated with maternal mortality. This information would provide insight into the reasons for this comparatively high MMR and thus inform strategies for reducing it.

1.3. Purpose

This study aims to provide information on the factors that are associated with maternal mortality in South East Botswana. Letamo and Rakgaosi (2003) provided insight on an important aspect of factors associated with maternal mortality, with respect to women who do not deliver at a health facility in Botswana. This study would complement their study as it would provide information on the factors that are associated with maternal mortality for women who deliver at the health facilities. Although such studies have been carried out in other parts of the world including countries in Africa, there is no documented comprehensive study to date that has been conducted in Botswana. This is particularly important as access to healthcare facilities (Cham, Sundby and Vangen, 2005) and use of traditional birth attendants (Aggarwal, Pandey and Bhattacharya, 2007), were associated with maternal mortality in these countries. These factors may not apply to Botswana, as 95% of the population live within 8km of a health facility (CSO, 2007a) and approximately 95% of deliveries take place at a health facility and are attended by a skilled health personnel (CSO, 2009a). Furthermore, these studies show conflicting findings. For example, where some studies reported increased maternal mortality with maternal age (Evjen-Olsen, Hinderaker, Lie, Bergsjø, Gasheka and Kvåle, 2008), others found no association (Høj, da Silva, Hedegaard, Sandström and Aaby, 2002). Therefore, this study will provide information about the factors associated with maternal mortality specific to Botswana. These findings will also be communicated to stakeholders such as the Safe Motherhood Initiative, who have indicated interest in such a study (Personal communication with B. Thipe, 23 February 2009), which may then be used to design appropriate interventions and policies that are relevant to Botswana.

2.0 CHAPTER TWO: LITERATURE REVIEW

This Chapter examines and reviews selected literature and provides information about maternal mortality studies worldwide and with respect to Botswana. It starts by providing the various definitions of maternal death. Then it describes global maternal mortality statistics, including Botswana. It also discusses the causes of maternal mortality and the maternal and health facility risk factors associated with maternal mortality in different countries. It concludes by briefly describing the methods used to study maternal mortality and the various policies and interventions for reducing maternal mortality.

2.1. Definition of Maternal Death

According to WHO (2004b), a maternal death is:

> *the death of a woman while pregnant or within 42 days of the end of the pregnancy, irrespective of the duration and the site of the pregnancy, from any cause related to or aggravated by the pregnancy or its management, but not from accidental or incidental causes* (WHO 2004b: 98).

Most studies use this definition of maternal death. However, some studies have also included late maternal death, as also defined by WHO (2004a) to include deaths that occur between 42 days and one year of termination of pregnancy as a result of direct and indirect obstetric causes. For example, Høj *et al.* (2002) defined late maternal death if it had occurred between 43 and 91 days postpartum. Another definition of maternal mortality is pregnancy-related death, which is a modification of the maternal death to include all deaths irrespective of the cause of death (WHO, 2004b). In Botswana, for the Safe Motherhood Initiative and Maternal Death Notification, the definition used is deaths within 42 days after termination of pregnancy (MOH, 2006).

2.2. Maternal Mortality Statistics

Maternal mortality data may be determined through a variety of sources such as civil registration, sisterhood estimates, disease surveillance, sample registration, household surveys and reproductive-age mortality studies (WHO, 2005; WHO, 2010). The sources are described and their limitations are discussed. It is important to note that, although civil registration is the preferred data source, it may also result in misidentification and misclassification leading to underreporting (WHO, 2010). They advance the reason that measuring maternal deaths by its nature is complex. For example, a maternal death may be missed in early pregnancy as it is not associated with a birth. In their literature review of studies that used civil registration as a data source, they established that the underreporting of maternal deaths may be as high as 220%. It should be noted that most of these studies were carried out in developed countries. They suggest that, additional investigations such as the Confidential Enquiry into Maternal Deaths should be carried out even in the presence of a functioning civil registration system (WHO, 2010).

Maternal mortality ratio is usually used to measure maternal mortality and is defined as the number of maternal deaths divided by the number of live births in a given population (WHO, 2005). It indicates the risk of a woman dying relative to the live births (WHO, 2005). Other measures of maternal mortality are the maternal mortality rate (MMRate), Adult Lifetime Risk of Maternal Death (WHO, 2005) and the proportion among deaths of females of reproductive age (PMDF) (WHO, 2010), however, these are less frequently used in the literature.

Worldwide, the MMR of different countries varies greatly (WHO, 2010), as can be seen in Table 2.1 below. In developed countries such as Sweden and Australia, the MMR is as low as 5 and 8 deaths per 100,000 live births, respectively. In contrast, the MMR of developing countries such as those of sub-Saharan Africa may be as high as 1,200 deaths per 100,000 live births, for both Chad and Somalia (Alvarez *et al.*, 2009; WHO 2010). It is important to note that these variations may also exist

because different sources were used for the estimations (WHO, 2010). Furthermore, for countries such as Botswana (MMR =190 deaths per 100,000 live births), where there was no appropriate national data on maternal mortality there is a possibility that the figure is an under-estimation. This can be seen by the wide range of uncertainty of 84 to 380 deaths per 100,000 live births (WHO, 2010).

Table 2.1. The MMR of different countries in 2008 (WHO, 2010)

Region	Country	MMR (maternal deaths per 100,000 live births)
Developed	Sweden	5
	Australia	8
	France	8
	United Kingdom (UK)	12
	United States of America (USA)	24
Developing		
Sub- Saharan Africa	Chad	1200
	Tanzania	790
	Angola	610
	Botswana	190
	Malawi	510
	Namibia	180
	South Africa	410
Other	Bangladesh	340
	India	230
	Kuwait	9
	Pakistan	260

According to WHO (2010), overall there has been a decrease in MMR between 1990 and 2008. Of the 172 countries included in the analysis, 85% (147 countries) had decreased their MMR over this period, 13% (23 countries) had increased and 1% (2

countries) had not changed their MMR. They noted that, the countries with the largest percentage increase, of which Botswana had the highest (133%), were in Southern Africa, a region with the world's highest HIV prevalence.

The Central Statistics Office (2011a) has also reported the MMR of Botswana from 2006 to 2010, as summarised in Table 2.2 below.

Table 2.2. MMR for Botswana: 2006-2010 (CSO, 2011a)

Year	MMR (maternal deaths per 100,000 live births)
2006	140
2007	183
2008	196
2009	190
2010	163

The data shows that the MMR increased up to 2008 and then started to decline in 2009. However, it should be noted that, even with this decline it may be difficult to attain the national target of 150 deaths per 100,000 live births by 2011, let alone the MDG target of 82 deaths per 100,000 live births (Government of Botswana and UN, 2010).

2.3. Causes of Maternal Death

Maternal deaths may be due to either direct or indirect obstetric causes. The direct obstetric causes are those which are a result of complications due to being pregnant such as during labour and any events resulting from the pregnancy state, such as interventions or omission of treatment (WHO, 2004b). These include haemorrhage, eclampsia and obstructed labour and sepsis (WHO, 2004a). The indirect obstetric causes on the other hand are those causes that may be due to a pre-existing maternal

condition or one that develops during pregnancy such as hepatitis, cardiovascular disease, malaria and HIV/ AIDS (WHO, 2004a).

The leading causes of death vary worldwide according to region (Khan, Wojdyla, Say, Gümezoglu and Van Look, 2006). In their systematic review of 34 datasets, they reported that in developed countries, the leading cause of death was other direct causes (21.3%), which were mainly complications of anaesthesia and caesarean sections. In Africa and Asia, the leading cause of death was haemorrhage, which accounted for 33.9% and 30.8%, respectively. In Latin America and the Carribbean, hypertensive disorders were the leading cause of death accounting for 20.8% of the deaths.

Similar findings were observed by Ganatra, Coyaji and Rao (1998) Nagaya *et al.*(2000) in their studies in India and Japan, respectively. Both studies reported haemorrhage as the leading cause of death. In India, postpartum (PPH) and antepartum (APH) haemorrhage accounted for 36% of the maternal deaths. In Japan, haemorrhage was the cause of 38% of the maternal deaths.

In Africa, varying results have been reported. Garenne, Mbaye, Bah and Correa (1997) reported haemorrhage (21%) as the second leading cause of death after sepsis (24%) in Senegal. In Kenya, Magadi, Diamond and Madise (2001), reported anaemia as the leading cause of death, followed by PPH. However, if they had combined PPH and APH then haemorrhage would have been found to be the leading cause of death as, APH was ranked fourth. Kazaura, Kidanto and Massawe (2006) reported haemorrhage (23.3%) as the second leading cause of death after eclampsia (23.5%).

In Botswana, the Safe Motherhood Programme (MOH, 2007; 2008) observed similar findings in their Maternal Mortality Reports for 2007 and 2008, as they found haemorrhage to be the leading cause of death in both years, accounting for 25% and 28%, respectively. However, in 2010, CSO (2011a), the leading cause of death was

found to be disease of the respiratory system (11%), followed by protozoal disease (9%) and eclampsia (7%).

2.4. Factors Associated with Maternal Mortality

Several studies have been carried out to determine the factors associated with maternal deaths in countries such as the USA (Panchal, Arria and Labhsetwar, 2001), Japan (Nagaya *et al.*, 2000), India (Ganatra, *et al*., 1998; Aggarwal *et al.*, 2007), Kenya (Magadi *et al*., 2001), Tanzania (MacLeod and Rhode, 1998; Evjen-Olsen *et al.*, 2008), Guinea-Bissau (Høj *et al.*, 2002) and Senegal (Garenne *et al*., 1997).

There are a number of variables that may be considered in the study of factors associated with maternal mortality depending on the setting. Some studies have divided them broadly as maternal and hospital factors (Panchal *et al.*, 2001). Maternal factors included age, race, payment source and marital status, whereas hospital factors were admission type and hospital type. It can be appreciated that in the USA race may play a role as a factor, whereas in a country like Botswana it would not, and so would not be included as a variable. In contrast, in a setting such as the Delhi slums, variables such as type of housing, type of toilet and the place of delivery would be of importance (Aggarwal *et al.*, 2007).

Other studies have even looked specifically at the health services factors, as was the case in Japan (Nagaya *et al.*, 2000), where factors such as pattern of transfer, staffing, facility operating hours and availability of laboratory and diagnostic services were investigated. In their study in Guinea- Bissau, Høj *et al.*, (2002), divided 20 factors into biological, demographic (including, age and parity), environmental (including access to water and toilets), effect of crowding (such as number of women per hut), availability and use of health system (place of delivery and distance to health post) and obstetric factors (such as outcome of last birth). In Tanzania, Evjen-Olsen *et al*., (2008), included factors such as religious affiliations of the husband and the wife and the education level of the husband and wife. In their

ecological study, Alvarez *et al.*, (2009), in addition to health-care system and educational variables, also assessed economic indicators of countries such as public expenditure on health and education and the gross national income per capita.

2.5. Maternal Characteristics Associated with Maternal Mortality

Studies have shown varying risk factors for maternal mortality, in the different settings. Maternal characteristics that have been associated with mortality include race (Panchal *et al.*, 2001), ethnicity (Evjen-Olsen *et al.*, 2008), age (Ganatra *et al.*, 1998; Magadi *et al.*, 2001; Aggarwal *et al.*, 2007), education (Aggarwal *et al.*, 2007; Alvarez *et al.*, 2009), marital status (Garenne *et al.*, 1997), gravidity (Ganatra *et al.*, 1998) or parity (Aggarwal *et al.*, 2007) and receiving antenatal care (Ganatra *et al.*, 1998; Aggarwal *et al.*, 2007).

Race and ethnicity were found to be risk factors for maternal mortality in Maryland (USA) (Panchal *et al.*, 2001) and in Tanzania (Evjen-Olsen *et al.*, 2008), respectively. Panchal *et al.* (2001) observed that the odds ratio for African-Americans and other races which were not African-American or Caucasian were 5.4 and 12.2, respectively. Similarly, in Tanzania, the authors observed that there was a higher odds ratio (OR) for ethnic groups (OR= 13.6) which were not indigenous to the study area (Evjen-Olsen *et al.*, 2008). In contrast, in Guinea Bissau (Høj *et al.*, 2002), although there appeared to be differences among the various ethnic groups, the results were not significant. This observation may indicate that it is the broader socio-economic and environmental context in which the racial/ethnic groups are located that ascribes their increased risk of maternal deaths.

Maternal age was indicated as a risk factor in Japan (Nagaya *et al.*, 2000), India (Ganatra *et al.*, 1998; Aggarwal *et al.*, 2007), Kenya (Magadi *et al.*, 2001) and Tanzania (MacLeod and Rhode, 1998; Evjen-Olsen *et al.*, 2008). In Japan, the risk of maternal mortality increased with maternal age especially for women aged over 35 years. Both studies in India showed that women aged less than 20 years and those

over 30 years were at a higher risk of maternal mortality compared to those between 21 and 29 years of age (Ganatra *et al.*, 1998; Aggarwal *et al.*, 2007). Similar findings were reported in Kenyan hospitals (Magadi *et al.* (2001)) and in Tanzania (MacLeod and Rhode, 1998; Evjen-Olsen *et al.*, 2008). It is important to note that since MacLeod and Rhode's study (1998) was a retrospective follow-up study using verbal autopsy, it was associated with limitations such as recall bias and not having a control group, which would strengthen the reported associations. Furthermore, it may have been associated with measurement bias, as verbal autopsy may result in misclassification and misidentification of maternal deaths (WHO, 2010). In the Maryland study, for the methods, Panchal *et al.* (2001) indicated three age groups, whereas, the age-specific delivery mortality rate was determined for two groups. This is of significance as the delivery mortality ratio was found to be larger in women aged more than 34 years, whereas the multiple logistic regression model showed no association between maternal mortality and age. It is suggested that if the age groups had been kept consistent in both analysis then the results may have been comparable. Maternal age was not a significant risk factor for maternal mortality in Senegal hospitals (Garenne *et al.*, 1997) and Guinea Bissau (Høj *et al.*, 2002).

Length of education of either the mother or partner/husband has also been reported as a risk factor for maternal mortality by several authors. Ganatra *et al.* (1998) showed that in India, when the husband had received less than five years of education the risk for maternal mortality was higher with OR of 2.77 compared to 1.9 for no education and one to five years of education, respectively. Also in India, Aggarwal *et al.* (2007) showed that the wife or the husband being illiterate were both risk factors with OR of 2.16 and 1.91, respectively. Similar findings were also observed in Kenya (Magadi *et al.*, 2001), where it was shown that having a secondary education and above was a protective factor (OR=0.56). In sub-Saharan Africa, Alvarez *et* al., (2009) reported a strong inverse relationship between MMR and education indicators such as adult literacy, contraception prevalence and the education index, with correlation coefficients (r) of -0,516, -0,622 and -0534,

respectively. In Tanzania (Evjen-Olsen *et al.*, 2008), Senegal (Garenne *et al.*, 1997) and Guinea Bissau (Høj *et al.*, 2002) lack of education appeared to be risk factors but the findings were not significant. In Guinea Bissau, this may have been due to the fact that the authors had two groups with either no schooling or schooling for more than one year. This is of significance as other studies have shown that less than five years of education (Ganatra *et al.*, 1998) or primary education are possible risk factors (Magadi *et al.*, 2001). Therefore, this may be why these authors observed no significant difference between the two groups.

Marital status was studied as a risk factor in the USA (Panchal *et al.*, 2001), Kenya (Magadi *et al.*, 2001), Tanzania (MacLeod and Rhode, 1998) and Senegal (Garenne *et al.*, 1997). In Senegal, not being married was found to be a risk factor for maternal mortality (OR= 2.47). In contrast, marital status was found not to be associated with maternal mortality in the other three studies.

Parity and gravidity have also been considered in maternal mortality risk factor studies. Aggarwal *et al.* (2007), observed that in India, women with a parity of one or more than four were more at risk (OR= 1.94) of maternal mortality than women with a parity of two or three. Also in India, Ganatra *et al.* (1998), reported that women with a gravida of one and those with a gravida of more than five were at higher risk of maternal mortality compared to women with a gravida of two. Similar findings were reported in Kenya (Magadi *et al.*, 2001) and Senegal (Garenne *et al.*, 1997). In contrast, in Guinea Bissau (Høj *et al.*, 2002), it was observed that parity was not a risk factor for maternal mortality. MacLeod and Rhode (1998), also included gravidity in their study in Tanzania. They described that the highest proportion of women who died had a gravida of five or more (34%), followed by the women who were primi-gravida (22.4%). However, they were unable to show if a relationship existed.

Evidence from the literature suggests that not receiving antenatal care is a risk factor for maternal mortality. Two studies in India by Ganatra *et al.* (1998) and Aggarwal *et al.* (2007) reported odds ratios of 3.33 and 2.95, respectively. Magadi *et al.* (2001) and Garenne *et al.* (1997), also reported not receiving antenatal care to be a risk factor in Kenya (OR= 2.92) and Senegal (OR= 6.57), respectively.

Other maternal characteristics that have been found to be risk factors for maternal mortality include obstetric factors (Høj *et al.*, 2002; Aggarwal *et al.*, 2007), pre-existing medical conditions (Garenne *et al.*,1997; Ganatra *et al.*,1998) and religious affiliations (Evjen-Olsen *et al.*, 2008).

2.6. Health Facility Characteristics Associated with Maternal Mortality

Health facility factors that have been studied with respect to maternal mortality include, type of facility at which the death occurred (Nagaya *et al.*, 2000; Panchal *et al.*, 2001), being transferred from another health facility (Panchal *et al.*, 2001), distance from the health facility (Høj *et al.*, 2002; Aggarwal *et al.*, 2007) and availability of staff and services (Garenne *et al.*, 1997; Nagaya *et al.*, 2000).

In the USA, Panchal *et al.*(2001) established that being cared for in a minor teaching hospital and being transferred from another health facility were risk factors for mortality with OR of 3.1 and 6.2, respectively. Nagaya *et al.* (2000) grouped health facilities in Japan into transferring, non-transferring and receiving health facilities in order of increasing size. They reported that the preventable maternal death rate was 14 times higher in transferring and approximately 6 times higher in non-transferring than in receiving facilities.

Residing far from the health facility was found to be a risk factor for maternal mortality in Guinea- Bissau (Høj *et al.*, 2002) and India (Aggarwal *et al.*, 2007). In Guinea- Bissau, the authors found that distance from the regional hospital was associated with maternal mortality such that, women who lived 6-25km from the

hospital and those who lived more than 25km were 3 times and 7 times, respectively, more likely to die compared to those who lived within 5km from hospital. Similarly, Aggarwal *et al.* (2007) reported that in India, women who lived 5km or more from the health centre were 7 times more likely to die compared to those who lived within 5km of the health centre. Distance to the health facility may not be a problem in Botswana, as 84% of the population live within a 5km radius of health facility (CSO, 2007a).

Availability of staff and services have also been associated with maternal mortality (Garenne *et al.*, 1997; Nagaya *et al.*, 2000). In Japan, Nagaya *et al.* (2000) attributed the increasing risk of mortality in the different facilities to availability of staff such as obstetricians, aneathesiologists, operating nurses and neonatologists, which decreased in the evenings and on weekends. Their data showed the number of prevenatable deaths, especially due to haemorrhage were higher in facilities with 1 obstetrician compared to those with 2 or more obststreicians. In Senegal (Garenne *et al.* (1997), found failure of medical equipment (OR=54.97) and referral after 24 hours or more after appearance of symptoms (OR= 23.17), to be both associated with maternal mortality. However, they reported that prenatal visits attendance at specialised centres and those performed by qualified personnel were not associated with maternal deaths. In Kenya, Magadi *et al.* (2001), also noted that there was significant variability in maternal mortality between hospitals. They attributed this to factors such as availability of human and financial resources, equipment, supplies and even administration and management of the facility. In Malawi, Kanyighe *et al.* (2008) also found that lack of equipment such as blood and drugs and receiving a blood transfusion after delivery, were both risk factors for maternal mortality, with odds ratios of 74.92 and 38.37, respectively. However, they did not find delay in referral to be a risk factor for maternal mortality.

2.7. Methods Used for Studying Maternal Mortality

The World Health Organisation (2004a) describes a variety of methods that may be used in studying maternal mortality and morbidity with respect to data sources. The type of data depends on the level of study such as community, regional or district. Additionally, it depends on the cases being studied, with respect to outcome and number available to be studied. This is particularly important when considering that maternal deaths are rare in some countries and so it would be more appropriate to study maternal morbidity, in the form of near-misses (Pattinson and Hall, 2003). Another alternative outcome that may be studied is infant outcomes (WHO, 2004a). The guide discusses five different approaches that may be used, three focus on maternal deaths (verbal autopsy, facility-based death reviews and confidential enquiry), one on near misses and one which assesses clinical conditions. Furthermore, the guide discusses the strengths and weaknesses of each approach.

The literature shows that researchers use various methods to study maternal mortality. Most of the researches used the case-control study design which better reveals relationships between exposure and outcome variables. However, studies by Nagaya *et al.*(2000) and MacLeod and Rhode (1997) used the cross-sectional study and retrospective follow-up designs respectively. It is important to note that, as the study design depends on the objectives, it may be strong in achieving some objectives and not others. For example, Nagaya *et al.* (2000), wanted to identify the causes of maternal mortality in Japan, determine the health facility factors associated with maternal mortality and the preventability of the maternal deaths. The cross-sectional study was able to achieve the first objective well but weakly achieved the last two. This is because in their results, they did not report on the analytical component of the cross-sectional study with respect to tests of association. However, they report in terms of preventable maternal deaths and unpreventable deaths without reporting whether the differences are significant or not.

Some authors such as, Nagaya *et al.*(2000) and Magadi *et al.*(2001) used inclusive sampling, whereby all the cases and possible controls were included in the study. Other authors used ratios of control to cases ranging from one (Ganatra *et al.*, 1998) to five (Aggarwal *et al.*, 2007). In their study, Ganatra *et al.*(1998) had two sets of controls, such that, each case was matched with two or more controls with the same biomedical complication and one control who had a normal pregnancy. It was noted that in all the studies, none of the authors indicated the reasons for the ratio used. This is despite the fact that, the precision increases up to a ratio of four as described by Ury (1975, cited by Wacholder, McLaughlin, Silverman and Mandel, 1992a).

2.8. Policies/ Interventions to Reduce Maternal Mortality

Due to the public health significance of maternal mortality, different countries have developed policies and interventions to reduce it. There have also been international initiatives such as the United Nations (UN) Millennium Development Goals of 2000 in New York (UN, 2000), the African Union (AU) Campaign on Reduction of Maternal Mortality in Africa (CARMMA), which was launched in May 2009 (African Union, Undated) and the Safe Motherhood Programme (World Bank, WHO and UNFPA) of 1987 in Nairobi (Family Care International, 2007).

The 2000 Declaration contains eight development goals of which, according to Millennium Development Goal 5 countries resolved to improve maternal health by reducing the maternal mortality by 75% by 2015 (UN, 2000). According to WHO (2010) a number of countries are on track to achieve this. Botswana, however, may not be able to do so due to the high HIV prevalence (Government of Botswana and UN, 2010). This is despite the fact of having a well functioning health system and having several interventions in place to promote maternal health such as The National Road Map for Accelerating the Reduction of Maternal and Newborn Mortality and Morbidity in Botswana and the National Sexual and Reproductive Health Programme Framework (Government of Botswana and UN, 2010). The latter being the guide for the implementation of the Safe Motherhood Programme.

CARMMA aims to reduce maternal and newborn mortality, mainly through dialogue, advocacy and community mobilization (UNFPA, 2011; AU, Undated). Through this strategy it will be able to mobilize political commitment and resources that will support and promote successful activities to be replicated in the region. The authors also describe the launch of CARMMA in the 29 countries that had taken place by March 2011, including Botswana. Furthermore, it highlights some notable post launch activities. It is worth noting that the involvement of several international and national stakeholders such as UN agencies, non-governmental organisations and civil society will ensure the success of this regional effort.

WHO (1994) and several partners have developed comprehensive guidelines, the Mother Baby Package, that can assist and guide countries to develop national Safe Motherhood Programmes. Fortney (2007) comments on some lessons and accomplishments made through the Safe Motherhood Initiative. The author discusses general interventions and also briefly describes country-specific interventions such as those in Uganda and Nigeria. In Botswana, there is a Safe Motherhood Programme in the Ministry of Health. The programme's interventions include screening for high risks, monitoring pregnancies, provision of supplementary food, supervision of deliveries and provision of family planning services and products (Government of Botswana and UN, 2010). Additionally, a Maternal Mortality Monitoring System (MMMS) was developed in 1998 and reviewed in 2002 and 2006, through workshops with stakeholders (Ministry of Health, 2006). The MMMS has data available from 2007 on the characteristics of mothers who died. Yet, there has been no systematic investigation of this data-set to understand the specific risk factors of reported maternal deaths in Botswana.

3.0 CHAPTER THREE: METHODOLOGY

This chapter provides the aims and objectives of the study. It also describes the study designs and why it was selected. Furthermore, it defines the study population, outlines the sampling procedures and presents how the data was collected and analysed. The chapter ends by discussing the rigour of the study and the ethical considerations.

3.1. Aim and Objectives

3.1.1. Aim

To identify the maternal and health-services factors associated with maternal mortality as reported in the Maternal Mortality Monitoring System (MMMS) for the South East district of Botswana.

3.1.2. Objectives

1. To describe the profile (number, causes, location and age distribution) of maternal deaths reported in the MMMS for South East Botswana
2. To determine the maternal factors associated with reported maternal deaths in the South East Botswana
3. To determine the health service related factors associated with reported maternal deaths in the South East district of Botswana

3.2. Study Design

This is a quantitative case-control study using retrospective review of medical records. This design was able to accomplish the above objectives as it was able to address both the descriptive (objectives 1) and analytical (objectives 2 and 3) components of the study. This is of importance because case-control designs are able to assess associations between different factors and a single outcome. Furthermore, they provide stronger evidence than cross-sectional studies in determining relationships (Morroni and Meyer, 2007). For purposes of this study, a quantitative approach is more suitable than a qualitative one. A quantitative study has the advantage because it was able to achieve all the objectives of this study through the methods that were followed.

3.3. Study Population and Sampling

The study population was all maternal deaths reported and recorded in the MMMS of the Safe Motherhood Programme for South East Botswana between 2007 and 2009.

The sample comprised of cases and controls. The Safe Motherhood Programme requested that the records be taken from the respective health facilities. It was established that all the maternal deaths that had occurred in South East between 2007 and 2009 had taken place at either Princess Marina Hospital in Gaborone or at the Bamalete Lutheran Hospital in Ramotswa. Therefore, all the cases which were found at these health facilities were included in the study. The controls were women who delivered during the same time period and were alive 42 days after delivery in the same health facility as the case. Bonita, Beaglehole and Kjellstrom (2006) and Ury (1975, as cited by Wacholder, McLaughlin, Silverman and Mandel, 1992a) suggest the use of a control to case ratio of four. The latter argue that "there is little marginal increase in precision from increasing the ratio of controls to cases beyond four" (Ury (1975, as cited by Wacholder *et al.*, 1992a: 1044)). Wacholder *et al.* (1992a) propose instead to increase precision by increasing the number of cases. For these reasons all the cases were included in the study and for each case there were four controls selected who delivered at the same health facility, within the same year.

The controls were selected using systematic random sampling of all the women who delivered in the same health facility during the same year. The sampling frame was the delivery register at the health facilities excluding maternal deaths. Consequently, the sample comprised of 72 cases and 288 controls, resulting in a total sample size of 360. However, records and information about one of the cases and four controls could not be established. Therefore, the final sample size was 71 cases and 284 controls, with a total sample size of 355.

3.4. Data Collection

Data collection was carried out by the researcher. Data for the cases and controls were collected by reviewing medical records from the health facilities. For each case, there was a copy of the Botswana Obstetric Record and a Maternal Death Notification Form kept either with the Safe Motherhood Programme Focal Person at the health facility or at the Medical Records Department (after copies had been sent to the Safe Motherhood Programme). Data for the controls were also taken from the obstetric record which was kept at each health facility after the women delivered.
The delivery register was used to establish the file number of each control. For the cases, whose records were not with the Focal Person, the file number was also established. The file number was then used to retrieve the records form the Medical Records Department.

The medical records were used to complete a data abstraction schedule (Appendix 1) for each of the cases and for the controls, a data abstraction schedule similar to that of the cases, with the exception of entries for place and cause of death (Appendix 2) was used. The data abstraction schedule was divided into three sections. The first section collected information about the maternal characteristics such as age, parity and type of delivery. The second section collected information about the health facility characteristics such as type of health facility and ANC provider. The third section was present on the schedule for the cases and not the controls, as it collected information about the maternal death.

3.5. Data Analysis

3.5.1. Data Checking

All records were checked for accuracy and completeness at the end of each day. This ensured that corrections were made as early as possible and before data collection was completed. If the data was missing on the medical record or the medical record was missing, for cases, the Focal Person was contacted and an attempt was made to find out the information. For controls, the information was taken from the delivery register. If the effort proved futile then the data was recorded as missing and the

variable was excluded from the analysis. Additionally, the proportion of missing data is discussed in the final report. The issue of missing data is worth noting because it is associated with the use of medical records as the information is usually not collected for research purposes (Katzenellenbogen and Joubert, 2007).

3.5.2. Data Preparation

Data preparation involved coding, entering and cleaning the data. The data was separated into cases and controls in preparation for processing. The data was then coded according to the pre-determined codes as most of the variables are categorical, except for age which was collected as a numerical variable. Age was entered as a numerical value in order to determine the measures of central tendency for the sample. Consequently, it was categorized according to the age groups of interest with respect to maternal mortality based on the literature. The data was entered into Predictive Analysis Software (PASW) (version 18).

After entering the data, a quality control check was done as suggested by Durrheim (2006). Ten percent of the data abstraction schedules were randomly selected, proportionally from the cases and controls, using systematic random sampling. These were re-entered and if they had errors, all the data would have been re-entered. Since they had no errors, all the variables were checked individually, for incorrect codes by producing frequency tables of each variable. When incorrect codes were found, they were corrected by going back to the data abstraction schedule.

3.5.3. Data Analysis

The data was analysed using Predictive Analysis Software (PASW) Version 18 (Simon, 2008; University of Reading, 2011). Univariate analysis of each variable was carried out to produce the descriptive statistics. One way frequency tables were used to provide a summary of each of the variables for the cases and controls, including the proportion of missing data. In order to test the difference between the proportions of the various categories of variables in cases and controls, a two-sample

t test was used for the continous variables and Pearson's Chi-square test and F exact test for the categorical variables, and any p-value less than 0.05 was considered significant.

One way frequency tables were also used to determine the leading causes of maternal death in 2007, 2008 and 2009. In order to establish which maternal and health facility characteristics were associated with maternal mortality, univariate logistic regression analysis was carried out. The odds ratio (OR) and 95% confidence limits were estimated for each variable. Missing and unknown data were excluded from this analysis. A variable was considered a risk factor if the odds ratio was greater than 1 and the Chi test p-value was less than 0.05, indicating that the odds ratio is statistically significant at 95 % confidence interval (CI).

Multiple logistic regression analysis was then carried out on the variables which were significant at 95% confidence interval to determine the contribution each made towards maternal mortality by establishing their partial regression coefficients. Once the coefficients had been determined they were used to construct a multiple logistic regression model. The model was tested using the Hosmer and Lemeshow goodness of fit test.

3.6. Validity

Several authors such as Wacholder *et al.* (1992 a, b & c), Bonita *et al.* (2006) and Morroni and Myer (2007) discuss the threats to validity and reliability associated with case- control studies. These are mainly selection bias, measurement bias, confounding, sampling error and measurement error. Selection bias was reduced by developing clearly defined selection criteria of cases and controls for the study. Additionally, the controls were randomly selected into the study from the same time period as the cases (Wacholder *et al.*, 1992b). Measurement bias was addressed with respect to recall bias and information bias. Recall bias was minimised by using the medical records of both the cases and controls, which were at the health facility. The

use of records ensured that the subjects were not required to recall the information as it had been recorded in real-time in the medical record. Information bias was reduced by collecting the information in the same manner for the cases and the controls using a similar data abstraction schedule (Appendices 1 and 2). The difference between the schedules was that the one for the cases has an additional section which collected information relating to death such as the cause of death. A pilot study was not conducted as the data abstraction schedule was developed using the medical records (Botswana Obstetric Record and a Maternal Death Notification Form). Confounding was reduced by matching the cases and controls with respect to the year of maternal death and year of delivery. Sampling error is usually addressed by increasing the sample size (Bonita *et al.*, 2006). To achieve this, all the cases were included in the study and a control to case ratio of four was used as suggested by Bonita *et al.*, (2006). Measurement error was reduced by the quality control that was carried out during data collection and data analysis.

3.7. Ethical Considerations

Permission to conduct the research was obtained from the UWC Research and Ethics Committees (Appendix 3) and the Health Research Unit of the Botswana Ministry of Health (Appendix 4). Permission to review the medical records was obtained from the Hospital Superintendents of the two facilities (Appendices 5 and 6). At Princess Marina Hospital, this was done by an Institutional Review Board (Appendix 5). Additionally, permission to review reports from the Safe Motherhood Programme was obtained from the Chief Health Officer for the Sexual and Reproductive Health Department of the Ministry of Health.

Furthermore, confidentiality of the information was ensured by assigning a study identification number to each medical record, instead of using names. The names and the study identification numbers were only on the master study identification sheet, which is password protected and only accessible to the researcher and supervisor.

The data abstraction schedules are also protected by keeping them in a locked cabinet, which is accessible only to the researcher.

4.0 CHAPTER FOUR: RESULTS

The chapter presents results for the reviewed records of the 355 subjects in the study. It describes the study sample and the maternal (demographic and obstetric) and health facility characteristics of the subjects. Additionally, the causes of maternal death and the factors associated with maternal mortality are presented. It concludes by presenting the multiple logistic regression model developed.

4.1. Description of the Study Sample

A total of 72 cases were identified for the study and were matched to 288 controls from the same health facility and year of death, yielding a total study sample size of 360. Table 4.1 below, describes the total number of cases and controls, with respect to the year in which death occurred and the health facilities from which they were identified. Princess Marina Hospital (PMH) experienced more maternal deaths than Bamalete Lutheran Hospital (BLH). The former, had 68 maternal deaths, transalating into an MMR of 409 maternal deaths per 100,000 livebirths (95%CI 312-507/100,000) between 2007 and 2009 compared to four, translating into an MMR of 173 maternal deaths per 100,000 livebirths (95% CI 3-343/100,000) at BLH during the same time period. However, records and information about one of the cases and four controls could not be established. Therefore, the final sample size used in analysis was 355 comprising 71 cases and 284 controls.

Table 4.1. Distribution of cases and controls according to year and health facility in South East from 2007 to 2009

Group	Year	Facility		Total
		PMH	BLH	
Cases	**2007**	25 (36.8)	1 (33.3)	26 (36.6)
	2008	19 (27.9)	2 (66.7)	21 (29.6)
	2009	24 (35.3)	0	24 (33.8)
Total		68	3	71
Controls				
	2007	98 (36.6)	4 (25.0)	102 (35.9)
	2008	75 (28.0)	12 (75.0)	87 (30.6)
	2009	95 (35.4)	0	95 (33.5)
Total		268 (94.4)	16 (5.6)	284

The health facility maternal mortality ratios, with respect to year, are presented in Table 4.2, below. At PMH, there were more deaths in 2007 (MMR= 571 maternal deaths per 100,000 live births, 95% CI 347-795/100,000), followed by 2009 (MMR= 372 maternal deaths per 100,000 live births, 95% CI 223-521/100,000) and the least number of deaths were in 2008 (MMR= 327 maternal deaths per 100,000 live births, 95% CI 180-475/100,000). At BLH, the most number of maternal deaths were observed in 2008 (MMR= 209 maternal deaths per 100,000 live births, 95% CI -27-445/100,000), followed by 2007 (MMR= 115 maternal deaths per 100,000 live births, 95% CI -110-340/100,000) and there were no maternal deaths in 2009.

Table 4.2. Health facility maternal mortality ratios according to year in South East from 2007 to 2009

Year	PMH			BLH		
	MMR	95% CI		MMR	95% CI	
		Lower limit	Upper Limit		Lower Limit	Upper Limit
2007	571	347	795	115	-110	340
2008	327	180	475	209	-27	445
2009	372	223	521	0	NA	NA
Total	409	312	507	173	3	343

Overall, there was a large amount of missing data for both the cases and controls, which has been included in Tables 4.3, 4.4 and 4.5 for each variable. There was more missing data for the cases than the controls. For the cases, this ranged from 2.8% for age to 62.0% for admissions during pregnancy. For the controls, this ranged from 1.1% for age to 32.0% for employment status.

4.2. Maternal Characteristics

The maternal characteristics have been presented as the demographic and obstetric characteristics of the cases and controls.

4.2.1. Demographic Characteristics

The maternal demographic characteristics analysed were age, education status, employment status and marital status. They are presented in Table 4.3 and Figures 4.1 to 4.4, below. With the exception of age and age less than 20 years, all the demographic characteristics were found not to be statistically different between the cases and controls.

Table 4.3. Demographic characteristics of the maternal deaths (cases) and the controls and t-test and chi-square test (p< 0.05) comparing their proportions in South East from 2007 to 2009

Characteristics	Cases (%) n=71	Controls (%) n=284	p-value
Age group (years)	n[a]=69	n=281	
Range	17- 43	16-48	-
Mean ± SD	28.0 ± 5.3	26.3 ± 5.8	0.031[b]
< 20	2 (2.9)	31 (11.0)	0.038
20- 35	61 (88.4)	228 (81.1)	0.154
>35	6 (8.7)	22 (7.8)	0.812
Missing	2 (2.8)	3 (1.1)	
Education	n=30	n=194	
None	1 (3.3)	0	0.200[c]
Primary	4 (13.3)	17 (8.8)	0.496[c]
Secondary	22 (73.3)	150 (77.3)	0.630
Tertiary	3 (10.0)	27 (13.9)	0.775[c]
Missing	30 (42.3)	90 (31.7)	
Employment status	n=34	n=193	
Employed	12 (35.3)	85 (44.0)	0.342
Unemployed	22 (64.7)	108 (56.0)	
Missing	37 (52.1)	91 (32.0)	
Marital status	n=36	n=202	
Single	29 (80.6)	167 (82.7)	0.759
Married	6 (16.7)	35 (17.3)	0.923
Divorced	1 (2.8)	0	0.151[c]
Missing	35 (49.3)	82 (28.9)	

[a] Sample size without the missing values

[b] t-test

[c] Fisher's exact test

For the cases, the age ranged from 17 years to 43 years, whereas for the controls it ranged from 16 years to 48 years. The mean age for the cases was higher than that of the controls, for the cases it was 28.0 ± 5.3 years and that for the controls was 26.3 ± 5.8 and this difference was found to be statistically significant (p= 0.031). Age was divided into three categories, less than 20 years, 20- 35 years and above 35 years and the groups were compared (Figure 4.1).

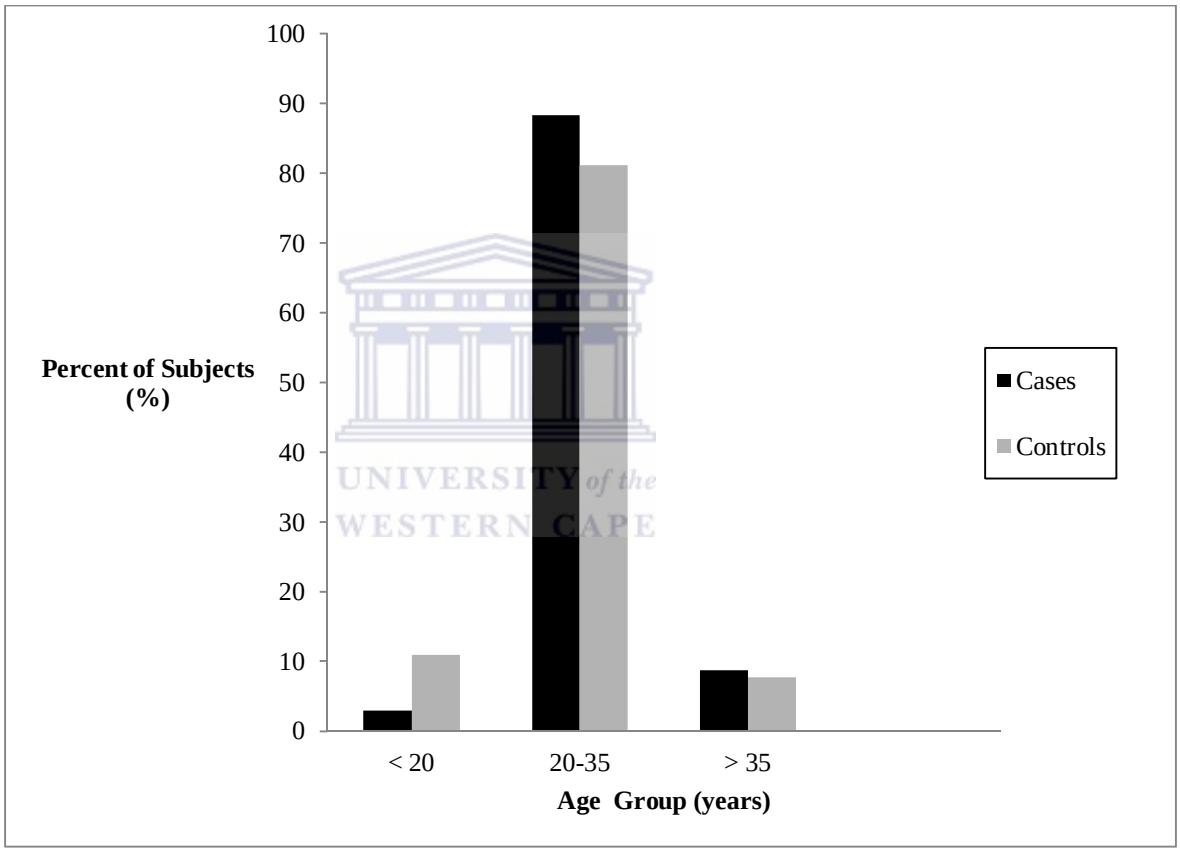


Figure 4.1. Age groups of cases and controls

For the cases, the modal age group was 20-35 years (88.4%), followed by above 35 (8.7%) and less than 20 had the least number of cases (2.9%). For the controls, the group with the most subjects was also 20-35 years (81.1%), followed by less than 20 (11.0%) and the group with the least number of subjects was the over 35 years (7.8%). When the cases and controls were compared, there were more controls

(11.0%) than cases (2.9%) in the less than 20 years, and this difference was found to be statistically significant (p= 0.038). Conversely, there were more cases than controls for the other two age groups. For the 20- 35 years group, there were 88.4% cases, compared with 81.1% controls and for the more than 35 years group, cases were 8.7%, compared to 7.8% for controls. However, both these differences were not found to be statistically significant.

In the entire sample, there was only one subject who had not received any education and the subject belonged to the cases (Figure 4.2). In both the cases and the controls, the highest number of subjects had received secondary education, accounting for 73.3% and 77.3%, respectively. This was followed by tertiary education (13.9%) for the controls and primary education (13.3%) for the cases. For the cases, tertiary education (10.0%) was third and the category with the least number of subjects was those who had not received any education (3.3%). For the controls, the third category was primary education (8.8%) and none of the controls had no education. For this reason, for further analysis the no education and primary education categories were combined.

There were more cases than controls who had received primary education (13.3% compared to 8.8%) and no education (3.3% compared to 0%). Conversely, there were more controls who had received secondary (77.3%) and tertiary (13.9%) education as compared to cases (73.3% and 10.0%, respectively). However, these differences were not found to be statistically significant.

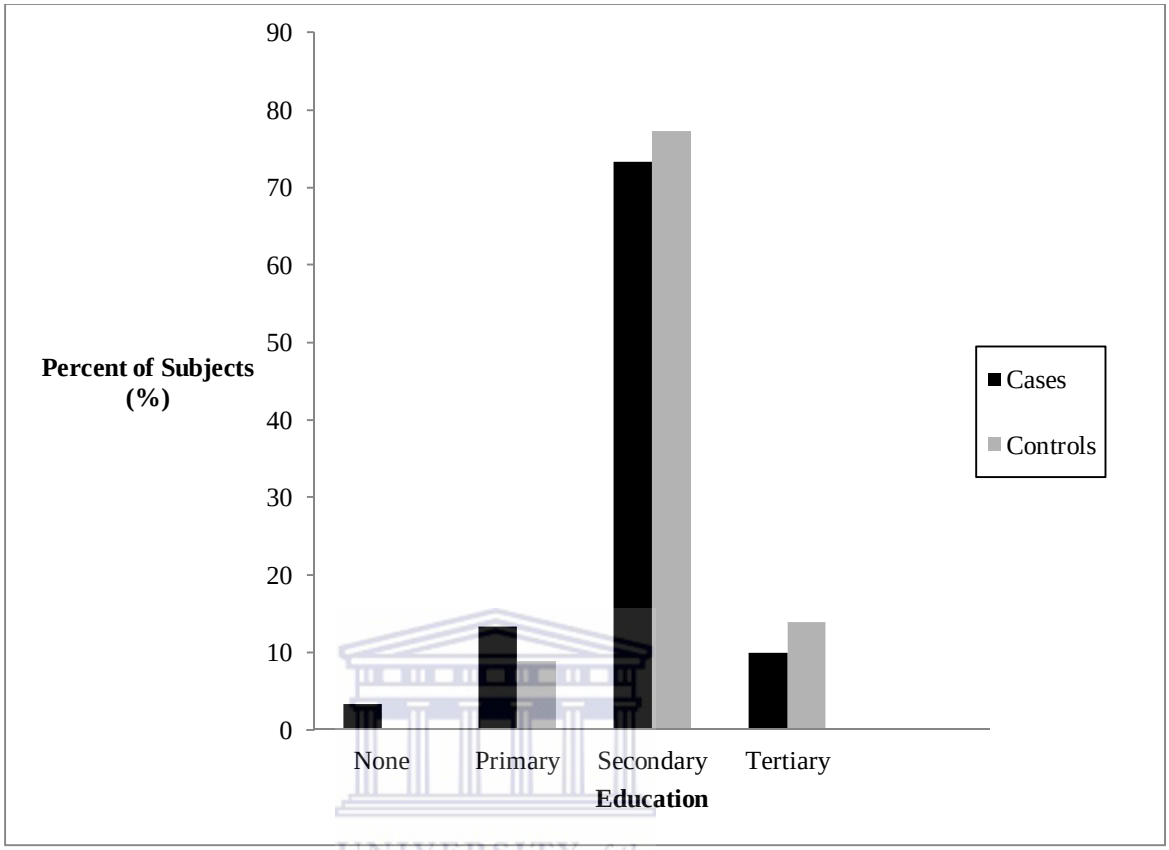


Figure 4.2. Education received by the cases and controls

Figure 4.3 shows that, there were more controls than cases who were employed (44.0% compared to 35.3%). However, there were more cases than controls who were unemployed (64.7% compared to 56.0%). The differences between the cases and the controls were not found to be statistically significant ($p > 0.05$).

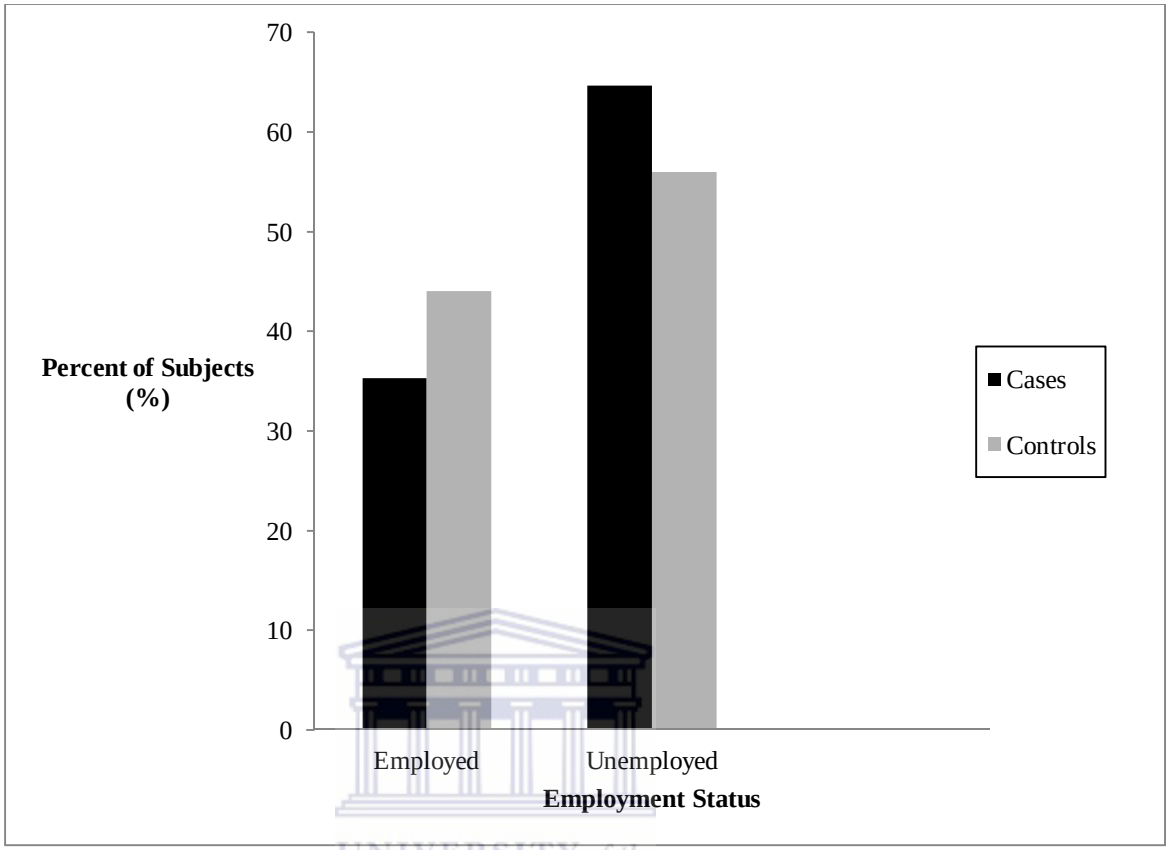


Figure 4.3. Employment status of cases and controls

Additionally, for both cases and controls there were more unemployed subjects than employed subjects. For the cases the unemployed were 64.7% compared to 35.3% employed, which is approximately double. For the controls, the unemployed were 56.0% compared to 44.0% who were employed.

Of the four categories included for marital status, only three had subjects who fell into them and these were single, married and divorced (Figure 4.4). Even for divorced, there was only one case who fell into this group. The other category widowed did not have any of the subjects fall into them. Therefore, for further analysis the divorced was combined with married.

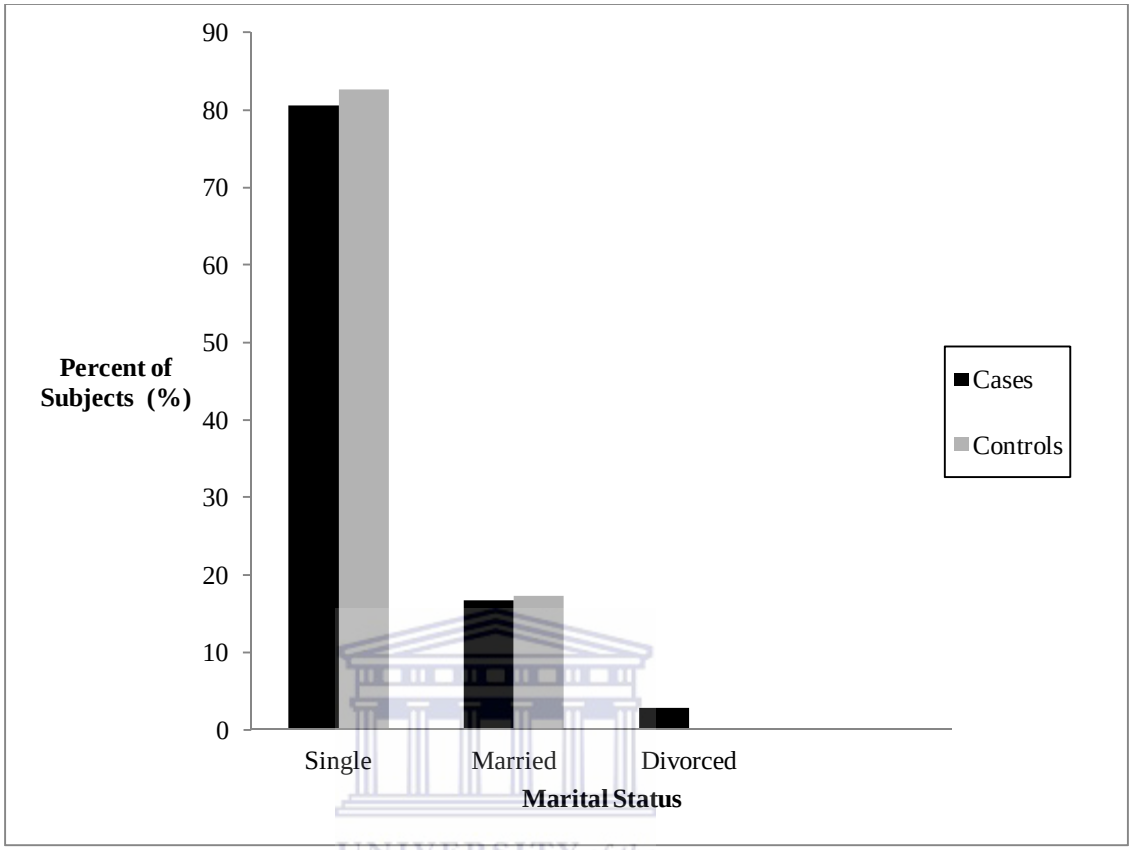


Figure 4.4. Marital status of cases and controls

Among both the cases and the controls, most of the subjects were single accounting for 80.6% and 82.7%, respectively. For the cases, this was followed by married (16.7%) and divorced (2.8%) and for the controls, the other subjects were married (17.3%). For both categories single and married, there were more controls than cases, but this difference was not statistically significant.

4.2.2. Obstetric Characteristics

Data collected for the maternal obstetric characteristics were parity, hospital admissions during pregnancy, ANC attendance, complications at hospital admission and type of delivery. Furthermore, the following complications were also analysed individually as they were found to be the most common in this study: HIV, elevated

blood pressure (including eclampsia), abortion, anaemia, preterm labour and haemorrhage. The obstetric characteristics for the cases and controls are presented in Table 4.4 and by Figures 4.5 to 4.10, below.

Table 4.4. Obstetric characteristics of the maternal deaths (cases) and the controls and chi-square test (p< 0.05) comparing their proportions in South East from 2007 to 2009

Characteristics	Cases (%) n=71	Controls (%) n= 284	p-value
Parity	n[a]=30	n=194	
0	16 (26.7)	114 (40.7)	0.042
1	35 (58.3)	133 (47.5)	0.128
2- 4	6 (10.8)	27 (9.6)	0.932
5 or more	3 (5.0)	6 (2.1)	0.200[b]
Missing	11 (15.5)	4 (1.4)	
Admissions during pregnancy	n=27	n=202	
Admitted	5 (18.5)	28 (13.9)	0.518
No Admissions	22 (81.5)	174 (86.1)	
Missing	44 (62.0)	82 (28.9)	
ANC attendance	n=36	n=277	
Attended ANC	27 (75.0)	265 (95.7)	0.000
No ANC Attendance	9 (25.0)	12 (4.3)	
Missing	35 (49.3)	7 (2.5)	
Complications at admission	n=52	n=277	
No Complications	4 (7.7)	176 (63.5)	0.000
At least one complication[c]	48 (92.3)	101 (36.5)	
Missing	19 (26.8)	7 (2.5)	
HIV Status	n=52	n=277	
HIV Positive	25 (48.1)	75 (27.1)	0.003
HIV Negative	27 (51.9)	202 (72.9)	
Missing	19 (26.8)	7 (2.5)	
Elevated BP	n=52	n=277	
BP Elevated	7 (13.5)	15 (5.4)	0.033
BP Not Elevated	45 (86.5)	262 (94.6)	
Missing	19 (26.8)	7 (2.5)	
Abortion	n=52	n=277	

Abortion	14 (26.9)	0	0.000[b]
No Abortion	38 (73.1)	277(100)	
Missing	19 (26.8)	7 (2.5)	
Anaemia	n=52	n=277	
Anaemia	4 (7.7)	3(1.1)	0.002
No Anaemia	48(92.3)	274(98.9)	
Missing	19 (26.8)	7 (2.5)	
Preterm labour	n=52	n=277	
Preterm labour	5(9.6)	3(1.1)	0.000
No Preterm labour	47(90.4)	274(98.9)	
Missing	19 (26.8)	7 (2.5)	
Haemorrhage	n=52	n=277	
Haemorrhage	4 (7.7)	2(0.7)	0.001
No Haemorrhage	48 (92.3)	275(99.3)	
Missing	19 (26.8)	7 (2.5)	
Type of Delivery	n=61	n=279	
Normal	15 (24.6)	223 (79.9)	0.000
Caesarean	10 (16.4)	56 (20.1)	0.511
No Delivery	36 (59.0)	NA	
Missing	10 (14.1)	5 (1.8)	

[a] Sample size without the missing values

b Fisher's exact test

[c] This would be any of the complications – the six in this table and the other ones below. Other complications were bacterial meningitis, burns, breathlessness, chest pain, headache, dizziness, Karposi's Sarcoma, polyhydramniosis in twin pregnancy, home delivery, pueral sepsis, pulmonary TB, thrombocytis, cardiac disease, twin pregnancy, cephalopelvic disproportion, draining clear liquor, foetal distress, high protein, high temperature, placenta abruption, prolonged labour and reduced outlet.

It can be seen from Figure 4.5, below, that among both the cases and controls, the most common parity was one, accounting for 58.3% and 47.5%, respectively. This was followed by a parity of zero, which was 26.7% among the cases and 40.7% for the controls. The next common parity was that of two to four, and it was 10.8% and 9.6% among the cases and controls, respectively. The parity of five or more was the least common among both the cases (5.0%) and the controls (2.1%).

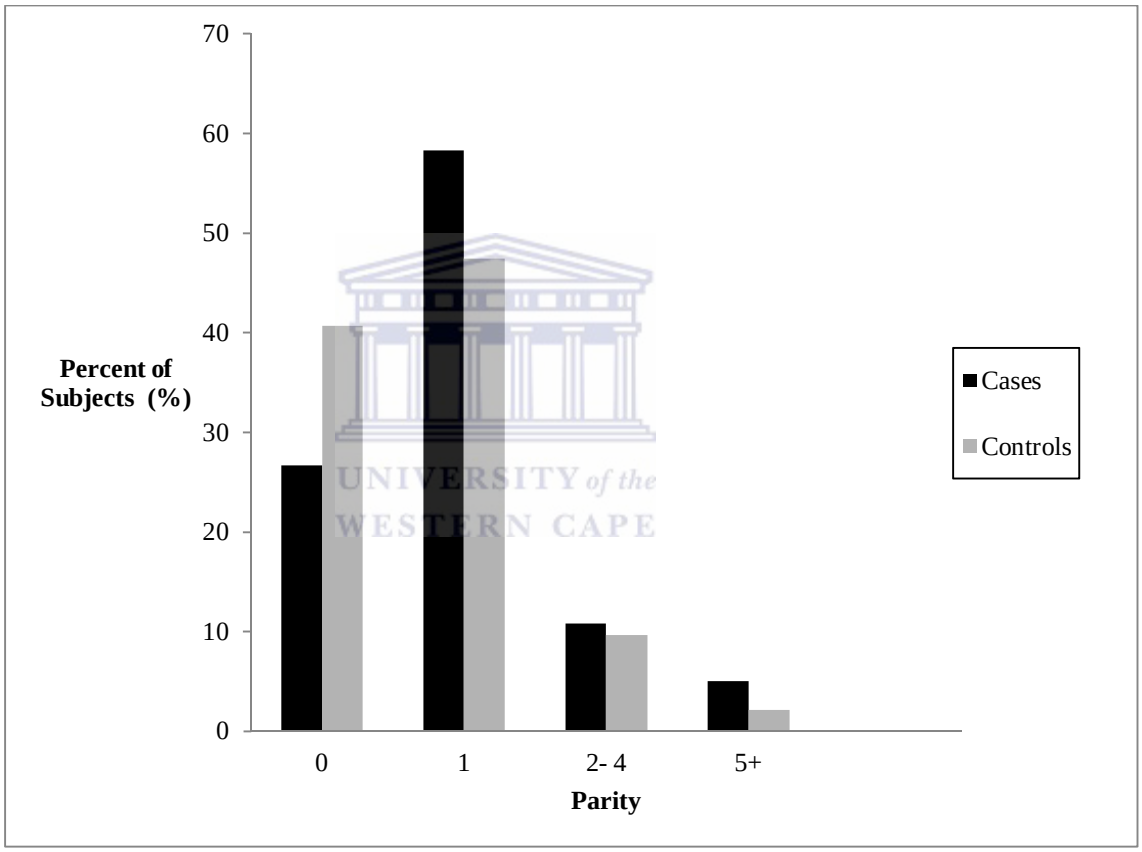


Figure 4.5. Parity of the cases and controls

When the two groups were compared, there were more controls (40.7%) than cases (26.7%) with a parity of zero, and this difference was found to be statistically significant (p=0.042). Similarly, there were more controls as compared to cases among the category with parity of two to four. Conversely, there were more cases

than controls in both the categories with parity of one and those with a parity of more than five. However, these differences were found not to be statistically significant.

It was also established whether the cases and controls had been admitted in hospital during the pregnancy and the data is presented in Figure 4.6, below.

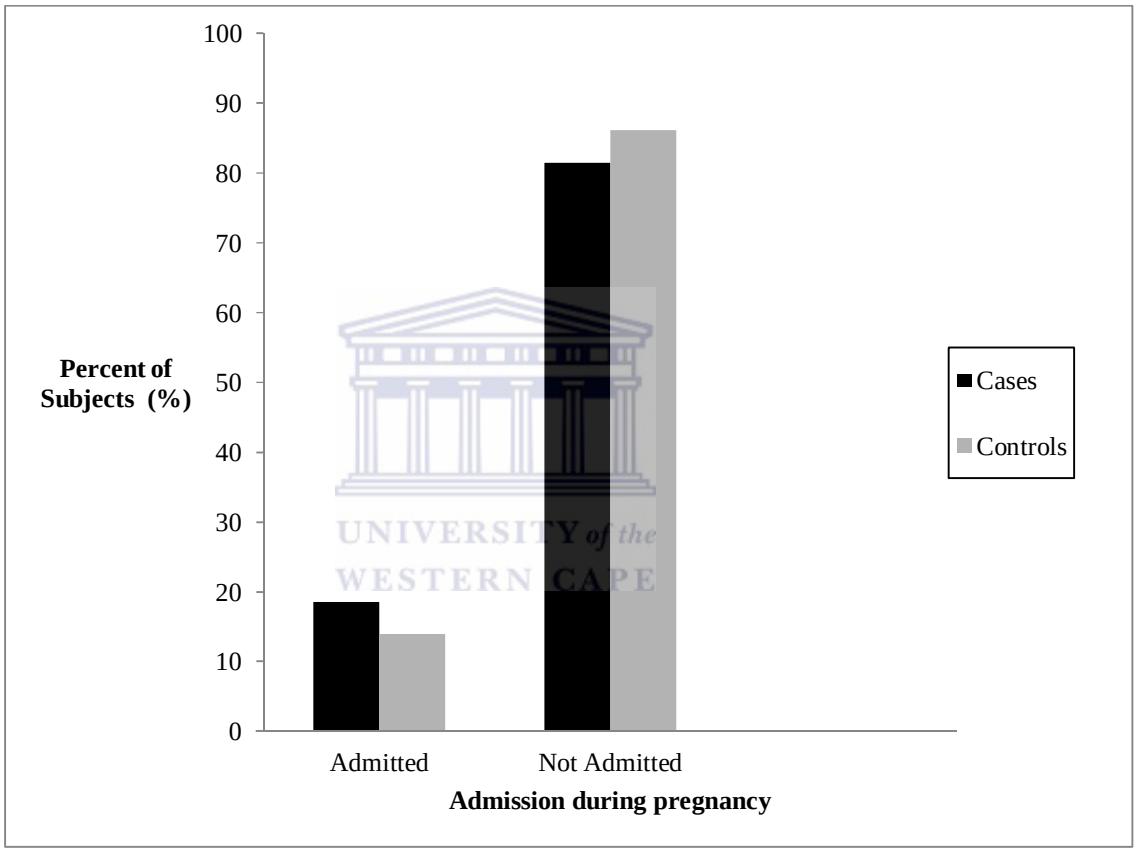


Figure 4.6. Admission during pregnancy of the cases and controls

Only 18.5% of the cases had been admitted to hospital during pregnancy compared to 81.5% that had not been admitted. For the controls, similar findings were observed, whereby 13.9% had been admitted compared to 86.1% that had not been admitted. For those who had been admitted, there were more cases than controls and the reverse was observed for those who had not been admitted. However, these differences were not statistically significant.

The results for ANC attendance (Figure 4.7), were the reverse of those for admission during pregnancy as among both the cases and the controls, there were more subjects who attended ANC (75.0% and 95.7%, respectively) when compared to those who did not attend ANC (25.0% and 4.3%, respectively).

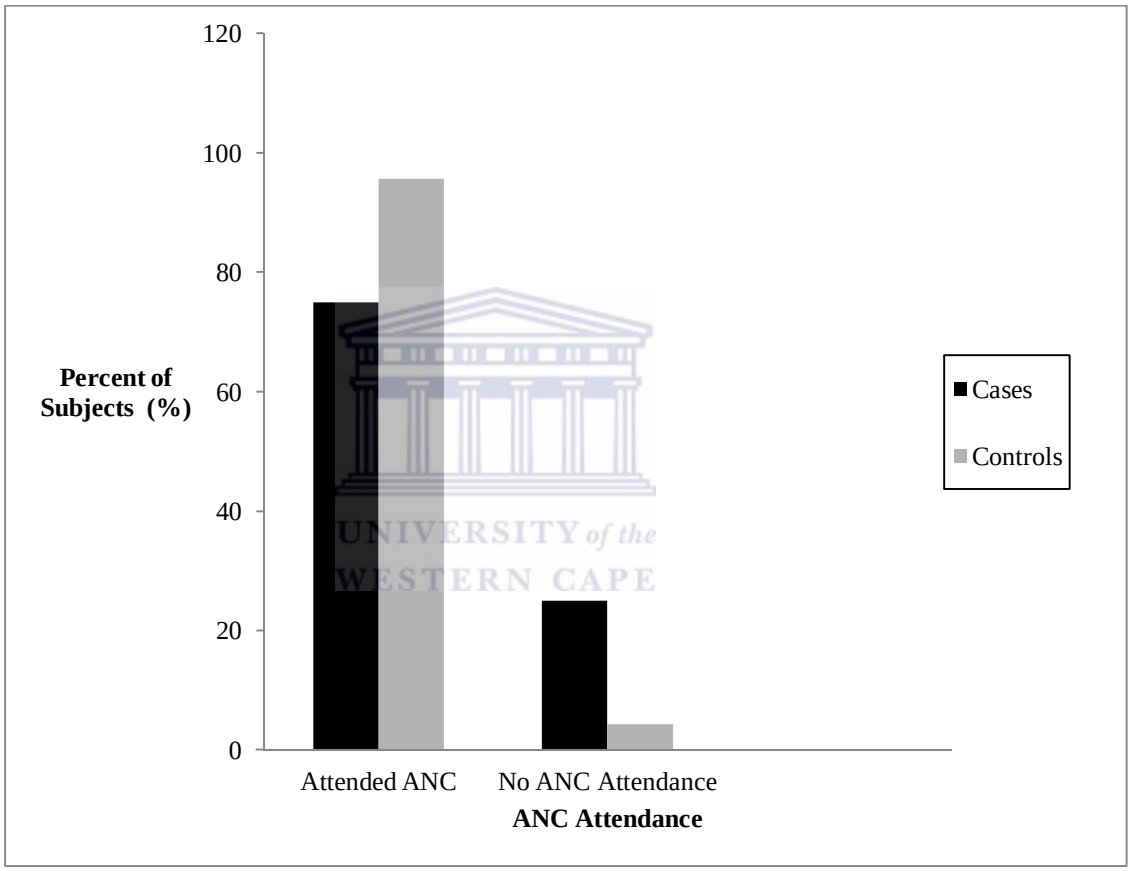


Figure 4.7. ANC attendance by the cases and controls

It can also be seen that, for those who attended ANC, there were more controls than cases and, for those who did not attend, there were more cases than controls. These differences were found to be statistically significant (p=0.000).

A wide range of complications were reported, and only six were individually analysed, as they were found to be significant in the literature, and in terms of frequency in this study. The other complications were analysed as at least one complication, as shown in Figure 4.8.

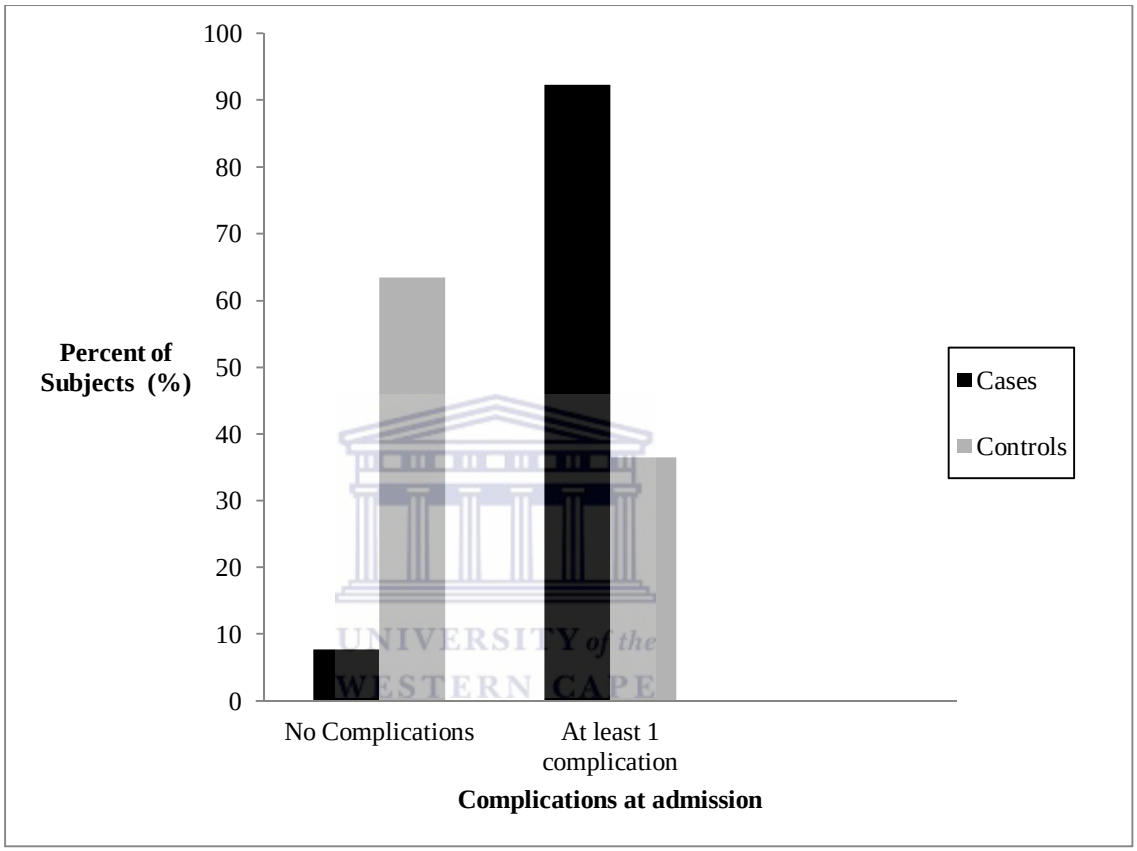


Figure 4.8. Complications at admission among the cases and controls

It can be seen that among the cases, there were more who had at least one complication (92.3%) as compared with 7.7% who had no complications at admission. The reverse was observed for controls, as more of them had no complication (63.5%) compared to 36.5% who were admitted with at least one complication. Additionally, more cases than controls were admitted with at least one complication. The reverse was also observed in that, there were more controls than cases who had no complications at admission. These differences were found to be statistically significant (p=0.000).

The complications which were analysed individually were HIV, elevated blood pressure (including eclampsia), abortion, anaemia, preterm labour and haemorrhage. This data is presented in Figure 4.9. Among the cases, the most common complication was HIV (48.1%), followed by abortion (26.9%), elevated BP (13.5%), premature labour (9.6%) and the least common were anaemia (7.7%) and haemorrhage (7.7%). Among the controls, the most common complication was HIV (27.1%), followed by elevated BP (5.4%), anaemia (1.1%), preterm labour (1.1%), haemorrhage (0.7%) and abortion (0%) was the least common.

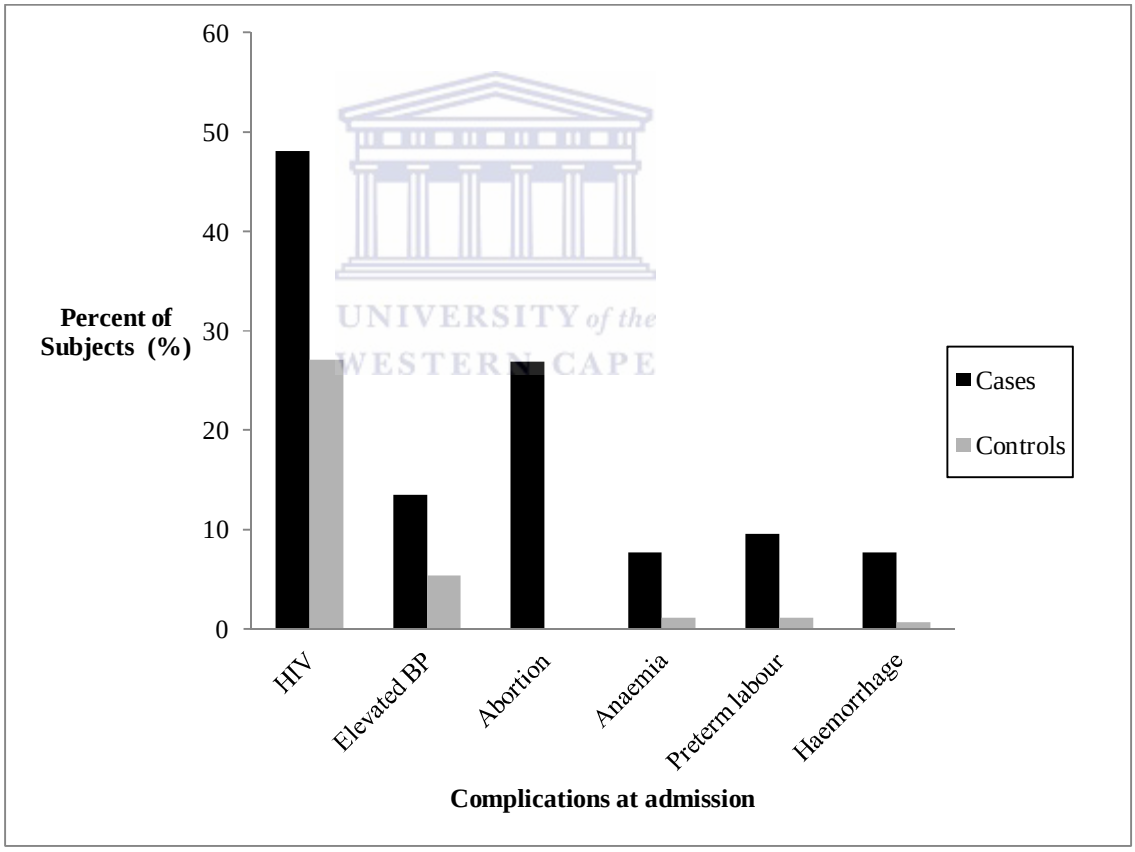


Figure 4.9. Specific complications among the cases and controls

It can also be seen that for all the complications, there were more cases than controls. These differences were all statistically significant, HIV (p= 0.003), elevated BP

(p=0.033), abortion (p= 0.000), anaemia (p=0.002), preterm labour (p= 0.000) and haemorrhage (p= 0.001).

The types of delivery were broadly categorized into normal delivery and caesarean section. For the cases, there was an additional category of no delivery as some of the maternal deaths took place before delivery occurred. This data for the cases and controls is shown in Figure 4.10.

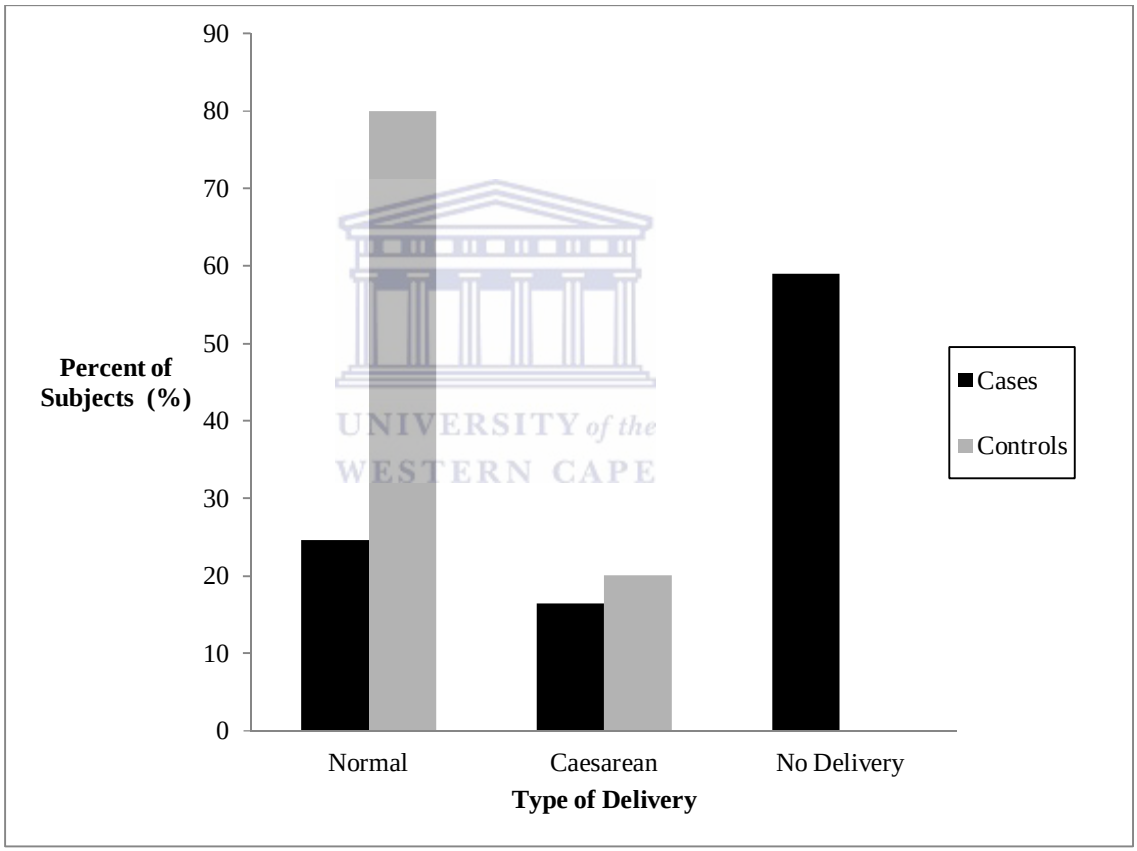


Figure 4.10. Type of delivery for cases and controls

Among both the cases and the controls, there were more normal deliveries (24.6% and 79.9%, respectively) as compared to the caesarean section (16.4% and 20.1%, respectively). For the cases, there were also 59.0% who did not deliver. Additionally, it can be seen that for the two major categories, there were more controls than cases.

It should be noted that the difference observed for normal delivery was found to be statistically significant (p= 0.000), whereas the one for caesarean was not (p= 0.511).

4.3. Health Facility Characteristics

The health facility characteristics studied were ANC provider, referral from another facility, the type of health facility for delivery and the place of death and the findings are presented in Table 4.5, below.

Table 4.5. Health facility characteristics of the maternal deaths (cases) and the controls and chi-square test (p< 0.05) comparing their proportions in South East from 2007 to 2009

Characteristics	Cases (%) n=71	Controls (%) n= 284	p-value
ANC Provider	n[a]=28	n=201	
Specialist	0	3 (1.5)	1.000[b]
Medical Officer	5 (17.9)	1 (0.5)	0.000[b]
Midwife	22 (78.6)	197 (98.0)	0.000[b]
Nurse	1 (3.6)	0	0.122
Missing	43 (60.6)	83 (29.2)	
Referral from another facility	n=55	n=209	
Referred	42 (76.4)	57 (27.3)	0.000
Not referred	13 (23.6)	152 (72.7)	
Missing	16 (22.5)	75 (26.4)	
Health facility for Delivery	n=64	n=284	
Clinic with maternity	1 (1.6)	0	0.091[b]
General Hospital	6 (9.4)	15 (5.3)	0.007[b]
Referral Hospital	18 (28.1)	266 (93.7)	0.000[b]
BBA	3 (4.7)	3 (1.1)	0.011[b]
Not Applicable[c]	36 (56.3)	NA	NA
Missing	7 (9.9)	0	
Place of death			
Hospital	71 (100)	Not Applicable	

[a] Sample size without the missing values

[b] Fisher's exact test

[c] This accounted for the cases that had died before delivery and so had not delivered.

The types of ANC providers that provided services to the cases and controls are shown in Figure 4.11. Among both the cases and controls, the most common ANC provider was a midwife, accounting for 78.6% and 98.0%, respectively. The least

common provider was found to be the specialist for the cases and the nurse for the controls, which were both 0%.

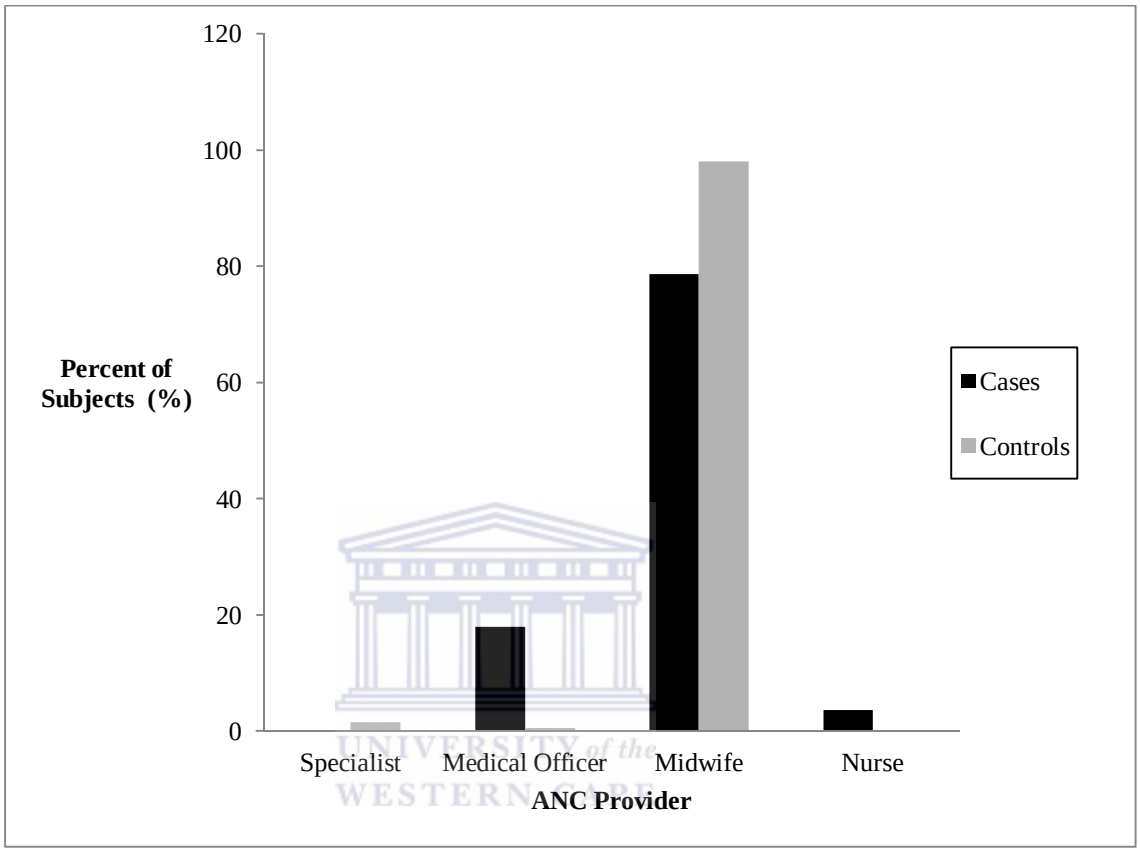


Figure 4.11. Type of ANC Provider for the cases and controls

There were more cases than controls whose ANC had been provided by a medical officer or nurse than the controls. Conversely, there were more controls than cases whose ANC had been provided by a specialist or midwife. The differences observed for the medical officer and midwife as ANC provider were found to be significantly different (p=0.000 and p=0.000, respectively), whereas those for nurse and specialist were not.

The referral pattern for the cases and controls is shown in Figure 4.12, below. It can be seen that, for the cases, there were more subjects who had been referred (76.4%) from another health facility compared to those who had not been referred (23.6%).

The reverse was observed for the controls, as those who had not been referred (72.7%) were more than those who had been referred (27.3%).

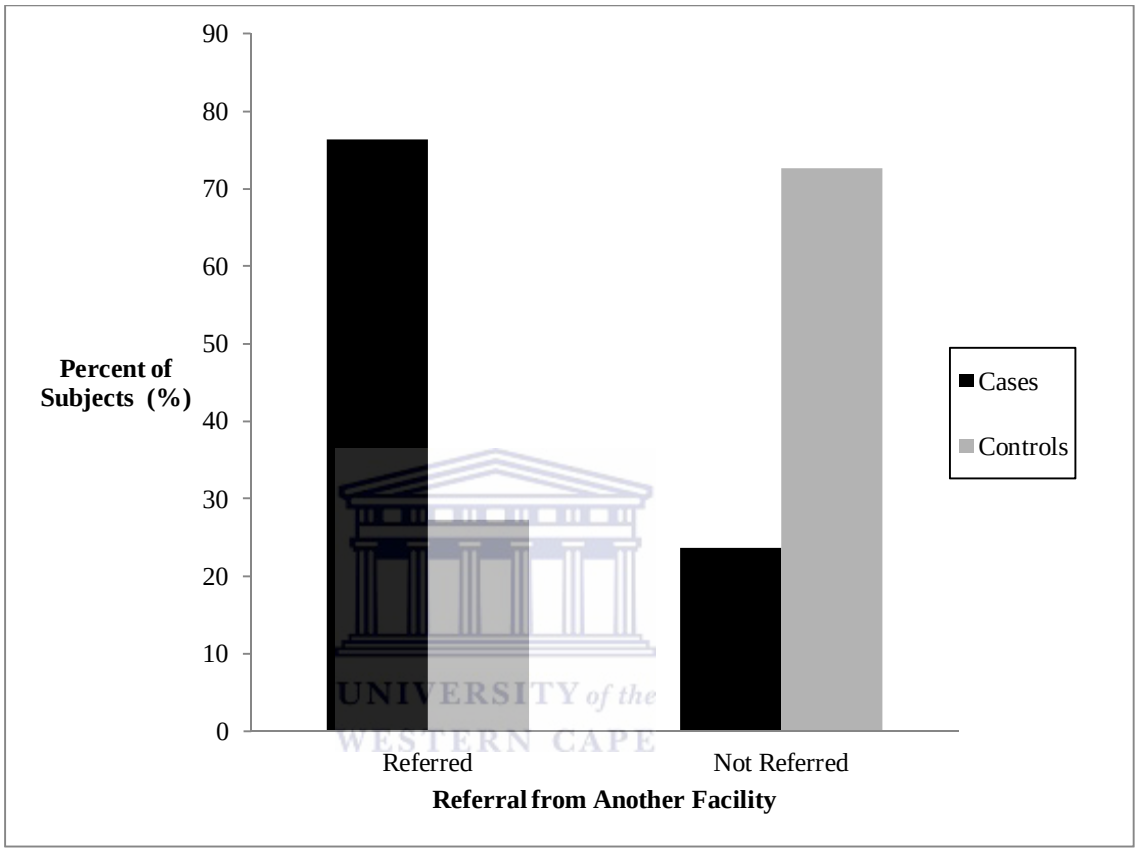


Figure 4.12. Referral pattern of the cases and controls at the time of delivery

This resulted in more cases than controls who were referred and, more controls than cases who were not referred. These differences between the cases and controls were found to be statistically significant (p= 0.000).

According to Figure 4.13 below, within both the cases and controls most of the deliveries took place at a referral hospital (28.1% and 93.7%, respectively), followed by general hospital (9.4% and 5.3%), then those who were born before arrival (BBA) (4.7% and 1.1%) and the least number of deliveries took place at the clinics (1.6% and 0%). Born before arrival, refers to the deliveries that took place before arriving

at a health facility. Therefore, the home deliveries have been included in this category.

It should be noted that for the cases, there were those who did not deliver as a high number of maternal deaths took place before they delivered, and so have been referred to as 'Not Applicable', accounting for 56.3%. Figure 4.13 also shows that there were more controls than cases, who delivered at the referral hospital and there were more cases than controls who delivered at the other three categories. The differences were found to be statistically significant for the differences observed between the general hospital (p=0.007), the referral hospital (p=0.000) and those born before arrival (p=0.011).

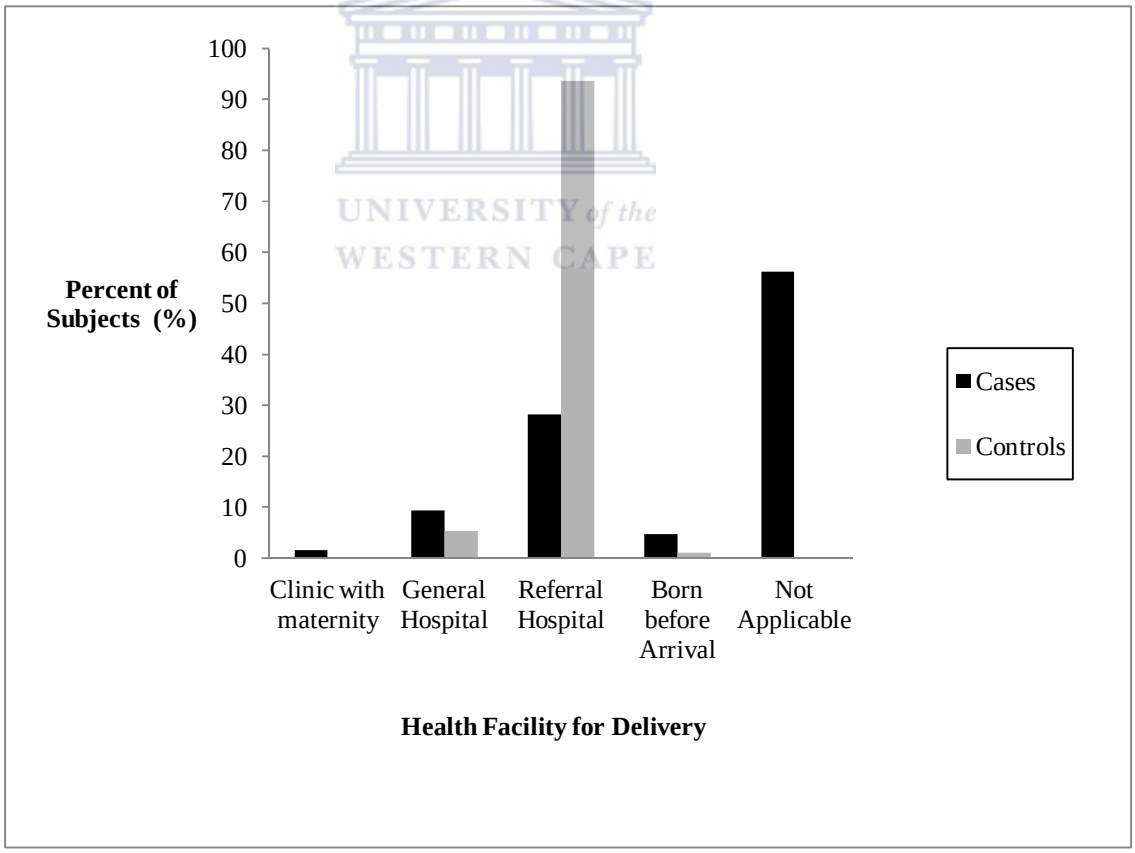


Figure 4.13. Type of health facility for delivery for the cases and controls

4.4. Causes of Maternal Death

The proportion of direct causes and indirect causes of maternal death is shown in Figure 4.14. It shows that there were more direct causes (73%) than indirect causes (27%).

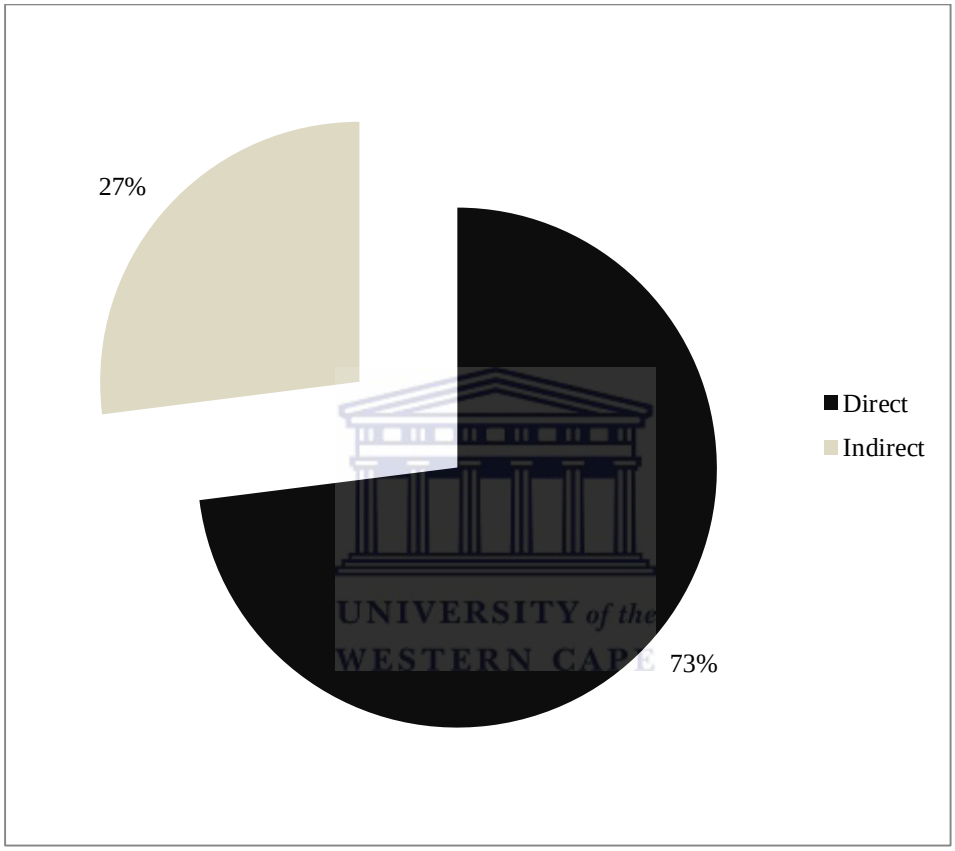


Figure 4.14. Proportion of direct and indirect causes of maternal mortality in South East between 2007 and 2009 (n=71)

The specific causes of maternal death are presented in Table 4.6, below. It should be noted that, the top five leading causes of death were all direct causes. The leading cause of death was found to be abortion, accounting for 22.5%, it was followed by haemorrhage (18.3%), eclampsia (8.5%) and sepsis (8.5%). The other direct causes (4.2%) were postpartum anaemia, retained placenta and ruptured ectopic pregnancy.

Among the indirect causes, the leading cause of death was cardiac complications and pneumonia, which accounted for 7.0% each. This was followed by HIV/ AIDS and TB, with 5.6% and 2.8%, respectively. The other indirect causes accounted for 4.2%, and they were bacterial meningitis, intestinal obstruction and suicide.

Table 4.6. Causes of maternal mortality in South East from 2007 to 2009

Cause of death	Deaths (n=71)	%
Direct causes		
Abortion	16	22.5
Haemorrhage (PPH and APH)	13	18.3
Embolism (Pulmonary and Amniotic)	8	11.3
Eclampsia (incl. pregnancy induced hypertension)	6	8.5
Sepsis[a]	6	8.5
Other direct causes	3	4.2
Indirect causes		
Cardiac Complications	5	7.0
Pneumonia	5	7.0
HIV/ AIDS	4	5.6
Tuberculosis	2	2.8
Other indirect causes	3	4.2

[a] Sepsis included septic caesarean section, puerperal sepsis and immunocompromised septic shock

4.5. Maternal Risk Factors Associated with Maternal Mortality

4.5.1. Demographic Risk Factors

The odds ratios (OR) for the maternal demographic risk factors are presented in Table 4.7, below. It can be seen that maternal age above 35 years, having no education or primary education and being unemployed were risk factors for maternal death with OR of 1.02, 2.00 and 1.44, respectively. Conversely, maternal age less

than 20 years, having a tertiary education and being single were found to be protective factors for maternal death with OR of 0.24, 0.76 and 0.87, respectively. However, all the analysis for the demographic characteristics were not statistically significant.

Table 4.7. Demographic risk factors for maternal deaths in South East from 2007 to 2009 with p<0.05

Risk factor	Odds Ratio	95% CI		p-value
		Lower limit	Upper limit	
Age group (years)				
< 20	0.24	0.52	1.04	0.055
20- 35 (Reference)				
>35	1.02	0.40	2.63	0.968
Education Level				
No Schooling and Primary	2.00	0.67	5.98	0.212
Secondary (Reference)				
Tertiary	0.76	0.21	2.71	0.669
Employment status				
Employed (Reference)				
Unemployed	1.44	0.68	3.08	0.343
Marital status				
Single	0.87	0.35	2.14	0.759
Married and Divorced (Reference)				

4.5.2. Obstetric Risk Factors

The maternal obstetric risk factors are shown in Table 4.8, below. The obstetric risk factors were having a parity of five or more (OR=1.90), having been admitted during pregnancy (OR= 1.41), having not attended ANC (OR=6.31), having had any complications at admission (OR=20.91), HIV (OR=2.49), elevated blood pressure (OR= 2.72), anaemia (OR= 7.61), preterm labour (OR= 9.72), haemorrhage (OR= 8.42) and having delivered by caesarean section (OR= 2.66). It should be noted that all these risk factors were statistically significant except for parity of five or more and having been admitted during pregnancy.

Table 4.8. Obstetric risk factors for maternal deaths in South East from 2007 to 2009 with p<0.05

Risk factor	Odds Ratio	95% CI		p-value
		Lower limit	Upper limit	
Parity				
0	0.53	0.28	1.01	0.055
1-2 (Reference)				
3-4	0.84	0.32	2.21	0.730
5+	1.90	0.45	8.0	0.381
Admissions during pregnancy				
Yes	1.41	0.49	4.03	0.519
No (Reference)				
ANC attendance				
Yes (Reference)				
No	6.31	2.38	16.74	0.000
Complications at admission for delivery				
Any Complication	20.91	7.33	59.69	0.000
No Complication				
HIV	2.49	1.36	4.57	0.003
Elevated BP (including eclampsia)	2.72	1.05	7.03	0.039
Abortion	1.17×10^{10}	0.00	-	0.998
Anaemia	7.61	1.65	35.08	0.009
Preterm Labour	9.72	2.25	42.02	0.002
Haemorrhage	11.46	2.04	64.30	0.006
Type of delivery				
Normal (Reference)				
Caesarean	2.66	1.13	6.22	0.025
No Delivery	2.40×10^{10}	0.00	-	0.997

The protective obstetric factors were having a parity of zero (OR=0.53) and that of three and four (OR=0.84). However, these were found not to be statistically significant.

It is important to note that among the maternal characteristics the greatest risk for maternal death was having at least one complication as it increased the risk of maternal death twenty times. Additionally, the specific complications also increased the risk substantially, for example haemorrhage and preterm labour increased the risk by eleven times and nine times, respectively. Not attending ANC was another notable risk factor, as it increased the risk of maternal death by six times.

4.6. Health Facility Risk Factors Associated with Maternal Mortality

The health facility risk factors for maternal mortality are presented in Table 4.9, below. They were found to be delivering at a general hospital (OR=5.91), delivering before arriving at the health facility (OR= 14.78) and having been referred from another facility (OR= 8.62). It is notable that, all these risk factors were found to be statistically significant.

Table 4.9. Health facility risk factors for Maternal Mortality in South East from 2007 and 2009 with p<0.05

Risk factor	Odds Ratio	95% CI		p-value
		Lower limit	Upper limit	
ANC Provider				
Specialist (Reference)				
Medical Officer	8.08×10^{9}	0.00	-	0.999
Midwife	1.80×10^{8}	0.00	-	0.999
Nurse	2.61×10^{18}	0.00	-	0.999
Referral from another facility				
Yes	8.62	4.31	17.22	0.000
No (Reference)				
Facility where delivery took place				
Clinic	2.39×10^{10}	0.00	-	1.000
General hospital	5.91	2.05	17.07	0.001
Referral Hospital (Reference)				
BBA	14.78	2.78	78.50	0.002

Among the health facility variables, the greatest risks for Maternal Mortality were presented by delivering before arriving at the health facility and being referred from another facility as they increased the risk of death 14 times and 8 times, respectively.

4.7. Multiple Logistic Regression Model

Multiple logistic regression analysis was carried out on the maternal and health facility risk factors, which were significant at 95% confidence interval to determine the contribution each made towards maternal mortality, and is presented in Table 4.10.

Table 4.10. Multiple logistic regression analysis showing risk factors included and excluded from the model

Risk Factor	Odds Ratio	95% CI		p-value	Coefficient
		Lower Limit	Upper Limit		
Included in Model					
Preterm Labour	67.09	4.93	913.92	0.002	4.21
Delivery at General Hospital	57.78	4.48	744.91	0.002	4.06
Delivery before arrival at health facility	205.85	4.20	10102.02	0.007	5.33
Referral from another facility	31.90	2.60	392.08	0.007	3.46
Excluded from Model					
ANC attendance	376	0.01	24.79	0.647	-0.98
Any Complications	1.33	0.15	12.05	0.802	0.28
HIV	1.96	0.41	9.42	0.401	0.67
Elevated BP (including eclampsia)	2.76	0.45	17.03	0.275	1.01
Anaemia	5.91	0.36	95.76	0.211	1.78
Haemmorhage	12.57	0.62	255.20	0.099	2.53
Caesarean delivery	4.27	0.83	22.02	0.083	1.45

The final model showed that the variables that were significantly associated with maternal mortality were one maternal characteristic and all 3 health facility characteristics analysed. The former was, being admitted with preterm labour (OR=67.09) and the latter were delivering at a general hospital (OR=57.78) or before arriving at the health facility (OR=205.85) and having been referred from another facility (OR=31.90). It should be noted that, all 3 health facility risk factors analysed were included in the model. Whereas, only 1 of the 8 maternal risk factors was included and the other 7 were excluded.

According to the partial regression coefficients presented in Table 4.10 the final logistic regression model was written as:

$\ln(p/1-p) = \alpha+\beta_1X_1 +\beta_2X_2+\beta_3X_3+\beta_4X_4$

whereby, p is the probability of maternal mortality;

α is the y-intercept when all the coefficients are zero and was found to be -7.18;

X are the covariates as follows X_1 is having premature labour

X_2 is delivering in a general hospital

X_3 is delivering before arriving at the health facility and

X_4 is having been referred from another facility

β_1, β_2, β_3, and β_4 are the partial regression coefficients corresponding to the above covariates and they were 4.21, 4.06, 5.33 and 3.46, respectively.

When all the values were substituted into the equation it was written as:

ln(p/1-p)= -7.18 +(4.21×premature labour) +(4.06×delivering in a general hospital) +(5.33×delivering before arriving at the health facility) +(3.46×having been referred from another facility)

When the model was tested using the Hosmer- Lemeshow goodness of fit test, it showed a good fit with a Chi-square of 0.377 and p value of 0.999. The p-value is larger than 0.05 therefore not significant. Since the p-value is not significant, the null hypothesis being tested that there is no difference between the expected frequencies and those observed in the model being tested, is not rejected. This shows that the expected and observed are not significantly different, indicating that the model fits well.

5.0 CHAPTER FIVE: DISCUSSION

This chapter provides a detailed discussion of the findings presented in the previous chapter. It discusses the variations in maternal deaths, the maternal and hospital profiles of the sample, causes of maternal death, maternal and health facility risk factors for maternal mortality and the multiple logistic regression model. It concludes by discussing the limitations of the study.

5.1. Hospital and Annual Variations

Princess Marina Hospital (PMH) experienced more maternal deaths than Bamalete Lutheran Hospital (BLH), during the study period. The former had an MMR of 409 maternal deaths per 100,000 (95% CI 223-521/100,000), whereas the latter had an MMR of 173 maternal deaths per 100,000 live births (95% CI 3-343/100,000). This is not surprising as PMH is a large referral hospital and BLH is a comparatively small general hospital. The former is a 543 bed hospital and the latter is a 140 bed hospital (CSO, 2011a). Therefore, PMH would have received cases from around the country, including from BLH, whereas BLH would have only received referrals from health facilities within a small radius, namely the South East district. According to CSO (2011a), PMH recorded 20,885 admissions compared to 6,505 admissions for BLH. Additionally, the more serious cases would have been referred to PMH due to the availability of better equipment and more skilled staff. It should however be noted that since the 95% confidence intervals overlap, these differences may not be significant.

Hospital variation in maternal mortality is not unique to this study, as it was also observed in Kenyan hospitals (Magadi *et al.*, 2001). The authors attributed this to a number of factors such as availability of resources, hospital administration, regional variations and high-risk women being admitted at certain hospitals. Indeed, Magadi *et al.* (2001) have shown that maternal mortality between hospitals is influenced by a

complex interaction of many factors. Garenne *et al*. (1997), also reported differences in the number of maternal deaths from three Dakar hospitals in the same year, which they attributed to screening for severe cases in the better equipped hospitals, which may also be the case in this study. Nagaya *et al*. (2000), also reported differences in maternal deaths between nontransferring, transferring and receiving medical facilities in Japan. They attributed these differences to the availability of staffing (obstetric and anaesthetic) and laboratory services during critical times, and may also apply to this study. Conversely, Panchal *et al.* (2001) reported more maternal deaths in the minor teaching hospitals, compared to the major teaching hospitals, as the former maybe smaller in size than the latter. However, the major teaching hospitals are probably better equipped to handle severe complications than the minor teaching hospitals.

This study has also revealed that there was an annual variation in maternal deaths, within the hospitals. This is not unique to this study and was also observed by other authors. Panchal *et al.* (2001) reported that the number of maternal deaths, and consequently, the delivery mortality ratios in Maryland changed from 1984 to 1997 in no particular pattern. For example, the lowest ratio was observed in 1992 and the highest was in 1985. However, in Tanzania, Kazaura *et al.* (2006), reported an increase in MMR between 1999 and 2005. Annual variations of maternal mortality have also been reported within countries (WHO, 2010) and these may either increase or decrease. Since this study looked at total number of maternal deaths in one region of the country, the results cannot be generalized for the whole country to establish if the MMR is increasing or decreasing between the years studied. However, WHO (2010) and CSO (2011a) provide an insight into the MMR of Botswana as a whole. The former noted an increase in MMR between 1990 and 2008. The latter report that the MMR has been declining between 2008 and 2010, which is a promising development, as it would show an improvement in maternal health.

5.2. Demographic Profile

The demographic profile of the cases and controls showed that their ages ranged from 17- 43 years and 16-48 years, respectively. The literature reported similar age ranges in other maternal mortality studies and this is not surprising as this is the reproductive age for women. This range was observed in studies such as that of Nagaya *et al.* (2000) in Japan, where the maternal deaths ranged from less than 19 years to above 45 years. In Kenya, the range was reported as 10 years to above 35 years (Magadi *et al.*, 2001). Whereas, in Tanzania, MacLeod and Rhode (1998) found a range of 15 to 44 years and Kazaura *et al.* (2006) reported a range of less than 20 to 50 years. The mean age for the cases (28.0 ± 5.3 years) was higher than that of the controls (26.3 ± 5.8 years) and this difference was found to be statistically significant. However, it did not fall within the high risk age group of above 35 years. A comparable mean age of 26.0 ± 6.1 years was reported by Kazaura *et al.* (2006) for maternal deaths in Tanzania.

Most maternal deaths were aged between 20 and 35 years (88.4%), followed by above 35 years (8.7%) and less than 20 years had the least number of deaths (2.9%). MacLeod and Rhode (1998) also observed that a large proportion (65.8%) of the women who died were aged between 20 and 34 years and those below 20 years accounted for 18.4%, whereas those who were 35 years or older were 15.8%. The authors explained this high proportion of women dying in this age group being a factor of the large number of women delivering in this age group. In the current study, this is illustrated among the controls. The age group with the most deliveries was also, 20-35 years (81.1%), followed by less than 20 (11.0%) and the group with the least number of deliveries was the over 35 years (7.8%). Several studies showed that the 20-35 years usually has the highest maternal deaths (McLeod and Rhode, 1998; Nagaya *et al.*, 2000; Magadi *et al.*, 2001). McLeod and Rhode (1998) suggested that a more useful comparison would be the maternal mortality ratio for the specific age groups.

The results showed that the highest number of subjects had received secondary education, accounting for 73.3% and 77.3% for the cases and controls, respectively. The least number of subjects were those with no education, accounting for 3.3% and 0%, respectively. This may be attributed to the fact that the government provides ten years of basic education to all citizens (Ministry of Finance and Development Planning, 2003). Similar findings were described by CSO (2009a) in the Botswana Family Health Survey IV (BFHS IV), which reported that of females aged between 12 and 49 years, most of them (69.9%) had received a secondary education. Similarly, those who had not received any education were the least represented accounting for 6.7%.

Among both cases and controls there were more unemployed subjects than employed subjects. For the cases, the unemployed were 64.7% compared to 35.3% employed, which is approximately double. For the controls, the unemployed were 56.0% compared to 44.0% who were employed. This finding is higher than according to the 2005 Labour Force Report (CSO, 2008), in which, unemployment among females in Gaborone and South East were reported as 15.9% and 22.6%, respectively. This may be due to the fact that, some of the subjects may be involved in informal employment and agriculture and may perceive themselves as unemployed. This would result in the underreporting of those who are employed.

Most of the subjects were single among both the cases and the controls, accounting for 80.6% and 82.7%, respectively. This was in contrast to the findings of Panchal *et al.* (2001) who reported that within both groups there were more married than single subjects. This may be due to the fact that according to the BFHS IV(CSO, 2009a) 30.1% of the females reported a marital status of 'living together', therefore in the obstetric record they may have chosen single or married depending on how the respondent viewed their relationship. Since, cohabiting couples are not recognized as

married by Botswana law, they probably would have chosen single and this would have reduced the proportion of married subjects reported in this study.

5.3. Obstetric Profile

The most common parity was one, accounting for 58.3% and 47.5% for the cases and controls, respectively. The parity of five or more was the least common among both the cases (5.0%) and the controls (2.1%). Similar findings were reported by Magadi *et al.* (2001) in Kenya who reported that the most common parity was one to two (46.3%), followed by zero, three to four and the least number were those of parity of five or more. This is also not surprising as the fertility rate of Botswana was reported as 2.9 children (CSO, 2009a) and so do not expect to find many women having more than 3 children.

For both groups, there were fewer subjects who had been admitted to hospital during pregnancy compared to those who had not been admitted. For cases, this was 18.5% compared to 81.5% and for the controls, it was 13.9% compared to 86.1%. This may be due to the fact that, most pregnancy complications such as hypertension, may be managed without requiring hospitalization. Furthermore, the results for ANC attendance were the reverse of those for admission during pregnancy among both the cases and the controls, such that, there were more subjects who attended ANC when compared to those who did not attend ANC. ANC attendance is of importance as any conditions that may lead to hospitalization would be identified and managed before hospital admission was required.

A large number of cases were admitted with at least one complication (92.3%) as compared with 7.7% who had no complications at admission. The reverse was observed for controls, as more of them had no complication (63.5%) compared to 36.5% who were admitted with at least one complication. Additionally, more cases

than controls were admitted with at least one complication. This is not surprising as complications depending on their severity and type may be fatal.

A wide range of complications were reported and only six were individually analysed. Among the cases, the most common complication was HIV (48.1%), followed by abortion (26.9%), elevated BP (13.5%), premature labour (9.6%) and the least common were anaemia (7.7%) and haemorrhage (7.7%). Similarly, for the controls, the most common complication was HIV (27.1%), followed by elevated BP (5.4%), anaemia (1.1%), preterm labour (1.1%), haemorrhage (0.7%) and abortion (0%) was the least common. This data is not surprising because of reasons such as the relatively high HIV prevalence in the country, unsafe abortions (MOH, Undated) and the rise of non-communicable diseases (Ministry of Finance and Development Planning, 2003). According to the Botswana AIDS Impact Survey III (CSO, 2009b), the prevalence among females aged 15 to 49 years was 29.2%. The prevalence for populations of Gaborone and South East were 17.1% and 12.6%, respectively.

According to the Ministry of Health (2007; 2008; Undated), unsafe abortions contribute to morbidity and mortality among women of reproductive age. Additionally, it accounts for approximately 30% of the causes of death among this group (MOH, Undated). According to MOH (2007; 2008), it was among the top 5 causes of maternal death in both 2007 and 2008, representing 16% and 13%, respectively. Therefore it is not surprising that it is one of the major complications that the subjects in this study were admitted with.

Furthermore, a low proportion of complications such as anaemia is also not surprising as it is usually due to diseases such as malaria (Magadi *et al.,* 2001), which is not common in Botswana- especially in the southern part of the country, where the study was conducted. Another possible cause of anaemia maybe nutritional (Brabin, Hakimi and Pelletier, 2001; Magadi *et al.,* 2001) or due to the use of the antiretroviral zidovudine (AZT) (Agarwal, Chakravarty, Chaube, Rai,

Agrawal and Sundar, 2010). The former is addressed by the provision of iron and folic acid supplementation and fortified maize meal to pregnant women during ANC (Ministry of Finance, 2003). The latter is also managed during ANC (MOH, 2007). Haemorrhage was also not a common complication, possibly due to the fact that, it is usually occurs postpartum, as opposed to antepartum. For example, in Dakar, Garenne *et al.*(1997) reported that of the 32 maternal deaths due to haemorrhage, 7 were antepartum or intrapartum, compared to 25 which were postpartum. Similarly, in India, Ganatra *et al.* (1998) reported that antepartum haemorrahge accounted for 4.9% of the maternal deaths, whereas postpartum haemorrhage accounted for 30.6%.

Among both the cases and the controls, normal delivery (24.6% and 79.9%, respectively) was more common than caesarean section (16.4% and 20.1%, respectively). For the cases, there was also a large number of women (59.0%) who did not deliver. In Japan, Nagaya *et al.* (2000) reported that normal delivery and caesarean were the same among maternal mortality cases, both accounting for 37%. Additionally, a comparatively lower proportion of deaths occurred before delivery (26%). In the USA, Panchal *et al.* (2001) reported similar findings for the controls but the reverse was observed for the cases. In their study, normal and caesarean delivery among the controls accounted for 73.3% and 26.7%, respectively, whereas among the cases they accounted for 40% and 60%, respectively. It is however, interesting to note that none of the maternal deaths occurred before delivery like in this study.

5.4. Health Facility Profile

The most common ANC provider among the cases and controls was a midwife, accounting for 78.6% and 98.0%, respectively. This is not surprising, as in most of the health facilities, the ANC services are provided by a midwife. The least common provider was found to be the specialist for the cases and the nurse for the controls, which were both 0%. Similar results were reported in the BFHS IV (CSO, 2009a),

which showed that 87.2% received antenatal care from either nurses or midwives compared to 6.4% from medical doctors.

It can be seen that, for the cases, there were more subjects who had been referred (76.4%) from another health facility compared to those who had not been referred (23.6%). The reverse was observed for the controls, as those who had not been referred (72.7%) were more than those who had been referred (27.3%). This was possibly due to the fact that the cases had complications, which the admitting health facility was unable to deal with and so referred them to the facility where they would later die.

The results show that among both the cases and controls, most of the deliveries took place at a referral hospital (28.1% and 93.7%, respectively), followed by general hospital (9.4% and 5.3%), then those who were born before arrival (BBA) (4.7% and 1.1%) and the least number of deliveries took place at the clinics (1.6% and 0%). It was noted that although PMH is a referral hospital, it does not only admit referrals from other health facilities but they also admit women who present themselves for delivery. This would explain the low number of women delivering in the clinics as they usually receive ANC at the clinics but go to the referral hospital for delivery. These findings also illustrate the access and utilization of health facilities by the population. High utilization of health facilities for delivery was also described in the BFHS IV (CSO, 2009a).

5.5. Causes of Maternal Death

It was observed that the proportion of direct causes of maternal death were more than indirect causes (73% compared to 27%). This situation was also observed when data for the whole country were analysed in 2007 and 2008 (MOH, 2007; 2008). In 2007, the direct causes accounted for 74% and the indirect causes accounted for 26%. Similarly in 2008, the direct causes accounted for 75%, whereas the indirect causes

accounted for 25%. In India, Ganatra *et al.* (1998) reported comparable findings, such that direct causes accounted for 71.9%, whereas indirect causes represented 28.1%. Other authors also describe the leading causes of death being due to direct causes (Garenne *et al.*, 1997; Nagaya *et al.*, 2000; Kazaura *et al.*, 2006).

The specific causes of maternal death showed that, the top five leading causes of death were all direct causes. The leading cause of death was found to be abortion, accounting for 22.5%, it was followed by haemorrhage (18.3%), eclampsia (8.5%) and sepsis (8.5%). The other direct causes (4.2%) were postpartum anaemia, retained placenta and ruptured ectopic pregnancy. It is not surprising that abortion was the leading cause of death due to its high prevalence in the country (MOH, Undated). The authors also provide some information as to the reasons women perform unsafe abortions such as family planning method failure and lack of information on availability of abortion services, such as following rape or incest. Furthermore, they present recommendations that may be used to reduce and prevent the high number of unsafe abortions.

Similar findings were observed in 2007 and 2008 by the MOH (2007; 2008), whereby the leading causes of maternal death in the country were haemorrhage, pregnancy induced hypertension/ eclampsia, AIDS, abortion and sepsis. For the direct causes they discussed that the contributory factors for these deaths maybe due to factors such as delay in seeking care or referral, substandard care and lack of blood or drugs. Substandard care included issues such as lack of skill among personnel and missed diagnosis (MOH, 2008). To illustrate this, according to the maternal mortality report (MOH, 2008), the major contributing factor among postpartum haemorrhage, eclampsia and abortion deaths were due to substandard care, delay in referral and delay in seeking care, respectively. This information is of importance as it provides insight into the opportunities for action. In 2007, among the contributing factors identified for haemorrhage, eclampsia and abortion were lack

of blood, no uristiks for proper diagnosis and poor management as a result of lack of skill (MOH, 2007).

Similar findings have been reported by several authors for Africa (Khan *et al.*, 2006), India (Ganatra *et al.*, 1998), Japan (Nagaya *et al.*, 2000), Senegal (Garenne *et al.*, 1997), Kenya (Magadi *et al.*, 2001) and Tanzania (Kazaura *et al.*, 2006). In Kenya, Magadi *et al.* (2001) reported that postpartum haemorrhage, sepsis and antepartum haemorrhage were the major causes of death. Additionally, anaemia and malaria were among the major causes of death, which was not the case in this study. They attributed anaemia to malaria, worm infestation and malnutrition, which are all not significant health problems among pregnant women in Botswana, especially in the study area, as malaria is usually reported in the Northern parts of the country. Ganatra *et al.*(1998) also reported that in India, the leading cause of maternal death was postpartum haemorrhage, peuperal sepsis, eclampsia and cerebral malaria. Unlike, in this study they reported that causes related to abortion were haemorrhage and perforation and they accounted for only 3.3%. They went on to say this showed that abortions were performed under relatively safe environments and so there were no septic abortions. This is in contrast to this study whereby 21.1% of the maternal deaths were due to septic abortions, implying that most abortions maybe carried out in an unsafe environment. This would not be surprising as abortion is illegal in Botswana except in specific circumstances such as when the pregnancy is a result of rape (MOH, Undated). This may also explain the delay in seeking care described by MOH (2008) among abortion cases.

Among the indirect causes, the leading cause of death was cardiac complications and pneumonia, which accounted for 7.0% each. This was followed by HIV/ AIDS and TB, with 5.6% and 2.8%, respectively. The other indirect causes accounted for 4.2% and they were bacterial meningitis, intestinal obstruction and suicide. It is important to note that although HIV was the most common complication at admission, it was not found to be the leading cause of death. This is possibly due to the availability of

health services that reduce the fatality of HIV/AIDS such as routine testing and provision of antiretroviral drugs. However, some of the other indirect causes such as pneumonia and bacterial meningitis may be attributed to an immunocompromised state even though the person may not know their HIV status. The high number of cardiac complications may be attributed to the increasing prevalence of chronic non-communicable diseases such as hypertension in Botswana (Ministry of Finance and Development Planning, 2003).

5.6. Maternal Risk Factors Associated with Maternal Mortality

5.6.1. Demographic Risk Factors

It should be noted that none of the analysis for demographic risk factors was found to be significant. This may be due to the fact that, there were no significant differences between the demographic variables for the cases and controls (Table 4.3). Furthermore, as already mentioned, due to the high prevalence of 'living together', there may be an underreporting of the 'marriage' characteristic, even though cohabitation may provide some of the protective effects of marriage such as an educated partner (Ganatra *et al.*, 1998) and economic and emotional support. Additionally, even for variables such as employment status, which revealed high unemployment, there are government policies that would have a protective effect. This would include provision of free healthcare and food supplementation to pregnant women even if they are unemployed.

It should also be noted that, studies show conflicting data on demographic risk factors for maternal mortality. However, those that have been documented to be risk factors in other studies should be minimized so that they do not become significant risk factors in the country. In Dakar, Garenne *et al.* (1997) also reported that the data for age and employment status were statistically not significant. However, they found that not being married and receiving less than seven years of schooling were risk factors for maternal mortality. In Kenya, Magadi *et al.* (2001) found age above

35 years to be a risk factor, whereas age groups 25-29 and 30-34 were both protective factors. In India, Ganatra *et al.* (1998) reported age below 20 years and above 35 years and not being in a monogamous marital relationship as risk factors for maternal mortality. In the USA, Panchal *et al.* (2001) also found age and marital status not to be statistically significant.

It should be noted that, although the data for age was not found to be statistically significant, it is notable that, approximately 16% of the subjects belonged to the two high-risk groups for maternal mortality of less than 20 years and above 35 years. Efforts should therefore be made to educate and discourage women from becoming pregnant at these ages to minimize putting their lives at risk, as both these age groups are prone to experiencing pregnancy complications that may be life-threatening.

5.6.2. Obstetric risk factors

Among the maternal obstetric characteristics studied the risk factors were found to be having a parity of five or more (OR=1.90), having been admitted during pregnancy (OR= 1.41), having not attended ANC (OR=6.31), having had any complications at admission (OR=20.91), HIV (OR=2.49), elevated blood pressure (OR= 2.72), anaemia (OR= 7.61), preterm labour (OR= 9.72), haemorrhage (OR= 8.42) and having delivered by caesarean section (OR= 2.66). It should be noted that all these risk factors were statistically significant except for parity of five or more and having been admitted during pregnancy.

Other authors also reported similar findings with respect to maternal obstetric risk factors. In Dakar, they observed that receiving no ANC, having any complication at admission, haemorrhage or eclampsia/ pre-eclampsia at admission and first and higher order pregnancies of above six were risk factors (Garenne *et al.*, 1997). Magadi *et al.* (2001) reported that not attending ANC was a risk factor, although the risk was lower than in this study. In a study of postpartum maternal deaths in

Malawi, Kanyighe *et al.* (2008) reported that maternal mortality was associated with being in a critical condition on admission, having a postpartum infection and having had a caesarean section. In India, Ganatra *et al.* (1998) reported having a preexisting medical illness such as hypertension, not receiving ANC and gravida of one or five and above as risk factors for maternal mortality. In the USA, Panchal *et al.* (2001) also found delivering by caesarean section to be a risk factor. The importance of obstetric factors cannot be disputed and so should be closely monitored during pregnancy.

It is important to note that among the maternal characteristics the greatest risk for maternal death was having at least one complication as it increased the risk of maternal death twenty times. Additionally, the specific complications also increased the risk substantially, for example haemorrhage and preterm labour increased the risk by eleven times and nine times, respectively. This is notable as complications are usually noted at admission and it may be too late to prevent the maternal death. Therefore, this would be an area which presents a great opportunity for reducing maternal deaths.

Not attending ANC was another notable risk factor, as it increased the risk of maternal death by six times. ANC attendance is critical as during these visits health facility staff are able to identify problems early and make the necessary referral of high risk cases. Letamo and Rakgoasi (2003) noted that the groups which were associated with non-use of maternal health services such as ANC were aged less than 20, primiparous and had received no formal education. However, according to the BFHS IV, there is a high utilization of antenatal services of about 95% (CSO, 2009a). Additionally, the report indicates that of these women, 73% had received more than four ANC visits and only 5.5% had received no ANC or traditional care. Therefore, it is of importance to continue emphasing and encouraging pregnant women to attend ANC with particular emphasis on the groups described by Letamo and Rakgoasi (2003).

5.7. Health Facility Risk Factors Associated with Maternal Mortality

The health facility risk factors, which were found to be statistically significant in order of increasing risk were delivering at a general hospital (OR=5.91), having been referred from another facility (OR= 8.62) and delivering before arriving at the health facility (OR= 14.78). This is not surprising as although the general hospital was smaller, it offers life saving services, as compared to delivering outside the health facility. Being referred was possibly a greater risk as the time factor may play a role and if there is a delay this may result in maternal death. Delivering outside the health facility presented the greatest risk because there is usually no skilled personnel attending the delivery, therefore even if there are complications, there is nobody to assess, monitor or even reduce the fatality. Other authors have also reported similar health facility risk factors. In Dakar, maternal mortality was strongly associated with late referral of 24 hours or more (Garenne *et al.*, 1997). In the USA, Panchal *et al.* (2001), also reported that hospital type and being transferred from another hospital were risk factors for maternal mortality.

Overall, there was a large amount of missing data for both the cases and controls, which may have affected the data analysis, especially as missing data was excluded from the logistic regression analysis. It should also be noted that the missing data, was of variables which were not recorded anywhere else, except the medical record, namely the obstetric record. For example, variables such as age and parity are usually recorded in the delivery register as well, whereas, data such as education and employment status would only be on the obstetric record. Generally, there was more missing data for the cases than the controls. This is surprising as the expectation would have been that since, the data for the cases would then be sent to the Safe Motherhood Programme, there would be a tendency towards completing it. However, the occurrence of missing data is not surprising as this is usually associated with use of medical records. Other authors also reported having large

amounts of missing data for some variables in their studies (Magadi *et al*., 2001; Kanyighe *et al.*, 2008).

5.8. Multiple Logistic Regression Model

The final multiple logistic regression model showed that, there was one maternal characteristic and three health facility characteristics significantly associated with maternal mortality. They were being admitted with preterm labour (OR= 67.09), delivering at a general hospital (OR= 57.78) or before arriving at the health facility (205.85) and having been referred from another facility (31.90). Therefore, the other maternal characteristics such as, ANC attendance, haemorrhage and caesarean delivery were only associated with maternal mortality independently but not in combination (Table 4.10). Aggarwal *et al.* (2007) also observed that in India, when multiple logistic regression analysis was applied to complications, jaundice was excluded as a confounding factor.

It is of significance that all 3 of the health facility characteristics analysed for the multiple logistic regression model were included in the model as this indicates that the health facility characteristics present an opportunity to reduce maternal mortality. It should be noted that although some variables, such as abortion may not have been shown to be statistically significant risk factors (and so were not included in the multiple logistic regression analysis), this may be due to the characteristics of the sample. To illustrate this, abortion was found to be the leading cause of death, however, univariate logistic analysis produced a large OR ($1.17 \text{ X } 10^{10}$), which was not statistically significant (p= 0.998). This may be explained by the fact that since none of the controls were admitted experiencing abortion as a complication, the results for the analysis were extremely large but were not statistically significant as one of the cells in the 2 X 2 table was 0. However, the Fisher's exact test in Table 4.4 shows that there is a statistically significant association between abortion and maternal mortality (p=0.000).

According to the Hosmer- Lemeshow goodness of fit test, the model produced by this study showed a good fit with a Chi-square of 0.377 and p-value of 0.999, as the p-value is larger than 0.05 therefore not significant. Therefore, this model would be able to predict the odds of a maternal death well and so may be used to identify women at high risk of maternal mortality and to develop interventions aimed at these risk factors.

5.9. Limitations

The limitations associated with retrospective case-control studies such as selection bias, confounding and information bias also apply to this study. Selection bias may occur because the data was collected from health facility records and so may not be generalised to the whole population. Confounding may occur due to other risk factors that are not measured in the study such as environmental factors. Information bias may occur because the records for the cases may be given more attention as they would have been later sent to the Safe Motherhood Programme. Additionally, medical records are associated with being cumbersome as data is usually incomplete as it was not collected for research purposes. Furthermore, since the data on medical records was collected by different people at different times, the variables may be inconsistently defined. It is important to note that, even with these limitations, the study will provide useful insight that will assist in developing strategies to reduce maternal mortality.

6.0 CHAPTER SIX: CONCLUSION

This chapter provides conclusions drawn from the discussion of the findings of this study. It also provides some recommendations for policy, interventions and research.

6.1. Conclusion

The profile of the maternal death showed that all the deaths took place in a hospital. Most of the women who died were single, aged between 20 and 35 years, had received a secondary education and were unemployed. Additionally, they had a parity of one, received ANC from a midwife and had not been admitted during pregnancy. However, most of them were admitted with at least one complication at delivery, the most common of which was HIV and abortion. Furthermore, most of them had a normal delivery at a referral hospital, after being referred from another facility. A large number of them died without delivering.

Most of the deaths were due to direct causes instead of indirect causes. The leading causes of death were abortion and haemorrhage. The leading indirect causes of death were cardiac complications and pneumonia.

The maternal risk factors associated with maternal mortality were not receiving ANC, having complications at admission and having delivered by caesarean section. The complications which were risk factors were HIV, elevated BP, anaemia and preterm labour. The health facility risk factors for maternal mortality were having been referred from another health facility and delivering at a general hospital or before arrival at the health facility.

The data produced a model with good fit that included one maternal risk factor and three health facility risk factors. The former was being admitted with preterm labour

and the latter were delivering at a general hospital or before arrival at the health facility and having been referred from another health facility.

The findings of this study illustrate that the factors associated with maternal mortality in South East Botswana are specific to this setting, even if there are some similarities to other countries. Therefore, they require a response that is relevant to the setting.

6.2. Recommendations

The findings show that there are policies in place that have resulted in reducing certain risk factors such as provision of education, and these need to be encouraged and strengthened. However, there are areas which require improvement and prevention strategies may be implemented to reduce maternal mortality in South East Botswana and indeed the country as a whole. With this in mind, the following recommendations are made:

- Since referral is a significant risk factor (individually and in combination), as is illustrated by the high number of deaths at the Referral hospital among referred cases, the referral system needs to be closely monitored and assessed regularly to ensure that it is well-functioning. Additionally, health facility staff need to be trained and encouraged to follow the necessary guidelines in making timely referrals. Furthermore, the referral health facilities need to be well equipped, with respect to staff and other resources, such as drugs and blood and blood products, to handle the various complications they may be faced with. This may be achieved through a multi-sectoral approach with other departments such as Central Transport Organisation, Central Medical Stores and the Blood Bank.
- As most of the obstetric variables were significant risk factors, health facility staff need to be trained to recognize and manage them. Women need to be

educated about the importance of receiving antenatal care and health facilities should be made to provide user friendly and easily accessible ANC services to encourage uptake. Furthermore, health personnel should be trained to recognise and manage obstetric complications such as preterm labour, haemorrhage and eclampsia, in order to make the appropriate decisions, including the need to deliver by caesarean section.

- With respect to the health facility risk factors, general hospital should be equipped to handle complications, if timely referral is not possible, to reduce maternal mortality. Furthermore, during ANC, women should be educated to recognise signs of complications and indeed labour, so that they may seek timely assistance from health facilities and reduce fatality of complications and delivery outside of health facilities.
- In order to reduce the mortality due to abortion, a multi-sectoral approach is required to prevent unwanted pregnancies and to encourage uptake of available abortion services. This would include, educating women to recognise signs of abortion and the importance of going to the health facility for assistance; education and religious institutions encouraging delay of sexual activity; educating the public about the availability of legal abortion services in cases of rape or incest and availability of post abortion care.
- The annual variation in maternal mortality symbolizes a need to continue monitoring maternal deaths, primarily through the Maternal Mortality Monitoring System to be able to evaluate if the policies and practices in place are resulting in an improvement over time. This would be indicated by a decrease in the maternal mortality ratio of the country. Furthermore, recommendations made by through this system need to be implemented.
- Although the demographic characteristics were not found to be risk factors for maternal mortality in this study, the government should continue policies such as providing free education and working with other organizations to promote the use of family planning. A reduction in unwanted pregnancies, this would lower the number of illegal abortions, which contribute

significantly to the number of maternal deaths. Additionally, this would reduce pregnancy in women in high risk age groups such as teenagers and those of advanced maternal ages.

- Initiatives such as Safe Motherhood and CARMMA, should be used to learn and adopt strategies used in other countries to reduce maternal mortality.
- Further research may be carried out to include data from the whole country, in order to obtain a better understanding of the situation. Furthermore, research may also be carried out to establish specific underlying issues through evaluating processes such as transportation, referral and response to obstetric emergencies. Additionally, qualitative and quantitative methods may be used to study more health facility characteristics and problems faced by specific health facilities. Findings from these studies may then be utilized to develop specific strategies for each facility, especially those with high maternal mortality.
- The amount of missing data in the obstetric records may be indicative of poor record taking by the health facility staff. Efforts need to be made to determine the reasons for this lack of completeness of records and these should be addressed, as they may also impact other aspects of the health system.

REFERENCES

African Union. (Undated). *Factsheet AU Campaign on Accelerated Reduction of Maternal Mortality in Africa (CARMMA)*. [Online], Available: http://www.google.com/url?sa=t&rct=j&q=CARMMA+FACTSHEET&source=web&cd=1&ved=0CC8QFjAA&url=http%3A%2F%2Fwww.africa-union.org%2Froot%2FUA%2FConferences%2F2010%2Fjuillet%2FSummit_2010_b%2Fdoc%2FSA%2FFactsheet%2520on%2520CARMMA%2520ENGLISH.doc&ei=zMqeUMqtKs_ptQayvoGwCA&usg=AFQjCNGfw30XyPsFIOvr3_jVLFk5jm5P9Q&cad=rjt [Downloaded: 05/28/12 12:22 PM].

Agarwal, D., Chakravarty, J., Chaube, L., Rai, M., Agrawal, N. R. and Sundar, S. (2010). High Incidence of Zidovudine Induced Anaemia in HIV Infected Patients in Eastern India. *Indian Journal of Medical Research*, 132: 386-389.

Aggarwal, A., Pandey, A. and Bhattacharya, B. N. (2007). Risk Factors for Maternal Mortality in Delhi Slums: A Community-based Case-control Study. *Indian Journal of Medical Sciences*, 61(9): 517-526.

Alvarez, J. L., Gil, R., Hernández, V., Gil, A. (2009). Factors Associated with Maternal Mortality in sub-Saharan Africa: An Ecological Study. *BioMed Central Public Health*, 9:462. Full-text. In BioMed Central doi: 10.1186/1471-2458-9-462. [Online], Available: http://www.biomedcentral.com/1471-2458/9/462 [Downloaded: 02/11/10 11:29AM]

Bonita, R., Beaglehole, R. and Kjellstrom, T. (2006). *Basic Epidemiology, 2nd Edition*. Geneva: WHO.

Brabin, B. J., Hakimi, M. and Pelletier, D. (2001). An Analysis of Anemia and Pregnancy-Related Maternal Mortality. *Journal of Nutrition*, 131: 604S- 615S.

Central Statistics Office. (2007a). Access to Health Services in Botswana. [Online], Available: http://www.cso.gov.bw/html/health/Access%20to%20Health%20Services%20Sept%202007%5B1%5D.pdf [Downloaded: 05/30/08 02:56 AM].

Central Statistics Office. (2007b). Stats Update December 2007. [Online], Available: http://www.cso.gov.bw [Downloaded: 03/18/08 04:42 PM].

Central Statistics Office (2008). 2005/06 Labour Force Report. [Online], Available: http://www.cso.gov.bw/templates/cso/file/File/2005LabourFS_Report_Feb_20_2008.pdf [Downloaded: 02/06/08 02:00 PM].

Central Statistics Office. (2009a). 2007 Botswana Family Health Survey IV Report. [Online], Available: http://www.cso.gov.bw/templates/cso/file/File/bfhs_report.pdf [Downloaded: 05/22/12 04:20 PM].

Central Statistics Office. (2009b). Botswana AIDS Impact Survey III Report. [Online], Available: http://www.cso.gov.bw/templates/cso/file/File/bfhs_report.pdf [Downloaded: 05/22/12 04:20 PM].

Central Statistics Office. (2011a). Botswana – Maternal Mortality Ratio (MMR) 2006-2010. [Online], Available: http://www.cso.gov.bw/templates/cso/file/File/maternal_statsbrief.pdf [Downloaded: 05/22/12 03:48 PM].

Central Statistics Office. (2011b) 2011 Population and Housing Census Preliminary Results Brief. [Online], Available: http://www.cso.gov.bw/.pdf [Downloaded: 02/09/12 08:14 AM].

Cham, M., Sundby, J. and Vangen, S. (2005). Maternal Mortality in the Rural Gambia, a Qualitative Study on Access to Emergency Obstetric Care. *Reproductive Health*, 2:3. Full-text. In BioMed Central doi:10.1186/1742-4755-2-3. [Online], Available: http://www.reproductive-health-journal.com/content/2/1/3 [Downloaded: 04/04/09 05:07 PM].

Durrheim, K., (2006). Ch 9- Basic Quantitative Analysis. In M.,Terre Blanch, K., Durrheim, and D., Painter. (eds). *Research in Practice, 2nd Edition*. Cape Town: University of Cape Town Press: 187- 214.

Evjen-Olsen, B., Hinderaker, S. G., Lie, R. T., Bergsjø, P., Gasheka, P. and Kvåle, G. (2008). Risk Factors for Maternal Death in the Highlands of Rural Northern Tanzania: A Case-Control Study. *BioMed Central Public Health*, 8:52. Full-text. In BioMed Central doi: 10.1186/1471-2458-8-52. [Online], Available: http://www.biomedcentral.com/1471-2458/8/52 [Downloaded: 03/01/09 02:51 PM].

Family Care International. (2007). *Safe Motherhood Initiative: A Review.* New York. [Online], Available: http://www.familycareintl.org/UserFiles/File/SM_A%20Review_Exec_Sum_%20FINAL.pdf . [Downloaded: 03/05/09 05:19 PM].

Fortney, J.A. (2007) Editor's Comment; Lessons and Accomplishments 20 Years After the Safe Motherhood Conference in Nairobi. *International Journal of Gynecology and Obstetrics*, 98: 269- 270.

Ganatra, B.R., Coyaji, K.J., and Rao, V.N. (1998). Too Far, Too Little, Too Late: A Community- Based Case-Control Study of Maternal Mortality in Rural West Maharashtra, India. *Bulletin of the World Health Organisation*, 76 (6): 591-598.

Garenne, M., Mbaye, K., Bah, M. D. and Correa, P. (1997). Risk Factors for Maternal Mortality: a Case-Control Study in Dakar Hospitals (Senegal). *African Journal of Reproductive Health*, 1(1): 14-24.

Government of Botswana and UN. (2010). *Botswana Millenium Development Goals Status Report 2010*. [Online], Available: http:/web.undp.org/africa/documents/mdg/botswana 2010.pdf [Downloaded: 05/29/12 10:20 AM].

Høj, L., da Silva, D., Hedegaard, K., Sandström, A. and Aaby, P. (2002). Factors Associated with Maternal Mortality in Rural Guinea-Bissau. A Longitudinal Population-Based Study. *British Journal of Obstetrics and Gynaecology*, 109: 792-799.

Kanyighe, C., Channon, A., Tadesse, E., Madise, N., Changole, J., Bakuwa, E., Malunga, E. and Stones, R.W. (2008). Determinants of Post-Partum Maternal Mortality at Queen Elizabeth Central Hospital, Blantyre, Malawi: A Case-Control Study 2001-2002. *African Journal of Reproductive Health*, 12 (3): 35-48.

Katzenellenbogen, J. and Joubert, G. (2007). Ch 9- Data Collection and Measurement. In G., Joubert, R., Ehrlich, J., Katzenellenbogen and S., Abdool Karim. (eds). *Epidemiology A Research Manual for South Africa*. Cape Town: Oxford University Press Southern Africa: 106- 123.

Kazaura, M. R., Kidanto, H. L. and Massawe, S. N. (2006). Maternal Mortality at Muhimbili National Hospital, Tanzania, 1999-2005: Levels, Causes and Characteristics. *East African Journal of Public Health*, 3 (2): 23- 25.

Khan, K., Wojdyla, D., Say, L., Gümezoglu, A.M. and Van Look, P. F. A. (2006). WHO Analysis of Causes of Maternal Death: A Systematic Review. *Lancet*, 367: 1066-1074.

Letamo, G. and Rakgaosi, S. D. (2003). Factors Associated with Non-use of Maternal Health Services in Botswana. *Journal of Health, Population and Nutrition*, 21 (1):40-47.

MacLeod, J. and Rhode, R. (1998). Retrospective Follow-up of Maternal Deaths and their Associated Risk Factors in a Rural District of Tanzania. *Tropical Medicine and International Health*, 3 (2): 130-137.

Magadi, M., Diamond, I. and Madise, N. (2001). Analysis of Factors Associated with Maternal Mortality in Kenyan Hospitals. *Journal of Biosocial Science*. 33: 375–389.

Ministry of Finance and Development Planning. (2003). *National Development Plan 9: 2003/04-2008/09* (Government National Plan). Gaborone. [Online], Available: http://www.sarpn.org.za/documents/d0001172/index.php. [Downloaded: 04/16/08 11:58 PM].

Ministry of Health. (2006). *Ministry of Health Confidential Maternal Death Notification Form*. Gaborone: Ministry of Health.

Ministry of Health. (2007). *Maternal Mortality System and the 2007 Report*. Gaborone: Ministry of Health.

Ministry of Health. (2008). *2008 Maternal Mortality Report.* Gaborone: Ministry of Health.

Ministry of Health. (Undated). *All About Unsafe Abortion*. Gaborone. [Online], Available: http://www.gov.bw/Global/MOH/PC_MOH_13.pdf. [Downloaded: 08/14/12 03:02 AM].

Morroni, C. and Myer, L. (2007). Ch 7- Study Designs. In G., Joubert, R., Ehrlich, J., Katzenellenbogen and S., Abdool Karim. (eds). *Epidemiology A Research Manual for South Africa*. Cape Town: Oxford University Press Southern Africa: 77- 93.

Nagaya, K., Fetters, M.D., Ishikawa, M., Kubo, T., Koyanagi, T., Saito, Y., Sameshima, H., Sugimoto, M., Takagi, K., Chiba, Y., Honda, H., Mukubo, M., Kawamura, M., Satoh, S. and Neki, R., (2000). Causes of Maternal Mortality in Japan. *Journal of American Medical Association*, 283 (20): 2661-2667.

Panchal, S., Arria, A. M. and Labhsetwar, S. A. (2001). Maternal Mortality During Hospital Admission for Delivery: A Retrospective Analysis Using a State-Maintained Database. *Anesthesia and Analgesia*, 93:134 –41.

Pattinson, R.C. and Hall, M. (2003). Near Misses: A Useful Adjunct to Maternal Death Enquiries. *British Medical Bulletin*, 67: 231–243.

Simon, S. (2008). *Logistic Regression*. [Online], Available: http://www.pmean.com/webinars/LogisticRegression.html [Downloaded: 04/23/12 06:25 PM].

UN. (2000). *United Nations Millennium Declaration. Resolution adopted by the General Assembly*. New York. [Online], Available: http://www.un.org/millennium/declaration/ares552e.pdf. [Downloaded: 04/06/09 01:53 AM].

UNFPA Africa Regional Office. (2011).*Campaign for Accelerated Reduction of Maternal Mortality in Africa (CARMMA)*. [Online], Available: http://africa.unfpa.org/webdav/site/africa/shared/Documents/CARMMA.pdf. [Downloaded: 05/29/12 05:06 PM].

Uiversity of Reading. (2011). *Statistics and Computing Tip Sheets*. [Online], Available: http://www.reading.ac.uk/maths-and-stats/about/maths-tipsheets [Downloaded: 04/01/12 11:43 PM].

Wacholder, S., McLaughlin, J.K., Silverman, D.T. and Mandel, J.S. (1992a). Selection of Controls in Case-Control Studies III. Design Options. *American Journal of Epidemiology,* 135 (9): 1042- 1050.

Wacholder, S., McLaughlin, J.K., Silverman, D.T. and Mandel, J.S. (1992b). Selection of Controls in Case-Control Studies I. Principles. *American Journal of Epidemiology*, 135 (9): 1019-1028.

Wacholder, S., McLaughlin, J.K., Silverman, D.T. and Mandel, J.S. (1992c). Selection of Controls in Case-Control Studies II. Types of Controls. *American Journal of Epidemiology*, 135 (9): 1029- 1041.

WHO. (1994). *Safe Motherhood Mother-Baby Package: Implementing Safe Motherhood in Countries*. Geneva: WHO. [Online], Available:

http://www.whqlib.who.int/hq/1994/WHO FHE MSM 94.11 Rev.1.pdf [Downloaded: 05/28/12 08:03 AM].

WHO. (2004a). *Beyond the Numbers: Reviewing Maternal Deaths and Complications to Make Pregnancy Safer*. Geneva: WHO. [Online], Available: http://www.who.int/reproductive-health/publications/btn/text.pdf [Downloaded: 02/27/09 07:15 PM].

WHO. (2004b). *International Statistical Classification of Disease and Related Health Problems: Tenth Revision, Volume 2, 2nd Edition*. Geneva: WHO. [Online], Available: http://www.who.int/classifications/icd/ICD-10_2nd_ed_volume2.pdf [Downloaded: 04/06/09 07:27 AM].

WHO. (2005). *Maternal Mortality in 2005: Estimates Developed by WHO, UNICEF, UNFPA, and the World Bank*. Geneva: WHO. [Online], Available: http://www.who.int/whosis/mme_2005.pdf [Downloaded: 04/04/09 09:01 PM].

WHO. (2010). *Trends in Maternal Mortality: 1990 to 2008 Estimates Developed by WHO, UNICEF, UNFPA, and the World Bank*. Geneva: WHO. [Online], Available: http://www.whqlibdoc.who.int/publications/2010/97892411500265_eng.pdf [Downloaded: 05/21/12 04:31 PM].

APPENDICES
APPENDIX 1
RECORD FORM- CASES

Instructions

i. Please complete all the questions
ii. Mark the appropriate block with an X or write the answer in the space provided
iii. Do not omit any item of information
iv. Do not fill in the boxes for office use

For Office Use

Study Number

C	A			

1. Date record form completed (dd/mm/yyyy) …../……./…….

A. MATERNAL CHARACTERISTICS

2. Date of birth or age (years) …../…../……. …… Years

3. Education level

1	No Schooling
2	Primary schooling
3	Secondary
4	Tertiary

4. Employment Status

1	Employed
2	Unemployed

5. Marital status

1	Single
2	Married
3	Widowed
4	Divorced

6. Parity

1	0
2	1-2
3	3-4
4	5 or more

7. Admissions during pregnancy

1	Yes
2	No

8. ANC Attendance

1	Yes
2	No

9. Complications at admission

1	None	
2	Pre-Eclampsia or Eclampsia	
3	Anaemia	
4	Haemorrhage	
5	Obstructed Labour	
6	Ruptured Uterus	
7	Other	please specify _____

10. Type of delivery

1	Normal
2	Ceasarean
3	No delivery

B. HEALTH FACILITY CHARACTERISTICS

11. Type of health facility for delivery

1	clinic with maternity	
2	primary hospital	
3	referral hospital	
4	Other	please specify _____

12. Referral from another facilty

1	Yes
2	No

13. ANC Provider

1	Specialist	
2	Medical Officer	
3	Midwife	
4	Other	please specify _____

C. MATERNAL DEATH INFORMATION

14. Place where death occurred

1	Clinic	
2	Hospital	
3	Home	
4	Other	please specify _____

15. Cause of death _____

APPENDIX 2

RECORD FORM- CONTROLS

Instructions

i. Please complete all the questions
ii. Mark the appropriate block with an X or write the answer in the space provided
iii. Do not omit any item of information
iv. Do not fill in the boxes for office use

For Office Use

Study Number

C	T			

1. Date record form completed (dd/mm/yyyy) …../..…../…….

A. MATERNAL CHARACTERISTICS

2. Date of birth or age (years) …../…../…….
……. Years

3. Education level

1	No Schooling
2	Primary schooling
3	Secondary
4	Tertiary

4. Employment Status

1	Employed
2	Unemployed

5. Marital status

1	Single
2	Married
3	Widowed
4	Divorced

6. Parity

1	0
2	1-2
3	3-4
4	5 or more

7. Admissions during pregnancy

1	Yes
2	No

8. ANC Attendance

1	Yes

	2	No	
9. Complications at admission			☐
	1	None	
	2	Pre-Eclampsia or Eclampsia	
	3	Anaemia	
	4	Haemorrhage	
	5	Obstructed Labour	
	6	Ruptured Uterus	
	7	Other	please specify _____
10. Type of delivery			☐
	1	Normal	
	2	Ceasarean	

B. HEALTH FACILITY CHARACTERISTICS

11. Type of health facility for delivery			☐
	1	clinic with maternity	
	2	primary hospital	
	3	referral hospital	
	4	Other	please specify _____
12. Referral from another facilty			☐
	1	Yes	
	2	No	
13. ANC Provider			☐
	1	Specialist	
	2	Medical Officer	
	3	Midwife	
	4	Other	please specify _____

APPENDIX 3

OFFICE OF THE DEAN
DEPARTMENT OF RESEARCH DEVELOPMENT

01 March 2012

To Whom It May Concern

I hereby certify that the Senate Research Committee of the University of the Western Cape has approved the methodology and ethics of the following research project by:
Mrs T Mokgatlhe (School of Public Health)

Research Project:	Factors associated with maternal mortality in South-East Botswana
Registration no:	10/3/8

Ms Patricia Josias
Research Ethics Committee Officer
University of the Western Cape

APPENDIX 4

Telephone: (267) 363200
FAX (267) 353100
TELEGRAMS: RABONGAKA
TELEX: 2818 CARE BD

MINISTRY OF HEALTH
PRIVATE BAG 0038
GABORONE

REPUBLIC OF BOTSWANA

REFERENCE NO: PPME 13/18/1 PS V (93) 22 March 2010

Health Research and Development Division

Notification of IRB Review: New application

Ms Tuduetso Mokgatlhe
P.O. Box 26317
Gaborone

Protocol Title:	**FACTORS ASSOCIATED WITH MATERNAL MORTALITY IN SOUTH EAST BOTSWANA**
HRU Protocol Number:	HRU 00606
Sponsor:	N/A
HRU Review Date:	19 March 2010
HRU Expiration Date:	18 March 2011
HRU Review Type:	HRU reviewed
HRU Review Determination:	Approved
Risk Determination:	Minimal risk

Dear Ms Mokgatlhe

Thank you for submitting a new Application for the above referenced Protocol.
This approval includes the following:

1. Application form
2. Proposal

This permit does not however give you authority to collect data from the selected sites without prior approval from the management. Consent from the identified individuals should be obtained at all times.

The research should be conducted as outlined in the approved proposal. Any changes to the approved proposal must be submitted to the Health Research and Development Division in the Ministry of Health for consideration and approval.

Furthermore, you are requested to submit at least one hardcopy and an electronic copy of the report to the Health Research, Ministry of Health within 3 months of completion of the study. Approval is for academic fulfillment only. Copies should also be submitted to all other relevant authorities.

If you have any questions please do not hesitate to contact Mr. P. Khulumani at pkhulumani@gov.bw, Tel +267-3914467 or Mary Kasule at mkasule@gov.bw or marykasule@gmail.com Tel: +267-3632466

Continuing Review
In order to continue work on this study (including data analysis) beyond the expiry date, submit a Continuing Review Form for Approval at least three (3) months prior to the protocol's expiration date. The Continuing Review Form can be obtained from the Health Research Division Office (HRDD), Office No. 9A 11 or Ministry of Health website: www.moh.gov.bw or can be requested via e-mail from Mr. Kgomotso Motlhanka, e-mail address: kgmmotlhanka@gov.bw As a courtesy, the HRDD will send you a reminder email about eight (8) weeks before the lapse date, but failure to receive it does not affect your responsibility to submit a timely Continuing Report form

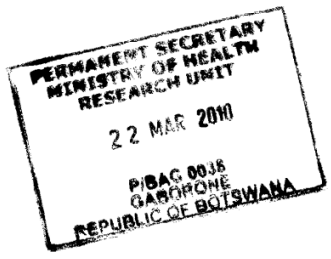
Amendments
During the approval period, if you propose any change to the protocol such as its funding source, recruiting materials, or consent documents, you must seek HRDC approval before implementing it. Please summarize the proposed change and the rationale for it in the amendment form available from the Health Research Division Office (HRDD), Office No. 9A 11 or Ministry of Health website: www.moh.gov.bw or can be requested via e- mail from Mr. Kgomotso Motlhanka, e-mail address: kmotlhanka@gov.bw . In addition submit three copies of an updated version of your original protocol application showing all proposed changes in bold or "track changes".

Reporting
Other events which must be reported promptly in writing to the HRDC include:
- Suspension or termination of the protocol by you or the grantor
- Unexpected problems involving risk to subjects or others
- Adverse events, including unanticipated or anticipated but severe physical harm to subjects.

Do not hesitate to contact us if you have any questions. Thank you for your cooperation and your commitment to the protection of human subjects in research.

Yours sincerely

P. Khulumani
For Permanent Secretary



APPENDIX 5

Princess Marina Hospital
P.O. Box 258
Gaborone Botswana

REPUBLIC OF BOTSWANA

Tel: 3621400
Fax: 3973776
Email: ygureja@gov.bw (chairman)
boisa2002@yahoo.com. (Secretary)

PRINCESS MARINA HOSPITAL INSTITUTIONAL REVIEW BOARD

Our Ref: PMH2/09-081

Date: 19 April 2010

Ms Tududetso Mokgatlhe
University of Western Cape
Cape Town

Dear Ms Mokgatlhe

RE: Factors Associated with Maternal Mortality in South East Botswana

Reference is herein made to the request for Ethical review of the above titled study submitted to the Research and Ethics Committee of Princess Marina Hospital. Following a review, the amendments have been approved on condition that the researcher:

- Seeks permission from the head of the institution/department in which the study will be conducted.
- Resubmit for approval should any changes be made to the protocol.
- Provide both a hard and an electronic copy of the report when the study is finished.

The study permit is still valid for a period of one year, from the date of this letter.

The Committee would like to communicate its support in this very important endeavour. Your continued communication and update is greatly appreciated.

Yours sincerely,

Boitumelo Mokgatla-Moipolai
Secretary
Contacts: 362 1778 (Office) or 71543980
Email: Boisa2002@yahoo.com

APPENDIX 6

TELEPHONE: (267) 5390212
FAX: (267) 5390826

BAMALETE LUTHERAN HOSPITAL

P.O. BOX V6
RAMOTSWA
BOTSWANA

Ramotswa, 07/06/2010

Ms. Tuduetso Mokgatlhe
P. O. Box 26317
Gaborone

RE: Request to do research at BLH

Dear Ms. Mokgatlhe,

Your request to conduct a research project at the Bamalete Lutheran Hospital has been discussed by management.

The request is granted.

You are requested to provide a copy of the research findings and report to the CMO office.
You are asked to fully share the results with the staff as soon as possible.

I wish you well for the research and hope you will be benefiting from the project as well as our institution.

Kind regards

Dr. S. Ostmann
Chief Medical Officer