KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY

Analysis Of Maternal Mortality In Wa District

By

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A THESIS SUBMITTED TO THE DEPARTMENT OF MATHEMATICS, KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY IN PARTIAL FUFILLMENT OF THE REQUIREMENT FOR THE DEGREE OF M.PHIL MATHEMATICAL STATISTICS

October 10, 2014

Declaration

I hereby declare that this thesis is the result of my own research work towards the award of the M. Phil degree and that, to the best of my knowledge, it contains no material previously published by another person nor material which had been accepted for the award of any other degree of the university, except where due acknowledgement had been made in the text.

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Dedication

This thesis is dedicated to my wife Nadiratu, my daughter Rajhaan and my sons Hamaad and Raagib.

Abstract

The research examined the occurrence and incidence of maternal deaths in Wa district from 1998 to 2010 as well as assessed the factors that contribute to maternal deaths at the Upper West Regional Hospital (UWRH) from 2008 - 2012. Poisson and logistic regression models were employed. Poisson regression model was used to examine the occurrence and incidence of maternal deaths while logistic regression was used to assess the factors that contribute to maternal death at UWRH. SAS and STATA statistical software were used to analyze the data. We found that, the mean number of occurrence of maternal mortality was high in 2001 and 2009 as compared to 2010 and also established that the mean number of occurrence of maternal mortality did not significantly reduce over the study period 1998-2010. The incidence of maternal mortality was high in 2001 but low in 2002, 2004 and 2008 as compared to 2010 (reference year). We also found that, the mean incidence of maternal death cases did not change. Finally, it was revealed that age, parity and delivery type contributed significantly to pregnancy outcome at the UWRH.

Acknowledgment

I would like to express my sincere gratitude to the almighty Allah for seeing me through this programme especially this thesis. My sincere thanks go to my supervisor Dr. R. K. Avuglah, for supervising this thesis and offering directions, suggestions and encouragement during the entire duration of the research work not forgetting the positive criticisms made by Mr. Emmanuel Harris of Mathematics Department (KNUST) that has brought me this far. I owe a debt of gratitude to Mr. Zacchi Sabogu of Ghana Health Service, Wa for his immense assistance during the data collection. I am also grateful to my office staff Mr. Amatus Sonviele Nobabumah, Mr Kanyiri Dekongmene Yakubu, Mr. Bisilin Alhassan, Mr. John Gambo and the Upper West Regional Statistician Mr. Sixtus J. Dery. I dully acknowledge here, the contribution of my class mates, friends and family.

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Chapter 1

Introduction

1.1 Background of the study

Pregnancy and childbirth are physiological events that should bring joy to the woman, the family and the society at large, but sometimes it turns out to be a source of sorrow. For some women in certain parts of the globe, particularly in developing countries, the reality of motherhood is often grim. For those women, motherhood is often marred by unforeseen complications or even a loss. Some women lose the fetus even before being born or shortly after birth; whiles some lose both their lives and the lives of their babies. Maternal processes in Africa are prone to crises as a result of multiple socio-economic and religious factors which interact with biological factors. A combination of cultural beliefs and practices, male-dominance, low status of women and high fertility affect pregnancy outcomes in the continent, especially in sub-Saharan Africa (Senah, 2003; AbouZahr (2007); Nwokocha (2007)).

Maternal mortality refers to the death of a woman from any cause related to or aggravated by pregnancy or its management (excluding accidental or incidental causes) during pregnancy and childbirth or within 42 days of termination of pregnancy, irrespective of the duration and site of the pregnancy (WHO).
According to the recent global estimates by World Health Organisation (WHO), the United Nation Children's Fund (UNICEF) and the World Bank, close to six hundred thousand women die annually from pregnancy-related complications, ninety-nine percent of which occur in less developed world. This situation makes maternal mortality the health indicator that shows the largest disparity between

developed and developing countries. In sub-Saharan Africa, one out of every 13 women dies of pregnancy-related causes during their lifetime as with one in 4,085 women in industrialised countries [McAlister and Baskett (2006)].

For every maternal death, approximately 30 more women suffer injuries, infections and disabilities during pregnancy or child birth - at least 15 million women a year. In Ghana one in 45 women has a risk of dying from pregnancy-related causes in her lifetime (WHO, UNICEF and World Bank, 2008).

It is therefore evident that developing countries continue to bear the larger portion of pregnancy-related deaths. It is also recognized that access to skilled delivery care of good quality will contribute to reducing maternal and prenatal mortality and morbidity. The importance of this situation is reflected in the Millennium Development Goal (MDG) 5 aimed at reducing maternal mortality ratios by 75% by the year 2015. In Ghana, maternal mortality ratio is estimated to range from 214 to 700 per 100,000 live births. These figures have persisted for some time despite various policies and initiatives including an Antenatal Care policy and the Safe Motherhood initiative African (2006).

In recent years, Ghana's maternal mortality ratio (MMR) decreased from 580 deaths out of 100,000 live births in 2007 to 485 deaths in 2010 (GMHS, 2007; PHC, 2010). According to CIA world fact book report (2011), Ghana has been ranked 41st on the world maternal mortality rate index. Ghana rates 350 deaths per 100,000 live births, Greece two deaths per 100,000 live births, Tunisia - 60 deaths / 100,000; South Africa - 410 deaths / 100,000; Burkina Faso - 560 deaths / 100,000; Nigeria - 850 deaths / 100,000; Sierra Leone - 970 deaths / 100,000; Liberia - 990 deaths / 100,000; Somalia - 1,200 deaths / 100,000; Guinea Bissau - 1,000 deaths / 100,000; Chad - 1,200 deaths / 100,000 and Afghanistan - 1,400 / 100,000.

The recent WHO/UNICEF/UNFPA/World Bank (2012) estimate of maternal mortality ratio for Ghana in 2010 was 350 deaths per 100,000 live births, with an uncertainty range between 210 and 630, taking into account the impact of sampling errors on the estimates constructed by the international organizations. The maternal mortality ratio of 485 deaths per 100,000 live births based on the 2010 Population and Housing Census data therefore appears to be a satisfactory indicator of the level of maternal mortality in the country. The report further shows a mortality ratio of 466 deaths per 100,000 live births for the Upper West Region as compared to 355 deaths per 100,000 live births for the Greater Accra Region, GSS (2013) as shown in Table 1.1. Again, this differential reflects inequities in access to health services, and highlights the gap between rich and poor.

Table 1.1: Showing the regional distribution of maternal mortality in Ghana

Country/Region	MM ratio (per 100,000 live birth)	MM rates (per 1,000 women)
Total Country	485	5
Western	435	4
Central	520	5
Greater Accra	355	2
Volta	606	6
Eastern	538	5
Ashanti	421	3
Brong Ahafo	421	4
Northern	531	5
Upper East	802	6
Upper West	466	4

Source: Ghana Statistical service 2010 Population and Housing Census

In the contemporary world, subjecting women to poor maternal health situation is considered as a violation of their rights (Republic of Ghana, 1992). According to the 1994 International Conference on Population and Development (ICPD), maternal mortality rate is perceived as a critical index of the level of development of a country. Consequently, nations all over the world have instituted programmes and policies within their available resources to combat this menace (McAlister and Baskett, 2006).

Global attention began to focus more seriously on maternal health when in 1985, Rosenfield and Maine published a thought provoking article in the Lancet entitled 'Maternal Mortality - neglected tragedy - where is the 'M' in MCH?' The article alerted the world that many developing countries were neglecting this important problem and that existing programmes were unlikely to reduce the high maternal mortality rates in the developing world. Almost immediately, Harrison (1985) conducted a research and his analysis of 22,774 consecutive hospital births in Zaria, Northern Nigeria, showed the appalling mortality associated with childbirth. The research findings also drew attention to the importance of social and cultural factors as critical underlying factors in the causation of high mortality and morbidity associated with pregnancy and delivery.

Another significant contribution to the crusade against maternal mortality was the WHO (1986) publication, Maternal Mortality: helping women off the road to death. All these led to the safe motherhood conference in Nairobi, Kenya (1987), where speakers presented global statistics on death and complications resulting from pregnancy and childbirth. They also showed that in sub-Saharan Africa, the lifetime risk that a woman would die in child birth was one in 21 and that this was 400 times higher than the lifetime risk for their counterparts in Western Europe or North America; Senah (2003). The conference concluded with strong recommendations about maternal health, and so the safe motherhood initiative was born. The call to action of the SMI demanded that health workers involved in the care of mothers and children took positive steps to reduce maternal morbidity and mortality. The target of this initiative was the reduction of the estimated yearly world maternal mortality figure of 500,000 by 50% by the year 2000. Since then, a number of international conferences have established goals related to the environment, population, development and health.

In 1998, the Government of Ghana introduced free antenatal care for all pregnant women and in September 2003, an exemption policy directed at making child delivery care free was also put in place. The thrust of these policies have been to improve uptake, quality financial and geographic access to delivery care services. The services covered by the exemption policy are normal deliveries, assisted deliveries, including Caesarean section and management of medical and surgical complications arising out of deliveries, including the repair of vesico-vaginal and recto-vaginal fistulae. The policy covered delivery services in public, private and faith-based health facilities.

1.2 Statement of the Research Problem

The rate of maternal mortality is an important indicator of a nations' socioeconomic welfare. Over 20 years after the Nairobi Conference, and over a decade after the 2000 World Summit, maternal health problems still confront Ghana and other developing countries perhaps, even more than ever before (Bawah, 2008). Research indicates that the developed world has been able to reduce maternal mortality through effective and efficient health care services such as provision of ambulatory services including accessible and motorable roads to deal with obstetric emergency conditions at all places, and training of qualified personnel for antenatal care and delivery services. Bawa (2008).

In Ghana, efforts made by successive governments to reduce maternal mortality and morbidity have resulted in the institutionalisation of policies and programmes in the form of interventions, such as: building of several maternal and child health (MCH) clinics across the country and expanding the existing ones; the training of over 6,000 traditional birth attendants (TBAs); the development of safe motherhood protocol for all levels of health institutions; the institution of free antenatal care (ANC) services and free child delivery policy; provision of ambulance service and the establishment of National Health Insurance Scheme (NHIS), among others (UNDP, 2007; GSS, GHS, and ICF Macro, 2008). Despite these efforts, maternal mortality rate is still unacceptably high in the country and the Wa district is no exception. The Upper West Region recorded 28 maternal deaths from January to May this year, a figure which represents the total figure for 2012. Given this current situation in the region, health authorities and other stakeholders fear that the region could experience a worse or similar situation that occurred in 2009 where it recorded 43 maternal deaths, if decisive measures are not taken to stem the trend. The trend, coupled with inadequate number of health facilities and personnel to help provide quality health care, has also put fears in many pregnant women in the region whose lives are at stake (GHS Wa, 2013).

Ghana's target is to reduce maternal mortality ratio to 54 per 100,000 live births by 2015 (MDG5). This target, according to health professionals and institutions, is likely not to be achieved within the expected period. However, there is little or no statistical evidence to justify this accession and very little studies have gone into the occurrence and incidence of maternal deaths especially in Wa district.

It is based on this premise that a retrospective study is necessary to examine the significance of the occurrence and incidence of maternal mortality in Wa district.

1.3 Research Objectives

To examine the significance of the occurrence and incidence of maternal mortality in Wa district.

To assess the factors that contributes to maternal mortality at the Upper West Regional Hospital (UWRH).

1.4 Methodology

Poisson regression model would be employed to examine the occurrence and incidence of maternal mortality in Wa district for the period 1998 - 2010. Binary logistic regression would be used to determine which factors affect the outcome of pregnancy at Upper West Regional Hospital. Sources of data would include the upper west regional hospital records and the regional annual reports of Ghana health service, Wa. The variables of interest for the study include supervised deliveries, maternal mortality ratios, delivery type and outcome of delivery, duration of stay at the hospital, gravid, parity and age. Statistical package SAS and STATA would be used to analyze the data.

1.5 Justification of the Study

The Millennium Development Goal Five seeks to improve maternal health and reduce maternal deaths by three-quarters by 2015 and improve skilled attendants to 95 percent by 2015. The government of Ghana, development partners and other stakeholders have implemented programs in pursuit of improving maternal health and in effect reducing maternal mortality.

Despite these laudable policies and programs, maternal mortality in Ghana is still unacceptably high. Although high maternal mortality rates and absence of gynaecologists and obstetricians are positively correlated, many of the programs established in the developing countries to improve maternal health care have not been shown to reduce maternal mortality (AbouZahr, 2007). The Upper West Region has recorded 28 maternal deaths from January to May 2013 and 13 of the deaths were recorded in the upper west regional hospital which is in the study area. The Upper West Regional Hospital is the referral hospital for the region, some part of Northern region and some communities in neighboring Burkina Faso.

The findings of this study will therefore be relevant to all stakeholders concerned about reducing maternal mortality by promoting maternal health in the study area and the country at large. The findings would also provide the needed statistical evidence to justify the success or failure of programs implemented so far. The model that will be generated would be useful in predicting the likelihood of maternal deaths in the Upper West Regional hospital. The study also seeks to furnish decision makers and other stakeholders with vital information regarding the trend of supervised delivery and maternal mortality in the facility for possible policy intervention. Finally, this study would stimulate further research in the application of Poisson regression model in the area of maternal health and mortality.

1.6 Scope of the Study

This research was limited or restricted to the former Wa district in the upper west region because of limited resources and time. Wa district in 2004 was split into three districts; namely, Wa municipal, Wa west and Wa east districts. For the purpose of this study the three districts were considered as one. Data on supervised delivery and maternal deaths in Wa district from 1998 to 2010 were extracted from annual reports and other documents of GHS (2010) Wa. Five years (2008-2012) information was also extracted from the registers at the Obstetrics and Gynaecology Unit of the Upper West Regional Hospital in Wa. This information includes; duration of stay, month, year, quarter, parity, gravid, delivery type and outcome for further analysis.

1.7 Organisation of Thesis

The study is organized in fives chapters. Chapter one is the introduction which comprises background issues, statement of research problem, research objective, methodology, justification of the study, the scope of the study and finally the organization of the thesis.

Chapter two contains the review of related literature and research in other fields in the mathematical theories and models under consideration have been applied.

Chapter three, deals with the mathematical concept of Poisson regression model and logistic regression analysis.

Chapter four covers data analysis and discussions. It deals with preliminary statistical analysis of the data, further analysis using the statistical models mention above and discussion of the results from the analysis.

The final part is chapter five. It presents conclusions and recommendations based on the findings.

Chapter 2

Literature Review

2.1 Introduction

This chapter discusses the available literature on Maternal Mortality in general.

2.2 State of Maternal Mortality

Maternal mortality is defined as the death of a woman while pregnant or within 42 days of termination of pregnancy, irrespective of the duration and site of the pregnancy, from any cause related to or aggravated by the pregnancy or its management (WHO-ICD 10).

Globally, some 287,000 women die annually while about 800 die daily from pregnancy-related complications. A woman's lifetime risk of maternal death - the probability that a 15 year old woman will eventually die from a maternal cause - is 1 in 3800 in developed countries, versus 1 in 150 in developing countries, WHO (2012). Most of these deaths occur in the developing world.

The fifth Millennium Development Goal is to improve maternal health, with a target to reduce the maternal mortality ratio by three quarters, between 1990 and 2015. Yet maternal mortality in developing countries has barely decreased over the past decade, and in parts of Africa it has increased. The national target for Ghana was to reduce the 1990 maternal mortality rate of 740 per 100,000 live births by 3/4 to 185 per 100,000 live births by 2015. In this thesis, we also looked at the prevalence of maternal mortality and the survival of pregnant women who go to the Upper West Regional Hospital to deliver.

The international definition of the maternal mortality ratio (MMR) is the number of Direct and Indirect deaths per 100,000 live births (ICD-10).

$$MaternalMortalityRatio = \frac{TotalMaternalDeaths}{TotalLiveBirths} \times 100,000 livebirths$$

In the journal of perinatology, Goffman. et al. (2007) published an article entitled "Predictors of maternal mortality and near-miss maternal morbidity". This article sought to identify risk factor for life-threatening outcomes.

Cases of maternal mortality and near-miss morbidity from the Weiler Hospital of the Albert Einstein College of Medicine/ Montefiore Medical Center, an inner city Regional Perinatal Center, from January 1995 through June 2001 were identified through quality improvement records, intensive care unit (ICU) admission records and a computerized search of the medical record database using ICD-9 discharge diagnoses. They defined near-miss morbidity as ICU admission, emergency unplanned return to the operating room or delivery room for hemorrhage, eclampsia, emergent hysterectomy, cardiac arrest, cerebral anoxia, shock and embolism. Maternal deaths were defined as those occurring in pregnancy, or within 1 year of pregnancy due to a pregnancy-related cause. They selected three unmatched controls from the same day that each case delivered. Significant risk factors were identified through simple and best subsets multiple logistic regression.

The research revealed eight cases of mortality and 69 near-miss cases. Significant risk factors with their odds ratios and 95% confidence intervals were: age 35 to 39 years (2.3, 1.2 to 4.4) and > 39 years (5.1, 1.8 to 14.4); African-American race (7.4, 2.5 to 22.0) and Hispanic ethnicity (4.2, 1.3 to 13.2); chronic medical condition (2.7, 1.5 to 4.8); obesity (3.0, 1.7 to 5.3); prior cesarean (5.2, 2.8 to 9.8) and gravidity (1.2, 1.1 to 1.5 per pregnancy). In multivariable logistic regression, race remained significant while controlling for other significant factors and markers of socioeconomic status. They concluded that some risk factors can be modified through medical care, education or social support systems. Racial disparity in outcome was confirmed and was unexplained by traditional risk factors.

Qin (2010) of the University Of Leicester conducted a Hospital-Based Review of Maternal Mortality in Ghana. This retrospective review was undertaken at the Obstetrics and Gynaecology Department of Komfo Anokye Teaching Hospital (KATH) in Kumasi, Ghana. Data from biostatistics unit as well as all maternal deaths following admission from the period 1st January 2008 to 31st May 2010 were analyzed. The result revealed an estimated maternal mortality ratio of 1021.9 per 100 000 live births (95% CI: 906.6 - 1130.8). This result is consistent with other institutional-based studies in Ghana.

Aremu et al. (2011) published a research that investigated the effect of neighborhood and individual socioeconomic position on the utilization of different forms of place of delivery among women of reproductive age in Nigeria. A population-based multilevel discrete choice analysis was performed using the most recent population-based 2008 Nigerian Demographic and Health Surveys data of women aged between 15 and 49 years. The analysis was restricted to 15,162 ever-married women from 888 communities across the 36 states of the federation including the Federal Capital Territory of Abuja. It was revealed that, the choice of place to deliver varies across the socioeconomic strata. The results of the multilevel discrete choice models indicated that with every other factor controlled for, the household wealth status, women's occupation, women's and partner's high level of education attainment, and possession of health insurance were associated with use of private and government health facilities for child birth relative to home delivery. The results also show that higher birth order and young maternal age were associated with use of home delivery. Living in a highly socioeconomically disadvantaged neighborhood is associated with home birth compared with the patronage of government health facilities. More specifically, the result revealed that choice of facility-based delivery is clustered around the neighborhoods. The study concluded that, home delivery cuts across all socioeconomic strata, and is a common practice among women in Nigeria. Initiatives that would encourage the appropriate use of healthcare facilities at little or no cost to the most disadvantaged should be accorded the utmost priority.

In his thesis titled "Analysis of Maternal Mortality with time: A case study of Okomfo Anokye Teaching Hospital- Kumasi (2000-2010)", Sarpong (2012) conducted a Hospital-Based retrospective analysis of the occurrence and incidence of Maternal Deaths as well as maternal mortality ratios at the Okomfo Anokye Teaching Hospital in Kumasi from 2000 to 2010. The study explored the feasibility for application of Poisson models and time series autoregressive integrated moving average (ARIMA) in the study of occurrence and incidence of Maternal Deaths and to predict Maternal Mortality ratios respectively. The results revealed that, the mean number of occurrence of maternal death cases were high for all the years considered and established that the mean number of occurrence of maternal death cases has not significantly reduced over the period 2000 to 2010. The hospitals Maternal Mortality Ratio (MMR) is relatively stable but has a very high average MMR of 967.7 per 100,000 live births. Although the ARIMA model adequately fits the data and is useful for predicting future mortality ratios, it is not recommended for medium and long term predictions.

Rahman et al. (2010) analyzed the temporal association between socioeconomic development indices and improved maternal, neonatal and perinatal survival in the state of Qatar over a period of 35 years (1974-2008). During this period a total of 323,014 births were recorded. The study revealed a remarkable decline ($p < 0.001$) in Qatar's neonatal mortality rate from 26.27/1000 in 1974 to 4.4/1000 in 2008 and in the perinatal mortality rate from 44.4/1000 in 1974 to

10.58/1000 in 2008. The maternal mortality rate for Qatar remained zero during 1993, 1995 and then in 1998-2000. The rate was however highest in 2008, 11.6/100,000 but remained approximately 10/100,000 live births for the rest of the years. The study also revealed a temporal association between the reduction in poverty, increased in maternal education and improved perinatal health care with a significant improvement in maternal, neonatal and perinatal survival.

Aikins (2010) in her thesis conducted at Komfo Anokye Teaching Hospital (KATH) in Kumasi, revealed an unstable situation regarding maternal deaths even though pregnant women have free access to antenatal care. The study aimed at finding out whether the free antenatal and delivery care provided by government is encouraging pregnant women to access the facility in order to improve maternal health and also, whether it is aiding in the reduction in maternal deaths. The study indicated that the presence of skilled birth attendants at delivery as per pregnant woman ratio is quite poor. The ratio is one doctor is to 17,733 and the Nurse-Population ratio is 1: 1,510 with disparities between urban and rural settings and dwellers. In Kumasi for instance, the Ratio of Midwives to Women of Reproductive Age is 1:427.

In the journal of Epidemiology Community Health 2009, Fernández et al. (2008) published a research report titled "Increase in maternal mortality associated with change in the reproductive pattern in Spain: 1996-2005". Their study aimed at analyzing the age-related trend in the maternal mortality ratio among mothers in Spain for the decade 1996-2005, and to describe the causes of death and associated socio-demographic factors for the years with highest mortality. An ecological study on trends, for the age-related trend in the maternal mortality ratio; an indirect standardization and Poisson regression model was used. They found that, Prevalence of live births among mothers aged 35 years and over was 15% higher in Spain than in Europe. The maternal mortality rate increased by 20% (standardized mortality ratio of 1.2, 95% CI 0.9 to 1.4) in 2005 with respect to 1996. The age-related risk of maternal mortality was three times higher (relative risk of 2.90, 95% CI 2.01 to 4.06) among mothers aged 35-44 years as compared to those aged under 35 years. The highest mortality was detected during 2003-2004. The study therefore concluded that there was a change in the maternal mortality trend characterized by an increase in deaths, associated with advanced maternal age, as well as an increase in the prevalence of live births among mothers aged 35 years and over.

Obiechima et al. (2013), conducted a research on maternal mortality at Nnamdi Azikiwe University Teaching Hospital (NAUTH) in Southeast Nigeria. The study sought to assess NAUTH'S progress in achieving a 75% reduction in the maternal mortality ratio (MMR) and to identify the major causes of maternal mortality. It was a 10-year retrospective study, conducted between January 1, 2003 and December 31, 2012. During the study period, there were 8,022 live births and 103 maternal deaths, giving an MMR of 1,284/100,000 live births. The MMR was 1,709 in 2003, reducing to 1,115 in 2012. This is to say that there was a 24.86% reduction over 10 years, hence, in 15 years; the reduction should be 37İThis extrapolated reduction over 15 years is about 38% less than the target of 75% reduction. The major direct causes of maternal mortality in this study were: pre-eclampsia /eclampsia (27%), hemorrhage (22%), and sepsis (12%). The indirect causes were: anemia, anesthesia, and HIV encephalopathy. Most of the maternal deaths occurred in unbooked patients (98%) and within the first 48 hours of admission (76%). The study concluded that MMRs in NAUTH were still very high and the rate of reduction was very slow. At this rate, it will take NAUTH 30 years, instead of 15 years, to achieve a 75% reduction in maternal mortality.

Adamu et al. (2002) published an article in the European Journal of Obstetrics and Gynecology and Reproductive Biology,titled "Maternal mortality in Northern Nigeria: a population-based study" by . They sought to determine the incidence and causes of maternal mortality as well as its temporal distribution over the last decade (1990-1999). All maternal deaths recorded within the study period in the State of Kano, Northern Nigeria, were analyzed. Maternal mortality ratios (MMR) were computed using the Poisson assumption to derive confidence intervals around the estimates. A non-linear regression model was fitted to obtain the best temporal trajectory for MMR across the decade of study. Their study reveals that a total of 4154 maternal deaths occurred among 171,621 deliveries, yielding an MMR of 2,420 deaths per 100,000. Eclampsia, ruptured uterus and anemia were responsible for about 50% of maternal deaths. They concluded that the area had one of the highest maternal mortality ratios in the world and suggested that maternal mortality could be reduced by half at the study site with effective interventions targeted to prevent deaths from eclampsia, ruptured uterus and anemia.

In International Journal of Women's Health, Garenne et al. (2013), published an article titled "maternal mortality in rural South Africa: the impact of case definition on levels and trends". According to them, uncertainty in the levels of global maternal mortality reflects data deficiencies, as well as differences in methods and definitions. Their study presented levels and trends in maternal mortality in Agincourt, a rural sub district of South Africa, under long-term health and socio-demographic surveillance. All deaths of women aged 15 years-49 years occurring in the study area between 1992 and 2010 were investigated, and causes of death were assessed by verbal autopsy. Two case definitions were used: "obstetrica" (direct) causes, defined as deaths caused by conditions listed under O00-O95 in International Classification of Diseases-10; and "pregnancy-related deaths", defined as any death occurring during the maternal risk period (pregnancy, delivery, 6 weeks postpartum), irrespective of cause. The study revealed that, case definition had a major impact on levels and trends in maternal mortality. The obstetric mortality ratio averaged 185 per 100,000 live births over the period (60 deaths), whereas the pregnancy-related mortality ratio averaged 423 per 100,000 live births (137 deaths). Results from both calculations increased over the period, with a peak around 2006, followed by a decline coincident with the national roll-out of Prevention of Mother-to-Child Transmission of HIV and antiretroviral treatment programs. The result indicated that mortality increase from direct causes was mainly due to hypertension or sepsis. Mortality increase from other causes was primarily due to the rise in deaths from HIV/AIDS and pulmonary tuberculosis. These trends underline the major fluctuations induced by emerging infectious diseases in South Africa, a country undergoing rapid and complex health transitions. Findings also pose questions about the most appropriate case definition for maternal mortality and emphasize the need for a consistent definition in order to better monitor and compare trends over time and across settings.

In their study titled "Maternal mortality in the former East Germany before and after reunification: changes in risk by marital status", Razum et al. (1999), examined the impact of marital status on maternal mortality in the period before and the period after German reunification in the area covered by the former East Germany. They calculated the maternal mortality ratio by relating the number of maternal deaths among women resident in eastern Germany in 1980-96 to the respective number of live births, using national register data. They then investigated the effect of marital status, controlling for maternal age and year of death, in a Poisson regression model. Altogether, 413 maternal deaths and 2.99 million live births were reported. The overall maternal mortality ratio was stable before, and declined after, reunification. Before reunification, unmarried women had a risk of maternal death equal to that of married women; after reunification, they had 2.6 times the age adjusted risk of married women. Unmarried status thus became a significant risk factor for maternal mortality in eastern Germany after reunification.

Sullivan et al. (2003), published the report of their study titled "Maternal-fetal medicine specialist density is inversely associated with maternal mortality ratios" in the American Journal of obstetric and Gynecol. (2005). Their objective was to determine the relationship between state-specific maternal mortality ratios and the density of maternal-fetal medicine specialists. State maternal mortality ratios from 1994 to 2001 were calculated from the Centers for Disease Control and Prevention WONDER database. Practitioner distribution data were obtained from professional associations. Demographic information regarding states was gathered from the 2000 US census data. Bivariable and multivariable analyses were conducted with the use of Spearman correlations and Poisson regression, respectively. The study showed that an increase of 5 maternal-fetal specialists per 10,000 live births results in a 27% reduction in the risk of maternal death ($relativerisk[RR] = 0.73$, $95\%CI = 0.58 - 0.93$, $P = 0.012$). This risk reduction was based on a multivariable Poisson regression model that included the following variables and their significant interactions: state-specific percentages of mothers in poverty, mothers without a high school diploma, minority mothers, and teenage mothers. The density of maternal-fetal medicine specialists is significantly and inversely associated with maternal mortality ratios, even after controlling for state-level measures of maternal poverty, education, race, age, and their significant interactions.

Agan et al. (2010) did a study titled "Trends in maternal mortality at the university of Calabar teaching hospital, Nigeria 1999 - 2009". They sought to assess trends in maternal mortality in a tertiary health facility, the maternal mortality ratio, the impact of sociodemographic factors in the deaths, and common medical and social causes of these deaths at the hospital. The study was a retrospective review of obstetric service delivery records of all maternal deaths over an 11-year period (01 January 1999 to 31 December 2009). All pregnancy-related deaths of patients managed at the hospital were included in the study. The results indicate that, a total of 15,264 live births and 231 maternal deaths were recorded during the period under review, giving a maternal mortality ratio of 1513.4 per 100,000 live births. In the last two years of the study period, there was a downward trend in maternal deaths of about 69.0% from the 1999 value. Most (63.3%) of the deaths were in women aged 20-34 years, 33.33% had completed at least primary education, and about 55.41% were unemployed. Eight had tertiary education. Two-thirds of the women were married. Obstetric hemorrhage was the leading cause of death (32.23%), followed by hypertensive disorders of pregnancy. Type III delay accounted for 48.48% of the deaths, followed by Type I delay (35.5%). The results also revealed that, about 69.26% of these women had no antenatal care. The majority (61.04%) died within the first 48 hours of admission. The study concluded that, although there was a downward trend in maternal mortality over the study period, the extent of the reduction is deemed inadequate. The medical and social causes of maternal deaths identified in this study are preventable, especially Type III delay. Efforts must be put in place by government, hospital management, and society to reduce these figures further. Above all, they recommended that, there must be an attitudinal change towards obstetric emergencies by health care providers.

The Journal of China Medical University in March 2011 conducted a study. The study was to explore the feasibility for application of time series ARIMA model to predict the maternal mortality ratio (MMR) in china so as to provide the theoretical basis for continuing to reduce the MMR. ARIMA model was established based on the MMR of China from 1991 to 2009. Using difference method to smooth the sequence, they determined the order and established the 2010 national maternal mortality ratio forecast model to evaluate the predicting results. It was found that ARIMA model fitted very well, the residual autocorrelation function graph showed the residuals were white noise sequences, the prediction results showed that maternal mortality ratio in national urban and rural areas would be 30.39%, 24.73% and 28.80% in 2010, which showed MMR, would decline and reach a lower level. The researchers concluded that the fitting result in ARIMA model of the incidence of the MMR is satisfactory, the forecasting achieve good effects, which also provides scientific basis for the prevention and control of maternal mortality ratio.

Yoko and Edwin (2011), did a study titled "Make it happen 2015: validation of the maternal mortality ratio in Trinidad and Tobago for 2000-2006". The aim of their work was to examine the quality of the data used for the estimates of MMR provided by the Trinidad and Tobago Central Statistical Office (CSO). A retrospective reproductive age mortality survey (RAMOS) was applied for 200-2006 to evaluate national estimates. They found that, data from CSO and external data sources yield conflicting results. The CSO estimate of MMR in 2005 was 34.8, while those provided by UNICEF and the World Bank were 45.0 and 55.0, respectively. They recommended that specific maternal death review committee be established as the ideal maternal death review mechanism across all health jurisdictions in Trinidad and Tobago.

Hogan et al. (2010), assessed levels and trends in maternal mortality for 181 countries in their report titled "Maternal mortality for 181 countries, 1980-2008: a systematic analysis of progress towards Millennium Development Goal 5". They constructed a database of 2651 observations of maternal mortality for 181 countries for 1980-2008, from vital registration data, censuses, surveys, and verbal autopsy studies. They used robust analytical methods to generate estimates of maternal deaths and the MMR for each year between 1980 and 2008. They explored the sensitivity of the data to model specification and show the out-of-sample predictive validity of the methods. As a result, they estimated that there were 342,900 maternal deaths worldwide in 2008, down from 526,300 in 1980. The global MMR decreased from 422 in 1980 to 320 in 1990, and was 251 per 100 000 live births in 2008. The yearly rate of decline of the global MMR since 1990 was 1.3%. They found out that in the absence of HIV, there would have been 281,500 maternal deaths worldwide in 2008.The report concluded that, although substantial progress has been made towards MDG 5, only 23 countries are on track to achieving a 75% decrease in MMR by 2015 and that countries such as Egypt, China, Ecuador, and Bolivia have been achieving accelerated progress.

Gonzales et al. (2013), conducted a research on pregnancy outcomes associated with cesarean deliveries in Peruvian public health facilities. Their study stemmed out of reports on continuous rise in the rate of cesarean deliveries in many countries over recent decades. This trend has prompted the emergence of a debate on the risks and benefits associated with cesarean section. The study was therefore designed to estimate cesarean section rates over time during the period between 2000 and 2010 in Peru and to present outcomes for each mode of delivery. The research considered a secondary analysis of a large database obtained from the Perinatal Information System, which includes 570,997 pregnant women and their babies from 43 Peruvian public health facilities in three geographical regions: coast, highlands, and jungle. The study revealed that, over 10 years, 558,901 women delivered 563,668 infants weighing at least 500 g. The cesarean section rate increased from 25.5% in 2000 to 29.9% in 2010 (26.9% average; $P < 0.01$). The rate of stillbirths was lower with cesarean than vaginal deliveries ($P < 0.01$). On the other hand, and as expected, the rates for preterm births, twin pregnancies, and preeclampsia were higher in women who delivered by cesarean section ($P < 0.01$). More importantly, the rate of maternal mortality was 5.5 times higher in the cesarean section group than in the vaginal delivery group. The data suggest that cesarean sections are associated with adverse pregnancy outcomes.

Worawan (2010) undertook a study aimed at using multiple sources of data to calculate the maternal mortality ratio (MMR) in 2004-2009, and to illustrate the difference between the official causes of death with the research findings. In the research titled "Thailand's approach to measuring maternal mortality ratio" individual data from civil registration and inpatient records from all public hospitals were used. The civil registration contains data about individual's personal identification (PID) and so forth. The result showed that, the number of maternal deaths declined from 362 in 2004 to 269 in 2009. The country's MMR declined from 44.5 to 35.2, a 21% reduction. The conclusion was that, using matching technique together with individual data, policy makers can get reliable information about the causes of maternal death.

In International Journal of Women's Health, Dinyain et al. (2013), published a report of their study titled "Autopsy-Certified Maternal Mortality at Ile-Ife, Nigeria". The study was to determine accurately the causes of maternal death as seen in a tertiary health facility in Nigeria. It was a descriptive, retrospective review of the postmortem autopsy findings from cases of maternal death at the Obafemi Awolowo University Teaching Hospitals Complex, Ile-Ife, Nigeria over a 5-year period. Analyses were performed for differences in proportions using PEPI computer programs for epidemiologists (P is significant at < 0.05). A total of 84 cases of maternal deaths were used for the study. The study revealed that, approximately 71.4% of the maternal deaths were due to direct causes and 28.6% were due to indirect causes. The mean age at the time of death was 27.9 $\pm$ 7.5 years. Overall, the three leading causes of death were obstetric hemorrhage (30.9%), complications of abortion (23.8%), and nongenital (nonobstetric) infections (14.2%). Of the direct causes of maternal death, obstetric hemorrhage (43.3%) was the leading cause, with postpartum hemorrhage accounting for most (65.0%) of such deaths; other causes included complications of unsafe induced abortion (33.3%) and of labour (11.7%). Of the indirect causes, nongenital infections (50.0%), anemia (25.0%), and preexisting hypertension (20.8%) accounted for the majority of the maternal deaths. The study also indicated that, there was disparity between the clinical and autopsy diagnoses in 34 of the 84 cases (38.1%). The study concluded that, the leading causes of maternal death in the study area are similar to those in other developing countries. Autopsy is an invaluable tool in accurately determining the cause of maternal death.

In his thesis titled "Maternal health in Awutu-Senya District", Bassoumah (2010) used the delays model, to explain how socio-cultural factors mediate to influence the use of health facilities during the pregnancy postpartum period in the Awutu-Senya District of the Central Region of Ghana. The study targeted women who gave birth between September 2007 and September 2009 in the sampled areas. Proportionate stratified sampling technique was used to select 246 respondents from the chosen communities. Among others, the study observed low antenatal, delivery and postnatal care attendance from 2006 to 2008. Maternal mortality ratio increased from 115 per 100,000 live births in 2004 to 176 per 100,000 live births in 2008, whilst proportion of births outside orthodox medical facilities continues to increase in the face of National Health Insurance and other maternal health policies and programmes. Results showed that there was no association between attendance at clinics for antenatal care and residence. However, there was a significant and a positive relationship between attendance at clinics for postnatal care and residence. Again, a significant and a positive relationship between supervised delivery and level of education was established. It is recommended that the Ghana Health Service should pay particular attention to the socio-cultural environment in order to encourage antenatal care attendance, supervised deliveries and postnatal care in the health facilities for achievement of the Millennium Development Goal 5.

In African Journal of Reproductive Health, Okaro et al. (2001) published the report of their study titled "Maternal Mortality at the University of Nigeria Teaching Hospital, Enugu, before and after Kenya". The study was a comparative retrospective analysis of maternal deaths at the University of Nigeria Teaching Hospital, Enugu, Nigeria, carried out for two ten-year periods: 1976-1985 and 1991-2000 - in order to evaluate the effect of Safe Motherhood Initiative on maternal mortality in the hospital. Variables for the two periods were compared by means of the t-test at 95% confidence level. Maternal mortality ratio was significantly higher in Period II than in Period I (1406 versus 270 per 100, 000 live births, $p = 000$). The leading causes of maternal death were uterine rupture for Period I and septicaemia for Period II. Although from the first to the second there was a significant decrease in the number of midwives, physicians and nurse anaesthetists, there was more than a proportionate decrease in the number of deliveries. There was also increase in the incidence of anaemia due to diminished standards of living and in the mean decision-intervention interval (1.5 ± 0.5 versus 5.8 ± 1.2 hours; $p = 0.000$) as a result of worker dissatisfaction and changes in hospital policies. The researchers conclude that since the launching of the Safe Motherhood Initiative, MMR at the University of Nigeria Teaching Hospital, Enugu, Nigeria, has increased five-fold as a result of institutional delays and a deterioration in the living standards of Nigerians, both consequences of a depressed economy. To halt this trend, the researchers recommend that the living standard of all Nigerians should be improved.

Ngwan and Swede (2011) designed a study to determine the maternal mortality ratio at the Jos University Teaching Hospital and ascertain the causes of maternal death. A prospective descriptive analysis of all maternal deaths at the Jos University Teaching Hospital (JUTH), Jos north central Nigeria between 1st June, 2006 and 31st May, 2008 was adopted. During the study period, there were 56 maternal deaths and 4443 live births at the Jos University Teaching Hospital giving a maternal mortality ratio of 1260/100,000 live births. Of these, there were 15 deaths among 81 unbooked patients giving a maternal mortality ratio of 18518/100,000 live births. Twenty-five deaths occurred among those who booked elsewhere (2969/100,000 live births) and 9 deaths among women who booked in JUTH with a maternal mortality ratio of 256/100,000 live births. Thirty nine (69.6%) of the deaths were direct maternal deaths while 17 (30.4%) were indirect maternal deaths. The leading causes of direct maternal deaths were eclampsia (28.6%), haemorrhage (23.1%), unsafe abortion (8.9%) and pulmonary embolism (5.4%). Of the indirect causes of maternal mortality, HIV/AIDS accounted for 14.3% while anaemia, anaesthetic complications and thyrotoxicosis accounted for 8.9%, 3.6% and 1.8% respectively. The study that maternal mortality ratio is still high in JUTH. It was found to be lower in those that had tertiary education and in booked patients. HIV/AIDS appears to be emerging as one of the leading causes of maternal mortality in this study.

Idris et al. (2011) conducted a research using the Indirect Sisterhood Method to estimate maternal mortality in three communities in Kaduna State, Northern Nigeria. The study recognize the fact that maternal mortality ratio (MMR) as a good indicator for national development but its calculation is challenging. Estimation can be expensive, labour-intensive and time consuming. Incomplete vital registration of maternal deaths further compounds the difficulty. This scenario necessitates their exploration of other means of estimating maternal mortality, usually indirect techniques. The study estimated the MMR, the percentage of deaths due to maternal causes, and the lifetime risk of maternal death in three rural communities in Zaria emirate, using the indirect sisterhood method. Respondents were mostly Hausa Muslim individuals from 15-49 years of age with a Quranic education. Maternal causes accounted for 46.8% of all deaths, with a 1:13 lifetime risk of dying from maternal causes, and an MMR of 1400 per 100,000 live births. They concluded that achieving the fifth MDG will require accurate estimates of maternal deaths. Community-based and survey-based methods such as the sisterhood method are valuable tool in rural area that lack reliable data.

2.3 Some Application of Logistic Regression

With regard to the applications of logistic regression on this research, we considered how logistic regression has been applied in other field of life.

Zhao et al. (2013) used elastic net logistic regression to investigate relapsing-remitting multiple sclerosis classification on gene expression data. It was sought to identify a robust diagnostic signature for relapsing-remitting multiple sclerosis from gene expression data. In this regard, they built a classifier that discriminates samples into two phenotype groups, either RRMS or controls, using the transcriptome of peripheral blood mononuclear cells. For their classifier, they used logistic regression with elastic net regression as implemented in the glmnet package in R. They selected the values of the regularization hyper-parameters using cross-validation performance on the provided training data, number of non-zero parameters in their model, and based on the distribution of output values when the input vector for the test data were used with their classifier. They analyzed their classifier performance with two different strategies for feature extraction, using either only genes or including additional constructed features from gene pathways data. The two different strategies produced little differences in performance when comparing the 10-fold cross-validation of the training data and prediction on the test data. Their final submission for the sub-challenge used only genes as features, and identified a diagnostic signature consisting of 58 genes, that was ranked second out of a total of 39 submissions.

Das and Rahman (2011), published a research titled "Application of ordinal logistic regression analysis in determining risk factors of child malnutrition in Bangladesh". The study attempted to develop an ordinal logistic regression (OLR) model to identify the determinants of child malnutrition instead of developing traditional binary logistic regression (BLR) model using the data of Bangladesh Demographic and Health Survey 2004. Based on weight-for-age anthropometric index (Z-score) child nutrition status was categorized into three groups-severely undernourished (< -3.0), moderately undernourished (-3.0 to -2.01) and nourished (≥ -2.0). Since nutrition status is ordinal, an OLR model-proportional odds model (POM) can be developed instead of two separate BLR models to find predictors of both malnutrition and severe malnutrition if the proportional odds assumption satisfies. The assumption was satisfied with low p-value (0.144) due to violation of the assumption for one co-variate. So partial proportional odds model (PPOM) and two BLR models were also developed to check the applicability of the OLR model. Graphical test was also adopted for checking the proportional odds assumption. All the models determine that age of child, birth interval, mothers' education, maternal nutrition, household wealth status, child feeding index, and incidence of fever, ARI and diarrhoea were the significant predictors of child malnutrition; however, results of PPOM were more precise than those of other models. The study concluded that, the findings clearly justified that OLR models (POM and PPOM) were appropriate to find predictors of malnutrition instead of BLR models.

Li et al. (2011) used logistic random effects models to analyze multilevel also called hierarchical data with a binary or ordinal outcome. Their aim was to compare different statistical software implementations of these models. They used individual patient data from 8509 patients in 231 centers with moderate and severe Traumatic Brain Injury (TBI) enrolled in eight Randomized Controlled Trials (RCTs) and three observational studies. They fitted logistic random effects regression models with the 5-point Glasgow Outcome Scale (GOS) as outcome, both dichotomized as well as ordinal, with center and/or trial as random effects, and as covariates age, motor score, pupil reactivity or trial. They then compared the implementations of frequentist and Bayesian methods to estimate the fixed and random effects. Frequentist approaches included R (lme4), Stata (GLLAMM), SAS (GLIMMIX and NLMIXED), MLwiN ([R]IGLS) and MIXOR, Bayesian approaches included WinBUGS, MLwiN (MCMC), R package MCMCglmm and SAS experimental procedure MCMC. Three data sets (the full data set and two sub-datasets) were analysed using basically two logistic random effects models with either one random effect for the center or two random effects for center and trial. For the ordinal outcome in the full data set also a proportional odds model with a random center effect was fitted. The packages gave similar parameter estimates for both the fixed and random effects and for the binary (and ordinal) models for the main study and when based on a relatively large number of level-1 (patient level) data compared to the number of level-2 (hospital level) data. However, when based on relatively sparse data set, i.e. when the numbers of level-1 and level-2 data units were about the same, the frequentist and Bayesian approaches showed somewhat different results. The software implementations differ considerably in flexibility, computation time, and usability. There were also differences in the availability of additional tools for model evaluation, such as diagnostic plots. The experimental SAS (version 9.2) procedure MCMC appeared to be inefficient. On relatively large data sets, the different software implementations of logistic random effects regression models produced similar results. Thus, for a large data set there seems to be no explicit preference (of course if there is no preference from a philosophical point of view) for either a frequentist or Bayesian approach (if based on vague priors). The choice for a particular implementation may largely depend on the desired flexibility, and the usability of the package. For small data sets the random effects variances are difficult to estimate. In the frequentist approaches the MLE of this variance was often estimated zero with a standard error that is either zero or could not be determined, while for Bayesian methods the estimates could depend on the chosen "non-informative" prior of the variance parameter. The starting value for the variance parameter may be also critical for the convergence of the Markov chain.

Chapter 3

Methodology

3.1 Introduction

This chapter discusses the method of data collection and some statistical tools used in analyzing maternal mortality in the former Wa District and the Upper West Regional Hospital. The statistical tools used for this research work include Poisson and logistic regression models.

Poisson regression model was used to examine the significance of the occurrence and incidence of maternal mortality in Wa district while binary logistic regression model was used to assess the factors that contribute to maternal death in the Upper West Regional Hospital.

3.2 GENERALIZED LINEAR MODELS

Generalized linear model (GLMs) was first formulated by Nelder and Wedderburn (1972). Generalized linear models extend ordinary regression models to encompass non-normal response distributions and modeling functions of the mean. It includes linear regression models, analysis of variance models, logistic regression models, Poisson regression models, log-linear models, as well as many other models. Generalized linear models consist of three components;

1. A random component, specifying the conditional distribution of the response variable, Y_i (for the i^{th} of n independently sampled observations), given the values of the explanatory variables in the model.

2. A linear predictor-that is a linear function of regressors

$$\eta_i = \alpha + \beta_1 x_{i1} + \beta_2 x_{i2} + ... + \beta_k x_{ik} \tag{3.1}$$

3. A smooth and invertible linearizing link function g(.), which transforms the expectation of the response variable,$\mu_i \equiv E(Y_i)$, to the linear predictor:

$$g(\mu_i) = \eta_i = \alpha + \beta_1 x_{i1} + \beta_2 x_{i2} + ... + \beta_k x_{ik} \tag{3.2}$$

3.2.1 The Link Function

The link function $g(\mu_i)$ is a one-to-one continuous differentiable function. It links μ_i to the linear predictor η_i.

Thus $\eta_i = g(\mu_i)$

Where $\eta_i = X_i^T \beta$

Hence

$$g(\mu_i) = X_i^T \beta \tag{3.3}$$

Since the link function is one-to-one, we can invert it to obtain

$$\mu_i = g^{-1}(X_i^T \beta) \tag{3.4}$$

Examples of link functions include the identity, log, reciprocal, logit and probit.

3.3 THE POISSON DISTRIBUTION

The Poisson distribution is a discrete probability distribution that expresses the probability of a number of events occurring in a fixed period of time if these events occur with a known average rate and independent of the time since the last event. This distribution was named after a French mathematician, Simeon Denis Poisson (1781 - 1840) who developed it. For instance, if the expected number of occurrences in an interval is λ, then the probability that there are exactly k occurrences (k is non-negative integer, k = 0, 1, 2, . . .) is equal to

$$P(k, \lambda) = \frac{\lambda^k e^{-\lambda}}{k!} \tag{3.5}$$

Where e is the base of the natural logarithm (e = 2.71828...), k is the number of occurrences of an event - the probability of which is given by the function, k! is the factorial of k, λ is a positive real number, equal to the expected number of occurrences that occur during the given interval. Lambda (λ) is not only the mean but also the variance of the distribution.

Assumptions of Poisson distribution are:

- Observations are independent.
- Probability of occurrence in a short interval is proportional to the length of the interval.
- Probability of another occurrence in such a short interval is zero.

3.3.1 Poisson Regression Model

The basic GLM for count data is the Poisson regression model with log link. It is a technique used to describe count data as a function of a set of predictor variables. Although a GLM can model a positive mean using the identity link, it is more common to model the log of the mean. Like the linear predictor $\alpha + \beta x$, the log mean can take any real value. The log mean is the natural parameter for the Poisson distribution, and the log link is the canonical link for a Poisson GLM. A Poisson loglinear GLM assumes a Poisson distribution for Y and uses the log link. The Poisson loglinear model with explanatory variable X is

$$log(\mu) = \alpha + \beta x \tag{3.6}$$

for this model, the mean satisfies the exponential relationship

$$\mu = exp(\alpha + \beta x) = e^{\alpha} e^{\beta x} \tag{3.7}$$

the result indicate that a unit increase in x has a multiplicative impact of e^{β} on μ.

When there are a set of predictor variables, then the model becomes

$$\mu = exp(X_i^T \beta) \tag{3.8}$$

Where; $\mu = E(Y) = Var(Y)$. This is the major assumption of the Poisson regression model.

3.3.2 Poisson Model for Rate Data

When events of a certain type occur over time, space, or some other index of size, it is usually more relevant to model the rate at which they occur than the number of them. For instance, our study of maternal deaths in a given year for a number of deliveries might model the maternal mortality rate, defined for a year as its number of maternal deaths divided by its total deliveries.

For the rate occurrence of an event let Y = count and t = index of time or space, then the rate of occurrence is Y/t and the expected value of the rate is

$$E(Y/t) = \frac{1}{t} E(Y) = \mu/t \tag{3.9}$$

Therefore the Poisson loglinear regression model for the rate of occurrence is

$$\log(\mu/t) = \alpha + \beta x$$

$$\log(\mu) - \log t = \alpha + \beta x$$

$$\mu = texp(\alpha + \beta x) = te^{\alpha}e^{\beta x} \tag{3.10}$$

Where $-\log t$ is an adjustment term and is referred to as offset.

With multiple explanatory variables, the rate model becomes

$$\mu = texp(X_i^T \beta) \tag{3.11}$$

3.4 ESTIMATION

Estimation involves estimating the regression parameters. Here we will consider the maximum likelihood for GLMs and zero in to Poisson regression model.

3.4.1 Maximum Likelihood Estimate (GLMs)

An important practical feature of generalized linear models is that they can all be fit to data using the same algorithm, a form of iteratively re-weighted least squares.

We first of all begin with a trial estimate of the parameters $\hat{\beta}$, we compute the estimated linear predictor $\hat{\eta_i} = X_i'\hat{\beta}$ and use that to obtain the fitted values $\hat{\mu_i} = g^{-1}(\hat{\eta_i})$. Using these quantities, we compute the working dependent variable

$$z_i = \hat{\eta_i} + (y_i - \hat{\mu_i})\frac{d\hat{\eta_i}}{d\hat{\mu_i}}$$

$$z_i = \hat{\eta_i} + (y_i - \hat{\mu_i})g'(\hat{\mu}) \tag{3.12}$$

where the rightmost term is the derivative of the link function evaluated at the trial estimate.

Then

$$E(z_i) = \eta_i = \alpha + \beta_1 X_{i1} + \beta_2 X_{i2} + ... + \beta_k X_{ik} \tag{3.13}$$

And

$$V(z_i) = [g'(\hat{\mu}_i)]^2 a_i v(\hat{\mu}_i) \tag{3.14}$$

Next we compute the iterative weight w_i which is inversely proportional to the variance of the working dependent variable z_i given the current estimate of the parameters. That is

$$w_i = \frac{1}{[g'(\hat{\mu}_i)]^2 a_i v(\hat{\mu}_i)} \tag{3.15}$$

Finally, we obtain an improved estimate of β regressing the working dependent variable z_i on the predictors x_i using the weights w_i, i.e. we compute the weighted least-squares estimate

$$\hat{\beta} = (X'WX)^{-1}X'WZ \tag{3.16}$$

Where $\hat{\beta}$ is a $(k + 1 \times 1)$ vector of regression coefficients at the current iteration, X is an (n × k+1) model matrix, W is an (n × n) diagonal weighted matrix and Z is an (n × 1) working response vector.

The procedure is repeated until successive estimates change by less than a specified small amount. At this point $\hat{\beta}$ converges to the maximum likelihood estimates of the βs.

3.4.2 Maximum Likelihood Estimate (Poisson)

Let $Y_1......Y_n$ be an i.i.d. collection of Poisson (μ) random variables, where $\mu > 0$. Thus the likelihood function is

$L(\mu; y) = \prod_{i=1}^{n} \frac{e^{-\mu}\mu_i^y}{y_i!}$

$$= e^{-n\mu}\mu \sum_{i=1}^{n} y_i \frac{1}{\prod_{i=1}^{n} y_i!} \tag{3.17}$$

$$\log L(\mu; y) = -n\mu + \sum_{i=1}^{n} y_i \log \mu - \log \prod_{i=1}^{n} y_i! \tag{3.18}$$

We note that $\log L(\mu; y)$ is a differentiable function over the domain $(0\ ,\ \infty)$ and so we determine the critical point by equating the differential to zero. Thus

$\frac{d}{d\mu} \log L(\mu; y) = 0$

$-n + \frac{\sum_{i=1}^{n} y_i}{\mu} = 0$

$$\mu = \overline{y} \tag{3.19}$$

Checking whether $\mu = \overline{y}$ is maximum, we take the second derivative, ie

$$\frac{d^2}{d\mu^2} \log L(\mu; y) = -\mu^{-2} \sum_{i=1}^{n} y_i < 0 \tag{3.20}$$

Thus, there is a local maximum at $\mu = \overline{y}$. That is the maximum likelihood estimate of μ is $\hat{\mu} = \overline{y}$.

3.4.3 Fisher Scoring in Log-linear Model

We also considered the Fisher scoring algorithm for Poisson regression models with canonical link, where we model

$$\eta_i = \log(\mu_i) \tag{3.21}$$

The derivative of the link is

$$\frac{d\eta_i}{d\mu_i} = \frac{1}{\mu_i} \tag{3.22}$$

Thus, the working dependent variable has the form

$$z_i = \eta_i + \frac{(y_i - mu_i)}{\mu_i} \tag{3.23}$$

And the iterative weight is

$w_i = 1/[b"(\theta_i)(\frac{d\eta_i}{d\mu_i})^2]$

$= 1/[\mu_i \frac{1}{\mu_i^2}]$

And simplified to

$$w_i = \mu_i \tag{3.24}$$

Note that the iterative weight w_i is inversely proportional to the variance of the working dependent variable z_i.

3.4.4 The Poisson Deviance

Let $\hat{\mu}$ denote the maximum likelihood estimate of μ_i under the model of interest and let $\hat{\mu} = y_i$ denote the maximum likelihood estimate of μ_i under the saturated model. From first principles, the deviance is

$$D = 2\sum[y_i \log(y_i) - y_i - \log(y_i!) - y_i \log(\hat{\mu_i}) + \hat{\mu_i} + \log(y_i!)] \tag{3.25}$$

The term on y_i! cancel out. Grouping like terms, we have

$$D = 2\sum[y_i \log(\frac{y_i}{\hat{\mu_i}}) - (y_i - \hat{\mu_i})] \tag{3.26}$$

The first term in the Poisson deviance has the form

$$D = 2\sum o_i \log(\frac{o_i}{e_i}), \tag{3.27}$$

This is identical to the Binomial deviance. For a canonical link the score is

$$\frac{d \log L}{d\beta} = X'(y - \mu) \tag{3.28}$$

Setting this to zero leads to the estimating equations

$$X'y = X'\hat{\mu} \tag{3.29}$$

Maximum likelihood estimation for Poisson log-linear models - and more generally for any generalized linear model with canonical link - requires equating certain functions of the MLE's (namely X'$\hat{\mu}$) to the same functions of the data (namely X' y). If the model has a constant, one column of X will consist of ones and therefore one of the estimating equations will be

$$\sum y_i = \sum \hat{\mu_i} or \sum (y_i - \hat{\mu_i}) = 0 \tag{3.30}$$

so the last term in the Poisson deviance is zero. The Poisson deviance has an asymptotic chi-squared distribution as n $\longrightarrow \infty$ with the number of parameters p remaining fixed, and can be used as a goodness of fit test.

3.5 LOGISTIC REGRESSION

Logistic regression is statistical tool that allows one to test models to predict categorical outcomes with two or more categories, Pallant (2007). The predictor (independent) variables can be either categorical or continuous, or a mix of both in one model. Where the outcome of the response (dependent) variable is dichotomous, the approach is called binary logistic regression. On the other hand, multinomial logistic regression is applied when the outcome of the response variable is more than two categories. In this research, the dependent variable is the outcome (result) of a pregnant woman (died or discharged) hence the use of binary logistic regression as the appropriate statistical tool.

Logistic regression is used increasingly in a wide variety of applications. Early uses were in biomedical studies but the past 20 years have also seen much use in social science research and marketing. It has also become a popular tool in business application, Agresti (2007).

3.5.1 Parameters in Logistic Regression

For a binary response variable Y and an explanatory variable X, let $\pi(x) = p(Y = 1/X = x) = 1 - p(Y = 0/X = x)$. The logistic regression model is

$$\pi(x) = \frac{exp(\alpha + \beta x)}{1 + exp(\alpha + \beta x)} \tag{3.31}$$

Equivalently, the log odds, called the logit, has a linear relationship

$$Logit[\pi(x)] = \log[\frac{\pi(x)}{1 - \pi(x)}] = \alpha + \beta x \tag{3.32}$$

This equates the logit link function to the linear predictor. The sign of β in the equation determines whether $\pi(x)$ is increasing or decreasing as x increases. The rate of climb or descent increases as $|\beta|$ increases, as $\beta \longrightarrow 0$ the curve flattens to a horizontal straight line. When $\beta = 0$, Y is independent of X. For a quantitative x with $\beta > 0$, the curve for $\pi(x)$ has the shape of cumulative density function (cdf) of the logistic distribution. Since the logistic density is symmetric, $\pi(x)$ approaches 1 at the same rate that it approaches 0.

3.5.2 Multiple Logistic Regression

Like ordinary regression, logistic regression extends to models with multiple explanatory variables. For instance, the model for $\pi(x) = P(Y = 1)$ at values $x = (x_i, ...x_p)$ of p predictors is

$$Logit[\pi(x)] = \alpha + \beta_1 x_1 + \beta_2 x_2 + ... + \beta_p x_p \tag{3.33}$$

For the purpose of the study, the alternative formula directly specifying $\pi(x)$ is

$$\pi(x) = \frac{\exp(\alpha + \beta_1 x_1 + \beta_2 x_2 + ... + \beta_p x_p)}{1 + \exp(\alpha + \beta_1 x_1 + \beta_2 x_2 + ... + \beta_p x_p)} \tag{3.34}$$

The parameter β_i refers to the effect of x_i on the log odds that $Y = 1$, controlling the other x_j. For instance, $\exp(\beta)$ is the multiplicative effect on the odds of a 1 - unit increase in x_i, at a fixed level of other x_j. The explanatory variable can be qualitative, using dummy variables for categories.

3.5.3 Fisher Scoring in Logistic Regression

Let us now find the working dependent variable and the iterative weight used in the Fisher scoring algorithm for estimating the parameters in logistic regression, where we model

$$\eta_i = logit(\pi_i) \tag{3.35}$$

It is usually convenient to write the link function in terms of the mean μ_i as

$$\eta_i = \log(\frac{\pi}{1-\pi}) = \log(\frac{\mu_i}{n_i - \mu_i}) \tag{3.36}$$

This equation can also be written as

$$\eta_i = \log(\mu_i) - \log(n_i - \mu_i) \tag{3.37}$$

Differentiating with respect to μ_i, we have

$$\frac{d\eta_i}{d\mu_i} = \frac{1}{\mu_i} + \frac{1}{n_i - \mu_i} = \frac{n_i}{\mu_i(n_i - \mu_i)} = \frac{1}{n_i \pi_i (1 - \pi_i)} \tag{3.38}$$

The working dependent variable which is general is given as

$$z_i = \eta_i + (y_i - \mu_i)\frac{d\eta_i}{d\mu_i} \tag{3.39}$$

This turns out to be

$$z_i = \eta_i + \frac{y_i - n_i\pi_i}{n_i\pi_i(1-\pi_i)} \tag{3.40}$$

The iterative weight which is inversely proportional to the variance of the working dependent variable is given as

$$w_i = 1/[b"(\theta_i)(\tfrac{d\eta_i}{d\mu_i})^2]$$

$$= \tfrac{1}{n_i\pi_i(1-\pi_i)}[n_i\pi_i(1-\pi_i)]^2$$

$$w_i = n_i\pi_i(1-\pi_i) \tag{3.41}$$

Chapter 4

DATA ANALYSIS AND DISCUSSION

4.1 Introduction

This chapter deals with the analysis of data and discussion of findings. Basically, secondary data was used for the thesis. Supervised deliveries and maternal deaths in Wa district from 1998-2010 were recorded from the regional annual report and other documents of GHS Wa. In 2004 Wa district was split into three districts, namely; Wa Municipal, Wa West and Wa East districts. For the purpose of this study, supervised deliveries and maternal deaths in the three districts were aggregated from 2004-2010.

Five years (2008-2012) information was also recorded from the registers at the Obstetrics and Gynaecology Unit of the Upper West Regional Hospital. The variables of interest recorded were;

- Length of stay at the hospital (duration in days)
- Parity and Gravida of mothers
- Delivery type (SVD or caesarian) and
- Outcome of admission (discharge or died).

A total of fifteen thousand four hundred and ten (15,410) live births and sixty two (62) maternal deaths were recorded.

We shall first look at preliminary analysis and then further analysis using both STATA and Statistical Analysis soft ware (SAS). The chapter used Poisson regression model to examine the significance of the occurrence and incidence of maternal mortality in Wa district while logistic regression was used to assess factors that affect maternal mortality at the Upper West Regional Hospital (UWRH).

4.2 Preliminary Analysis

A total of 15,410 deliveries took place at UWRH during the study period and there were 62 maternal deaths with maternal mortality rate of 402 per 100,000 live births.

Table 4.1: Age group distribution nof deliveries and maternal deaths at UWRH from 2008-2012.

Age group	Deliveries	Maternal deaths	Percent
14 - 19	1543	6	9.7
20 - 24	4106	16	25.8
25 - 29	4553	20	32.3
30 - 34	3169	9	14.5
35+	2039	11	17.7
Total	15410	62	100

From table 4.1, the number of maternal deaths for the age groups is associated with the number of deliveries. For instance, the age group 25 - 29 recorded the highest deliveries of 4,553 with maternal deaths of 20 (32.3%), followed by age group 20-24 also recording 4,106 deliveries with 16 (25.8%) maternal deaths. The least deliveries of 1,543 with 6 (9.7%) maternal deaths was recorded among the age group 14 - 19.

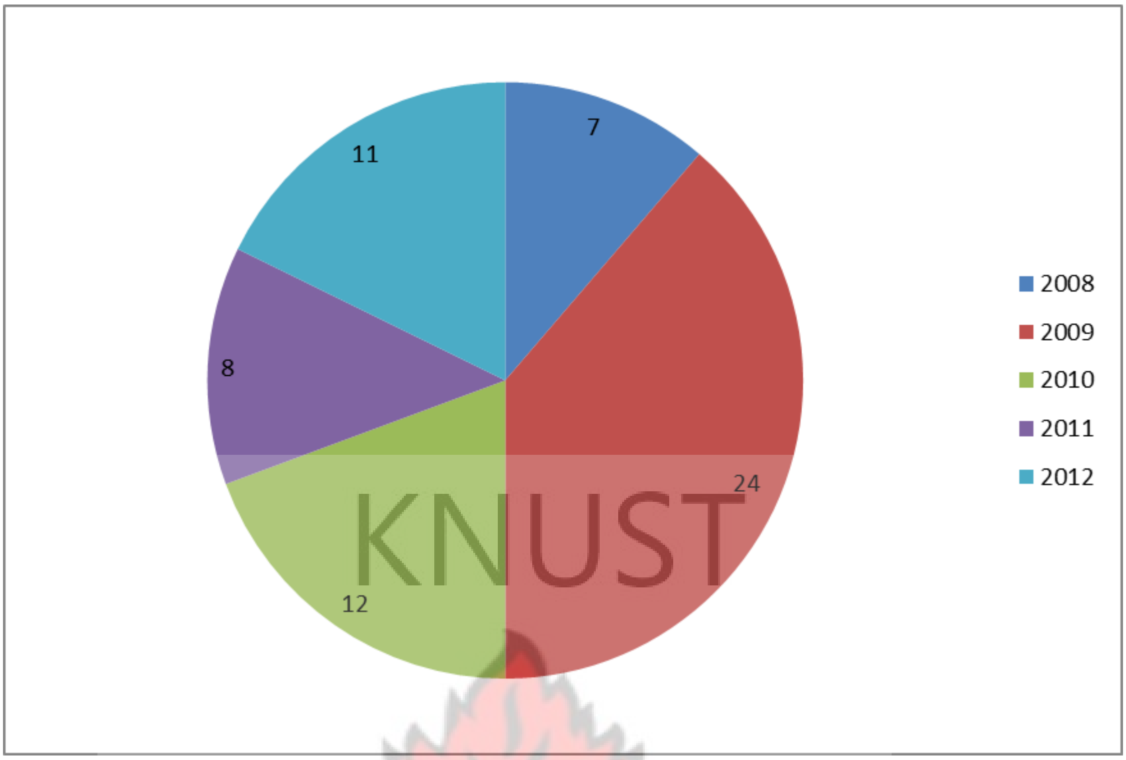

Figure 4.1: Pie chart showing yearly distribution of maternal mortality at UWRH.

The highest maternal mortality of 24 deaths (39%) was recorded in 2009 and the least of 7 (11%) was recorded in 2008.

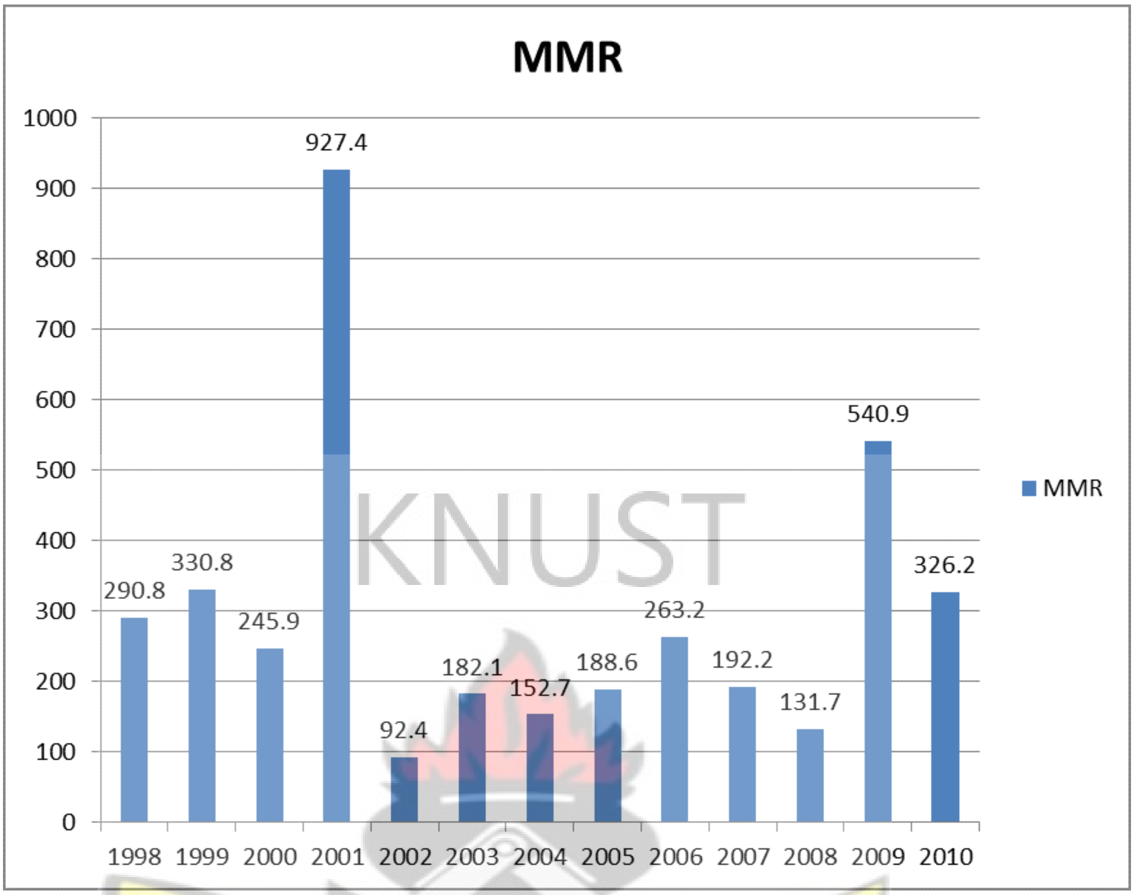

Figure 4.2: Bar chart showing the distribution of maternal mortality ratios in Wa district for 1998 - 2010.

From the chart the highest maternal mortality ratio of 927.4 / 100,000 was recorded in 2001and the least of 92.4 / 100,000 was recorded in the following year 2002. Maternal mortality ratio has been between 131.7/100,000 to 263.2/100,000 from 2003 to 2008, rose up to 540.9/100,000 in 2009 and finally drop to 326.2/100,000 live births in 2010.

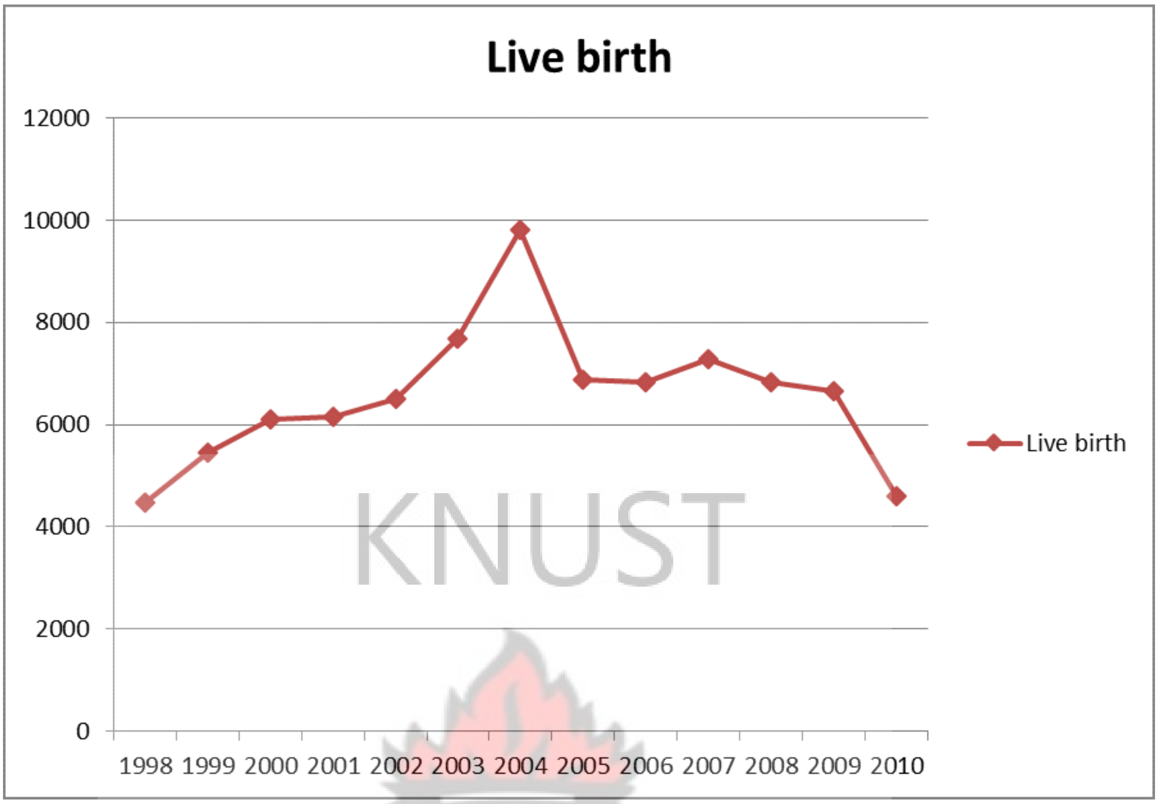

Figure 4.3: Chart showing trend of supervised deliveries in Wa district from 1998 - 2010.

The chart indicates that, supervised deliveries increased steadily from 1998 to 2004. It dropped through 2005 to 2006, rose again in 2007 where it finally dropped through 2008 to 2010. In fact, the graph for supervised deliveries in Wa district from 1998 - 2010 has a shape of a hat.

4.3 Further Analysis

A major objective of many statistical investigations is to establish a relationship which makes it possible to predict one or more variables in terms of others. In this session, further analysis will be made on the data set with the help of Poisson and logistic regression models. For the purpose of the set objectives, we shall first examine the significance of the occurrence and incidence of maternal mortality in Wa district. Finally, logistic regression would be employed to assess the contribution of some identified variables on maternal mortality at the UWRH.

4.3.1 Modelling The Occurrence Of Maternal Mortality Cases

We used SAS statistical package version 9.1 in modeling the occurrence of maternal mortality cases in Wa district. Poisson distribution with log link function was used in modeling. One hundred and fifty-six (156) observations were used in 13 years period. In the model, maternal deaths was used as the response variable while time (years) was used as the only predictor variable.

The model is given as follows;

$$\log(mean_{death}) = \alpha + \beta * year_i \tag{4.1}$$

where $i = 1998 - 2010$ Thus

$$mean_{death} = \exp(\alpha + \beta * year_i) = e^{\alpha} e^{\beta * year_i} \tag{4.2}$$

The fitted model has a deviance value of 148.6857 which follows a chi-square distribution with 143 degrees of freedom. The ratio of the deviance and the degrees of freedom is 1.0398 indicating a clear absence of over dispersion in the data. The scaled deviance and the scaled Pearson chi-square had 148.6857 and 122. 7933 values respectively with the same degrees of freedom of 143. See Table 5.1 in appendix for the detailed Analysis of the Criteria for Assessing Goodness of Fit.

Table 4.2: Analysis of parameter estimates for occurrence of maternal mortality

Parameter		DF	Estimate	Std Err	Wald 95% conf Lmt	Chi-sq	Pr¿Chi-sq
Intercept		1	0.0231	0.2411	(-0.2493 , 0.6956)	0.86	0.3546
year	1998	1	-0.1413	0.3538	(-0.8365 , 0.5503)	0.16	0.6858
year	1999	1	0.1823	0.3264	(-0.4574 , 0.8220)	0.31	0.5764
year	2000	1	0.0000	0.3409	(-0.6682 , 0.6682)	0.00	1.0000
year	**2001**	**1**	**1.3350**	**0.2709**	**(0.8040 , 1.8660)**	**21.16**	**¡ .0001**
year	2002	1	-0.9163	0.4510	(-1.8002 , -0.0324)	3.60	0.0578
year	2003	1	-0.0690	0.3469	(-0.7490 , 0.6110)	0.04	0.8424
year	2004	1	0.0000	0.3409	(-0.6682 , 0.6682)	0.00	1.0000
year	2005	1	-0.1431	0.3538	(-0.8368 , 0.5503)	0.16	0.6858
year	2006	1	0.1823	0.3264	(-0.4574 , 0.8220)	0.31	0.5764
year	2007	1	-0.0690	0.3469	(-0.7490 , 0.6110)	0.04	0.8424
year	2008	1	-0.6282	0.4087	(-0.4297 , 0.1725)	2.06	0.1510
year	**2009**	**1**	**0.8755**	**0.2869**	**(0.3131 , 1.4378)**	**8.12**	**0.0044**
year	**2010**	**0**	**0.0000**	**0.0000**	**(0.0000 , 0.0000)**	.	.
Scale		0	0.9336	0.0000	(0.9336 , 0.9336)		

Table 4.2 presents detail analysis of the of maternal mortality cases in Wa district from 1998 to 2010. The only predictor variable, time in years was treated as a discrete variable. The intercept has a chi-square and p-value of 0.86 and 0.3546 respectively. This implies that the intercept is not significant, thus $\alpha \approx 0$. It can be seen from the table that parameter estimates for 1999, 2001, 2006 and 2009 were all positive while those of 1998, 2002, 2003, 2005, 2007 and 2008 were also all negative. Positive estimates mean that the mean number of occurrence of maternal deaths was higher in those years than 2010 which is the reference year. On the other hand, negative parameter estimates mean that the mean number of occurrence in those years was lower than the reference year 2010. However, only 2001 and 2009 experienced significant increase in the mean number of occurrence of maternal mortality cases in the Wa district as compared to 2010. For instance, the year mean number of maternal deaths for all the months in 2001 $(e^0 e^{1.3350}) = 3.80$ and that of 2009 $(e^0 e^{0.8755}) = 2.40$ higher than the mean number of death for all the months in 2010.

Table 5.2 in appendix which contains detailed analysis of parameter estimates for the occurrence of maternal deaths for continuous time revealed that the mean number of occurrence of maternal deaths throughout the period under study (1998 - 2010) is insignificant. This implies that the mean number of occurrence of maternal death cases in Wa district has not significantly reduced over the period under study.

4.3.2 Modeling The Incidence Of Maternal Mortality Cases

Again we used SAS statistical package version 9.1 in modeling the incidence of maternal mortality cases in Wa district. Poisson distribution with log link function was used in modeling. The offset variable used was log of the total deliveries which is the population at risk. One hundred and fifty-six (156) observations were used in 13 years period. In the model, maternal deaths was used as the response variable while time (years) was used as the only predictor variable. The model is given as follows;

$$\log(\frac{mean_{death}}{deliveries}) = \alpha + \beta * year_i \tag{4.3}$$

Where $i = 1998 - 2010$

Thus

$\log(mean_{death}) - \log(deliveries) = \alpha + \beta * year_i$

$$Mean_{death} = deliveries\{\exp(\alpha + \beta * year_i)\} = del.(e^{\alpha} e^{\beta * year_i}) \tag{4.4}$$

The major assumption of Poisson regression model is that the mean and the variance should be the same. This assumption determines the appropriateness of a Poisson model. To assess, an objective test for over dispersion which follows the Pearson chi-square was performed. For the appropriateness of Poisson model, the dispersion parameter should not be significantly different from one.

Table 5.3 (see appendix) presents a detailed analysis of the Criteria for Assessing Goodness of Fit. From the table, the dispersion parameter was 0.9096 indicating a clear absence of over dispersion in the data. The dispersion parameter is the ratio of the deviance value 130.0797 which follows the Pearson chi-square and the degrees of freedom 143.

Table 4.3: Analysis of parameter estimates for incidence of maternal mortality

Parameter		DF	Estimate	Std Err	Wald conf. Lmt	Chi-sq	Pr¿Chi-sq
Intercept		**1**	**-5.7253**	**0.2208**	**(-6.1583 , -5.2927)**	**491.69**	**¡ .0001**
year	1998	1	-0.1142	0.3241	(-0.7494 , 0.5210)	0.12	0.7245
year	1999	1	0.0142	0.2990	(-0.5718 , 0.6003)	0.00	0.9621
year	2000	1	-0.2824	0.3123	(-0.8945 , 0.3296)	0.82	0.3657
year	**2001**	**1**	**1.0448**	**0.2482**	**(0.5585 , 1.5315)**	**12.96**	**0.0003**
year	**2001**	**1**	**-1.2615**	**0.4131**	**(-2.0710 , -0.4576)**	**6.82**	**0.0090**
year	2003	1	-0.5831	0.3178	(-1.2060 , 0.0398)	3.37	0.0666
year	**2004**	**1**	**-0.7588**	**0.3123**	**(-1.3737 , -0.1496)**	**4.32**	**0.0377**
year	2005	1	-0.5476	0.3241	(-1.1828 , 0.0875)	2.86	0.9110
year	2006	1	-0.2146	0.2990	(-0.8006 , 0.3714)	0.52	0.4729
year	2007	1	-0.5287	0.3178	(-1.1516 , 0.0942)	2.77	0.0962
year	**2008**	**1**	**-1.0252**	**0.3744**	**(-1.7588 , -0.2911)**	**5.48**	**0.0192**
year	2009	1	0.5058	0.2628	(-0.0093 , 1.0209)	3.69	0.0548
year	**2010**	**0**	**0.0000**	**0.0000**	**(0.0000 , 0.0000)**	**.**	**.**
Scale		0	1.0000	0.0000	(1.0000 , 1.0000)		

Table 4.3 presents the detailed analysis of the parameter estimates for incidence of maternal mortality. Positive parameter values for 1999, 2001 and 2009 indicate that the mean number of incidence of maternal mortality was high compared to the mean number of the year 2010, the reference year. On the other hand, negative parameter estimates for 1998, 2000, 2002, 2003, 2004, 2005, 2006, 2007 and 2008 also indicate that the mean number of maternal deaths was low compared to the mean of the reference year 2010. The value of the intercept -5.7253 is significant with chi-square value 491.69 and p-value of ¡.0001.

The results show that there was a statistically significant difference between 2010 and years 2001, 2002, 2004 and 2008. Their chi-square values were 12.96, 6.82, 4.32 and 5.48 with p-values of 0.0003, 0.0090, 0.0377 and 0.0192 respectively. Maternal death rate was significantly high in 2001 compared to 2010 but significantly lower in 2002, 2004 and 2008 compared to 2010. For instance, in 2001 maternal mortality rate increased by $(e^{-5.7253}e^{1.0448}) = 0.009274$ compared to 2010. On the other hand, in 2002, 2004 and 2008, maternal mortality rate decreased by $(e^{-5.7253}e^{-1.0261})) = 0.001169$, $(e^{-5.7253}e^{-0.7588}) = 0.001528$ and $(e^{-5.7253}e^{-1.0252}) = 0.001170$ respectively compared to the reference year 2010.

Table 5.4 in appendix presents detailed analysis of parameter estimates for incidence of maternal mortality for continuous time. It is obvious from the table that the mean incidence of maternal mortality in Wa district has neither reduced nor increased over the period under study. With a chi-square value of 1.32 and p-value of 0.2510, we can conclude statistically that the mean rate of maternal death cases is not significant over the period considered.

4.3.3 Model containing Factors That Affect Pregnancy Outcome at UWRH.

STATA statistical package version 11 was used in modeling the factors that contribute to maternal mortality at the Upper West Regional Hospital. The following variables duration, age, parity, gravid and delivery type were initially considered for the model. However, it was established that there was high correlation between duration and delivery type and parity and gravid (see table 5.6 in appendix). Hence duration and gravid were eliminated from the model to avoid the issue of multicollinearity.

A direct binary logistic regression was performed to assess the impact of age, parity and delivery type on the likelihood of a pregnant woman on admission at Upper West Regional Hospital dying. The response variable is the outcome of pregnancy. The outcome and delivery type are categorical variables. Their categories are as follows;

$$Outcome = \{^{1, if dead}_{0, if discharched} \tag{4.5}$$

$$Deliverytype = \{^{1 if caesarian surgery}_{0 if spontaneous virginal delivery} \tag{4.6}$$

The model containing all the predictor variables is statistically significant with chi-square value of 29.73 and p-value of 0.0000. The Pseudo $R^2 = 0.269$ indicate that only 26.9% of the variation in the response variable is explained by the predictor variables (PVs). In all 15410 observations were made in the five year period under study (2008 - 2012) (see table 5.5 in appendix). The binary logistic regression model is given as;

$$Prob(outcome = 1/PVs) = \frac{\exp(\alpha + \beta_1 * age + \beta_2 * parity + \beta_3 * deliverytype)}{1 + \exp(\alpha + \beta_1 * age + \beta_2 * parity + \beta_3 * deliverytype)} \tag{4.7}$$

where PVs = predictor variables

The model predicts the likelihood of a pregnant woman on admission at the UWRH of dying of complication during child birth.

Table 4.4: Analysis of parameter estimates for factors that affect maternal mortality.

Variable	Odds Ratio	Estimate	Std Error	95% conf. Interval	p-value
Intercept		-6.611			0.000
Age	1.067	0.065	0.028	(1.010 , 1.126)	0.020
Parity	0.72	-0.319	0.104	(0.593 , 0.892)	0.000
Delivery Type	2.190	0.784	0.287	(1.248 , 3.844)	0.006

Table 4.4 presents details of the analysis of parameter estimates for age, parity and delivery type. The table also presents the odds ratio, standard error, confident intervals and p-values of individual parameter estimates. The odds ratio of

2.190 indicate that pregnant women on admission at the Upper West Regional Hospital who delivered through caesarian surgery are 2 times more likely to die than those who delivered through spontaneous virginal delivery, controlling all other factors in the model. Also the odds ratio of 0.727 for parity is an indication of the fact that, women with high parity are 0.737 less likely to experience the event than those with low parity. In fact, the negative coefficient of -0.319 for parity attest to the fact that the higher the parity the less likely the event happening controlling all other factors. An odds ratio of 1.067 for indicates that the effect of age is rather random.

4.4 DISCUSSION

Supervised deliveries in Wa district assumed an upward trend from 1998 and reached its peak in 2004, the year in which free delivery policy was fully implemented in the region. After 2004, supervised deliveries assumed a downward trend to 2010.

Maternal mortality ratio was high in 2001(927.4/100,000) and significantly reduced to 92.4/100,000 the following year (2002). However, it rose again to 540.9/100,000 in 2009. On the other hand, analyses on the data from the UWRH from 2008 to 2012 indicate that women in the age group 25-29 recorded the highest maternal deaths. This means that they are more vulnerable followed by age group 20-24.

The study established that 2001 and 2009 experienced significant increase in the mean number of occurrence of maternal mortality cases in the Wa district as compared to 2010. For instance, the year mean number of maternal deaths for all the months in 2001$(e^0 e^{1.3350}) = 3.80$ and that of 2009 $(e^0 e^{0.8755}) = 2.40$ higher than the mean number of death for all the months in 2010. It further shows that the mean number of occurrence of maternal deaths throughout the period under study (1998 - 2010) is insignificant. This implies that the mean number of occurrence of maternal death cases in Wa district has not significantly reduced over the period under study.

For the incidence of maternal mortality in Wa district, there was a statistically significant difference between the reference year 2010 and years 2001, 2002, 2004 and 2008. Their chi-square values were 12.96, 6.82, 4.32 and 5.48 with p-values of 0.0003, 0.0090, 0.0377 and 0.0192 respectively. Maternal death rate was significantly high in 2001 compared to 2010 but significantly lower in 2002, 2004 and 2008 compared to 2010. For instance, in 2001 maternal mortality rate increased by $(e^{-5.7253}e^{1.0448}) = 0.009274$ compared to 2010. On the other hand, in 2002, 2004 and 2008, maternal mortality rate decreased by $(e^{-5.7253}e^{-1.02615}) = 0.001169$, $(e^{-5.7253}e^{-0.7588}) = 0.001528$ and $(e^{-5.7253}e^{-1.0252}) = 0.001170$ respectively compared to the reference year 2010. The research revealed that the mean incidence of maternal mortality in Wa district has neither reduced nor increased over the period under study. With a chi-square value of 1.32 and p-value of 0.2510, we can conclude statistically that the mean rate of maternal death cases is not significant over the period considered.

The logistic regression analysis results revealed that age, parity and delivery type affect the outcome of pregnancy. The results indicate that pregnant women who delivered through caesarian section were 2 times more likely to die than those who delivered through spontaneous virginal delivery (SVD). Parity on the other hand, reduces the risk of dying. That is, pregnant women with parity are 0.727 times less likely of dying than those with no parity controlling all other factors in the model. The effect of age on pregnancy outcome at the hospital was found to be random. The three variables however, accounted for only 26.9% of the variations in the outcome or response variable.

Chapter 5

CONCLUSION AND RECOMMENDATION

5.1 Introduction

This chapter focuses on the outcome of the analysis in the last chapter and considers the extent to which the objectives of the research have been achieved. It also covers recommendations the researcher wishes to put across for consideration which will be essential for stakeholders.

5.2 Conclusion

The research was aimed at first, to examine the significance of the occurrence and incidence of maternal mortality in Wa district and secondly to assess the factors that contribute to maternal mortality at the Upper West Regional Hospital (UWRH).

The Poisson regression model for the occurrence of maternal mortality in Wa district was considered. Only the parameter estimates for years 2001 and 2009 were significant with chi-square values of 21.16 and 8.12 and p-values ¡.0001 and 0.0044 respectively. That is, the year mean number of maternal deaths for all the months in 2001 $(e^0 e^{1.3350}) = 3.80$ and that of 2009 $(e^0 e^{0.8755}) = 2.40$ higher than the mean number of death for all the months in 2010. With a chi-square value of 0.30 and p-value of 0.5825, we can conclude that the occurrence of maternal mortality has not significantly reduced over the period under study.

In the Poisson regression model for incidence of maternal mortality, the parameter estimates for the years 2001, 2002, 2004 and 2008 were significant with chi-square values of 12.96, 6.82, 4.32 and 5.48 and p-values of 0.0003, 0.0090, 0.0377 and 0.0192 respectively. However, the parameter estimate for 2001 was positive while those of 2002, 2004 and 2008 were negative. This implies that in 2001 maternal mortality rate increased by $(e^{-5.7253}e^{1.0448}) = 0.009274$ compared to 2010. On the other hand, in 2002, 2004 and 2008, maternal mortality rate decreased by $(e^{-5.7253}e^{-1.02615}) = 0.001169$, $(e^{-5.7253}e^{-0.7588}) = 0.001528$ and $(e^{-5.7253}e^{-1.0252}) = 0.001170$ respectively compared to the reference year 2010. The research revealed that the mean incidence of maternal mortality in Wa district has neither reduced nor increased over the period under study. With a chi-square value of 1.32 and p-value of 0.2510, we can conclude statistically that the mean rate of maternal death cases is not significant over the period considered.

It was also established that three variables namely; age, parity and delivery type had effect on pregnancy outcomes at the Upper West Regional Hospital. However, their effect accounted for only 26.9% of the overall outcome of pregnancy at the hospital. The literature reviewed also revealed that, type I and type III delays, educational level of mother are some of the major causes of maternal mortality in sub-Saharan Africa. However, data on these variables were not readily available at the Obstetrics and Gynaecology Unit of the hospital.

5.3 Recommendation

Finally, in this session we make the following recommendations based on the findings of the research work.

1. The mean number of occurrence and incidence of maternal mortality in Wa district has neither increased nor reduced over the thirteen year period under study (1998 - 2010). We therefore recommend that government, stakeholders and policy makers should as a matter of urgency evaluate and review all the existing intervention programs of maternal health since they

seem not to have yielded the expected results over the past thirteen years (1998 - 2010).

2. The study also revealed that parity, age and delivery type contributes significantly to maternal deaths at the UWRH. We recommend that management of the hospital to put in more effort at implementing existing programs aimed at reducing this problem and also introduce new ones if necessary. Caesarian surgery should not be seen as a last resort but a means for save delivery. This if implemented, can significantly reduce maternal mortality at the hospital and the district as a whole.

3. Finally, we recommend further study on effect of type I and type III delays on maternal mortality at the hospital.

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Appendix

Table 5.1: Criteria for assessing goodness of fit for the occurrence of maternal Mortality

Criterion	DF	Value	Value/DF
Deviance	143	148.6857	1.0398
Scaled Deviance	143	148.6857	1.0398
Pearson Chi-square	143	122.7933	0.8587
Scaled Pearson X^2	143	122.7933	0.8587
Log Likelihood		190.0023	

Table 5.2: Analysis of parameter estimate for occurrence of maternal mortality for continuous time

Parameter	DF	Estimate	Std Err	Wald 95% Conf. Lt	Chi-sq	p-value
Intercept	1	10.3712	34.4400	(-48.1289, 86.8720)	0.32	0.5738
Time	1	-0.0094	0.0172	(-0.0431, 0.0241)	0.30	0.5825
Scale	0	1.0000	0.0000	(1.0000, 1.0000)		

Table 5.3: Criteria for assessing goodness of fit for incidence of maternal mortality

Criterion	DF	Value	Value/DF
Deviance	143	130.7097	0.9096
Scaled Deviance	143	130.7097	0.9096
Pearson Chi-square	143	101.4954	0.7098
Scaled Pearson X^2	143	101.4954	0.7098
Log Likelihood		180.6998	

Table 5.4: Analysis of parameter estimate for incidence of maternal mortality for continuous time

Parameter	DF	Estimate	Std Err	Wald 95% Conf. Lt	Chi-sq	p-value
Intercept	1	36.9556	37.2933	(-36.1379, 110.0492)	0.98	0.3217
Time	1	-0.0214	0.0186	(-0.0578, 0.0151)	1.32	0.2510
Scale	0	1.0000	0.0000	(1.0000, 1.0000)		

Table 5.5: Criteria for assessing goodness of fit for logistic regression model

Criterion	Value
LR Chi-square(3)	17.65
Prob ¿ Chi-square	0.0005
Pseudo R^2	0.269
Log Likelihood	295.0198
Number of Observation	15,410

Table 5.6: A matrix determining the correlation between variables

Variable	Constant	Duration	Parity	Gravida	Delivery Type	Age
Constant	1.000	-0.215	0.060	0.189	0.146	-0.914
Duration	-0.215	1.000	-0.053	0.021	-0.898	0.056
Parity	0.060	-0.053	1.000	-0.936	0.118	-0.140
Gravida	0.189	0.021	-0.936	1.000	0.069	-0.284
Delivery Type	0.146	-0.898	0.118	0.069	1.000	-0.103
Age	-0.914	0.056	-0.140	-0.284	-0.103	1.000