STATISTICAL ANALYSIS OF RETROVIRAL (HIV) STATUS AND OTHER MATERNAL RISK FACTORS ASSOCIATED WITH LOW BIRTH WEIGHT AND LOW APGAR SCORE OF INFANTS: EVIDENCE FROM THE GREATER ACCRA REGIONAL HOSPITAL.

BY

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THIS THESIS IS SUBMITTED TO THE UNIVERSITY OF GHANA, LEGON IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE AWARD OF MPHIL STATISTICS DEGREE

JUNE, 2015

DECLARATION

I hereby do declare that this thesis is the results of my own research work and that no part of it has been presented for another degree in this university or elsewhere.

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We hereby certify that this thesis was prepared from the candidate's own research work and has been submitted for examination with our approval as University supervisors.

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ABSTRACT

Low birth weight and low Apgar score are major determinants of morbidity, mortality and disability in infancy and childhood. These are very important health indicators, but little is known about their causes among HIV-infected mothers in Ghana. They are also risk factors for long-term impact on health outcomes in adult life. Quantitatively, birth weight and Apgar score of an infant summarizes the morbidity conditions (LBW and LAS), with Apgar score measuring the extent of asphyxia. The study comprised data obtained through personal interviews from mothers in their postpartum at Ridge Hospital, and a secondary data generated from the mother's antenatal book. The study sought to identify risk factors associated with LBW and LAS. The study encompassed 330 women who delivered at Ridge Hospital between February and March 2015. The prevalence of LBW and LAS at Ridge Hospital were 18.8% and 15.2% respectively. Using logistic regression, the significant risk factors associated with LBW were found to be Retroviral (HIV) status of the mother, Gestational Age, Daily Hours Rested, Frequency of Eating and Type of Cooking Fuel used. The factors that significantly influenced LAS were Retroviral (HIV) status of the mother, Gestational Age and Daily Expenditure. The results have shown that HIV-Positive Mothers are more likely to give birth to a newborn with LBW and LAS. There is also evidence that significant differences exist between the two levels of Retroviral (HIV) status with regards to birth weight and Apgar score using multivariate analysis of variance (MANOVA). Retroviral (HIV) status of the mother was found to be the most important determinant for both LBW and LAS. Therefore, it is recommended that mothers infected with HIV should be made aware so that this knowledge can facilitate early counseling and treatment to prevent LBW and LAS, and the transmission from mother-to-child. Also during pregnancy, antenatal clinic services should be encouraged especially on health education.

DEDICATION

Great is His faithfulness. This thesis is dedicated to the Almighty God, who led me through it all to complete this research work successfully.

I also dedicate this work to my dear Uncle Mr. Kwabena Appiah, Mum Francisca Amankwah and Fiance Caleb Afoakwah Oppong for making me who I am today, for their financial support and for teaching me the value of education.

To my brothers Bright, Charles and Isaac for their daily encouragement and inspiration.

Lastly, this work is dedicated to my aunty Mrs Joyce Appiah for her advice, love and support.

ACKNOWLEDGEMENT

First and foremost, I would like to thank the Almighty God for the gift of breath, health and strength throughout the process of carrying out this study and for seeing me through all.

I wish to acknowledge the support of all who contributed in various ways to make this study a success. My deepest gratitude goes to my able supervisors Dr. Felix O. Mettle and Dr. K. Doku-Amponsah who went through my thesis, guided and advised me accordingly.

Special thanks to my uncle and fiancé, Mr. Kwabena Appiah and Caleb Afoakwah Oppong, who supported and stood by me from the beginning till the end. I also wish to express my thanks to all my friends, especially Caleb Owusu Ansah, who assisted and encouraged me during my thesis write up.

I am grateful to the administration, the Head of Department (Obstetrics and Gynecology) of Ridge Hospital for allowing the usage of their facility for this project not forgetting the matrons and nurses of the maternity ward and postnatal clinic and the entire staff who assisted me in one way or the other and to the mothers for taking their time to be interviewed.

Last, but certainly not the least, my heartfelt appreciation goes to the Postdoctoral Fellowship of the Noguchi Memorial Institute for Medical Research for funding this research.

May the good Lord bless you in all your endeavors.

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ANC	Antenatal Clinic
AS	Apgar Score
BMI	Body Mass Index
BW	Birth Weight
CD4	Cluster of Differentiation 4
CI	Confidence Interval
CS	Caesarean Section
DBP	Diastolic Blood Pressure
GSS	Ghana Statistical Service
HB	Haemoglobin
HIV	Human Immunodeficiency Virus
IOM	Institute of Medicine
IUGR	Intrauterine Growth Retardation
LAS	Low Apgar Score
LBW	Low Birth Weight
LR	Logistic Regression
MANOVA	Multivariate Analysis of Variance
MDG	Millennium Development Goals
MICS	Multiple Indicator Cluster Survey
NAS	Normal Apgar Score

NBW	Normal Birth Weight
OLS	Ordinary Least Squares
OR	Odds Ratio
PTB	Preterm Birth
RR	Relative Risk
PTD	Preterm Delivery
SBP	Systolic Blood Pressure
SES	Socioeconomic Status
SGA	Small for Gestational Age
SIDS	Sudden Infant Death Syndrome
SVD	Spontaneous Vaginal Delivery
UNICEF	United Nations International Children’s Emergency Fund
WHO	World Health Organization

CHAPTER ONE

INTRODUCTION

1.0 Background of Study

The birth of a child all over the world mostly brings joy not only to the parents, but the whole family at large (Fosu et al, 2013). It attracts attention from both close relatives and the community members. Typically, in Ghana the women dress in white clothing from headgear to footwear. However the course of pregnancy is not given such needed attention. The onus lies solely on the one who is pregnant despite the fact that scientific literature has indicated that the outcome of pregnancy depends on both external and internal factors experienced by the pregnant woman (Abel, 1980).

The main direct causes of neonatal mortality in Africa are respiratory related problems – birth asphyxia (40%), low birth weight (25%), infections (20%), congenital defects (10%) and others (5%) (WHO, 2004). It can be seen from the report by WHO that birth asphyxia and birth weight contributes more than two-thirds of the factors that cause neonatal mortality.

In Ghana, the issue of birth weight and factors influencing it has not received the much needed attention. This should not be the case because birth weight is a strong predictor of an individual baby's survival and the personality of the person (Datta, 1978). The recommended weight at birth should be in a range of 2.5kgs to 4.0kgs (Garner et al, 1992).

Low Birth Weight (LBW) defined as the weight at birth less than 2.5kg (WHO, 1995) is either the result of Preterm (less than 37 weeks gestational age) delivery or due to intrauterine growth retardation or of both and that in full term pregnancy, birth weight is greatly influenced by the fetal growth which is closely linked to nutritional status during the pregnancy period and also after birth to the next pregnancy (Yadav & Lee, 2013). The majority of low birth weight infants are also premature (Joyce et al, 2012).

Risk factors for preterm delivery include maternal or fetal stress, infections, and violence. Low birth weight has also been associated with socioeconomic indicators such as education and income as well as with stress during pregnancy. In addition, high-risk behaviors, such as smoking, may themselves be associated with low birth weight (Ricketts et al., 2005).

Intrauterine growth retarded babies are also known as small-for-gestational age (SGA). These babies may be full term, but they are underweight. Some of these babies are healthy even though they are small and may be small because their parents are smaller than average. Others are underweight because something slowed or halted their growth in the uterus, for example problems with the placenta, the mother's health (chronic health problems) or birth defects (Back, 2010).

In spite of consistent efforts to improve the quality of maternal and child health, more than 20 million infants in the world (15.5% of all births) are born with low birth weight, 95.6% of them born in developing countries (Aurora et al, 1994; Khatum & Rhaman, 2008). The largest number of LBW babies is concentrated in two regions of the developing world which are Asia and Africa. Seventy two percent of LBW in developing countries are born in Asia, specifically, South Asia, which accounts for half of the LBW, and 22% are born in Africa (UNICEF & WHO, 2004). The rest of the major contributors of neonatal mortality are respiratory problems (birth asphyxia), congenital defects and infection.

According to WHO (2012), birth asphyxia (which is failing to initiate and sustaining breathing at birth), contributes to about 25% of neonatal deaths worldwide. What determines whether the newborn baby suffers from birth asphyxia is the Apgar score. The Apgar score was developed on purpose to detect birth asphyxia so as to intervene with resuscitation (Apgar, 1953). The APGAR is measured by examining the following from the baby; Appearance, Pulse, Grimace, Activity and Respiration (Apgar, 1953). These five categories put together form the acronym APGAR. The score of each category put together gives the Apgar score recorded at one minute and five minutes after birth (University of Maryland, 2013). Even though it is purposely to detect asphyxia (respiratory problems), other medical conditions are included too. A newborn baby with a low Apgar score means the child is in a critical health condition and as such requires a special intensive care. There is a significant relationship between children with low Apgar score and short term mortality (Weinberger B, 2000; Addo-Yobo, 2007). Not only is low Apgar score related to just short term complication but also long-term medical complications as well (Ehrenstein, 2009). Since the birth weight is not considered when taking an Apgar score, it is logic to say the health status of a new born baby can be summarized by the two vital scores; Weight at Birth and APGAR score.

Maternal HIV infection has been shown to be associated with a number of adverse perinatal outcomes including Preterm Delivery (PTD) and LBW. One of the earlier systematic reviews by Brocklehurst & French reported that, adverse perinatal outcomes related to maternal HIV infection included, intrauterine growth retardation, low birth weight, and PTD (Brocklehurst & French, 2005). In a later review by Ter Kuile in 2004, several studies were identified that examined the effect of dual infection with malaria and HIV on birth outcomes (Steketee et al., 1996; Ticcconi, et al., 1999; Ayisi, et al., 2003). In Tanzania, Villamor et al (2005) examined the risk of adverse perinatal outcomes in relation to maternal or unbilical cord Plasmodium falciparum parasitemia among HIV-infected women and also reported that malaria and HIV were associated with LBW and PTD. Low birth weight (LBW) infants are at higher risk of mortality and morbidity than infants with normal weight at birth (Bakketeig et al., 2006). Studies in Tanzania, Kenya, Rwanda, and Zambia found that HIV-1 infection was associated with adverse pregnancy outcomes of low birth weight (LBW), prematurity and intrauterine growth retardation (Dreyfuss et al., 2001; Villamor et al., 2003).

Goldstein et al. (2000) argued that, HIV- infected women with lower CD4 count are particularly prone to have LBW infants. There was also a significantly higher risk of low birth weight and prematurity among symptomatic HIV-infected women (Coley, et al., 2001). HIV-infected women are more likely to deliver LBW infants due to inadequate maternal weight and maternal anemia (Kennedy-Oji et al., 2001). As antiretroviral therapy expands in Sub-Saharan Africa, the population of HIV-1 exposed uninfected infants continues to grow. HIV-exposed uninfected infants have increased rates of morbidity and mortality compared to unexposed infants (Slyker, et al., 2014). The reason for increased morbidity among HIV-exposed uninfected infants is likely due to a combination of factors including reduced maternal transfer of antibodies, increased exposure to infectious pathogens from their mother, and altered immunologic development.
According to Khatum & Rhaman (2008), neonatal survival depends on both gestational maturity and birth weight and is not significantly better in babies who are low birth weight for gestational age. From 1998 to 2004, Ghana recorded higher LBW cases of 16% compared to the average of 14% for the Sub-Saharan Africa (Amagloh et al, 2009). In East Africa the prevalence of LBW is

13.5% (UNICEF and WHO, 2004). The 2006 MICS report, however, found the prevalence rate to be 9.1%. The difficulty is that only 2 of 5 babies were weighed at birth (MICS, 2006).

In developing countries, the major determinants of LBW are racial origin, nutrition, low pre-pregnancy weight, short maternal stature, and malaria (Fosu et al, 2013). Although the genetic makeup of a baby is from both paternal and maternal, physiology suggests mothers are largely responsible for the growth of the fetus since they are the direct carriers (Walton & Hammond, 1938).Poor nutrition is a known cause of low birth weight and that maternal nutritional factors both before and during pregnancy account for more than 50% of cases of low birth in many developing countries (Ramakrishnan, 2004). Most of this evidence was based on pre-pregnancy nutritional status assessed by using anthropometric criteria and the adequacy of energy and protein intakes during pregnancy.

WHO (1995), reported that weight gained at 5 or 7 lunar months was the most practical screening for LBW and Intrauterine Growth Retardation (IUGR).The reduction of the incidence of LBW also forms an important component of the Millennium Development Goals (MDGs) on child health. The activities towards the achievement of the MDGs will need to ensure a healthy start in life by making certain that women commence pregnancy healthy and well nourished, and go through pregnancy and childbirth safely (GSS et al, 2004). Low birth weight is, therefore an important indicator for monitoring the progress towards these internationally agreed-upon goals. Earlier works have stated that the birth weight of infants in Ghana ranged from 2.0kgs to 3.0kgs (Amagloh et al, 2009).

More babies are surviving despite being born early because of tremendous advances in care of sick and premature babies. However, prevention of preterm births is one of the best ways to prevent babies born with LBW (UNICEF & WHO, 2004). This study is aimed at identifying maternal HIV status and other maternal risk factors affecting birth weight and the Apgar score of infants in Ghana.

1.1 Problem Statement

The larger proportion of neonatal mortality is caused by low birth weight and birth asphyxia. Quantitatively the two are measured using birth weight and Apgar score. Having a low birth weight baby can cause emotional, social and financial stress for the family. This is because LBW babies can have a life- long health problems and it is also the main reason why babies die in the first year of life (UNICEF & WHO, 2004.). Low birth weight babies are at higher risk for serious health problems and long lasting disabilities. It is therefore a major determinant of mortality, morbidity and disability in infancy and childhood, and has a long-term impact on health outcomes in adult life. Although advances in newborn medical care have greatly reduced the number of deaths associated with low birth weight, a small percentage of survivors develop mental retardation, learning problems, cerebral palsy, vision and hearing loss.

According to WHO, the 30 million low birth babies born annually (23.8% of all births), often face severe health problems. Low birth weight is a challenging health problem and interventions need to be put in place to reduce its incidence. Since LBW is preventable, it is important to establish the factors associated with this outcome. Weight at birth is also a good indicator not only of the mother’s health and nutritional status, but also of the newborn's chances of survival, growth, long-term health and psychophysical development.

There are few available researches on maternal HIV status and other risk factors associated with birth weight, of which there are few ones conducted in Ghana. In the case of Apgar score, there are almost non-existing researches associating HIV and other maternal factors to its outcome in Ghana. Low Apgar score is a major contributor of neonatal mortality and therefore if its risk factors are in connection with some antepartum factors, knowledge of it will be vital in curbing neonatal mortality through early intervention

Some of the researches that have been carried out on birth weights and Apgar score include: Fosu et al (2013), Njuki (1983), Jammeh et al (2011) and Odd et al (2008), and among many others used logistic regression to select the maternal factors that significantly affect only birth weight because of subjective measures of some of the maternal confounders. However, in Ghana not many studies have been done to indicate maternal HIV and other factors associated with low birth weight and low Apgar score. Therefore, this study seeks to use logistic regression to select significant maternal factors that affect birth weight and Apgar scores and then proceed to use MANOVA to determine if differences exist between HIV-negative and HIV-positive mothers on birth weight and Apgar score.

1.2 Objectives of the Study

1.2.1 General Objectives

The main objectives of this research is to seek a model that predicts low birth weight and low Apgar score of infants using the maternal factors as cofounders.

1.2.2 Specific Objectives

The Specific Objectives would be to:

a) To examine maternal risk factors that have significant impact on birth weight of infants.

b) To investigate maternal risk factors that have significant impact on Apgar score of infants.

c) To determine whether there is any difference existing between HIV-negative and HIV-positive mothers on Birth Weight and Apgar score of newborn infants.

1.3 Significance of the Study

This study is aimed at providing data and information that will help healthcare providers administer proper education to mothers during pregnancy with regards to HIV and other risk factors associated with low birth weight and low Apgar score.

The results from this study will help stakeholders of health, WHO, Government of Ghana through the Ghana Health Service to forecast the Low Birth Weight of an about to be born baby using maternal factors. The outcomes of this research will help health institutions to sknow the effects of HIV infection on pregnancy by providing possible interventions to prevent the delivery of LBW and LAS babies and also avoid mother-to-child transmission.

The study will also form a basis for further in-depth medical research about HIV and other significant maternal factors that affects the low birth weight of the newborn baby. Besides, the study will contribute to existing literature on the use of Logistic regression and Multivariate analysis of Variance (MANOVA).

1.4 Scope and Methodology

The target population for this research is mothers at Ridge Hospital who are in their postpartum stage. The data used for this study comprised of both primary and secondary sources. The primary data were obtained through interviews whereas the secondary data were recorded from the mother's antenatal book. Statistical Package for Social Sciences (SPSS) version 20 was used to analyze the data by applying Logistic Regression and Multivariate Analysis of Variance (MANOVA).

1.5 Organization of the Study

This study is organized into five chapters. Chapter one deals with the introduction, which comprises of the background of the study, problem statement, objectives, significance of the study and organization of the study. The rest of the chapter will be organized as follows. Chapter two discusses the literature review. Chapter three elaborates on the manner in which research methodology is designed and conducted. Chapter four presents the results and discussions of the research findings. The final chapter provides conclusions and contributions of the study as well as well as recommendations for future research.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

This chapter is about to review some works or studies which have been carried out by other researchers in relation to birth weight and Apgar score and their relationship with maternal factors. It also aims at identifying some of the areas that logistic regression analysis and multivariate analysis of variance can be used. This chapter is divided into the main headings: Low birth weight and Apgar score (birth asphyxia) and their association with some of the maternal factors, variable selection with significant associations to outcome variable which basically deals with comparative importance and use of Logistic Regression (LR) and lastly the use of Multivariate analysis of Variance (MANOVA).

2.1 Low Birth Weight

Birth weight is the body weight of a baby at birth. It is taken just after the baby is born. Immediately a child is born, a weighing scale is used to measure its weight in grams (g) or kilograms (kg) and it's recorded. Accurate birth weights can be measured when delivery takes place in a health institution and by skilled personnel. A birth weight is considered low if the baby weighs less than 2.5kg and normal if the baby weighs between 2.5kg and 4.0kg. It is believed that the incidence of low birth weight is about 20 million each year (UNICEF & WHO, 2004). The figure 2.5kg was chosen as a bound because studies over the years discovered that, the odds ratio of children weighing less than 2500grams dying to those weighing above 2500 grams is 20.

Low birth weight is a reliable indicator for observing and assessing the success of maternal and child health programs and has been defined as a birth weight less than 2500g (WHO, 1992). It is a complicated public health problem (UNICEF & WHO, 2004) and a major determinant of morbidity, mortality and disability in neonates, infancy and childhood (WHO, 2010). It has a long term effect on health outcomes in adult life. Apart from the immediate impact of low birth weight on the neonate, studies have shown it is also a major risk factor in later life of the baby who survives this morbidity condition. According to Thompson et al (2001), low birth weight is an anticipated risk factor for depression among men in their later life. This is because they found out that the odds ratio of having depression in later life between men who had lower birth weight to those who had normal weight at birth is 12.8. Hack (2006) also claimed that children with lower birth weight tend to have poorer educational achievements compared to those who had normal birth weights.

According to UNICEF & WHO (2004), low birth weight babies are more likely to experience neonatal mortality 20 times as compared to heavy weight babies worldwide. While in industrialized countries, majority of LBW infants do well, thanks to the advances of obstetric and neonatal care, the chances for survival of LBW infants is much lower in Africa and other developing countries due to inadequate or limited medical care including proper antenatal care (Elshibly & Schmalisch, 2008).

In addition to its impact on infant mortality, LBW especially due to IUGR (intrauterine growth retardation) is accompanied with higher chances of infections, malnutrition and handicapping conditions during childhood, including cerebral palsy, mental deficiencies and problems related to behavior and learning (Berkowitz & Papiernik, 1993). Children who survive LBW have, a higher prevalence of diseases, retardation in cognitive development and undernourishment

(Barker et al., 2001). There is an indication that LBW or its determinant factors are associated with the tendency of having higher rates of diabetes, cardiac diseases and other future chronic health problems (Torres-Arreola et al., 2005). In a systematic review, de Onis et al. (1998) found that IUGR babies are at increased risk of perinatal mortality and morbidity conditions, including sudden infant death syndrome, poor cognitive development and neurologic impairment, cardiovascular disease, high blood pressure, diabetes, high cholesterol concentrations, obstructive lung disease and renal damage in adult life. Such babies continue to be a burden on government expense and a permanent problem for their families.

To a certain extent, some studies have been carried out worldwide on maternal risk factors with regards to low birth weight.

In order to establish the maternal risk factors for low birth weight (LBW) using data from a District Hospital in the Ashanti Region of Ghana in 2013, Fosu et al. (2013) used logistic regression analysis to control the maternal confounders. The maternal factors, namely; age, socioeconomic factors, antenatal services, residence/location (urban, rural), gestational age, haemoglobin levels, placental malfunction, weight, height, mothers' education, fetal infection, babys' sex among others were studied. Out of the total of 1,200 mothers sampled, 153 gave birth to babies who weighed less than 2.5kg, giving the LBW prevalence in this study as 21.1%. Their results revealed that the significant factors were fetal infection (p-value=0.000), residence, haemoglobin level (p-value=0.000), antenatal care (p-value=0.000) and maternal age (p-value=0.016). Their results again showed that, the possibility of giving birth to children of low birth weight among women who did not attend antenatal care was higher than those who received antenatal care even once (29.0% versus 20.4%). Furthermore, women who were less than 24 years or above 35 years had the highest proportion of children who weighed less than 2.5kg.

A four month prospective study carried out in the Machakos Provincial Hospital by Njuki (1983) to investigate the incidence, aetiology and mortality in LBW infants placed the incidence of LBW at 9.3%. The factors that contributed to the delivery of LBW infants in this study were maternal factors including age, marital status, parity, height, maternal illness and attendance of the antenatal clinic, and maternal medical diseases which included febrile illness, pre-eclampsia, eclampsia and antepartum haemorrhage.

In order to find out the maternal and obstetric risk factors of low birth weight (LBW) and pre-term births with data from two rural hospitals in Gambia in 2008, Jammeh et al (2011) used logistic regression to estimate the odds ratios of occurrence of low birth weights. The rate of LBW (irrespective of gestational age) and preterm birth were 10.5% and 10.9% respectively. The significant factors were maternal age less than 20 years (OR=1.45) in delivering with low birth weight compared to above 30 years, Parity; primipara had OR of 2.48 CI (1.05-5.83) compared to over 5 parity (grand multiple) in delivering LBW, antepartum hemorrhage (OR=6.59, CI (1.86-23.36)) and Pregnancy Induced Hypertension (OR=2.71). Antenatal clinic visits was not a significant factor. They advocated for focused antenatal care and encouraged frequent attendance of antenatal clinic to help monitor antepartum hemorrhage and Pregnancy Induced Hypertension.

Another study was conducted in Kisumu by Were & Karanja (1994) on LBW deliveries in the Nyanza Provincial Hospital over a period of four months and estimated the incidence of LBW at 15%. The most common antenatal complications associated with LBW delivery were pyrexia, premature rapture of membranes before term and multiple pregnancy. Of the multiparae who delivered LBW babies gave history of previous abortion, premature delivery, neonatal birth and stillbirth.

2.1 Factors associated with LBW

Some factors associated with low birth weight, which includes maternal HIV status, smoking, nutrition, socio-demographic and maternal anthropometric measurement are discussed.

2.1.1 Maternal Retroviral (HIV) Status

The effect of HIV on children is seen very early in life, manifested as intrauterine growth retardation, low birth weight and poor growth during the early months of life and HIV-infected children suffer stunting and wasting within the first few months after birth (Venkatesh et al., 2010). In a randomised, controlled trial involving HIV- positive pregnant women in Tanzania, multivitamin supplements significantly reduced the risks of fetal death, low birth weight, and preterm birth and increased maternal CD4 cell counts and haemoglobin levels (Fawzi et al., 2007). Because these benefits might not apply to HIV-negative women, they conducted a similarly designed trial, which involved HIV-negative women in Tanzania to assess the effects of these supplements on birth outcomes and maternal health indicators.

In determining the correlation between maternal and infant HIV-infection and low birth weight, Mwanyumba et al.,(2001), used data from 8563 singleton live borns in Mombasa, Kenya. Using multivariate analysis, they found that maternal HIV-infection was independently associated with LBW (RR=1.46, 95% CI=1.20-1.79, P =0.0002). Maternal age, primiparity, sex of the baby, religion, syphilis infection, anemia and previous history of stillbirth were also independently associated with LBW (RR: 1.32, 2.19, 1.44, 1.56, 1.61, 1.31 and 1.69, respectively). They concluded that HIV-infected mothers were more likely to have small babies, even after controlling for possible confounding factors and that low birth weight babies were more at risk for peripartum HIV transmission but then suggested further research is needed to study mechanisms of transmission in relation to birth weight.

Schulte et al. (2007), determined the trends in low birth weight and preterm birth among US infants who were born to HIV-infected women. They used data from the longitudinal Pediatric Spectrum of HIV Disease, a large HIV cohort, to assess trends in low birth weight and preterm birth from 1989 to 2004 among 11321 study infants. The risk factors they evaluated comprised maternal antiretroviral therapy during pregnancy, that were predictive of low birth weight and preterm birth using univariate and multivariate logistic regression models. They deduced that the proportion of HIV-exposed infants who had low birth weight decreased from 35% to 21% and occurred in all racial or ethnic groups. They found that among 8793 women who had prenatal care, low birth weight was associated with a history of illicit maternal drug use, unknown maternal HIV status before delivery, symptomatic maternal HIV disease, black race, Hispanic ethnicity, and infant HIV infection. Antiretroviral therapy or lack of it was not associated with low birth weight.

2.1.2 Maternal Smoking

Maternal smoking during pregnancy impairs foetal growth and shortens gestation causing premature birth with significant foetal and infant mortality and morbidity. Studies have suggested that carbon monoxide and nicotine are among the main ingredients in cigarette smoke responsible for adverse foetal effects (Haustein, 1999). In pregnant women, carbon monoxide and high doses of nicotine interfere with oxygen supply to the foetus. Nicotine readily crosses the placental barrier and reduces foetal blood supply, altering oxygen delivery to the foetus (Oncken, et al, 1998). The carbon monoxide from smoke also causes foetal hypoxia and blunts the adaptive response that would normally occur.

Pregnant women who smoke cigarettes are nearly twice as likely to have a low birth weight baby as women who do not smoke. Results of seven studies reviewed by Haustein (1999) on effects of cigarette smoking and nicotine on pregnancy outcomes indicated that the mean birth weight of infants of women who smoke during pregnancy is 200-300grams less than that of infants of nonsmokers. Newborns born to smokers are smaller at every gestational age. Prenatally, women who smoke during pregnancy have a higher risk of placental abruption, spontaneous abortions, and premature birth. Postnatally, the most dramatic effect of maternal smoking is the increased risk of sudden infant death syndrome (SIDS). It has also been linked to an increased likelihood of asthma in childhood and a lower IQ in adulthood (Lanting et al., 2009).

A pilot study done by Stark & Stepans (2004) indicated an elevation in systolic and diastolic blood pressure in term, low birth weight infants of smoking mothers when compared to infants born to nonsmoking mothers. Passive smoking can also be a contributing factor. Maternal use of smokeless tobacco should also receive specific attention as a part of routine prenatal care (Gupta & Sreevidya, 2004). Alcohol and illicit drugs can limit foetal growth and cause birth defects (Berghella, 2007). Some drugs, such as cocaine, may increase the risk of premature delivery.

2.1.3 Maternal Nutrition

Maternal nutritional status is considered to be an important factor that affects the successful completion of pregnancy (Abrams & Selvin, 1995). In extreme cases of chronic undernutrition, low energy intake during pregnancy was associated with low birth weight (Eastman & Hellman, 1996). However the effect of moderate malnutrition on foetal growth is not clear. Other interacting factors such as racial and genetic background, age, general health, educational status, cigarette smoking, past nutritional status of the mother, parity, multiple pregnancies, climate, socioeconomic conditions related to sanitation and infections, and the availability of health services make interpretation of the association between maternal nutrition and foetal development difficult.

According to Stephenson & Symonds (2002), maternal nutrition, including maternal dietary intake, circulating concentrations, uteroplacental blood flow, and nutrient transfer across the placenta, influences birth weight. He stated that maternal nutrition describes the pregnant woman's diet and the effects of severe macronutrient deficiency depend on the stage of gestation. Poor nutrition is a known cause of LBW, especially in developing countries (Ramakrishnan, 2004). In his classic review published more than a decade ago, Kramer (1987) concluded that maternal nutritional factors both before and during pregnancy account for more than 50% of cases of LBW in many developing countries.

2.1.4 Socio-demographic factors

Some of the socio-demographic factors include maternal age, educational level and income level, poverty and unemployment among others. Low maternal age or teenage pregnancy is accompanied with maternal complications, premature birth, LBW, perinatal mortality and increased infant mortality. In developing countries it has also been observed that, teenage mothers were at increased risk of maternal anemia, preterm birth and Caesarean delivery (Yadav et al., 2008). Low income and lack of education are associated with increased risk of having LBW babies although the underlying reasons are not well understood (ACOG, 2000). Women of low financial standing have been linked with a high risk of having low birth weight babies (Brown, 1985; Chuku, 2008).

According to Foster et al (2000), as socioeconomic status (SES) increases, the occurrence of low birth weight and preterm birth decreases regardless of social class. High SES women of low birth weight are less likely to report that they are in poor or fair health than other LBW women (Currie & Hyson, 1999). According to Reichman (2005), education may also have independent effects, above and beyond income, because more highly educated mothers may know more about family planning and healthy behaviours during pregnancy.

Tuntiseranee et al. (1999), looked at the effect of socioeconomic determinants of pregnancy outcomes for Thailand and even after adjusting for maternal characteristics and number of antenatal visits, found out that the mean birth weight correlated with family income. In his assessment, socioeconomic status of the household is a major determining factor of birth weight.

While some studies are questionable about the role of maternal education on pregnancy outcomes, it is likely that education and occupation will have a negative impact on poor pregnancy outcomes (Ebomoyi et al. 1991; Tuntiseranee et al., 1999) as a result of their ability to improve women's status and access to information. On the contrary, some studies have found that the more educated a woman is, the more her chances of experiencing poor birth outcomes. The finding from the study on Nigeria, Adetunji (1995) who suggested that unemployment rate was high among secondary school graduates which impacted their socioeconomic status thus reducing access to health care is a possible explanation. Prazuck et al (1993), anticipated that educated mothers were more likely to use motorbikes on bumpy roads which caused intrauterine vibrations, affecting poor birth outcomes.

2.1.5 Maternal Anthropometric Measurements

According to Muthayya (2009), the causes of low birth weight are multifaceted and mutually dependent, but the anthropometry of the mother and her nutritional intake are believed to be among the most important. WHO (1995) suggested that energy balance is an important determinant of birth outcomes since pre-pregnancy weight, body mass index (BMI) and gestational weight gain all have strong, positive effects on foetal growth. The WHO collaborative study on Maternal anthropometry and pregnancy outcomes, using data from 111,000 women from across the world reported that mothers in the lowest quartile of prepregnancy weight was at higher risk of IUGR and low birth weight of 2.55 (95% CI 2.3, 2.7) and 2.38 (95% CI 2.1, 2.5) respectively, compared to the upper quartile. Attained maternal weight at 20, 28 or 36 week of gestation showed even higher odds ratios for IUGR of 2.77, 3.03 and 3.09 respectively when women were compared between quartiles of highest to lowest attained weight. This probably considers weight gain in pregnancy including that of the foetus.

Excessive weight gain during pregnancy is a major determinant of high postpartum weight retention and long term obesity in women (Phelan et al 2011; Ashley et al 2001). This is linked with several adverse maternal and foetal outcomes, including gestational hypertension, diabetes, preeclampsia, and cesarean delivery in mother and macrosomia and long-term obesity in the offspring. The liberalisation of the weight gain recommendations was associated with increased means of both pregnancy weight gain and infant birth weight (Abrams, 1994). According to Kruger & Pharm in 2005, the Institute of Medicine (IOM) published recommended weight gains by prepregnancy BMI in 1990. The table below shows the recommended total weight gain during pregnancy by pre-pregnancy BMI.

Table 2.1 Recommended total weight gain during pregnancy by pre-pregnancy BMI

BMI category (kg/m2)	**Recommended total weight gain (kg)***	**Second and third trimester weekly weight gain (kg)**
Low (BMI<19.8)	12.5-18	0.49
Normal (BMI 19.8-26.0)	11.5-16	0.44
High (BMI>26.0-29.0)	7-11.5	0.3
Obese (BMI>29.0)	6	

 # BMI = body mass index

An overall weight gain during pregnancy of 11.5-16 is considered appropriate for a woman of normal weight. A total gestational weight gain for women with twin pregnancies is 16-20.5kg. Feig & Naylor (1998), assessed the IOM recommendations and recommended a weight gain range of 7-11.5kg for women with a normal pre-pregnant BMI, which is closer to the recommendations of 30 years ago. They stated that weight gain within the IOM recommendations will produce obese mothers and overgrown babies, necessitating ceaserian deliveries.

Using data from a prospective study of pregnancy outcome risk factors in 2301 women in greater New Haven, Conn, who had singleton deliveries by primary (n = 312) or vaginal delivery (n = 1989) and for whom height, prepregnancy weight, and weight gain were available, Shepard et al in 1998, predicted that proportional weight gain was more predictive of ceserean delivery than absolute weight gain and that underweight women gaining more than 27.8% of their prepregnancy weight had a 2-fold adjusted relative risk of ceserean delivery.

2.2 Apgar score (Birth Asphyxia)

According to WHO (2012), birth asphyxia is the leading cause of neonatal mortality and is simply defined as the inability of a newborn baby to start and sustain breathing at birth.

The new born baby is assessed whether asphyxia is present or not using Apgar score immediately after birth. The Apgar score was first developed in 1952 by Dr. Virginia Apgar, a woman anesthesiologist and is used to evaluate the survival of newborn babies (Apgar, 1953). This scoring system provided a standardized assessment for infants after delivery.

The Apgar score comprises five components: heart rate, respiratory effort, muscle tone, reflex irritability, and color, each of which is given a score of 0, 1, or 2 for a maximum score of 10. According to Steven & Utpalla (2004), although the Apgar score can somewhat predict mortality, it is not a tool to be used alone in determining neurologic outcomes of infants who survive. Apgar scoring is best used in conjunction with additional evaluative techniques such as physical assessment and vital signs (Montgomery, 2000). The table below shows how the Apgar score is given to newborn babies. A heart rate below 100 signifies an asphyxiated baby and a heart rate above 160 signifies distress.

Table 2.2: The Apgar Scoring System

	0	1	2
Heart rate	Absent	Below 100	Above 100
Respiratory effort	Absent	Slow, irregular	Good, crying
Muscle tone	Flaccid	Some flexion of extremities	Active motion
Reflex irritability	No response	Grimace	Vigorous cry
Color	Pale	Cyanotic	Completely Pink

These scores are given at birth by skilled personnel (a doctor or a midwife). Therefore the total score will be from 0 to 10 inclusive. An Apgar score of zero means the baby is a still born. It is in this light that the Apgar score was designed initially to detect survival. Clearly looking at some of the components of Apgar score one may conclude that it shows more than just determining asphyxia.

Apgar scores are recorded at both 1minute and 5 minutes after birth. Since the child struggles before coming out, the 1-minute Apgar score though used in the evaluation of the child is not over emphasized but rather the 5-minute score. With depressed infants, scoring should be repeated every five minutes as needed. An Apgar score of less than 7 is regarded as low (Steven & Utpalla, 2004). Hence a 5-minute Apgar score less than 7 may be interpreted as the presence of asphyxia and as such, the baby requires an intensive care and resuscitation if necessary.

The importance of low Apgar scores of babies cannot be underemphasized. A low Apgar score, which suggests the presence of birth asphyxia is the leading cause of death of neonates across the globe (WHO, 2012).

Some researchers have also attempted to relate Apgar score with other various outcomes including development, later delinquency, intelligence and neurological development, which are respectively discussed.

In demonstrating to what degree Apgar scores predict developmental outcome, Behnke et al, (1989), provided a data base for premature infants. They tested Apgar scores alone and in combination with two other easily quantified variables, birthweight and gestational age, as predictors of risk for 256 infants who weighed less than 1800gm at birth. Although they found that significant correlations existed between Apgar scores and Bayley Mental and Psychomotor Developmental Indices, multiple regression analyses demonstrated that these relationships were not significantly independent of birth weight and gestational age. That is, after they have controlled for birth weight and gestational age, they concluded that, Apgar scores did not predict morbidity in low birth weight infants and so should not be used to provide a developmental prognosis.

Using a longitudinal data set from the Philadelphia portion of the Collaborative Perinatal Project which consisted of 832 inner-city, African-American youths, Gibson & Tibbetts (1998), examined the interaction of maternal cigarette smoking during pregnancy and 1-minute Apgar scores at birth in predicting individuals' later offending behavior. In their analysis, a logistic regression indicated that the combined effect of maternal cigarette smoking and low Apgar scores had a significant influence in predicting offending behavior, whereas the independent effects of the component variables did not.

Nelson & Ellenberg (1981), in trying to investigate Apgar scores as being predictors of chronic neurologic disability, recorded Apgar scores at one and five minutes for approximately 49,000 infants, and at 10, 15, and 20 minutes for babies who did not achieve a score of 8 or higher at five minutes. They followed the children to the age of 7 years and found out that, low Apgar scores were risk factors for cerebral palsy, but 55% of children with later cerebral palsy had Apgar scores of 7 to 10 at one minute, and 73% scored 7 to 10 at five minutes. They also deduced that, Of 99 children who had Apgar scores of 0 to 3 at 10, 15, or 20 minutes and survived, 12 (12%) had later cerebral palsy; 11 of the 12 were also mentally retarded (in ten, IQ less than 50) and half had seizure disorders. Eight children who survived after having very low late Apgar scores and who did not have cerebral palsy had lesser but significant disabilities. Of the children who had Apgar scores of 0 to 3 at ten minutes or later and survived, 80% were free of major handicap at early school age.

In determining their Apgar score at 5 and 10 minutes, Misra et al, (1994), followed 64 term asphyxiated newborns (Apgar score = or 6) and 90 term nonasphyxiated newborns at Queen Mary's Hospital in Lucknow to compare their outcomes in terms of mortality and neurodevelopment. Their results showed that neonatal mortality increased as the 5-minute Apgar score decreased (5.6% for controls [=or 7], 6.3% for 6, 20% for 5, 25% for 4, and 63.3% for 0-3). It was significantly higher for the 10-minute Apgar groups (16.7% for 6, 33.3% for 5, 40% for 4, and 77.8% for 0-3). At 3, 7 and 11 month follow-up, the neurodevelopmental outcome of infants whose 5-minute Apgar score was 6 was similar to that of the controls. Their findings then suggested that a 5-minute Apgar score of 6 should not be considered as asphyxia (i.e scores of 5 or less should denote asphyxia). They also found that the Apgar score should be repeated at 10 minutes so health providers can better predict neurodevelopmental outcome.

Also, quite a few studies have linked prevalence of low Apgar scores to some maternal factors just like birth weight.

A research conducted by Ondoa-Onama & Tumwine (2003) to determine the prevalence of low Apgar score and to establish the immediate outcome and possible risk factors, used babies who were delivered in Mulago Hospital between September and October 1999. Their studies showed that the prevalence of low Apgar scores at one and five minutes was 8.4% and 2.8% respectively. They found that the maternal factors are significantly associated with low Apgar scores included primiparity, abnormal delivery, age and medical diseases during pregnancy.

Odd et al (2008), used data from all male-born in Sweden from 1973 to 1976 and compared it to the Population and Housing Census in the same area and time period to ascertain which maternal factors had an impact on low Apgar score. They deduced that maternal occupation type and education had significant association with Apgar score. Particularly, education had a positive impact on the risks of low Apgar score.

Salustiano et al (2012) used a retrospective cohort and case-control design of 27,252 consecutive term newborns in a low risk obstetrical population between January 2003 and December 2010 to evaluate the association between Apgar scores of less than seven at five minutes and antenatal factors and postnatal outcomes. They used multiple regression analysis and found that repeated late decelerations on cardiotocography (OR=2.4) and prolonged second stage of labour (OR=3.3) were associated with Apgar score less than 7 at 5minutes. However, they found no other antenatal factors to be associated with Apgar score less than 7 at 5minutes ($p > 0.05$).

In trying to find an association between maternal factors and low Apgar score Straube et al (2010) used data of all singleton term pregnancies from 1998 – 2000 from the German perinatal statistics. They used simple chi – square test to check the significance of the association and found out that, maternal age, parity and body mass index are significantly associated with low Apgar scores. Using logistic regression to compute the odds, they observed that, low Apgar score was more common among heavier mothers (OR= 1.24, CI= 1.10 – 1.40), primiparity (OR= 1.52, CI= 1.37 – 1.70) and older maternal age (above 35) (OR= 1.35, CI= 1.16 – 1.58). They concluded that BMI, parity and age are risk factors for low Apgar score of a newborn baby and as such efforts must be made to advice pregnant and potential pregnant mothers on these potential dangers.

However, Milsom et al (2002) used a case-control design to study the risk factors of prevalence of birth asphyxia in urban population in Sweden. They found no maternal factor significantly linked to birth asphyxia. This may possibly be due to smaller incidence of neonatal morbidity in that region as reported by WHO in 2004.

2.3 Selection of Variables

Depending on the characteristics of the dependent or the independent variable or both, several statistical methods have been developed and can be used to select variables which are also used to build a model. These characteristics include their measurement scales, the underlying assumptions about the variables, and the method used for the study (whether bivariate or multivariate). This section reviews the works on the statistical tools that can be used to test the association between a dependent (outcome) variable and an independent (explanatory) variable.

2.3.1 Procedure for Bivariate Selection

In this procedure, each independent variable is paired with the dependent variable to test for their relationship whether it is significant or not. There are several statistical tests of significance used for this procedure. These statistical tools depend on the nature of the dependent and independent variables.

The two most widely used summaries that are often of interest in epidemiology as a measure of association are the relative risk (RR) and odds ratio (OR) and they apply when the outcome variable and explanatory variable are both categorical. RR describes the ratio of contracting a disease when exposed to and when not exposed and its interpretation is easy and straightforward, whereas OR gives the ratio of disease odds given the exposure status and it's widely used when prevalence or incidence rates are not available. Odds ratios are often used in the analysis of 2 by 2 contingency tables (Bland & Altman, 2000).

The odds ratio is sometimes confused with the relative risk, which is the ratio of probabilities rather than odds. Only when the probability of the event is very low can the odds ratio be considered a good approximation to the relative risk (Kirkwood and Sterne, 2003). Relative Risk, Odds Ratio and incidence may be estimated from cohort studies, while of the three, only the Odds Ratio is available from case-control studies (Hailpern and Visintainer, 2003). In many settings the relative risk is preferred over the odds ratio because it addresses the more readily understood probability of the events rather than its odds (LaValley, 2008). However, logistic regression results are typically presented by odds ratios because these are the natural estimates from the model and try to transform these to relative risks can distort the results (McNutt et al., 2003).

According to Bland & Altman (2000), there are three reasons why odds ratios are used. Firstly, they provide an estimate (with a confidence interval) for the relationship between two binary ("yes or no") variables. Secondly, they enable us to examine the effects of other variables on that relationship, using logistic regression and thirdly, they have a special and very convenient interpretation in case-control studies.

One may use the Chi- square test of independence, which provides a test of the association between two or more groups, populations, or criteria. The Pearson Chi-square test of independence, which is a summary measure may be used to test the significance of the relative risk or the odds ratio. It can be used to test "the strength of the association between exposure and disease in a cohort study, an unmatched case-control study, or a cross-sectional study" (Diener-West, 2008).

The measures of extent of association apart from RR and OR for contingency tables generally include, Phi coefficient, Cramer's V (which is used with contingency tables of four or fewer cells), Gamma (which is a measure like that has a proportional reduction in error interpretation), Lambda, coefficient of contingency, Pearson C, Yule's Q but to mention a few. These are selected based on the level of the variables involved (Sheskin, 1997). These are computed alongside the chi-square test of independence.

Also, when the outcome variable is continuous and the explanatory variables are categorical, then the t-test, ANOVA may be used or their non-parametric counterparts Mann-Whitney or Kruskal Wallis test depending on their level and their underlying distributions and assumptions. Any of the correlation coefficients may be used to measure the association between a continuous outcome and explanatory variables depending on the underlying assumptions. Pearson product moment (parametric), Spearman and Kendall (nonparametric) are the distinguished ones.

Pairing just each explanatory variable (exposure status/confounders) against the outcome variable (disease status) is not that advisable. This is because the intra confounder effects are not adjusted to depict a true fair measure of association. That is to say the bivariate will give specific cases, whereas the multivariate will give general cases which are good for inferences (Tabachnick & Fidell, 2007). Therefore the multiple selection methods are the preferred ones.

2.3.2 Procedure for Multivariate Selection

Regression methods have become an integral component of any data analysis concerned with describing the relationship between a response variable and one or more explanatory variables. Different regression models have been developed in dependence on the measurement scale of the response (outcome) variable. The basic standard regression models are linear regression (also known as ordinary least squares) for continuous outcomes, logistic regression for binary outcomes, Cox regression to analyze time-to event data, that is, the response is the time an individual takes to present the outcome of interest and Poisson regression for predicting an outcome variable which represents counts from a set of continuous predictor variable (Barros & Hirakata, 2003).

Since OLS applies to continuous outcome or dependent variables, it cannot be used in instances where the dependent variable is dichotomous (that is it takes arbitrary values 0 and 1). This is because OLS may give predicted values beyond the range (0, 1), but the analysis may still be useful for classification and hypothesis testing. Similarly, Poisson and Cox regression are not advisable since they also have a boundary problem just like the OLS. The normal distribution and homogeneous error variance assumptions of OLS will likely be violated with a binary dependent variable, especially when the probability of the dependent event varies widely. In situations where the dependent variable is not continuous but dichotomous, the more familiar OLS regression has limitations and a logistic regression, or its very similar probit regression, is the appropriate choice. Specifically, the two main limitations of OLS are that, fitted values of the dependent variable can fall outside the zero-one range and secondly, the error term is necessary heteroskedastic (Pohlman & Leitner, 2003). But then both models allow continuous, ordinal and/or categorical independent variables.

And so logistic regression has been suggested to be a more appropriate alternative to ordinary least squares (OLS) linear regression for modeling categorical (dichotomous) dependent variables. Both techniques were subsequently found to be less than ideal for handling dichotomous outcomes due to their strict statistical assumptions, i.e., linearity, normality, and continuity for OLS regression and multivariate normality with equal variances and covariance for discriminant analysis (Peng et al., 2002). With a dichotomous dependent variable, all of the observed dependent data points will fall on one of two horizontal lines that are parallel, which is a difficult condition to model with the single straight line produced by an OLS linear model. Peng et al. (2002) suggested a potential solution to this problem via plotting the calculated means of the dependent variables for categories of the independent variable. Such a plot takes a sigmoid shape, which they rightly point out, has extremes that do not follow a linear trend.

Though many have expressed concerns about the limitations of OLS when predicting dichotomous outcomes, Pohlmann & Leitner (2003) found very similar results when they compared OLS and logistic regression methods using two data sets. In both data sets, logistic regression produced more accurate estimates. While the logistic function was restrained to range between 0 and 1, OLS predicted negative values outside the range of (0,1). They found identical conclusions in regard to significance testing, and they found the predicted values for both modeling methods to be quite similar. They concluded that the logistic regression model is designed for binary outcomes, whereas OLS is not.

It should however be noted that, there can be a case where the dependent variable has more than two nominal or unordered categories, and this is called the multinomial logistic regression. This is an extension of the binomial or binary logistic regression where the outcome or dependent variable is dichotomous. Because of the difficulty in its interpretation, the multinomial is not very common.

Logistic regression estimates the probability of an outcome variable as a function of the independent or explanatory variable and should be noted as such. In other jurisdictions, LR reports the OR for each explanatory adjusting the effects of the other explanatory variable in the case of more than one independent variable.

Now, since the outcome is 0 (failure) or 1 (success), if the OR is computed the logit model requires that a transformation is made to the original linear model through link functions so that the bounds 0 and 1 are not exceeded. A more detailed explanation of the model can be found in Tabachnick & Fidell (2007) and Hosmer & Lemeshow (2000).

According to King & Ryan (2002), logistic regression analysis is one of the most frequently used statistical procedures, and is especially common in medical research. This may possibly be as result of OR which are reported in LR and has close relation with RR (Sedgwick, 2014). Hence, they may help gain insight in the estimation of prevalence and incidence rates (Schmidt & Kohlmann, 2008). It is then not surprising that almost all the studies relating the maternal risk factors to birth weight status as discussed above used LR. This is because in medical related issues the outcome variables are always dichotomized or binary. Such is the case of birth weight.

Logistic regression has been used in several sophisticated modeling exercises. One is that, econometricians like McFadden (1976) used the procedure to model utility maximization. Other researchers have used logistic regression to construct path models for data containing nominal-level endogenous or exogenous variables (Winship & Mare, 1983). Also application of logistic regression in the clinical medicine has been widespread.

Takahashi et al. (1998), for example, in their study investigated the risk factors for diabetic severe neuropathy independent of glycemic control and duration of diabetes, used logistic regression analysis technique to establish that maximum body mass index (BMI) in the past minus present BMI and the level of erythrocyte aldose reductase protein together with measurement of erythrocyte AR level may be useful for predicting severe neuropathy in non-insulin-dependent diabetes mellitus (NIDDM).

Similarly, Clark, et al., (1989), in their study of tumor progression used multi-variable logistic regression technique to develop a prognostic model for primary, clinical stage I cutaneous melanma. Out of the twenty-three attributes that were tested, only six had independently predictive prognostic information. The model, so developed, was 89% accurate in predicting survival of tumor patients.

In administration and economic sciences, Sakinc & Ugurlu (2013), determined the factors affecting gender diversity amongst the board of directors in Turkey, examined 40 firms in Instabul Stock Exchange (ISE) in Corporate Governance index (XKURY) for the year 2011. Logistic regression was used to analyze the effects of independent variables (free float rate (FFR), size of board of directors (SIZE), have a foreign ownership or not (FOR) and education) on a binary dependent variable in terms of the probability of being in one of the other. The model results showed that the size of the board of directors and education had a positive impact on gender diversity whilst foreign ownership and free float rate had a negative impact on gender diversity.

In geology, Riba et al (2011), developed a logistic regression model which was used to predict the probability of accidents occurring in mines and estimated the occurrence of accidents due to machines and falling rocks. With a total of 372 respondents who worked in the mines of the Burgerfort area in the Limpopo Province in South Africa, only 29% of them were accident victims. The independent variables used were accident victims due to machines and accident victims due to falling rocks and the variables were significant to enter the model which predicted the occurrence of accidents in the mines. Their results showed that most accidents in the mines occurred due to conduct with machines and falling rocks and that falling rocks in the mines was the most cause of accidents. They concluded by advocating for awareness campaigne programs which should be carried out to educate miners on the major causes of accidents in the mines and how to prevent them.

In Finance, Upadhyay et al (2012), in using 30 large market capitalization companies' ratio of four years (2005-2008), which are actively traded in the Indian Stock Market, investigated and determined the financial indicators that significantly affect the share performance by using multinomial logistic regression method. The method was constructed with seven financial ratios that is, Book Value, PBIDT/Sales (PBIDTS) and Earnings per Share (EPS), Percentage change in operating profit (OP), Percentage change in net sales (NS), Price to cash per share (PECEPS) and Price to book value (PEBV). The classification results showed high predictive accuracy rates of 56.80% and conclude that, the model can be used by investors, fund manager and investment companies to enhance their ability to pick outperforming stock.

2.4 Multivariate Analysis of variance (MANOVA)

The general purpose of multivariate analysis of variance (MANOVA), which is a multivariate statistic, is to determine whether multiple levels of independent variables on their own or in combination with one another have an effect on the dependent variables. Like the analysis of variance (ANOVA), MANOVA has variations. For example, the one-way MANOVA contains a single factor (independent variable) distinguishing participants into groups and two or more quantitative dependent variables. One could do three separate one-way ANOVAs. However, this approach is not advantageous because (a) conducting multiple ANOVAs increases the likelihood of committing a Type I error and, (b) multiple ANOVAs cannot determine whether independent variable(s) are related to combinations of dependent variables (Warne, 2014). So using MANOVA, you will see how the combination of the three variables distinguishes the groups, in one analysis. The MANCOVA (Multivariate Analysis of Covariance) is used when you include both nominal (independent variable) and scale (covariate) variables as predictors of the linear combination of two or more quantitative dependent variables. MANOVA evaluates whether the population means on a set of dependent variables vary across the levels of a factor or factors. That is, a one way-MANOVA tests the hypothesis that the population means for the dependent variables are the same for all levels of a factor (across all groups). If the population means of the dependent variables are equal for all groups, the population means for any linear combination of these dependent variables are also equal for all for all groups. Consequently, a one-way MANOVA evaluates a hypothesis that includes not only equality among groups on the dependent variable, but also equality among groups on linear combinations of these dependent variables.

The dependent variables should be related conceptually, and they should be correlated with one another at a low to moderate level. If they are highly correlated, one runs the risk of multicollinearity. If they are uncorrelated, there is usually no reason to analyze them together. Like an ANOVA, MANOVA examines the degree of variance within the independent variables. If the within subjects variance is smaller than the between subjects it means the independent variable has had a significant effect on the dependent variable. A number of statistics to evaluate the MANOVA hypothesis are Wilks' Lambda, Pillai's Trace, Hotelling's Trace (T), and Roy's Largest Root (Green & Salkind, 2003). Each statistic evaluates a multivariate hypothesis that the population means on the multiple dependent variables are equal across groups. Most statisticians use Wilks' Lambda, Λ, and as such, it is frequently reported in the social and behavioral sciences literature.

A few applications of Multivariate Analysis of Variance (MANOVA) are discussed below.

In Psychology, Kaufman & McLean (1998) used a questionnaire to investigate the relationship between interests and intelligence. They used the Kaufman Adolescent and Adult Intelligence Test (KAIT) and the Strong Interest Inventory (SII) which contained six subscales on occupational themes (GOT) and 23 Basic Interest Scales (BISs). Kaufman et al. used the MANOVA model which had four independent variables: age, gender, KAIT IQ and Fluid-Crystal intelligence (F-C). The dependent variables were the six occupational theme subscales

(GOT) and the twenty-three Basic Interest Scales (BIS). Kaufman and McLean used the Wilks' lambda to consider the significance of their results and reported only the interactions which were significant. The values which proved to be significant are the majority of the main effects which are Gender and KAIT IQ for 6 GOT subscales whilst Age, Gender and KAIT IQ are for 23 BITS. For the 2-way interactions only Age × Gender was significant. They noted that although KAIT IQ had a significant main effect none of the interactions which included this variable were significant. On the other hand, age and gender showed a significant interaction in the effect which they had on the dependent variable.

In education, a research was conducted by Deka & McMurry (2006) of the Missouri Western State to find out the student success in Traditional Face-To-Face and Distance Tele class Environments. They employed a Multivariate Analysis of Variance (MANOVA) to compare the distance and in-class students on all variables. Learning group (distance or face-to face) was the independent variable and the background (i.e Gender and Age), reading, study skills, self-esteem, and success variables were the dependent variables. A significant effect was found with (P – value <.009). Follow – Up Analysis of Variances (ANOVAs) indicated significant learning group differences in the following variables: Age with (p – value <.0001), Reading comprehension with (p – value <.04) and success with (p – value <.03). However distance education learners were significantly older than traditional face - to –face learners.

Snow & Bruce (2003) in health explored the factors involved in Australian teenage girls smoking, collecting data from 241 participants aged between 13 and 16 years. The responses were used to divide the respondents into three smoking groups (current smokers, experimental smokers, never smokers). In their analysis, Snow & Bruce used MANOVA with smoking group as the independent variable. In one of the MANOVAs, the dependent variables were the measures on three different coping strategies. They were only interested in the main effects of the smoking group on the dependent variables so they converted the Wilks' lambda to F values and significance levels. They used Scheffe post hoc analysis to determine which of the three smoking groups differed significantly on the dependent variables, and found that on the 'productive' coping strategy, there was a significant difference between the current and experimental smokers, on the 'non-productive' coping strategy, there was a difference between the current smokers and those who had never smoke, and on the 'rely on others' coping strategy there was a difference between current and experimental smokers.

The two quantitative measures, birth weight and Apgar score have been dealt with in this chapter. Literatures reviewed so far show that, there are possible association between these quantities and some maternal factors. The possible burdens of having low birth weight or Apgar score have also been reviewed. In addition, statistical ways of choosing explanatory variables which have significant association with an outcome variable have been discussed. Logistic regression is chosen to the be best descriptive tool to select the possible maternal antepartum risk factors and MANOVA can help determine if there are any differences between HIV-negative and HIV-positive mothers on birth weight and Apgar scores. The fundamental statistical theories that make up the LR and the MANOVA as well as the sample selection and the variables considered in this study are further discussed in the next chapter.

CHAPTER THREE

METHODOLOGY

3.0 Introduction

This chapter deals with the methodology for the study and apart from the introduction it has been subdivided into five sections. Section one looks briefly at how the data was collected and section two explains generally the tools and methods used in the study to achieve the set objectives. The preliminary analysis technique and detailed fundamentals about logistic regression which is useful in selecting the significant maternal factors are explained in section three. Section four explains multivariate analysis and lastly, section five elaborates on how multivariate analysis of Variance (MANOVA) is used to determine the differences, if any exist, between HIV-negative and HIV-positive mothers on birth weight and Apgar score.

3.1 Data Collection Strategy

It was impossible to use secondary data from GDHS (Ghana Demographic Health Survey) since the measurement of some variables like Apgar score are not captured in those surveys. This is due to the nature of the measurement of most of the variables considered in the study. Measurement of some variables like weight gain during pregnancy and pregnancy induced hypertension also required not less than two antenatal clinic attendance at specific times. The study was conducted at Ridge Hospital, which is currently the Greater Accra Regional Hospital located in the Accra metropolis. The hospital offers public health services to the people in the entire Accra Metropolis and beyond. It also serves as a referral hospital in the region. The target population was mothers in their postpartum period.

Purposive sampling technique was used to select only mothers with singleton deliveries. It employed a total of 330 mothers who were interviewed between February and March 2015. The birth weights and Apgar score of a child are recorded in the Antenatal card of the mother. Both primary data (obtained through personal interviews using a drafted interview guide to record the summaries) and secondary data (where majority of the variables were extracted from the mothers antenatal record book) were collected. A copy of the interview guide is found in the Appendix section. The medical director and the head of obstetrics and Gynecology Department of the hospital allowed us to carry on with our research.

The maternal risk factors which were used as the predictors or explanatory variables, are those recorded from the ANC book which include; Retroviral (HIV) status, Maternal Age, Gestational age, weight gain during pregnancy (which is obtained as a change in final and initial weight), height, Employment status, Marital status, Educational level, Hemoglobin level to measure anemia, Number of ANC visits, Parity, Gravida, Change in Systolic Blood Pressure, Change in Diastolic Blood Pressure, and Mode of delivery. Information on other risk factors like, Daily hours rested, Daily Expenditure, Frequency of eating, Type of cooking fuel, Cigarette Smoking and Alcohol Consumption were obtained from the mothers. These factors were selected based on previous works and upon advice from the obstetrics and Gynecology specialist. In all twenty (21) risk factors were considered as explanatory variables in the study.

3.1.1 A General review of Methods in the Study

Birth weight and Apgar score are the dependent or the outcome variables and the maternal risk factors are considered the explanatory variables in the study. Both sets of variables are recorded immediately after birth and are found in the Antenatal card of the mother. A birth weight of less than 2.5kg is considered low and normal otherwise whilst an Apgar score of less than 7 is considered low and more than 7 normal.

To examine the pairwise effect and the extent of each explanatory variable on each of the outcome variables, the chi-square test for trend in $2 \times k$ tables, chi-square test for independence and correlation analysis were used. Specifically Pearson Correlation was used. This process will end for the use of multivariate analysis to select the significant risk factors. Logistic regression was then used to select the maternal confounders, which have a significant relationship with birth weight and Apgar score. To assess the overall significance of the explanatory variables on the outcome variable, we used the likelihood ratio test, Cox & Snell R Square and Nagelkerke R Square. Then the Wald test was further used to select the significant maternal confounders.

Multivariate analysis of variance (MANOVA) was used to determine the differences between HIV-negative and HIV-positive mothers on birth weight and Apgar score. Here the Wilks' Lambda, a statistic which varies between 0 and 1 and which indicates whether the means of groups differ was used. A value of 1 means the groups have the same mean.

3.2 Bivariate measure of association with dependent variable

In order to make some decision about some of the variables, it is most times better to start a multivariate analysis with a univariate analysis. In order to estimate the direction of a linear relationship between explanatory variables and outcome variables, the chi-square test for trend in $2\times k$ tables and Chi- square test of independence were computed. Therefore, to check whether any of the risk factors are significantly related to birth weight or Apgar score, the Pearson correlation will be computed and its significance tested to ascertain the direction of their relationship.

3.2.1 Chi-square Test for Trend in $2\times k$ Tables

One weakness of the chi-square test is that it is an "omnibus" test; it tests for independence versus dependence without specifying the nature of the dependence. In some cases, a small subset of alternative hypothesis may be specified to increase the power of the chi-square test by defining a special test. One such situation occurs in $2\times k$ tables when the alternative hypothesis is that there is an ordering in the variable producing the k categories. For example, exposure categories can be ordered, and the alternative hypothesis may be that the probability of disease increases with increasing exposure.

In such cases the row variable takes on one of two states (say + or – for definiteness). For each state of the column variable $\left(j=1,2,...,k\right)$, let π_j be the conditional probability of a positive response. The test for trend is designed to have statistical power against the alternatives:

$$H_1 : \pi_1 \le \pi_2 \le ... \le \pi_k, \quad \text{with at least one strict inequality,}$$
$$H_2 : \pi_1 \ge \pi_2 \ge ... \ge \pi_k, \quad \text{with at least one strict inequality.}$$

Thus, the alternatives of interest are that the proportions of + responses increase or decrease with the column variable. To compute the statistic, scores (x_j) are assigned so that they increase or decrease.

The data are laid out as shown below:

i	j 1	2	...	K	**Total**
1+	n_{11}	n_{12}	$\cdots$	n_{1k}	$n_{1\bullet}$
2−	n_{21}	n_{22}	$\cdots$	n_{2k}	$n_{2\bullet}$
Total	$n_{\bullet 1}$	$n_{\bullet 2}$	$\cdots$	$n_{\bullet k}$	$n_{\bullet\bullet}$
Score	x_1	x_2	$\cdots$	x_k	

Before stating the test, we define some notation. Let

$$[n_1 x] = \sum_{j=1}^{k} n_{1j} x_j - \frac{n_{1\bullet} \sum n_{\bullet j} x_j}{n_{\bullet\bullet}}$$

and

$$\left[x^2\right] = \sum_{j=1}^{k} n_{\bullet j} x_j^2 - \frac{\left(\sum n_{\bullet j} x_j\right)^2}{n_{\bullet\bullet}}$$

and

$$p = \frac{n_{1\bullet}}{n_{\bullet\bullet}}$$

Then the chi-square test for trend is defined by

$$\chi^2_{\text{trend}} = \frac{[n_1 x]^2}{\left[x^2\right] p(1-p)} \sim \chi_1^2$$

And when there is no association this quantity has approximately a chi-square distribution with one degree of freedom.

3.3 Logistic regression

Logistic regression analysis (or simply logistic regression) is part of a category of generalized linear models. It is a type of multivariate regression that has a predictive model that can be used when the target variable is a categorical variable. The technique aims at modeling the relationship between a set of independent variables and the probability that a case is a member of one of the categories of the dependent variables.

Logistic regression has many uses- It is used to predict a dependent variable on the basis of continuous and/or categorical independent variable; to determine the percentage of variance in the dependent variable explained by the independent variable; to rank the relative importance of independent variables; to assess interaction effects; and to understand the impact of covariate control variable (Garson, n.d).

Generally, the dependent or response variable in logistic regression is dichotomous, such as presence/absence or success/failure, but the multinomial logistic regression also exists to handle situations with more than two dependent variables such as low/medium/high (McCullagh & Nelder, 1989). In a case of where the outcome variable is continuous we use the multiple regressions known as the least square regression. But with the outcome variable of interest being categorical irrespective of the form of the explanatory variables, the logistic regression is preferred (Vittinghoff et al, 2012). This is because the assumptions of least square regression which include normality and homogeneity of residuals are violated. These assumptions are also questioned if some of the explanatory variables are discrete or categorical. There is also the problem of predicting out of range. In this study, for instance, we denote birth weight by Y, Apgar score by Z, and the matrix of explanatory variables $\mathbf{X} = (X_1, X_2, ..., X_{21})^T$ to represent the 21 risk factors. We defined Y and Z as follows

$$Y = \begin{cases} 0 \text{ if birth weight is 2.5kg or more (normal)} \\ 1 \text{ if birth weight is less than 2.5kg (low)} \end{cases} \quad Z = \begin{cases} 0 \text{ if Apgar is 7 or more (normal)} \\ 1 \text{ if Apgar is less than 7 (low)} \end{cases}$$

Evidently, the outcome variables of interest are dichotomous.

What the researcher wants to find is how to expect the birth weight and Apgar score of an infant to be when given the risk factors assuming linear relationship. That is, we want, $E(Y \mid \mathbf{X}) = \beta_0 + \mathbf{X}^T\mathbf{B} + \varepsilon$, where $\mathbf{B}$ is the coefficient matrix for birth weights and $E(Z \mid \mathbf{X}) = \alpha_0 + \mathbf{X}^T\mathbf{A} + \gamma$ in the case of Apgar score, $\mathbf{A} = (\alpha_1, \alpha_2, ...\alpha_p)^T$ is the coefficient matrix for Apgar score, ε and γ are the error terms in each case and α_0 and β_o are the constant coefficients.

Now, since the predictors are unbounded and measured in different scales and units, estimates of the expectation will take values from $-\infty$ to $+\infty$. Therefore, using a least square regression will not be feasible. Since in our case the outcome variables are each dichotomous and our explanatory variables are mixture of continuous and categorical, we employ the binary logistic regression due to the nature of the outcome variables.

Binary Logistic Regression is a predictive model that can be used when the target variable is a categorical variable with two categories (dichotomous) - for example, in our case birth weight is either low or normal and the independent variables are of any type. Binary logistic regression has other application of combining the independent variables to estimate the probability that a particular event will occur, that is, a subject will be a member of one of the groups defined by the dichotomous dependent variable.

The variate or value produced by the binary logistic regression is a probability value between 0 and 1. If the probability for group membership in the modeled category is above some cut point (usually 0.5), the subject is predicted to be a member of the modeled group. If the probability is below the cut point, the subject is predicted to be a member of the other group. Logistic regression is currently one of the most applied method of regression when dealing with categorical outcome variables and due to its assumption free nature. The only assumption is the independence of the explanatory variables (Peng et al, 2002).

The outcome variables take a value of 0 and 1 as codes. Therefore the conditional expectation is turned chances of being in the morbidity situation when you are not initially, given the explanatory variables. That is, for instance, the chances of giving birth to low birth weight given the risk factors will be $P(Y=1/\mathrm{X})$. In the same way the values will not be bounded if we use least square regression violating the fundamental probability axiom.

3.3.1 Odds ratio

In epidemiology, one vital statistic of interest is the odds ratio (OR) which compares the likelihoods of contracting a disease if one is exposed to risk to the likelihoods of contracting the disease if one is not exposed to the risk. Given the probability that an event Y occurs is $P(Y)$, then $1-P(Y)$ is the probability of not occurring. The odds ratio is defined as $OR=\frac{P(Y)}{1-P(Y)}$.

This is used in assessing whether a risk factor improves the chances of contacting a disease or not. An OR of more than one means the chances of getting the disease when exposed is higher than when not exposed. That is such a risk factor is associated with a higher chance of getting the disease. But since the $P(Y=1/\mathrm{X})$ and $P(Z=1/\mathrm{X})$, are not properly defined, we cannot compute the odds ratio.

3.3.2 Logit transformation

One way of bounding the expectation is using the logit function to transform the linear models given above to make the possible values fall between 0 and 1. The logit function is given as $f(\theta)=\frac{1}{1+e^{-\theta}}$. We notice that

$$\lim_{\theta\to-\infty} f(\theta)=0 \quad \text{and} \quad \lim_{\theta\to\infty} f(\theta)=1 \quad \text{and} \quad f'(\theta)=\frac{e^{-\theta}}{\left(1+e^{-\theta}\right)^2}\geq 0,\ \forall\theta$$

This means that the function is monotone increasing over the domain $(-\infty,\infty)$ and with the range $[0,1]$. Therefore, transforming the conditional expectations above using the logit function will ensure we get values only between 0 and 1 inclusive.

Therefore on letting $\theta=\beta_0+\mathbf{X}^T\mathbf{B}+\varepsilon$ in the case of birth weight and $\theta=\alpha_0+\mathbf{X}^T\mathbf{A}+\gamma$ in the case of Apgar score the corresponding transformed models will be:

$$P(Y=1|\mathbf{X})=\frac{1}{1+e^{-\left(\beta_0+\mathbf{X}^T\mathbf{B}+\varepsilon\right)}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

and

$$P(Z=1|\mathbf{X}) = \frac{1}{1+e^{-(\alpha_0+\mathbf{X}^T\mathbf{A}+\gamma)}} \quad \text{...(2)}$$

Equations (1) and (2) are known as the logistic function of birth weight and Apgar score respectively. We note from the logit function that,

$\ln\left[\frac{f(\theta)}{1-f(\theta)}\right]=\theta$, *ln* denotes the natural logarithm. Hence equation (1) becomes

$$\ln\left[\frac{P(Y=1|\mathbf{X})}{1-P(Y=1|\mathbf{X})}\right]=\beta_0+\mathbf{X}^T\mathbf{B}+\varepsilon \quad \text{...(3)}$$

The expression $\frac{P(Y=1|\mathbf{X})}{1-P(Y=1|\mathbf{X})}$ is clearly the OR for low birth weight per changes in the explanatory variables. Therefore using the logit model we rather regress the natural log of the OR of the outcome variable on the explanatory variables. The coefficients of the explanatory variables in this case are the log OR of the outcome variable. We take the antilog of the coefficients before interpreting them as unit changes to the OR of the outcome variable holding other explanatory variables constant. Similar intuitions are done for Apgar score.

3.3.3 Estimation of Parameter Coefficients in Logistic Regression

Although logistic regression finds a “best fitting” equation just as linear regression does, the principles on which it does so are different. Instead of using a least-squared deviations criterion for the best fit, as in the case of linear regression, the logistic regression analysis uses maximum likelihood estimation method to compute the coefficients for the logistic regression equation. The maximum-likelihood parameters are chosen to maximize the likelihood. The maximum likelihood is a conditional probability, that is, ($P(i/\theta i)$, the probability of being in group i given the set of risk factors in group i, where i=1 or 0) since the outcome variable is a Bernoulli random variable and its independent. The likelihood function is found which is a complicated function and cannot be easily maximized using normal calculus. The technique actually employed to find the maximum likelihood estimates is iterative Newton-Raphson algorithm embedded in the software used for the analysis and attempts to find coefficients that match the breakdown of cases on the dependent variable. The maximum-likelihood estimation procedure successively tries to get closer and closer to the correct answer and it iterates until the absolute value of the largest parameter change is less than the value specified for "Tolerance" on the logistic regression modeling.

3.3.4 Testing the importance of all risk factors-Likelihood Ratio Test

In logistic regression the generalized likelihood ratio test specifically the asymptotic generalized likelihood ratio test is used to test the hypothesis that at least one of the predictor variables is significant. We test the null hypothesis that none of the coefficients are significant against the alternative, at least one is significant. This is done after estimating the parameters. For instance, in the case of birth weight we test

$H_0 : \beta_i = 0,\ \forall i = 1, 2, ..., p$ against $\mathrm{H}_1 : \beta_i \neq 0$ at least for one i

The test statistic is $-2\ln\Lambda$ which is distributed as a chi-square on p degrees of freedom where

$\Lambda = \frac{L(\mathbf{B} \mid H_0)}{L(\hat{\mathbf{B}})}$, where the numerator represents the value of the likelihood function, L, when the null hypothesis is true and the denominator is the value of the likelihood function using the maximum likelihood estimators of the coefficient vector $\hat{\mathbf{B}}$. This chi-square statistic is used to statistically test whether including a variable reduces badness-of-fit measure. If chi-square is significant, the variable is considered to be a significant predictor in the equation. If not, the variable is considered unimportant and is excluded from the logistic regression model.

3.3.5 Selection of risk factors - Wald test

The wald test is used to select the explanatory variables that are significant provided the likelihood ratio test is significant. A wald test is the squared ratio of the coefficient to its SE (standard error). It tests the null hypothesis that each coefficient is zero, $H_0 : \beta_i = 0$. The test statistic is $z = \left(\frac{b_i}{se(b_i)}\right)^2$ whose null distribution is the standard normal variable. b_i is the estimate of β_i and $se(b_i)$ is the standard error of b_i.

If the corresponding significance probability is less than significance level, the null hypothesis is rejected and such variable will be considered. Otherwise that variable is dropped and will not form part of the analysis again.

3.4 Multivariate Analysis

According to Tabachnick & Fidell (2007), multivariate statistics are increasingly popular techniques used for analyzing complicated data sets. They provide analysis when there are many Independent Variables (IVs) and/or many Dependent Variables (DVs) all correlated with one another to varying degrees.

3.5 Multivariate Analysis of Variance (MANOVA) Model for Comparing Several Population Mean Vectors

Multivariate Analysis of Variance (MANOVA) is used to investigate whether the population mean vectors are the same, and if not, which mean components differ significantly.

3.5.1 One – Way Multivariate Analysis of Variance (MANOVA) Model

Multivariate Analysis of Variance (MANOVA) evaluates differences among centroids (composite means) for a set of Dependent Variables (DVs) when there are two or more levels of an Independent Variable (IV) groups. One-way MANOVA contains a single factor (independent variable) distinguishing participants into groups and two or more quantitative dependent variables. In this study for instance, the dependent variables are birth weight and Apgar score of infants and the independent variable is maternal HIV status with two levels, i.e HIV-negative and HIV-positive. The model is given below:

$$X_{\ell j} = \mu + \tau_{\ell} + \ell_{ij}, \quad j = 1, 2, \ldots, n_{\ell} \quad and \quad i = 1, 2, \ldots, g \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

Where ℓ_{ij} are independent $N_P(0,\varepsilon)$ variables. The parameter vector μ is the overall mean and τ_ℓ represents the ℓ^{th} interaction effect with $\sum_{\ell=1}^{g} n_\ell \tau_\ell = 0$

A vector of observations may be decomposed as below:

$$X_{\ell j} = \bar{X} + (\bar{X}_\ell - \bar{X}) + (X_{\ell j} - \bar{X}_\ell)$$

$$(\text{observation}) = \begin{pmatrix}\text{overall}\\ \text{sample}\\ \text{mean } \hat{\mu}\end{pmatrix} + \begin{pmatrix}\text{estimated}\\ \text{interaction}\\ \text{effect } \hat{\tau}_\ell\end{pmatrix} + \begin{pmatrix}\text{residual}\\ \hat{\ell}_{\ell j}\end{pmatrix} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

The decomposition in the equation above leads to the multivariate analogue of the univariate sum of squares.

Thus, the product

$$\left(X_{\ell j} - \bar{X}\right)\left(X_{\ell j} - \bar{X}\right)' \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(3)$$

Can be written as:

$$\begin{aligned}\left(X_{\ell j} - \bar{X}\right)\left(X_{\ell j} - \bar{X}\right)' &= \left[\left(X_{\ell j} - \bar{X}_\ell\right) + \left(\bar{X}_\ell - \bar{X}\right)\right]\left[\left(X_{\ell j} - \bar{X}_\ell\right) + \left(\bar{X}_\ell - \bar{X}\right)\right]' \\ &= \left(X_{\ell j} - \bar{X}_\ell\right)\left(X_{\ell j} - \bar{X}_\ell\right)' + \left(X_{\ell j} - \bar{X}_\ell\right)\left(\bar{X}_\ell - \bar{X}\right)' \\ &\quad + \left(\bar{X}_\ell - \bar{X}\right)\left(X_{\ell j} - \bar{X}_\ell\right)' + \left(\bar{X}_\ell - \bar{X}\right)\left(\bar{X}_\ell - \bar{X}\right)' \quad \ldots\ldots\ldots\ldots\ldots(4)\end{aligned}$$

The sum over j of the middle two expressions is the zero matrix, because

$$\sum_{j=1}^{n_\ell}\left(X_{\ell j} - \bar{X}_\ell\right) = 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(5)$$

Hence, summing the cross product over ℓ and j yields

$$\sum_{\ell=1}^{g}\sum_{j=1}^{n_\ell}\left(X_{\ell j}-\bar{X}\right)\left(X_{\ell j}-\bar{X}\right)' = \sum_{\ell=1}^{g} n_\ell\left(\bar{X}_\ell-\bar{X}\right)\left(\bar{X}_\ell-\bar{X}\right)' + \sum_{\ell=1}^{g}\sum_{j=1}^{n_\ell}\left(X_{\ell j}-\bar{X}_\ell\right)\left(X_{\ell j}-\bar{X}_\ell\right)'$$

$$\begin{bmatrix}\text{total (corrected) sum}\\ \text{sum of squares and}\\ \text{cross products}\end{bmatrix} = \begin{bmatrix}\text{interaction (Between)}\\ \text{sum of squares and}\\ \text{cross products}\end{bmatrix} + \begin{bmatrix}\text{residual (Within)}\\ \text{sum of squares and}\\ \text{cross products}\end{bmatrix} \quad \ldots\ldots\ldots\ldots\ldots\ldots(6)$$

The within sum of squares and cross products matrix can be expressed as

$$W=\sum_{\ell=1}^{g}\sum_{j=1}^{n_\ell}\left(X_{\ell j}-\bar{X}_\ell\right)\left(X_{\ell j}-\bar{X}_\ell\right)'=\left(n_1-1\right)S_1+\left(n_2-1\right)S_2+\ldots+\left(n_g-1\right)S_g \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(7)$$

Where S_ℓ is the sample covariance matrix for the ℓ^{th} sample.

To test for interaction effects:

$H_0: \text{all } \tau_i = 0$

$H_a: \text{not all } \tau_i \text{ equal zero}$

The calculation leading to the test statistic in a MANOVA can be summarized below in Table 3.1

Table 3.1 MANOVA Table for comparing Population Mean Vectors

Sources of Variation	Matrix of Sum of Squares and cross Products (sscp)	Degrees of freedom (df)
Treatment	$B=\sum_{\ell=1}^{g} n_\ell \left(\bar{X}_\ell - \bar{X}\right)\left(\bar{X}_\ell - \bar{X}\right)'$	$g-1$
Residual (Error)	$W=\sum_{\ell=1}^{g}\sum_{j=1}^{n_\ell}\left(X_{\ell J} - \bar{X}_\ell\right)\left(X_{\ell j} - \bar{X}_\ell\right)'$	$\sum_{\ell=1}^{g} n_\ell - g$
Total (corrected for the mean)	$B+W=\sum_{\ell=1}^{g}\sum_{j=1}^{n_\ell}\left(X_{\ell j} - \bar{X}\right)\left(X_{\ell j} - \bar{X}\right)'$	$\sum_{\ell=1}^{g} n_\ell - 1$

3.5.2 Statistic for testing the Multivariate Hypothesis

According to Olson (1974), there are several test statistics available. The one that is most widely used is called the Wilks' Lambda (Λ), and it's given by

$$\Lambda=\frac{|W|}{|T|}=\frac{|W|}{|B+W|} \quad 0\le\Lambda\le 1 \qquad \ldots\ldots(8)$$

Where $|W|$ and $|T|$ are the determinants of the within and total sum of squares and cross products matrices.

Wilks' Λ is the statistics for determining whether there is a significant association between dependent variables and predictors.

For Multivariate Analysis of Variance (MANOVA), the corresponding matrix analogue holds:

$$T = B + W \quad \text{...}(9)$$

Total Sum of Squares and Cross Products Matrix = Between Sum of Squares and Cross Products Matrix + Within Sum of Squares and Cross Products Matrix

It should be noted that the smaller the value of Wilks' Λ, the more evidence for treatment effects (between group associations). If there is no treatment effect, then $B=0$ and

$$\frac{|W|}{|0+W|}=1 \quad \text{...}(10)$$

According to (Stevens, 2009), two approximations of Wilks' Λ sampling distributions are available.

(a) Rao's F. Bartlett's χ^2, which is given by

$$\chi^2=-\left[(N-1)-.5(P+K)\right]\text{In}\Lambda P(K-1)\text{degrees of freedom} \quad \text{...}(11)$$

Where N is the total sample size, P is the number of dependent variables, and K is the number of groups.

(b) Bartlett's χ^2, given by

$$-\left(n-1-\frac{(p+g)}{2}\right)\text{In}\Lambda=-\left(n-1-\frac{(p+g)}{2}\right)\text{In}\left(\frac{|W|}{|B+W|}\right) \quad \text{...}(12)$$

For smaller sample size, Rao's F is a better approximation and for moderate large sample sizes, Bartlett's χ^2 approximation is good (Lohnes, 1961). Generally the two statistics will lead to the same decision on H_0.

According to Johnson and Wichern (2007), Bartlett has shown that if H_0 is true, and

$\sum n_\ell = n$ is large

$$-\left(n-1-\frac{(p+g)}{2}\right)\ln\Lambda = -\left(n-1-\frac{(p+g)}{2}\right)\ln\left(\frac{|W|}{|B+W|}\right) \quad \text{...}(13)$$

has approximately a chi-square distribution with $p(g-1)$ degrees of freedom

Consequently, for $\sum n_\ell = n$ large large, we reject H_0 at significant level α if:

$$-\left(n-1-\frac{(p+g)}{2}\right)\ln\left(\frac{|W|}{|B+W|}\right) > \chi^2 p(g-1)\alpha \quad \text{...}(14)$$

CHAPTER FOUR

DATA ANALYSIS AND DISCUSSION OF RESULTS

4.0 Introduction

This chapter has been organized to present the data analysis and to discuss the results obtained from the study. This chapter has also been divided into the following sections, excluding the introduction: Data description, which is with respect to basic statistics for birth weight and Apgar score are done under section 4.1. Preliminary analysis of the data, which takes care of the bivariate analysis of the association between the maternal factors and the birth weight as well as Apgar score are dealt with in section 4.2. Section 4.3 considers using logistic regression to select the significant predictor variables for each dependent variable. The next section, 4.4 deals with multivariate data analysis of respondents with HIV (Positive/Negative) status with respect to birth weight and Apgar scores and Discussion of Results is the last chapter to be discussed in this chapter. Statistical Package for Social Sciences (SPSS) Version 20 was used to analyze the data by applying Logistic regression (LR) and Multivariate Analysis of Variance (MANOVA).

4.1 Description of Data and Summary Statistics

Mothers who were in their postpartum stage and also attended a postnatal clinic at Ridge Regional Hospital from the month of February to March 2015 constitute a total sample of size three hundred and thirty (330).

4.1.1 Distribution of Gender of infants

As shown in figure 4.1, it can be seen that male infants constitute 54.5% (180 infants) of the sample whereas female infants constitute 45.5% (150 infants). This is an indication that there are more male infants than female infants in the study.

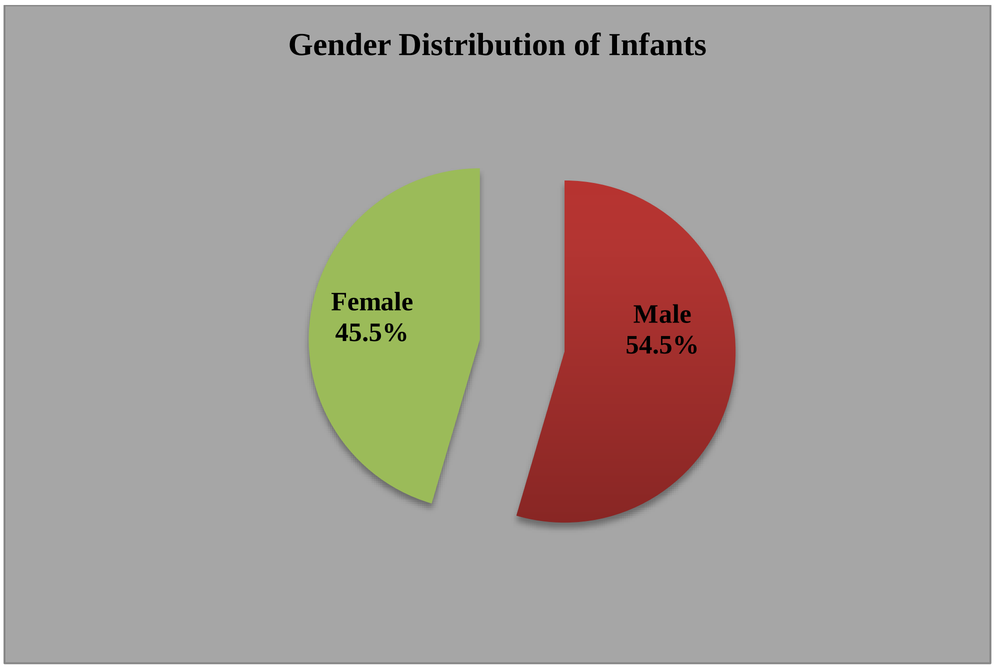

Figure 4.1: Gender Distribution of Infants

Source: Field Data, March-2015

4.1.2 Birth weight of Infants

One of the main focuses of this study was birth weight. Therefore, infants that belong to each of the birth weight categories, which are normal and low were considered. Table 4.1 and Figure 4.2 give a detailed description of birth weight.

Table 4.1: Descriptive Statistics for Birth Weight and Across Gender

Statistics/ Gender	N	Mean	Std. Error	Std. Dev.	Median	Min	Max	Skew
Male	180	2.96	0.05	0.61	2.98	1.05	4.8	0.11
Female	150	3.00	0.04	0.52	3.00	2.00	4.7	0.30
Total	**330**	**2.98**	**0.05**	**0.57**	**3.00**	**1.05**	**4.8**	**0.16**

Source: Field Data, March-2015

An assessment of birth weight and across gender is presented in Table 4.1. From the table, the mean birth weight for the study is 2.98kg with a standard error of 0.05kg and standard deviation of 0.57kg. The minimum birth weight is 1.05kg while the maximum is 4.8kg. The median birth weight is 3.00kg which is approximately equal to the mean birth weight suggesting a possible symmetric distribution of birth weight. The minimum birth weight for male infants is 1.05kg whereas the maximum is 4.80kg. The minimum and maximum birth weights for female infants are 2.00kg and 4.70kg respectively. The distribution of both male and female infants is slightly right-tailed with respective coefficient of skewness 0.11 and 0.30.

A birth weight is considered low if it is less than 2.5kg and normal if 2.5kg or more. The distribution of the categories is shown in Figure 4.2.

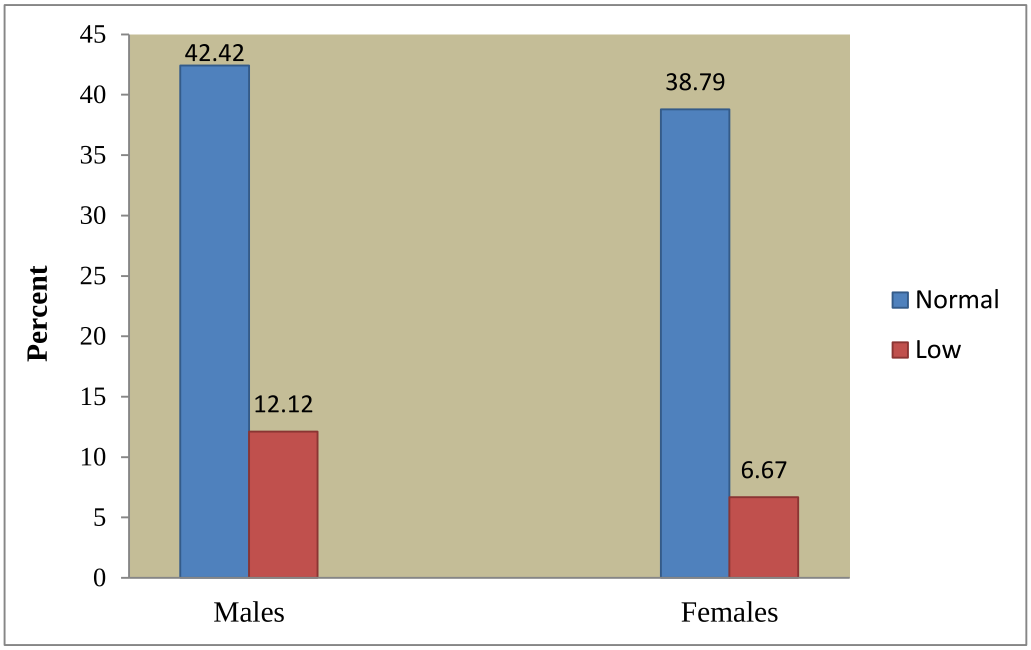

Figure 4.2: Birth Weight Categories and Gender of Infants

Assessment of the group bar chart shows that, the category of low birth weight infants who (weigh less than 2.5kg at birth) is 18.79% (62) and those with normal birth weight who (weigh 2.5kg or more at birth) is 81.21% (268) of the total sample size. For those in the low birth weight category, their standard deviation is 0.25kg with 1.05kg and 2.45kg being their minimum and maximum respectively. Their mean birth weight is 2.19kg. For infants with normal birth weight, their mean, standard deviation, minimum and maximum respectively are 3.16kg, 0.46kg, 2.5kg and 4.8kg. The Appendix section gives the detailed descriptive statistics.

4.1.3 Apgar Score of Infants

Another main focus of the study is the Apgar score of the baby at birth just like birth weight. Both birth weight and Apgar score determine an incidence of illness or disease of a new born baby quantitatively. The detailed description of Apgar Scores is given below in Table 4.2 and Figure 4.3.

Table 4.2: Descriptive Statistics for Apgar Scores and Across Gender

Statistics/ Gender	N	Mean	Std. Error	Std. Dev.	Median	Min	Max	Skew
Male	180	8	0.10	1.31	8	1	10	-1.26
Female	150	8	0.09	1.14	8	4	10	-0.77
Total	**330**	**8**	**0.07**	**1.24**	**8**	**1**	**10**	**-1.10**

Source: Field Data, March-2015

From the table above, the mean Apgar score is 8 with a standard deviation of 1.24 and standard error 0.07. Though same as mean, the median which is also reported as 8 is the best measure of central tendency. The range of Apgar score is 9 since the minimum and maximum Apgar scores for all the infants are 1 and 10 respectively. The coefficient of skewness is -1.10, which indicates that the distribution of the Apgar score is left-tailed and that majority of the Apgar scores are high. The mean Apgar score for male infants is 8 with a standard deviation 1.31 and their respective minimum and maximum scores are 1 and 10. The mean, median and standard deviation for female infants are 8, 8 and 1.14 respectively. There is an indication that the Apgar scores recorded are same for both male and female infants as the means and medians are the same.

Just like birth weight, Apgar scores also has two categories, namely, low and normal Apgar scores. The distribution of the categories is shown in Figure 4.3 below.

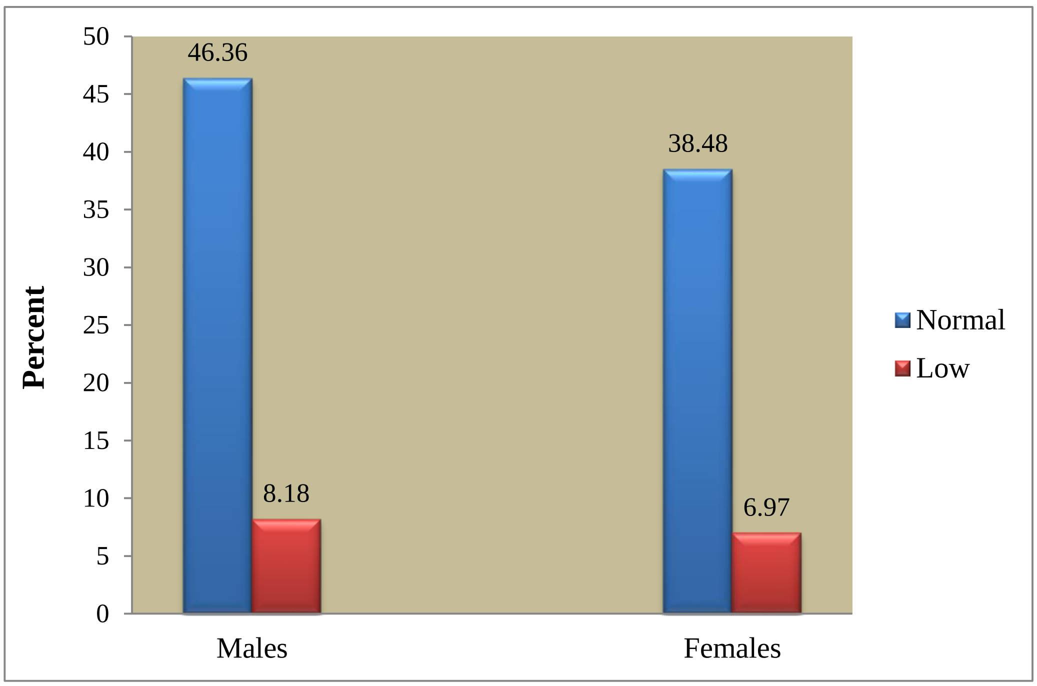

Figure 4.3: Apgar score Categories and Gender of Infants

It can be seen in Figure 4.3 that, 15.15% of the infants (50) have low Apgar scores (less than 7) and 84.84% of the infants (280) has normal Apgar scores (7 or more). In the low Apgar score category, there are more males (8.18%) than females (6.97%) and the same goes for normal Apgar score category as males form 46.36% and females 38.48%. The range of the low Apgar score category is 1 to 6 whereas normal Apgar score is 7 to 10. There is a little difference between the number of male infants and female infants in both cases. Additional descriptive Statistics can be found in the Appendix Section.

4.1.4 Cross-tabulation of Birth weight and Apgar score

Since birth weight and Apgar scores are the focus of this study, the two are cross-tabulated to see if their categories have something in common. But a newborn baby with a low birth weight does not necessarily mean the Apgar score of that baby is automatically low and vice versa. The cross tabulation between the categories of birth weight and Apgar score is shown in Table 4.3.

Table 4.3: Cross-tabulation of Birth Weight and Apgar Score Categories of Infants

		Apgar Score		
	Category	Normal	Low	Total
Birth Weight	Normal	244 73.94%	24 7.27%	268 81.21%
	Low	36 10.91%	26 7.88%	62 18.79
	Total	**280** **84.85%**	**50** **15.15%**	**330** **100.00%**

Source: Field Data, March-2015

From table 4.3, we realize that 73.94% of the infants had normal birth weight as well as Apgar score. On the other hand, 7.88% of infants had both low birth weight and low Apgar score. Of those who have LBW, 36 (10.91%) rather have a normal Apgar score whilst of those who have low Apgar score, 24 (7.27%) rather have normal birth weight.

4.1.5 Maternal Risk Factors

In this study there are a number of maternal antepartum risk factors which are considered as possible predictors of birth weight and Apgar score. The factors considered are; Retroviral (HIV) status, Mode of Delivery, Maternal Age, Gestational Age, Height, Weight Gain, Marital Status, Educational Level, Employment Status, Haemoglobin Level, Antenatal visits, Parity, Gravida, Daily Hours of Rest, Daily Expenditure, Frequency of Eating, Change in Systolic Blood Pressure, Change in Diastolic Blood Pressure, Type of Cooking Fuel, Alcohol Consumption and Cigarette Smoking.

4.1.5 Selected Clinical Characteristics among Study Mothers

The assessment of HIV status and Mode of Delivery of the mothers are presented in Table 4.4, and the distribution of HIV status in Figure 4.4.

Table 4.4: Cross-tabulation of Mode of Delivery and Retroviral (HIV) Status Categories

		Retroviral (HIV) Status		
	Category	Negative	Positive	Total
Mode of Delivery	SVD	136 41.21%	14 4.24%	150 45.45%
	Caesarian Section	166 50.30%	14 4.24%	180 54.55%
	Total	**302** **91.52%**	**28** **8.48%**	**330** **100%**

Source: Field Data, March-2015

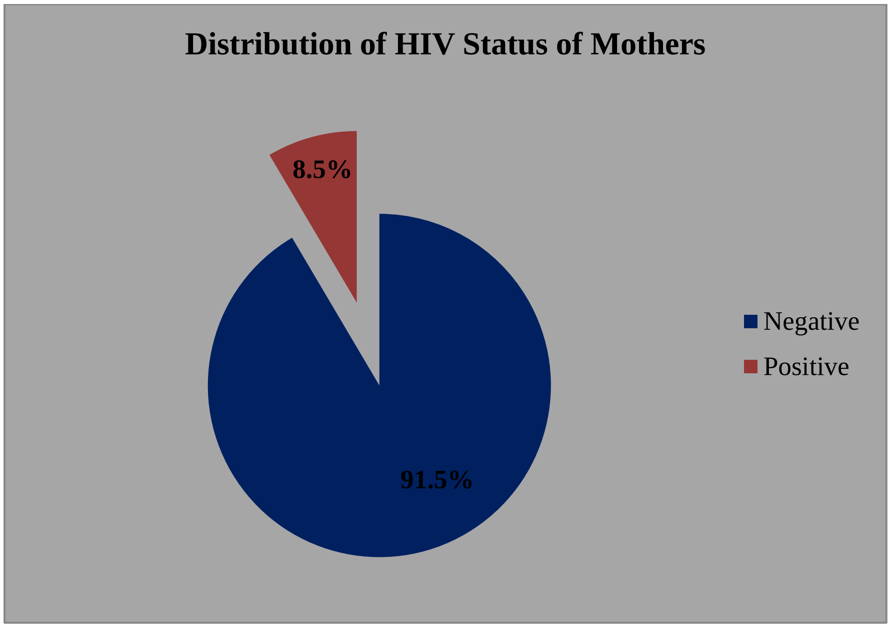

Figure 4.4: Percentage Distribution of HIV Status of Mothers

The assessment and distribution of HIV status revealed that 302 (91.50%) of the mothers were HIV-Negative whilst 28 (8.50%) of the mothers are HIV-Positive, that is to say, majority of the mothers are HIV-Negative. From table 4.4, those women who delivered via spontaneous vaginal delivery were 45.45% and 54.55% delivered via caesarian section. The percentage of HIV-Positive mothers who had Spontaneous Vaginal Delivery was the same for those who delivered through Caesarian Section which is 14 (4.24%).

4.1.6 Retroviral (HIV) Status and Birth Weight

One of the main factors that is very important in this study is the Retroviral (HIV) status of the mother. The retroviral status is divided into two main categories, namely, HIV-Negative and HIV-Positive and it is cross tabulated with birth weight categories, low and Normal as shown in Table 4.5 and Table 4.6.

Table 4.5: Cross-tabulation of Birth Weight and Retroviral (HIV) Status Categories

Birth Weight Category	**Retroviral (HIV) Status**		
	Negative	Positive	Total
Normal	252	16	268
Low	50	12	62
Total	**302**	**28**	**330**
	91.52%	**8.48%**	**100.00%**

Source: Field Data, March-2015

Table 4.6: Percentages of Mothers with Low and normal Birth Weight based on their Retroviral (HIV) Status

Birth Weight	**Retroviral (HIV) Status**	
	Negative	Positive
Normal	83.44%	57.14%
Low	16.56%	42.86%
Total	**100.00%**	**100.00%**

From the tables above, we found that, HIV-Negative mothers (91.52%) are more than HIV-Positive mothers (8.48%) in this study. Out of 302 HIV-Negative mothers, 16.56% (50) had low birth weight babies and 83.44% (252) had normal babies. Also, out of 28 HIV-Positive mothers, 42.86% (12) had low birth weight babies whilst 57.14% (16) had normal birth weight babies. Comparison of HIV-Negative and HIV-Positive mothers against birth weight categories shows that, HIV-Positive mothers (42.8 6%) are likely to give birth to more low birth weight babies than HIV-Negative mothers (16.56%).

4.1.7 Retroviral (HIV) Status and Apgar Score

Just like the birth weight, the HIV status of the mother was again cross tabulated with the Apgar score of the infant. Apgar score also has two categories, namely, normal and low. Table 4.7 below shows the cross tabulation between the categories of Apgar score and HIV status.

Table 4.7: Cross-tabulation Between Apgar Score and Retroviral (HIV) Status Categories

Apgar Score Category	**Retroviral (HIV) Status**		
	Negative	Positive	Total
Normal	263	17	280
Low	39	11	50
Total	**302**	**28**	**330**
	91.52%	**8.48%**	**100.00%**

Source: Field Data, March-2015

Table 4.8: Percentage Distribution of Mothers with Low and normal Apgar Score based on their Retroviral (HIV) Status.

Apgar Score	**Retroviral (HIV) Status**	
	Negative	Positive
Normal	87.09%	60.71%
Low	12.91%	39.29%
Total	**100.00%**	**100.00%**

Assessment of the cross-tabulation between HIV status and the Apgar score of the infant shows that, HIV-Positive mothers are more likely to give birth to low Apgar infants 39.29% (11) than HIV-Negative mothers 12.91% (39). Out of 280 HIV mothers who had normal Apgar babies, 60.71% (17) were HIV-Positive and 87.09% (263) were HIV-Negative.

4.1.8 Socio-demographic Characteristics of the Study Population

Another factor that this study focuses on is the socio-demographic characteristics of the mother. This includes: Maternal age, Marital Status, Educational level and Employment Status of the mother.

Table 4.9: Summary of Selected Demographic Characteristic of the Study Mothers

Demographic Characteristics	n=330	Proportion (%)
Age of Respondent (years)		
Mean Age (Range)	28 (14-45)	
<20 years	15	4.5
20-24 years	65	19.7
25-29 years	120	36.4
30 or more	130	39.4
Marital Status of Respondents		
Single	105	31.8
Married	198	60
Co-habiting	27	8.2
Educational Level of Respondents		
None	8	2.4
Primary	37	11.2
Secondary	257	77.9
Tertiary	28	8.5

Source: Field Data, March-2015

From Table 4.9, the mean maternal age was 28years with a range of 14 to 45years. Of the 330 mothers, 19.7% were aged between 20-24years, 36.4% were aged between 25-29years, 4.5% were aged below 20years old and 39.4% were above 30years old. Those who reported to be married were 198 (60%), single were 105 (31.8%) and those who Co-habited were 27 (8.2%). The proportion of mothers with primary level of education was 11.2%, secondary level of education 77.9%, meaning most of the mothers had their education up to the secondary level and tertiary level of education 8.5%. Those who had no formal education accounted for only 2.4%.

4.1.9 Employment Status of the Study Mothers

Assessment of employment status revealed that 15.2% of the study mothers were unemployed, 70.6% self-employed and 14.2% were formally employed as shown in Figure 4.5 below. Out of the 198 study mothers who reported they were married, 10.6% (35) of them were formally employed, 42.2% (140) were self-employed and 7.0% (23) were unemployed. This can be seen in Table B3 in the Appendix Section.

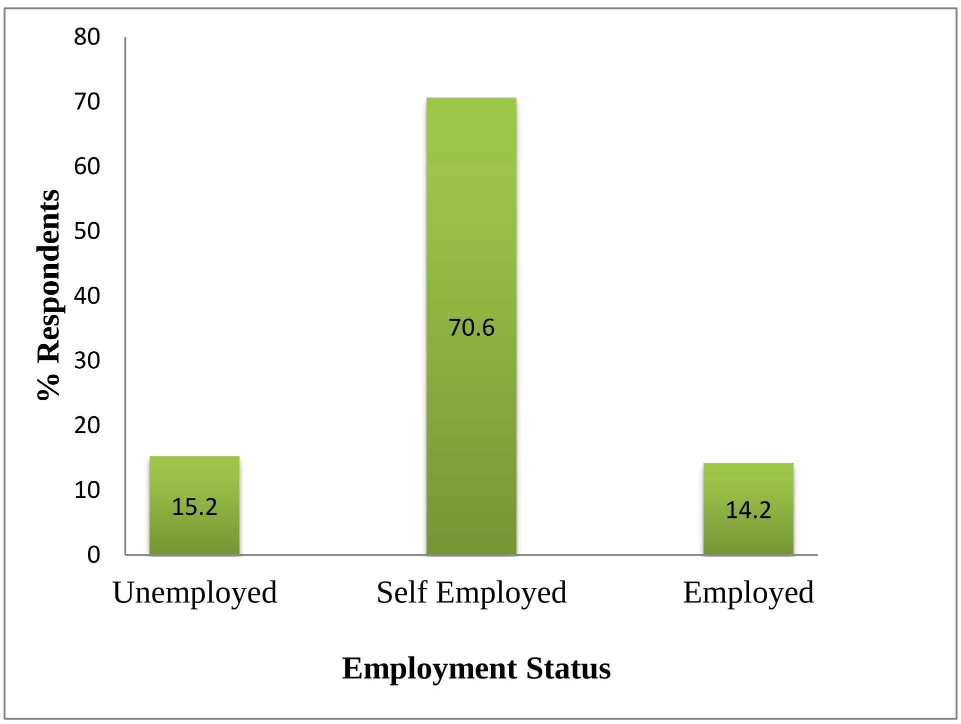

Figure 4.5: Employment Status of women who delivered in Ridge Hospital

Table 4.10: Descriptive Statistics of Some Maternal Factors

Statistic/Factors	Mean	Std. Error	Std. Dev.	Median	Min	Max	Skew
Gestational Age (Weeks)	37.97	0.23	4.120	38	24	47	-0.430
Weight Gain (Kg)	8.98	0.40	7.220	8.65	-18	42	0.750
Height (Kg)	158	0.47	8.550	159.5	102	178	-1.195
Haemoglobin Level (g/dl)	10.89	0.07	1.320	10.9	5.9	15	-0.430
Parity	1.32	0.07	1.300	1	0	6	0.920
Gravida	2.82	0.10	1.750	2	0	11	1.310
Number of Antenatal Visits	6.84	0.15	2.681	7	1	15	0.144
Daily Exp. (Ghc)	19.47	0.30	5.451	20	10	35	0.310
Daily Frequency of Eating	3.76	0.048	0.864	4	2	6	0.733
Daily Hours of Rest	6.41	0.076	1.373	6	3	10	0.114
Change in Systolic Blood Pressure in (mm/Hg)	4.89	0.969	17.599	0	-30	80	0.839
Change in Diastolic Blood Pressure in (mm/Hg)	3.05	0.793	14.408	0	-40	60	0.511

Source: Field Data, March-2015

From the table above, the mean gestational age is approximately 38 weeks with a standard deviation of 4 weeks. The median gestational age is also 38 weeks. The minimum and maximum gestational ages recorded are 24 and 47 weeks respectively. The distribution of the gestational age is a left tailed with a coefficient of skewness recorded as -0.43.

Two anthropometric measurements used in the study, namely, weight gain and height of the mother are factors considered in pregnancy. Weight gain was measured as the difference in initial weight and final weight. On the whole, the mean weight gain is 8.98kg with standard error and standard deviation 0.40kg and 7.22kg respectively. The median weight gain 8.65kg showing a slight left-tailed distribution. The minimum weight gain is -18kg, which means there was a drop in weight during pregnancy, and the maximum is 42kg. Again the mean average height is 158cm and the median height is approximately 160cm. The minimum and maximum heights are 102cm and 178cm respectively.

To check for the extent of anemia in pregnancy, the haemoglobin (HB) levels of mothers are taken into consideration. The mean HB level is 10.89d/gl with standard error and standard deviation of 0.07d/gl and 1.32d/gl respectively. The median HB level is 10.90d/gl which is not very different from the mean HB level suggesting a symmetric distribution though slightly left-tailed. The minimum and maximum HB levels are 5.90d/gl and 15.00d/gl respectively.

The average parity is 1 which is the same as the median with 0 and 6 being the minimum and maximum parity respectively. Also, the average Gravida is approximately 3 with 2 as the median. The minimum and maximum Gravida are respectively 0 and 11. The mean and median numbers of antenatal clinic visits are 7 each with minimum and maximum visits being 1 and 15. The daily expenses by mothers, reported that the mean average daily expenditure is Ghc19 with a standard deviation of Ghc5 and the minimum and maximum to be Ghc10 and Ghc35 respectively. Again the average daily frequency of eating reported by the mothers is approximately 4 times with 2 and 6 times daily being the minimum and maximum. To add to this, the daily hours of rest is considered since rest is an important factor in pregnancy. The mean average daily rest hours are 6 which is same as the median with minimum and maximum of 3 and 10 respectively.

Majority of the mothers reported that they didn't consume alcohol during pregnancy as 68.8% attested to this. Only 31.2% consumed alcohol during pregnancy. Further assessment of the mothers showed only 9.4% reported that they smoked cigarettes. Details of alcohol consumption and smoking habits of the mothers are found in the Appendix section. Most of the mothers at Ridge Hospital used Gas as 52.1% confirmed this, followed by charcoal (45.5%) and firewood (2.4%) and these can be seen in Table B5 in the Appendix.

The mean average for change in systolic blood pressure is approximately 5mm/Hg with standard error and standard deviation of 0.97mm/Hg and 18mm/Hg respectively. The minimum change in SBP is -30mm/Hg showing a reduction and the maximum is 80mm/Hg. The change in diastolic blood pressure has an average mean of 3.05mm/Hg with a standard deviation of 14.41mm/Hg. The minimum change in DBP is -40mm/Hg, which means there was a drop in DBP, and a maximum of 60mm/Hg. Any other additional results with regards to other maternal factors are presented in Table B6 in the Appendix section.

4.2 Preliminary Analysis

This section tries to find the maternal antepartum risk factors associated with birth weight and Apgar score at bivariate analysis. Possible risk factors for LBW/LAS and poor outcome were analyzed as follows: for the variables that are categorical, the chi-square test for trend in $2 \times k$ tables and the chi-square test of independence and its associated p-value were used. For continuous risk factors, the Pearson correlation coefficient between the raw scores of each of the outcome variables (birth weight and Apgar score) against the explanatory variables was computed.

4.2.1 Association between birth weight/Apgar score and clinical characteristics of the mothers.

The association between birth weight/Apgar score of infants and the clinical characteristics of the mothers are presented in Table 4.11, Table 4.12, Table 4.13 and Table 4.14.

Table 4.11: Relation of Retroviral (HIV) Status and Birth Weight of Infants

	Birth Weight				
HIV Status	**1-2**	**2-3**	**3-4**	**4-5**	**Total**
Positive	5	13	10	0	**28**
Negative	9	158	124	11	**302**
Total	14	171	134	11	**330**
Proportions	**0.357**	**0.076**	**0.075**	**0.000**	

Chi-square trend = 4.888 **p-value = 0.003**

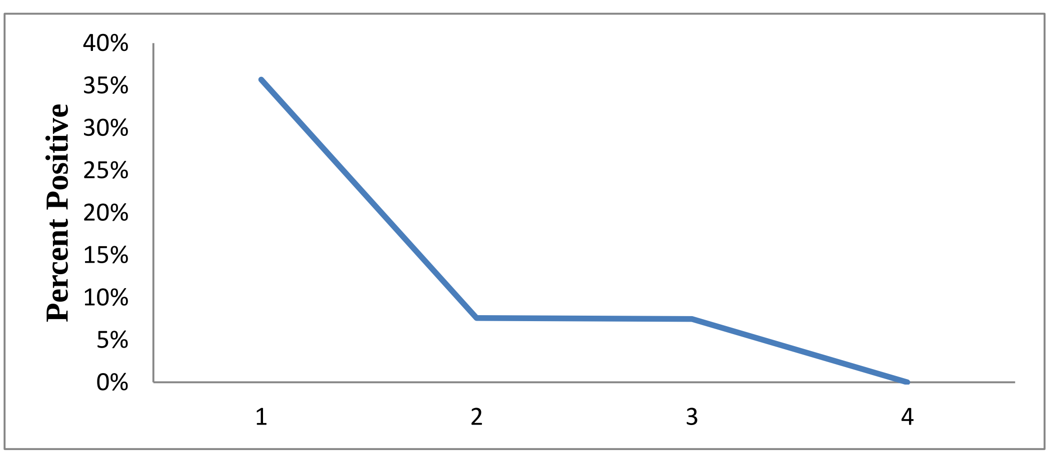

Figure 4.6: Graph of percentage of HIV-Positive mothers versus birth weight of infants

There was a significant relationship between infant birth weight and HIV status of the mother (χ^2_{trend} = 4.888, p=0.003) as shown in table 4.11. From the figure above, it was observed that mothers who are HIV-Positive gave birth to babies with decreasing birth weight, which imply, HIV-Positive mothers are more likely to have low birth weight babies compared to HIV-Negative mothers.

Table 4.12: Relation of Retroviral (HIV) Status and Apgar Score of Infants

	Apgar Score						
HIV Status	**1-4**	**5**	**6**	**7**	**8**	**9-10**	**Total**
Positive	1	3	6	4	9	5	**28**
Negative	2	9	29	58	97	107	**302**
Total	3	12	35	62	106	112	**330**
Proportions	**0.333**	**0.25**	**0.171**	**0.065**	**0.085**	**0.045**	

Chi-square trend = 9.386 **P-value = 0.002**

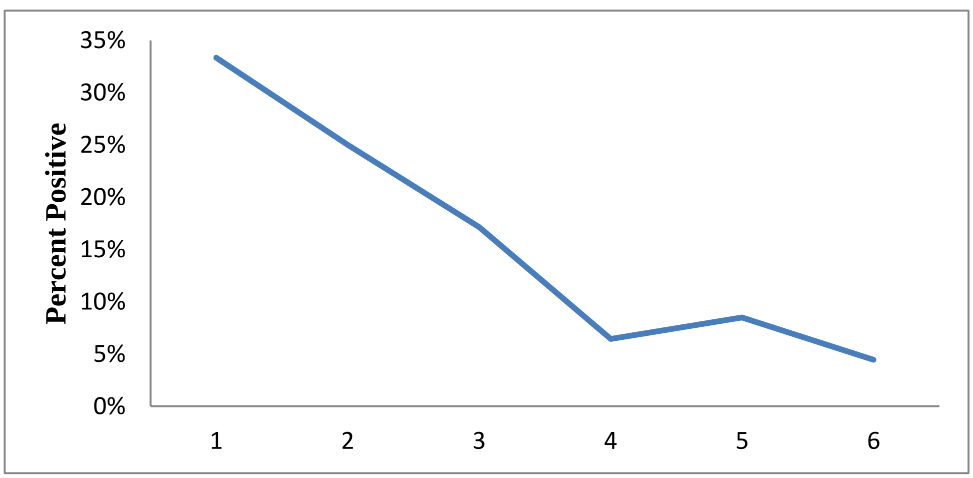

Figure 4.7: Graph of percentage of HIV-Positive mothers versus Apgar score of infants

There was a significant relationship between the Apgar score of an infant and HIV status of the mother (χ^2_{trend} = 9.386, p = 0.002). From figure 4.7, HIV-Positive mothers had their infants

Apgar score to be decreasing, thus the proportion of mothers with low Apgar score babies is higher among HIV-Positive mothers and so they are more likely to have low Apgar score babies whilst HIV-Negative mothers are less likely to deliver low Apgar score babies.

Table 4.13:Relation of Mode of Delivery and Birth Weight of Infants

	Birth Weight				
Mode of Delivery	**1-2**	**2-3**	**3-4**	**4-5**	**Total**
SVD	9	85	55	1	**150**
CS	5	86	79	10	**180**
Total	**14**	**171**	**134**	**11**	**330**
Proportions	**0.643**	**0.497**	**0.41**	**0.091**	

Chi-square trend = 8.435 P-value = 0.004

Table 4.14: Relation of Mode of Delivery and Apgar Score of Infants

	Apgar Score						
Mode of Delivery	**1-4**	**5**	**6**	**7**	**8**	**9-10**	**Total**
SVD	0	8	19	36	55	32	**150**
CS	3	4	16	26	51	80	**180**
Total	3	12	35	62	106	112	**330**
Proportions	**0.000**	**0.667**	**0.543**	**0.581**	**0.519**	**0.286**	

Chi=square trend = 10.892 P-value = 0.001

Results from table 4.13 show that, there was a significant association between Mode of delivery and birth weight. The proportion of mothers who delivered through SVD decreases with birth weight of infants, meaning they are more likely to have infants with low birth weight babies compared to mothers who delivered via CS. Also from table 4.14, there was a significant relationship between Mode of Delivery and Apgar score. The proportions of mothers who delivered via SVD are less likely to deliver low Apgar score infants.

4.2.2 Association between Birth weight/Apgar score and selected behavior characteristics

The association between birth weight/Apgar score and selected behavioral characteristics of the study population are shown in Table 4.15, Table 4.16, Table 4.17 and Table 4.18.

Table 4.15: Relation of Alcohol Consumption and Birth Weight of Infants

	Birth Weight				
Alcohol Consumption	**1-2**	**2-3**	**3-4**	**4-5**	**Total**
Yes	7	55	36	5	**103**
No	7	116	98	6	**227**
Total	14	171	134	11	**330**
Proportions	**0.500**	**0.322**	**0.269**	**0.455**	
Chi-square trend = 1.008		**P-value = 0.315**			

Table 4.16: Relation of Alcohol Consumption and Apgar Score of Infants

	Apgar Score						
Alcohol Consumption	**1-4**	**5**	**6**	**7**	**8**	**9-10**	**Total**
Yes	1	4	10	17	34	37	**103**
No	2	8	25	45	72	75	**227**
Total	3	12	35	62	106	112	**330**
Proportion	**0.333**	**0.333**	**0.286**	**0.274**	**0.321**	**0.330**	
Chi-square trend = 0.279			**P-value = 0.598**				

From tables 4.15 and 4.16, it was found that, alcohol consumption had no significant association with birth weight and Apgar score with p-values 0.315 and 0.598 respectively. Looking at the proportions of women who consume alcohol during pregnancy, they had their infants birth weight to be decreasing. This implies that, women who do not consume alcohol are less likely to give birth to low birth weight babies compared to those who consume alcohol. With the Apgar score, it can be seen that the proportion of women who consume alcohol are less likely to have low Apgar score babies.

Table 4.17: Relation of Cigarette Smoking and Birth Weight of Infants

	Birth Weight				
Smoking Habits	**1-2**	**2-3**	**3-4**	**4-5**	**Total**
Yes	4	16	10	1	**31**
No	10	155	124	10	**299**
Total	14	171	134	11	**330**
Proportions	**0.286**	**0.094**	**0.075**	**0.091**	

Chi-square trend = 2.599 **P-value = 0.110**

Table 4.18: Relation of Cigarette Smoking and Apgar Score of Infants

	Apgar Score						
Smoking Habits	**1-4**	**5**	**6**	**7**	**8**	**9-10**	**Total**
Yes	0	3	6	5	8	9	**31**
No	3	9	29	57	98	103	**299**
Total	**3**	**12**	**35**	**62**	**106**	**112**	**330**
Proportions	**0.000**	**0.250**	**0.171**	**0.081**	**0.075**	**0.080**	

Chi-square trend = 2.902 **P-value = 0.088**

Results from table 4.17 indicate that smoking habits had no significant linear trend with birth weight (χ^2_{trend} = 2.599, p = 0.110). Looking at the proportions, mothers who smoked cigarette during pregnancy are more likely to give birth to low birth weight babies. Again table 4.18

shows that there was no significant relationship between smoking habits and Apgar score (χ^2_{trend} = 2.902, p = 0.088)

4.2.3: Association between birth weight/Apgar score and selected Socio-demographic and household characteristics of the Mothers.

The association between the outcome variables (birth weight and Apgar score) and selected socio-demographic and household characteristics are presented in Table 4.19.

Table 4.19: Summary of selected socio-demographic and household characteristics of the mothers in relation to infant birth weight/Apgar score

Characteristics	LBW (n=62) n(row %)	NBW (n=268) n(row %)	χ^2 p-value	LAS (n=50) n(row %)	NAS (n=280) n(row %)	χ^2 p-value
Marital Status						
Not Married	32(24.2)	100(75.8)	4.290	27(20.5)	105(79.5)	4.813
Married	30(15.2)	168(84.8)	0.038	23(11.6)	175(88.4)	0.028
Educational Level						
None	2(25.0)	6(75.0)		1(12.5)	7(87.5)	
Primary	8(21.5)	29(78.4)	9.132	3(8.1)	34(91.9)	6.215
Secondary	43(16.7)	214(83.3)	0.104	44(17.1)	213(82.9)	0.286
Tertiary	9(32.1)	19(67.9)		2(7.1)	26(92.9)	
Employment Status						
Unemployed	16(32.0)	34(68.0)	7.612	19(38.0)	31(62.0)	24.218
Employed	10(21.3)	37(78.7)	0.022	4(8.5)	43(91.5)	0.000
Self-employed	36(15.5)	197(84.5)		27(11.6)	206(88.4)	
Type of Cooking Fuel						
Gas	15(8.7)	157(91.3)	29.785	18(10.5)	154(89.5)	11.937
Charcoal	42(28.0)	108(72.0)	0.000	28(18.7)	122(81.3)	0.003
Firewood	5(62.5)	3(37.5)		4(50.0)	4(50.0)	

The results show that the relationship between socio-demographic and household variables and infant birth weight is significant for marital status, employment status and type of cooking fuel. There was a significant association between Apgar score and all of the socio-demographic and household factors except for educational level (p=0.286). The proportion of women with low birth weight babies is higher among mothers who were not married, women who had tertiary level of education and those who were unemployed. A higher proportion (62.5%) of LBW observed among mothers who used firewood compared to those who use charcoal (28.0%) and gas (8.7%). The same explanation goes for Apgar score except that for the Apgar score the proportion of mothers with low Apgar score babies is rather higher (16.7%) among those who had secondary level of education.

4.2.4 Association between birth weight/Apgar score and some maternal factors

Eight out of thirteen maternal factors are significantly associated ($p<0.05$) with birth weight whilst Seven out of the thirteen maternal factors are significantly associated with Apgar score.

Table 4.20a: Summary of some maternal factors in relation to infant birth weight/Apgar score

Variables	Statistics	Birth weight	Comments	Apgar score	Comments
Age	p-value	0.013	Significant	0.000	Significant
	Correlation	0.137		0.214	
Gestational Age	p-value	0.000	Significant	0.000	Significant
	Correlation	0.346		0.230	
Weight Gain	p-value	0.511	Insignificant	0.537	Insignificant
	Correlation	0.036		0.034	
Height	p-value	0.026	Significant	0.029	Significant
	Correlation	0.122		0.120	

Table 4.20b: Summary of some maternal factors in relation to infant birth weight/Apgar score

Variables	Statistics	Birth weight	Comments	Apgar score	Comments
Haemoglobin Level	p-value	0.040	Significant	0.872	Insignificant
	Correlation	0.113		0.009	
Parity	p-value	0.567	Insignificant	0.552	Insignificant
	Correlation	0.032		0.033	
Gravida	p-value	0.627	Insignificant	0.443	Insignificant
	Correlation	-0.027		0.042	
Number of ANC Visits	p-value	0.001	Significant	0.014	Significant
	Correlation	0.188		0.135	
Daily Expenditure	p-value	0.000	Significant	0.000	Significant
	Correlation	0.192		0.270	
Daily Freq. of Eating	p-value	0.000	Significant	0.004	Significant
	Correlation	0.310		0.160	
Daily Hours of Rest	p-value	0.000	Significant	0.029	Significant
	Correlation	0.305		0.120	
Change in SBP	p-value	0.980	Insignificant	0.521	Insignificant
	Correlation	-0.001		-0.035	
Change in DBP	p-value	0.901	Insignificant	0.440	Insignificant
	Correlation	0.007		0.043	

From tables 4.20a and 4.20b, those factors significantly associated ($p<0.05$) with birth weight are Age, gestational age, height, haemoglobin level, number of antenatal clinic visits, daily expenditure, daily frequency of eating and daily hours of rest. For birth weight, the correlation with the maternal factors are positive except for change in SBP with a negative correlation coefficient of -0.001. The variables with the positive correlation coefficients mean that they are directly or positively linearly related to birth weight. Therefore, an increase in their value is expected to have a similar impact on the birth weight of the infant. On the other hand, those that are negatively correlated with birth weight rather have an inverse linear relationship with birth weight.

In the case of Apgar score, the significant ($p<0.05$) predictor variables include Age, gestational age, height, number of antenatal clinic visits, daily expenditure, daily frequency of eating and daily hours of rest. The predictors which had positive correlation coefficients with Apgar score implying an increase in any of them is related with a similar change in Apgar score include gestational age, weight gain, height, Parity, Gravida, number of ANC visits, daily expenditure, daily frequency of eating, daily hours of rest and change in DBP. Change in SBP is negatively correlated with Apgar score which imply that its high values are expected to be associated with low Apgar score. The predictor variable that recorded the highest correlation coefficient with the Apgar score was daily income spent which is 0.270.

4.3: Logistic Regression Analysis

4.3.1 Logistic Regression Analysis for Birth Weight

To determine the variables which have significant impact on birth weight, the logistic regression is used to achieve it. Logistic regression estimates the probability of observing a category of birth weight given the predictor variables, that is $P(Y/X)$. The effect of the other predictors on each other is adjusted accordingly. Thirteen (13) factors associated with birth weight at $p<0.05$ in bivariate analysis were considered for multivariate analysis. Six successive iterations were performed using the Enter Method retaining five (5) significant factors in the model.

Table 4.21a: Logistic regression model for low birth weight

Predictor Variables	Coefficient	S.E.	Wald	p-value	Odds Ratio
Retroviral (HIV) Status					
Positive	2.239	0.604	13.757	0.000	9.387
Negative	Reference				
Mode of Delivery					
SVD	0.674	0.375	3.231	0.072	1.962
Caesarian Section	Reference				
Marital Status					
Not Married	-0.005	0.408	0.000	0.991	0.995
Married	Reference				
Employment Status					
Unemployed	0.979	0.522	3.517	0.061	2.662
Employed	-0.044	0.509	0.007	0.932	0.957
Self-employed	Reference				
Type of Cooking Fuel					
Gas	Reference				
Charcoal	1.162	0.446	6.776	0.009	3.197
Firewood	3.25	1.086	8.964	0.003	25.797
Age	-0.048	0.041	1.398	0.237	0.958
Gestational Age	-0.232	0.052	20.174	0.000	0.793
Height	0.019	0.02	0.879	0.349	1.019
Haemoglobin Level	0.158	0.14	1.284	0.257	1.171
Number of ANC Visits	0.078	0.079	0.965	0.326	1.081

Table 4.21b: Logistic regression model for low birth weight

Predictor Variable	Coefficient	S.E	Wald	p-value	Odds Ratio
Daily Expenditure	-0.019	0.047	0.173	0.677	0.981
Frequency of Eating	-0.79	0.295	7.176	0.007	0.454
Daily Hours of Rest	-0.516	0.151	11.641	0.001	0.597
Constant	7.972	3.882	4.218	0.04	

We begin with the omnibus test of the model coefficients which tests if the model with the predictors is significantly different from the model with only the intercepts. From the test, the likelihood Ratio test statistic is 112.474 distributed as the chi-square with 15 degrees of freedom and it is presented below the table. The overall model is significant in predicting the birth weight categories since the p-value is less than 0.05 (p=0.000). Because the omnibus test corresponds to the conclusion that there is adequate fit of the data to the model, we now determine which predictors are significantly related to birth weight. It can be seen that Nagelkerke's R squared is 0.466 which indicates that the model is good but not great.

Table 4.21 is the most important one for our logistic regression analysis. The table includes the test of significance for each of the coefficients in the logistic regression model as well as their corresponding odds ratio (OR). The significance of each predictor is determined by the Wald statistic (which is the squared ratio of the logistic coefficient to its standard error). Since the success group is the LBW group, the OR is interpreted towards it. A risk odds ratio significantly greater than one indicates improvement in the odds of LBW whereas below one signifies reduction in the odds as against the odds of NBW for a unit increase in the predictor holding the other predictors constant. The results of logistic regression containing the five predictors significantly associated with birth weight are shown in Table 4.21.

Setting our level of significance at 5%, we observe that the variables that are statistically significant are Retroviral (HIV) status, Type of cooking fuel, Gestational Age, Frequency of Eating and Daily Hours of Rest. Results from table 4.21 show that HIV-Positive mothers (OR=9.387, p=0.000) presented significantly increased odds of having a low birth weight infant compared to HIV-Negative mothers. In other words, HIV-Positive mothers are about 9 times more likely to deliver low birth weight infants relative to HIV-Negative mothers. Mothers who were not married and those who were employed had reduced odds for a LBW infant although they were not statistically significant. Mothers who used firewood had significantly increased odds of having low birth weight babies (OR=25.797, p=0.003) and those who used charcoal also presented significantly higher odds of having LBW babies (OR=3.197, p=0.009).

The number of antenatal visits, height and haemoglobin level of mothers showed increased odds of delivering LBW babies although these are not significant factors. Mother's Gestational age, frequency of eating and daily hours of rest are significantly related to the odds of having normal birth weight babies. In other words, the higher the mother's gestational age, frequency of eating and daily hours of rest, the less likely they are to have low birth weight babies. Also as mother's age and daily expenditure increase, the less likely they are to deliver low birth weight infants.

4.3.2 Logistic Regression Analysis for Apgar score

In choosing the predictor variables which significantly have an impact on Apgar score, we use the same logistic regression. Recall that the Apgar score was denoted by Z. Using the same set of predictors, we determine $P(Z/X)$,the probability of observing an Apgar category given the predictor variables. Twelve (12) factors associated with Apgar score at p<0.05 in bivariate analysis were considered for the analysis of logistic regression. Six successive iterations were performed retaining only three (3) significant factors in the model.

Table 4.22a: Logistic regression model for low Apgar score

Predictor Variables	Coefficient	S.E.	Wald	p-value	Odds Ratio
Retroviral (HIV) Status					
Positive	1.952	0.558	12.240	0.000	7.043
Negative	Reference				
Mode of Delivery					
SVD	0.085	0.379	0.050	0.823	1.088
Caesarian Section	Reference				
Marital Staus					
Not Married	-0.196	0.406	0.233	0.629	0.822
Married	Reference				
Employment Status					
Unemployed	0.817	0.475	2.959	0.085	2.264
Employed	-0.374	0.650	0.331	0.565	0.688
Self-employed	Reference				
Type of Cooking Fuel					
Gas	Reference				
Charcoal	-0.340	0.428	0.628	0.428	0.712
Firewood	1.993	0.982	4.116	0.042	1.070

Table 4.22b: Logistic regression model for low Apgar score

Predictor Variables	Coefficient	S.E.	Wald	p-value	Odds Ratio
Age	-0.062	0.044	1.955	0.162	0.940
Gestational Age	-0.145	0.049	8.590	0.003	0.865
Height	0.000	0.022	0.000	0.982	1.000
Number of ANC Visits	0.098	0.077	1.641	0.200	1.103
Daily Expenditure	-0.155	0.050	9.441	0.002	0.857
Frequency of Eating	-0.166	0.256	0.419	0.517	0.847
Daily Hours of Rest	-0.048	0.138	0.120	0.729	0.953
Constant	8.183	3.748	4.767	0.029	

Chi-square = 74.195 **Significance = 0.000**

Cox & Snell R Square = 0.201 **Nagelkerke R Square = 0.351**

Degrees of freedom = 14

For Apgar score, the overall significance of the model using the likelihood Ratio test can also be found below Table 4.22b. From the test, 74.195 is recorded as the likelihood Ratio test statistic which is distributed as a chi-square with 14 degrees of freedom. The corresponding p-value of the omnibus test is 0.000 which implies that the model is significant which allows us to look at the individual predictors. The second table which gives the model summary provides some approximations. The Cox & Snell's R Square and Nagelkerke's R Square of the logistic regression were 20.1% and 35.1%, both indicating a weak relationship between prediction and predictors. The logistic regression table includes the coefficients of the predictor, wald test and its associated p-value and their OR. The OR interpretations are the same as given under birth weight.

From table 4.22 above, Retroviral (HIV) status of the mother, Gestational Age and Daily Income Spent were the significant risk factors for low Apgar score with a significance level of 5%. Also from the table, HIV-Positive mothers are about 7 times more likely to give birth to a low Apgar score baby compared to HIV-Negative mothers. From the table, the retroviral (HIV) status of the mother was the strongest predictor of the odds of having a LAS baby. Mothers who were not married, mothers who were employed and mothers who used charcoal as cooking fuel showed reduced odds of having low Apgar score infants although these are not statistically significant. The number of antenatal visits and height of the mother presented increased odds of giving birth to a LAS infant although these are not significant factors. From the table, we realize that the variables which increase the risk of low Apgar score with their increasing values are; Mother's age, gestational age, daily expenditure, frequency of eating and daily hours of rest.

4.4 Multivariate Data Analysis

Multivariate Analysis of Variance (MANOVA) was used to run the model of the data gathered to see which of the categories of HIV status (Negative or Positive) is statistically significantly with regards to birth weight and Apgar score of the infant.

4.4.1 Descriptive Statistics of the Results

Table 4.23 depicts the mean values of birth weight and Apgar score of the baby for HIV-Negative and HIV-Positive mothers at the Ridge Hospital.

Table 4.23: Descriptive statistics of mean values for HIV-Negative and HIV-Positive mothers at Ridge Hospital.

	HIV-Negative		HIV-Positive	
Statistic	**Birth Weight**	**Apgar score**	**Birth Weight**	**Apgar score**
Mean	3.00	8.00	2.7	7.00
Std. Error	0.03	0.07	0.11	0.23
Std. Dev.	0.56	1.20	0.59	1.43
Total(n)	**302**		**28**	

Source: Field Data, March-2015

Table 4.23 above represents the mean values of birth weight and Apgar score for HIV-Negative and HIV-Positive mothers at Ridge Hospital. As shown in Table 4.23, the mean values for birth weight and Apgar score of the baby for HIV-Negative mothers are respectively higher than HIV-Positive mothers. Thus, HIV-Negative mothers had mean values of 3.00 and 8.00 for birth weight and Apgar score respectively and HIV-Positive mothers were 2.7 and 7.00. The standard deviations for HIV-Negative and HIV-Positive mothers with regards to birth weight are respectively 0.56 and 0.59 and looking at the values it tells they are almost the same. For Apgar score, HIV-Negative and HIV-Positive mothers have 1.20 and 1.43 as their standard deviations.

4.4.2 Multivariate Data Analysis of Retroviral (HIV) Status of Mothers from Ridge Hospital

The first table (Table 4.24) shows the results of the multivariate tests whilst table (Table 4.25) shows the full model in which birth weight and Apgar scores were considered as dependent variables whereas retroviral status with two levels (HIV-Negative and HIV-Positive) was treated as independent variable.

Table 4.24: Multivariate Tests of birth weight and Apgar score on Retroviral status of Mothers

Effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared
Intercept	Wilks' Lambda	0.059	2609.4	2	327	0.000	0.941
Retroviral status	Wilks' Lambda	0.962	6.480	2	327	0.002	0.038

Table 4.24 is the multivariate tests table which depicts the actual result of the one-way MANOVA by looking at the second effect which is labeled 'Retroviral Status' and the Wilks' Lambda row. To determine whether the one-way MANOVA was statistically significant, the significant column was looked at. It can be seen from the table that, we have a significant value of 0.002 which means p<0.005. Therefore, we can conclude that there was a statistically significant difference in birth weight and Apgar scores of the baby based on the mothers Retroviral (HIV) status with $F(2, 327) = 6.48$, $P<0.005$; Wilks' $\Lambda = 0.962$ and Partial $\eta^2 =0.038$.For these F-tests results, the section labeled 'Intercept' is ignored.

Table 4.25: Multivariate Analysis Results of Retroviral Status of Mothers from Ridge Hospital Full Model

Source of Variation	Dependent Variable	Degrees of Freedom (d.f)	Mean Square	F-Ratio	Sig.
Intercept	Birth weight	1	834.482	2618.261	0.000
	Apgar score	1	5768.364	3848.803	0.000
Retroviral Status	Birth weight	1	2.332	7.317	0.007
	Apgar score	1	13.212	8.816	0.003

Source: Field Data, March-2015.

Looking at the values of birth weight and Apgar score as far as category of retroviral status (thus HIV-Negative and HIV-Positive) is concerned, it can be seen in Table 4.25 that differences in means of birth weight and Apgar score were statistically significant with p-values 0.007 and 0.003 respectively.

4.5 Discussion of Results

One of the objectives that this research intended to study was to find out if maternal factors are certainly significant risk factors of low birth weight/Apgar score. Quantitatively, birth weight and Apgar score are used and the inputs of the results are discussed below.

The prevalence of low birth weight in this study was estimated at 18.79%. In the bivariate analysis, the relationship between Retroviral (HIV) status, Mode of delivery and infant birth weight was statistically significant. In the multivariate analysis using logistic regression, HIV status of the mother is found to be significantly associated with low birth weight and this is in concordance with the works by Mwanyumba et al (2001). It was also found that, HIV-Positive mothers are at higher risk of giving birth to low birth weight babies. Mode of delivery presented increased odds of having low birth weight babies.

The relationship between all maternal socio-demographic characteristics and birth weight was significant except educational level of mothers. Type of cooking which is a household variable also had a significant relationship with birth weight. There was no significant association between low birth weight and socio-demographic factors such as maternal age, marital status and employment status in the multivariate analysis. Studies have indicated that lower educational level mothers give birth more to LBW infants. However, in the bivariate analysis of this study, the proportion of women who had LBW babies was higher among mothers with tertiary level of education.

The relationship between LBW and behavioral characteristics of the mothers. None of the behavioral characteristics considered a ‘risk’ were significantly associated with low birth weight in this study. These results contrasts with those study reported by Lanting et al (2009) in

Netherlands which indicated that prenatal exposure to alcohol as well as smoking increases the risk of low birth weight. It is also known that maternal cigarette smoking reduces birth weight. In contrast to this, results of this study indicated that there was no significant association between maternal smoking and LBW. There was no significant relationship between cigarette smoking, alcohol consumption and low birth weight/Apgar score in the bivariate analysis.

The height of the mother and number of antenatal visits are found to be positively related to birth weight in the bivariate analysis. These factors showed increased odds of having LBW babies in the multivariate analysis yet are not significant factors. Gestational age was found to be a significant factor as with the case of (Jammeh et al, 2011). In the bivariate analysis, gestational age, frequency of eating, daily expenditure and daily hours of rest are all positively related with birth weight and their increasing values reduce the risk of LBW in the multivariate analysis. With pregnancy induced hypertension measured by changes in SBP and DBP, change in SBP is negatively correlated with birth weight but is considered insignificant whilst change in DBP is positively related to birth weight and also insignificant in the initial analysis. In all the maternal factors that are significant in predicting birth weight are Retroviral (HIV) status of the mother, Gestational Age, Frequency of Eating, Daily hours of Rest and Type of Cooking Fuel.

With the Apgar score, the prevalence of low Apgar score is 15.15%. Only change in SBP is negatively related with Apgar score in the bivariate analysis. HIV status of the mother is positively related with Apgar Score in the bivariate analysis but using logistic regression it presented significantly increased odds of having low Apgar score babies with HIV-Positive mothers having a higher risk of giving birth to low Apgar score babies. Just like birth weight, the height and number of antenatal visits presented increased odds of giving birth to low Apgar score babies although these are not statistically significant. Maternal age, gestational age, daily expenditure, frequency of eating and daily hours of rest reduce the odds of having low Apgar score babies with their increasing values. In all the three (3) significant factors used in predicting the Apgar score of the baby are Retroviral (HIV) status of the mother, Gestational Age and Daily Expenditure.

To examine the differences, if any that exist between HIV status (with two levels, HIV-Negative and HIV-Positive) of the mother on birth weight and Apgar score of the infant, one-way MANOVA was used. HIV-Negative and HIV-Positive mothers of Ridge Hospital were selected for the study of this research.

There have been differences in the mean values of the two levels of HIV status. This is because HIV-Negative mothers had 3.00 and 8.00 as mean values for birth weight and Apgar score respectively. Similarly, HIV-Positive mothers had 2.7 and 7.00 as mean values for birth weight and Apgar score. We can therefore deduce that, the mean values for HIV-Negative mothers are respectively higher than HIV-Positive mothers with regards to birth weight and Apgar score.

As revealed in this research the findings have shown that there were significant differences in birth weight and Apgar score with regards to the retroviral (HIV) status of the mother with the following p-values; birth weight and Apgar score with p-values of 0.000 and 0.003 respectively.

It is therefore concluded that the null hypothesis defined as “There is no significant difference in the two levels of Retroviral (HIV) status with regards to birth weight and Apgar score” should be rejected.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.0 Introduction

This chapter summarizes the results and discussions of the findings as well as conclusions drawn that reflects the objectives of the study, recommendations and areas for future research on maternal risk factors for low birth weight and Apgar score.

5.1 Summary

In Ghana few studies have been carried out on low birth weight and Apgar score and so this study seeks to determine which of the maternal risk factors significantly affect these two conditions. The largest proportion of neonatal mortality is caused by low birth weight and Apgar score (birth asphyxia). Having a low birth weight and Apgar score baby can cause emotional, social and financial stress for the family. Therefore to measure these two conditions, the raw values of birth weight and Apgar score are used.

Using logistic regression to select the significant maternal factors, birth weight and Apgar score were considered as the dependent variables and the maternal risk factors as independent variables. In addition, MANOVA was also used as a statistical tool for running of the analysis of this research. It was therefore used to examine if there is any significant difference between HIV status of the mother on birth weight and Apgar score. Here the HIV status of the mother with two levels, HIV-Negative and HIV-Positive, was treated as the only and main independent variable and the raw values of birth weight and Apgar scores considered as dependent variables.

5.2 Observations

Findings from this research have shown that, the average birth weight is 2.98kg with a standard deviation and standard error of 0.57kg and 0.05kg respectively. Similarly, the average Apgar score is 8 with respective standard deviation and standard error of 1.24kg and 0.07kg. In this study, the female infant had a higher average birth weight (3.00kg) compared to the male infants (2.96kg). The average Apgar score for both males and females is 8.

The significant risk factors for delivering a low birth weight baby include Retroviral (HIV) status, Gestational Age, Frequency of Eating, Daily Hours Rested and Type of Cooking Fuel. It was also found that HIV-Positive mothers are about 9 times more likely to deliver low birth weight relative to mothers who are HIV-Negative. Retroviral (HIV) status of the mother has the strongest influence in determining the birth weight of a baby among mothers in this study.

It was observed that, the likelihood of having infants with low birth weight was higher among mothers who delivered via SVD, mothers who were not married, mothers who had tertiary-level education and mothers who used firewood for cooking during pregnancy.

Retroviral (HIV) status of the mother, Gestational Age, and Daily Expenditure during pregnancy are the significant risk factors for giving birth to low Apgar score babies. HIV-Positive mothers have a higher risk of giving birth to a new born with LAS. Gestational age and daily expenditure were found to be significant in reducing the risk of low Apgar score with their increasing values in the multivariate analysis. Factors such as marital status, mother's age, frequency of eating and daily hours of rest were also found to reduce the odds for LAS with their increasing values but in this case the association was not significant.

Findings from the MANOVA analysis have shown that differences in means of birth weight and Apgar score with regards to the two levels of HIV status were statistically significant with p-values of 0.007 and 0.003 respectively.

5.3 Conclusion

Our study findings suggest that risk factors contribute to the burden of low birth weight and Apgar score and are indeed significantly related to them. In this study, birth weight and Apgar score are used to determine whether a newborn baby has low birth weight/Apgar score or has a normal birth weight/Apgar score. More importantly, this study contributes to the understanding of the individual and the effects of maternal factors influencing birth weight and Apgar score at Ridge Hospital.

We found out that Retroviral (HIV) status of the mother, Gestational Age, Daily Hours Rested, Frequency of Eating and Type of Cooking Fuel during pregnancy are the significant risk factors of low birth weight whereas Retroviral (HIV) status, Gestational Age and Daily Expenditure are the significant risk factors of low Apgar score. Retroviral (HIV) status and Gestational Age of the mother are found to be significant risk factors for both low birth weight and low Apgar score. The HIV status of the mother was the strongest predictor of the odds of having LBW and LAS babies.

Lastly, this research has provided evidence that HIV-Positive mothers are associated with a higher risk of low birth weight and low Apgar score than HIV-Negative mothers. This research also has shown evidence of significant differences of means in birth weight and Apgar score as far as HIV-Negative and HIV-Positive mothers are concerned. It is therefore suggested that, programmes that work to lessen especially the rate of low birth weight and low Apgar score among infants should also focus on improving maternal lifestyle choices.

5.4 Recommendations

The following recommendations are made both in the area of policy formulation and future studies based on the findings and conclusions made from the study.

Policy makers must put in place intervention programmes which will focus on significant risk factors associated with low birth weight and low Apgar score. They should also target pregnant women at risk specifically at Ridge Hospital. Health education during pregnancy should be strengthen to promote care-seeking, this way healthier infants are produced who have a better chance of surviving. Especially in the case of maternal age, more efforts must be put to curb the problem of teenage pregnancy. Antenatal care visits must also be encouraged to prevent preterm birth or low gestational age (less or equal to 36 weeks) as well as formulating policies that will reduce poverty.

With the factors that affect birth weight and Apgar score, HIV status of the mother is the one associated with a higher risk of LBW and LAS. Therefore during pregnancy, mothers infected with HIV should be made aware so that this knowledge can facilitate early counseling and treatment to prevent LBW and LAS. Also during pregnancy, mothers should be diagnosed to allow appropriate treatment and follow-up of the child and interventions should be made available by health institutions to prevent mother to child-to-child transmissions.

Finally, it is recommended that, two or more years-study is used to conduct a similar study and to examine the trend of differences in birth weight and Apgar score at Ridge Hospital as far as retroviral (HIV) status is concerned and including other factors like maternal nutrition, multiple births and residence of the mother.

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APPENDICES

APPENDIX A

Table A1: Interview Guide Questionnaire for Data Collection

Number		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
CHILD	**Birth Weight**										
	Apgar										
	Gender										
MATERNAL CONFOUNDERS/FACTORS	**Retroviral (HIV) Status**										
	Mode of Delivery										
	Age										
	Marital Status										
	Educational Level										
	Employment Status										
	Gestational Age										
	Initial Weight										
	Final Weight										
	Height										
	HB level										
	No. of ANC visits										
	Parity										
	Gravida										
	Initial DBP										
	Final DBP										
	Initial SBP										
	Final SBP										
	Daily hours of rest										
	Daily Expenditure										
	Frequency of eating										
	Type of cooking fuel										
	Alcohol Consumption										
	Smoking Habits										

APPENDIX B

Table B1: Descriptive statistics for birth weight across categories of birth weight

Birth Weight Category	N	Minimum	Maximum	Mean	Std. Dev.	Skew
Normal	268	2.5	4.8	3.1581	0.4558	0.7951
Low	62	1.05	2.45	2.1865	0.2501	-2.2514
Total	**330**	**1.05**	**4.8**	**2.9786**	**0.5699**	**0.1598**

Table B2: Descriptive statistics for Apgar score across categories of Apgar score

Apgar score Category	N	Minimum	Maximum	Mean	Std. Dev.	Skew
Normal	280	7	10	8.1964	0.799	-0.1565
Low	50	1	6	5.58	0.859	-3.4749
Total	**330**	**1**	**10**	**7.8**	**1.2368**	**-1.1013**

Table B3: Cross-tabulation between Employment status and marital status

	Marital Status			
Employment Status	Single	Married	Co-habiting	**Total**
Unemployed	25	23	2	**50**
Employed	10	35	2	**47**
Self-employed	70	140	23	**233**
Total	**105**	**198**	**27**	**330**

Table B4: Summary of Behavioral Characteristics of Mothers

Behavioral Characteristics	n=330	Proportion (%)
Alcohol Consumption		
Yes	103	31.2
No	227	68.8
Smoking Habits		
Yes	31	9.4
No	299	90.6

Table B5: Summary of Type of Cooking fuel used by Mothers

Type of Cooking	Frequency	Percent
Gas	172	52.1
Charcoal	150	45.5
Firewood	8	2.4
Total	**330**	**100.0**

Table B6: Descriptive Statistics of other Maternal Factors

Statistics/Factors	N	Minimum	Maximum	Mean	Std. Error	Std. Dev.	Skew
Initial weight	330	0	132	66.554	0.8059	14.6396	0.21
Final weight	330	0	130	75.533	0.8012	14.5537	0.066
Initial Diastolic pressure	330	50	130	68.9818	0.57383	10.42412	1.224
Final Diastolic Pressure	330	50	120	72.3394	0.72176	13.1114	1.205
Initial Systolic Pressure	330	80	200	110.509	0.71047	12.90631	1.467
Final Systolic Pressure	330	87	210	115.403	0.94431	17.15417	1.69

Table B7: Other descriptives of HIV status with regards to Birth weight and Apgar score

Dependent Variable		Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Birth weight	Negative	0.032	2.940	3.068
	Positive	0.107	2.493	2.912
Apgar Score	Negative	0.07	7.722	8.000
	Positive	0.231	6.688	7.598