UNIVERSITY FOR DEVELOPMENT STUDIES

PREDICTORS OF BIRTH WEIGHT AMONG MOTHERS DELIVERING IN A
HEALTH FACILITY IN THE KASENA-NANKANA MUNICIPALITY

AGORINYA AWINTUEN ISAIAH

Thesis Submitted To The Department Of Statistics, Faculty Of Mathematical Sciences,
University For Development Studies In Partial Fulfillment Of The Requirements For
The Award Of Master of Science Degree In Biometry

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BY

AGORINYA AWINTUEN ISAIAH (BSc. Mathematical Science, Statistics Option)
(UDS/MBM/0008/11)

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October, 2013

DECLARATION

I hereby declare that this dissertation is the result of my own original work and that no part of it has been presented for another degree in this university or elsewhere. Related works by others which served as a source of knowledge has been duly referenced.

Agorinya Awintuen Isaiah 13-11-2013

(Candidate)   Signature   Date

I hereby declare that the preparation and presentation of the dissertation was supervised in accordance with the guidelines on supervision of dissertation laid down by the University for Development Studies.

Supervisor

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ABSTRACT

Birth weight is important to infant survival and the later health of a child. To promote optimum birth weight, in an environment that is vulnerable to varying socio-economic and demographic factors, it is important to understand the relationship between birth weight and these factors. This study determined the seasonal effects on birth weight and examined the ability of maternal and seasonal variables to predict birth weights. The study was conducted in the Kassena-Nankana municipality in the Upper Eastern part of Ghana. Information including date of birth of infants, birth weight of infants, maternal parity, the socio-economic status of maternal household, educational and marital status, ethnicity and religious affiliation of mother were systematically and retrospectively extracted from 8,263 Antenatal Clinic (ANC) records from January, 2009 to December, 2011. There were 4,012 male infants and 3,980 female infants. Correlations among birth weights and selected predictor variables we explored using correlation analysis while predictors of birth weights were modeled and assessed through regression analysis. The study showed significant difference in the mean birth weight of male and female infants with a (P-value =0.000) as well as a significant seasonal pattern in birth weights. While Maternal age had a significant and positive ($r = 0.1470$, $p<0.05$) relationship with birth-weight, the best predictors of birth-weight were maternal parity, (P-value =0.000), socio-economic status of mother and season of birth (P-value =0.042). Thus, the season of birth which also tells the length of exposure to the hungry season, is important in determining pregnancy outcomes.

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DEDICATION

I dedicate this work to my lovely wife and Son, Gayire Abisiboba Marese and Agorinya

Wintuen Light Jr.

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LIST OF ACRONYMS

BW	Birth Weight
LBW	Low Birth Weight
UDS	University for Development studies
WHO	World Health Organization
UNICEF	United Nations Children's Emergency fund
KNM	Kassena-Nankana Municipal
NHRC	Navrongo Health Research Centre
CHPS	Community-based Health Planning and Services
LR	Logistic Model/Likelihood Ratio
SGA	Small for Gestational Age
AGA	Appropriate for Gestational Age
BPD	Bronchopulmonary Dysplasia
VLBW	Very Low Birth Weight
IQ	Intelligence Quota
ELBW	Extremely Low Birth Weight
SE	Special Education
LD	Learning Disabilities
EH	Emotional Handicaps
AP	Academic Problems
PVL	PerventricularLeukomalacia

CLD	Chronic Lung Disease
ICH	Intracranial Hemorrhage
GHQ	General Health Questionnaire
PID	Pelvic Inflammatory Disease
ART	Artificial Reproductive Technology
MAR	Medical Assisted Reproduction
IVF	In Vitro Fertilization
MLE	Maximum Likelihood Estimator
CI	Confidence Interval
OR	Odds Ratio
ROC	Receiver Operation Characteristics
VIF	Variance Inflation Factor
AIC	Akaike Information Criteria
BIC	Bayesian Information Criteria
LL	Likelihood
ASE	Asymptotic Standard Error

CHAPTER ONE

INTRODUCTION

1.1 Background

It is well recognized that birth weight is the single most important factor that determines infant and childhood morbidity and mortality De Onis et al. (1998). Birth weights that ranged from 3500 to 4500g have been associated with favorable outcomes whilst birth weights below 2500g have been associated with increased episodes of diarrhea and pneumonia in children under the age of five. More recently, research also indicated that birth weight is significantly associated with early onset of stunting (Neumann et al. 1994). Birth weight as well as pregnancy weight gain are also important indicators of maternal health and nutritional status, especially in environments that are vulnerable to seasonal food shortages. Studies have demonstrated that adults, especially women, undergo seasonal body weight loss, Ferro-Luzziet al. (1994).

Earlier research by Huxley et al. (2000) cited by Roseboom et al. (2001), Stein et al. (1995), and Stein et al. (1975), documented that, nutritional deprivation brought about by famine during the Second World War, early in pregnancy and during the third trimester was associated with poor pregnancy outcomes. Several research studies; Neumann et al. (1994) and Lawrence et al. (1987) conducted in Tropical Africa indicated that women whose third trimester of pregnancy coincided with the

nutritionally debilitating season (hungry/wet season) experienced lower pregnancy weight gains and lower birth weights. The dry season is characterized by favorable pregnancy outcomes (due to decreased maternal labor and plentiful food stocks) as evidenced by birth weights well above 3000g and maternal weight gains (>0.5 kg/week) that are comparable to industrialized countries. Studies conducted in developing countries showed that pregnancy weight gains are generally inadequate, averaging 6.3kg for the entire pregnancy in the wet season (Neumann et al. 1994). In addition, researchers have shown that birth weight is influenced by non-seasonal factors such as increasing maternal age and parity which are associated with increased birth weight (Feleke and Enquoselassie, 1999, and Ali and Lulsege, 1997). Kassena-Nankana Municipal food and nutrition situation is characterized by unfavorable climatic conditions contributing to food insecurity especially for the 99% (NHRC, 2011 annual report) of the population who live in rural areas.

Food insecurity becomes more pronounced during the hungry season. Stunting amongst children under the age of five years and chronic energy deficiency in women of child bearing age are the most prevalent forms of malnutrition in the District (MHSW, 1995).According to WHO (2011) the incidence of low birth weight in Ghana is estimated at 14.3% or more of live newborns and is well above the 10% recommended by UNICEF, (2001).

It is important to study the effect of season on birth weight in a temperate climate such as that in KNM, which has two distinct climatic seasons which affect food production

throughout the year. In this study, the hungry season was defined as the pre-harvest months of January to June. Finally, research that explores the effect of season on maternal nutritional status in relation to birth weight is limited in Ghana.

1.2. Problem Statement

The proportion of low birth weight babies in Ghana was reported at 13.4% in 2008, according to the World Bank's global health facts (2008). Low birth weight babies are newborns weighing less than 2,500 grams, with the measurement taken within the first hours of life, before significant postnatal weight loss has occurred. According to WHO, A baby's low weight at birth is either the result of preterm birth (before 37 weeks of gestation) or of restricted foetal (intrauterine) growth. Low birth weight is closely associated with fetal and neonatal mortality and morbidity, inhibited growth and cognitive development, and chronic diseases later in life according to Huxley et al. (2000). Many factors affect the duration of gestation of fetal growth, and thus, the birth-weight. They relate to the infant, the mother or the physical environment and play an important role in determining the infant's birth-weight and future health; Stein *et al*. (1995). Stated that; for the same gestational age, girls weigh less than boys, firstborn infants are lighter than subsequent infants, and twins weigh less than singletons. He also stated that, Birth weight is affected to a great extent by the mother's own fetal growth and her diet from birth to pregnancy, and thus, her body composition at conception. Their study also revealed that young women have smaller babies and that

mothers in deprived socio-economic conditions frequently have low birth weight infants. The consequence of low birth weight range from short to long term, birth weight is one of many early measurements that can indicate long-term consequences of prenatal development on psychological variables, such as cognitive abilities, temperament, and behavior. Cognitive abilities and birth weight often show a positive correlation in studies of low birth weight infants, but a very recent study (Richards *et al*. 2001) reports that cognitive function is related to birth weight for the general population as well.

Low birth weight thus defines a heterogeneous group of infants: some are born early, some are born growth restricted, and others are born both early and growth restricted. It is generally recognized that being born with low birth weight is a disadvantage for the baby. Short gestation (preterm birth) is the main cause of death, morbidity and disability, the shorter the gestation, the smaller the baby and the higher the risk of death, morbidity and disability. It has been shown that the mortality range can vary 100-fold across the spectrum of birth weight and rises continuously with decreasing weight according to Basso et al. (1998). Low birth weight due to restricted foetal growth affects the person throughout life and is associated with poor growth in childhood and a higher incidence of adult diseases, such as type 2 diabetes, hypertension and cardiovascular disease. An additional risk for girls is having smaller babies if they become mothers. Season of birth as a consequence of season of conception has been found to be closely related to birth weight according to Aitkin

(1990) and Wendle-Ritcher (1997). Higher ambient outdoor temperature in the first trimester of pregnancy and/or low ambient outdoor temperature in the third trimester are associated with reduced birth weight of offspring according Lawlor *et al*. (2005).

An understanding of the determinants of birth weight will be key to understanding and promoting better health interventions that will help reduce the incidence of childhood morbidity and mortality. Most current health care intervention policies in the Municipality for the reduction of morbidity and mortality in children under five years are based on quality improvement in service delivery which do not focus on the maternal characteristics and the social environment of the mothers before, during and after pregnancy. It is therefore a critical subject to investigate and identify the independent determinants of birth weights of new born babies which can be used as a proxy measure to control and reduce the incidence of infant morbidity and mortality.

It is in this light that this study seeks to establish the prevalence of LBW in the KNM and also to identify the predictors that determine the Weight of a new born baby in the KNM.

1.3. Research Questions

For the achievement of the study objectives, the following questions are used asked.

i.   Are neonates born to adolescent mothers heavier than those born to older mothers (20-35 years)?

ii. Does season of birth affect the birth weight of infants?

iii.   Does rainfall and humidity affect the birth weight of newborns?

iv.   What other socio-demographic factors affect the birth weight of a child?

1.4 Objectives of the Study

1.4.1 General Objectives
To determine the predictors of birth weights in women who delivered in a health

facility

1.4.2 Specific Objectives
Specifically, the study aimed to;

   i.   Compare the birth weight of adolescents to that of older mothers

   ii.   Identify the seasonal distribution of birth weights of women attending a rural

         clinic/Health Centre

iii.   Asses the effects of rainfall on birth weights

iv.   Fit a predictive Model for the birth weight of new born babies

1.5 Justification of the Study

Many research papers on birth weight exist with hundreds more appearing every year.

One factor is that birth weight data are precisely recorded, free (through vital statistics),

and available in vast numbers. A second factor is that birth weight is an extremely

powerful predictor of an individual baby's survival. In general, the lower the weight, the

higher a baby's risk of infant mortality, Wilcox AJ (1983).A third factor is that, on a

population level, mean birth weight is associated with infant mortality. Groups with

lower mean birth weight often have higher infant mortality (e.g. the infants of mothers who smoke, or of mothers with lower socioeconomic status), (Wilcox, 1993) and (Humphrey & Elford, 1988). Finally, birth weight is associated with health outcomes later in life. Asthma, low IQ, and hypertension have all been reported to be more common among those who were small at birth. (Richards, Hardy, Kuh, & Wadsworth, 2001).

The strong association of birth weight with infant mortality is the usual focus of birth weight research, with the assumption that birth weight is a major determinant of infant survival.

This study will help establish the prevalence of LBW children in the KNM and also identify the main predictors of LBW in the district; this will help health delivery services and maternity homes to adequately prepare for children born with LBWs.

CHAPTER TWO

LITERATURE REVIEW

2.1 Health Consequences of Low Birth-Weight

The prevalence of low birth weight has increased over the course of the last decade. The later development of low birth weight children is still not very well known. All studies of low birth weight agree though that, after controlling for social and economic factors, low birth weight has an independent negative effect on child health outcomes, and this effect worsens as birth weight decreases (Boardman *et al*. 2004). The same observation has been made for infants 'small-for gestational age' (SGA). The following sections discuss the independent effects of low birth weight (by birth weight category) and the role of social factors.

2.1.1 New Babies Born Small for Gestational Age (SGA)

Many studies have suggested that infants born SGA, are at greater risk for health problems later in life than infants born 'appropriate for gestational age'(AGA). In the early years of the child's life, these problems are mainly of a neurological nature. Later on, learning and behavioral problems become more important (Andersson *et al.* 1997). Markestad et al (1997) (cited in Matsuo, 2005) tried to compare the growth patterns and psychomotor development of healthy SGA and AGA infants, and identified factors predictive of outcome at 13-14 months of age. By that age, SGA infants had showed partial catch-up in growth, but they still had smaller weight, crown-heel length, and

head circumference than AGA infants. SGA children scored as well as AGA children on the motor, but lower on the mental scale.

Larroque *et al.* (2001) (cited in Matsuo, 2005) studied the relationship between being born SGA or AGA and school difficulties at ages 11 and 18 years. Compared to being AGA, being born SGA was associated with poorer school performance, even after controlling for factors such as maternal age and educational level, parental socio-economic status, family size, and gender.

2.1.2 New born babies with Low Birth Weight (<2,500g)

Avchen *et al.* (2001) stated that "while mortality rates declined for low birth weight infants, the consequences of survival for these children may be associated with adverse developmental outcomes". And indeed a number of studies have established links between low birth weight and;

i.   Problems pertaining to school performance, psychomotor development and emotional well-being, and conduct disorders in children and adolescents (Cheung, 2002).

ii. Problems in pulmonary function, physical growth, neurological outcome, psycho-social development and social disadvantages (*Gissler et al.* 1999).

iii. Respiratory problems, cognitive, neurological and psychological deficits (Kelly *et al.* 2001).

Gissler*et al.* (1999), in their study of whether children's health at age 7 could be predicted by perinatal health, found a clear association between poor perinatal and poor subsequent health. The best individual predictors in the study were gestational age and birth weight, though even those could not predict the health outcome sufficiently.

Avchen*et al.* (2001), in their study of birth weight and school age disabilities for a population-based cohort of Florida children born between 1982 and 1984 and receiving a public school education in 1996-97, found that risk ratios for specific school-identified disabilities increased as birth weight decreased for all birth weight strata of <3,500g. They emphasized that low birth weight was mostly related to cognitive and motor development but less to learning, speech, and behavior disabilities.

Cheung, (2002), in his study on the early origins and adult correlates of psychosomatic distress, made use of the 1970 British Birth Cohort Study and found that, even after controlling for social factors, birth weight standardized for gestational age had a "reverse J" relation with psychological distress at age 26.

2.1.3 New born babies with very Low Birth Weight (<1,500g)

Very low birth weight survivors are at greater risk for health problems later in life than low birth weight children. Problems include childhood neurodevelopmental morbidity, general health problems, recurrent infections and hospitalizations, poor physical growth, behavioral and attention disorders, and difficulties at school in mid-childhood,

with a high proportion requiring special educational assistance, Hack *et al.* (2002)(cited in Matsou,2005), Saigal *et al.* 2000a/b).

Singer *et al.* (1997), in their study of the developmental outcomes of infants with Bronchopulmonary Dysplasia (BPD) and very low birth weights, found that birth weight had no significant effect on motor development by age 3, once BPD and neurological risk were accounted for.

Walther *et al.* (2000), in their study of the outcomes of a Dutch national cohort of very preterm infants, focusing on 1,338 live born infants with a gestational age <32 weeks and/or a birth weight <1,500g, found that a rather small percentage of these very preterm infants (10 percent) had a severe disability or handicap at school age. However, although 90 percent of the children were without severe disabilities at school age, many of them met serious difficulties in everyday life, and the burden of mild developmental abnormalities, behavioral and learning disorders increased with age. Not less than 40 percent of survivors would not be able to become fully independent adults.

At the School age (6-8 years); Smith et al (2003) examined the relationship between breastfeeding and childhood cognitive development among 439 school-age children weighing <1,500g. Higher test scores for each domain of cognitive function except memory were observed among children who were breastfed directly. A comparison with normal birth weight children was not carried out, so on the basis of this study it could not be concluded direct that, breastfeeding completely makes up for deficits.

On the other hand, Hack *et al.* (2002), in their study of outcomes in young adulthood for very-low-birth-weight infants, compared a cohort of 242 VLBW survivors with 233 controls with normal birth weights. Fewer very-low-birth weight young adults had graduated from high school. Very-low-birth-weight men, but not women, were significantly less likely than normal-birth-weight controls to be enrolled in postsecondary study. Very-low-birth-weight participants also had a lower mean IQ and lower academic achievement scores. In addition, they had higher rates of neurosensory impairment and subnormal height.

2.1.4 New born babies with Extremely Low Birth Weight (<1,000g)

Extremely low birth weight children have higher mortality rates and survivors are at greater risk for health problems later in life than low and very low birth weight children. Among extremely low birth weight infants, high rates of neonatal morbidity can be found (Hack *et al.* 1994). Survivors have a 20 to 50 percent neurodevelopmental impairment rate during early childhood. At school, in mid-childhood, children who are ELBW are more likely to have lower IQ and academic achievement scores, experience greater difficulties, and require significantly more educational assistance than children who are born at term. They are particularly vulnerable to problems related to inattention and hyperactivity at school age (Saigal *et al.* 2003). Compared with normal-birth-weight controls, fewer persons with birth weights below 1,000g graduate from high school (Hack *et al.* 2002).

In their study of the neurodevelopmental and functional outcomes of extremely low birth weight infants, Vohr *et al.* (2000) found that 37 percent had a Bayley mental developmental index below 70; 29 percent had a psychomotor developmental index below 70; 25 percent had an abnormal neurological examination; 11 percent suffered from hearing impairment; and 9 percent suffered from vision impairment. It was also found that neurological, developmental, neurosensory and functional morbidities increased with decreasing birth weight.

Resnick *et al.* (1999), in their study of the impact of low birth weight, found that both perinatal and socio-demographic factors influenced educational outcomes. Perinatal factors, in particular birth weight <1000g, had the largest effect on the need for special education (SE), whereas socio-demographic factors had a larger effect on mild educational disabilities, such as learning disabilities (LD), emotional handicaps (EH), academic problems (AP) and to some extent educable mental handicaps (EMH).

Also, Piecuch *et al.* (1997), in their study of the outcome of extremely low birth weight infants (500 to 999 grams), looked at a total of 446 infants born between 1979 and 1991 and followed them to a mean age of 55 months+/- 33 standard deviations. They found that within this group, low birth weight was not associated with abnormal outcomes. The associated risk factors for poor outcomes were specific and included intracranial hemorrhage (ICH), cystic periventricular leukomalacia (PVL), chronic lung disease (CLD) and social risk.

Avchen *et al.* (2001),looked at birth weight and school age disabilities for a population-based cohort of Florida children born between 1982 and 1984 and receiving a public school education in 1996-1997. They found that the lightest infants born (<999g) accounted for only 0.2 percent of the population, but had a disability rate of no less than 45 percent. On the other hand, the heaviest children born (>5,000g) also accounted for only 0.2 percent of the population, but had a disability rate of only 18.7 percent. The majority of children (37.5 percent of the population) weighed between 3,000g and 3,499g, and this category had a disability rate of 15.9 percent.

Saigal *et al.* (2000a,b),found that ELBW children are in a disadvantaged position. In their study on school difficulties, differences by birth weight became apparent between age 8 and the teenage period. Parental perceptions of the health status and social competencies of adolescents were negative. Across four different populations -children 8 to 11 years old in New Jersey and Ontario in the US, Bavaria in Germany, and Holland (2000b), they consistently found similar behavioral outcomes, with ELBW children requiring special educational assistance or repeating grades.

2.1.5 New born Babies with Even Lower Birth Weights (<750g)

Many recent studies have focused on even lower birth weight survivors. Sweet *et al.* (2003), in their study of the age 2 outcome of infants weighing 600g or less at birth, found that 24% of those babies had survived and that 90 percent of the surviving infants were abnormal in neurodevelopmental terms. Major problems included cerebral palsy,

blindness, gastrostomy and ventriculoperitoneal shunts were associated with such babies

Hack *et al.* (1994), in their study of school-age outcomes in children with birth weights under 750g, compared a regional cohort of 68 surviving children born from 1982 through 1986 with birth weights under 750g with 65 children weighing 750 to 1499 g at birth and 61 children born at full term. They found that those who weighed 750g and less had less cognitive ability, psychomotor skills and academic achievement as well as poorer social skills, adaptive behavior and attention.

2.1.6 The Role of Social Factors in Low Birth Weight

Most studies of low birth weight and SGA have focused on the relationship between perinatal factors, cognitive and neurological development. Relatively little is known about other factors which are important to child health development, such as the social and home environment (Andersson *et al.* 1997). Nevertheless, it has been suggested that the environment especially the early home environment, plays a central role in child health and (cognitive) development. Andersson *et al.* (1997), for instance, have noted how the quality and amount of stimulation received by children in different environments varies greatly; care-taking practices of lower- and middle-class parents differ substantially, and children from lower-class families seem to develop more slowly. Angelsen *et al.* (2001) highlighted the importance of environmental factors such as adequate nutrition and the parental ability to create a good and stimulating

home environment and focused on the positive correlation between breastfeeding and cognitive development in children. Further, in the study by Smith *et al*. (2003), where the effect of breastfeeding (which was believed to be associated with confounding socio-economic factors) on childhood cognitive development among VLBW children was examined, it was found that both expressed milk feedings and direct breast feedings were associated with improved visual motor function. Breastfeeding mothers were more likely to be older and married, and to smoke less. So far, however, the role of the environment in shaping low birth weight children's health outcomes had not been studied sufficiently, or incorrectly. Andersson *et al*. (1997) noted that "the relationship between cognitive development and social conditions among infants born SGA had been sparsely studied. On the other hand, Saigal *et al*. (2003) noted that "socio-economic factors, racial and ethnic differences, the nature of funding of health care may further contribute to differences in the reported outcomes but that quite often these are not sufficiently controlled for. Finally Kelly *et al*. (2001) found that one of the reasons for the existing inconsistencies between different studies on low birth weight was not considering the impact of the social environment.

One of the main obstacles to properly controlling for the impact of the social environment on health outcomes is the already aforementioned usually high sample attrition rate affecting longitudinal studies. The 1970 British Birth Cohort Study, for instance, noted "the considerable sample attrition rate". Cheung (2002) referred to a study following new-born SGAs from birth to adolescence (Westwood *et al.* 1983),

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which had a 72 percent attrition rate. Another problem can be a strong selection effect generating an overrepresentation of lower socio-economic groups. In one study on the outcome of infants weighing 600 grams or less at birth (Sweet et al. 2003), for instance, all mothers were of low socio-economic origin, whether measured by race, marital status, the receipt of social assistance, or tobacco use. This selection effect may stem from the fact that higher socio-economic groups are more likely to engage less in behavior possibly giving rise to low birth weight (smoking, drinking, drugs, etc.). Furthermore, even if a low birth weight child is born to women in these groups, they may prefer not to pursue aggressive health treatments since they are better able to assess the possible negative impacts of low birth weight on later health and on their own lives. Those findings that are available thus far on the role of the socioeconomic environment tend to contradict each other. At least one study found that the socio-economic background does not matter much for child health outcomes (Hack et al.2002). On the other hand, Resnick *et al*. (1999) concluded that the impact of socio-demographic factors on adverse educational outcomes is greater than that of perinatal factors. Avchen *et al*. (2001) have demonstrated the independent effect of birth weight, while not denying the fact that black babies were two (for babies between 2000-2499g) or three (for babies<999g) times more likely than white babies to be small in the US. Singer et al. (1997) noted that mental outcomes at age 3 were affected by socio-economic factors such as minority status, race and lower social class. The relation with

Bronchopulmonary Dysplasia (BPD) and higher rates of learning disabilities at school age in VLBW cohorts was not clear, however.

2.1.7 Summary of Factors affecting Low Birth Weight Babies

Some studies looked at the relative contribution of birth weight and socio-demographic factors to health outcomes at the population level, other studies focused on the relative contribution of these factors within the group of (very/extremely) low birth weight children.

Andersson *et al.* (1997) found that SGA children are more vulnerable to adverse social conditions and in greater need of living in a protective environment than infants born AGA. They suggested that SGA infants' cognitive impairments may have been both as a result of intrauterine growth retardation and/or as a result of less than optimal simulation for cognitive growth experienced in their home environments. They further noted that, the differences in cognitive competence between the two groups might be due to their social differences and also possibly due to differences in their parents' general intelligence.

Resnick *et al.* (1999) studied the impact of low birth weight, perinatal conditions, and socio-demographic factors on educational outcomes in kindergarten. They concluded that adverse perinatal conditions resulted in severe educational disabilities, whereas less severe outcomes were influenced by socio-demographic factors. Kelly *et al.* (2001) made use of the 1997 Health Survey for England to study children of 4-15 years, and

argued that both birth weight and social class had an important influence on the psychological well-being of the child. In their study, the birth weight effect was clearly mediated by social factors: social class, family structure, smoking environment, and maternal characteristics including age and General Health Questionnaire (GHQ) scores. On the other hand, a disadvantageous social environment appeared to increase the risk of behavioral problems regardless of birth weight. Shenkin *et al.* (2001) focused on birth weight and cognitive function at age 11 and examined whether this relation is independent of social class. They concluded that social class, birth weight, age, pregnancy number, and legitimacy of birth contribute some non-overlapping predictive power to cognitive function at the age 11 years. They further noted that, birth weight and social class explained the largest amount of variance, that are not significantly correlated. Each made an independent contribution to IQ at age 11.

Resnick *et al.* (1998) assessed low birth weight and sick infants hospitalized at regional neonatal intensive care units, the relationship between perinatal and socio-demographic factors on the one hand and subsequent educational disabilities on the other. They concluded that educational disabilities of NICU survivors were influenced differently by perinatal and socio-demographic variables. They could not, however, present conclusions on which one mattered most.

Vohr *et al.* (2000) studied the neurodevelopmental and functional outcomes of extremely low birth weight infants, they found that factors associated with decreased morbidity included increased birth weight, female sex of the child, higher maternal

education, and white race. Piecuch *et al*. (1997), in their study of the outcomes of extremely low birth weight infants (500 to 999g), looked at a total of 446 infants born between 1979 and 1991 (a period during which neonatal care evolved substantially). They found that low birth weight was not associated with abnormal outcomes. They also found that the risk factors ICH III-IV/cystic PVL11, chronic lung disease, and high social risk were associated with abnormal outcomes. Sweet *et al*. (2003) studied age 2 (years) outcome of infants weighing 600 grams or less at birth and found that 90 percent of surviving infants were abnormal in neurodevelopmental terms. Major problems were cerebral palsy, blindness gastrostomy, and ventriculoperitoneal shunts. They observed that all the mothers were of low socio-economic status, which was clearly associated with poor infant outcome. On the other hand, Hack *et al*. (1994), considered school-age outcomes for children with birth weights under 750g and concluded that social disadvantage was not associated with major developmental impairment.

2.2 Risk Factors for Low Birth Weight

Risk factors for low birth weight are likely to be determinants mediating the health consequences of low birth weight after birth. We distinguish in the discussion of risk factors between risk factors associated with prematurity and risk factors associated with IUGR (Kramer, 1987).

2.2.1 Behavioral risk Factors of Low Birth Weight

Jaakkola and Gissler (2004) (cited in Matsuo, 2005) attempted to assess the causal relationship between maternal smoking and asthma at age 7. They studied the 1987 Finnish cohort of singleton births, and found that the risks for low birth weight, SGA, and preterm delivery were strongly related to maternal smoking during pregnancy. Zarén *et al*. (1997)(cited in Matsuo, 2005)examined the effect of maternal smoking on the relationship between maternal hemoglobin levels and pregnancy outcome by analyzing data on Swedish and Norwegian women coming to antenatal care from before 17 to after 37 weeks between January, 1986 and March, 1988. They found that maternal smoking negatively affects foetal growth. In another article, based on the same population and study design, Zarén *et al.* (2000) (cited in Matsuo, 2005) found out that maternal smoking affects male and female fetuses differently. Male and female fetuses of smoking mothers had mean birth weights lower by 316g and 177g respectively compared to fetuses of non-smoking mothers.

Copper *et al.* (1996) in a psychosocial assessment study at 25 to 29 weeks of gestation, and based on an analysis of data from the Maternal-Fetal Medicine Units Network of the National Institute of Child Health and Human Development between, October 1992 and July 1994 found that after adjusting for maternal demographic and behavioral characteristics, stress was associated with spontaneous preterm birth and low birth weight.

Vik*et al.* (2003), in their study in Norway and Sweden of enrolments that took place between 1ˢᵗJanuary, 1986 and 31ˢᵗMarch, 1988 of women at either parity 1 or 2, of Caucasian origin, singleton pregnancy and registered before the 20th week of gestation, found that a high caffeine intake in the third trimester of pregnancy was associated with an increased risk of SGA. The increased risk was only found for male fetuses, not for female fetuses; the association held even after controlling for smoking.

2.2.2 Health-Related Risk Factors

A distinction has to be made between spontaneous and induced abortion. Based on an analysis of the Danish population registry over the period 1980-1992, Basso *et al.*(1998) found that a prior spontaneous abortion constitutes a risk factor for both very preterm and preterm delivery. Even though spontaneous abortion and preterm delivery themselves appear to share some risk factors. Another study by Henriet and Kaminski (2001), on the basis of the 1995 French national perinatal survey, found that women who had experienced induced abortion had a higher risk of preterm delivery. Identical results were obtained by Foix-L'Helias and Blondel (2000) on the basis of a nationally representative sample for the years 1981 and 1995. When controlling for other maternal characteristics, a woman was more likely to have a preterm delivery if she had had at least one prior induced abortion.

Hypertension is considered to be a risk factor mainly for IUGR, although more study is required to verify this. Studying French data for the years 1991 and 1993, Haelterman

et al. (1997) (cited in Matsuo, 2005) found that chronic hypertension has an impact on having a small child. In their analysis, the mean birth weight decreased by 161g for women with chronic hypertension compared to other women.

2.2.3 Socio-demographic Risk Factors

Socio-demographic factors such as age, marital status and education are highly complex and have their own independent effect. They also interact among themselves for example; age, education and class interact with each other. Furthermore, they interact with behavioral and health related factors.

Maternal age constitutes an important risk factor. Foix-L'Helias and Blondel (2000) found that in France a maternal age above 34 years old constituted an important risk factor in both 1981 and 1995 while a maternal age below 20 years constituted an important risk factor in 1981 but not in 1995. Similar results were obtained by Dičkute et al. (2004) (cited in Foix et al. 2000) who in their study of Lithuania in 2001-2002 identified a U-shaped relationship between maternal age and LBW risk (younger than 20 years and 35 years or older). The importance of a young maternal age appears to be decreasing in European countries. In countries where the proportion of young mothers is small (below 3 percent), examples being France, Finland and Sweden in the 1990s, there is no (or only a weak) association between young maternal age and pre-term birth (Foix-L'Helias and Blondel, 2000, referring to Hemminki and Gissler, 1996) (cited in Foix et al. 2000). On the other hand, as Foix-L'Helias and Blondel, (2000) and others have demonstrated, a higher maternal age remains an important risk factor.

Other authors have also found a strong relationship between a higher maternal age and the risk for premature birth. An Italian study (Astolfi and Zonta, 2002) found that the 35 plus age group always has a significantly higher risk of still or preterm birth, or low birth weight at term, even when parity and education variables are controlled for. A French study (Bréart, 1997) similarly found negative consequences of delayed childbearing (35 plus) in the format of higher foetal death rates. Similar findings were also reported for Alberta, Canada, where Tough *et al*. (2002) reported that when only those age 35 or older of first parity were considered, the contribution to the population increase in LBW and preterm delivery was less than half of the total contribution for this age group (36%). The negative effect of a higher maternal age can be weakened by education and parity, but only to a rather small extent (Astolfi and Zonta, 2002, referring also to the Danish case-study of Basso et al. 1997).

Age plays a multi-dimensional role on low birth weight and can be categorized as follows;

Age first of all has an 'independent effect'. Tough *et al.* (2002 suggested that fecund ability (the ability to conceive) and fertility decrease with maternal age, whereas conception delay increases. Advanced maternal age may be an impaired functional capacity of uterus, biological aging, and synergistic effects related to systematic disease.

In addition, age interacts with behavioral risk factors such as smoking. As already mentioned above, smoking has an independent effect, but smoking may also be more

prevalent in particular age groups. Jakkola *et al.* (2001) found that smoking during pregnancy remained constant in Finland between 1987 and 1997, but that smoking itself had increased. According to their findings, the smokers were young (below 20years), single and less educated, and mainly living in the North and East of the country.

Age also interacts with health-related risk factors such as a prior experience of induced or spontaneous abortion or preterm delivery. Older women were more likely to have such experiences compared to younger women. Henriet and Kaminski (2001) found that women who reported previous induced abortions were significantly older. They had a higher number of previous pregnancies and an obstetric history of adverse pregnancy outcome. Most of such women were unmarried, non-French nationality, low educational level, not working during pregnancy and smokers. Mothers with a high number of induced abortions were at higher risk, although no distinction was made in the study by the kind of technique used for the abortion.

Based on their study of the 1991 Finnish Birth Register, Hemminki and Gissler (1996) found that low birth weights and pre-term births were mainly found among old primiparous women. Older multiparous women also experienced high proportions of low birth weights and preterm births but the effect was smaller than for older primiparous mothers. In addition to the usual characteristics, the study concluded that these women were urban oriented and had miscarriages and induced abortions in their obstetric histories.

Another socio-demographic factor is education. Most studies conclude that higher levels of maternal educational attainment led to better pregnancy outcomes. Raum *et al.* (2001) examined the influence of maternal education on IUGR in two different political and social systems, West and East Germany in 1987/1988 and 1990/1991 respectively. They found that mothers were among the lowest category of education in both West and East Germany had an unadjusted relative risk of 2.5 for delivering an SGA child compared to those of the highest education category. This indicates that the education of the mother is a proxy for the socio-economic and lifestyle status, including smoking behavior, frequency of prenatal care visits (health seeking behavior).

Another socio-demographic factor is marital status. Foix- L'Helias and Blondel (2000) found that the risk factors included being single in 1981 but not in 1995. So at the country level, the importance of being single as a risk factor appears to decrease over time in France. In countries with a high proportion of non-married mothers there is no association between marital status and pre-term birth. Examples of such countries are Finland, Sweden and France in 1995 (Foix-L'Helias and Blondel, 2000, referring to Rantakallio and Oja, 1990; Hemminki and Gissler, 1996; Villeneuve- Gokalap, 1990; Toulemon, 1996). In countries with a small share of extramarital births, both cohabitation and single motherhood are important risk factors for premature birth (Zeitlin *et al.* 2002). Thus, obtaining a better insight into a country's historical nuptiality pattern may throw light on low birth weight patterns. It is interesting to note, for instance, that cohabitation (living with a partner) has a longer history of wide

acceptance in Finland than in many other countries. In France, for instance, cohabitation was largely restricted to the working classes in the 1970s, but became more accepted in the 1980s regardless of socio-economic background.

The socio-demographic risk factor of class interacts with behavioral risk factors such as smoking. This is demonstrated by inter alia Kramer et al. (2000). Many times, the socio-demographic risk factor of class is treated together with education and marital status. Dičkute *et al.* (2004), based on a study of Lithuania in 2001-2002, found that there exist a U-shaped relationship between maternal age and LBW risk (younger than 20 years and 35 years or older) but clearly say that low birth weight is associated with other factors: low levels of education, unstable marital status, and low income. However, the role of socio-economic status is very complex. A good example is its interaction with selection and screening processes. Carlson *et al.* (1999) and Carlson and Hoem (1999), by focusing on trajectories of foetal loss in the Czech republic, identified pregnancy outcomes that are more positive for low than for high socioeconomic status women, in the format of the 'survival paradox'.

2.3 Statistical Techniques used in analyzing Birth Weight

Different researchers have used different statistical techniques to study the predictors of birth weights. For instance,

Nketia *et al.* (2012) employed multiple logistic regression to determine the predictors of birth weight across Ghana the 2008 Ghana Demographic and Health Survey (GDHS)

data, In their paper, the birth weight of the infant was captured as a dichotomous and in an ordered form and hence employed the ordered logistic regression in which the mothers' subjective assessment of their babies was ranked from very large, the highest which is accorded a value of one (1) to very small, the lowest which is assigned a value of five (5) with 5 categories. In their concluding remarks, they stated that LBW was positively and significantly predicted by geographical area of residence, gender of the child, multiple births and mother's age and that conversely, maternal education especially beyond the primary education and birth order were found to be statistically and inversely related to LBW.

Rondo *et al*. (2003) used the multiple logistic regression models to evaluate the associations between maternal psychological stress, distress and low birth weight (LBW), prematurity and intrauterine growth retardation (IUGR); the interactions between maternal stress, distress and smoking, alcohol and coffee intake; and the prevalence of stress and distress in pregnancy. Measures of stress and distress were obtained, by interview, three times in pregnancy: at a gestational age (GA) lower than 16 weeks, from 20 to 26 weeks and from 30 to 36 weeks. Stress was investigated by the perceived stress scale, PSS, and distress by both the general health questionnaire, GHQ, and the State Trait Anxiety inventories, STAI. The outcomes were: LBW (birth weight <2500 g), prematurity (gestational age (GA) at birth <37 weeks) and IUGR (birth weight for GA ≤10th percentile of William's curve). They found that Maternal distress was associated with LBW (RR=1.97, P=0.019) and prematurity (RR=2.32, P=0.015),

respectively. There was an interaction between distress and smoking in the second interview (P=0.05). The prevalence of stress and distress in the different interviews of pregnancy varied from 22.1 to 52.9%.

Oken *et al.* (2003) who were investigating nearly continuous measure of birth weight for gestational age using a United States national reference used a resistant nonlinear smoothing technique to account for the same birth weight value straddling several percentiles within each week of gestation, which might represent a bias towards reporting round numbers of birth weight values. In their analysis, they first calculated actual percentile ranks, and then assigned z-values for each percentile. This amounted to a non-parametric transformation to a normal distribution. Thus, a research subject in the 5th percentile or with a z-value of -1.695 is lighter than 95% and heavier than 4% of the reference population at that gestational age. They provided the z-value corresponding to the middle of each percentile step which spans babies from >4% to 5%, they presented the z-value corresponding to 4.5%. Babies with weights greater than the 99th percentile should be assigned a z-value of 2.576, corresponding to 99.5%. Their approach however differed from that used by Alexander, et al. (1996), who smoothed across gestational age groups.

Richardson *et al.* (1993) employed Logistic regression analyze data from a cohort of 1621 consecutive admissions to three neonatal intensive care units (92 deaths), to test six alternative predictive models. The best logistic model was then used to develop a

simple additive clinical score, the SNAP Perinatal Extension (SNAP-PE).Their analyses demonstrated that, birth weight and illness severity were powerful independent predictors across a broad range of birth weights and that their effects are additive. They further revealed that below 750 g, there was an interaction between birth weight and SNAP. Other factors that showed independent predictive power were low Apgar score at 5 minutes and small size for gestational age. Separate derivation and test samples were used to demonstrate that the SNAP-PE was comparable to the best logistic model and has a sensitivity and specificity superior to either birth weight or SNAP alone (receiver-operator characteristic area .92 ± .02) as well as excellent goodness of fit.

Many other researchers have used different methods and approaches in analyzing birth weight related studies.

In this study, a combination of some techniques is employed to unravel some of the mysteries underpinning low birth weights in the KNM. Since the primary objective of this study is to determine the predictors of low birth weights among births in the KNM, with the outcomes classified as dichotomous (low birth and normal birth weights), the logistic regression was used to develop a predictive model of low birth weights in the KNM: This model also shows some prognostic factors of low birth weights as well as how they are associated with the phenomenon and the odds of having a low birth weight child. Other interest in relationship of the birth weight with seasonality and other covariant were also explored using T-test and chi square test.

CHAPTER THREE

METHODS AND MATERIALS

3.1 Introduction

Data was collected from the Kassena-Nankana Municipality (KNM) of the Upper East region. The KND covers a land area of 1685 km^2 and has an estimated population of 150 000 according to the Navrongo Health Research Centre's demographic surveillance report, 2012. The district has one major hospital that acts as a referral hospital to 5 health Centre's. The primary occupation is subsistence agriculture and most parts are rural. A small central area of the municipal, Navrongo township, has suburban character, a population of 20 000 according to the Navrongo Health Research Centre's demographic surveillance report, 2012, and is the district capital. The majority of inhabitants in the district are subsistence farmers who live in small, scattered settlements. There are few health facilities and many transportation challenges, all of which are representative of many rural West African countries

3.2 Source of Data, Data Extraction and Study Design

The data was extracted from the case records of all booked patients who had birth weight singletons recorded at term at the Clinic, Hospital, Health Centre or CHPS compound over a three-year period. Data regarding weather was obtained from the meteorological station in the KNM for the period 2009 to 2011. This study is a review of retrospective data extracted from the case records. The variables extracted for the

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study included, marital status, parity, and date of birth, birth weight of children, religion and type of birth.

3.3 Statistical Analysis

All data was analyzed using STATA 11.0 SE. Descriptive analyses was conducted to describe gestational age, delivery location, maternal characteristics and infant characteristics. Factors potentially associated with birth weights were grouped into three domains: socio-demographic maternal characteristics, delivery location, and infant characteristics. Unadjusted and adjusted odds ratios with 95% confidence intervals were computed to assess the relationship between the outcomes (Birth weight) and selected variables. Reference categories were defined as those usually associated with the lowest birth weight. All variables found to be significantly associated with LBW were included into the Generalized Estimation Equation model, and adjusted odds ratios with 95% confidence intervals obtained. Means was employed to examine the differences in birth-weight by month of birth. The Pearson Product Moment Correlations will be used to assess the relationship between birth-weight, and maternal parity, maternal age, and number of weeks during the first and third trimester of pregnancy that occurred during the hungry season. Logistic regression was used to determine the best predictors of birth-weight among the independent variables maternal parity, maternal age, season, and exposure to the hungry season. Exposure to the hungry season will be determined by calculating the number of weeks in the first and

third trimester a mother was exposed to the hungry season (November to January) based on the infant's birth date.

3.3.1 Logistic Regression (LR)

Logistic regression or logit regression is a type of regression analysis used for predicting the outcome of a categorical dependent variable based on one or more predictor variables. That is, it is used in estimating empirical values of the parameters in a qualitative response model. The probabilities describing the possible outcomes of a single trial are modeled as a function of the explanatory (predictor) variables, using a logistic function. Frequently and subsequently in this study, logistic regression is used to refer specifically to the problem in which the dependent variable is binary. That is, the number of available categories is two and problems with more than two categories are referred to as multinomial logistic regression or, if the multiple categories are ordered, as ordered logistic regression.

Logistic regression measures the relationship between a categorical dependent variable and one or more independent variables, which are usually (but not necessarily) continuous, by using probability scores as the predicted values of the dependent variable. As such, it treats the same set of problems as does probit regression using similar techniques.

There are three major types of logistic regression, they include; Dichotomous outcome in which the binary logistic regression method is applied, the Polychotomous outcome

where Multinomial logistic regression method is applied, and the Ordered outcome, where the Ordinal logistic regression method is applied.

For this study will focus on the binary logistic regression approach.

3.3.1.1 Binary Logistic Regression

Binomial (or binary) logistic regression is a form of regression which is used when the dependent is a dichotomy and the independents are of any type. For this study, a new born baby will be assigned 1 (success) if it attains a normal birth weight $\geq 2500g$ and zero otherwise.

The Logistic regression model is used to predict the Birth weight on the basis of the independents and to determine the percent of variance in the Birth weights explained by the independents; to rank the relative importance of independents; to assess interaction effects; and to understand the impact of covariate control variables.

Logistic regression applies maximum likelihood estimation after transforming the dependent into a logit variable (the natural log of the odds of the dependent occurring or not). In this way, logistic regression estimates the probability of a certain event occurring. It should be note that logistic regression calculates changes in the log odds of the dependent, not changes in the dependent itself as OLS regression does.

Logistic regression has many analogies to OLS regression: logit coefficients correspond to b coefficients in the logistic regression equation, the standardized logit coefficients correspond to beta weights, and a pseudo R^2 statistic is available to summarize the

strength of the relationship. Unlike OLS regression, however, logistic regression does not assume linearity of relationship between the independent variables and the dependent, does not require normally distributed variables, does not assume homoscedasticity, and in general has less stringent requirements. Goodness-of-fit tests such as model chi-square are employed in this study as indicators of model appropriateness as is the Wald statistic to test the significance of individual independent variables. The Maximum likelihood estimation, MLE, was employed to calculate the logit coefficients. This contrasts to the use of ordinary least squares (OLS) estimation of coefficients in regression. OLS seeks to minimize the sum of squared distances of the data points to the regression line. MLE seeks to maximize the log likelihood, LL, which reflects how likely it is (the odds) that the observed values of the Birth weight may be predicted from the observed values of the independents. The MLE is an iterative algorithm which starts with an initial arbitrary "guesstimate" of what the logit coefficients should be, the MLE algorithm determines the direction and size change in the logit coefficients which will increase LL. After this initial function is estimated, the residuals are tested and a re-estimate is made with an improved function, and the process is repeated (usually about a half-dozen times) until convergence is reached (that is, until LL does not change significantly). The Log Likelihood Significance Tests was employed to test the probability that the observed values of the dependent (Birth weight) may be predicted from the observed values of the independents. Like any probability, the likelihood varies from 0 to 1. The log likelihood (LL) is its log and

varies from 0 to minus infinity (it is negative because the log of any number less than 1 is negative). LL is calculated through iteration, using maximum likelihood estimation (MLE). Log likelihood is the basis of two alternative tests of a logistic model, deviance chi-square and the more widely used model chi-square test. The Wald statistic was used to test the significance of individual logistic regression coefficients for each independent variable (that is, to test the null hypothesis in logistic regression that a particular logit (effect) coefficient is zero). It is the ratio of the unstandardized logit coefficient to its standard error. The confidence interval around the logistic regression coefficient is plus or minus 1.96*ASE, where ASE is the asymptotic standard error of logistic β

The Hosmer and Lemeshow's Goodness of Fit Test, tests the null hypothesis that the data were generated by the model fitted. The test divides subjects into deciles based on predicted probabilities, and computes a chi-square from observed and expected frequencies. Then a probability (p) value is computed from the chi-square distribution with 8 degrees of freedom to test the fit of the logistic model. If the Hosmer and Lemeshow Goodness-of-Fit test statistic is .05 or less, we reject the null hypothesis that there is no difference between the observed and model-predicted values of the dependent. (This means the model predicts values significantly different from what they ought to be, which the observed values is). If the H-L goodness-of-fit test statistic is greater than .05, as we want for well-fitting models, we fail to reject the null

hypothesis that there is no difference, implying that the model's estimates fit the data at an acceptable level. Logit coefficients, also called unstandardized logistic regression coefficients or effect coefficients, correspond to the β (unstandardized regression) coefficients in ordinary least squares (OLS) regression. Logits are the natural log of the odds called the logit transformation

The logistic regression model is given by;

$$P(Y \mid X) = \frac{e^{\beta_o + \beta_1 X}}{1 + e^{\beta_o + \beta_1 X}} \qquad \ldots\ldots\ldots\ldots(3.1)$$

which is equivalent to; $\qquad \ln\left(\dfrac{P(Y \mid X)}{1 - P(Y \mid X)}\right) = \beta_o + \beta_1 X \qquad \ldots\ldots\ldots\ldots(3.2)$

They are used in the logistic regression equation to estimate (predict) the log odds that the dependent equals 1. If the logit for a given independent variable is β_1, then a unit increase in the independent variable is associated with a β_1 change in the log odds of the dependent variable (the natural log of the probability that the dependent = 1 divided by the probability that the dependent = 0). Consider a dichotomous predictor (X) which represents the presence of risk (1= present)

	Risk Factor	
Birth weight (Y)	NBW (X=1)	LBW (X=0)
Yes (Y=1)	P(Y=1|X=1)	P(Y=1|X=0)

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| No (Y=0) | 1-P(Y=1|X=1) | 1-P(Y=1|X=0) |

$$\frac{P}{1-P}=e^{\beta_o+\beta_1 X} \begin{cases} \text{Odds for Birthweigh with Risk Present} = \dfrac{P(Y=1\,|\,X=1)}{1-P(Y=1\,|\,X=1)} = e^{\beta_o+\beta_1} \\[4mm] \text{Odds for Birthweight with Risk Absent} = \dfrac{P(Y=1\,|\,X=0)}{1-P(Y=1\,|\,X=0)} = e^{\beta_o} \end{cases}$$

$$(3.3)$$

If the odds of females being LBW is 0.55 and the odds of males being LBW is 0.45 and we wish to compare females to the reference category of males, then the odds ratio is 0.55/0.45 = 1.22. This odds ratio means that the odds of females being LBW are 1.22 times greater than the odds of males being LBW. Note that an odds ratio above 1.0 means that the odds of getting "1" on a Birth weights are greater for females than for the reference category which is the males. The closer the odds ratio is to 1.0, the more the males and females are independent of Birth weight. Odds ratios below 1.0 indicate the reference category (males) is associated with greater odds of getting "1" on Birth weight. The logit can be converted easily into an odds ratio simply by using the exponential function (raising the natural log e to the β_1 power). For instance, if the logit $\beta_1 = 2.303$, then its log odds ratio (the exponential function, e^b) is 10 and we may say that when the independent variable increases one unit, the odds that the Birth

weight = 1 increase by a factor of 10, when other variables are controlled. Similarly, in the prior example of male and female for birth weight, an odds ratio of 1.22 means that when the males changes by 1 unit, the odds of having normal birth weight increase by a factor of 1.22.

This means that, the original odds are multiplied by e to the βth power, where β is the logistic regression coefficient, when the given independent variable increases one unit. The ratio of odds ratios of the independents is the ratio of relative importance of the independent variables in terms of effect on the dependent variable's odds.

3.3.1.2 The general LR model with multiple covariates:

$$log\left\{\frac{\pi}{1-\pi}\right\} = \alpha + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_k x_k \ldots\ldots\ldots\ldots\ldots\ldots(3.3)$$

Where log odds are a linear function of the covariates

3.3.2 Chi-Squared Test

Chi-square test examines the magnitude of discrepancy between observed frequencies (obs) and expected frequencies (exp). It measures the significance of association between two categorical variables. The hypothesis being tested is;

H_0: The two (categorical) variables are independent, H_1: The two (categorical) variables are not independent; with a test statistic given by;

$$x^2 = \sum \frac{(Obs-Exp)^2}{Exp}\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(3.4)$$

Where $Exp = \frac{RTGT}{GT}$. The test statistic is defined as a chi-square distribution with (r-1)(c-1) degree of freedom. If p<0.05, the null hypothesis of independence is rejected; i.e. the two (categorical) variables are significantly associated

3.3.3 Receiver Operating Characteristic curve

The Receiver Operating Characteristic curve (or ROC curve) is a plot of the true positive rate against the false positive rate for the different possible cut points of a diagnostic test.

An ROC curve demonstrates several things:

i. It shows the tradeoff between sensitivity and specificity (any increase in sensitivity will be accompanied by a decrease in specificity).

ii. The closer the curve follows the left-hand border and then the top border of the ROC space, the more accurate the test.

iii. The closer the curve comes to the 45-degree diagonal of the ROC space, the less accurate the test.

iv. The slope of the tangent line at a cut point gives the likelihood ratio (LR) for that value of the test.

v. The area under the curve is a measure of text accuracy

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1 Descriptive Statistics

This section gives the descriptive analysis of the variables, which include frequencies, proportions, and graphs.

4.1.1 Maternal Age

The chart below shows the distribution of the age group of mothers of babies under this study. Majority of the mothers were between the ages of 20 and 34 years (68%), 11% constituted mothers under the age of 20 years and 21% constituted mothers who were 35 years and above.
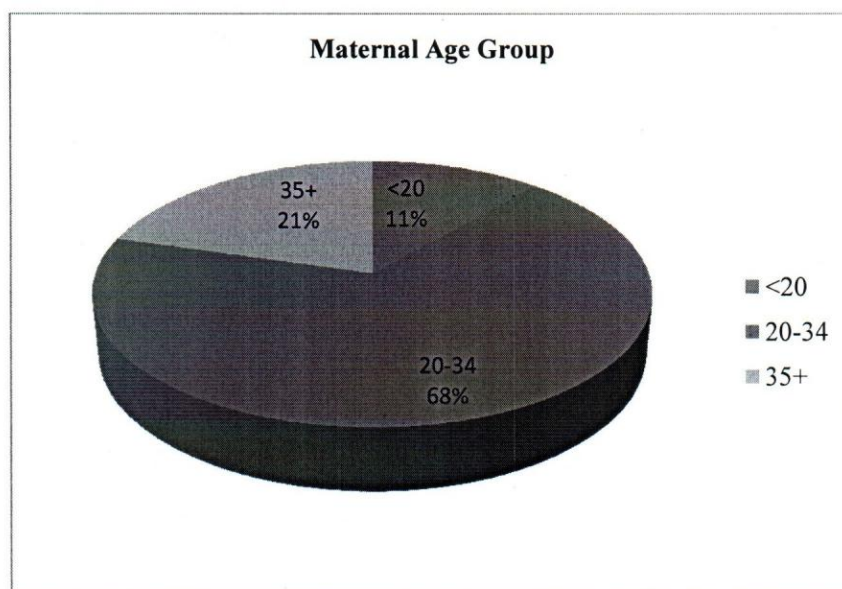
Figure 4.1 Age Group of Mothers

4.1.2 Educational Status of Mothers

Figure 4.2 showed that the educational distribution of the mothers is skewed towards higher education. A higher proportion (33%) of the mothers were educated to the Primary level, JHS, SHS and Tertiary recorded proportions of 23.4%, 9.5% and 3.5% respectively. Mothers who did not have any form of education at all recorded 30.5%.
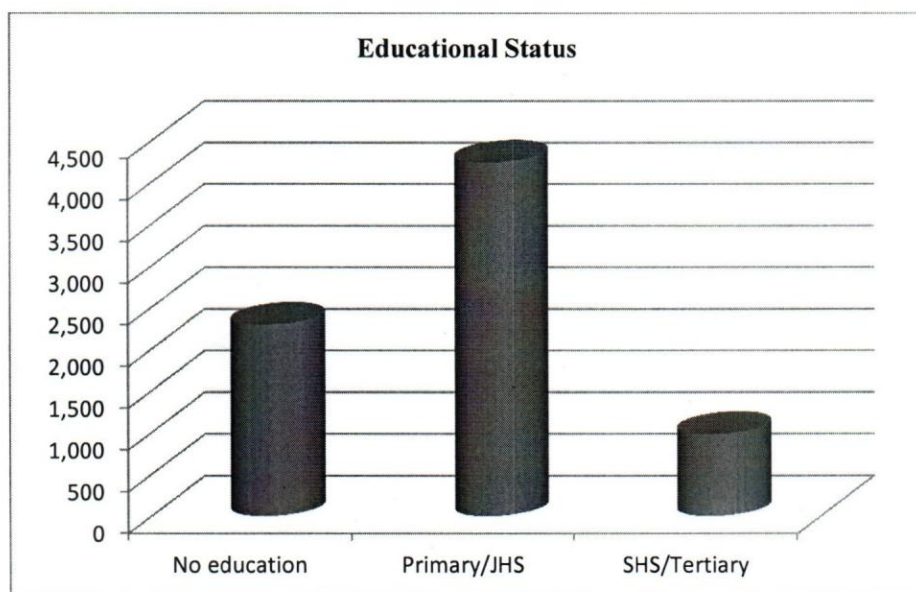
Figure 4.1 Educational Status of Mother

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4.1.3 Religious Affiliation

The distribution of respondents by religion is shown in Figure 4.3. It was observed that, most clients were Christians (60.6%) followed by Traditionalist (30.3%) and Muslims (8.2%), with only one person who does not belong to any religion.
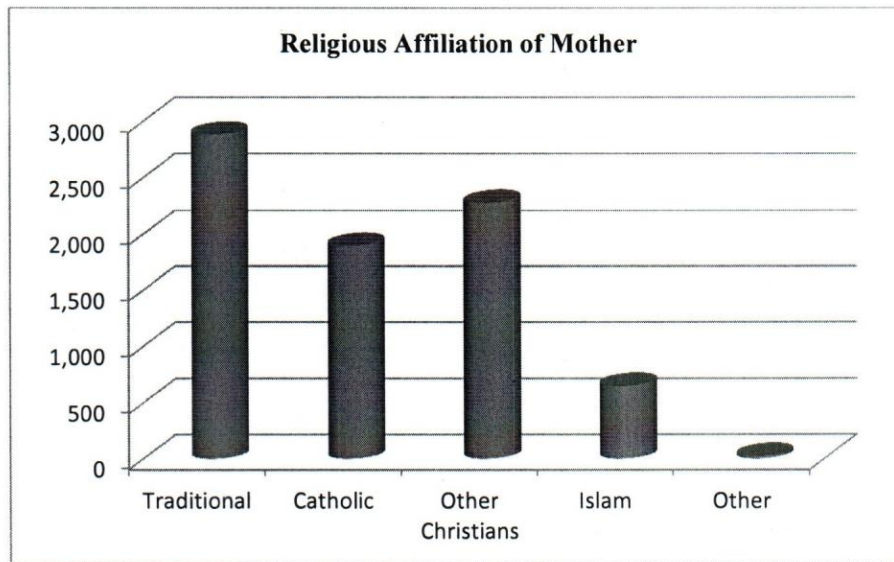
Figure 4.2 Religious Affiliation of Mother

4.1.4 Socio-Economic Status of Family

The household wealth index measures the wealth of the household of the mother of the new born as shown in Figure 4.4.From the figure, majority of the mothers under this study fell in the category of a poor socio-economic status with 1794 mothers (constituting 23% of the total mother), 22% fell in the richest category, 19% in the Poorest, 18% in the Average and the Rich group.
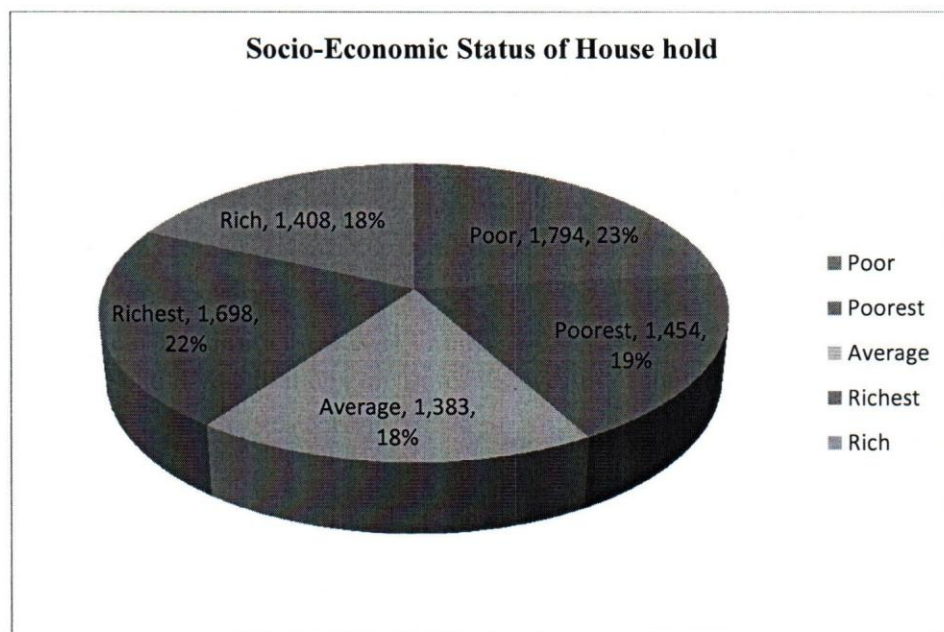
Figure4.3 Socio-Economic Status of Family

4.1.5 Test for Association between Birth weight and the Predictor Variables

The contingency table shows the Chi square test for association between the selected predictor variables and birth weight of new born babies. From the table, gender of the child, age of the mother, season of birth, marital status of the woman, type of birth, and

the socio-economic status of the maternal household are significantly associated with birth weight, whilst level of education, ethnicity of the mother and religion are not significantly associated with birth weight.

Table 4.1Contingency Table for LBW Babies

Variable	df	Chi Square	P-value
Gender	2	35.33	0.0000
Age	2	20	0.0000
Season of birth	1	6.11	0.0013
Level of Education	4	8.3255	0.080
Marital Status	5	43.71	0.0000
Type of Birth	1	140.29	0.0000
Ethnicity	3	4.68	0.197
Religion	4	1.46	0.833
Socio-economic status	4	12.29	0.015

4.2 Birth-Weight and Weather Parameters Compared

Table 4.2 shows the monthly distribution of the number of LBW babies born and the associated weather parameters recorded over the same period.

Table 4.2 Low Birth Weight and Weather

Month	Average Rainfall	Number of Low Birth weight	Average Maximum Temperature	Average Sunshine	Average Humidity
Jan	0.3	86	37.59	15.52	33.4
Feb	18.7	76	39.22	11.09	31.88
Mar	6.97	100	40.07	7.08	41.59
April	10.13	88	38.83	8.81	67.84
May	10.91	88	36.31	8.35	79.59
June	16.94	92	33.27	8.45	87.9
July	13.4	95	31.28	8.52	91.04
Aug	17.93	109	30.89	5.98	93.66
Sept	13.23	128	31.47	6.39	93.29
Oct	9.83	121	33.38	7.81	90.56
Nov	0	84	36.67	9.24	66.49
Dec	0	76	37.93	8.62	42.42

4.2.1 LBW and Average Monthly Maximum Temperature

The number of Low birth-weight babies born by month for average monthly temperature can be shown on a line plot.. The number of LBW rose steadily from the month of April to September and gently dropped from September through to February. However, the behavioral pattern of temperature was opposite to the pattern for the

number of LBW cases across the months. That is, at high temperatures lower number of LBW were recorded, and at lower temperatures high number of LBW babies were recorded. This is confirmed by a Pearson product moment correlation test with a correlation coefficient of -0.659 and a p-value of 0.0199. Figure 4.5 below shows the pattern of LBW and Temperature.
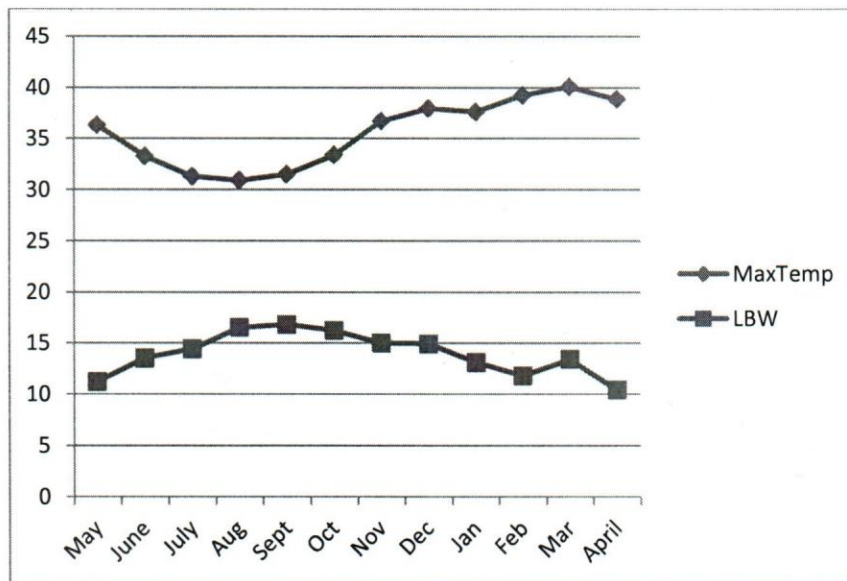
Figure 4.4 LBW and Average Monthly Maximum Temperature

4.2.2 LBW and Average Monthly Humidity

Figure 4.6 shows the pattern of number of LBW in a month and the humidity recorded for the same period. Both Humidity and number of LBWs assumed the same pattern peaking in August and September. Fewer number of LBW babies were recorded between October and April compared to the number of LBW babies recorded between May and September. These two periods characterized the dry and wet seasons. A Pearson product moment correlation test confirmed this behavioral pattern with a correlation coefficient of 0.668 and a p-value of 0.0176.
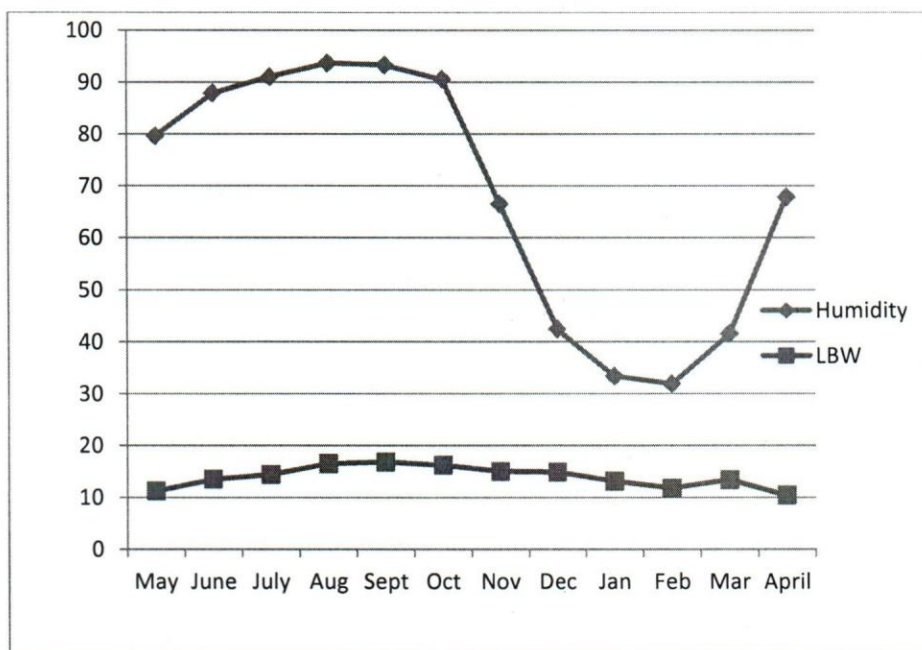
Figure 4.5 LBW And Average Monthly Humidity

4.2.3 LBW and Average Monthly Sunshine

Figure 4.7 shows the pattern for average monthly sunshine and the number of LBW babies born. The behavior of the pattern of the number of LBW babies born is opposite to the behavioral pattern for average monthly sunshine from February to December; that is, the higher the sunshine, the lower the number of LBW babies born and vice versa. This behavioral pattern was however different from January to February where both sunshine and number of LBW babies displayed similar pattern. A Pearson product moment correlation test confirmed the behavioral pattern but did not find this pattern significant as the test reported a correlation coefficient of -0.559 with a p-value of 0.0059
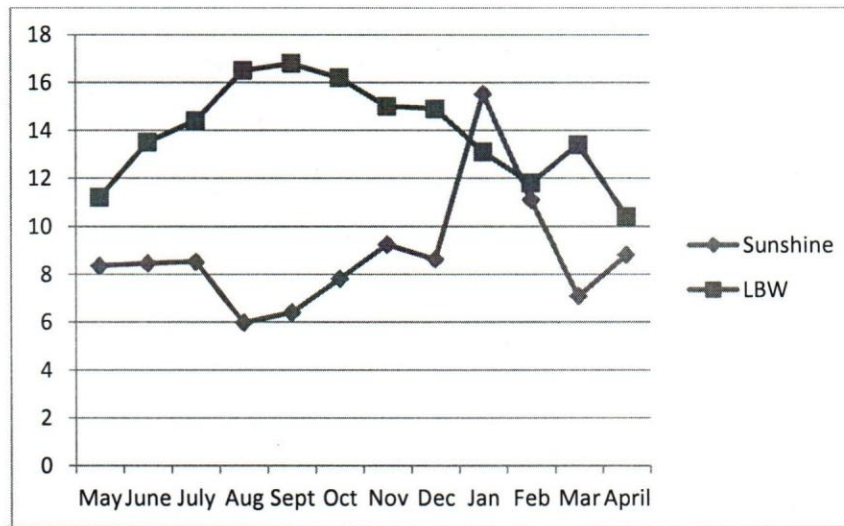
Figure 4.6 LBW and Average Monthly Sunshine

4.3.2 Variance Inflation Factor Test for Multi-colinearity (VIF Test)

Results of the variance inflation factor test are shown in Table 4.3. Type of birth and

Maternal age exhibits the characteristics of multi-collinearity as shown in the table

below.

Table 4.3 VIF Test

Variable	VIF	1/VIF
Type of birth	30.73	0.032541
Maternal Age	22.04	0.045364
Education of mother	9.67	0.103431
Sex	8.87	0.112756
Season of Birth	8.77	0.114051
Parity	8.01	0.124843
Wealth Index	6.03	0.165953
Ethnicity	5.86	0.1707
Religion	5.55	0.180164
Marital Status	2.9	0.34435
Mean VIF	10.84	

4.4 Models Selection for Birth Weight of New Born

Two Logistic models are considered in this study, the variables maternal age, Type of

Birth, and Parity were highly correlated so they were run separately with the other

covariates. This section is focusing on the selection process of the models and the selection of the best model for the predictors/determinants of Birth weights.

4.4.1 Logistic Regression Model

The Forward stepwise selection procedure was used for the entry of the variables into the model at a probability of 0.2. Any variable that did not meet the probability mark for entry into the model was dropped. Two models were fitted to the same data and the AIC and the BIC method were used to select the appropriate model.

4.4.1.1 Logistic Model I

This model includes type of birth (First born or otherwise) and excludes maternal age which it highly correlates with. The Table 4.4 shows the output for logistic regression model for birth-weight and the covariates sex of baby, season of birth, level of education of mother, wealth index of household. The Number of observations is 6576. A Wald chi-square test with 11 degrees of freedom yield a value of 2427.01which tested significant with p-value< 0.0001 and a Log likelihood = -2544.9538. From the table, Nankana's are about 67.5% more likely to have a normal birth weight baby than the Kassenas. Being born in the Dry season raises the odds of having a baby with normal birth weight by 35.5% compared to babies born in the wet season. The odds are higher for women with higher educational level with odds ratios of 1.506 and 1.428 for primary/JHS and SHS respectively compared to women with no formal education. Also, being a primigravida reduces a woman's odds of having a child with normal birth

weight with none primigravida women being 3 times more likely to have babies with

normal birth weight. Higher social class was also protective against low birth weight.

Table 4.3 Logistics regression model I

Variable	Coef.	Std. Err.	z	P>z	[95%Conf.	Interval]
Ethnicity(compared with Kassena)						
Nankana	0.5159	0.072	7.11	0	0.3737	0.658
Season of birth (Compared with Wet season)						
Dry season	0.3042	0.070	4.33	0	0.1664	0.442
Level of Education (Compared with No education)						
Prim/JHS	0.4101	0.07	5.75	0	0.2702	0.549
SHS	0.356	0.128	2.78	0.005	0.1052	0.607
Type of birth (Compared with First birth)						
Not first born	1.165	0.064	18.15	0	1.039	1.291
Socio-Economic status (Compared with Poor social class)						
Poorest social class	0.1615	0.096	1.67	0.094	-0.0277	0.350
Next rich social class	0.3203	0.094	3.39	0.001	0.1348	0.505
Rich social class	0.5642	0.127	4.44	0	0.3152	0.813
Religious status (Compared with Traditional religion)						
Other Christians	0.3629	0.087	4.15	0	0.1915	0.534
Islam	0.2663	0.153	1.74	0.082	-0.0339	0.566
Catholic	0.2629	0.095	2.76	0.006	0.076	0.449

Table 4.4 Odds Ratios for Model I

Variables	Odds Ratio	Std. Err.	z	P>z	[95% Conf. Interval]	
Ethnicity(compared with Kassena)						
Nankana	1.675	0.121	7.11	0.000	1.453	1.931
Season of birth (Compared with Wet season)						
Dry season	1.355	0.095	4.33	0.000	1.181	1.555
Level of Education (Compared with No education)						
Prim/JHS	1.506	0.107	5.75	0.000	1.310	1.733
SHS	1.428	0.182	2.78	0.010	1.110	1.835
Primigravida status (Compared with Primigravida)						
Not Primigravida	3.207	0.206	18.2	0.000	2.828	3.638
Socio-Economic status (Compared with Poor social class)						
Poorest social class	1.175	0.113	1.67	0.090	0.972	1.420
Richest social class	1.377	0.130	3.39	0.000	1.144	1.658
Rich social class	1.758	0.223	4.44	0.000	1.370	2.255
Religious status (Compared with Traditional religion)						
Islam	1.305	0.199	1.74	0.080	0.966	1.762
Catholic	1.300	0.123	2.76	0.010	1.079	1.567
Other Christians	1.437	0.125	4.15	0.000	1.211	1.706

4.4.1.2 Logistic Regression Model II

In the second logistic model, maternal age is included in the model with the other uncorrelated covariates. The number of observations is 6576, the Wald chi square with 12 degrees of freedoms 2505.38 and with a p-value < 0.0001 and a Log likelihood of 572.1771.

Table 4.5 Logistics Regression Model II

variable	Coef.	Std. Err.	z	P>z	[95% Conf. Interval]	
Sex of child(Compared with male)						
Female	-0.09	0.061	-1.41	0.158	-0.233	0.038
Season of birth (Compared with Wet season)						
Dry season	0.299	0.072	4.24	0	0.160	0.437
Level of Education (Compared with No education)						
Prim/JHS	0.360	0.068	5.27	0	0.226	0.494
Religious status (Compared with Traditional religion)						
Islam	0.224	0.153	1.47	0.142	-0.075	0.524
Other Christians	0.324	0.088	3.68	0	0.152	0.497
Catholic	0.182	0.094	1.92	0.054	-0.003	0.368
Socio-Economic status (Compared with Poor social class)						
Poorest	0.149	0.096	1.55	0.122	-0.040	0.339
Richest	0.278	0.094	2.94	0.003	0.092	0.463
Rich	0.473	0.118	4	0	0.241	0.705
Maternal Age (Compared with Under 20 years)						
20-35 yrs	1.144	0.076	14.87	0	0.993	1.294
35+ years	1.345	0.099	13.58	0	1.150	1.539
Ethnicity(compared with Kassena)						
Nankana	0.430	0.075	5.73	0	0.283	0.577

Table 4.6 Odds Ratios for Model II

variable	Odds Ratio	Std. Err.	z	P>z	[95% Interval]	Conf.
Sex of child(Compared with male)						
Female	0.906	0.062	-1.41	0.158	0.791	1.038
Season of birth (Compared with Wet season)						
Dry season	1.348	0.095	4.24	0	1.174	1.548
Level of Education (Compared with No education)						
Prim/JHS	1.434	0.098	5.27	0	1.254	1.640
Religious status (Compared with Traditional religion)						
Islam	1.252	0.191	1.47	0.142	0.927	1.690
Other Christians	1.383	0.122	3.68	0	1.164	1.644
Catholic	1.200	0.114	1.92	0.054	0.996	1.446
Socio-Economic status (Compared with Poor social class)						
Poorest	1.161	0.112	1.55	0.122	0.960	1.404
Richest	1.320	0.124	2.94	0.003	1.097	1.589
Rich	1.605	0.189	4	0	1.273	2.024
Maternal Age (Compared with Under 20 years)						
20-35 yrs	3.139	0.241	14.87	0	2.700	3.650
35+ years	3.838	0.380	13.58	0	3.161	4.661
Ethnicity(compared with Kassena)						
Nankana	1.537	0.115	5.73	0	1.327	1.780

The results of the Logistic models, depicting the parameter estimates and their significance or otherwise to the model, are shown in Table 4.7 and Table 4.8 above. The Odd ratios are also reported for both models. In the first model, sex of the new born and marital status did not meet the probability mark for entry into the model and so were dropped. In the second model, the presence of maternal age caused sex of the baby to attain the 0.2 probability mark for entry into the model but still did not turn out

significant as it recorded a p-value of 0.158. Marital status could not meet the required probability for entry into the model, Season of birth turned out highly significant in determining the weight of a new born as it recorded a p-value less than 0.0001 in both models.

Birth-weight of new-borns in this study significantly showed difference for mothers of different levels of education. The wealth index or socio-economic status of the household of the mother also showed significance in the model for Birth-weights of new-borns.

4.5 Best Model for Birth Weight of New Born Babies

The best model was selected using the Bayesian Information Criteria (**BIC**) and the Akaike Information Criteria (**AIC**) of the models. The covariates of "Model I" include, Sex of baby, Season of Birth, Maternal Age, Level of Education of Mother, Wealth Index of Household, Marital Status of Mother, Ethnicity and Religion.

The covariates of "Model II" include Sex of baby, Season of Birth, Parity, Level of Education of Mother, Wealth Index of Household, Marital status of mother, Ethnicity and Religion.

The model with the lowest BIC or AIC was considered the best model for the prediction of birth-weights of new-born babies. The Table 4.8 shows the BIC and AIC computed for the two models for birth-weight prediction with their estimates and level

of significance. The standard errors are shown in brackets below the estimates of the covariates.

The best model for this study according to AIC and BIC is "Model I" which utilizes information from Type of Birth (primigravid) and has a BIC of 5281.910 and an AIC of 5200.415 smaller than "Model II", which has a BIC of 5329.389 and an AIC of 5254.686, and utilizes information from Maternal Age.

Table 4.7 BIC and AIC for Model I and Model II

Predictor Variables	Model I	Model II
Ethnicity		
Nakani	0.516*** (0.073)	0.430*** (0.075)
Season of birth		
Dry Season	0.304*** (0.070)	0.299*** (0.071)
Educational level		
Primary/JHS	0.410*** (0.071)	0.361*** (0.068)
SHS	0.356** (0.128)	
Type of birth		
Not first born	1.166*** (0.064)	
Socio-Economic status		
Poorest	0.162 (0.097)	0.150 (0.097)
Richest	0.320***	0.278**

	(0.095)	(0.095)
Rich	0.564***	0.473***
	(0.127)	(0.118)
Religion		
Islam	0.266	0.225
	(0.153)	(0.153)
Other Christians	0.363***	0.325***
	(0.087)	(0.088)
Catholic	0.263**	0.183
	(0.095)	(0.095)
Sex of child		
Female		-0.098
		(0.069)
Age of mother		
20-34 years		1.144***
		(0.077)
35+ years		1.345***
		(0.099)
N	**6576**	**6576**
AIC	**5111.908**	**5168.354**
BIC	**5186.611**	**5249.848**

Standard errors in parentheses. $^{*}p< 0.05$, $^{**}p< 0.01$, $^{***}p< 0.001$

4.5.1 General Model Expression for Prediction

The best model for the prediction of the birth weight of a new born child is given in the expression for the logistic regression model. The general logit model contains all the variables the met the criteria for entry into the predictive model, they include ethnicity, season of birth, level of education, type of birth, religion and socio-economic status.

The general predictive model is expressed as:

$$Logit_e(\pi) = 0.5159 * Nankana + 0.3042 * wetseason + 0.4101 * prim/JHS$$
$$+ 0.3563 * SHS/Tertiary + 1.165 * primigravida + 0.1615 * Poorest + 0.3203 * Richest$$
$$+ 0..5642 * Rich + 0.2663 * Islam + 0.2629 * Catholic + 0.3629 * OtherChristians$$

$$(4.1)$$

4.5.2 The Reduced Model for Prediction

The reduced predictive model is an expression for only the variables that turned out significant after entry into the general predictive model. The expression below is the reduced predictive model for predicting birth weight of new born child in KNM is expressed as:

$$Logit_e(\pi) = 0.5159 * Nankana + 0.3042 * wetseason + 0.4101 * prim/JHS$$
$$+ 0.3563 * SHS/Tertiary + 1.165 * primigravida + 0.3203 * Richest + 0.5642 * Rich$$
$$+ 0.3629 * Otherchristians + 0.2629 * Catholic \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (4.2)$$

4.6 Model Evaluation

4.6.1 ROC Curve

The evaluation of the model is shown in the ROC plots below. It shows that our model will in 60.7% of the times predict the BW of a new born correctly.
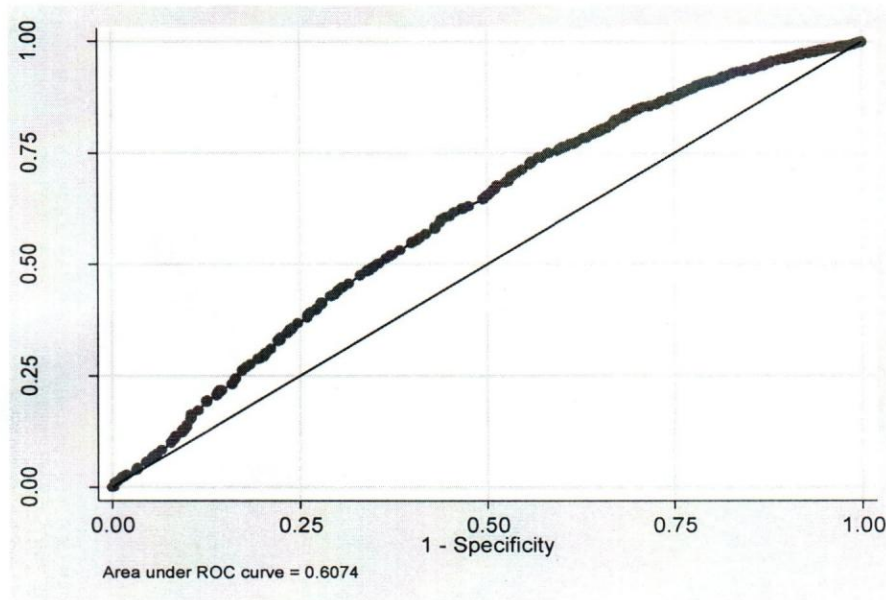
Area under ROC curve = 0.6074

Figure 4.8 ROC Curve

4.6.2 Logistic Model Goodness-of-Fit Test

The insignificance (p-value =0.1165) of the Hosmer-Lemeshow Chi-Squared test shows that the model fits the data well. The test used 128 covariate patterns with 6576 observations and a Pearson chi square of 138.71 with 120 degrees of freedom

4.7 Discussion of Results

Birth weight

In this study, we found that the mean birth weight of the babies for KND was 2900 g ±10 which is low compared to mean birth weight found in industrialized countries (Straus and Dietze, 1999).Maternal age constitutes an important risk factor.Majority (68%) of the women in this study were between the ages of 20 to 34 years, those under

20 years of age constituted 11% and this group also recorded the highest proportion (19.8%) of LWB born for this study.

This study found a strong association between maternal age and Birth weight which is consistent withMacLeod and Kiely (1988), where there was a significant progression of birth weight with advancing age. Their results also showed that birth weight increased from parity 1 to parity 3, but dropped markedly in the higher parity groups which is consistent with the results of this study. This study also found a strong association between parity and birth weight.

Foix-L'Helias and Blondel (2000) found that in France, a maternal age above 34 years old constituted an important risk factor in both 1981 and 1995, while a maternal age below 20 years constituted an important risk factor in 1981 but not in 1995. Similar results were obtained by Dičkute *et al.* (2004) who in their study of Lithuania in 2001-2002 identified a U-shaped relationship between maternal age and LBW risk (younger than 20 years and 35 years or older) consistent with the under 20 year group of this study but not the 34 year group, higher proportions of LBW were recorded for under 20 years and 20- 34 years but lowest for the above 34years group. Some other factors might have also clearly played a role in this variation in the 34 year group of mothers. Several other studies have shown results that are consistent with the results of this study. The negative effect of a higher maternal age can be weakened by education and parity, but only to a rather small extent (Astolfi and Zonta, 2002, referring also to the

Danish case-study of Basso *et al.* 1997) which is likely to be the case with the low proportion of LBW recorded for the 35 plus age group for this study.

Educational status

The Chi square test of association did not find any association between birth weight and the educational status of the mother, but when the socio-economic status of the mother was controlled for in the model, the level of education became a significant predictor of birth weight of a new born; which is consistent with Arnaud *et al.* (2007) (cited in Mathule, 2005) who stated that there was positive correlation with birth weight and further identified a causal effect of education on birth weight.

The study found that mothers with no formal education were 1.5 times more at risk of having a LBW baby compared to mothers who had Primary/JHS education. The risk was 1.4 times when compared to mothers who had SHS/tertiary education. The results are consistent with Raum *et al.* (2001) who examined the influence of maternal education on IUGR in two different political and social systems, West and East Germany in 1987/1988 and 1990/1991 respectively. They found that mothers among the lowest category of education in both West and East Germany had an unadjusted relative risk of 2.5 for delivering an SGA child compared to those of the highest education category. This indicates that the education of the mother is a proxy for the socio-economic and lifestyle status, including smoking behavior, frequency of prenatal care visits.

Marital status

This study did not find any association between marital status of the mother and birth weight of a new born baby according to the logistic regression model, but a chi square test of association found a significant association between marital status and birth weight; consistent with other studies, Foix- L'Helias and Blondel (2000) who found risk factors including being single in 1981, but did not find any association in their 1995 work.

Religion and Birth weight

Majority (54%) of the mothers in this study were Christians, 37.3% were traditionalist and 8.4% were Muslims. A chi squared test did not show any association between religious affiliation of the mother and birth weight, but when it was included in the model for prediction, it turned out as a significant influence to the birth weight of a new born baby. These results are consistent with Burdette *et al.* (2012) where maternal religious attendance was protective against low birth weight and stated that lower rates of cigarette use help to mediate 11% of the association between religious attendance and low birth weight. Their results further suggested that the health benefits of religious involvement may extend across generations. Traditional religious group were more at risk 1.3, 1.4, and 1.3 times compared to Catholic, Other Christians (Pentecostal churches) and Islam respectively.

Socio-economic status and birth weight

The results of this study confirmed previous studies by Kehinde *et al.* (2013) who found a strong association between parental socio-economic status and birth weight. Spencer *et al.* (1999) also concluded in their study that, a substantial proportion of births<2500g and <1500g are "attributable" to social inequality, their results demonstrated the likelihood of being born weighing ≥3500g , the most advantage group is substantially greater among the socially advantaged. Consistent with results from previous studies on socio-economic status and birth weight, we found that mothers who belonged to the poor social class were 1.2 times more likely to have a LBW child compared to their immediate category of social class (poorest social class group). Comparing this same poor social class group to the richest social class, they were 1.4 times more at risk of having a LBW child, and 1.8 times more at risk when compared to the Rich social class group. This confirms Spencer et al. (1999) results.

Seasonal distribution in birth weight

In contrast with the findings of Tjon *et al.* (1986) (cited in Mathule, 2005), this study demonstrates a seasonal pattern in birth weight in which the hungry season was associated with lower mean birth weights. Tjonet *et al.* (1986) (cited in Mathule, 2005)did not observe a seasonal pattern in birth weight in the remote mountain villages of Lesotho. The observed lower birth weights during the hungry season in this study are however consistent with other studies. Studies by Aitkin (1990) and Wendle-Ritcher (1997) in Burkina Faso observed that the lowest birth weights were associated with the

rice cultivation and harvesting of field crops. In Lesotho, the hungry season coincides with the harvest season which is characterized by heavy agricultural labor that could influence energy balance in pregnant mothers. In this study Rice, Maize and Millet are the major food consumed and their hunger periods are April to November for Rice, January to July/November for Millet and, April to October for Maize (Quaye, 2008). The hunger period for Millet which is the most consumed food in KNM significantly affected the birth weight with about 16% of all pregnancies exposed to this period having LBW babies.

Temperature and birth weight

Higher ambient outdoor temperature in the first trimester of pregnancy and/or lower ambient outdoor temperature in the third trimester are associated with reduced birth weight of offspring, Lawlor *et al*. (2005). The proportion of LBWs for this study rose steadily from April to September (Figure 4.5). When the number of LBW babies was plotted against Maximum monthly temperature, the pattern depicts the results of Lawlor *et al*. (2005)

This study also found a seasonal pattern for birth weight with Humidity and average monthly sunshine. (Figure 4.6 and Figure 4.7 respectively).Murray et al. (2000) found in their studies that Infants born during late spring and summer are lighter than those born in winter, which might be the result of exposure to low winter temperatures.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The study found that, the prevalence of LBW is 13.8% in the KNM with a mean birth weight of 2900g (10). This study found a strong association between maternal age and birth weight where there was a significant progression of birth weight with advancing age. The study showed that birth weight increased from parity 1 to 5 but dropped markedly in the higher parity groups.

We also found in this study that, mothers with no formal education were 1.5 times more at risk of having a LBW baby compared to mothers who had either primary or JHS education. The risk was 1.4 times when mothers with no formal education were compared to those who had higher education.

According to our findings marital status did not play any significant role as a predictor of birth weight as found by other researchers in other locations, but socio-economic status of the maternal household however was a significant predictor of the weight of a new born baby, the study found that women who were socially disadvantaged class were more at risk of having LBW babies.

On the seasonality of birth weights, this study found a seasonal pattern in birth weight of new born babies in KNM, consequently, the study found a significant positive

correlation between birth weight and humidity. There was however a significant negative correlation between temperature, sunshine and birth weight.

In summary, BW is positively and significantly predicted by socio-economic status of mothers, mother's age and parity, season of birth, mother's level of education, religious affiliation of mother and ethnicity.

The logit model for predicting the birth weight of a new born in the Kassena-Nankana Municipal is expressed as;

$$Logit_e(\pi) = 0.5159 * Nankana + 0.3042 * wetseason + 0.4101 * prim / JHS$$

$$+ 0.3563 * SHS / Tertiary + 1.165 * primigravida + 0.3203 * Richest + 0.5642 * Rich$$

$$+ 0.3629 * Otherchristians + 0.2629 * Catholic$$

5.2 Recommendations

Based on the findings of the work, the following recommendations are given;

i.   Improving data collection and recording methods of vital statistics during ANC, Collecting additional data on variables such as gestational age, ponderal index, and socioeconomic status in pre-natal risk assessment is strongly recommended.

ii. Promotion of pre-natal care at the community level through Safe Motherhood Initiatives for women who do not attend antenatal clinics and incorporating the

use of home-based maternal record should be practiced to help educate these women on the importance of nutrition before and during pregnancy

iii. Studying the impact of seasonal hunger throughout the course of pregnancy in women who do not attend antenatal clinics is highly recommended.

iv. Food intake behavior and maternal care practices are targets for a prospective community based study in an area with a high prevalence of malnutrition.

v. Future research should expand to include maternal health related risk factors.

vi. A genome wide association study be conducted to explore the genomic variation among LBW babies in the African setting.

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