# THE RELATIONSHIP BETWEEN SELECTED NEONATAL, MATERRNAL ANTHROPOMETRIC CHARACTERISTICS AND BIRTH WEIGHT AS PREDICTORS OF NEONATAL WELL- BEING, AMONGFULL-TERM SINGLETON BABIES IN KANO STATE NIGERIA

**BY**

**Musa Habibu MODIBBO**
**MBBS (A.B.U.) 2003; MSc. (A.B.U.) 2012**
**P15MDHA9005**

**A DISSERTATION SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES, AHMADU BELLO UNIVERSITY ZARIA IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF PHILOSOPHY DEGREE IN HUMAN ANATOMY**

**MARCH, 2021**

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**DEPARTMENT OF HUMAN ANATOMY,**

**FACULTY OF BASIC MEDICAL SCIENCES,**

**COLLEGE OF MEDICAL SCIENCES,**

**AHMADU BELLO UNIVERSITY,**

**ZARIA**

**MARCH, 2021**

## DECLARATION

I declare that the work in this Thesis entitled: **The impact of the relationship between selected neonatal, maternal anthropometric characteristics and birth weight as predictors of neonatal well- being, among full-term singleton babies in Kano state Nigeria**

have been performed by me in the Department of Human Anatomy, Ahmadu Bello University Zaria. The information derived from the literature has been duly acknowledged in the text and a list of references provided. No part of this thesis was previously presented for another degree or diploma at any university.

| | | |
|---|---|---|
| | _____ | _____ |
| Musa Habibu MODIBBO | Signature | Date |

## CERTIFICATION

This thesis entitled THE IMPACT OF THE RELATIONSHIP BETWEEN SELECTED NEONATAL; MATERNAL ANTHROPOMETRIC CHARACTERISTICS AND BIRTH WEIGHT AS PREDICTORS OF NEONATAL WELL- BEING, AMONG FULL-TERM SINGLETON BABIES IN KANO STATE NIGERIA by Musa Habibu MODIBBO meets the regulations governing the award of Ph.D. Human Anatomy of the Ahmadu Bello University, and is approved for its contribution to knowledge and literary presentation.

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## ABSTRACT

Neonatal and maternal anthropometric characteristics are fundamental in health management. Numerous studies have established the relationship between birth weight and other neonatal and maternal anthropometric parameters. Hospitals in rural (or busy) settings in many cases lack appropriate tools for the measurement of neonatal as well as maternal anthropometric parameters. The aim of the study is to evaluate impact of the relationship between selected neonatal, maternal anthropometric characteristics and birth weight as predictors of neonatal well- being, among full-term singleton babies in Kano state nigeria. And (also) to develop appropriate stepwise multiple linear regression equation models and to determine the cut off values for the select neonatal parameters that discriminate between low and high birth weight for the urban and rural deliveries in Kano State, Nigeria. The study involved a total of 1,203 mother-child pair from the urban and rural hospitals in Kano State. Several selected neonatal anthropometric parameters such as birth length, hand breadth, thigh circumference among others were measured. Similarly, maternal anthropometric characteristics such as maternal height, maternal arm circumference, and symphysio-fundal height together with maternal haemoglobin, age, parity and educational level were also considered. The entire data were collected from six hospitals (three from the urban and three from the rural areas). Data collected were expressed as mean ± SD, independent sample *t*-test was used to determine the differences between the variables. Pearson's correlation was used in relating the variables with one another. Binary logistic regression was employed to determine the effect of maternal characteristics, and Apgar score on the birth weight. Stepwise multiple linear regression analyses were all carried out to provide models for predicting birth weight among the neonates. The predictive probabilities for the variables to discriminate between low and high birth weight were analyzed using ROC

curves. The data analyses were carried out using IBM SPSS version 25.0 statistical software (Armonk, NY: IBM Corp.), and a *P* value of < 0.05 was considered statistically significant. The study found a significant impact of the relationship between the neonatal and maternal anthropometric characteristics ($P < 0.001$) on birth weight. The mean birth weight, mean placental weight, mean value of ponderal index as well as the placental-birth weight ratio among the neonates were also found to be 3079.30 ± 491.77kg, 526.02 ± 83.09kg, 2.66 ± 0.63 and 17.17 ± 1.73 (1:6) respectively. Among the maternal anthropometric parameters, the mean maternal height stood at 160.22 ± 5.82cm. Other parameters such as the mean maternal arm circumference, the mean symphysio-fundal height and the mean maternal haemoglobin level were also determined as 26.60 ± 3.15cm, 37.46 ± 0.93 cm and 12.18 ± 1.40g/dl respectively. Furthermore, stepwise multiple linear regression models were formed to ease birth weight estimation among the neonates in Kano State, Nigeria. In conclusion, the study has determined the mean values of the select neonatal and maternal anthropometric characteristics in Kano State, Nigeria. Significant variations exist among the maternal and the neonatal anthropometric parameters in the urban and rural areas of Kano State. Stepwise multiple linear regression models were formed for the estimation of birth weight. Receiver operator characteristic curve was also employed to discriminate between low and high birth weight.

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## LIST OF ABBREVIATIONS

| | |
|---|---|
| AC | Abdominal Circumference |
| ANC | Antenatal Care |
| Apg. Sco. | Apgar Score |
| *b* | Regression coefficient |
| BL | Birth Length |
| BMI | Body Mass Index |
| B.P. | Blood Pressure |
| BPD | Biparietal Diameter |
| BW | Birth weight |
| CC | Chest Circumference |
| d | Sampling error |
| DBP | Diastolic Blood Pressure |
| DVM | Doctor of Veterinary Medicine |
| EFW | Estimated Foetal Weight |
| ELBW | Extremely Low Birth Weight |
| FB | Foot Breadth |
| FL | Foot Length |
| FMH | Federal Ministry of Health |
| FS | Family Size |
| g | Grams |
| g/dl | Grams per decilitre |
| HB | Hand Breadth |
| Hb | Haemoglobin |
| HC | Head Circumference |

| | |
|---|---|
| HBW | High Birth Weight |
| HL | Hand Length |
| Kg | Kilograms |
| Km | Kilometres |
| LBW | Low Birth Weight |
| LGA | Large for gestational age |
| MA | Maternal Age |
| MAC | Mid arm circumference |
| Max. | Maximum |
| MEL | Maternal Educational Level |
| MH | Maternal Height |
| Min. | Minimum |
| mmHg | Millimeters of Mercury |
| MP | Maternal Parity |
| n | Minimum sample size |
| NAC | Neonatal arm circumference |
| NICU | Neonatal Intensive Care Unit |
| NPC | National Population Commission |
| P | Proportion in the target population |
| PCOS | Polycystic ovarian syndrome |
| PI | Ponderal Index |
| PIH | Pregnancy Induced Hypertension |
| PPROM | Preterm Premature Rupture of Membranes |
| PW | Placental weight |
| q | 1 – Proportion in the target population |

| | |
|---|---|
| *r* | Coefficient of correlation |
| SBP | Systolic Blood Pressure |
| SD | Standard Deviation |
| SEE | Standard Error of Estimate |
| SFH | Symphysio-fundal height |
| SRS | Simple Random Sampling |
| TC | Thigh Circumference |
| UNICEF | United Nations Children Educational Fund |
| VLBW | Very Low Birth Weight |
| WHO | World Health Organization |
| Z | Standard normal distribution |

# CHAPTER 1

## 1.0 INTRODUCTION

### 1.1 Back ground to the study

Birth weight (BW), is defined as the immediate body weight at birth (Blanc and Wardlaw, 2005). A weight of 22.5 to 4.0 kg has been termed as normal birth weight (WHOSIS, 2011). It has long been documented that BW is the single most important criterion for determining neonatal and infant morbidity and mortality (McCormick, 1985). The term "Low birth weight" (LBW) has been defined as the birth weight of less than 2.5 kg irrespective of the duration of the gestational period (Kramer, 1987; Ghai, 1989; UNICEF, 2004; Park, 2011). While, high birth weight (HBW) is the BW of more than 4000 grams (more than 4.0 kg). There is an association between the BW of a baby and that of both parents, but this is more strongly linked to the maternal line (deStavola *et al*., 2011). astudy conducted by Lawn *et al.* (2005) documented that in Africa, infant mortality is very high mainly due to LBW, hence the importance of weight determination at birth. Available evidence from poor-resource settings shows that extra essential newborn care for LBW babies can reduce the number of neonatal deaths by 20% - 40% (Darmstadt *et al*., 2005). One of the major risk factors for neonatal mortality is LBW, which is a sensitive indicator of socio-economic conditions and indirectly measures the health of the mother and the child. Studies by Pojda and Kelley (2000) revealed that in every 10 seconds an infant from a developing country (Nigeria inclusive) dies from a disease or infection that can be attributed to LBW. It has been documented that most deliveries occur at home or rural health centres, where scales are not always available or are defective, consequently weight at birth is either unknown or measured imprecisely some busy centres gestimate birth weight in the absence of a weighing or faulty measuring scale (Lawn *et al*., 2010; Wall *et* al., 2010). It has long been established in some communities that BW is a major determinant of infant mortality in the first year of life (Steer *et al*., 1995) and that mortality rates are more sensitive to BW than gestational age (Williams *et al*., 1982). Marchant *et al*. (2010) revealed that nearly all of the newborns who die immediately after their delivery are of LBW and are mostly in rural communities where weighing scales are not readily available. Reports by (Bhutta *et al*., 2005; Lawn *et al*., 2009; Lawn *et al*., 2010; Wall *et al*., 2010) showed that more than half of these LBW babies were deliveries from rural families at home, and the babies die shortly after birth. Other analyses by the World Health Statistics Report revealed that 15% of babies are born worldwide with LBW (WHO, 2012). The BW of twins is considerably lower than those of singletons and is associated with higher risk for adverse perinatal and infant outcomes (Cheung *et al*., 2000; Garite *et al*., 2004). Also, BW centiles by gestational age are often used as a health indicator and to understand the natural extent of variation in BW.

Neonatal BW should preferably be measured within the first 24 hours of delivery before the onset of significant postnatal weight loss (Chandrashekar *et al*., 2008). This is

because the newly born babies lose weight after they are born, no matter what or how they are fed. It is normal for breastfed infants to lose weight during the first three days after birth, and gain back the weight (after breast-feeding) within the first two or three weeks after delivery. Furthermore, it was documented by MacDonald *et al.* (2003) that immediately after birth, there is low glomerular filtration rate, which initiates diuresis and obligatory sodium ion ($Na^+$) loss; thus leading to weight loss after delivery. The weight loss was about 5% in pre-term babies, and about 10 to 15% less loss was observed in sick babies. Additionally, weight loss in babies after delivery can also be explained as a situation whereby there is the loss of fluid by the babies (via urine and stool) or when breast milk is not immediately available, which may take some time, (at times days) before it becomes available. However, in these circumstances, a baby may regain its weight (or gain more) within two weeks of delivery. Many babies go through a growth spurt at seven to 10 days old; there is manifestation of the phenomenon three to six weeks after birth. This make taking birth weight within the first 24 hours of life profitable.

Growth of baby in-utero is presumed to be a function of the placenta. The placenta is derived from both foetal and maternal cells. It first takes shape when cells from the foetus, called trophoblasts, attach themselves to the uterine wall and then proceed to invade the tissues of the uterus. They eventually reach deep into the wall and connect with the mother's blood vessels. It has been suggested that during placental development the trophoblast invade the spiral arteries more in women with anaemia in pregnancy (Dadhich *et al.*, 2012). The placenta has been identified as the most accurate record of the infant's prenatal experiences (Chandrakant *et al*., 2015). The ratio between the placental and BW is a useful marker of foetal nutrition and utero-placental function (Cunningham *et al*., 2005). Recently, it has been shown by Gunapriya *et al*. (2011) that foeto-placental ratio and placental coefficient can be used for the assessment of the severity of toxemia in pregnancy.

Maternal anthropometric characteristics such as maternal age, maternal education, per capita income of the family, time of antenatal registration, number of antenatal visits, physical work during pregnancy, height and weight in pregnancy, have all showed a significant association with BW (Rao *et al*., 2007). Earlier studies conducted by Newcombe (1981), Raman (1981), Dougherty and Jones (1982) and later Talat *et al*. (1991), have all reported a positive influence of maternal factors on weight at birth.

Maternal anaemia in pregnancy is of health concern during pregnancy, because it affects the growth and development of the developing baby. Haemoglobin concentration (Hb) of less than 11 g/dl or a pack cell volume (PCV) of less than 33% is declared as anaemia in pregnancy by WHO (1992). Certain factors like cigarette smoking are associated with

LBW, as its smoke contains hydrogen cyanide and carbon monoxide. Consequently, the inhalation of cigarette smoke during development (intra uterine life) by pregnant women may lead to intrauterine growth restriction, thus causing LBW (MacMahon *et al*., 1966; Yerushalmy, 1971; Ronald and James, 2005).

Receiver (relative) operator characteristic (ROC) curve is a graphical representation of the relationship between two variables that discriminate the cut off values between them. It determines the sensitivity and specificity of the given variables. The curves are said to be a popular method for displaying sensitivity and specificity (Patrick *et al*., 2004).

Therefore, there is a need to develop uncomplicated and practical method for the estimation of neonatal birth weight, so as to plan for delivery especially in rural areas, or places where the weighing scale, ultrasound machine or manpower (expertise) are not readily available in order to identify those with LBW (Mullany *et al*., 2006), for prompt and appropriate referral for immediate action. This will go a long way in reducing neonatal mortality rate. One such method could be through the use of regression equation models or developing a ROC curve (generated from selected neonatal anthropometric parameters) using one or the combined parameters of birth length (BL), foot length (FL), foot breadth (FB), thigh circumference (TC), hand length (HL), hand breadth (HB), neonatal arm circumference (NAC), chest circumference (CC) and head circumference (HC). This can easily be achieved by using a non-elastic measuring tape (tailors tape) to carry out the measurements. The tape is readily available, inexpensive, easy to carry about and maintain, and can be easily used by community health workers, or in places where the recognised weighing scale is not readily available or is faulty (WHO, 1993; Sreeramareddy *et al*., 2008; Goto 2011; Das *et al*., 2012).

## 1.2 Statement of the Research Problem

Numerous studies have established a relationship between birth weight (BW) and other neonatal and maternal anthropometric parameters with a number of regression models already developed for the estimation of neonatal weight in some ethnic populations. There is paucity of literature on stepwise regression models for estimating BW among the urban and rural neonates in Kano State using simple neonatal and maternal anthropometric parameters. Similarly the generation of receiver operation curve for the

discrimination between low and high BW using the neonatal parameters has not been established in the study area.

## 1.3 Justification

Estimation of weight at birth is a major determinant of infant morbidity and mortality while maternal anthropometry indicates the risk of intrauterine growth retardation and low birth weight. However, in many of the health centers in third world nations and their urban and rural district such as Kano State and its rural communities, resources for estimation of birth weight are not always available, therefore weight at birth is not readily measured. This study can validate an appropriate regression equation that is potentially populated by easily measurable selected neonatal and maternal anthropometric variables with a view to predicting birth weight. It therefore provides useful, simple, cheap, noninvasive and convenient methods for the identification of neonatal birth weight using simple maternal and neonatal anthropometric parameters. Also, the estimation and determination of birth weight is a cornerstone of neonatology that is vital for identifying neonates with abnormal birth weights for immediate medical intervention. Furthermore, the study will provide reference values for average anthropometric parameters among the neonates in Kano State, Nigeria.

To the best of my knowledge, so far no stepwise multiple linear regression equations or ROC-curve (for cut off values) has been developed for the estimation/discrimination of neonatal weight at birth among the urban and rural neonates from maternal and neonatal anthropometric parameters, among the newborn babies in Kano State, Nigeria. This is what prompted the conduct of this study. Another factor which inspired the conduct of the study is the paucity of literature on the ponderal index value, placental weight and its ratio to birth weight of the neonates at birth in Kano State.

## 1.4 Aim and Objectives of the Study

### 1.4.1 The aim of the Study

The aim of the study was to elucidate the impact of the relationship between selected neonatal, maternal anthropometric characteristics and birth weight as predictors of neonatal well- being, among full-term singleton babies in Kano state Nigeria

### 1.4.2 The Objectives of the Study

The objectives of the study are to:

i. determine the mean values of the neonatal birth weight, the selected neonatal (BL, HL, HB, NAC, FL, FB, TC, CC and HC) and maternal anthropometric parameters (MA, MH, MAC, SFH and BP) among the urban and rural deliveries in Kano State, Nigeria

ii. determine the effect of urbanization on the selected neonatal and maternal anthropometric parameters among the mother-child pair in Kano State, Nigeria

iii. determine the influence of urbanization, maternal characteristics (MP, MEL, FS and ANC) and Apgar score on birth weight among the mother-child pair in Kano State, Nigeria

iv. determine the cut off values of the selected neonatal anthropometric parameters that discriminate between low and high birth weight among the urban and rural neonates in Kano State, Nigeria

v. determine the effect of urbanization on placental weight and placental birth weight ratio among the neonates in Kano State, Nigeria

vi. determine the mean ponderal index value, and the effect of urbanization among full-term neonates in Kano State, Nigeria

vii. determine the impact of the relationship between birth weight with the selected neonatal and maternal anthropometric parameters among the deliveries in Kano State, Nigeria

viii. develop stepwise multiple linear regression models for estimating neonatal birth weight from the selected neonatal anthropometric parameters

## 1.5 Research Hypotheses

i. There is a relationship between birth weight with the selected neonatal and the maternal anthropometric characteristics

ii. the parameters will increase with the increasing level of urbanization

# CHAPTER 2

## 2.0 LITERATURE REVIEW

### 2.1 Neonatal Birth Weight

The mean birth weight can be described as a function of gestational age. It has been documented (Janssen *et al*., 2007) that the average normal birth weight globally is 3,500 g (3.5 kg). Growth of the foetus in-utero is an important determinant of health and disease conditions for the entire life span of human's life. Foetal weight estimation is a useful parameter with which to predict birth weight and birth outcome when it is considered a few days before delivery. It was earlier documented to have accuracy similar to that of ultrasound examination for pregnancies at or beyond 37 weeks of gestation (Chauhan *et al*., 1998). The equations commonly used for calculating the estimated foetal weight (EFW) sonographycally were reported as Shepard and Hadlock formulae (Unterscheider *et al*., 2013). Despite the use of any of the formulae, the accurateness of the sonographic estimate of the EFW is affected by suboptimal imaging and biological variations. Additionally, there is a decrease in accuracy with increasing birth weight during sonographic EFW (Mongelli and Benzie, 2005). Therefore, there is the tendency of overestimation in pregnancies suspected of being large for gestational age (LGA) and underestimation in pregnancies with preterm premature rupture of membranes (PPROM) and suspected foetal growth restriction. Furthermore, many studies have reported that foetal growth restriction has been found to be associated with an increased risk of morbidity in childhood, and has also been found to increase the risk of having chronic diseases during the adult hood (Whincup *et al*., 2008; White *et al*., 2009; Wang *et al*., 2014; Bruno *et al*., 2015). Gestational age at birth and diastolic blood pressure are significant determinants of weight at birth (Atuahene *et al*., 2015). They also concluded that an increase in gestation at birth by one week results in over twice more likelihood of a normal birth weight, while a rise in diastolic blood pressure is less likely to produce a normal birth weight neonate. Furthermore, Grifiths *et al*. (2007) reported that maternal adult weight has a greater influence than paternal adult weight on BW. However, it has been shown recently that mid-parental weight was the most explanatory variable of baby's weight (Taiwo and Akinde, 2012). The BW has also been accepted as the most reliable index of health status of a community (Kumar and Datta, 1984). It has been reported that in Nigeria a quarter of a million newborn babies die during neonatal period, which is the highest number of neonatal deaths in Africa and the second highest in the world (Federal Ministry of Health Report, 2011). The estimation of foetal gestational weight is done routinely in clinical practice using ultrasonography by using the anthropometric parameters of foetal biparietal diameter (BPD), head circumference (HC), femur length (FL) and abdominal circumference (AC), and from among them, AC is the parameter with the highest sensitivity (Abdellah *et al.*, 2014; Turitz *et al.*, 2014). Several studies have indicated that estimation of foetal gestational weight with multiple parameters may give a more accurate value compared to that with a single parameter (Hua and Liu, 2001; Wang and Xu, 2004; Guo and Yuan,

2006; Li *et al*., 2006; Sanyal *et al*., 2012). However, it has been observed that nearly all the formulae used in sonographically estimating foetal weight have either under estimated or over estimated the birth weight in singleton pregnancies (Kumarasiri *et al*., 2013). Several other attempts have been carried out earlier to estimate birth weight from simple anthropometric measurements (Bhatia and Tyagi, 1984; Sharma *et al*., 1988; Sharma *et al*., 1989). Further attempts have also been made to estimate birth weight sonographically (Akinola *et al*., 2009). Hadlock *et al*. (1984) showed that using foot length in addition to other neonatal anthropometric parameters significantly improves foetal weight estimation. Similarly, the addition of thigh circumference to head, abdominal and femur length measurements give an even better predictive value and, hence, better identification of high risk pregnancies. High morbidity and mortality rates occur in very small or very large babies when compared to foetuses whose birth weight is within the normal birth weight range (i.e. 2,500 g to 4,000 g) antenatally (Barker, 2013).

### 2.1.1 Low birth weight

It has been documented that in Nigeria low birth weight (LBW) affects about 56 million children every year (Olu, 2005). Recently, Achebe *et al*. (2014) revealed that in the South-west of Nigeria, 11.4% of children are born with LBW, and 12.2% in Northern Nigeria have LBW at delivery. Low birth weight could occur as a result of either preterm birth (delivery before 37 completed weeks of gestation) or due to restricted foetal growth (Adamson, 2007). Restricted foetal growth may result from small for gestational age babies, these are babies born with birth weight below the10th percentile for that gestational age. It has been found in recent years that, the percentage of babies born before 37 completed weeks of gestation and having LBW are at increase worldwide (Altenhöner *et al*., 2016). Similarly, over the years, there has been a significant improvement on birth outcomes in the developed countries. However, there are still high rates of preterm deliveries and low birth weight among the parturient mothers in the developed countries (Hamilton *et al*., 2012; World Health Organization, 2013). Additionally, it has been documented that across the world neonatal mortality is 20 times more likely for LBW babies compared to heavier babies (Ticconi *et al*., 2005). In a study conducted by Otupiri *et al*. (2014), on anthropometric measurements: Options for identifying LBW newborns in Kumasi, Ghana, 973 mother and newborn pairs at the Komfo Anokye Teaching and the Suntreso Government hospitals were considered. It was concluded that anthropometric measurements, such as the chest circumference, mid-upper arm circumference and calf circumference, offer an opportunity for the identification of and subsequent support for LBW newborns in settings in Ghana, where BW are not measured by standardized weighing scales. Several studies (Barker, 1997; Primatesta *et al*., 2005; Cosmi *et al*., 2009; Kark *et al*., 2009; Morrison *et al*., 2010; Xiao *et al*., 2010; Zanardo *et al*., 2011; Zanardo *et al*., 2013) conducted in various communities have proven that LBW is an important risk factor for the development of atherosclerosis, type II diabetes mellitus, hypertension, metabolic syndrome and

endothelial dysfunction. An additional risk for female babies with LBW is the threat of having smaller babies when they become mothers (Adamson, 2007). Most LBW babies are born prematurely. It has been observed that the shorter the gestational age the smaller the baby and the higher the risk of morbidity, disability and death. Small for gestational age (SGA) babies is the term used for infants having a BW of more than two standard deviations (SD) below the mean or less than the 10th percentile for the gestational age. The primary causes of very low birth weight (VLBW) are premature birth (born less than 37 completed weeks of gestation, and often less than 30 weeks of gestation) and intrauterine growth restriction (IUGR) is usually due to placenta problems, maternal health, or birth defects. Many VLBW babies with IUGR are preterm and, thus, are both physically small and physiologically immature. The commonly used classification of underweight newborn babies based on weight alone is:

i. Low birth weight (1,500 to less than 2,500 g).

ii. Very low birth weight (1,000 to 1,500 g).

iii. Extremely low birth weight (500 to less than 1,000 g).

Babies born at below-normal weight (low birth weight) are associated with a lower intelligence quotient (IQ) not only in childhood and young adulthood, but even at an older age. Also, IQ differences between underweight and normal-weight babies remain stable into midlife, and even within the normal birth weight range, higher weights are equated with slightly higher IQ throughout life (Curt *et al*., 2016). It was concluded by Yan *et al*. (2014) that low birth weight is directly predictive of higher risk of type II diabetes mellitus later in life. Reports showed an association between maternal caffeine intake and infant growth restriction (Rhee *et al*., 2015). This is because pregnant women have a slower caffeine metabolism than the non pregnant ones, thus caffeine intake during pregnancy may lead to miscarriage, preterm birth, and ultimately LBW. It has been documented that caffeine has been detected in the amniotic fluid, umbilical cord, urine, and plasma of foetuses, which suggests that caffeine is easily transmitted across the placenta (Goldstein and Warren, 1962; Knutti *et al*., 1981; Soyka, 1981). Furthermore, it is proven that the foetu's liver is immature, thus caffeine metabolism is deficient due to the inability of the immature foetu's liver to produce enough enzymes necessary for the caffeine metabolism; this leaves the foetus at risk of adverse outcomes including LBW (Bakker *et al*., 2010). In contrast, it has been suggested that moderate caffeine consumption (of less than 200 mg/day) during pregnancy does not seem to be a major risk factor of miscarriage or preterm birth. Also it is clear that the association between the maternal caffeine intake and infant growth restriction remains irresolute (Gynecologists, 2010). But, Greenwood *et al*. (2014) found that increasing caffeine consumption to about 100 mg/day has about 7% risk of LBW. However, Rhee *et al*. (2015), in a meta-analysis, suggested that consuming 100 mg of caffeine per day may lead to a small, but significant, increase in the risk of LBW.

Multiple pregnancies, like twin gestation, have also been found to cause LBW (Buekens and Wilcox, 1993). A maternal elevated testosterone level is associated with low birth weight in humans. Hyperandrogenism coupled with polycystic ovarian syndrome (PCOS) and pre-eclampsia have a higher prevalence of small-for-gestational age newborns. A rat model study suggests that maternal testosterone does not cross the placenta to directly suppress foetal growth but affects nutrient delivery to the foetus by down-regulating specific amino acid transporter activity (Sathishkumar *et al*., 2011). It has also been observed that high altitude may lead to the development of gastrochisis and also can cause LBW in the foetus (Payne *et al*., 2011).

The prevalence of LBW differs between developed and developing countries. In developed countries, the prevalence has an occurrence of about 7%, while that of developing countries is about 15% (Ramakrishnan, 2004). Additionally, the prevalence in the sub-Saharan Africa varies from region to region. It is about 28.3% in Ethiopia (Assefa *et al*., 2012) and 19.9% in Zimbabwe (Feresu *et al*., 2004). In Nigeria, Christopher *et al*. (2012) found the prevalence of LBW in Jos (north-central) to be 9.4%, while in Ogun (south-south) it stand at 11.4% (Olowonyo *et al*., 2006) and Takai *et al*. (2014) in Maiduguri (north-east) found the prevalence value to be 16.9%. Other unhealthy lifestyles among pregnant mothers such as smoking or ingestion of some antenatal drugs like malaria prophylaxis have been associated with increased incidence of LBW (Gao *et al*., 2006).

### 2.1.2 High birth weight (HBW)

The HBW is classified in general as birth weight of more than 4000 g (4.0 kg); this is termed as foetal macrosomia. It has been associated with the development of excess body weight during childhood and adolescence (Stettler *et al*., 2002; Monteiro *et al*., 2003; Reilly *et al*., 2005). Similarly, Rossi and Vasconcelos (2010) have concluded that HBW is associated with overweight/obesity.

The perinatal complications that arise from high birth weight may include the following:

i. shoulder dystocia
ii. brachial plexus palsy
iii. bone injuries/fracture
iv. prolonged obstructed labour
v. birth asphyxia/low Apgar scores
vi. perineal lacerations
vii. postpartum haemorrhage
viii. Cephalo-pelvic disproportion
ix. Caesarean delivery

It has also been found recently that increase in birth weight may lead to an increased incidence of childhood cancer development (Hill, 2018). Also, HBW has been shown to be associated with an increased risk of disease conditions such as obesity, cardiovascular diseases, diabetes mellitus and carcinomas (Szostak-Wegierek; and

Szamotulska, K. (2011); Cnattingius *et al*., 2012; O'Neill *et al*., 2015; Zimmermann *et al*., 2015).

## 2.2 The Apgar Score

Apgar score as created by Dr. Virginia Apgar in 1952 stands for "*Appearance* (skin colour)*, Pulse, Grimace, Activity and Respiration*" is a simple and quick method of assessing the health and vital signs of a newborn baby. It is said to be a comprehensive screening tool used in evaluating newborn's condition at birth .These five entities are used to verify the health of a new-born. It is performed at one, five, ten and twenty minutes of birth respectively, but its assessment is based on the score taken at the fifth minute.. The newborn babies are evaluated based on the five variables as:

i. heart rate

ii. respiratory effort

iii. muscle tone

iv. reflex irritability, and

v. colour

Each of the variables is assigned a value of 0, 1 or 2. Therefore a score of 0 to 3 is classified as critically low, a value of 4 to 6 indicate below normal and a value $\geq 7$ is considered generally as normal (Appendix I)

## 2.3 Placental Weight Estimation

The placenta plays an important role during intrauterine development. Impaired placental function leads to foetal growth restriction. The placenta is a transient organ that provides nutrients, endocrine signals, cytokines and growth factors that regulate embryo development. Placenta is an active organ that is able to adapt itself to metabolic perturbations in the mother with changes of its structure and function (Sandovici *et al*., 2012). Foetal weight estimation is used to monitor the status of placenta. If the foetus is too small, there may be a problem with the placenta or with the foetus and if it is too big, the mother could have either diabetes mellitus or gestational diabetes as the case may be (Baptiste-Roberts, 2008). The growth of foetus in-utero depends on the ability of the placenta to provide oxygen and nutrients to the growing foetus (Janthanaphan *et al*., 2006). Transportation of nutrients by the placenta is associated with the supply of nutrients to the developing foetus. If the transportation of nutrients is not enough the situation could lead to the impairment of foetal growth while excess transportation of nutrients could cause the developing foetus to overgrow (Jones *et al*., 2007). Absolute and relative changes in the amount of nutrients supplied to the developing foetus result

in change of the placental phenotype which is likely to have long-term consequences on health and illness during the adult period. Baschat (2004) stresses that placental function is a major cause of intra-uterine growth anomalies. The relationship between placental and neonatal weights at birth has been established in some communities (Adair and Thelander, 1925). Recently, Chandrakant *et al*. (2015) revealed that a strong relationship exists between placental and neonatal birth weights.

### 2.3.1 Placental weight measurement

An earlier study by Thomson *et al*. (1969) revealed that different measurements of the placenta have been obtained in different countries with different placental preparations. Different methods have been employed in the measurement of placental weight. These include the trimmed, the untrimmed and the partially trimmed method of measurement. The customary approach proposed by Benirschke (1961) is to weigh the placenta after the extra placental membranes and the umbilical cord are trimmed from the placental disc. This approach may limit the measurement to the weight of the placental disc, which is the actual site for nutrient exchange in the placenta. In addition, Leary et al. (2003) reported that the correlation between births and placental weights do not change when the placentae are weighed trimmed compared to when they are weighed untrimmed. Therefore, the trimmed and the untrimmed placental weights are exchangeable, based on their high correlation.

### 2.3.2 Placental size

Factors such as socioeconomic status and the race of an individual affect the placental weight; thus, the weight varies from area to area (Perry et al., 1995). Placental size could limit intrauterine foetal growth and can lower the efficiency of the placenta shortly before delivery (Fowden *et al*., 2008). Similarly, small placenta is unable to meet the needs of the foetus, this could lead to the growth restriction of the foetus, which may lead to low birth weight. It has also been established that small babies with large placentae show a higher incidence of developing hypertension later in adult life (Barker *et al*., 1990). When the placenta is large, this is mainly attributable to the accumulation of fluid in the placenta (placental hydrops). This leads to the baby becoming big (macrosomic) due to the development of diabetes mellitus by the mother, which may be related to the index pregnancy (gestational diabetes). It is established (using rat's models) that sex chromosomes have an effect on the size of placenta, with the placenta of a male newborn being larger than that of the female. And this was found to be independent of androgen effect (Ishikawa *et al.,* 2013). Van-Abeelan *et al*. (2011) reported that changes in maternal diet during pregnancy alter the correlation between the size of the placenta and hypertension during the course of pregnancy.

Meanwhile, placental weights were reported to be 537 g in Mexico (Sanin *et al*., 2001). Little *et al.* (2003) revealed a placental weight of 470 g among Americans. A value of 646 g was reported among the Chinese (Burkhardt *et al*., 2006) and 519 g in Thailand (Janthanaphan *et al*., 2006). An average placental weight of 500 g has also been reported (Inderbir and Pal, 2007; Kadasne, 2012). Sitti *et al*. (2015) reported a weight of 585g among parturient mothers who gave birth in Mother and Child Hospital Siti Fatimah Makassar City, Indonesia. Recently, Nkwabong *et al*. (2018) reported a mean placental weight value for male and female newborns among parturient mothers that delivered at maternity of the Yaoundé University Teaching Hospital, Cameroon, as 492.5 and 409.7 g respectively. However in Nigeria, placental weight was reported among mothers of consecutive live, singleton, full term babies delivered at the Wesley Guild Hospital Ilesa as 565.2 g (Adebami *et al*., 2007). A placental weight between 500 to 600 g has been earlier documented among full term babies (Sadler, 1995; Agboola, 1999).

## 2.4 Placental-Birth Weight (PW/BW) Ratio

The PW/BW ratio is obtained by dividing the placental weight (g) by birth weight (g) and thereby multiplying it by 100 [PW/BW ratio = Placental Weight (g)/Birth Weight (g) × 100]. There is a close relationship between placental weight and birth weight (Salafia *et al*., 2008) and the ratio is often used as an index of placental nutrient efficiency, which may lead to adverse perinatal outcomes, such as perinatal death, non-reassuring foetal status and low Apgar scores (Molteni, 1984; Wallace *et al*., 2013). Similarly, Lao and Wong (2001) reported an increased incidence of low Apgar score (less than 7.0) among non-diabetic mothers with high PW/BW ratio. Additionally, Shehata *et al*. (2011) documented that high PW/BW ratio is associated with the increased risk of neonatal intensive care unit (NICU) admission, low Apgar score (score of less than 7) and respiratory distress syndrome, whereas the comparison of low PW/BW ratio shows decreased risk of NICU admission and good perinatal outcome. Yoshio *et al*. (2015) observed that various factors affect the placental-birth weight ratio, such as ethnicity, gestational age, the mode of delivery, gender and the maternal parity. Therefore, these factors should be considered when evaluating the weight of placenta to ascertain whether it is heavy or not.

In an earlier study conducted by Bonds *et al*. (1984) shows that a heavy placenta in respect to the neonatal birth weight leads to an increased risk of poor pregnancy outcome. In another study conducted by Naeye (1987) it is reported that high placental weight has poor perinatal outcome such as low Apgar score, respiratory distress syndrome and perinatal death while low placental weight is discovered to be associated

with some medical complications in the mother. Barker et al. (1990) reported that alteration in placental growth predicts maternal medical disease conditions such as hypertension, diabetes mellitus and cardiovascular diseases. Agboola (1999) in Lagos, Nigeria documented placental-birth weight ratio of about one-sixth the normal weight of the newborn baby. In another separate study, Cunningham *et al*. (2005) also documented a value of 1:6 as birth weight: placental weight ratio among the newborn babies. A correlation exists between the placental weight and birth length of a neonate (Lo *et al*., 2002). This shows that placenta has a significant role in foetal growth during intra-uterine development. Janthanaphan *et al*. (2006) found that the ratio of placental weight to that of the birth weight in normal singleton pregnancies at term was approximately 1/6 (or 17%) in Thailand. In another study conducted by Lampl *et al.* (2010) it was revealed that the placental birth weight ratio is higher in male neonates compared to the female ones. This further shows that the wellbeing of the foetus is highly dependent on the placenta, since it serves as a link between the mother and the developing foetus for nutritional support, excretory functions as well as immunological and hormonal support. A study conducted by Eskild *et al*. (2009) revealed that placental weight is heavier than birth weight in babies delivered with low birth weight. Furthermore, it was documented by Abubakar *et al*. (2012) that an association exists between birth weights and the weight of the placenta weight among the neonates in Nigerian hospitals. Moreover, of more recent, Nkwabong *et al*. (2018) concluded that the mean placental birth weight ratio among the male and the female neonates is 12.8% and 16.9% in non-anaemic and anaemic pregnant women respectively.

## 2.5 Maternal Characteristics

Maternal anthropometric characteristics have long been used in the indirect clinical assessment of foetal weight (Mongelli and Gardosi, 1999). Low socio-economic status is one of the underlying causes of LBW. Additional causes may include maternal malnutrition; maternal diseases like antepartum hemorrhage, anaemia, cervical incompetence; adolescent pregnancies; short birth intervals; intrauterine infections; multiple gestation; congenital malformations and placental dysfunction. In a more recently concluded work, Amosu *et al*. (2014) concluded that maternal age, parity, height, occupation, level of formal education and socioeconomic status are associated with birth weight. Furthermore, it has been observed that towards the last end of the pregnancy (third trimester), the foetal weight is highly influenced by some maternal factors (Adediji *et al*., 2015). Additionally, it has been documented that adequate maternal nutrition during pregnancy is vital for foetal growth (Nnam, 2015).

### 2.5.1 Maternal age

The rate of low birth weight decreases considerably with the increasing age of mothers after 19 years of age (Samarin *et al*., 2006; Kiran *et al*., 2011). Similarly, an earlier report has documented that there is an increased risk of low birth weight among young mothers less than 20 years as compared to mothers above 20 years of age (Adamson, 2007). Rocha *et al*. (2010) reported that the age of the mother is a significant factor that leads to low birth weight. A number of studies have concluded that mothers aged 35 years and above are more prone to having low birth weight babies (Amin and Sampathkumar, 1993; Fraser *et al*., 1995; Astolfi and Zonta, 2002; Khoshnood *et al*., 2004; Machado, 2006). A study conducted by Haavaldsen *et al*. (2011) found the existence of association between the maternal ages with the placental weight.

### 2.5.2 Maternal parity

It has been acknowledged that maternal parity is an important factor that influences the incidence of LBW (Shah, 2010). Other authors have found that a positive correlation exists between parity and birth weight (Arild *et al*., 2010). In some studies, it has been reported that the first parity (first born) had a higher incidence of low birth weight (Murphy and Mulcahy, 1971; Dowding 1981; Dougherty and Jones, 1982; Van Roosmallen, 1988). Kiran *et al*., (2011) concluded that preterm birth (i.e. birth occurring prior to 37 weeks of gestation) is associated with high parity.

### 2.5.3 Maternal educational level

It has been reported that women with higher education level give birth to normal birth weight babies than women with low education levels (Arif *et al*., 1998). Khan *et al*. (2013) reported that the frequency of low birth weight decreases with an increase in maternal educational level. In a study conducted by Metgud *et al*. (2012), it is realised that maternal illiteracy, exposure to passive smoking, late child bearing, shorter inter-pregnancy interval, previous low birth weight baby, maternal weight, weight gain during pregnancy, pregnancy induced hypertension, high risk pregnancy and late antenatal registration form the risk factors significantly associated with the birth weight of a newborn. Currie and Moretti (2003) documented a fundamental effect of maternal education on birth weight and found a strong correlation exists between maternal education and weight at birth in that the maternal education affects birth weight by improving the probability and/or productivity of health investment. Additionally, maternal education improves the financial resources available to the child, directly and indirectly through the choice of partner, timing of fertility, and number of offspring in developed countries (Behrman and Wolfe, 1989; World Bank, 1993). Similarly, many factors such as genetics, gestation duration and foetal growth are found to be among the leading factors that affect birth weight. Other identified risk factors such as smoking,

nutrition, alcohol consumption, coffee intake, frequency of visits to ante natal clinic, physical and emotional stress during pregnancy are all found to be associated with neonatal weight at birth. However, among these factors that affect birth weight, smoking during pregnancy is the one that is preventable. Therefore, since all these factors are within the control of the mothers, improving maternal education can be seen as a potential instrument for the improvement of birth weight and the possible prevention of birth defects (Arnaud and Vincent, 2007).

### 2.5.4 Antenatal care utilization

Women who receive antenatal care (ANC) services tend to give birth to normal weight babies more than those who do not receive antenatal care services (ANC). Sitti *et al*. (2015) established that placental weight is influenced by the utilization of ANC, maternal age and the intake of vitamin C. The utilization of ANC services has a significant relationship with placental weight, is but negatively related with increased (more frequent) ANC visits (Asgharnia *et al*., 2008). This further shows that the utilization of high quality ANC services does not guarantee superior outcome of the pregnancy. Also, the average placental weight is four times higher in pregnant women who attend ANC services more regularly. Therefore, the frequency of ANC visit is an important point to note by health workers in providing the ANC services to pregnant women. The ANC services do not limit themselves providing five types of services namely, height and weight body measurements, blood pressure measurement, fundus height measurement, tetanus toxoid immunization, and the provision of iron-folic acid tablets, but also educate pregnant women on nutrition and healthy living. It has also been documented that pregnant women who gave birth to neonates with less heavier (lighter) placenta were more commonly found among pregnant women who attended ANC more than four times (Amiruddin, 2007; Sitti *et al*., 2015). All the hospitals in which this study was carried out (in Kano State-Nigeria) practice "focus ANC visit" which implies pregnant women visit the facility four times only before delivery.

In contrast to the relationship between ANC visits and placental weight, Takai *et al*. (2014), Mbuagbaw and Gofin (2011) have stressed that the frequency of ANC visits and parity is significantly associated with birth weight. In a separate study, it is observed that pregnant mothers who attended less than four ANC visits double their risk of delivering LBW babies compared to those visiting it four or more times (Mohanty *et al*., 2005; Janjua *et al*., 2008). Furthermore, studies have found that the prevalence of LBW is high, up to 57 to 61% among mothers who received no ANC (Idris *et al*., 2000; Joshi *et al*., 2005). Additionally, pregnant mothers with irregular ANC visits and those who have poor compliance with ANC prescribed medications are believed to have an increased incidence of LBW delivery (Agarwal *et al*., 2011).

### 2.5.5 Area of Residence (location)

Separate studies conducted by Nair *et al*. (2000); Acharya *et al*. (2004) have emphasized that significant associated risk factors for the birth weight of a newborn, vary according to geographical location and study population. In a study conducted by Michael *et al*. (2013) it is shown that mothers in rural areas tend to give birth to low birth weight babies than women who live in urban areas. Recently, it has been shown that the mother's residence is strongly associated with LBW, as mothers residing in rural areas are discovered to be four times more likely to have LBW babies compared to those who live in urban areas (Meresa *et al*., 2015).

### 2.5.6 Anaemia in Pregnancy (Hb concentration)

Anaemia in pregnancy has been defined as Hb concentration of less than 11 g/dl or Hb concentration of 10.5 g/dl in the second trimester of gestation (Goonewardene *et al*., 2012). Furthermore, in some pregnant women, haemodilution may markedly appear in early pregnancy; in this category of pregnant women, anaemia in pregnancy can be defined as Hb concentration of less than 10 g/dl (Levy *et al*., 2005; Grewal, 2010). Anaemia in pregnancy has prevalence as high as 56 to 61% in developing countries (Badshah *et al*., 2008). However, in a more recent study, the prevalence is found to be 30 to 65% in Africa (Ali *et al*., 2011; Barroso *et al*., 2011; Koura *et al*., 2011; Olubukola *et al*., 2011). Studies conducted by Beischer *et al*. (1970), Kosanke *et al*. (1998), Nkwabong *et al*. (2018) concluded that, anaemia during pregnancy is capable of inducing hyperplasia and hypertrophy; thus the reason for the increase of placental weight among anaemic parturient mothers. Women may develop anaemia during pregnancy because the growing foetus may draw upon the mother's iron for the development of red blood cells (RBCs) and other tissues (Lone *et al*., 2004). Iron deficiency anaemia during pregnancy can also develop from repeated (too close) pregnancies; it can also be caused by the lack of iron in the diet. Anaemia in pregnancy has also been found to be an important risk factor for neonatal morbidity (Borja and Adair, 2003; Valero De Bernabé *et al*., 2004). A strong relationship exists between maternal anaemia and low birth weight (LBW) babies (Malhotra *et al*., 2002). It has been observed that, LBW among anaemic pregnant women is due to decrease in oxygen supply to the developing foetus (Giussani *et al*., 2007). Earlier report (Ghosh *et al*., 1977) has shown that reduction of haemoglobin (Hb) level during pregnancy leads to LBW. The link between maternal anaemia in pregnancy with increased risk of LBW babies has been established (Muhammad *et al*., 2011). The study has also revealed that anaemia in pregnancy has continued to be a source of concern. It has been documented recently that anaemia in pregnancy, low socioeconomic status, maternal height and weight are significantly associated with low birth weight (Khan *et al*., 2016).

### 2.5.7 Maternal Blood Pressure [B.P. (mmHg)]

Blood pressure (B.P.) is recorded routinely during the first and subsequent antenatal visits. It is mostly recorded using the Korotkoff phase IV heart sound. Reports have shown that heart sounds could be heard almost down to 0 mm Hg in a proportion of pregnant women (MacGillivray *et al*., 1969; Davey and; De Swiet, 1991; Perry *et al*., 1991). However, there has been a gradual change to using the Korotkoff phase V heart sound (Shennan *et al*., 1996; Lenfant, 2001). It has been reported that post-natal weight gain may have a higher effect on blood pressure than birth weight (Back *et al*., 2005; Primatesta *et al*., 2005; Bowers *et al*., 2011; Visentin *et al*., 2014). Moreover, low blood pressure during pregnancy may lead to poor placental perfusion which in turn leads to increase placental weight (Philip *et al*., 2004). It has been documented severally that during the course of pregnancy, both low and high diastolic blood pressures in women are associated with small for gestational age babies whose condition lead to an increase risk of perinatal mortality. The B.P. in pregnant women without pre-existing hypertension or pre-eclampsia falls slightly during the first half of pregnancy, but then rises from around 34 weeks of gestation onwards, suggesting a physiological mechanism (Reiss *et al*., 1987; Clapp *et al*., 1988; Halligan *et al*., 1993; Brown *et al*., 1998). Philip *et al*. (2004) has documented that a diastolic blood pressure (DBP) of 70 mmHg and above, but not exceeding 10 mmHg increments at the first ANC visit (ANC booking), is found to be associated with HBW. When the DBP raises greater than 10 mmHg, BW falls sharply. If the B.P. at booking is less than 70 mm Hg, BW too rises and as the rise becomes greater, it starts to fall again if the rise exceeds 30 mmHg.

## 2.6 Maternal Anthropometric Parameters

### 2.6.1 Maternal height

Recently, maternal anthropometric parameters such as maternal height, mid upper arm circumference and weight have been used to predict poorer birth outcomes (Sachiko *et al.*, 2016). A strong correlation exists between maternal height and birth weight (Hussain and Omololu, 1983). Similarly, an earlier study reported an existence of correlation between BW and maternal anthropometric parameters that is age of the mother, maternal parity and gestational age (Nyaruhucha and Msimbe, 1993). Several studies have emphasised that short maternal height is associated with reduced foetal growth and low birth weight (Kramer, 2003; Jananthan *et al*., 2009; Ozaltin *et al*., 2010; Wills *et al*., 2010). In a study conducted by Witter and Luke (1991), it is reported that new born babies born to shorter mothers are often symmetrically smaller than those born to taller mothers in United States.

### 2.6.2 Symphysio-fundal height

Symphysio-fundal height (SFH) can be used to estimate foetal weight objectively using a non elastic tape measure (Johnson and Toshach, 1954; Johnson, 1957; Bailey *et al*., 1989; Jeffery *et al*., 2001). Estimated foetal weight (EFW) using fundal height was shown to have comparable accuracy to that using ultra sound (Mongelli and Gardosi, 1999). Minimal experience is required to identify the upper edge of the pubic symphysis and the highest point on the uterus (fundal height). No simple formula that converts SFH measurement into foetal weight exists. However, Johnson formula is the only formula frequently quoted, where birth weight calculated in g as (SFH in cm – 13) × 155, with further adjustments (Johnson, 1957). The SFH measurement is a common screening method used to estimate gestational age and foetal growth after 24 weeks gestation. However, it is worth noting that the sensitivity of SFH measurement for detecting abnormal intrauterine growth is less than 35% (Sparks, 2011). Roex *et al.* (2012) observed that the sensitivity of SFH measurement for detecting foetal growth abnormalities could be improved by the serial plotting of the SFH on customized charts. Similarly, sonographic estimation of foetal weight prenatally is used together with weight tables to evaluate foetal growth. Correct evaluation depends on the accuracy of the gestational age being used, the precision of the weight measurements, and using a weight curve that represents the population being studied. A study conducted in South African found a good correlation of intrapartum SFH measurement with birth weight and a regression equation formulated. However, the researchers involved in the study have admitted that the derived formula was not sufficiently accurate to be clinically useful (Bothner *et al*., 2000). A simple formula was derived using SFH by Eckhart and Karabo (2009) among a population in South Africa. The formula may be useful for intrapartum use in term pregnancies to identify those parturient mothers at risk of developing cephalo-pelvic disproportion (CPD) or shoulder dystocia.

## 2.7 Neonatal Anthropometric Parameters

Anthropometric parameters at birth are considered to be of great value. Though study on anthropometric parameters on neonate in Kano State had been undertaken in the past (Modibbo *et al*., 2013; Datti *et al*., 2016), to the best of our knowledge, so far there has not been any study conducted on several neonatal anthropometric parameters at a time among the neonates of Kano State. Here, an attempt has been made to study maximum anthropometric parameters on neonates at a time so that an idea can be gotten on these parameters. According to a research carried out by Jagadish (2012), the mean birth weight stood at 2,770 g and approximately 47% of the babies manifested of low birth weight (less than 2500 g). In the same study, the observed mean birth length among the term neonates regardless of gestational age stood at 48.1 cm and the average length for term babies was found to be 49.4 cm. Values of observed mean mid arm circumference, head circumference, chest circumference, abdominal girth and calf circumference were 9.6 cm, 33.7 cm, 30.2 cm, 27.7 cm and 10.1 cm respectively. All anthropometric

parameters manifested themselves more in male than in female neonates. In another study carried out by José *et al*. (2014), sex-specific observed and smoothed centiles for birth weight, birth length, and head circumference for gestational age at birth were calculated. It was established that observed and smoothed centiles were almost identical.

Suneetha and Kavitha (2016) studied the relationship between birth weight and various anthropometric parameters among 500 neonates in Niloufer Hospital, Hyderabad. The mean thigh, mid arm, head and chest circumferences were found to be 14.5 cm, 9.5 cm, 32.7 cm and 30.7 cm respectively among the newborn babies. However, the birth weight was recorded as 2.6 kg. Similarly, Srinivasa *et al*. (2017) studied the relationship between foot length and other anthropometric parameters among the neonates delivered at Kempegowda Medical Institute, India, birth weight, head circumference, chest circumference, birth length and foot length were recorded as 2.74 kg, 33.51 cm, 31.04 cm, 47.84 cm and 7.58 cm respectively.

## 2.8 Ponderal Index

Birth weight and length can be assessed at birth and used to calculate a Ponderal index standardized for gestational age at birth. Rohrer's Ponderal index (PI) in newborn babies is determined as a ratio of birth weight (g) and birth length ($cm^3$). That is "PI = Birth Weight (g)/Birth Length $cm^3 \times 100$)". The method has been used as an indicator of foetal growth status, especially to assess asymmetrical intrauterine growth retardation (Muin *et al*., 1990). The PI is a useful parameter used for the identification of impaired foetal growth in-utero. It can be said to be a measure of body weight (physically correct body mass) in relation to the body size, similar to the body mass index (BMI) in adults. However, in contrast to BMI, the body mass (weight) is divided by the third power of the body size (length), i.e. to a (fictive) volume instead of to a surface. It therefore, gives a more fair comparison between neonates of different stature (birth length). Furthermore, the terms high birth weight, low birth weight, very low birth weight or extremely low birth weight used in describing some alterations in body composition in-utero cannot identify some alterations in body composition that might be identified by the ponderal index (Caiza *et al*., 2003).

The PI value of less than 2.00 $g/cm^3$ in newborn babies that were delivered between 29 to 37 weeks of gestation is indicative of intrauterine foetal malnutrition, and these babies are also known as disproportionate. However, in pregnancies beyond 37 weeks gestation, a value less than 2.25 $g/cm^3$ is considered as intrauterine foetal malnutrition (Dure and Fehmina, 2005). It has been found that individuals with a high ponderal index at birth are at a significantly decreased risk for a diagnosis of generalized anxiety disorder based on the Diagnostic and Statistical Manual of Mental Disorders (DSM) criteria compared to individuals with a lower PI (Curt, *et al*., 2016).

# CHAPTER 3

## 3.0 MATERIALS AND METHODS

### 3.1 Materials

#### 3.1.1 Study design

This is a prospective, cross-sectional, hospital based study conducted among the deliveries at the six selected hospitals within Kano State from November 2017 to May 2018. The selection of the hospitals was done using simple random sampling (SRS) by listing the hospitals in each of the senatorial zones which formed the sampling frame. A random number was chosen using the random number table (Appendix II), and the six hospitals were selected accordingly. The participants were selected using consecutive sampling technique. All measurements were recorded on the designed proforma (Appendix III).

#### 3.1.2 The study area

Kano State is located between latitude 12.2º North and longitude 9.4º East with the Kano city as the State capital. At present, the State is the most populous in Nigeria, with over 9,000,000 people (National Population Commission, 2006). Mainly Hausa and Fulani tribes reside in the State. The urban Fulani have been absorbed into Hausa community through intermarriage over many centuries and as such are been considered as Hausa by tribe. The vast majority are Muslims by religion.

### 3.1.3 The study location

The study was conducted in three hospitals within Kano metropolis (urban centres) and one hospital from each of the three senatorial zones (rural centres). Among the hospitals situated in the urban area (those within the Kano metropolitan area) are:

i. Murtala Muhammad Specialist Hospital. It registers (on average) about 1,000 birth per month and takes the delivery of about 33 to 38 per day [Labour ward statistics (appendix IV)]. The hospital serves as a referral centre from the other hospitals within and outside the state.

ii. Nasarawa (Muhammad Abdullahi Wase) Specialist Hospital is also situated within the metropolis but outside the ancient city of Kano. The hospital is a government (private) hospital, which recently (precisely in 2017), was converted into a teaching hospital for the training of resident doctors. The hospital mainly serves the elites of the State. It takes about 650 delivaries per month on average.

iii. Sabo Bakin-zuwo (Jakara) Maternity Hospital is also situated within the ancient city of Kano. It serves the masses within its locality, and refer patients with complication(s) to any of the referral centres within the State. Averagely, it takes about 400 deliveries per month.

Among the hospitals in the three senatorial districs, the selected hospitals are:

i. Bichi General Hospital situated in Bichi Local Government in Kano North Senatorial Zone. The hospital is located at about 45 km from Kano City. It serves the people within the Local Government.

ii. In Kano South Senatorial Zone, Kura General Hospital is the selected one. Kura town is about 35 km from Kano city, and the hospital caters for the people

within and aroud Kura town. It takes on average about five deliveries per day, and refers any case with complications to the referral hospital.

iii. Gaya General Hospital is situated in Gaya town in Kano East Senatorial Zone. It is about 40 km from Kano and the hospital serves the people of Gaya Local Government and its environs. The maternity unit of the hospital takes about three to five deliveries per day. Also the hospital refers any case with complication to an appropriate referral centre.

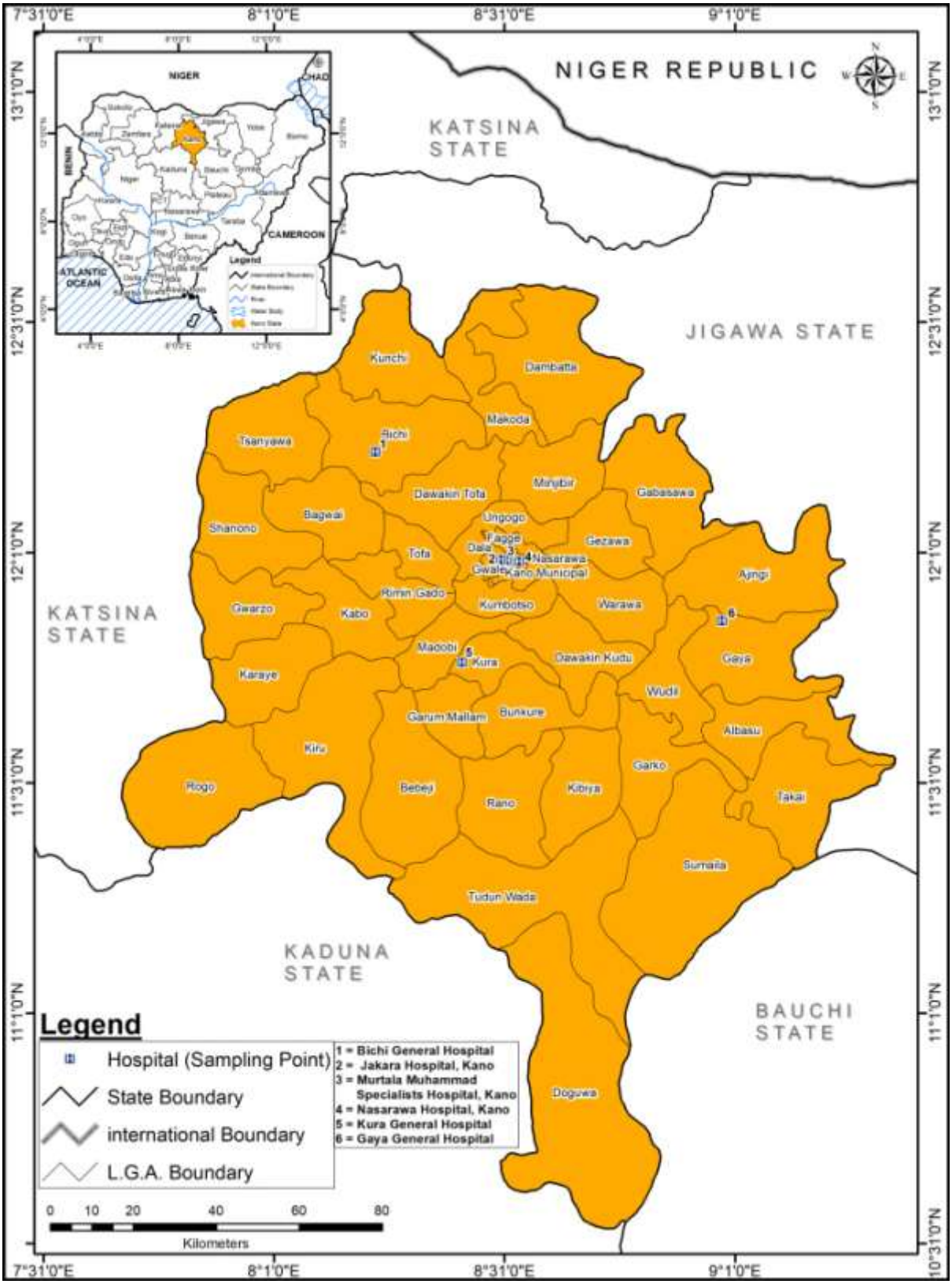



**Figure 3.1**: The study location

**Source:** Map Gallery, Geography Department, ABU Zaria, 2019

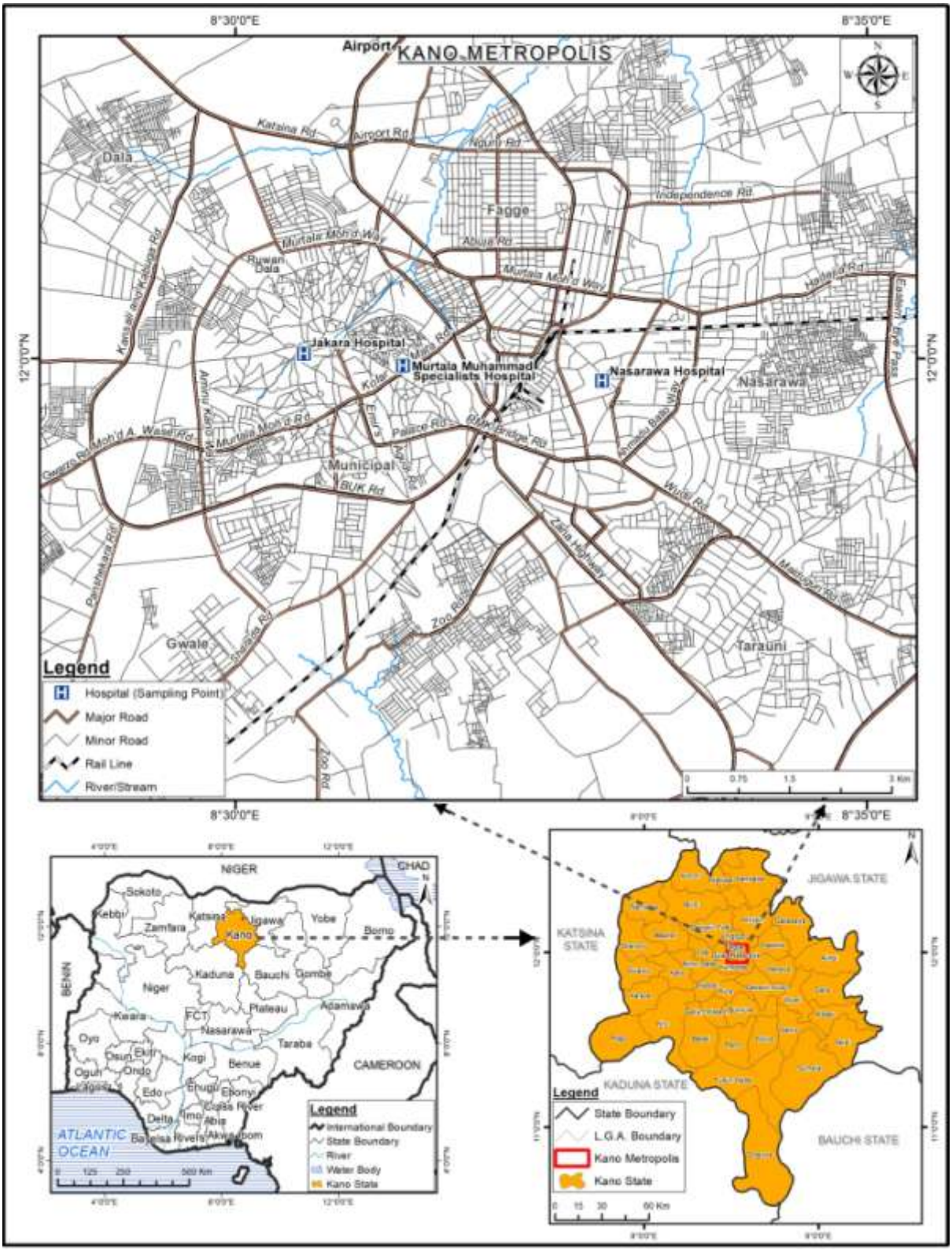



**Figure 3.2:** Urban study locations

**Source:** Map Gallery, Geography Department, ABU Zaria, 2019

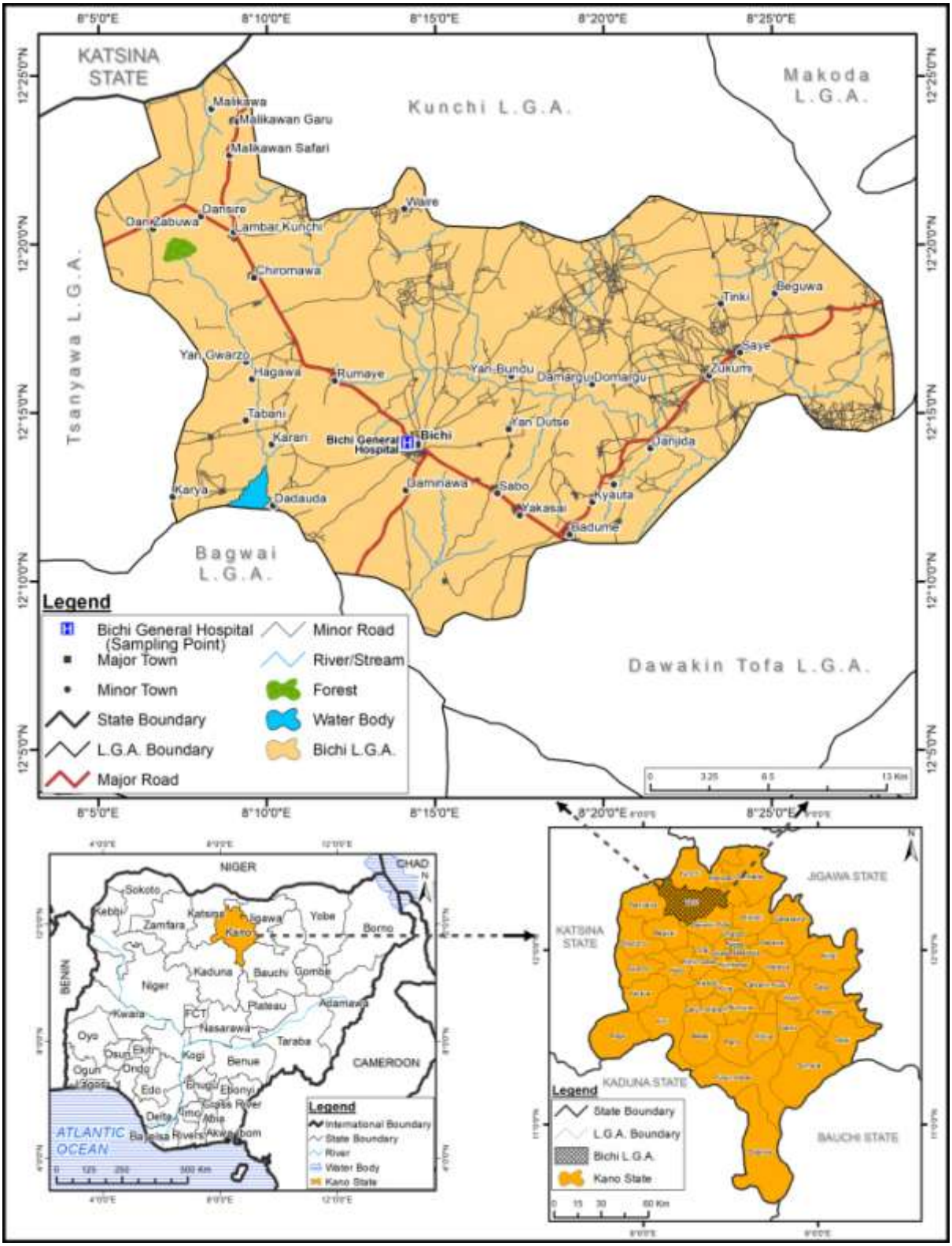



**Figure 3.3:** Bichi L.G.A. study location

**Source:** Map Gallery, Geography Department, ABU Zaria, 2019

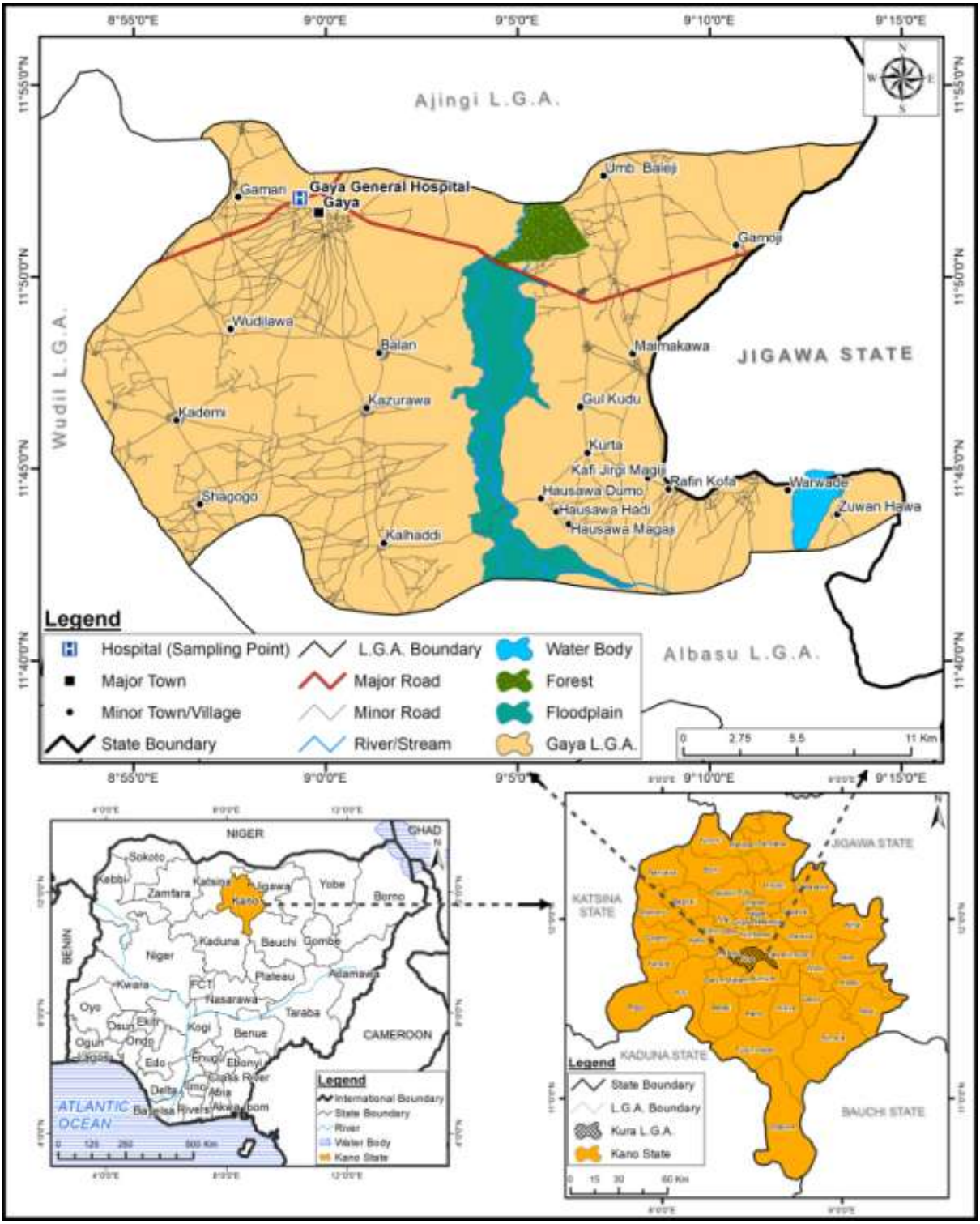



**Figure 3.4:** Gaya L.G.A. study location

**Source:** Map Gallery, Geography Department, ABU Zaria, 2019

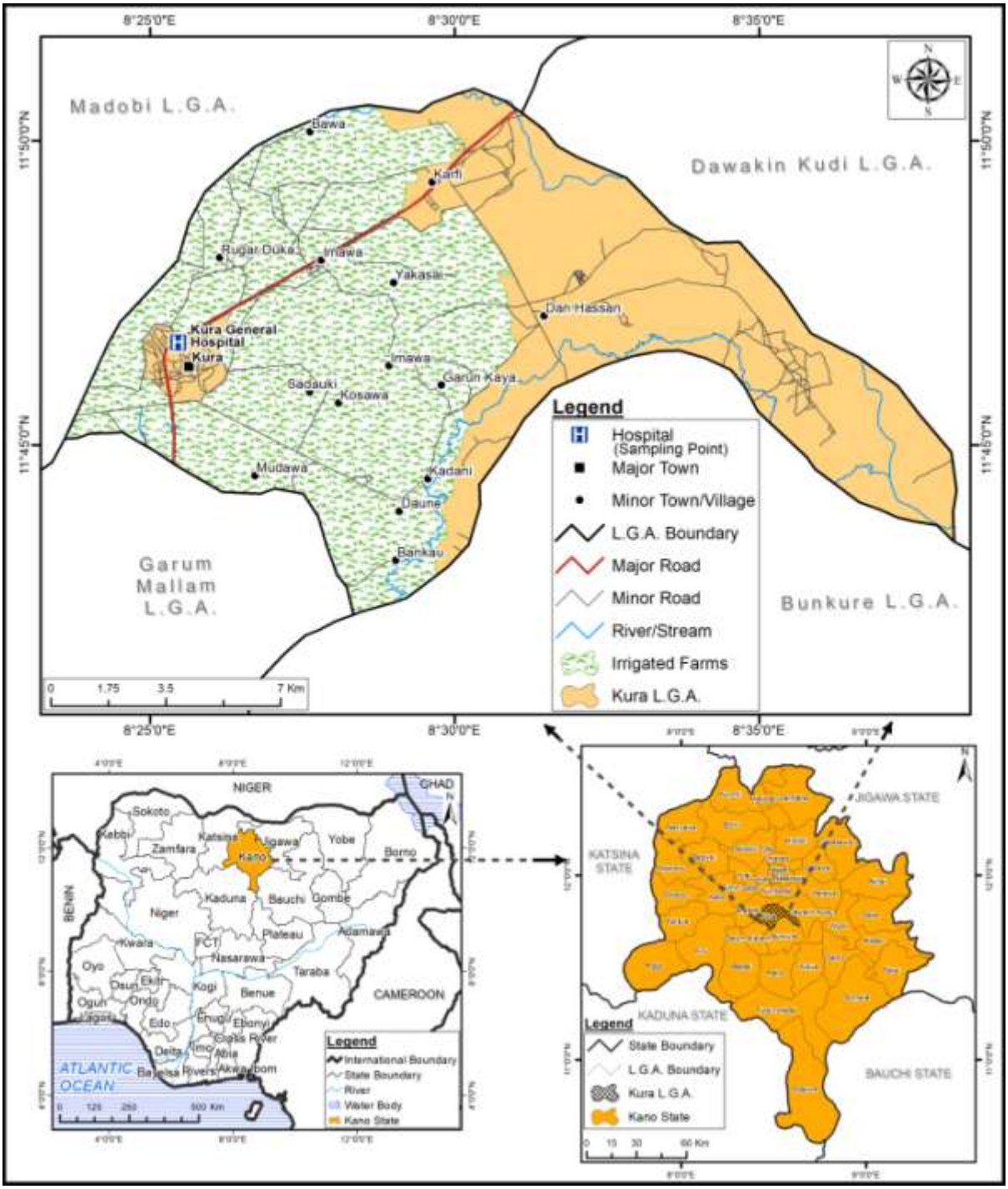



**Figure 3.5:** Kura L.G.A study location

**Source:** Map Gallery, Geography Department, ABU Zaria, 2019

### 3.1.4 Sample size determination

Many parameters were considered in the process of selecting the sample size ($n_o$). The sample size was determined using the Cochran formula as:-

$$n_o = \frac{Z^2Pq}{e^2}$$ [(Cochran, 1957, as cited in Pourhoseingholi, 2013)

(Appendix VIII a)]

Values were substituted using a proportion of the target population as 50% (0.5), as follows

$$n_o = \frac{(1.96)^2 \times 0.5 \times 0.5}{(0.05)^2} \approx \mathbf{384}$$

The minimum number of subjects for the study to allow meaningful statistical analyses of the results is 384. However, 1,203 subjects were enrolled for the study (for precision).

### 3.1.5 Consent

The study subjects were recruited from the parturent mothers brought to the hospitals. The subjects were briefed on the study and its likely outcomes as it appeared on the consent form (Appendix V). Recruitment for the study was only made upon signing the written consent form (by the mothers).

### 3.1.6 Selection of participants

Recruitment of the participants was done from the successive admissions in the delivery units of the selected hospitals (Arild *et al*., 2010). Therefore, it was only those who fulfilled the criteria below that were considered eligible to get involved in the study.

### 3.1.7 Inclusion/Exclusion criteria

#### *3.1.7.1 Inclusion criteria:*

i. entire recognizable dwelling period of at least a year

ii. signing of a written consent form (by the mother)

iii. single full term-babies (of 37 completed weeks)

iv. babies delivered within 24 hours (one day)

v. babies delivered without any physical deformity

vi. apparently normal pregnancy

***3.1.7.2 Exclusion criteria:***

i. babies delivered prematurely

ii. mothers with multiple gestation

iii. neonates older than one day

iv. mothers with pregnancy related hypertension (at the time of presentation) i.e. PIH, preeclampsia, eclampsia (convulsion during labour), bleeding or retained placenta

### 3.1.8 Equipment used in data collection

The following equipment were used for the study:

i. digital baby weighing scale (EBSA-20, Kologn Industrial Limited, China)

ii. compact bowl digital scale (LB-3000, American weigh scales Inc., China)

iii. stadiometer (ZT – 160, Seca, USA)

iv. sphygmomanometer (Accoson, A.C. Cossor and Sons (surgical) Ltd., England)

v. non-elastic measuring tape (Butterfly, Chinese Butterfly Company, People's Republic of China)

vi. plastic meter rule (TR15, Bestlink rule, China)

vii. tallquist hemoglobin scale (R. Terry, Rub. Terry ind. and co. Ltd, Long island, New York, United States of America)

viii. combi – 2 urinalysis reagent strips (Medi – Test Combi-2, BHR Pharmaceuticals Ltd., UK)

ix. lancets

x. skin pencil

xi. disposable hand gloves




**Plate I:** Digital weighing scale

**Model:** EBSA-20

**Manufacturer:** Kologn Industrial Limited

**Location:** China




**Plate II:** Compact bowl digital scale

**Model:** LB-3000

**Manufacturer:** American weighing scales Inc.

**Location:** China



**Plate III:** Stadiometer

**Model:** ZT – 160

**Manufacturer:** Seca

**Location:** USA

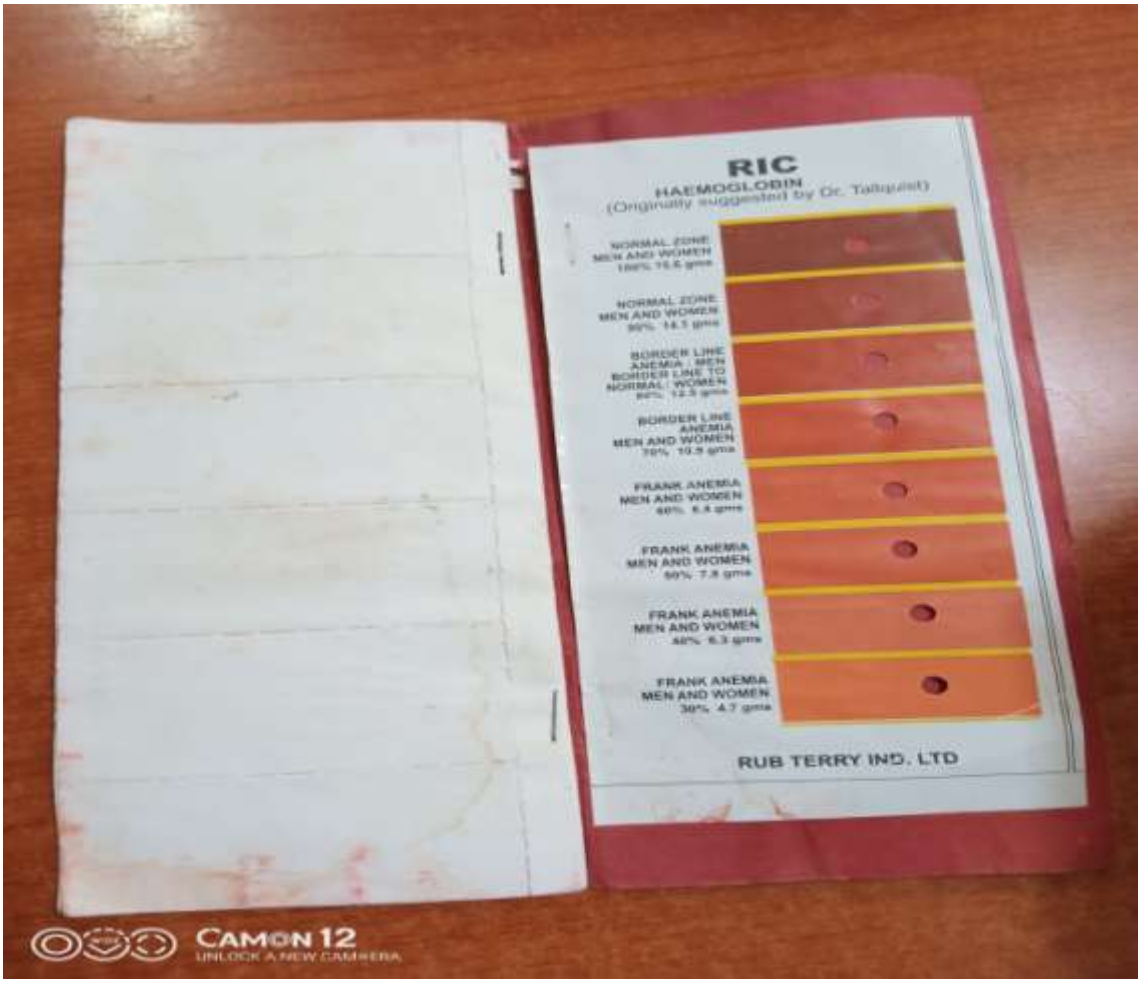



**Plate IV:** Tallquist hemoglobin scale

**Model:** R. TERRY®

**Manufacturer:** Rub. Terry ind. and co. Ltd;

**Location:** New York, United States of America



**Plate V:** Non-elastic measuring tape

**Model:** Butterfly

**Manufacturer:** Chinese Butterfly Company

**Location:** People's Republic of China




**Plate VI:** Combi-2 test strip

**Model:** Medi – Test Combi 2

**Manufacturer:** BHR Pharmaceuticals Ltd.

**Location:** UK.




**Plate VII:** Sphygmomanometer

**Model:** Accoson

**Manufacturer:** A.C. Cossor and Sons (surgical) Ltd

**Location:** England




**Plate VIII:** Plastic meter rule

**Model:** TR15

**Manufacturer:** Bestlink rule

**Location:** China

## 3.2 Methodology

### 3.2.1 Ethical consideration

The proposal passed through the Ahmadu Bello University Committee on Use of Human Subjects for Research (ABUCUHSR) and was then presented to and approved by the Ethical and Scientific Committee of Kano State Ministry of Health [MOH/Off/797/T.I/683 (Appendix VI)].

### 3.2.2 Data collection

In each of the selected hospitals, two research assistants (which are regular, and full time midwives) working in the delivery room, were trained on the standard procedures of measuring and recording the selected parameters on a proforma (Dure and Fehmina 2005).

### 3.2.3 Maternal characteristics recording

Mothers who fulfilled the inclusion criteria were included in the study. However, about twenty eight women (approximately 2%) declined participating in the study (Appendix VII). Information obtained from the mothers was recorded on the proforma as:

i. **Maternal age** (MA).

The age of the mothers was asked and recorded in years as at the last birth day.

ii. **Maternal parity (MP).**

Information about the MP was gotten from the mothers. This relates to how many time(s) she has delivered, regardless of whether the child (ren) is/ are alive now or not.

iii. **Antenatal care (ANC) attendance.**

The ANC information on the mothers attendance to antenatal clinic during the index pregnancy or not was gotten from the antenatal card records. Providing the antenatal card at point of delivery signifies attendance, while not providing the card (without valid evidence) signifies non attendance.

iv. **Location (Area of residence).**

This is the area of residence, whether rural or urban (level of urbanization).

v. **Haemoglobin concentration (Hb) estimation.**

The haemoglobin testing was made with R. TERRY haemoglobin scale (Rub. Terry ind. and Co. Ltd) using Tallquist absorbent paper. It requires a small (a drop) sample of easily obtained blood. Before the blood was taken, the middle finger was wiped with a swab dumb in a methylated spirit and allowed to air-dry. Then the palm side of the end of the middle finger was pricked with a sterile, non-reusable, self-retractable lancet and a drop of blood was collected using a Tallquist absorbent paper. The Tallquist absorbent paper was slowly brought in contact with the drop of blood. Next the paper was compared with the haemoglobin scale by holding it against the opening on the haemoglobin scale. Each hole has a different colour which can be compared with the colour of the blood on the absorbent paper. The haemoglobin scale can read the haemoglobin level of 4.7 g to 15.6 g (equivalent to Hb or PCV of 14.1 to 46.8% respectively). All the readings obtained were converted and recorded in g/dl.

**vi. Urinalysis.**

A urine test strip or dipstick test is a basic diagnostic tool used to determine pathological changes in a person's urine in standard urinalysis (Yetisen, 2013). In this study, urine glucose level was measured using Combi-2 test strips. The test strips consist of a ribbon made of paper of about 5 mm wide. The strips reactants are absorbed directly onto the paper, which are specific to glucose and protein. The urinalysis test was performed by collecting about 30 to 60 mL of urine sample from the pregnant mother in a specimen container. The sample was collected from spontaneous mid-stream urine or through the urethral catheter (when the pregnant woman cannot produce the urine spontaneously). The strip was immersed in and then removed from the urine sample. The detection of glucose by test strips is based on the enzymatic reaction of glucose oxidase. The glucose oxidase is an enzyme that catalyses the oxidation of glucose by atmospheric oxygen to form D-glucono-δ-lactone and hydrogen peroxide. A second linked reaction, mediated by a peroxidase, catalyses the reaction between the peroxide and a chromogen (a substance that acquires colour after a chemical reaction) to form a coloured compound that indicates the glucose concentration.

**vii. Maternal blood pressure**

The blood pressure (B.P.) was taken with a mercury sphygmomanometer about 5 to 10 minutes from the time the pregnant mother walked into the labour ward. The cuff of the sphygmomanometer was tired about 2 cm above the elbow joint. The B.P. was measured on two occasions with an interval of five minutes between the measurements. Two readings were taken–the "systolic" pressure was recorded as the heart beats, and the second "diastolic" reading was taken during the "rest" between beats. The mean of the last two measurements was used (Atuahene *et al*., 2015).

### 3.2.4 Maternal and neonatal anthropometric measurements

All the maternal and neonatal parameters were taken using standard techniques (Jelliffe, 1966; Sharma *et al*., 1988); and by using the left side of the body (Martin and Sallar, 1959; Allbrook, 1961). The measurements were taken within 24 hours of delivery using the same (identical) equipments provided to all the sites (Chandrashekar *et al*., 2008; Cheikh-Ismail *et al*., 2013). The measurement procedures were standardized based on the World Health Organization's (WHO) recommendations to ensure maximum validity (de Onis *et al*., 2004). During the standardization sessions, the intra observer and inter observer error of measurement values for the measured neonatal and maternal anthropometric parameters were done by the same or different person as appropriate (i.e. intra and inter observer error). This is done by obtaining a sample of 10 neonetes at random; the results obtained were tested using Pearson's correlation (r). Values greater than 70% were accepted and recorded, while values less than 70% were repeated twice and even thrice where appropriate (Cheikh-Ismail *et al*., 2013).

### 3.2.5 Maternal anthropometry

The maternal anthropometric parameters were measured before delivery (Talat *et al*., 1991) as:

**Maternal height (MH)**

The maternal height was taken using ZT-Seca stadiometer with minimal clothing. The pregnant mother was asked to maintain an upright and erect posture with her feet together (Frankfort position). Height was measured in cm as a straight distance between the head and the barefoot. This was done by lowering the horizontal headpiece that is attached to the stadiometer onto the woman's head. Reading was recorded to the nearest cm (Ozaltin *et al*., 2010).




**Plate IX:** Measurement of maternal height using stadiometer (ZT – 160, Seca, USA)

**Maternal arm circumference (MAC)**

The MAC was measured using a non elastic plastic measuring tape as a distance mid way between the tip of the shoulder (acromium) and the tip of the elbow (olecranon process); this is in line with Meresa *et al*. (2015). The measurement was done by bending the examination hand at the elbow joint. With the arm hanging straight down, the tape was wrapped up around the arm at the midpoint mark. Measurement was recorded to the nearest 1 cm in the proforma.

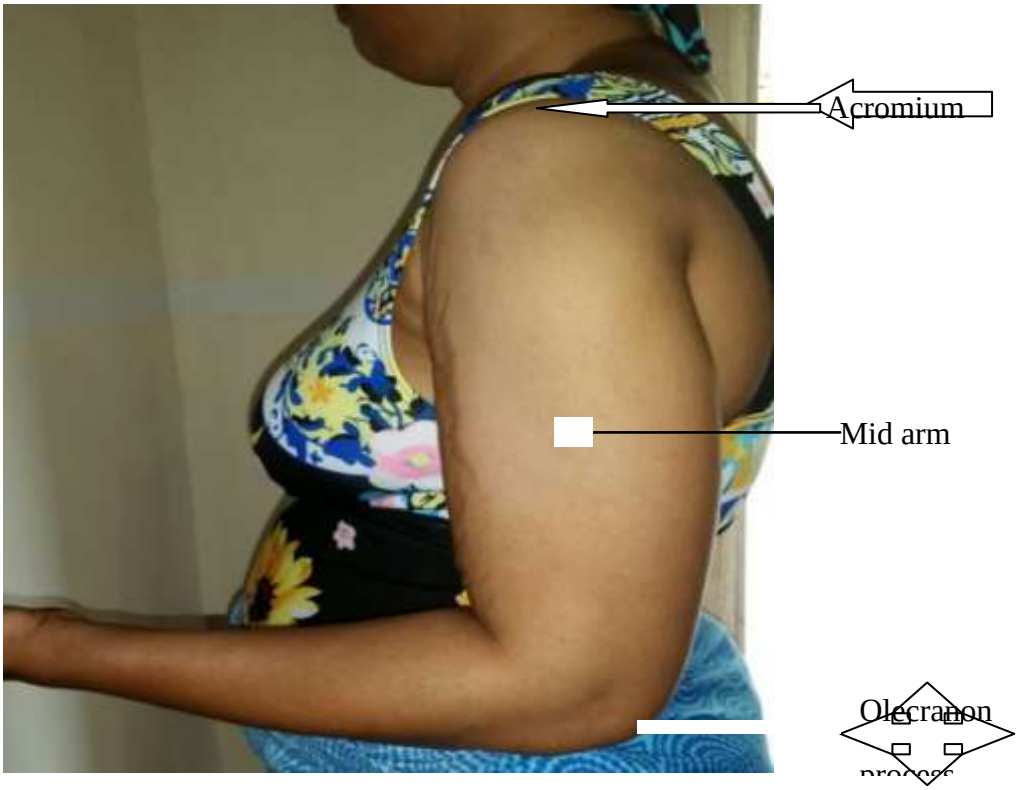



**Plate X a:** Land marks for the measurement of maternal arm circumference.




**Plate X b:** Measurement of maternal arm circumference using non-elastic tape.

**Symphysis-fundal height (SFH)**

The SFH was measured with a non-elastic plastic measuring tape as the distance between the symphysis pubis and the highest point of the uterine fundus, with the mother in supine position. The measurement was made from the upper edge of the symphysis pubis following the curvature of the abdomen with the tape; the upper hand was placed firmly against the top of the fundus with the measuring tape passing between the index and middle fingers. Readings were taken from the perpendicular intersection of the tape with the fingers **(**Mallikarjuna and Rajeshwari, 2015).

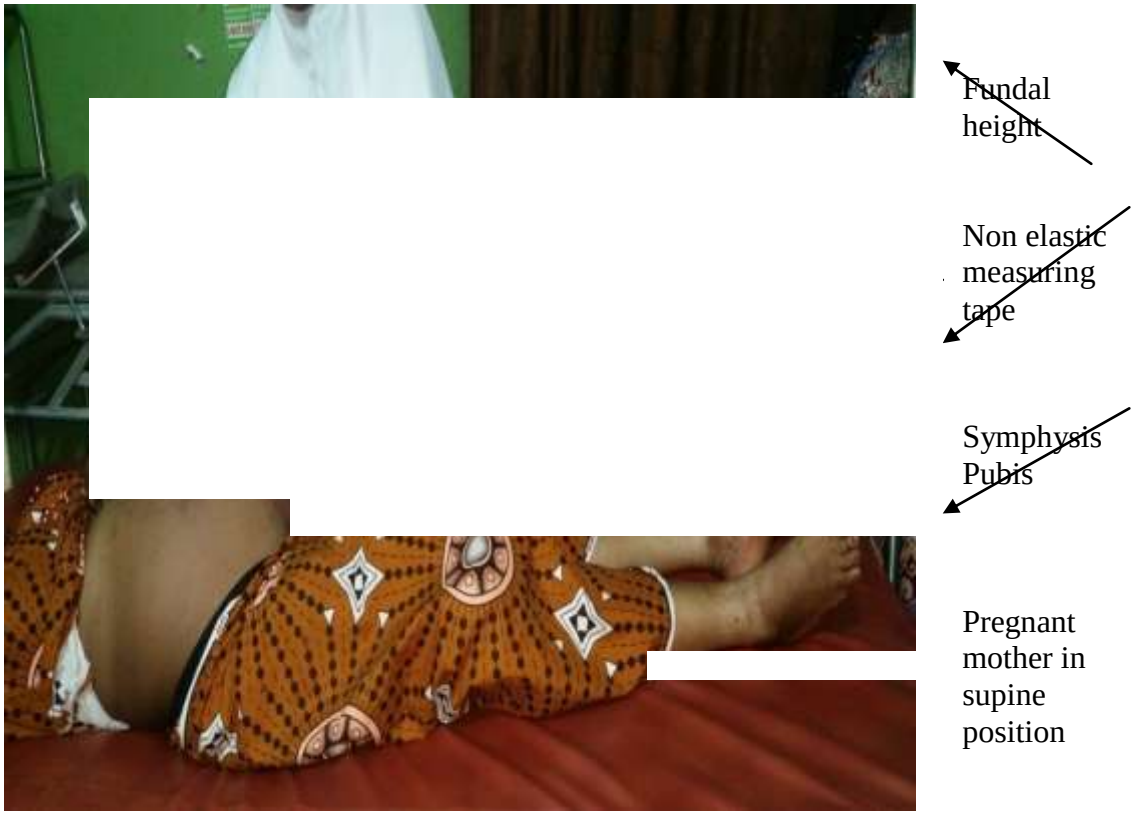



**Plate XI:** Measurement of symphysio-fundal height using a non-elastic measuring tape

### 3.2.6 Neonatal Anthropometry

The neonatal anthropometric parameters were measured within 24 hours of delivery (Chandrashekar *et al*., 2008) as:-

**Birth Weight**

The BW was taken in g using a digital weighing scale with a capacity of up to 20,000 g and a resolution of 0.00 g. The weighing scale was cleansed with a sterilized drape, and then the baby was placed on the weighing scale naked. Reading was recorded to the nearest g (Abubakar *et al*., 2012).




**Plate XII:** Measurement of neonatal birth weight using digital baby weighing scale

**Placental weight (PW)**

The placenta was weighed within one hour after delivery (Chandrakant *et al*., 2015). The blood contained in the superficial foetal blood vessels was drained. Obvious blood clots adherent to the maternal placental surface were also removed. The placenta was weighed together with the membranes and the cord (untrimmed) using a Compact bowl digital weighing scale, and recorded to the nearest g (Abubakar *et al*., 2012).

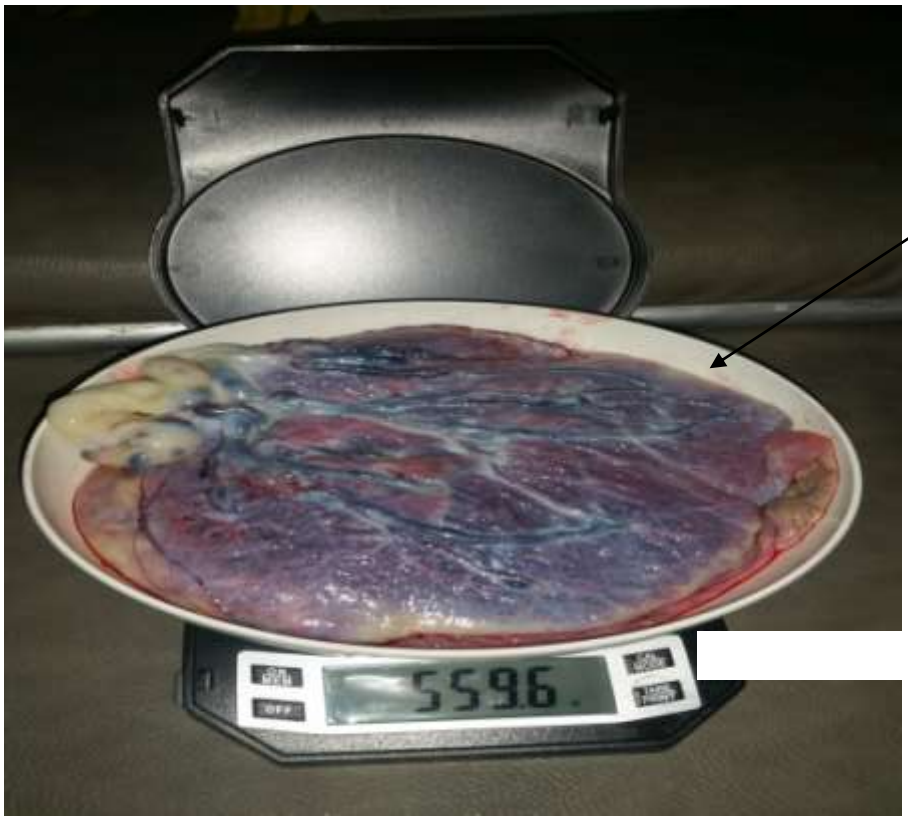



**Plate XIII:** Measurement of placenta using a compact bowl digital weighing scale

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**Birth Length (BL)**

The BL was measured as the projective distance between the highest point on the head (vertex) and the most posterior projecting point of the heel in supine position. The measurement was carried out by two healthcare providers using a non elastic measuring tape. The neonate was kept in supine position (face-up). The first healthcare provider correctly positioned the neonatal head against a horizontal flat surface gently holding the head in position and the area was marked. The second healthcare provider gently presses the neonate's knees to straighten the legs; the heel position was marked. The distance between the two marked surfaces was measured and recorded on the proforma to the nearest 0.1 cm.

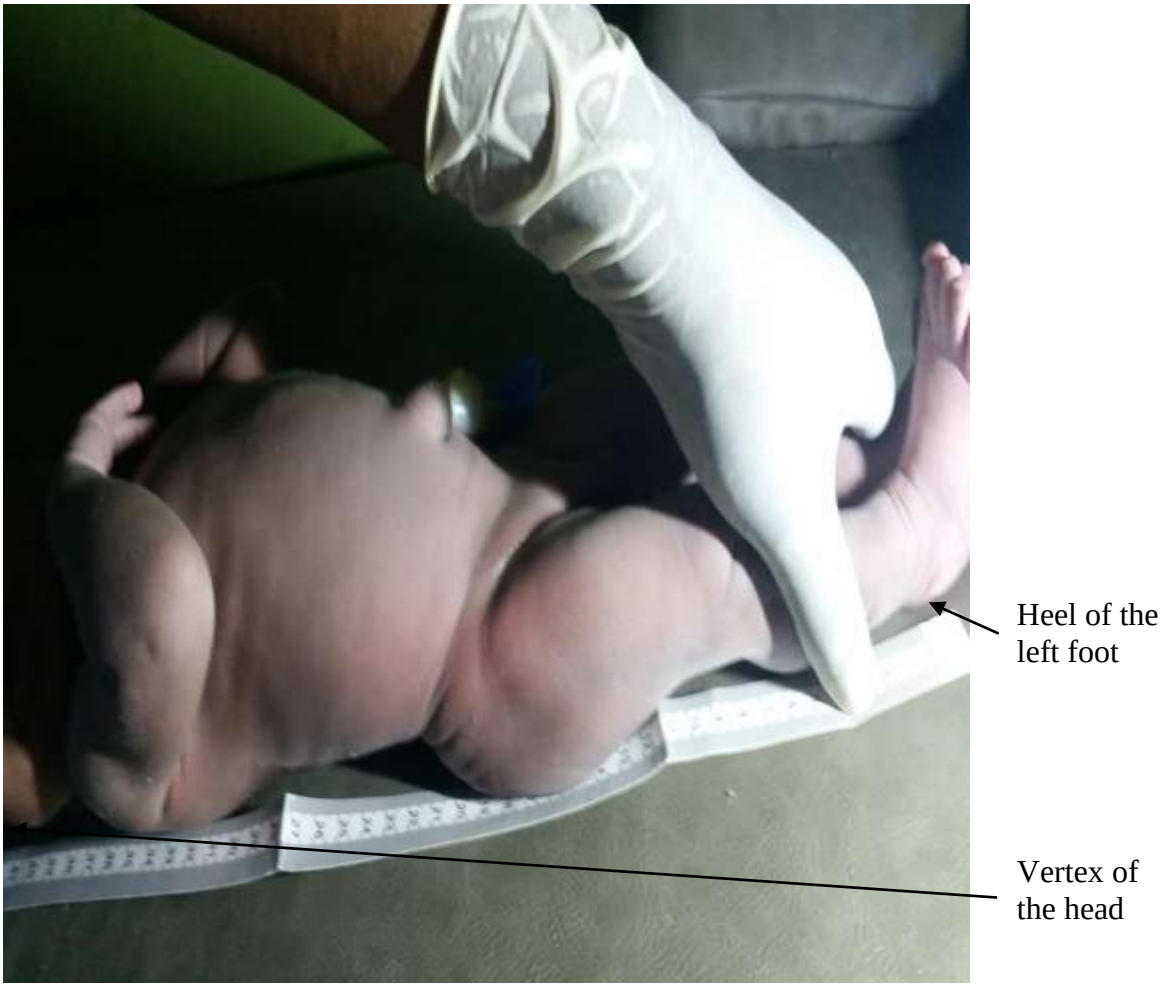



**Plate XIV:** Measurement of neonatal birth length using a non-elastic measuring tape

**Foot Length (FL)**

The FL was measured in cm as a straight distance between the most posterior projecting point of the heel and anterior projecting point (the end of 1st or 2nd toe) using a meter rule from the planter surface of the sole of the foot according to the method of Sen Ghosch (2008).

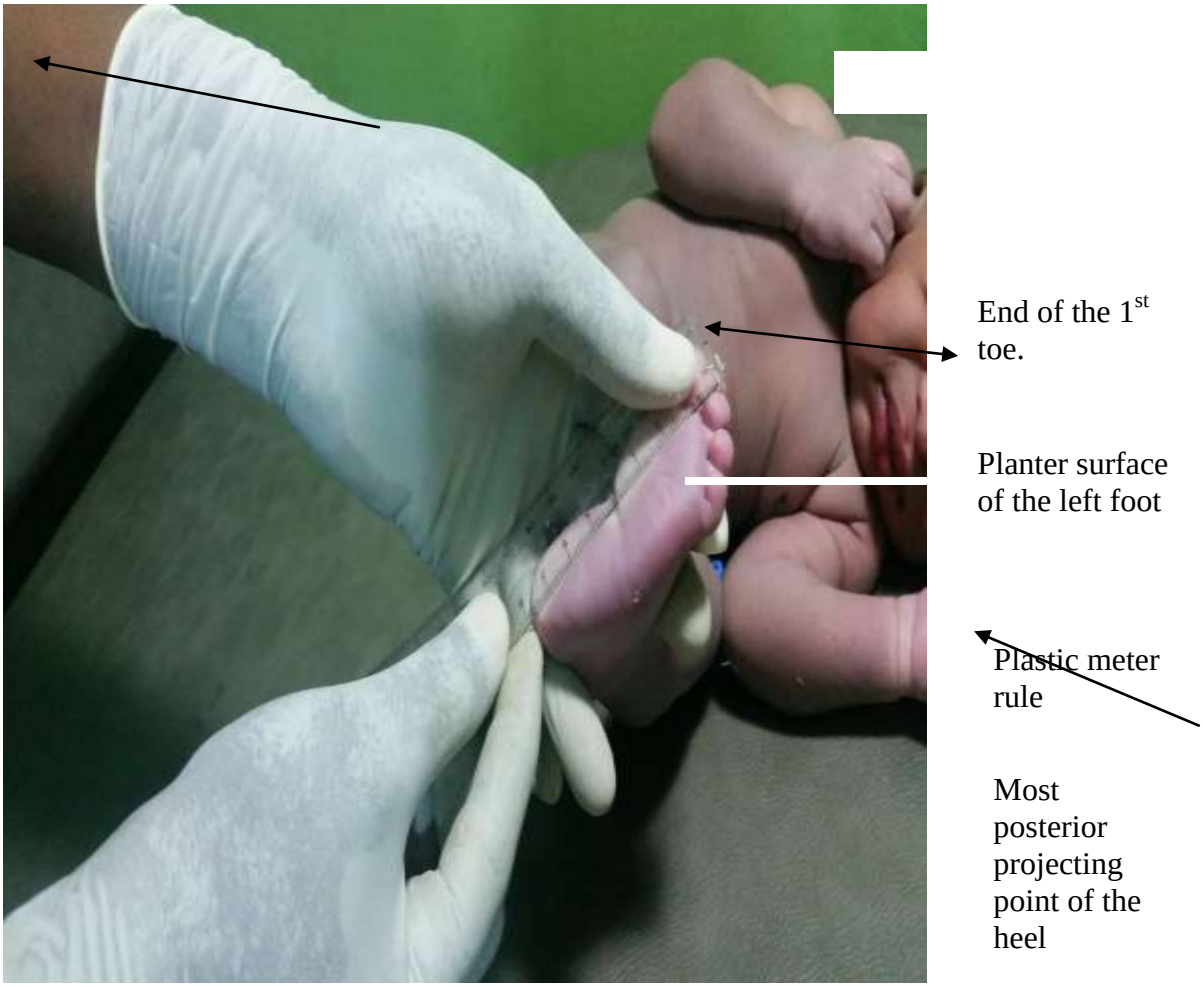



**Plate XV:** Measurement of neonatal foot length using a plastic meter rule

**Foot Breadth (FB)**

The FB was measured in cm (at the widest point of the sole) as the distance between the first to the fifth metatarso-phalangeal joint of the foot, using a meter rule from the plantar view of the sole of the foot according to the method of Sen and Ghosch (2008).




**Plate XVI:** Measurement of foot breadth using a plastic meter rule

**Thigh circumference (TC)**

The TC was measured with the measuring tape placed around the mid-thigh at the midpoint between the knee and the hip joint. The measuring tape was placed around the mid-thigh. The tape was positioned perpendicular to the long axis of the thigh with the zero end of the tape held below the measurement value. The tape rests firmly on the skin without compressing the skin. The thigh circumference was measured to the nearest 0.1 cm (Suneetha and Kavitha, 2016).




**Plate XVII:** Measurement of thigh circumference using a plastic meter rule

**Hand Length (HL)**

The HL was measured in cm from the mid-point of the distal wrist crease to the tip of the middle finger using a plastic meter rule from the palmer surface of the left hand (Chikhalkar *et al*., 2010).




**Plate XVIII:** Measurement of hand length using a plastic meter rule

**Hand Breadth (HB)**

The HB was measured in cm as a distance from the base of second to fifth proximal phalanx (metacarpo-phalangeal joint) of the hand using a plastic meter rule from the palmer surface of the hand (Chikhalkar *et al*., 2010).




**Plate XIX:** Measurement of hand breadth using a plastic meter rule

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**Neonatal Arm Circumference (NAC)**

The mid-arm circumference was measured in cm as the circumference between the midpoint of the tip of the acromion process and the olecranon process of the ulna, with the newborn in dorsal position (decubitus) and with arm lying laterally to the trunk. The measuring tape was placed around the upper arm at the marked point perpendicular to the long axis of the arm. The tape rests on the skin surface but not pulled tight enough to compress the skin. The arm circumference was recorded to the nearest 0.1 cm (Mohsen *et al*., 2011).




**Plate XX:** Measurement of neonatal arm circumference using a plastic meter rule

**Chest Circumference (CC)**

The CC was measured with the tape placed along the point of nipples, round the back. Measurements were recorded to the nearest 0.1 cm (Mohsen *et al*., 2011).




**Plate XXI:** Measurement of neonatal chest circumference using a plastic meter rule

**Head Circumference (HC)**

The HC was obtained by placing tape along the largest occipitofrontal diameter. The tape was placed across the frontal bones just above the eyebrows (glabella), around the head above the ears on each side, and over the occipital prominence at the back of the head. The tape was held snugly around the head. The tape was moved up and down over the back of the head to locate the maximal circumference of the head. The tape was kept perpendicular to the long axis of the face and was pulled firmly to compress the hair and underlying soft tissues. The measurement was recorded to the nearest 0.1 cm (Mohsen *et al*., 2011).




**Plate XXII:** Measurement of neonatal head circumference using a plastic meter rule

### 3.3 Data Analyses and Presentation

Data collected were expressed as mean ± standard deviation (SD). Tables, graphs and charts were used in expressing the data. Independent sample *t*-test was used to determine the differences between the variables. Receiver operator characteristic (ROC) curve was constructed to determine the cut off values of the measured neonatal anthropometric parameters that discriminate between low and high birth weight. Pearson's correlation was then used to relate the variables with one another. Analysis of covariance (ANCOVA) was employed to determine the effect of maternal characteristics on the birth weight. Furthermore, stepwise multiple linear regression analyses were carried out to provide models for predicting neonatal birth weights. Data analyses were carried out using IBM Statistical Package for Service Solution (SPSS) version 25.0 (Armonk, NY: IBM Corp.). $P < 0.05$ was considered statistically significant.

## CHAPTER 4

## 4.0 RESULTS

### 4.1 Frequency Distribution and Descriptive Statistics of the Maternal and Neonatal Anthropometric Characteristics

Table 4.1 shows the frequency distribution of the maternal characteristics in Kano, Nigeria. Location [(LCT) or area of residence], maternal parity (MP) i.e. primigravida

(first time of delivery) or multipara (those that had two or more deliveries), maternal educational level (MEL), antenatal care (ANC) utilization and the presence or absence of glucose (UGL) in the urine of the pregnant mothers were considered. A total of 1,203 pregnant mothers were considered, 717 (59.6%) of the participants were located in the urban area, while 486 (40.4%) were located in the rural areas. Among the parturition mothers, 285 (23.7 %) of them are primigravidae and 918 (76.3 %) are multiparous mothers. The mothers with tertiary education were 133 (11.1 %), while 486 (40.4%) and 336 (27.9%) had secondary and primary education respectively. Furthermore, 248 (20.6 %) had other type of education e.g. Qur'anic and Islamiyya education among others. Considering the ANC utilization, 893 (74.2 %) attended the antenatal clinics, while 310 (25.8 %) did not attend them. When the urine of the pregnant mothers were tested for the presence or absence of glucose, 156 (13.0 %), 68 (5.7 %) and 48 (4.0 %) had UGL of 1+, 2+ and 3+ respectively. However, 931 (77.4 %) had no glucose detected in their urine.

Table 4.1: Frequency distribution of the maternal characteristics in Kano Nigeria

| **Variables** | | **Frequency (n)** | **Percentage** |
|---|---|---|---|
| Location | Urban | 717 | 59.6 % |
| | Rural | 486 | 40.4 % |
| Maternal parity | Primigravida | 285 | 23.7 % |
| | Multipara | 918 | 76.3 % |
| Maternal educational level | Tertiary | 133 | 11.1 % |
| | Secondary | 486 | 40.4 % |
| | Primary | 336 | 27.9 % |
| | Others | 248 | 20.6 % |
| Antenatal care | Attended | 893 | 74.2 % |
| | Not attended | 310 | 25.8 % |
| Urine glucose level | 1+ | 156 | 13.0 % |
| | 2+ | 68 | 5.7 % |
| | 3+ | 48 | 4.0 % |
| | Negative | 931 | 77.4 % |

The descriptive statistics of the maternal and neonatal anthropometric parameters among the mother-child pair in Kano State, Nigeria is highlighted on Table 4.2. The mean age of the mothers and the mean family size (FS) were found to be 27.86 ± 6.78

and 6.61± 4.17 respectively. Similarly, the mean MH, MAC, SFH and Hb concentration were 160.22 ± 5.82, 26.60 ± 3.15, 37.46 ± 0.93 and 12.18 ± 1.40 respectively. The mean value of the SBP (123.52 ± 16.12) and DBP (82.21 ± 10.58) fall with the normal value of blood pressure. However, the mean BW, BL and PW were 3079.30 ± 491.77, 49.01 ± 3.34 and 526.02 ± 83.09 respectively. The neonates have higher mean thigh (14.77 ± 2.07) and head (32.38 ± 3.61) circumferences, compared to neonatal arm (11.00 ± 1.36) and chest (30.05 ± 3.45) circumferences respectively. The FL (8.16 ± 0.65) was higher than the HL (6.79 ± 0.51) whereas the HB (3.43 ± 0.33) was higher than FB (3.17 ± 0.39). The Apgar score at first and fifth minutes were also found to be 8.19 ± 1.27 and 9.68 ± 0.64.

Table 4.2: Descriptive statistics of the maternal and neonatal anthropometric parameters among the mother-child pair in Kano, Nigeria (n = 1203)

| | Variables | Mean ± SD | Min. | Max. |
|---|---|---|---|---|
| Maternal parameters | Age (years) | 27.86 ± 6.78 | 13.00 | 49.00 |
| | Family size | 6.61 ± 4.17 | 2.00 | 23.00 |
| | Maternal height (cm) | 160.22 ± 5.82 | 143.00 | 175.40 |
| | Maternal arm circumference (cm) | 26.60 ± 3.15 | 17.90 | 36.30 |
| | Symphysio-fundal height (cm) | 37.46 ± 0.93 | 36.00 | 40.00 |
| | Haemoglobin (g/dl) | 12.18 ± 1.40 | 8.30 | 15.20 |
| | Systolic blood pressure (mmHg) | 123.52 ± 16.12 | 70.00 | 210.00 |
| | Diastolic blood pressure (mmHg) | 82.21 ± 10.58 | 60.00 | 140.00 |
| Neonatal parameters | Birth weight (g) | 3079.30 ± 491.77 | 1800.00 | 4600.00 |
| | Placental weight (g) | 526.02 ± 83.09 | 315.10 | 833.80 |
| | Birth length (cm) | 49.01 ± 3.34 | 38.00 | 56.00 |
| | Foot length (cm) | 8.16 ± 0.65 | 5.10 | 10.00 |
| | Foot breadth (cm) | 3.17 ± 0.39 | 2.00 | 4.50 |
| | Thigh circumference (cm) | 14.77 ± 2.07 | 8.70 | 18.50 |
| | Hand length (cm) | 6.79 ± 0.51 | 5.00 | 8.50 |
| | Hand breadth (cm) | 3.43 ± 0.33 | 2.30 | 4.80 |
| | Neonatal arm circumference (cm) | 11.00 ± 1.36 | 5.50 | 13.70 |
| | Chest circumference (cm) | 30.05 ± 3.45 | 18.50 | 36.00 |
| | Head circumference (cm) | 32.38 ± 3.61 | 17.50 | 39.20 |
| | Apgar Score (at 1 minute) | 8.19 ± 1.27 | 4.00 | 10.00 |
| | (at 5 minutes) | 9.68 ± 0.64 | 7.00 | 10.00 |

The frequency distribution of the maternal characteristics among the urban populace in Kano, Nigeria is shown on Table 4.3. Of the 717 of the pregnant mothers that live in the urban area of Kano State, 164 (22.9 %) of them are primigravidae and 553 (77.1 %) are multipara. Considering the MEL, 90 (12.5%) of the mothers had tertiary education, while the mothers that had secondary, primary and other type of educational system constitute 285 (39.7%), 201 (28.0) and 141 (19.7%) respectively. Furthermore, among the parturition mothers, 533 (74.3 %) have attended ANC, while 184 (25.7 %) did not. The UGL in mothers with 1+ stood at 89 (12.4 %), and those mothers with 2+, 3+ and no glucose in the urine (negative) were having frequencies of 48 (6.7 %), 38 (5.3 %) and 542 (75.6 %) respectively.

Table 4.3: Frequency distribution of the maternal characteristics among the urban populace in Kano, Nigeria

| **Variables** | | **Frequency (n)** | **Percentage** |
|---|---|---|---|
| Maternal parity | Primigravidae | 164 | 22.9 % |
| | Multiparous | 553 | 77.1 % |
| Maternal educational level | Tertiary | 90 | 12.5 % |

| | | | |
|---|---|---|---|
| | Secondary | 285 | 39.7 % |
| | Primary | 201 | 28.0 % |
| | Others | 141 | 19,7 % |
| Antenatal attendance | Attended | 533 | 74.3 % |
| | Not attended | 184 | 25.7 % |
| Urine glucose level | 1+ | 89 | 12.4 % |
| | 2+ | 48 | 6.7 % |
| | 3+ | 38 | 5.3 % |
| | Negative | 542 | 75.6 % |

Table 4.4 shows the descriptive statistics of the maternal and neonatal anthropometric parameters among the urban populace in Kano, Nigeria. The mean age and the family size among the study participants were found to be 28.03 ± 6.74 and 6.91 ± 4.36. Similarly, the mean MH, MAC, SFH and Hb stood at 160.48 ± 5.83, 26.68 ± 3.2, 37.52 ± 0.96 and 12.69 ± 1.39 respectively, while the mean values of SBP and DBP stood at 124.17 ± 17.36 and 82.31 ± 11.30. The mean BW, PL and BL were found to be 3174.60 ± 508.30, 534.49 ± 88.64 and 48.69 ± 3.37. Also, the FL, FB, HL and HB have mean values of 8.12 ± 0.67, 3.20 ± 0.41, 6.77 ± 0.54 and 3.44 ± 0.34. The thigh, neonatal arm, chest and the head circumferences were having mean values of 14.79 ± 2.03, 10.97 ± 1.35, 30.25 ± 3.32 and 32.60 ± 3.44 respectively. The Apgar score of the delivered babies were gotten as 8.29 ± 1.33 at the first minute and 9.69 ± 0.64 at the fifth minutes.

Table 4.4: Descriptive statistics of the maternal and neonatal anthropometric parameters among the urban populace in Kano, Nigeria (n = 717)

| | **Variables** | **Mean ± SD** | **Min.** | **Max.** |
|---|---|---|---|---|
| Maternal parameters | Age (years) | 28.03 ± 6.74 | 15.00 | 46.00 |
| | Family size | 6.91 ± 4.36 | 2.00 | 21.00 |
| | Maternal height (cm) | 160.48 ± 5.83 | 145.00 | 175.40 |
| | Maternal arm circumference (cm) | 26.68 ± 3.2 | 17.90 | 36.30 |

| | | | | |
|---|---|---|---|---|
| | Symphysio-fundal height (cm) | 37.52 ± 0.96 | 36.00 | 40.00 |
| | Haemoglobin (g/dl) | 12.69 ± 1.39 | 8.30 | 15.20 |
| | Systolic blood pressure (mmHg) | 124.17 ± 17.36 | 100.00 | 210.00 |
| | Diastolic blood pressure (mmHg) | 82.31 ± 11.30 | 60.00 | 140.00 |
| Neonatal parameters | Birth weight (g) | 3174.60 ± 508.30 | 1800.00 | 4600.00 |
| | Placental weight (g) | 534.49 ± 88.64 | 330.00 | 833.80 |
| | Birth length (cm) | 48.69 ± 3.37 | 38.00 | 54.50 |
| | Foot length (cm) | 8.12 ± 0.67 | 6.00 | 10.00 |
| | Foot breadth (cm) | 3.20 ± 0.41 | 2.20 | 4.50 |
| | Thigh circumference (cm) | 14.79 ± 2.03 | 9.80 | 18.50 |
| | Hand length (cm) | 6.77 ± 0.54 | 5.50 | 8.50 |
| | Hand breadth (cm) | 3.44 ± 0.34 | 2.70 | 4.80 |
| | Neonatal arm circumference (cm) | 10.97 ± 1.35 | 7.00 | 13.70 |
| | Chest circumference (cm) | 30.25 ± 3.32 | 20.20 | 36.00 |
| | Head circumference (cm) | 32.60 ± 3.44 | 20.00 | 39.20 |
| | Apgar Score (at 1 minute) | 8.29 ± 1.33 | 4.00 | 10.00 |
| | (at 5 minutes) | 9.69 ± 0.64 | 7.00 | 10.00 |

Table 4.5 shows the frequency distribution of the maternal characteristics among the rural populace in Kano State. Among the considered variables, the primigravidae and the multiparous had frequencies of 121 (24.9 %) and 365 (75.1 %) respectively. Similarly, 43 (8.8 %) had tertiary education, 201 (41.4 %) had secondary education, 135 (27.8 %) had primary education. Furthermore, 107 (22.0 %) had other forms of education. For glucose in the urine, 67 (13.8 %), 20 (4.1 %) and 10 (2.1 %) were having 1+, 2+ and 3+ glucose level in their urine. About 389 (80 %) of them had no glucose detected in their urine.

Table 4.5: Frequency distribution of the maternal characteristics among the rural populace in Kano Nigeria

| **Variables** | | **Frequency (n)** | **Percentage** |
|---|---|---|---|
| Maternal parity | Primigravidae | 121 | 24.9 % |
| | Multiparous | 365 | 75.1 % |
| Maternal educational level | Tertiary | 43 | 8.8 % |
| | Secondary | 201 | 41.4 % |
| | Primary | 135 | 27.8 % |
| | Others | 107 | 22.0 % |
| Antenatal attendance | Attended | 360 | 74.1 % |
| | Not attended | 126 | 25.9 % |
| Urine glucose level | 1+ | 67 | 13.8 % |
| | 2+ | 20 | 4.1 % |
| | 3+ | 10 | 2.1 % |
| | Negative | 389 | 80 % |

Table 4.6 makes obvious the descriptive statistics of the neonatal and maternal anthropometric variables among the rural populace in Kano State Nigeria. Maternal age and family size have mean values of 27.60 ± 6.84 and 6.17 ± 3.83. The mean MH, MAC, SFH and Hb stood at 159.84 ± 5.78, 26.47± 3.05, 37.37± 0.87 and 11.45 ± 1.03 respectively, while the mean values of SBP and DBP were found to be 122.57 ± 14.06 and 82.08 ± 9.44. Among the neonatal anthropometric parameters, the mean BW, PL and BL were 2938.70 ± 429.80, 513.51 ± 72.43 and 49.48 ± 3.26. The FL (8.21 ± 0.63) have a higher mean value than HL (6.82 ± 0.47), similarly the HB (3.42 ± 0.31) have a higher mean value than FB (3.12 ± 0.36). The thigh, neonatal arm, chest and the head circumferences were 14.76 ± 2.13, 11.06 ± 1.37, 29.75 ± 3.60 and 32.05 ± 3.82 respectively. Apgar score among the neonates was 8.03 ± 1.16 at the first minute and 9.66 ± 0.63 at the fifth minutes of delivery.

Table 4.6: Descriptive statistics of the maternal and neonatal anthropometric parameters among the rural populace in Kano Nigeria (n = 486)

| | Variables | Mean ± SD | Min. | Max. |
|---|---|---|---|---|
| Maternal parameters | Age (years) | 27.60 ± 6.84 | 13.00 | 49.00 |
| | Maternal height (cm) | 159.84 ± 5.78 | 143.00 | 173.40 |
| | Maternal arm circumference (cm) | 26.47± 3.05 | 17.90 | 36.30 |
| | Symphysio-fundal height (cm) | 37.37± 0.87 | 36.00 | 40.00 |
| | Haemoglobin (g/dl) | 11.45 ± 1.03 | 9.00 | 14.30 |
| | Systolic blood pressure (mmHg) | 122.57 ± 14.06 | 70.00 | 180.00 |
| | Diastolic blood pressure (mmHg) | 82.08 ± 9.44 | 60.00 | 110.00 |
| Neonatal parameters | Birth weight (g) | 2938.70 ± 429.80 | 1900.00 | 4100.00 |
| | Placental weight (g) | 513.51 ± 72.43 | 315.10 | 765.70 |
| | Birth length (cm) | 49.48 ± 3.26 | 40.00 | 56.00 |
| | Foot length (cm) | 8.21 ± 0.63 | 5.10 | 9.80 |
| | Foot breadth (cm) | 3.12 ± 0.36 | 2.00 | 4.10 |
| | Thigh circumference (cm) | 14.76 ± 2.13 | 8.70 | 16.70 |
| | Hand length (cm) | 6.82 ± 0.47 | 5.00 | 7.60 |
| | Hand breadth (cm) | 3.42 ± 0.31 | 2.30 | 4.50 |
| | Neonatal arm circumference (cm) | 11.06 ± 1.37 | 5.50 | 12.50 |
| | Chest circumference (cm) | 29.75 ± 3.60 | 18.50 | 34.20 |
| | Head circumference (cm) | 32.05 ± 3.82 | 17.50 | 37.30 |
| | Apgar Score (at 1 minute) | 8.03 ± 1.16 | 6.00 | 10.00 |
| | (at 5 minutes) | 9.66 ± 0.63 | 7.00 | 10.00 |

## 4.2 Mean Neonatal and Maternal Anthropometric Parameters among the Mother-child Pair in Kano State

Table 4.7 shows the mean values of both the measured neonatal and maternal anthropometric parameters. The mean BW, PW and BL were calculated as 3079.30 ± 491.77, 526.02 ± 83.09, and 49.01 ± 3.34 respectively. The neonates have higher mean thigh (14.77 ± 2.07) and head (32.38 ± 3.61) circumferences values, compared to neonatal arm (11.00 ± 1.36) and chest (30.05 ± 3.45) circumferences values respectively. The FL (8.16 ± 0.65) value was higher than the HL (6.79 ± 0.51) value, whereas the HB (3.43 ± 0.33) had higher mean value than the FB (3.17 ± 0.39). Similarly, among the maternal anthropometric parameters, MH, MAC, SFH and Hb concentration were found to have mean values of 160.22 ± 5.82cm, 26.60 ± 3.15cm, 37.46 ± 0.93cm and 12.18 ± 1.40 g/dl. In addition, the mean values of SBP (123.52 ± 16.12) and DBP (82.21 ± 10.58) are found to be within the normal limits (BP of 110 – 120 mmHg for the systolic and 80 – 90 mmHg for the diastolic).

Table 4.7: The mean values of the selected neonatal and maternal anthropometric parameters among the mother-child pair in Kano State, Nigeria

| **Groups (n = 1203)** | **Variables** | **Mean ± SD** | **Minimum** | **Maximum** |
|---|---|---|---|---|
| Neonatal Anthropometric Parameters | Birth weight (g) | 3079.30 ± 491.77 | 1800.00 | 4600.00 |
| | Placental weight (g) | 526.02 ± 83.09 | 315.10 | 833.80 |
| | Birth length (cm) | 49.01 ± 3.34 | 38.00 | 56.00 |
| | Foot length (cm) | 8.16 ± 0.65 | 5.10 | 10.00 |
| | Foot breadth (cm) | 3.17 ± 0.39 | 2.00 | 4.50 |
| | Thigh circumference (cm) | 14.77 ± 2.07 | 8.70 | 18.50 |
| | Hand length (cm) | 6.79 ± 0.51 | 5.00 | 8.50 |
| | Hand breadth (cm) | 3.43 ± 0.33 | 2.30 | 4.80 |
| | Neonatal arm circumference (cm) | 11.00 ± 1.36 | 5.50 | 13.70 |
| | Chest circumference (cm) | 30.05 ± 3.45 | 18.50 | 36.00 |
| | Head circumference (cm) | 32.38 ± 3.61 | 17.50 | 39.20 |
| Maternal Anthropometric Parameters | Maternal height (cm) | 160.22 ± 5.82 | 143.00 | 175.40 |
| | Maternal arm circumference (cm) | 26.60 ± 3.15 | 17.90 | 36.30 |
| | Symphysio-fundal height (cm) | 37.46 ± 0.93 | 36.00 | 40.00 |
| | Haemoglobin level (g/dl) | 12.18 ± 1.40 | 8.30 | 15.20 |
| | Systolic blood pressure (mmHg) | 123.52 ± 16.12 | 70.00 | 210.00 |
| | Diastolic blood pressure (mmHg) | 82.21 ± 10.58 | 60.00 | 140.00 |

Table 4.8 showed sexual dimorphism in BW, PI and other anthropometric parameters among the neonates in Kano State. A significant ($P$ = 0.0181) sexual dimorphism was observed in PI with females (2.70 ± 0.59) having higher mean value compared to males (2.62 ± 0.66). For other neonatal anthropometry the males had significantly ($P < 0.05$) higher mean values only in BL (49.50 ± 4.74), FL (8.23 ± .65) and HL 6.84 ± 0.50. No significant sexual dimorphisms were observed in body breadth and circumferences among the neonate in Kano State.

Table 4.8: Sexual dimorphism in birth weight, ponderal index and the selected neonatal anthropometric parameters among the neonates in Kano, Nigeria

| **Variables** | **Male (n = 555)**<br>**Mean ± SD** | **Female (n = 648)**<br>**Mean ± SD** | ***t*-value** | ***P*-value** |
|---|---|---|---|---|
| Birth weight (g) | 3106.85 ± 483.36 | 3055.71 ± 498.03 | 1.80 | 0.072 |
| Ponderal index | 2.62 ± 0.66 | 2.70 ± 0.59 | -2.37 | 0.018 |
| Birth length (cm) | 49.50 ± 3.40 | 48.59 ± 3.24 | 4.74 | < 0.001 |
| Foot length (cm) | 8.23 ± 0.65 | 8.10 ± 0.65 | 3.42 | < 0.001 |
| Foot breadth (cm) | 3.19 ± 0.39 | 3.15 ± 0.40 | 1.95 | 0.051 |
| Thigh circumference (cm) | 14.87 ± 2.03 | 14.69 ± 2.10 | 1.49 | 0.137 |
| Hand length (cm) | 6.84 ± 0.50 | 6.76 ± 0.52 | 2.72 | < 0.001 |
| Hand breadth (cm) | 3.45 ± 0.31 | 3.42 ± 0.34 | 1.75 | 0.081 |
| Neonatal arm circumference (cm) | 11.01 ± 1.36 | 11.00 ± 1.35 | 0.23 | 0.814 |
| Chest circumference (cm) | 29.95 ± 3.25 | 30.12 ± 3.61 | -0.86 | 0.392 |
| Head circumference (cm) | 32.31 ± 3.39 | 32.43 ± 3.79 | -0.58 | 0.561 |

### 4.3 The Effect of area of residence on Maternal and Neonatal Anthropometric Parameters, among the Mother-child Pair in Kano State, Nigeria

Table 4.9 shows the effect of urbanization on maternal anthropometric parameters in Kano State. A significantly ($P$ = 0.005) higher mean SFH (37.52 ± 0.96cm) was observed in mothers domicile in urban area of Kano State. Also, there was a significant ($P$ < 0.001) reduction in the mean Hb (11.45 ± 1.03g/dl) level among the mothers whose domicile is in the rural area of Kano State. No significant effects of urbanization were observed in MH, MAC and BP (both systolic and diastolic values) among the population.

Table 4.9: The effects of area of residence on maternal anthropometric parameters in Kano State Nigeria

| **Variables** | **Urban (n = 717) Mean ± SD** | **Rural (n = 486) Mean ± SD** | ***t*-value** | ***P*-value** |
|---|---|---|---|---|
| Maternal height (cm) | 160.48 ± 5.83 | 159.84 ± 5.78 | -1.88 | 0.060 |
| Maternal arm circumference (cm) | 26.68 ± 3.21 | 26.47 ± 3.05 | -1.11 | 0.268 |
| Symphysio-fundal height (cm) | 37.52 ± 0.96 | 37.37 ± 0.86 | -2.81 | 0.005 |
| Haemoglobin level (g/dl) | 12.69 ± 1.39 | 11.45 ± 1.03 | -16.79 | < 0.001 |
| Systolic blood pressure (mmHg) | 124.17 ± 17.36 | 122.57 ± 14.06 | -1.68 | 0.092 |
| Diastolic blood pressure (mmHg) | 82.31 ± 11.30 | 82.08 ± 9.44 | -0.37 | 0.713 |

Similarly, Table 4.10 highlights the effect of urbanization on the selected neonatal anthropometric parameters among the neonates in Kano State, Nigeria. A significant effect of urbanization was observed on BW ($P < 0.001$), BL ($P < 0.001$) and FB ($P < 0.001$) with neonates from the urban area having higher mean values. Additionally, statistically significant mean values were observed in FL ($P = 0.024$), chest ($P = 0.015$) and head ($P = 0.009$) circumferences. However, no significant effect of urbanization was observed on hand length and breadth, as well as on thigh and neonatal arm circumference.

Table 4.10: The effect of area of residence on the selected neonatal anthropometric parameters in Kano Nigeria

| **Variables** | **Urban (n = 717) Mean ± SD** | **Rural (n = 486) Mean ± SD** | ***t*-value** | ***P*-value** |
|---|---|---|---|---|
| Birth weight (g) | 3174.62 ± 508.28 | 2938.68 ± 429.80 | -8.40 | < 0.001 |
| Birth length (cm) | 48.69 ± 3.37 | 49.48 ± 3.26 | 4.06 | < 0.001 |
| Foot length (cm) | 8.12 ± 0.66 | 8.21 ± 0.63 | 2.25 | 0.024 |
| Foot breadth (cm) | 3.20 ± 0.41 | 3.12 ± 0.36 | -3.61 | < 0.001 |
| Thigh circumference (cm) | 14.79 ± 2.03 | 14.76 ± 2.13 | -0.23 | 0.818 |
| Hand length (cm) | 6.77 ± 0.54 | 6.82 ± 0.47 | 1.54 | 0.123 |
| Hand breadth (cm) | 3.44 ± 0.34 | 3.42 ± 0.31 | -0.70 | 0.482 |
| Neonatal arm circumference (cm) | 10.97 ± 1.35 | 11.06 ± 1.37 | 1.14 | 0.253 |
| Chest circumference (cm) | 30.24 ± 3.33 | 29.75 ± 3.60 | -2.43 | 0.015 |
| Head circumference (cm) | 32.60 ± 3.45 | 32.04 ± 3.82 | -2.61 | 0.009 |

Furthermore, Tables 4.11 and 4.12 indicate the sex specific effect of area of residence on the selected anthropometric parameters among the deliveries in Kano State. In males, similar patterns were observed as in the general study population except that urbanization has no significant effect on chest and head circumferences (Table 4.11). For female neonates, no significant effects of urbanization on FL and HC were recorded. However, BW, BL and FB appeared to be affected by urbanization in a similar pattern with male neonates. Moreover, CC is discovered to be of no significant effect on ($P$ = 0.046) the neonates from the rural area (Table 4.12).

Table 4.11: The effect of area of residence on the selected neonatal anthropometric parameters among the male neonates in Kano State, Nigeria

| **Variables** | **Urban (n = 323) Mean ± SD** | **Rural (n = 232) Mean ± SD** | ***t*-value** | ***P*-value** |
|---|---|---|---|---|
| Birth weight (g) | 3203.41 ± 490.55 | 2972.41 ± 440.11 | -5.71 | < 0.001 |
| Birth length (cm) | 49.07 ± 3.47 | 50.10 ± 3.20 | 3.55 | < 0.001 |
| Foot length (cm) | 8.17 ± 0.68 | 8.31 ± 0.59 | 2.55 | 0.011 |
| Foot breadth (cm) | 3.22 ± 0.40 | 3.15 ± 0.37 | -1.98 | 0.048 |
| Thigh circumference (cm) | 14.84 ± 1.99 | 14.92 ± 2.09 | 0.45 | 0.656 |
| Hand length (cm) | 6.80 ± 0.55 | 6.88 ± 0.44 | 1.81 | 0.071 |
| Hand breadth (cm) | 3.44 ± 0.31 | 3.46 ± 0.31 | 0.97 | 0.333 |
| Neonatal arm circumference (cm) | 10.95 ± 1.35 | 11.11 ± 1.37 | 1.36 | 0.175 |
| Chest circumference (cm) | 30.11 ± 3.12 | 29.73 ± 3.42 | -1.37 | 0.172 |
| Head circumference (cm) | 32.52 ± 3.17 | 32.01 ± 3.66 | -1.73 | 0.084 |

Table 4.12: The effect of area of residence on the selected neonatal anthropometric parameters among the female neonates in Kano State Nigeria

| **Variables** | **Urban (n = 394) Mean ± SD** | **Rural (n = 254) Mean ± SD** | ***t*-value** | ***P*-value** |
|---|---|---|---|---|
| Birth weight (g) | 3151.02 ± 521.80 | 2907.87 ± 418.66 | -6.24 | < 0.001 |
| Birth length (cm) | 48.38 ± 3.25 | 48.92 ± 3.21 | 2.09 | 0.037 |
| Foot length (cm) | 8.09 ± 0.65 | 8.12 ± 0.66 | 0.61 | 0.544 |
| Foot breadth (cm) | 3.18 ± 0.42 | 3.08 ± 0.36 | -3.15 | 0.002 |
| Thigh circumference (cm) | 14.74 ± 2.06 | 14.61 ± 2.16 | -0.77 | 0.443 |
| Hand length (cm) | 6.75 ± 0.53 | 6.76 ± 0.50 | 0.35 | 0.724 |
| Hand breadth (cm) | 3.44 ± 0.36 | 3.39 ± 0.32 | -1.80 | 0.072 |
| Neonatal arm circumference (cm) | 10.98 ± 1.35 | 11.01 ± 1.37 | 0.29 | 0.775 |
| Chest circumference (cm) | 30.35 ± 3.50 | 29.77 ± 3.76 | -2.00 | 0.046 |
| Head circumference (cm) | 32.66 ± 3.66 | 32.07 ± 3.97 | -1.94 | 0.053 |

## 4.4 The Influence of area of residence, Maternal Characteristics and Apgar score on Birth Weight among the Neonates in Kano State, Nigeria

Table 4.13 makes obvious the influence of area of residence, maternal anthropometric characteristics and Apgar score on BW among the deliveries in Kano State using analysis of covariance (ANCOVA). Urbanization has proven to have a significant effect on neonatal BW ($P < 0.001$).

Among the maternal characteristics, only family size ($P = 0.025$) and antenatal care utilization ($P = 0.041$) were found to have significant influence on BW respectively.

Similarly, Apgar score in one ($P < 0.001$) and five ($P < 0.001$) minutes were also found to have significant effect on the neonatal BW.

Table 4.13: The influence of urbanization, maternal characteristics and Apgar score on birth weight among the neonates in Kano State, Nigeria

| **Variables** | **Type III Sum of Squares** | ***F*-value** | ***P*-value** |
|---|---|---|---|
| Urbanization (Domicile) | 16123836.74 | 70.53 | < 0.001 |
| Age | 812356.64 | 3.37 | 0.067 |
| Maternal parity | 301755.42 | 1.25 | 0.264 |
| Family size | 2371734.30 | 11.12 | 0.025 |
| Maternal educational level | 612082.78 | 2.53 | 0.112 |
| Antenatal care | 2170081.70 | 10.12 | 0.041 |
| Apgar score (1minute) | 6905872.88 | 29.23 | < 0.001 |
| Apgar score (5 minutes) | 3636122.54 | 15.21 | < 0.001 |

Table 4.14 shows a gender (sex) specific influence of urbanization, maternal characteristics and Apgar score on BW among the neonates in Kano State using analysis of covariance (ANCOVA). In both sexes, it is discovered that only urbanization and Apgar score at the first minute have a significant influence on the neonatal BW; whereas the maternal educational level and Apgar score at the fifth minute shows a significant influence on BW among the female neonates only.

Table 4.14: The gender specific influence of urbanization, maternal characteristics and Apgar score on birth weight among the neonates in Kano State, Nigeria

| Gender | Variables | Type III Sum of Squares | Mean Square | *F* value | *P* Value |
|---|---|---|---|---|---|
| **Male** | Urbanization (Domicile) | 7204279.84 | 7204279.84 | 32.59 | < 0.001 |
| | Age | 230580.40 | 230580.40 | 0.99 | 0.321 |
| | Maternal parity | 89046.93 | 89046.93 | 0.38 | 0.537 |
| | Family size | 93326.75 | 93326.75 | 0.40 | 0.528 |
| | Maternal educational level | 99923.25 | 99923.25 | 0.43 | 0.514 |
| | Antenatal care | 324494.13 | 324494.13 | 11.10 | 0.036 |
| | Apgar score (1minute) | 1266846.44 | 1266846.44 | 5.47 | 0.020 |
| | Apgar score (5minutes) | 684957.12 | 684957.12 | 2.94 | 0.087 |
| **Female** | Urbanization (Domicile) | 9130027.58 | 9130027.58 | 38.97 | < 0.001 |
| | Age | 607542.94 | 607542.94 | 2.45 | 0.118 |
| | Maternal parity | 867199.96 | 867199.96 | 3.51 | 0.061 |
| | Family size | 186012.04 | 186012.04 | 0.75 | 0.387 |
| | Maternal educational level | 1770286.30 | 1770286.30 | 7.21 | 0.007 |
| | Antenatal care | 3082599.64 | 3082599.64 | 10.54 | 0.045 |
| | Apgar score (1 minute) | 6540935.76 | 6540935.76 | 27.45 | < 0.001 |
| | Apgar score (5 minutes) | 3082814.43 | 3082814.43 | 12.65 | < 0.001 |

## 4.5 The Cut off Values of the Select Neonatal Anthropometric Parameters that Discriminate between Low and High Birth Weight among the Urban and Rural Neonates in Kano State Nigeria

Table 4.15 shows the cut off values and area under the curve (AUC) of the selected neonatal anthropometric parameters for discrimination between low and high birth weight. All the measured parameters have exhibited a statistically significant AUC ($P <$ 0.001) discrimination potential between low and high BW, except CC and HC which has a *P*-value of 0.170 and 0.901 respectively. The higher values are an indication of higher BW. The cut off value of BL with the highest sensitivity (79.2%) and specificity (63.5%) for discriminating between low and high BW is 47.25 cm. Similarly, the cut off values of FL, FB and TC with the highest sensitivity (85.8 %, 81.2 %, and 77.3 %) and specificity (54.8%, 50.8%, and 69.0%) for discriminating between low and high BW are 7.65, 2.85 and 13.25 cm respectively. While the highest sensitivity and specificity for the discriminating between low and high BW among the variables of HL, HB and NAC are 70.7 %,74.7 % 80.2 % and 66.7 %, 72.2 % 46.8 % respectively, with the cut off values of 6.55, 3.35 and 10.35cm. However, CC and HC shows lower values which indicate discrimination potentials with sensitivity (89.9 % and 94.3 %) and specificity (21.4 % and 18.3 %) respectively, with cut off points of 24.80 and 25.90 cm.

Table 4.15: The cut off values and area under the curve of the selected neonatal anthropometric parameters for discrimination between low and high birth weight **(n = 1203)**

| **Variables (cm)** | **Cut off value (cm)** | **AUC (%)** | **Sensitivity (%)** | **Specificity (%)** | ***P*-value** |
|---|---|---|---|---|---|
| Birth length | 47.25 | 76.80 | 79.20 | 63.50 | < 0.001 |
| Foot length | 07.65 | 74.20 | 85.80 | 54.80 | < 0.001 |
| Foot breadth | 02.85 | 67.00 | 81.20 | 50.80 | < 0.001 |
| Thigh circumference | 13.25 | 77.30 | 77.30 | 69.00 | < 0.001 |
| Hand length | 06.55 | 70.80 | 70.70 | 66.70 | < 0.001 |
| Hand breadth | 03.35 | 75.70 | 74.70 | 72.20 | < 0.001 |
| Neonatal arm circumference | 10.35 | 68.30 | 80.20 | 46.80 | < 0.001 |
| Chest circumference | 24.80 | 53.70 | 89.90 | 21.40 | < 0.170 |
| Head circumference | 25.90 | 50.30 | 94.30 | 18.30 | < 0.901 |

### 4.5.1 Receiver operator characteristic (ROC) curve to determine the cut off values of the selected neonatal anthropometric parameters that discriminate between the low and high birth weight

Figure 4.1 shows the AUC of the measured neonatal anthropometric parameters in the study (n = 1203). It was observed that, the AUC of all the measured neonatal parameters were above the reference line (which indicate 50% area under the curve) with exception of HC which also exhibited area under the curve of 50.3 %. Figures 4.2 – 4.10 shows the separate receiver operator characteristics (ROC) curve of the measures neonatal parameters in the study. The highest AUC was recorded in BL (Figure 4.2) and the least in HC (Figure 4.10).

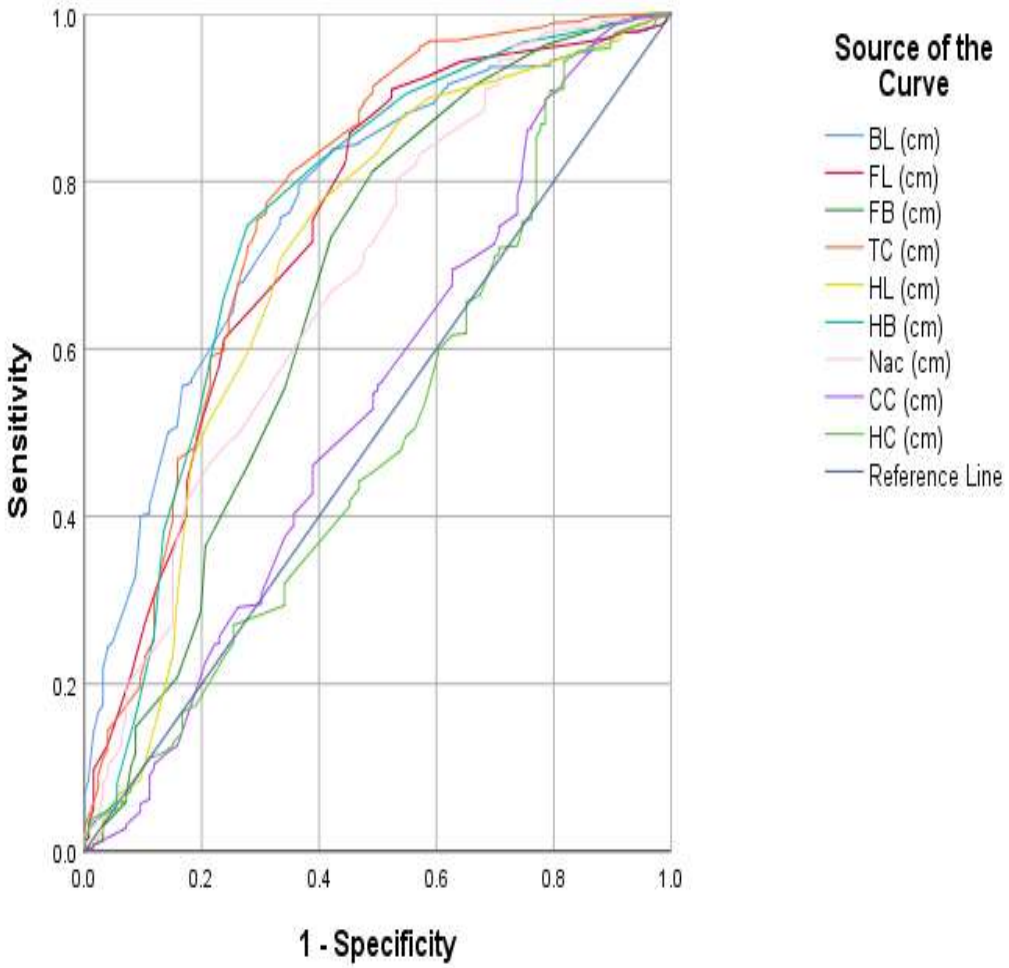



**Figure 4.1:** Receiver operator characteristics curve of the neonatal anthropometric parameters in cm (n = 1203). The areas under the curve among the selected neonatal parameters were above the reference line (which indicates 50% area under the curve) with exception of HC which also exhibited area under the curve of 50.3 %.

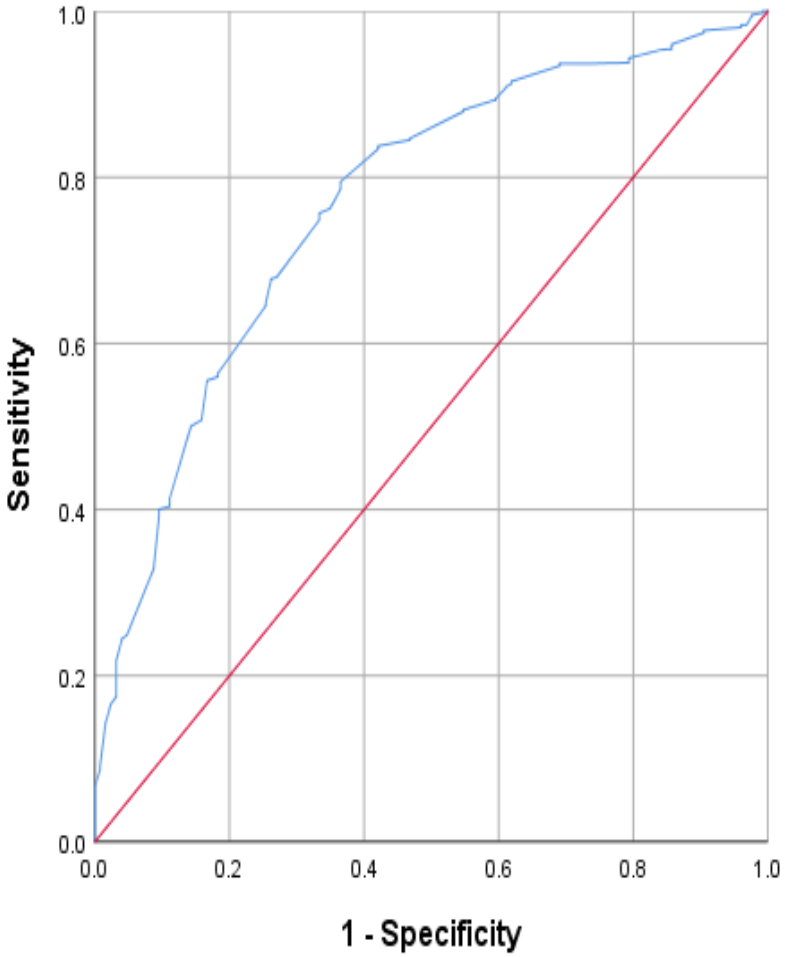



**Figure 4.2:** Receiver operator characteristics curve of birth length (cm) covering an area under the curve of 76.80% with sensitivity and specificity of 79.20 and 63.50 % with a cut off value of 47.25 cm ($P < 0.001$).

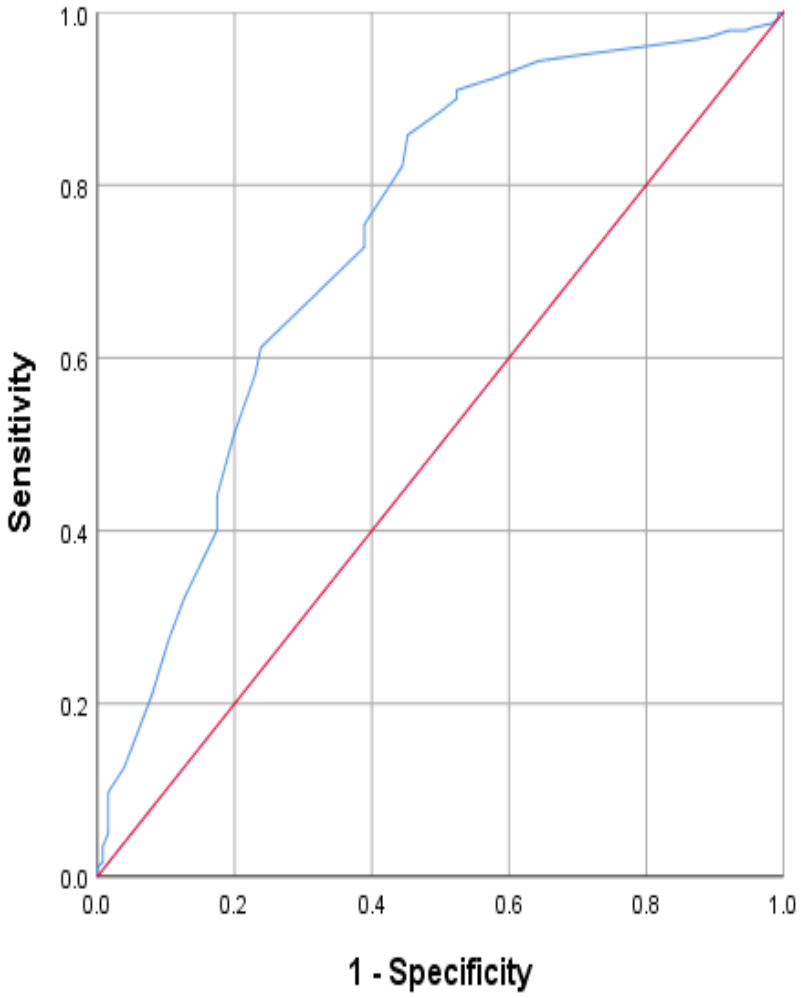



**Figure 4.3:** Receiver operator characteristics curve of foot length (cm) covering an area under the curve of 74.20% with sensitivity and specificity of 85.80 and 54.80 % respectively, with a cut off value of 7.65 cm ($P < 0.001$)

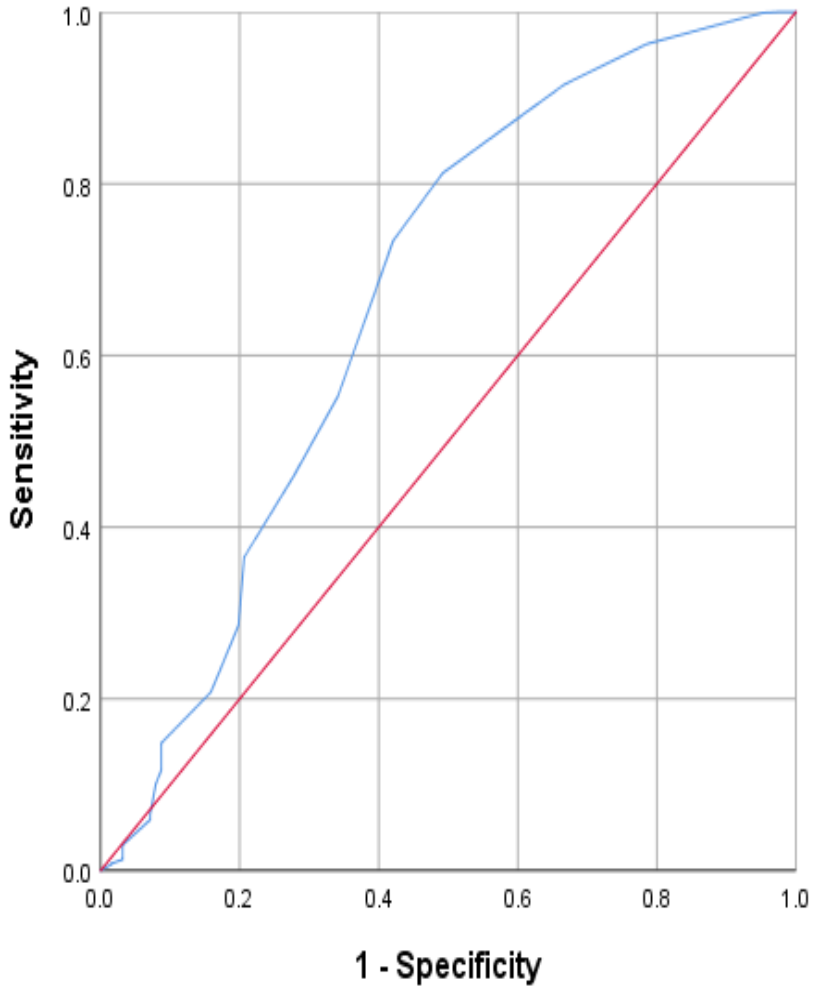



**Figure 4.4:** Receiver operator characteristics curve of foot breadth (cm) covering an area under the curve of 67.00% with sensitivity and specificity of 81.20 and 50.80% respectively, with a cut off value of 2.85 cm ($P < 0.001$)

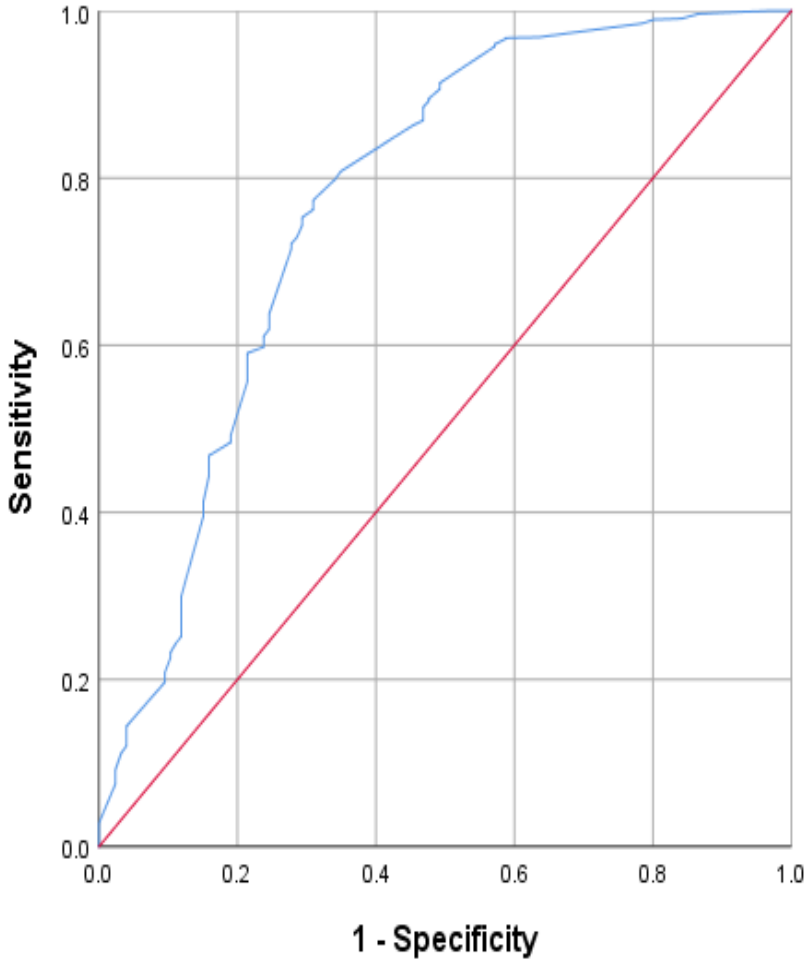



**Figure 4.5:** Receiver operator characteristics curve of thigh circumference (cm) covering an area under the curve of 77.30 % with sensitivity and specificity of 77.30 and 69.00% respectively, with a cut off value of 13.25 cm ($P < 0.001$).

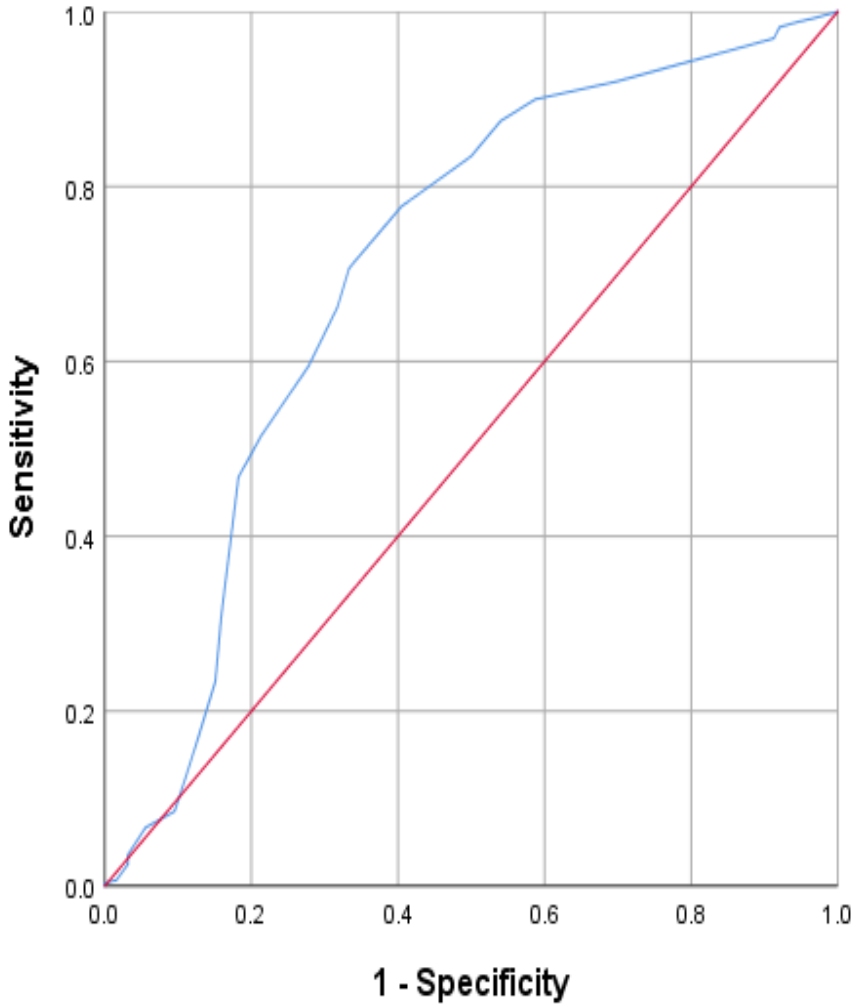



**Figure 4.6:** Receiver operator characteristics curve of hand length (cm) covering an area under the curve of 70.80% with sensitivity and specificity of 70.70 and 66.70% with a cut off value of 6.55 cm ($P < 0.001$).

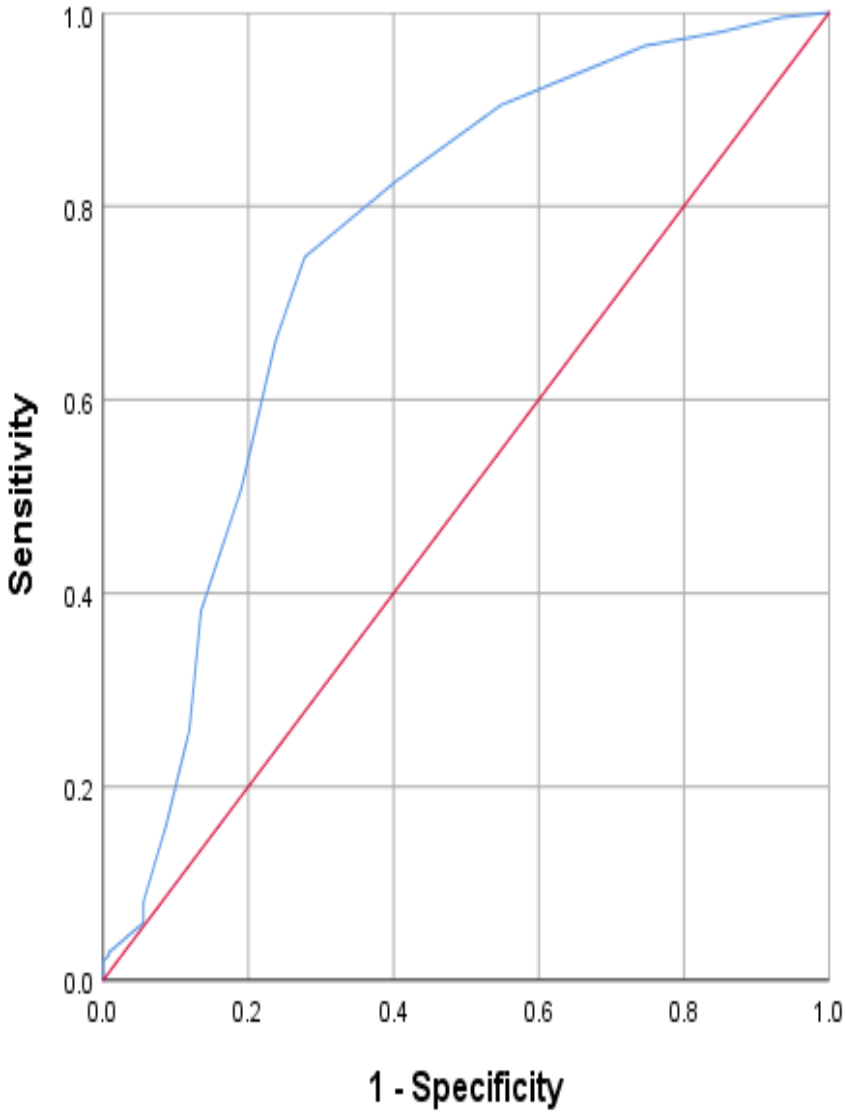



**Figure 4.7:** Receiver operator characteristics curve of hand breadth (cm) covering an area under the curve of 75.70% with sensitivity and specificity of 74.70 and 72.20% respectively, with a cut off value of 3.35 cm ($P < 0.001$).

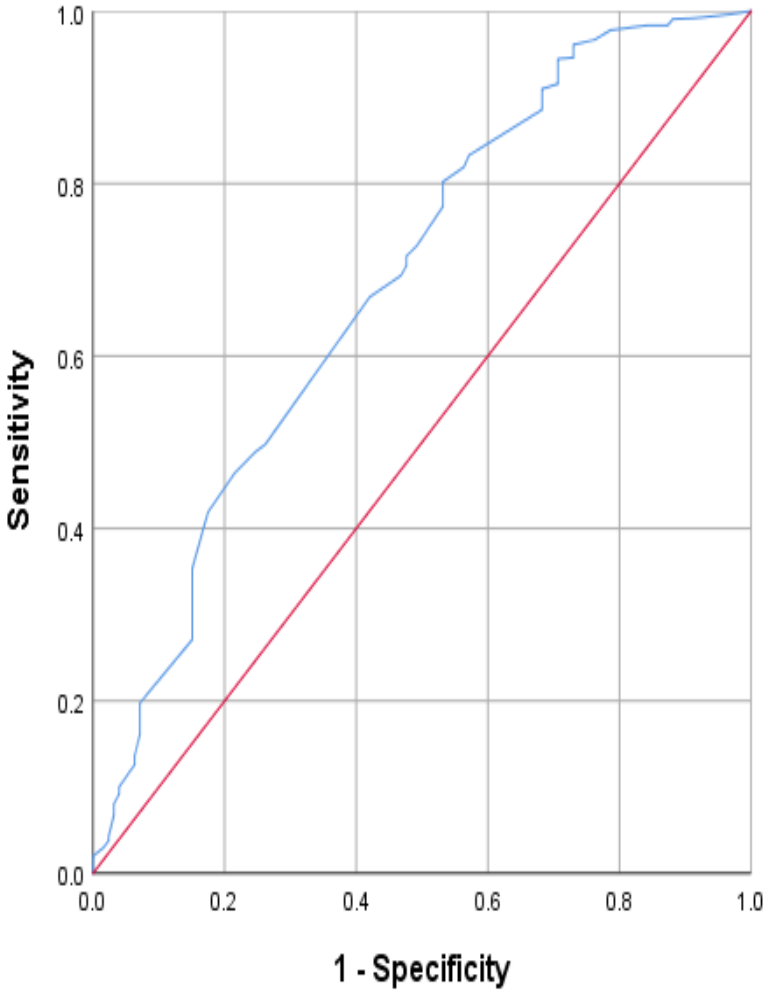



**Figure 4.8:** Receiver operator characteristics curve of neonatal arm circumference (cm) covering an area under the curve of 70.80% with sensitivity and specificity of 70.70 and 66.70% respectively, with a cut off value of 6.55 cm ($P < 0.001$)

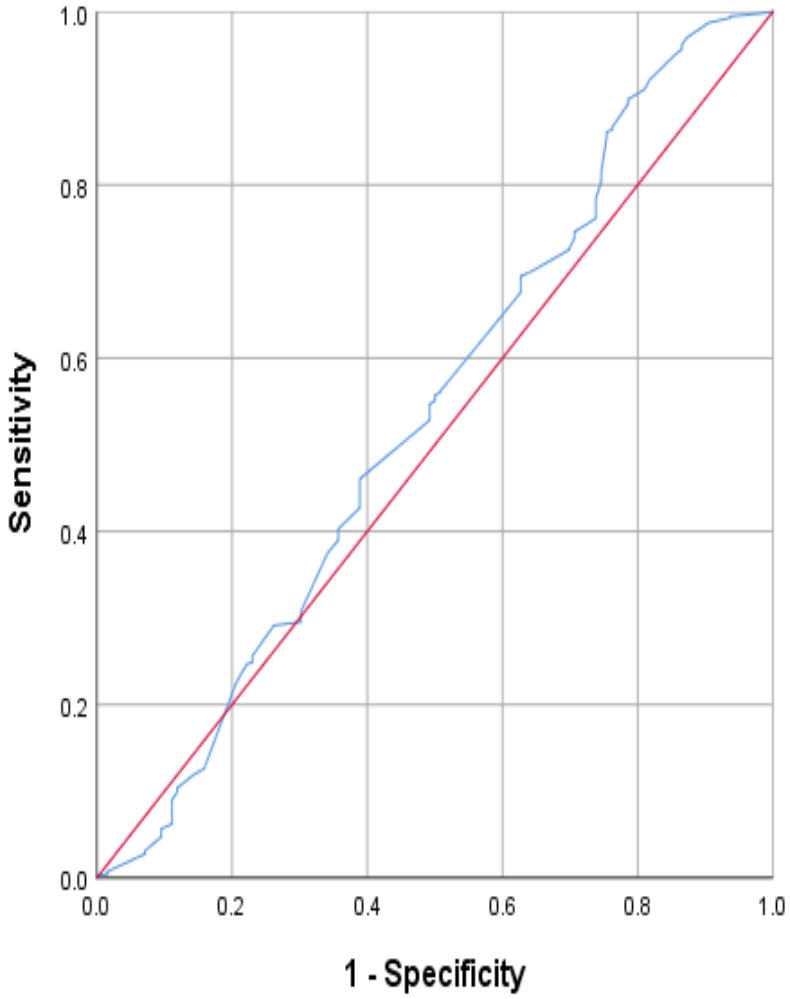



**Figure 4.9:** Receiver operator characteristics curve of chest circumference (cm) covering an area under the curve of 53.70% with sensitivity and specificity of 89.90 and 21.40% respectively, with a cut off value of 24.80 cm ($P < 0.170$).

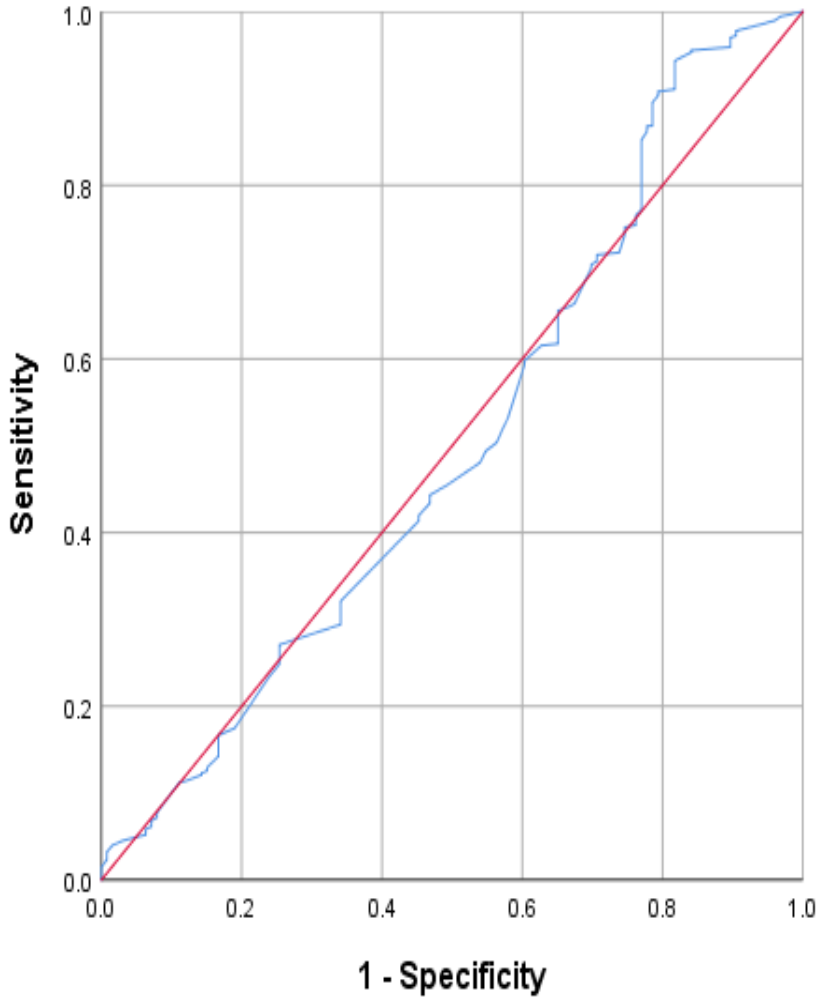



**Figure 4.10:** Receiver operator characteristics curve of head circumference (cm) covering an area under the curve of 50.30% with sensitivity and specificity of 94.30 and 18.30% respectively, with a cut off value of 25.90 cm ($P < 0.901$).

### 4.5.2 Receiver operator curve (ROC) for the discrimination between low and high birth weight among the urban neonates in Kano State Nigeria

Table 4.16 shows the AUC among the neonates in the urban settings in Kano State. The AUC of BL was observed to be 0.781 with regards to the prediction of BW, having the cutoff value of 46.65 cm and sensitivity of 80.7% and a specificity of 69.0% for discrimination between the low and high birth weight babies. The AUC for FL was 0.778 with a cut off value of 0.765cm, having sensitivity and specificity of 83.5% and 62.1% respectively. Similarly, AUC for FB was 0.674. The cut off value, sensibility and specificity were found to be 2.85cm, 82.5% and 51.7% for discrimination of low and high birth weight babies among the urban neonates in Kano State Nigeria. For the TC, the AUC was 0.782 while the cutoff value of 13.55 was observed. It has sensitivity of 75.0% and specificity of 75.9 % among the neonates as regards to the prediction of BW in the urban setting. Also, the AUC for HL was 0.737 with regards to the prediction of BW. The cutoff value for the HL parameter of 6.55cm observed had a sensitivity of 67.1% and a specificity of 74.1% for discrimination of low birth weight from high birth weight babies in the urban areas. Moreover, the AUC for HB was observed to be 0.772. The cutoff value for the HB parameter of 3.25cm had a sensitivity and specificity of 72.7% and 74.1% respectively for discrimination of low birth weight from the high birth weight babies. The NAC had the AUC of 0.701 with regards to the prediction of BW. The cutoff value was found to be 8.55cm. The observed sensitivity and specificity were found to be 94.5% and 37.9% respectively for the discrimination between the low and high birth weight babies. However, the area under the curve for CC was 0.583 with a cutoff value of 24.8 cm had a sensitivity of 91.5% and a specificity of 25.9%. For the HC, the AUC was 0.546. The cutoff value for the HC parameter of 25.9 cm observed had a sensitivity of 95.6% and a specificity of 22.4% for discrimination of low and high birth as represented on figure 4.11.

Table 4.16: The cut off values that discriminate between low and high birth weight among the urban neonates in Kano Nigeria (n = 717)

| **Variables (cm)** | **Cut off value (cm)** | **AUC (%)** | ***P*-value** | **Sensitivity (%)** | **Specificity (%)** |
|---|---|---|---|---|---|
| Birth length | 46.65 | 78.10 | < 0.001 | 80.70 | 69.00 |
| Foot length | 7.65 | 77.80 | < 0.001 | 83.50 | 62.10 |
| Foot breadth | 2.85 | 67.40 | < 0.001 | 82.50 | 51.70 |
| Thigh circumference | 13.55 | 78.20 | < 0.001 | 75.00 | 75.90 |
| Hand length | 6.55 | 73.70 | < 0.001 | 67.10 | 74.10 |
| Hand breadth | 3.25 | 77.20 | < 0.001 | 72.70 | 74.10 |
| Neonatal arm circumference | 8.55 | 70.10 | < 0.001 | 94.50 | 37.90 |
| Chest circumference | 24.80 | 58.30 | < 0.037 | 91.50 | 25.90 |
| Head circumference | 25.90 | 54.60 | < 0.244 | 95.60 | 22.40 |

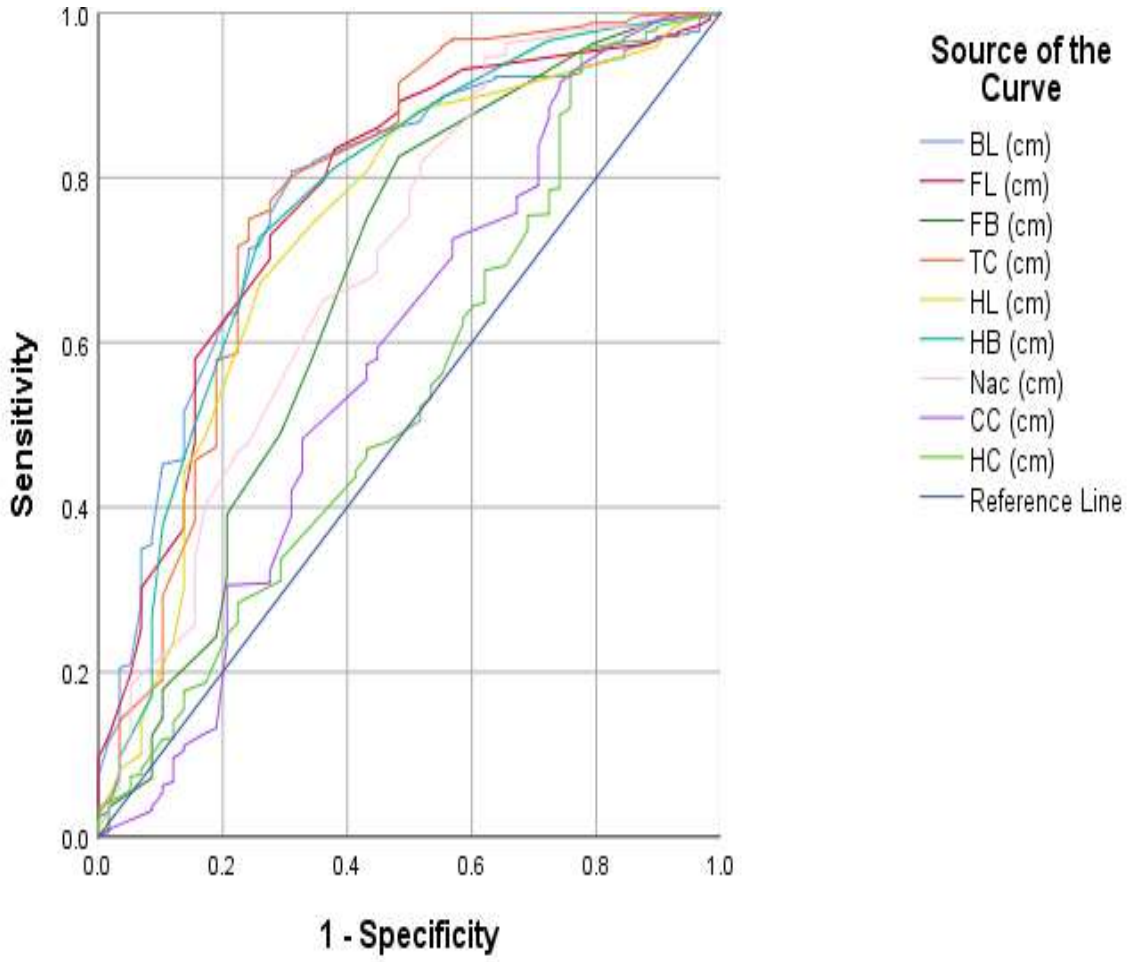



**Figure 4.11:** Receiver operator curve among the urban neonates (cm) in Kano State

### 4.5.3 Receiver operator curve (ROC) for the discrimination between low and high birth weight among the rural neonates in Kano State Nigeria

Table 4.17 shows the AUC among the rural neonates that discriminate against low and high birth weight. The AUC for BL was 0.784 with regards to the prediction of BW. The cutoff value for the BL parameter of 43.10 cm observed had a sensitivity of 96.7% and a specificity of 17.6% for discrimination of low birth weight from the high birth weight babies. The FL had the AUC value of 0.725 with regards to the prediction of BW among the rural neonates. The cutoff value for the FL parameter of 7.65cm observed had a sensitivity of 89.5% and a specificity of 48.5%. However, the AUC for FB was 0.658. The cutoff value is 2.95cm with sensitivity of 70.8% and a specificity of 58.8%. Considering the AUC for TC was found to be 0.768, having cutoff value of 13.05cm with sensitivity and specificity of 63.2% and 80.6% respectively. The AUC for HL was 0.694 with regards to the prediction of BW. The cutoff value for the HL parameter of 6.45 cm observed had a sensitivity of 82.8% and a specificity of 54.4% for discrimination of low birth weight from large birth weight babies. The HB AUC was found to be 0.747. The cutoff value stood at 3.25 cm, while the sensitivity and specificity were found to be 78.0% and 70.6% respectively. The AUC for NAC was 0.679 with regards to the prediction of BW. The cutoff value for the NAC parameter of 11.35 cm observed had a sensitivity of 49.3% and a specificity of 77.9% for discrimination of low birth weight from large birth weight babies. Furthermore, the AUC for CC was 0.487 and the cutoff value was observed to be 21.6 cm. The sensitivity of 96.2% and a specificity of 88.2% were obtained for the discrimination between the low and high birth weight among the rural neonates in Kano State Nigeria. The AUC for HC was 0.455 with regards to the prediction of BW. The cutoff value for the HC parameter of 25.15 cm observed had a sensitivity of 94.3% and a specificity of 14.7% for discrimination of low birth weight from large birth weight babies. As demonstrated on figure 4.12.

Table 4.17: The cut off values that discriminate between low and high birth weight among the rural neonates in Kano State Nigeria (n = 486)

| **Variables (cm)** | **Cut off value (cm)** | **AUC (%)** | ***P*-value** | **Sensitivity (%)** | **Specificity (%)** |
|---|---|---|---|---|---|
| Birth length | 43.10 | 78.40 | < 0.001 | 96.70 | 17.60 |
| Foot length | 7.65 | 72.50 | < 0.001 | 89.50 | 48.50 |
| Foot breadth | 2.95 | 65.80 | < 0.001 | 70.80 | 58.80 |
| Thigh circumference | 13.05 | 76.80 | < 0.001 | 80.60 | 63.20 |
| Hand length | 6.45 | 69.40 | < 0.001 | 82.80 | 54.40 |
| Hand breadth | 3.25 | 74.70 | < 0.001 | 78.00 | 70.60 |
| Neonatal arm circumference | 11.35 | 67.90 | < 0.001 | 49.30 | 77.90 |
| Chest circumference | 21.60 | 48.70 | < 0.729 | 96.20 | 88.20 |
| Head circumference | 25.15 | 45.50 | < 0.231 | 94.30 | 14.70 |

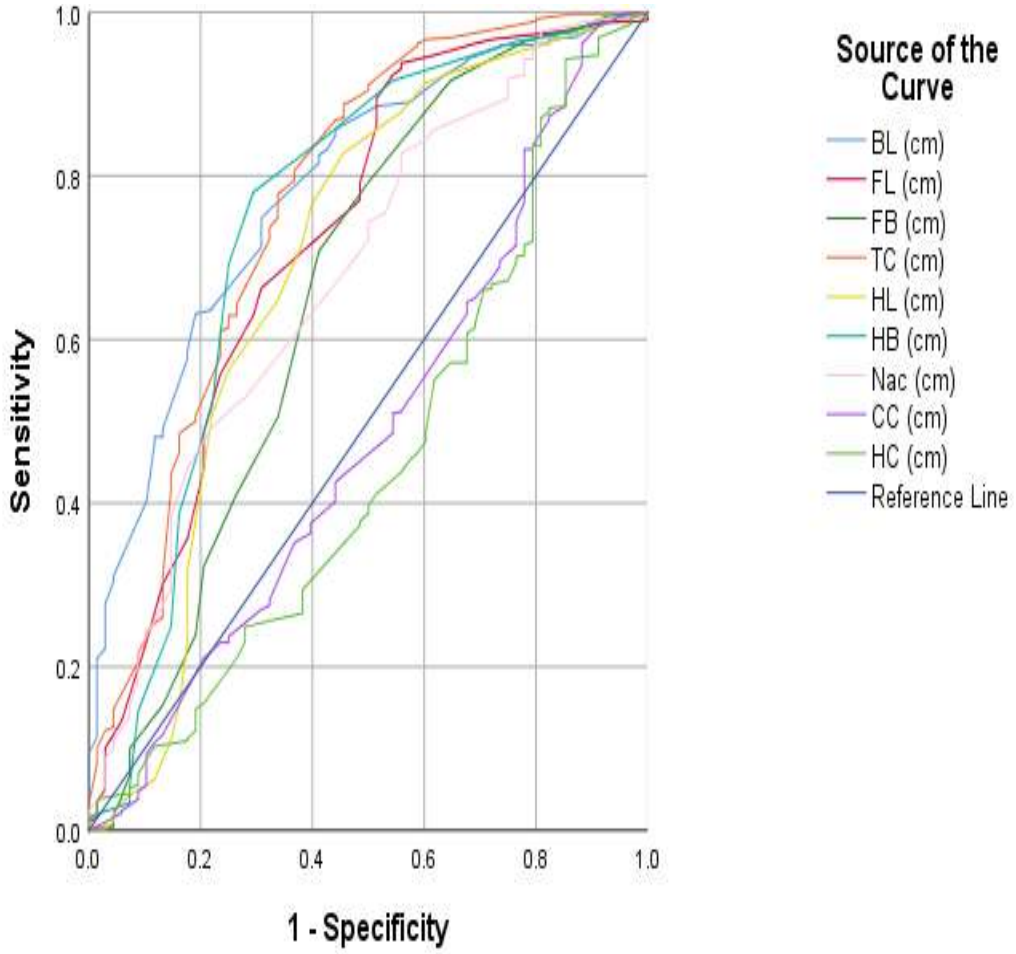



**Figure 4.12:** Receiver operator curve among the rural neonates in Kano State

## 4.6 The effect of urbanization on placental weight and placental-birth weight ratio among the neonates in Kano State, Nigeria

Table 4.18 highlights the effect of urbanization on PW as well as the PW/BW ratio among the neonates in Kano State. A significant increase in PW (534.49 ± 88.64) and decrease in PW/BW ratio (16.91 ± 1.72) i.e. a ratio of 1:6 were observed in mothers living in the urban areas of Kano State, Nigeria. Furthermore, on the gender specific analyses (Table 4.19), it is shown that in both sexes the same trend of increase in PW and decrease in PW/BW ratio were observed in neonates delivered in the urban area. However, the magnitude (measured by level of significance) of the increase in the PW was higher in males whereas the decrease in PW to birth weight ratio was higher among the female neonates.

Table 4.18: The effect of urbanization on placental weight and placental-birth weight ratio among the neonates in Kano State Nigeria

| **Variables** | **Urban + Rural (n = 1203)**<br>**Mean ± SD** | **Urban**<br>**(n = 717)**<br>**Mean ± SD** | **Rural**<br>**(n = 486)**<br>**Mean ± SD** | ***t*-value** | ***P*-value** |
|---|---|---|---|---|---|
| Placental weight (g) | 526.02 ± 83.09 | 534.49 ± 88.64 | 513.5 ± 72.43 | - 4.33 | < 0.001 |
| Birth weight (g) | 3079.30 ± 491.77 | 3174.60 ± 580.30 | 2938.70 ± 429.80 | - 6.24 | < 0.001 |
| Placental-birth weight ratio (%) | 17.17 ± 1.73 | 16.91 ± 1.72 | 17.47 ± 1.69 | 6.53 | < 0.001 |

Table 4.19: Gender specific analyses on the effect of urbanization on placental weight and placental-birth weight ratio among the neonates in Kano State Nigeria

| **Group** | **Variables** | **Urban (n = 717) Mean ± SD** | **Rural (n = 486) Mean ± SD** | ***t*-value** | ***P*-value** |
|---|---|---|---|---|---|
| Male | Placental weight (g) | 539.08 ± 86.33 | 515.84 ± 74.05 | -3.32 | < 0.001 |
| | Placental/Birth weight ratio | 16.89 ± 1.69 | 17.43 ± 1.47 | 3.90 | < 0.001 |
| Female | Placental weight (g) | 530.72 ± 90.43 | 511.39 ± 70.99 | -2.88 | 0.004 |
| | Placental/Birth weight ratio | 16.93 ± 1.75 | 17.69 ± 1.84 | 5.30 | < 0.001 |

Table 4.20 highlighted the PW, BW and the PW/BW ratio among anaemic and non anaemic pregnant mothers in Kano State, Nigeria. The PW and BW among the anaemic mothers were found to have lower values compared to the values of the non anaemic mothers. However, the PW/BW ratio of the anaemic mothers is higher than that of the non anaemic mothers. Also, there is a statistically significant difference between the parameters among both the anaemic and the non anaemic mothers ($P < 0.001$), as also pictorially represented in Figure 4.13, 4.14 and 4.15.

Table 4.20: Placental-birth weight ratio among the anaemic and non anaemic pregnant mothers in Kano Nigeria

| **Group** | **Variables** | **Mean ± SD** | ***P*-value** |
|---|---|---|---|
| Anaemic (n = 209) | Placental weight (g) | 470.88 ± 78.07 | < 0.001 |
| | Birth weight (g) | 2610. 53 ± 452.75 | < 0.001 |
| | Placental-birth weight ratio | 18.18 ± 23.84 | < 0.001 |
| Non anaemic (n = 994) | Placental weight (g) | 537.61 ± 79.41 | < 0.001 |
| | Birth weight (g) | 3177.87 ± | < 0.001 |
| | Placental-birth weight ratio | 16.96 ± 14.78 | < 0.001 |

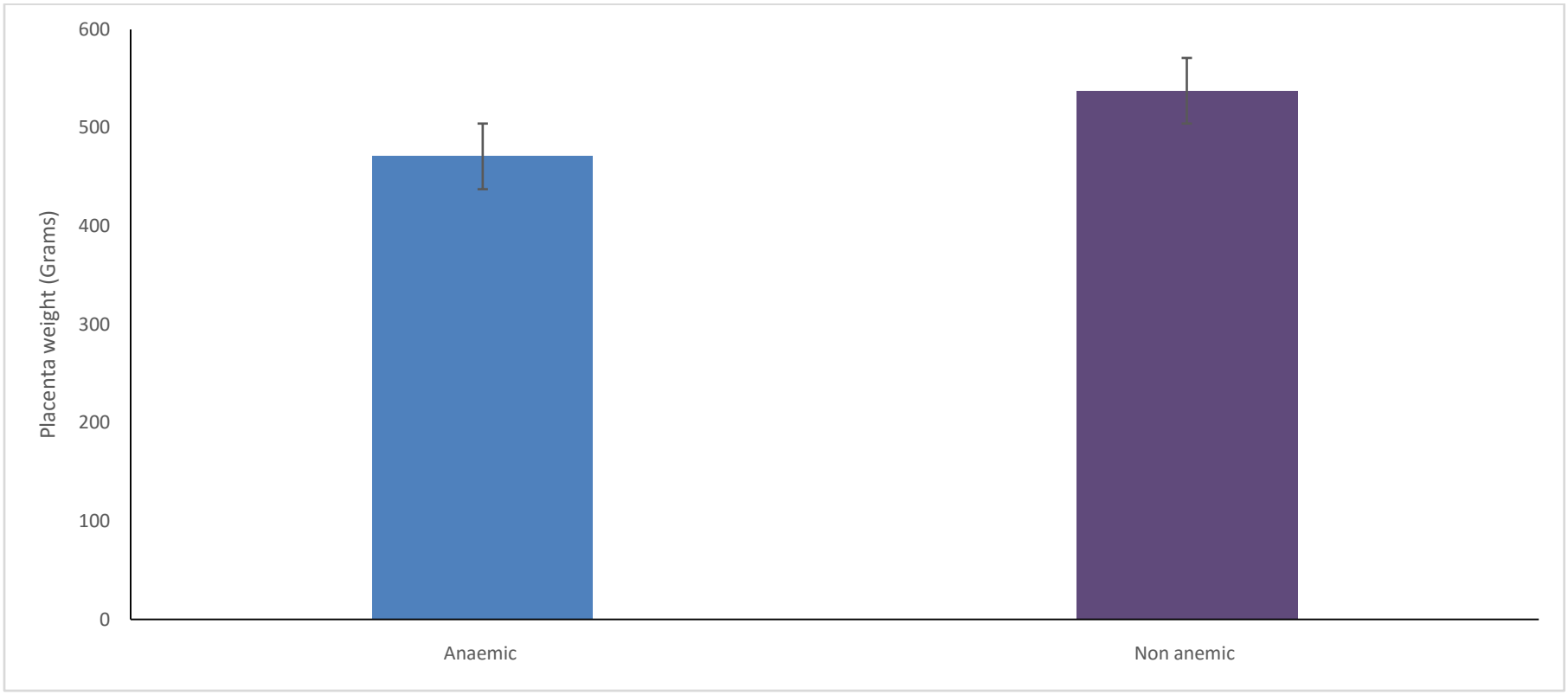



**Figure 4.13:** Placental weight between anaemic and non anaemic mothers in Kano State Nigeria

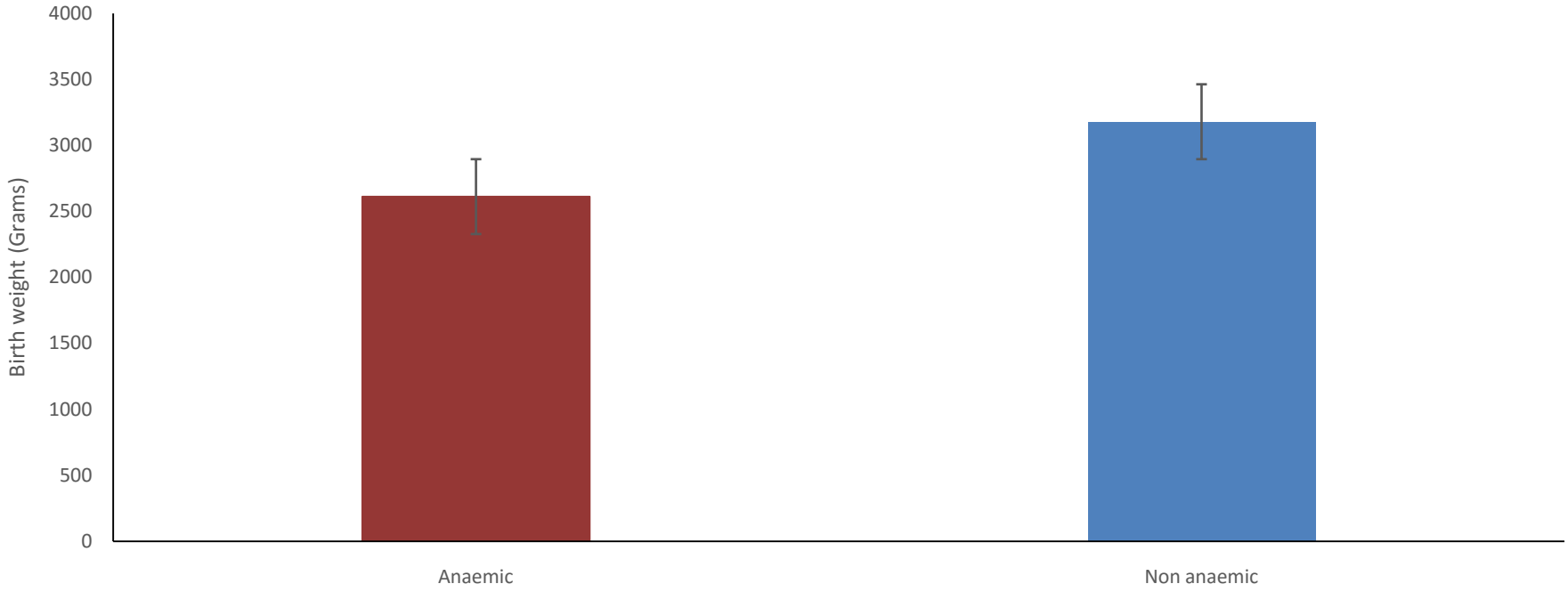



**Figure 4.14:** Birth weight between anaemic and non anaemic mothers in Kano State, Nigeria

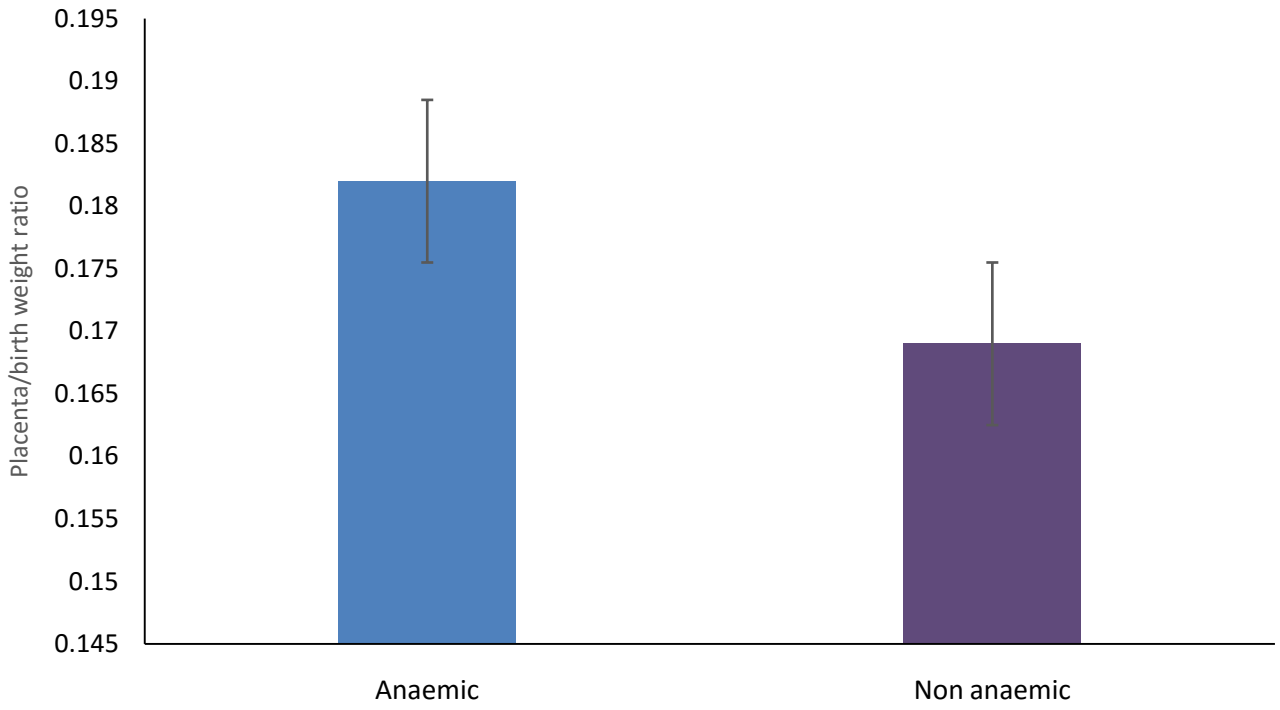



**Figure 4.15:** Placental/birth weight ratio between anaemic and non anaemic mothers in Kano State, Nigeria

From Table 4.21 there is no significant sex differences observed in placental weight and placental-birth weight ratio parameters among the neonates in Kano State, Nigeria.

Table 4.21 Sexual dimorphism in placental weight and placental-birth weight ratio parameters among the neonates in Kano State Nigeria

| **Variables** | **Male (n = 555)**<br>**Mean ± SD** | **Female (n = 648)**<br>**Mean ± SD** | ***t*-value** | ***P*-value** |
|---|---|---|---|---|
| Placental weight (g) | 529.37 ± 82.16 | 523.14 ± 83.83 | 1.30 | 0.195 |
| Placental/birth weight ratio | 17.11 ± 1.62 | 17.22 ± 1.82 | -1.10 | 0.270 |

## 4.7 The Mean Ponderal Index Value and the effect of Urbanization among Full term Neonates in Kano State, Nigeria

Table 4.22 and figure 4.16 shows the mean ponderal index (PI) value among the full term neonates. The mean PI among the neonates stood at 2.66 ± 0.63. A significant effect of urbanization was observed on PI ($P < 0.001$), with neonate from the urban areas having higher mean PI values.

Table 4.22: The mean ponderal index value and the effect of urbanization among the full term neonates in Kano Nigeria

| Variable | Domicile | n | Mean ± SD | *t*-value | *P*-value |
|---|---|---|---|---|---|

| | | | | | |
|---|---|---|---|---|---|
| Ponderal index | All | 1203 | 2.66 ± 0.63 | | |
| | Urban | 717 | 2.80 ± 0.67 | - 9.61 | < 0.001 |
| | Rural | 486 | 2.46 ± 0.50 | | |

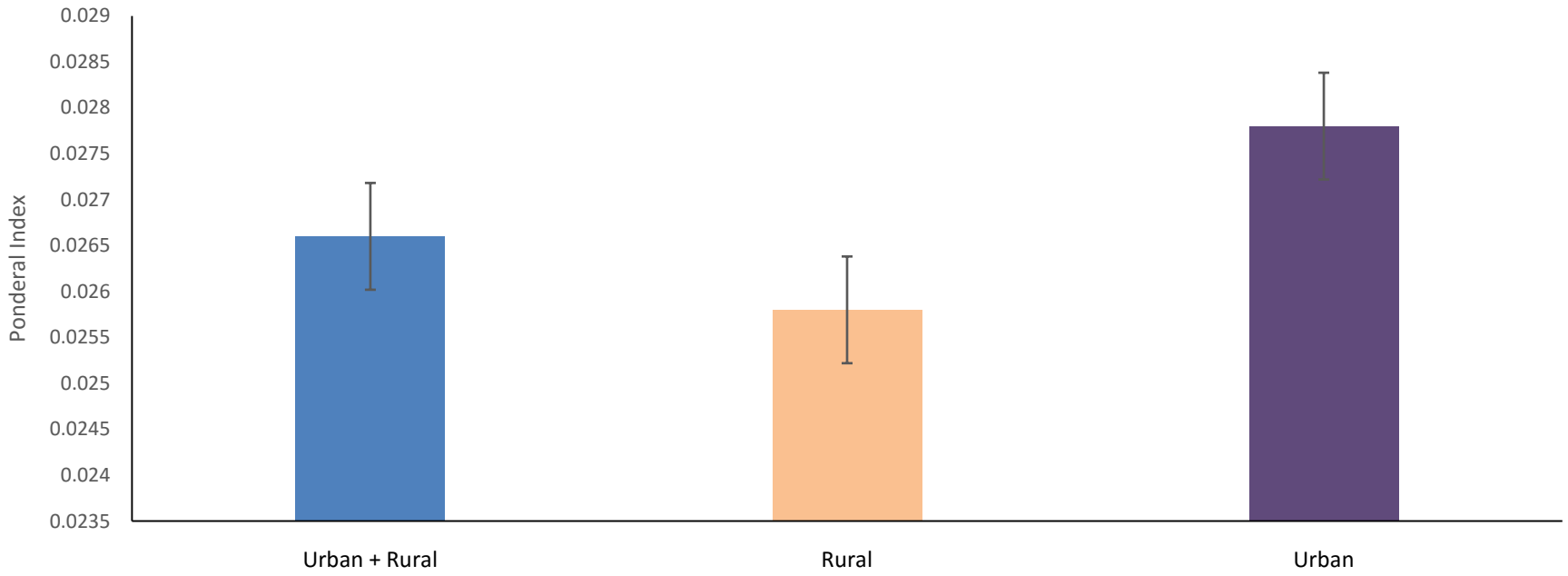



**Figure 4.16:** Mean ponderal index among the neonates

Table 4.23 shows the effect of urbanization on PI and the neonatal anthropometric parameters among the new born babies in Kano State, Nigeria. A significant effect of urbanization was observed on PI ($P < 0.001$) and BW ($P < 0.001$) with neonate from urban area having higher mean value. A significantly higher mean value was also observed among neonate of urban area in FB ($P < 0.001$), CC ($P = 0.015$) and HC ($P = 0.009$). However, a significant higher mean values were obtained among neonate of rural area in BL ($P < 0.001$) and FL ($P = 0.024$).

Table 4.23: Effect of urbanization on ponderal index and the selected neonatal anthropometric parameters among the full term neonates in Kano Nigeria

| **Variables** | **Urban (n = 717) Mean ± SD** | **Rural (n = 486) Mean ± SD** | ***t*-value** | ***P*-value** |
|---|---|---|---|---|
| Ponderal index | 2.80 ± 0.67 | 2.46 ± 0.50 | -9.61 | < 0.001 |
| Birth weight (g) | 3174.62 ± 508.28 | 2938.68 ± 429.80 | -8.40 | < 0.001 |
| Birth length (cm) | 48.69 ± 3.37 | 49.48 ± 3.26 | 4.06 | < 0.001 |
| Foot length (cm) | 8.12 ± 0.66 | 8.21 ± 0.63 | 2.25 | 0.024 |
| Foot breadth (cm) | 3.20 ± 0.41 | 3.12 ± 0.36 | -3.61 | < 0.001 |
| Thigh circumference (cm) | 14.79 ± 2.03 | 14.76 ± 2.13 | -0.23 | 0.818 |
| Hand length (cm) | 6.77 ± 0.54 | 6.82 ± 0.47 | 1.54 | 0.123 |
| Hand breadth (cm) | 3.44 ± 0.34 | 3.42 ± 0.31 | -0.70 | 0.482 |
| Neonatal arm circumference (cm) | 10.97 ± 1.35 | 11.06 ± 1.37 | 1.14 | 0.253 |
| Chest circumference (cm) | 30.24 ± 3.33 | 29.75 ± 3.60 | -2.43 | 0.015 |
| Head circumference (cm) | 32.60 ± 3.45 | 32.04 ± 3.82 | -2.61 | 0.009 |

Tables 4.24 shows the gender specific effect of urbanization on BW, BL and PI value among the neonates in Kano State. A significant effects of urbanization was observed on mean PI in males ($P < 0.001$) and females ($P < 0.001$) respectively. Similarly, BW and BL also varied significantly between the urban and rural neonates in both sexes.

Table 4.24: The effect of gender and urbanization on ponderal index value among the neonates in Kano Nigeria

| **Gender** | **Variables** | **Domicile** | **n** | **Mean ± SD** | ***t*-value** | ***P*-value** |
|---|---|---|---|---|---|---|
| Male | Birth weight (g) | Urban | 323 | 3203.41 ± 490.55 | -5.71 | < 0.001 |
| | | Rural | 232 | 2972.41 ± 440.11 | | |
| | Birth length (cm) | Urban | 323 | 49.07 ± 3.47 | 3.55 | < 0.001 |
| | | Rural | 232 | 50.10 ± 3.20 | | |
| | Ponderal index ($g/cm^3$) | Urban | 323 | 2.77 ± 0.72 | -6.90 | < 0.001 |
| | | Rural | 232 | 2.40 ± 0.49 | | |
| Female | Birth weight (g) | Urban | 394 | 3151.02 ± 521.80 | -6.24 | < 0.001 |
| | | Rural | 254 | 2907.87 ± 418.66 | | |
| | Birth length (cm) | Urban | 394 | 3151.02 ± 521.80 | 2.09 | 0.037 |
| | | Rural | 254 | 48.92 ± 3.21 | | |
| | Ponderal index ($g/cm^3$) | Urban | 394 | 2.82 ± 0.62 | -6.61 | < 0.001 |
| | | Rural | 254 | 2.52 ± 0.49 | | |

Table 4.25 shows the separated data for the neonates with normal BW (2,500 g to 4,000 g) and those with LBW (< 2,500 g), the PI among the babies with normal BW is found to be 2.64 g/cm$^3$ and that of LBW is 2.77 g/cm$^3$ ($P$ = 0.043). The PI shows normal values in both groups.

Table 4.25: Ponderal index among neonates with normal and low birth weight in Kano Nigeria

| **Variable** | **Birth weight** | **n** | **Mean ± SD** | ***t*-value** | ***P*-value** |
|---|---|---|---|---|---|
| Ponderal index ($g/cm^3$) | All | 1203 | 2.66 ± 0.63 | | |
| | Normal birth weight (2,500 g – 4,000 g) | 1077 | 2.64 ± 0.61 | | |
| | Low birth weight (< 2,500 g) | 126 | 2.77 ± 0.68 | - 2.021 | 0.043 |

Table 4.26: Shows the sexual dimorphism in PI, and the neonatal anthropometric parameters Kano State. A significant ($P$ = 0.018) sexual dimorphism was observed in PI with females (2.70 ± 0.59) having higher mean value compared to males (2.62 ± 0.66). For the neonatal anthropometry, the males had significantly ($P$ < 0.05) higher mean values only in BL (49.50 ± 4.74), FL (8.23 ± .65) and HL 6.84 ± 0.50. No significant sexual dimorphisms were observed in body breath and circumferences among the neonates in Kano State.

Table 4.26: Mean ponderal index value among the selected neonatal anthropometric parameters in both sexes in Kano State, Nigeria

| **Variables** | **Male (n = 555) Mean ± SD** | **Female (n = 648) Mean ± SD** | ***t*-value** | ***P*-value** |
|---|---|---|---|---|
| Ponderal index ($g/cm^3$) | 2.62 ± 0.66 | 2.70 ± 0.59 | -2.37 | 0.018 |
| Birth weight (g) | 3106.85 ± 483.36 | 3055.71 ± 498.03 | 1.80 | 0.072 |
| Birth length (cm) | 49.50 ± 3.40 | 48.59 ± 3.24 | 4.74 | <0.001 |
| Foot length (cm) | 8.23 ± 0.65 | 8.10 ± 0.65 | 3.42 | 0.001 |
| Foot breadth (cm) | 3.19 ± 0.39 | 3.15 ± 0.40 | 1.95 | 0.051 |
| Thigh circumference (cm) | 14.87 ± 2.03 | 14.69 ± 2.10 | 1.49 | 0.137 |
| Hand length (cm) | 6.84 ± 0.50 | 6.76 ± 0.52 | 2.72 | 0.007 |
| Hand breadth (cm) | 3.45 ± 0.31 | 3.42 ± 0.34 | 1.75 | 0.081 |
| Neonatal arm circumference (cm) | 11.01 ± 1.36 | 11.00 ± 1.35 | 0.23 | 0.814 |
| Chest circumference (cm) | 29.95 ± 3.25 | 30.12 ± 3.61 | -0.86 | 0.392 |
| Head circumference (cm) | 32.31 ± 3.39 | 32.43 ± 3.79 | -0.58 | 0.561 |

### 4.8 The Correlation between Birth Weight with Maternal and the Selected Neonatal Anthropometric Parameters among the Mother-child Pair in Kano State

Table 4.27 establishes the relationship between neonatal BW and the maternal anthropometric parameters. The BW shows a significant positive correlation with MH and SFH. Among the male neonates, in addition to MH and SFH, a significant correlation was also observed between BW and MAC.

Table 4.27: The correlation between birth weight and maternal anthropometric parameters among the mother-child pair in Kano Nigeria

| | **Variable** | **MH** | **MAC** | **SFH** |
|---|---|---|---|---|
| All (n = 1203) | BW | 0.089** | -0.018 | 0.538** |
| | MH | - | 0.025 | 0.048 |

| | | | | |
|---|---|---|---|---|
| | MAC | | - | 0.008 |
| Male (n = 555 ) | BW | 0.120** | -0.136** | 0.516** |
| | MH | - | -0.103* | 0.083* |
| | MAC | | - | -0.033 |
| Female (n = 648 ) | BW | 0.064 | 0.088* | 0.560** |
| | MH | - | 0.146** | 0.020 |
| | MAC | | - | 0.049 |

BW; birth weight, MH; maternal height, MAC; mid-arm circumferences, SFH; symphysio-fundal height, * $P < 0.05$, ** $P < 0.01$

Table 4.28 makes clear the relationship between neonatal BW with placenta and the select neonatal anthropometric parameters. A significant positive correlation was observed between the BW with PW and other neonatal anthropometric parameters. The highest correlation was observed in PW followed by TC and the least correlation was observed in CC.

Table 4.28: The correlation between birth weight and selected neonatal anthropometric parameters among the neonates in Kano Nigeria

| **Variables** | **PW** | **BL** | **FL** | **FB** | **TC** | **HL** | **HB** | **NAC** | **CC** | **HC** |
|---|---|---|---|---|---|---|---|---|---|---|
| BW | 0.825** | 0.378** | 0.361** | 0.233** | 0.458** | 0.283** | 0.349** | 0.272** | 0.117** | 0.096** |
| PW | - | 0.335** | 0.347** | 0.230** | 0.422** | 0.287** | 0.345** | 0.220** | 0.097** | 0.073* |
| BL | | - | 0.684** | 0.088** | 0.425** | 0.487** | 0.378** | 0.372** | 0.034* | - 0.007 |
| FL | | | - | 0.235** | 0.375** | 0.593** | 0.502** | 0.336** | 0.086** | 0.060* |
| FB | | | | - | 0.236** | 0.306** | 0.526** | 0.067* | 0.137** | 0.150** |
| TC | | | | | - | 0.252** | 0.245** | 0.281** | 0.126** | 0.080** |
| HL | | | | | | - | 0.559** | 0.243** | 0.016* | 0.042 |
| HB | | | | | | | - | 0.295** | 0.109** | 0.125** |
| NAC | | | | | | | | - | 0.143** | 0.110** |
| CC | | | | | | | | | - | 0.930** |
| HC | | | | | | | | | | - |

BW; birth weight, PW; placental weight, BL; birth length, FL; foot length, FB; foot breadth, TC; thigh circumferences, HL; hand length, HB; hand breadth, NAC; neonatal arm circumferences, CC; chest circumferences, HC; head circumferences, *$P < 0.05$,**$P < 0.01$

From Table 4.29, it is obvious that the same correlation pattern was observed in both males and females, except in males where there was absence of correlation between the BW and CC. Also the PW is the best neonatal parameter that correlates with BW; it is followed by TC.

Table 4.29: The correlation between birth weight and the selected neonatal anthropometric parameters based on gender

| Sex | Variables | PW | BL | FL | FB | TC | HL | HB | NAC | CC | HC |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Male | BW | 0.839** | 0.326** | 0.329** | 0.248** | 0.372** | 0.255** | 0.311** | 0.310** | -0.004 | -0.013 |
| | PW | - | 0.320** | 0.325** | 0.249** | 0.355** | 0.269** | 0.329** | 0.277** | -0.013 | -0.047 |
| | BL | | - | 0.723** | 0.156** | 0.425** | 0.483** | 0.451** | 0.415** | -0.045 | -0.096* |
| | FL | | | - | 0.230** | 0.380** | 0.547** | 0.512** | 0.397** | -0.003 | -0.041 |
| | FB | | | | - | 0.236** | 0.306** | 0.483** | 0.138** | 0.087* | 0.101* |
| | TC | | | | | - | 0.201** | 0.231** | 0.281** | -0.037 | -0.111** |
| | HL | | | | | | - | 0.567** | 0.272** | -0.053 | -0.020 |
| | HB | | | | | | | - | 0.338** | -0.019 | -0.016 |
| | NAC | | | | | | | | - | 0.085* | 0.021 |
| | CC | | | | | | | | | - | - |
| Female | BW | 0.813** | 0.418** | 0.382** | 0.216** | 0.524** | 0.300** | 0.376** | 0.240** | 0.210** | 0.179** |
| | PW | - | 0.346** | 0.361** | 0.212** | 0.475** | 0.299** | 0.356** | 0.171** | 0.183** | 0.164** |
| | BL | | - | 0.643** | 0.0168 | 0.422** | 0.483** | 0.316** | 0.338** | 0.104** | 0.069 |
| | FL | | | - | 0.233** | 0.368** | 0.625** | 0.492** | 0.285** | 0.160** | 0.141** |
| | FB | | | | - | 0.232** | 0.301** | 0.557** | 0.007 | 0.179** | 0.189** |
| | TC | | | | | - | 0.289** | 0.252** | 0.281** | 0.249** | 0.224** |
| | HL | | | | | | - | 0.552** | 0.219** | 0.071 | 0.089* |
| | HB | | | | | | | - | 0.262** | 0.201** | 0.223** |
| | NAC | | | | | | | | - | 0.189** | 0.180** |
| | CC | | | | | | | | | - | 0.932** |

BW; birth weight, PW; placental weight, BL; birth length, FL; foot length, FB; foot breadth, TC; thigh circumferences, HL; hand length, HB; hand breadth, NAC; neonatal arm circumferences, CC; chest circumferences, HC; head circumferences. * $P < 0.05$, ** $P < 0.01$

Table 4.30 shows the correlation pattern among the male and female neonates living in the urban and rural settlement in Kano State, Nigeria. It was observed that there is a significant association between the male and female neonates ($P < 0.001$) in both the urban and rural areas, except CC (- 0.012) and HC (- 0.076) were a negative correlation exists with BW among the male and female neonates respectively in the urban area. However, among the male neonates in the rural areas, PW shows to be the best neonatal parameter that correlates with BW in both the male (0.870) and female (0.793) neonates.

Table 4.30: The correlation among the selected neonatal parameters based on urbanization and gender

| Domicile | Sex | | BW | PW | BL | FL | FB | TC | HL | HB | NAC | CC | HC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Urban | **M** | BW | - | 0.820** | 0.340** | 0.361** | 0.269** | 0.388** | 0.275** | 0.331** | 0.331** | -0.013 | -0.012 |
| | **F** | PW | 0.824** | - | 0.312** | 0.313** | 0.243** | 0.362** | 0.272** | 0.330** | 0.270** | -0.058 | -0.076 |
| | | BL | 0.443** | 0.0358** | - | 0.724** | 0.142* | 0.412** | 0.484** | 0.430** | 0.386** | -0.070 | -0.114* |
| | | FL | 0.392** | 0.373** | 0.623** | - | 0.201** | 0.351** | 0.566** | 0.491** | 0.406** | -0.032 | -0.076 |
| | | FB | 0.201** | 0.205** | -0.025 | 0.210** | - | 0.187** | 0.330** | 0.526** | 0.117* | 0.070 | 0.091 |
| | | TC | 0.544** | 0.473** | 0.397** | 0.339** | 0.223** | - | 0.167** | 0.179** | 0.310** | -0.039 | -0.125* |
| | | HL | 0.300** | 0.305** | 0.462** | 0.610** | 0.263** | 0.263** | - | 0.594** | 0.245** | -0.053 | -0.011 |
| | | HB | 0.354** | 0.358** | 0.289** | 0.472** | 0.576** | 0.247** | 0.547** | - | 0.288** | -0.052 | -0.057 |
| | | NAC | 0.259** | 0.209** | 0.345** | 0.281** | 0.023 | 0.325** | 0.214** | 0.243** | - | 0.027 | -0.053 |
| | | CC | 0.215** | 0.214** | 0.091 | 0.140** | 0.199** | 0.282** | 0.057 | 0.198** | 0.181** | - | 0.916** |
| | | HC | 0.173** | 0.194** | 0.042 | 0.112* | 0.209** | 0.244** | 0.077 | 0.211** | 0.144** | 0.922** | - |
| Rural | **M** | BW | - | 0.870** | 0.437** | 0.379** | 0.178** | 0.390** | 0.296** | 0.330** | 0.340** | -0.030 | -0.060 |
| | **F** | PW | 0.793** | - | 0.412** | 0.407** | 0.236** | 0.364** | 0.306** | 0.354** | 0.321** | 0.030 | -0.030 |
| | | BL | 0.476** | 0.037** | - | 0.713** | 0.218** | 0.450** | 0.470** | 0.481** | 0.451** | 0.010 | -0.060 |
| | | FL | 0.421** | 0.036** | 0.675** | - | 0.314** | 0.429** | 0.499** | 0.547** | 0.377** | 0.050 | 0.010 |
| | | FB | 0.178** | 0.194** | 0.122 | 0.287** | - | 0.315** | 0.286** | 0.432** | 0.183** | 0.100 | 0.110 |
| | | TC | 0.523** | 0.492** | 0.472** | 0.413** | 0.245** | - | 0.262** | 0.300** | 0.242** | -0.030 | -0.110 |
| | | HL | 0.341** | 0.301** | 0.521** | 0.651** | 0.386** | 0.331** | - | 0.525** | 0.315** | -0.040 | -0.020 |
| | | HB | 0.408** | 0.034** | 0.388** | 0.538** | 0.511** | 0.259** | 0.569** | - | 0.403** | 0.030 | 0.040 |
| | | NAC | 0.236** | 0.108 | 0.329** | 0.290** | -0.017 | 0.218** | 0.228** | 0.300** | - | 0.165* | 0.100 |
| | | CC | 0.171** | 0.112 | 0.142* | 0.195** | 0.127* | 0.201** | 0.097 | 0.196** | 0.203** | - | 0.093** |
| | | HC | 0.158* | 0.093 | 0.123 | 0.179** | 0.137* | 0.193** | 0.109 | 0.222** | 0.224** | 0.936** | - |

M; male (up), F: female (down), BW; birth weight, PW; placental weight, BL; birth length, FL; foot length, FB; foot breadth, TC; thigh circumferences, HL; hand length, HB; hand breadth, NAC; neonatal arm circumferences, CC; chest circumferences, HC; head circumferences. * $P < 0.05$, ** $P < 0.01$

Table 4.31 highlighted the correlation between BW, PW and maternal Hb level among the urban and rural populace. All the results obtained were observed to show a statistically significant level of correlation ($P < 0.001$) between the study parameters (Hb level, PW and BW) irrespective of the location (urbanization).

Table 4.31: The correlation between birth weight, placental weight and maternal haemoglobin level among the urban and rural populace in Kano Nigeria

| **Urbanization** | **Variables** | **BW** | **PW** | **Hb** |
|---|---|---|---|---|
| Rural (486) | BW | - | 0.823** | 0.485** |
| | PW | 0.823** | - | 0.375** |
| | Hb | 0.485** | 0.375** | - |
| Urban (717) | BW | - | 0.831** | 0.546** |
| | PW | 0.831** | - | 0.385** |
| | Hb | 0.546** | 0.385** | - |

**Correlation is significant at the 0.01 level (2-tailed)

## 4.9 Stepwise Regression Models for Estimating Neonatal Birth Weight from the Selected Neonatal Anthropometric Parameters

Table 4.32 shows the stepwise multiple linear regression models for the estimation of BW from the select neonatal anthropometric parameters. The best single estimator of BW in both male and female neonates was TC followed by HB. The overall equation of BW estimation in males includes TC, HB, NAC, FB and FL. In females, the overall models include BL in addition to TC and HB. The overall accuracy measured by standard error of estimate (SEE) was low in females (SEE = 398.19) compared to males (SEE = 426.63). Highest correlation coefficient (*r*) and $R^2$ (measure of variance) were found to be higher in females.

Table 4.32: Stepwise multiple linear regression models for estimating neonatal birth weight from neonatal anthropometric parameters in Kano Nigeria

| Sex | Steps | Models | *r* | $R^2$ | SEE | *F*-value | *P*-value |
|---|---|---|---|---|---|---|---|
| All | 1 | BW (g) = 1472.59 + 108.75 × TC | 0.458 | 0.2093 | ± 437.47 | 317.94 | < 0.001 |
| | 2 | BW (g) = 392.86 + 94.08 × TC + 377.85 × HB | 0.519 | 0.2692 | ± 420.75 | 221.01 | < 0.001 |
| | 3 | BW (g) = -298.98 + 81.07 × TC + 310.19 × HB + 22.77 × BL | 0.536 | 0.2869 | ± 415.79 | 160.826 | < 0.001 |
| | **4** | **BW (g) = -358.17 + 78.87 × TC + 292.76 × HB + 20.17 × BL + 25.35 × NAC** | **0.539** | **0.2909** | **± 414.79** | **122.89** | **< 0.001** |
| Male | 1 | BW (g) = 1788.31 + 88.67 × TC | 0.372 | 0.1387 | ± 448.98 | 89.08 | < 0.001 |
| | 2 | BW (g) = 706.31 + 75.63 × TC + 369.91 × HB | 0.438 | 0.1920 | ± 435.26 | 65.60 | < 0.001 |
| | 3 | BW (g) = 437.32 + 67.11 × TC + 294.64 × HB + 59.50 × NAC | 0.464 | 0.2156 | ± 429.25 | 50.49 | < 0.001 |
| | 4 | BW (g) = 331.48 + 64.02 × TC + 228.70 × HB + 61.48 × NAC + 112.07 × FB | 0.471 | 0.2217 | ± 427.98 | 39.16 | < 0.001 |
| | **5** | **BW (g) = 82.34 + 58.27 × TC + 163.81 × HB + 54.50 × NAC + 118.95 × FB + 74.56 × FL** | **0.477** | **0.2280** | **± 426.63** | **32.42** | **< 0.001** |
| Female | 1 | BW (g) = 1230.36 + 124.24 × TC | 0.524 | 0.2743 | ± 424.60 | 244.15 | < 0.001 |
| | 2 | BW (g) = 169.35 + 108.68 × TC + 377.52 × HB | 0.581 | 0.3376 | ± 405.98 | 164.33 | < 0.001 |
| | **3** | **BW (g) = -763.90 + 92.73 × TC + 317.76 × HB + 28.23 × BL** | **0.603** | **0.3637** | **± 398.19** | **122.71** | **< 0.001** |

BW; birth weight, BL; birth length, FL; foot length, FB; foot breadth, TC; thigh circumferences, HB; hand breadth, NAC; neonatal arm circumferences, SEE; standard error of estimate.

Considering the area of residence (urbanization), Table 4.33 clearly shows the stepwise multiple linear regression equations among the urban and rural neonates in Kano State, Nigeria. The overall equation of BW among the urban neonates are TC, HC, BL and NAC ($r$ = 0.478 at $P$ < 0.0001). However, when gender was considered (male and female) neonates in the urban settlement, the overall models for the BW estimation includes TC, NAC and HB (r = 0.497, $P$ < 0.0001) in males and BL, TC HB (r = 0.623, $P$ < 0.0001) in females respectively. Similarly when the neonates in the rural areas were considered, the overall BW equation includes the BL, TC and HB (r = 0.563, $P$ < 0.0001). Furthermore, when gender was factored in, the overall BW model of the males (r = 0.510) and females (r = 0.621) are BL, TC and NAC and BL, TC and HB respectively. Also, the highest correlation coefficient ($r$) and $R^2$ (measure of variance) were found to be higher among the female neonates, but the overall accuracy measured by standard error of estimate (SEE) was low in the rural neonates (SEE = 356.22) compared to the urban neonates (SEE = 420.89). The difference between the adjusted $R^2$ and the $R^2$ values throughout the equations were found to be less than 10%, thus confirming the acceptability of the $r$-value. The $F$-values reported shows the fitness of the regression models.

Table 4.33: The stepwise regression equation models among the urban and rural populace in Kano Nigeria

| Domicile | Sex | Steps | Models | *r* | $R^2$ | Adjusted $R^2$ | SEE | *F* | *P*-value |
|---|---|---|---|---|---|---|---|---|---|
| Urban | All | 1 | BW = 1405.77+ TC (119.64) | 0.478 | 0.228 | 0.230 | 446.8 | 211.61 | < 0.0001 |
| | (n = 717) | 2 | BW = 311.93 + TC (105.84) + HB (377.61) | 0.537 | 0.288 | 0.290 | 429.35 | 144.74 | < 0.0001 |
| | | 3 | BW = -546.69 + TC (27.72) + HB (90.03) + BL (302.74) | 0.561 | 0.314 | 0.310 | 421.77 | 108.95 | < 0.0001 |
| | | 4 | BW = -614.05 + TC (25.29) + HB (86.74) + BL (288.64) + NAC(25.78) | 0.564 | 0.318 | 0.315 | 420.89 | 83.05 | < 0.0001 |
| Rural | All | 1 | BW = -74.56 + BL (60.89) | 0.461 | 0.213 | 0.215 | 381.7 | 130.92 | < 0.0001 |
| | (n = 486) | 2 | BW = -56.68 + BL (41.56) + TC (63.62) | 0.539 | 0.291 | 0.288 | 362.77 | 98.89 | < 0.0001 |
| | | 3 | BW = -386.91 + BL (31.93) + TC (59.94) + HB (251.56) | 0.563 | 0.317 | 0.313 | 356.22 | 74.68 | < 0.0001 |
| Urban | Male | 1 | BW = 1784.205 + TC (95.652) | 0.388 | 0.151 | 0.148 | 452.76 | 56.99 | < 0.0001 |
| | (n = 323) | 2 | BW = 502.175 + TC (83.752) + HB (424.206) | 0.470 | 0.221 | 0.216 | 434.26 | 45.44 | < 0.0001 |
| | | 3 | BW = 205.058 + TC (72.313) + NAC (63.364) + HB (358.223) | 0.497 | 0.247 | 0.240 | 427.69 | 34.87 | < 0.0001 |
| | Female | 1 | BW = 1123.458 + TC (137.530) | 0.544 | 0.296 | 0.294 | 438.46 | 164.60 | < 0.0001 |
| | (n = 394) | 2 | BW = -576.225 + BL (43.390) + TC (110.432) | 0.598 | 0.358 | 0.354 | 419.41 | 108.66 | < 0.0001 |
| | | 3 | BW = -1071.988 + BL (36.573) + TC (102.981) + HB (272.273) | 0.623 | 0.388 | 0.384 | 409.57 | 82.63 | < 0.0001 |
| Rural | Male | 1 | BW = -35.430 + BL (60.038) | 0.437 | 0.186 | 0.187 | 396.71 | 54.31 | < 0.0001 |
| | (n = 232) | 2 | BW = -47.879 + BL (45.039) + TC (51.215) | 0.488 | 0.238 | 0.231 | 385.84 | 35.78 | < 0.0001 |
| | | 3 | BW = -124.896 + BL (35.123) + TC (49.496) + NAC(53.971) | 0.510 | 0.260 | 0.251 | 380.94 | 26.78 | < 0.0001 |
| | Female | 1 | BW = 1425.060 + TC (101.472) | 0.523 | 0.274 | 0.270 | 357.66 | 94.65 | < 0.0001 |
| | (n = 254) | 2 | BW = 327.692 + TC (86.775) + HB (387.539) | 0.594 | 0.353 | 0.347 | 338.24 | 68.30 | < 0.0001 |
| | | 3 | BW = -531.522 + BL (28.208) + TC (70.061) + HB (305.856) | 0.621 | 0.387 | 0.378 | 330.22 | 52.22 | < 0.0001 |

BW; birth weight, BL; birth length, FL; foot length, FB; foot breadth, TC; thigh circumferences, HB; hand breadth, NAC; neonatal arm circumferences, SEE; standard error of estimate.

The multiple linear regression models derived from the select neonatal anthropometric parameters that can be used for the estimation of BW of neonates in Kano State, Nigeria irrespective of area of residence are highlighted on table 4.34. The models were constructed based on straight line equation y = a + bx (Appendix VIII b) as represented on the scatter plots Figures 4.6 to 4.14 (with the best line of fitness). The preeminent estimator of the BW among the neonatal anthropometric parameters was found to be TC ($r$ = 0.458; $P$ < 0.001) followed by BL. The HC has the lowest estimation precision ($r$ = 0.096; $P$ < 0.001). The accuracy of the equations was given by SEE, and also the fitness of the models was measured by the $F$-value.

Table 4.34: Linear regression equation models for the estimation of birth weight from the selected neonatal anthropometric parameters in Kano Nigeria

| S/No. | Variables | B | Linear regression equations | *r* | SEE | *F*-value | *P*-value |
|---|---|---|---|---|---|---|---|
| 1. | Thigh circumference | 108.75 | BW (g) = 1472.6 + 108.75 TC (cm) | 0.458 | 437.47 | 3317.94 | < 0.001 |
| 2. | Birth length | 55.60 | BW (g) = 354 + 55.60 BL (cm) | 0.378 | 455.46 | 200.30 | < 0.001 |
| 3. | Foot length | 272.00 | BW (g) = 860 + 272.00 FL (cm) | 0.361 | 458.74 | 180.36 | < 0.001 |
| 4. | Hand breadth | 522.80 | BW (g) = 1285 + 522.80 HB (cm) | 0.349 | 461.01 | 166.78 | < 0.001 |
| 5. | Hand length | 270.20 | BW (g) = 1244 + 270.20 HL (cm) | 0.283 | 471.87 | 104.54 | < 0.001 |
| 6. | Neonatal arm circumference | 98.50 | BW (g) = 1995 + 98.50 NAC (cm) | 0.272 | 473.48 | 95.71 | < 0.001 |
| 7. | Foot breadth | 291.40 | BW (g) = 2157 + 291.40 FB (cm) | 0.233 | 478.47 | 68.79 | < 0.001 |
| 8. | Chest circumference | 16.65 | BW (g) = 2579 + 16.65 CC (cm) | 0.112 | 488.61 | 16.62 | < 0.001 |
| 9. | Head circumference | 13.13 | BW (g) = 2654 + 13.13 HC (cm) | 0.096 | 489.70 | 11.23 | < 0.001 |

**n = 1203**

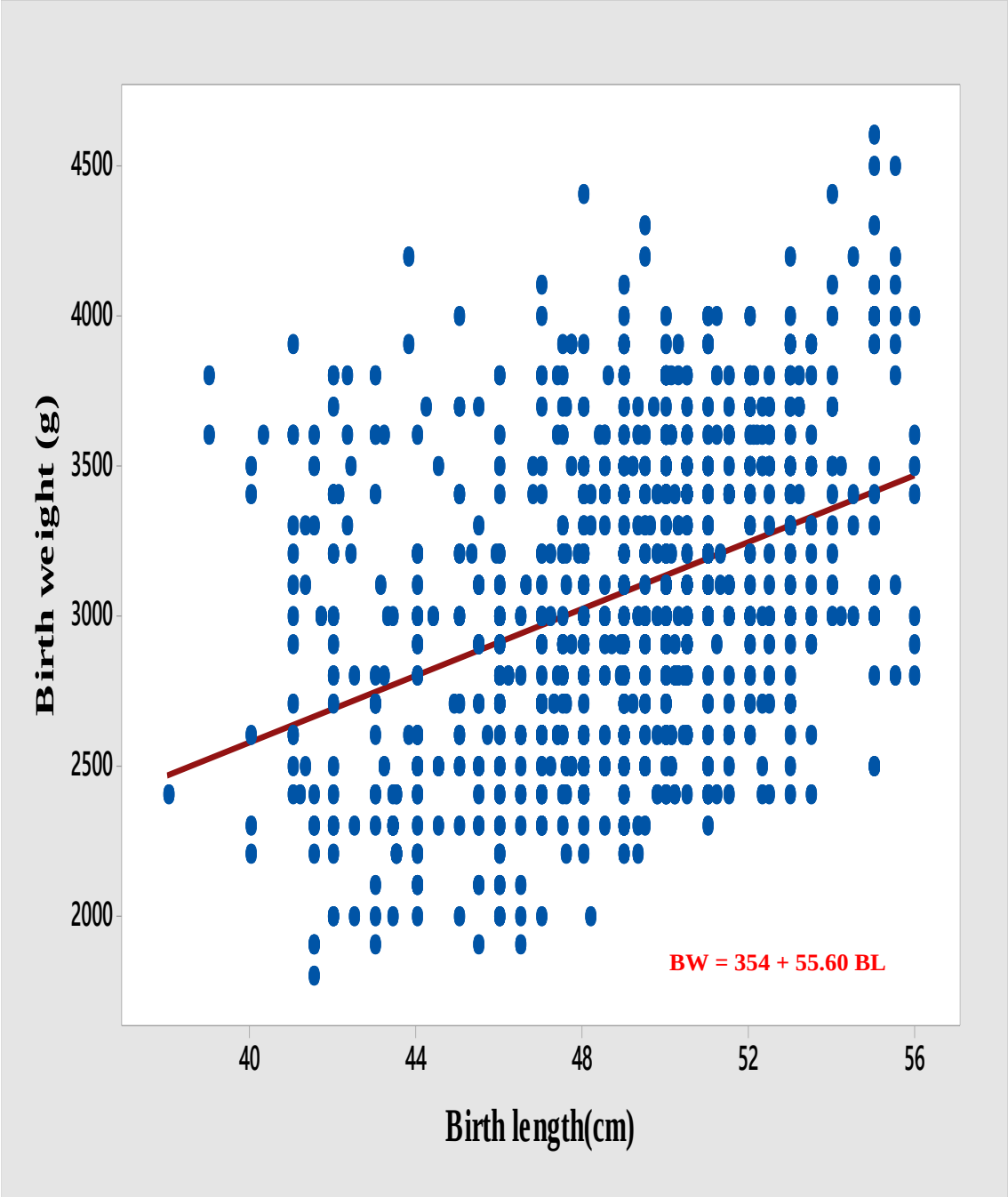



**Figure 4.17:** Scatter plot of birth weight on birth length

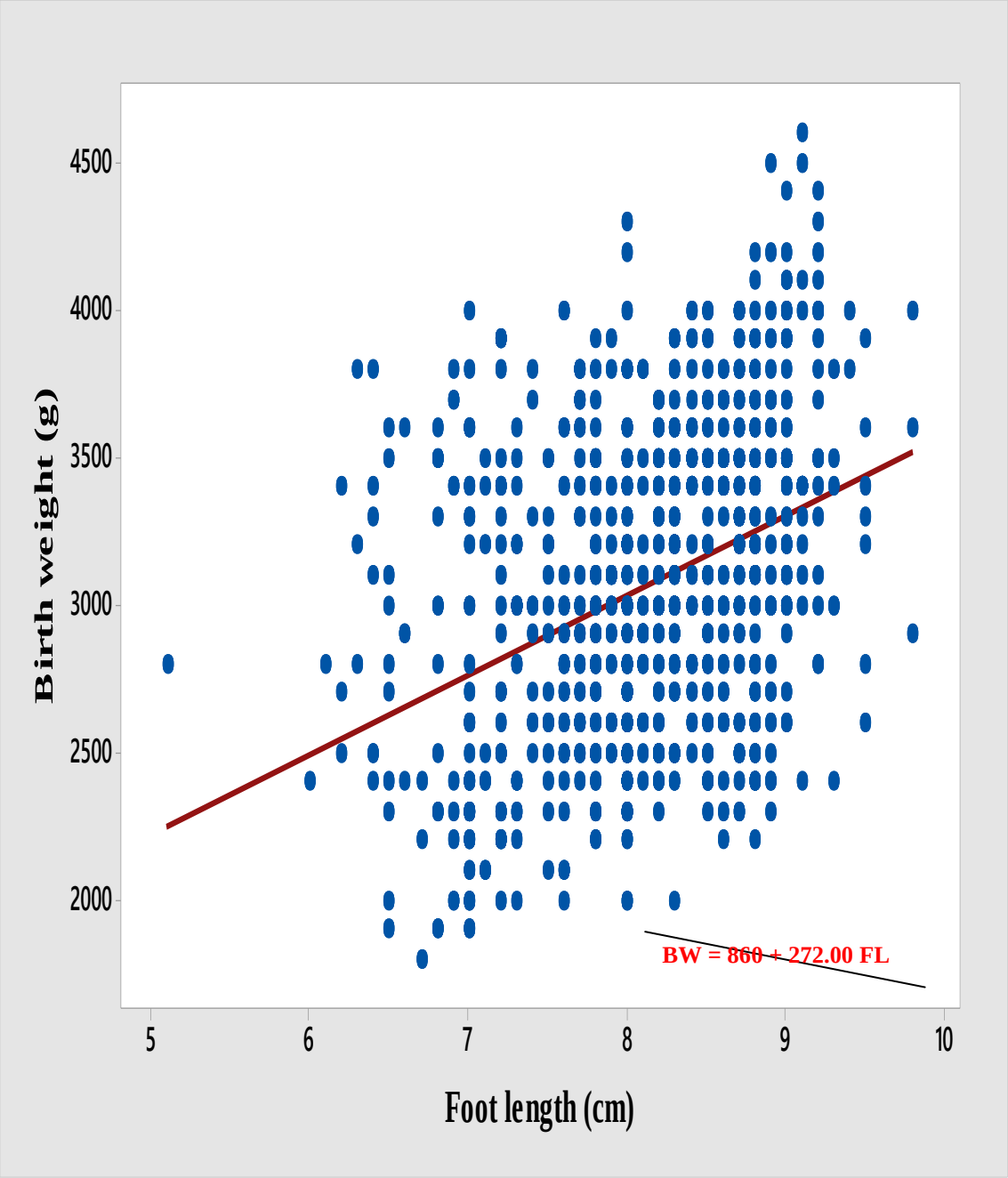



**Figure 4.18:** Scatter plot of birth weight on foot length

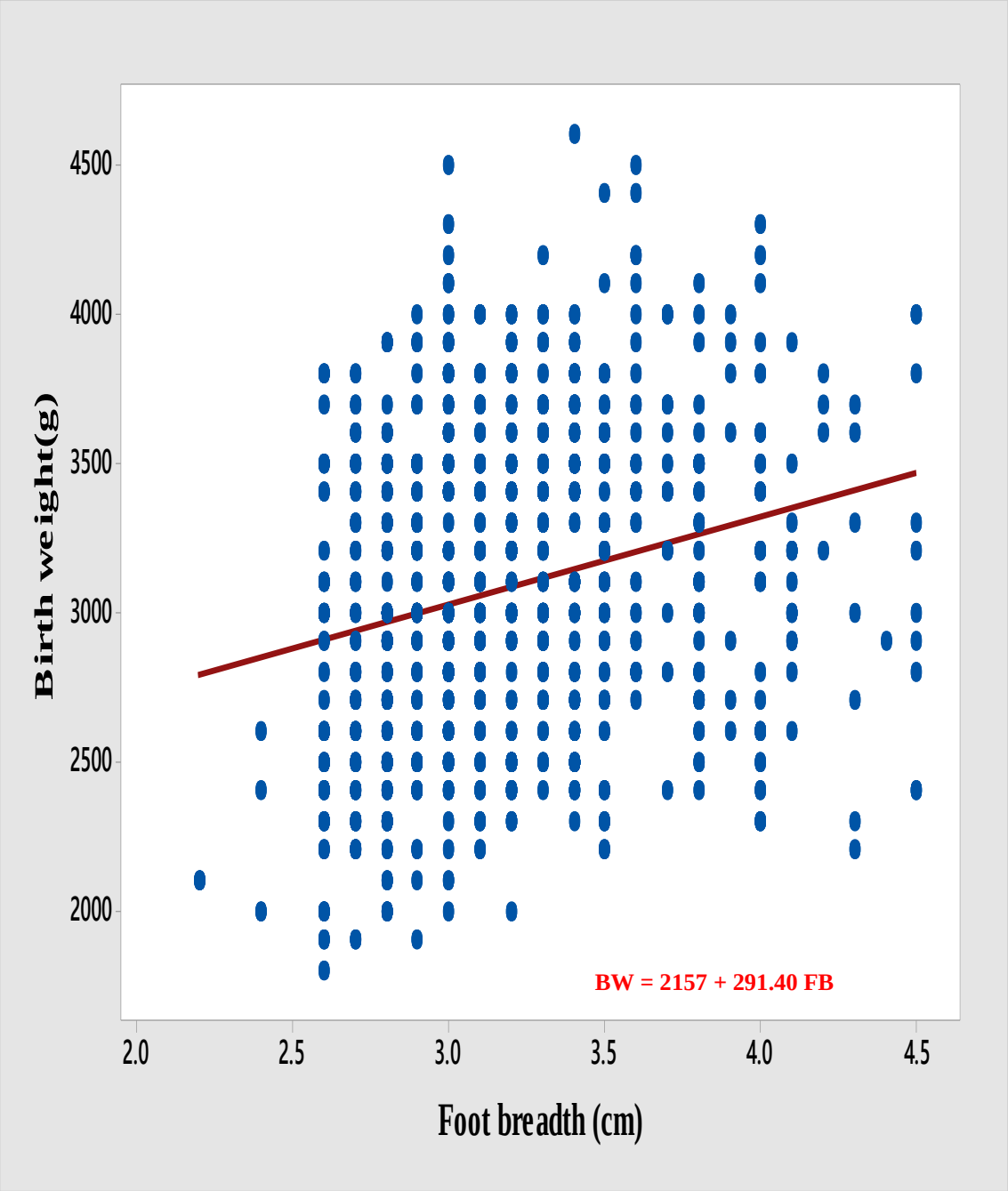



**Figure 4.19:** Scatter plot of birth weight on foot breadth

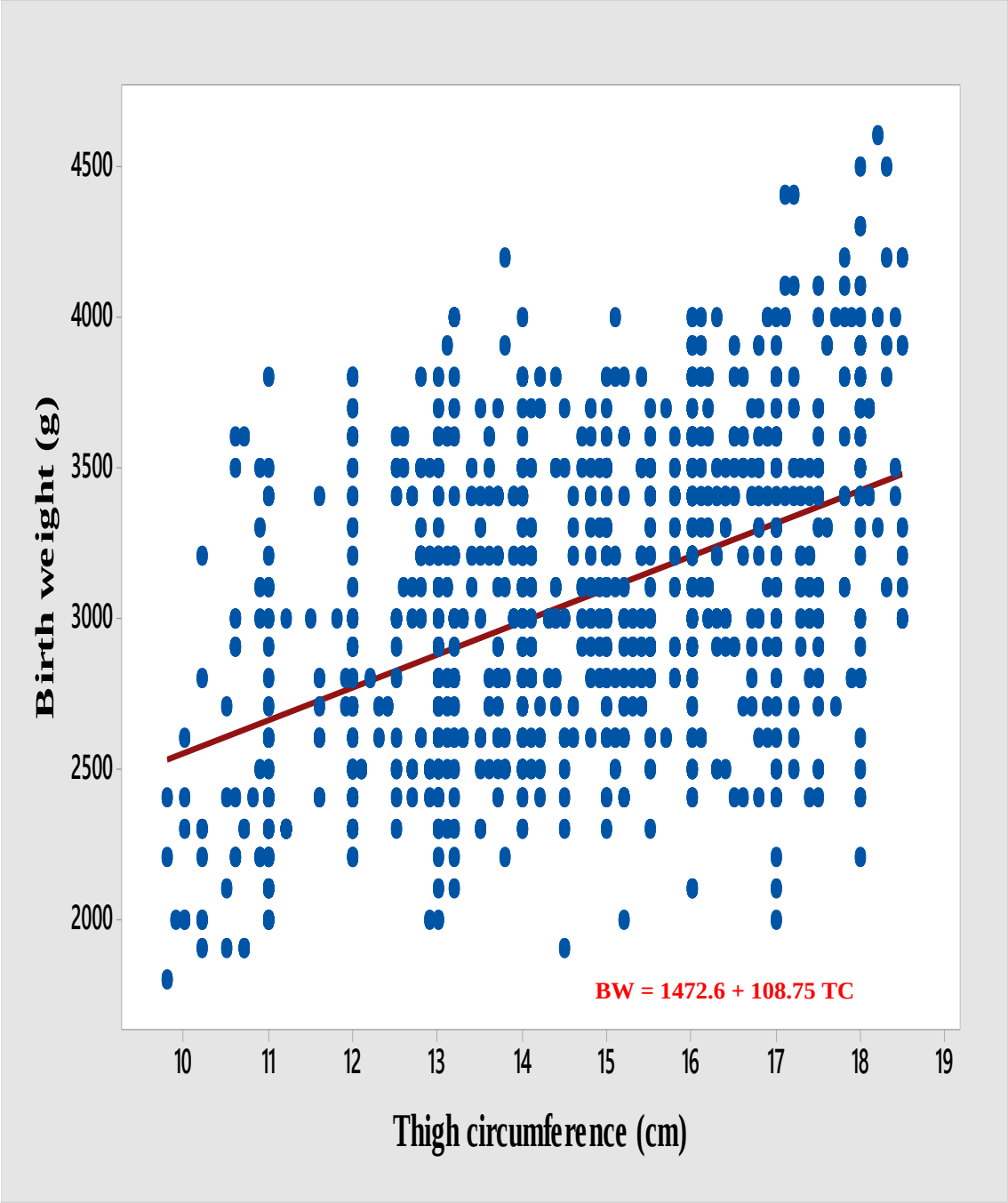



**Figure 4.20:** Scatter plot of birth weight on thigh circumference

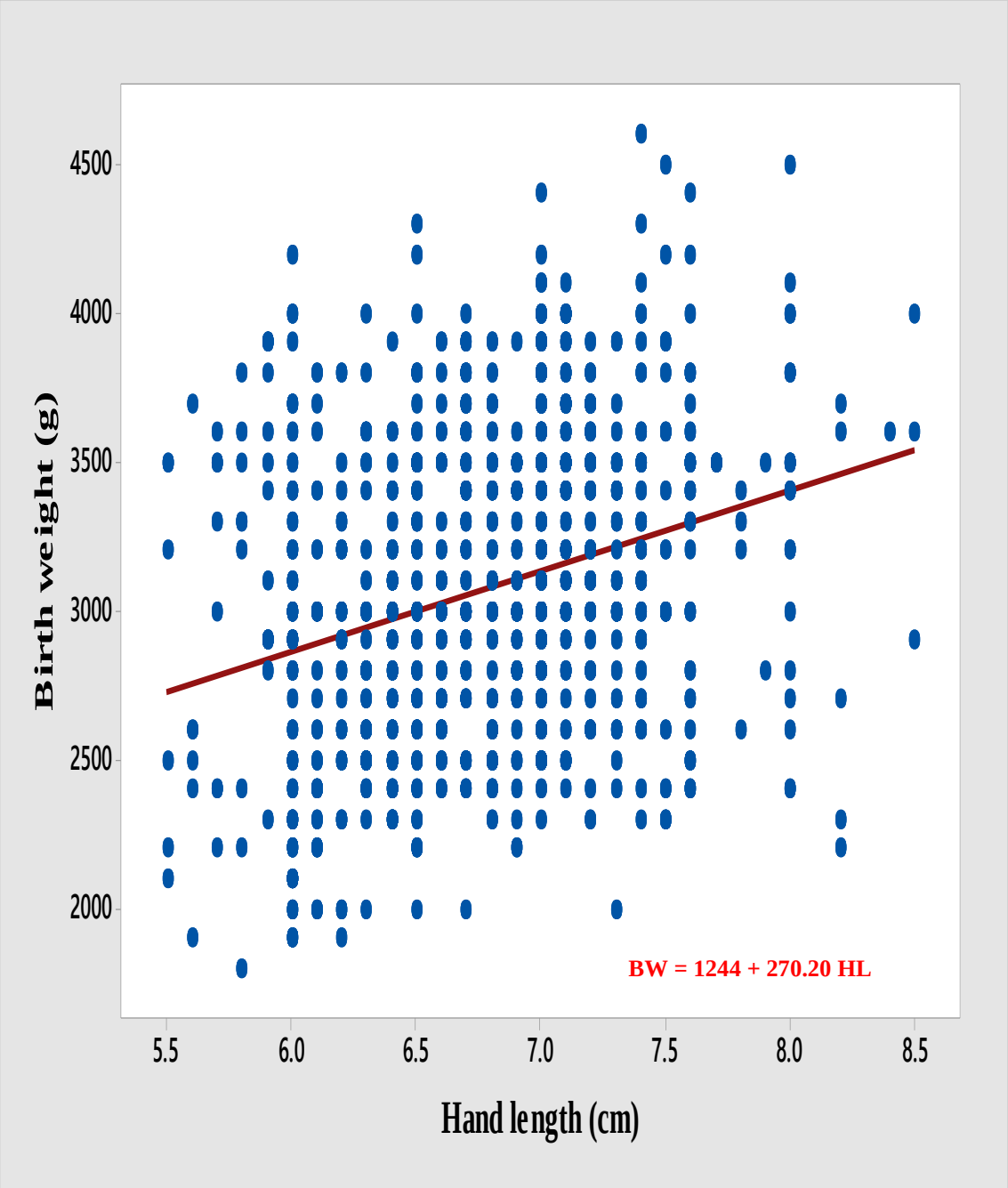



**Figure 4.21:** Scatter plot of birth weight on hand length

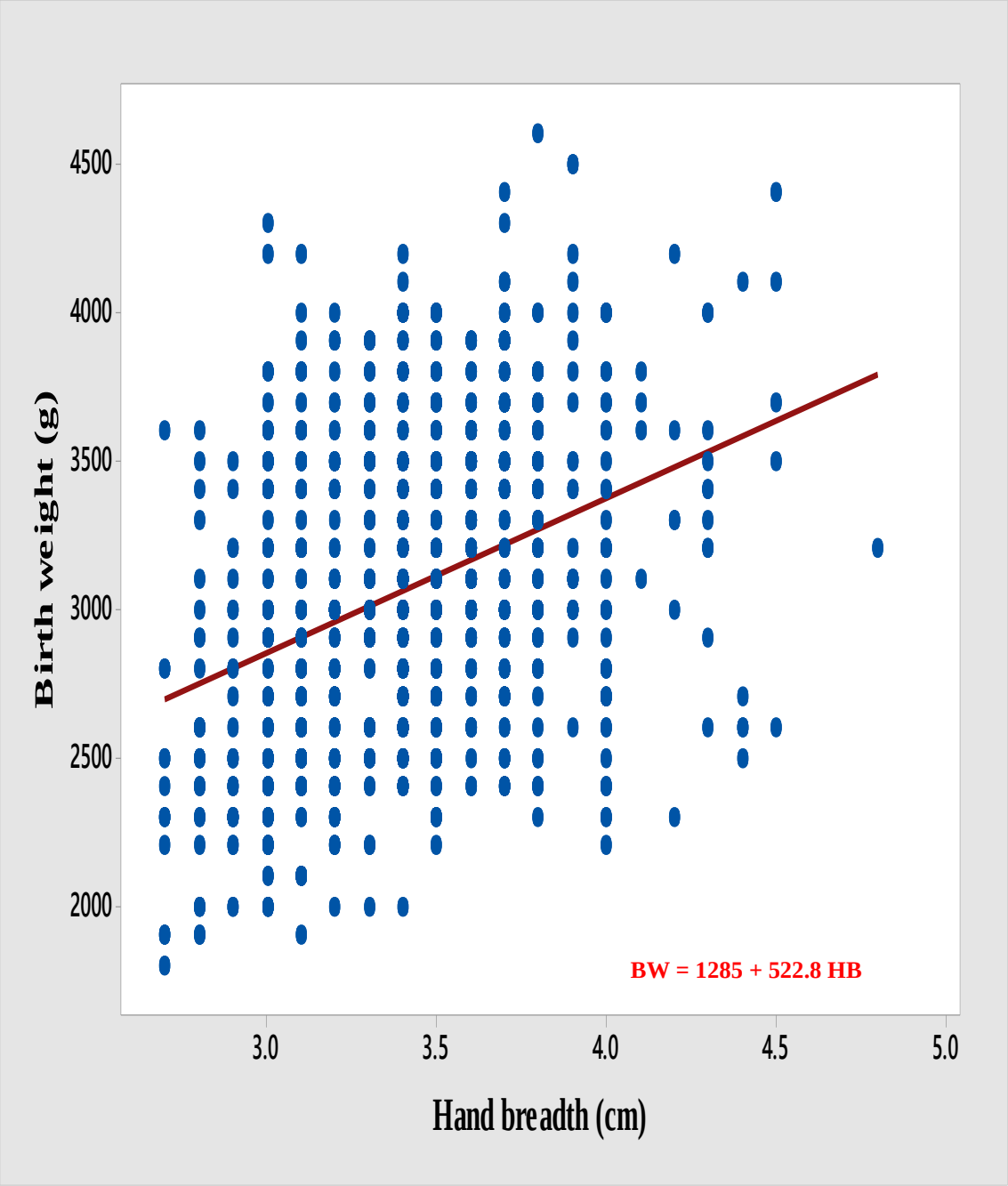



**Figure 4.22:** Scatter plot of birth weight on hand breadth

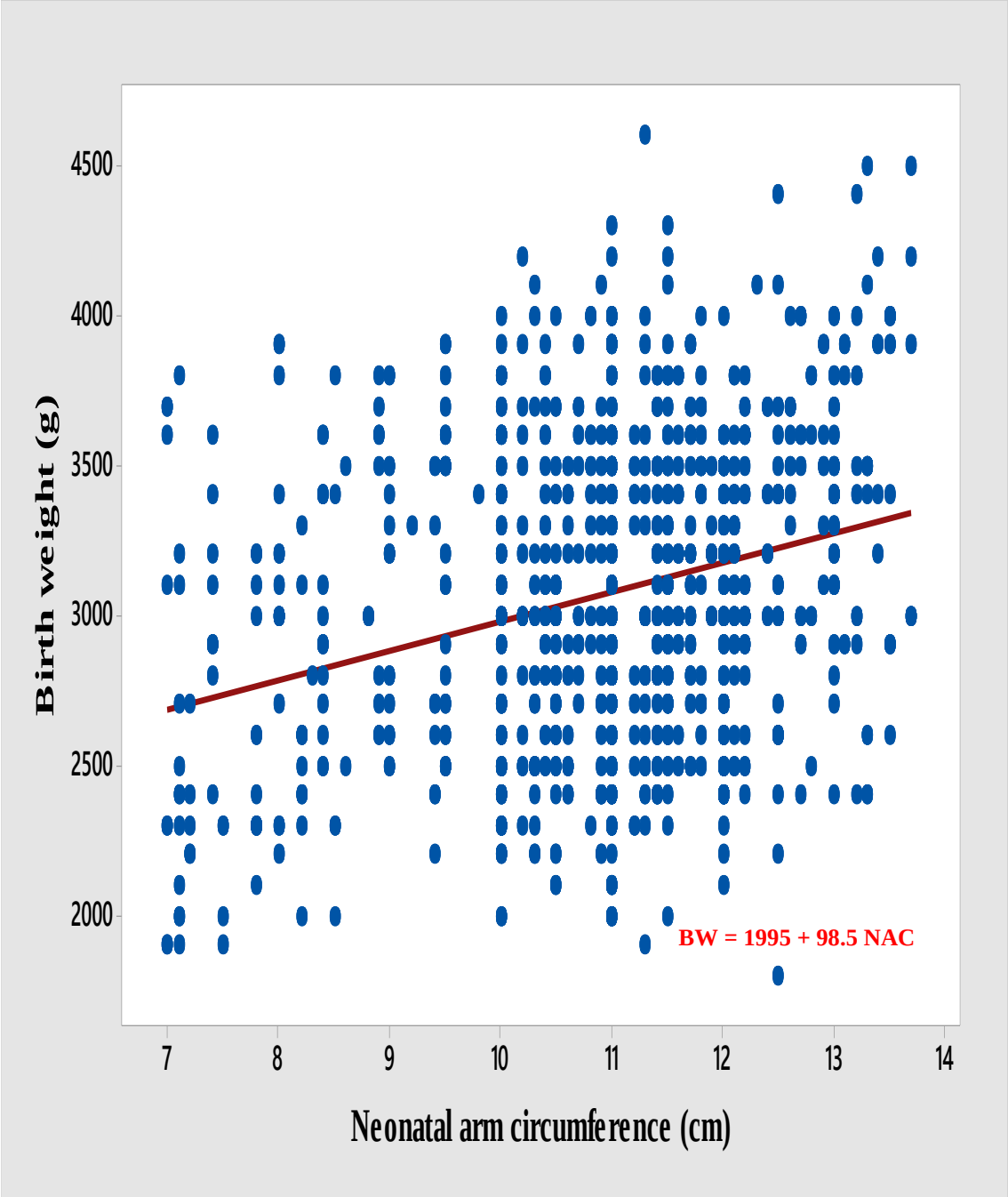



**Figure 4.23:** Scatter plot of birth weight on neonatal arm circumference

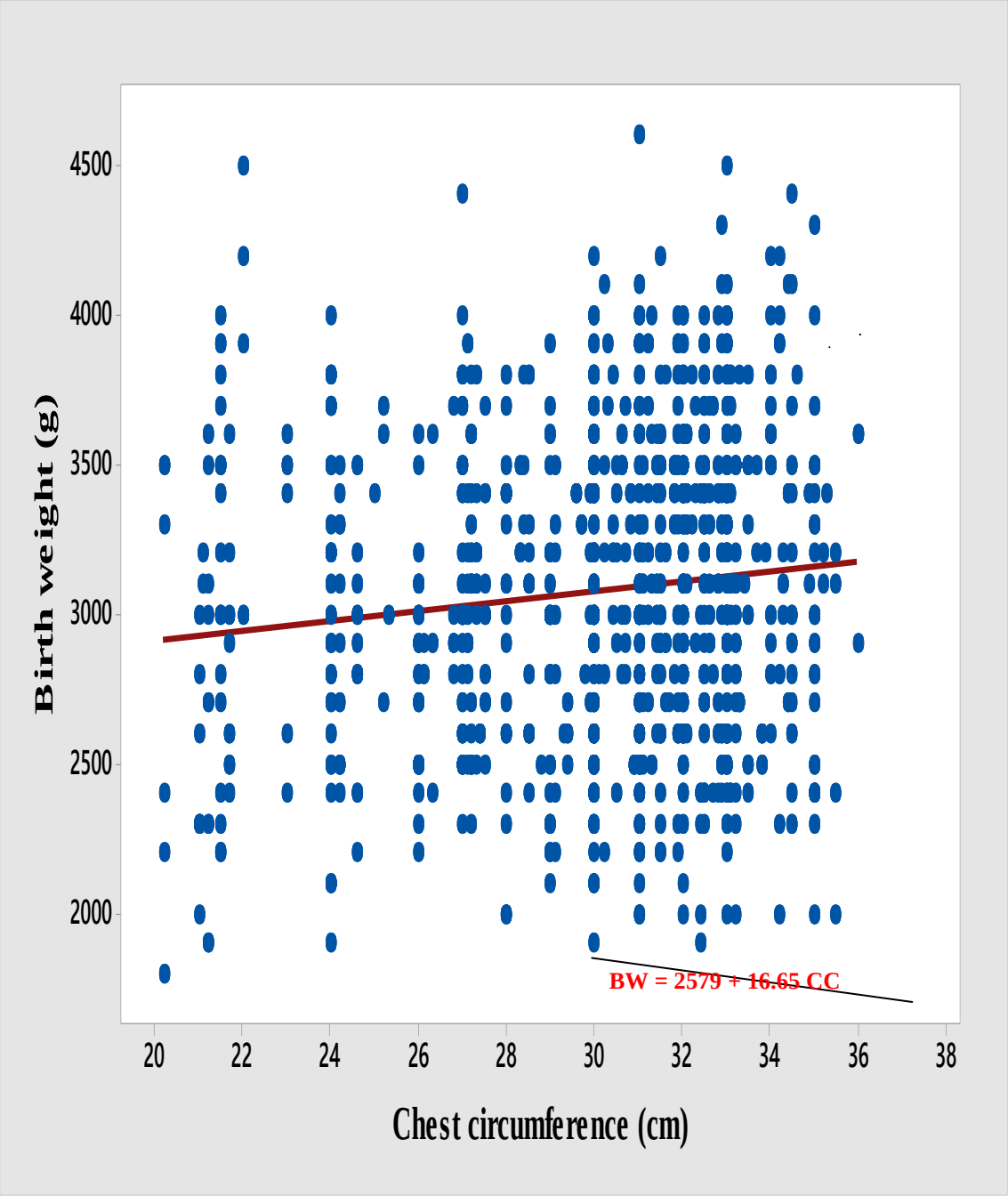



**Figure 4.24:** Scatter plot of birth weight on chest circumference

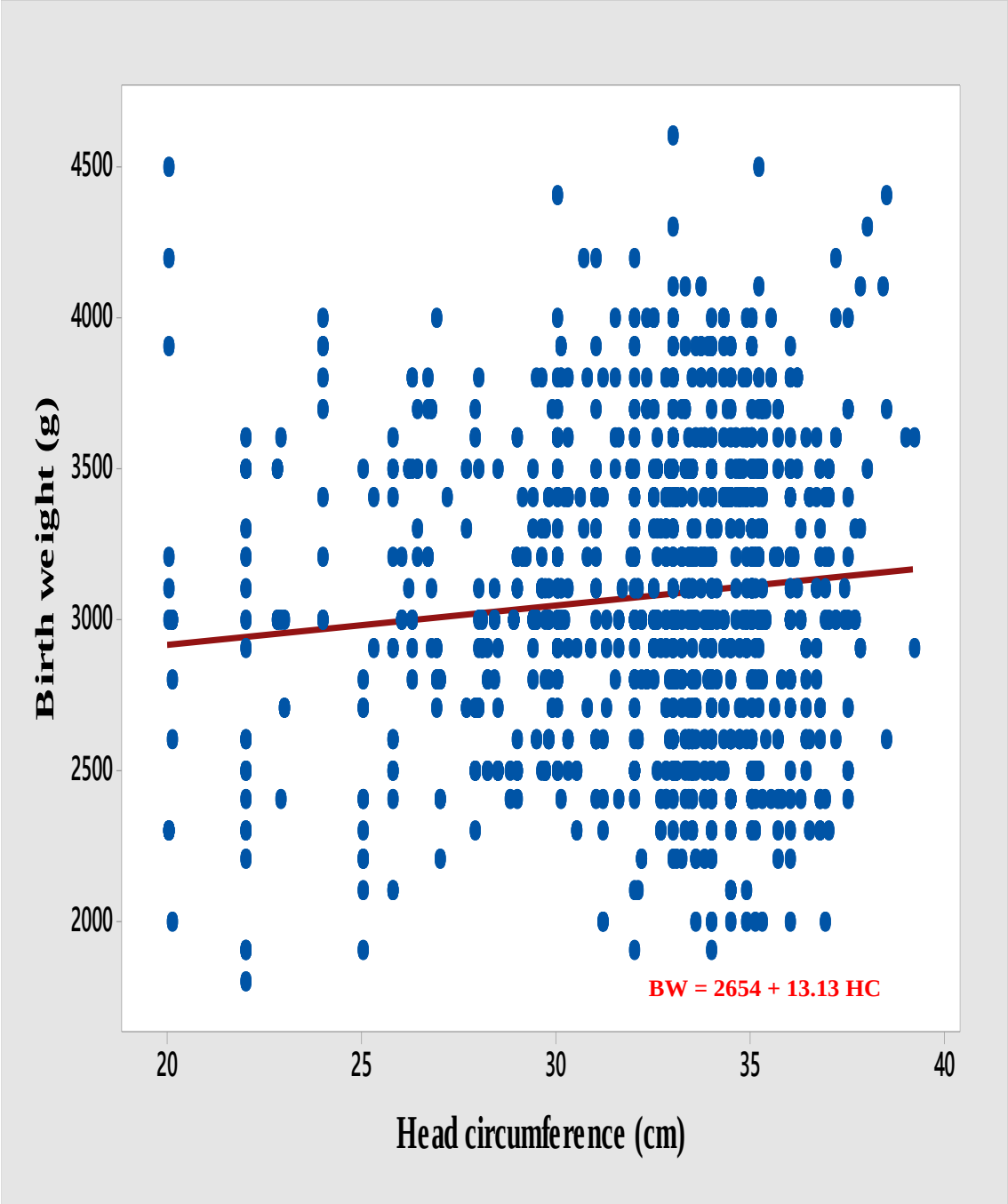



**Figure 4.25:** Scatter plot of birth weight on head circumference

Table 4.35 similarly shows the linear multiple regression models (with best fit line) derived from the maternal anthropometric parameters that can be used for the estimation of BW of neonates before delivery. Among the maternal anthropometric parameters, SFH ($r$ = 0.538; $P$ < 0.001) was found to be the best estimators, while the MH followed with $r$ value of 0.089 and a $P$ value of 0.002. The MAC shows the least precision with an $r$ and $P$ values of - 0.018 and 0.541 as shown on figures 4.24 to 4.26 respectively. The fitness and accuracy of the models was measured by $F$-value and SEE respectively.

Table 4.35: Linear multiple regression equation models for the estimation of birth weight from the maternal anthropometric parameters in Kano Nigeria (n = 1203)

| S/No. | Variables | B | Equations | *r* | SEE | *F*-value | *P*-value |
|---|---|---|---|---|---|---|---|
| 1. | Symphysio-fundal height | 285.60 | BW (g) = – 7618 + 285.60 SFH (cm) | 0.538 | ± 414.64 | 489.85 | < 0.001 |
| 2. | Maternal height | 7.51 | BW (g) = 1877 + 7.51 MH (cm) | 0.089 | ± 490.04 | 9.54 | 0.002 |
| 3. | Maternal arm circumference | 2.76 | BW (g) = 3153 – 2.76 MAC (cm) | -0.018 | ± 491.90 | 0.37 | 0.541 |

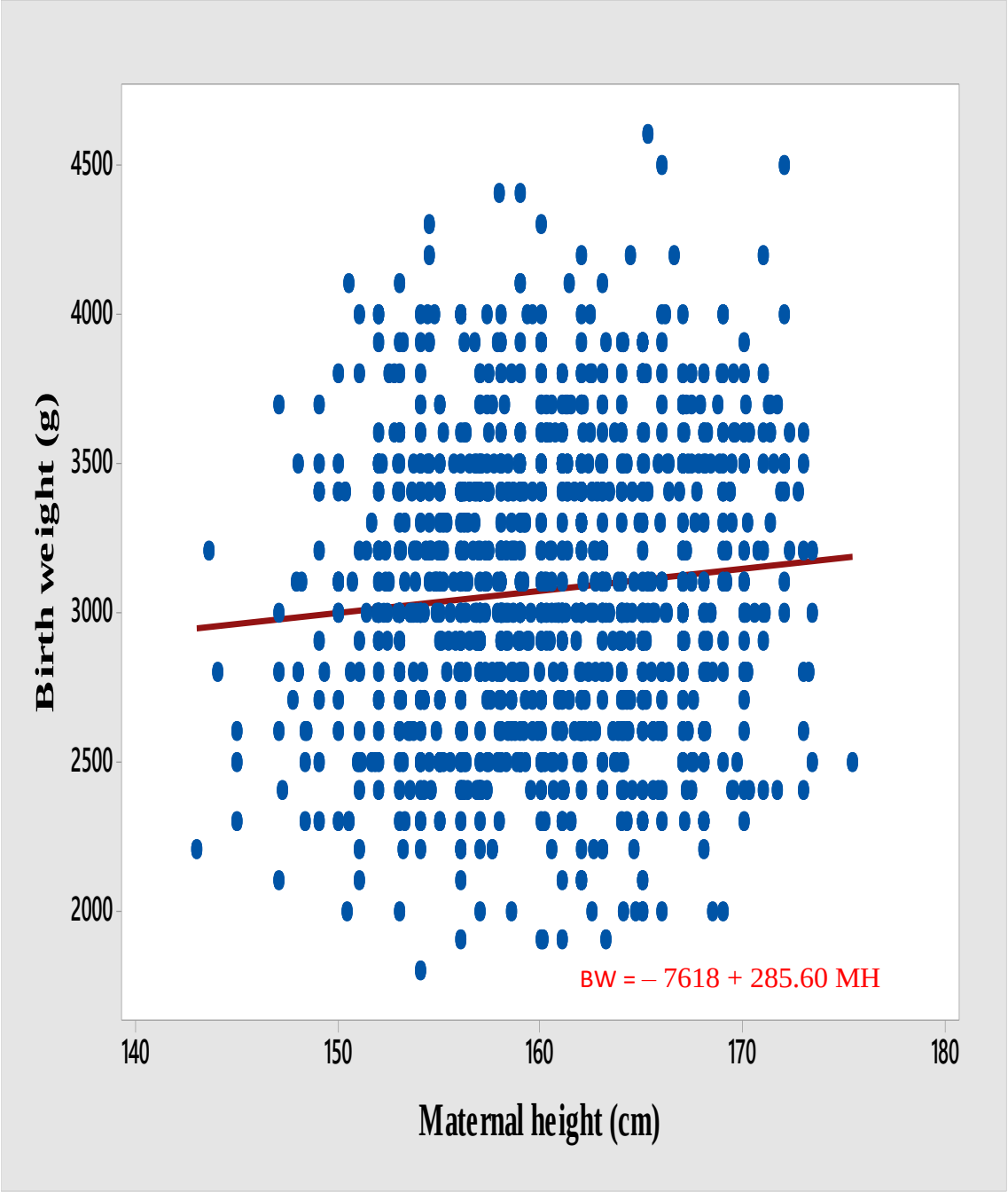



**Figure 4.26:** Scatter plot of birth weight on maternal height

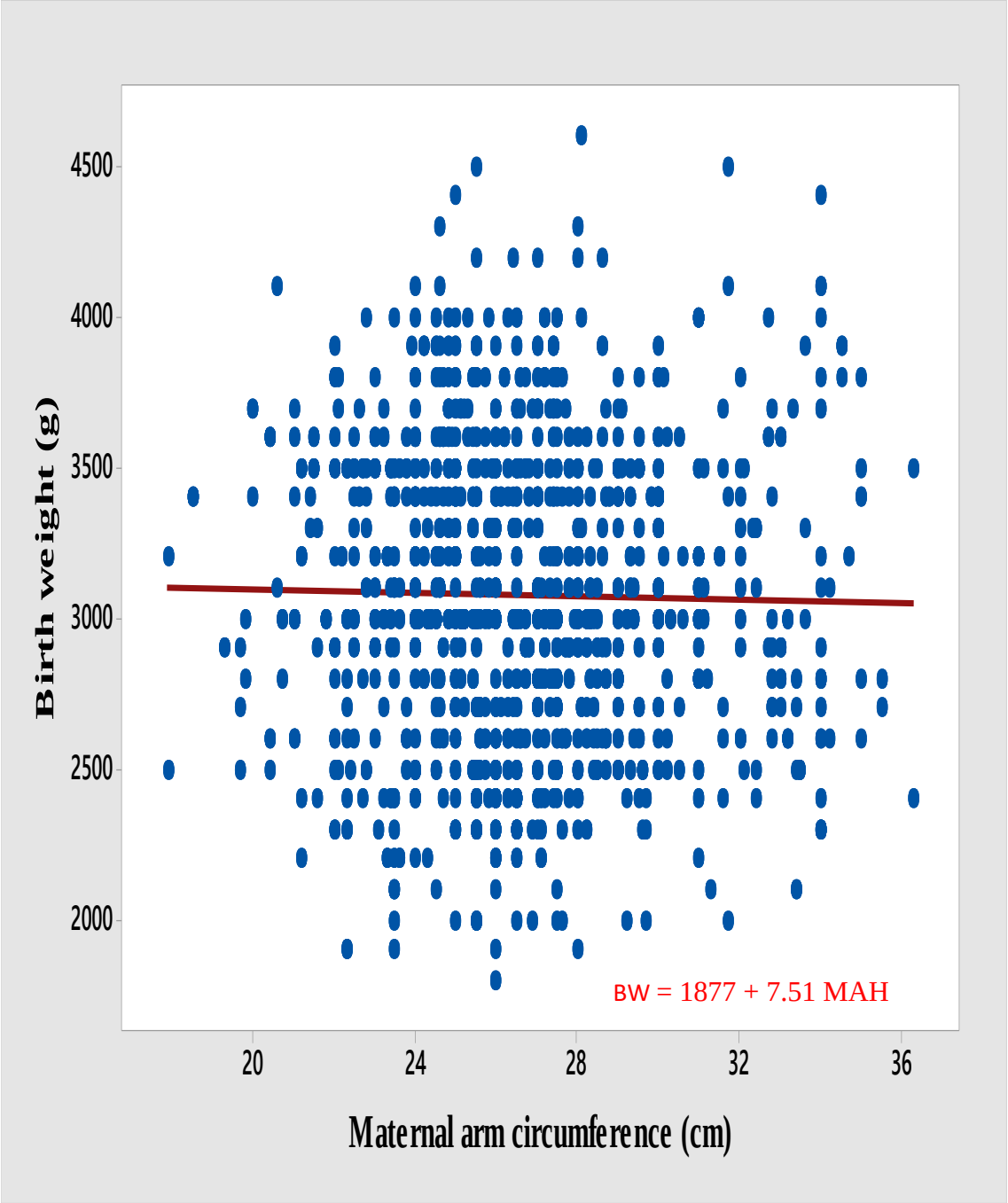



**Figure 4.27:** Scatter plot of birth weight on maternal arm circumference

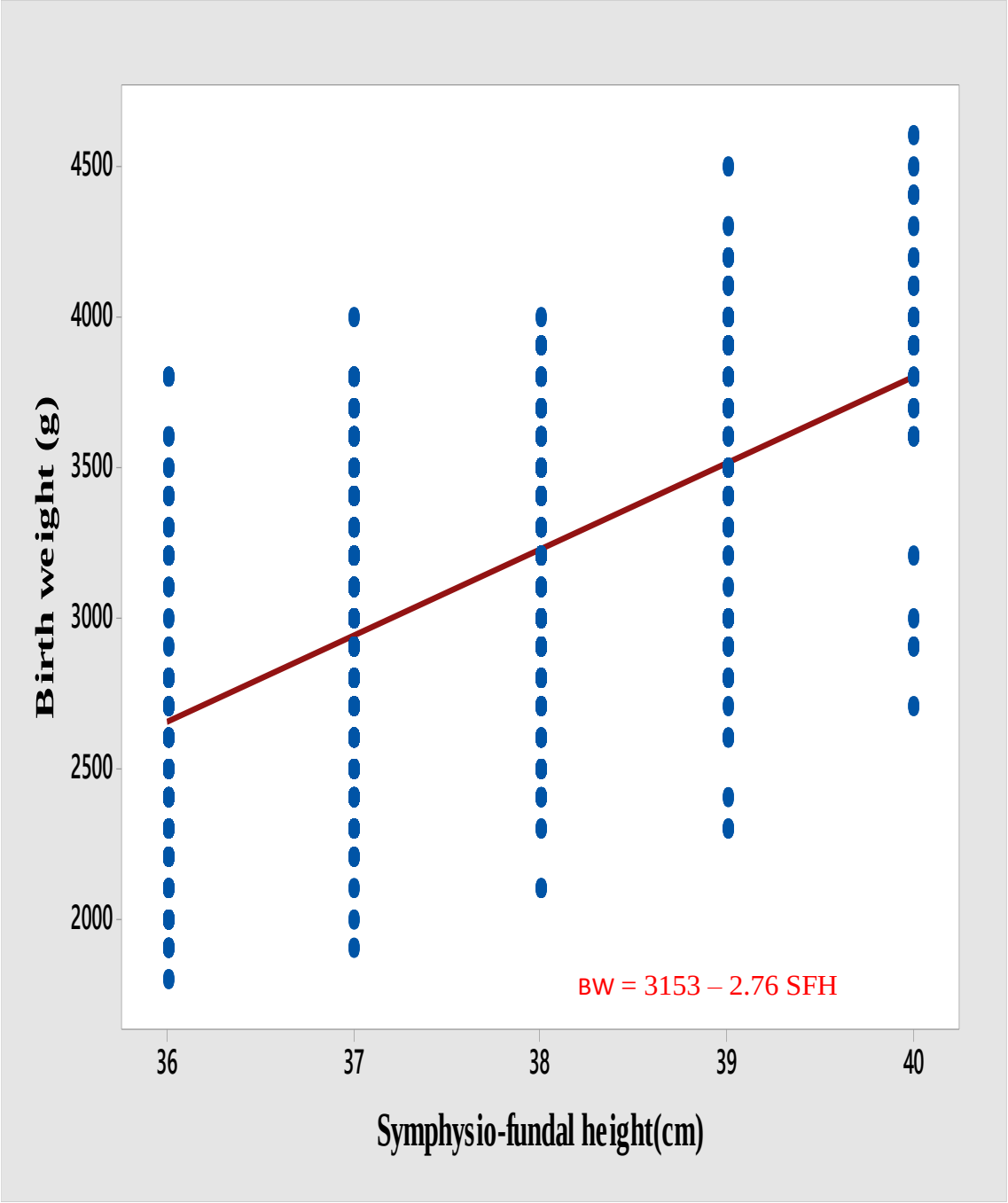



**Figure 4.28:** Scatter plot of birth weight on Symphysio-fundal height

**CHAPTER 5**

## 5.0 DISCUSSION

Neonatal and maternal anthropometric characteristics are important and easily used parameters in evaluating or assessing pregnant mothers, their foetuses in-utero and their newborn babies. Therefore, these parameters have become very useful in monitoring and making strategic health planning in both urban and rural areas. However, the importance of these parameters in the identification of pregnant mothers and their un-born babies and the effect of urbanization has so far received less attention. It is this phenomenon that prompted this research on the selected neonatal and maternal anthropometric characteristics and the effect of urbanization on the parameters among the mother-child pair in Kano State, Nigeria.

In the evaluation of the mean birth weight of neonates, irrespective of their gender or the influence of urban or rural location (level of urbanization) for health facilities in which recruitment of the study participants were done, the means were observed to be 3079 ± 491.77 g in the current study. In an analysis conducted by Datti *et al*. (2016) on the same population to evaluate the influence of maternal parity on neonatal anthropometric parameters among Hausa population in Kano State, reported a mean birth weight value similar to that was obtained in the present study. Similarly, the birth weight value documented by Onubogu *et al*. (2017) among singleton newborn babies in South-Eastern, Nigeria was also similar to the value found in this study. Furthermore, birth weight studies by Akinola *et al*. (2007) in South-West Nigeria and Lawoyin (1991) in Ilorin, Kwara State, had established the mean birth weight values among their respective population which approximate the value obtained in the current study. These similarities in the mean birth weight values may be due to racial and geographical location between the study groups. Additionally, in another study conducted by Suneetha and Kavitha (2016) on the relationship between birth weight and various anthropometric parameters in neonates born at Niloufer Hospital, Hyderabad, the mean of thigh, mid-arm, head and chest circumferences were all found to be similar to the values obtained in the present study. However, the mean birth weight value in the study was reported to be lower than the value obtained in this study. The difference in the birth weight may be due to variation in the selection criterion; only babies with congenital anomalies, unidentified reasons for not recording the anthropometric parameters and preterm babies (less than 32 weeks gestation) were excluded from their study. While, in the present study, other criteria such as multiple pregnancies and post datism (pregnancy of more than 40 weeks), which can influence the birth weight were excluded. Racial and geographical differences could also be responsible for the difference in the mean birth weight.

In another separate study conducted by Srinivasa *et al*. (2017) on the foot length of newborn and its correlation with gestational age and various anthropometric parameters among the newborn babies delivered at Kempegowda Institute of Medical Sciences,

Karnataka, India, the measured parameters of birth weight, head circumference, chest circumference, birth length and foot length were considered respectively. The generated values approximate the values obtained in this study, but the mean birth weight, which was reported to be lower than the one obtained in the current study. Racial and geographical differences could also be a factor for this difference in the birth weight value; as race, age and sex can influence anthropometric variables. In addition, the mean birth length observed in the current study irrespective of gender or urban and/or rural location of the hospital in which the recruitment was carried out was reported to be similar to that obtained by Talat *et al*. (1991) in a study carried out at Jinnah Postgraduate Medical Centre, Karachi. Another study conducted among the Bangladeshi population (Jagadish, 2012) on head and chest circumferences was similar to the findings of the present study.

In contrary, in a multicentre study conducted by the World Health Organization (1994) among newborn babies in Sri Lanka, India and Nepal reported mean birth weight of the newborn babies different from the values obtained in this study. The differences in findings between the current study and the results from the World Health Organization study appears to be chiefly due to differences in race (Africans as against Asians). Other factors that may contribute to the difference in the study findings are the variation in sample size and race with respect to the anthropometric variables.

All the parameters considered above did not factor any information regarding urban-rural location (level of urbanization) for the data collection. Therefore, when the evaluation of the neonatal birth weight was based on urban-rural location (area of domicile) of the hospitals from which the data collection was done, the mean birth weight between the neonates in the urban and rural areas were observed to be significantly higher among the neonates domiciled in the urban areas. This implies that the urban/rural location of centres for data collection is a factor that influences neonatal birth weight. Therefore, it can be said that, the variation in the mean between the mean value in which urbanization (area of residence) is considered and the one in which urbanization is not considered is significant. This implies that the level of urbanization significantly affects birth weight. These findings are similar to those obtained by Michael *et al*. (2013) which shows that mothers in rural areas tend to give birth to low birth weight babies than those mothers who live in the urban areas. Additionally, it has been documented that mothers living in rural areas were found to be four times more likely to have low birth weight babies than those who reside in the urban areas (Meresa *et al*., 2015). As urbanization (urban or rural residence) was further considered in this study, it is evident that there is a significant effect of urbanization on birth length, foot length, foot breadth, chest and head circumferences. However, no significant effect of urbanization is seen on thigh circumference, hand length, hand breath and neonatal arm circumference. The reason for the disparity between the anthropometric parameters

based on urbanization factor may be probably due to the potentially higher living conditions [including access to nutritious diet and good health delivery (ANC)] among the urban participants compared to the rural participants.

Moreover, the mean maternal height, maternal arm circumference, Symphysio-fundal height as well as the haemoglobin concentration in the current study were found to be slightly different from the values obtained by Talat *et al*. (1991) in a study that considered 200 pregnant mothers at Jinnah Postgraduate Medical Centre, Karachi. Racial differences between the study populations and sample size may underlie the differences in the maternal parameters observed in this study when compared to the literature. Also, the blood pressure in pregnant women without pre-existing hypertension or pre-eclampsia falls slightly, but then rises from around 34 weeks of gestation onwards (Reiss *et al*., 1987; Clapp *et al*., 1988; Halligan *et al*., 1993; Brown *et al*., 1998). Also, in another study carried out by Philip *et al*. (2004) shows that a diastolic blood pressure of 70 mmHg and above, but not exceeding 10 mmHg increment at the first antenatal care visit (ANC booking) was found to be associated with high birth weight. When the diastolic blood pressure raises greater than 10 mmHg, birth weight fell sharply. If the blood pressure at booking was less than 70 mm Hg, birth weight rose as the rise became greater, but started to fall again if the rise exceeded 30 mm Hg. In the present study, the mean values of the systolic and diastolic blood pressure obtained were found to be within the normal value of less than 140 mmHg in the systolic blood pressure and less than 90 mmHg in the diastolic blood pressure (the normal value as stated by the British Cardiac Society is 120/80 to 140/90 mmHg). It is noted that when habitation (either rural or urban residence) is considered, it is discovered in this study that there exists no significant effect of urban or rural difference in the site for data collection on the values for maternal height, maternal arm circumference and blood pressure (both systolic and diastolic values).

The maternal anthropometric characteristics have long been used in the indirect clinical assessment of foetal weight (Mongelli and Gardosi, 1999). In the current study, maternal characteristics such as maternal educational level are found to exert no influence on neonatal birth weight in the evaluation of the entire recruited study population. However, on evaluating the study population based on gender of neonates (male or female), it is observed that for the female neonates, maternal educational level and urban site for data collection significantly affect the neonatal birth weight. Earlier studies conducted by Newcombe (1981), Raman (1981), Dougherty and Jones (1982) and, later, Talat *et al*. (1991), have all reported a positive influence of maternal factors on weight at birth. In the literature, the foetal weight, especially during the third trimester was found to be influenced by some maternal characteristics (Adediji *et al*., 2015). Similarly, in an earlier study, maternal characteristics have shown a significant association with birth weight (Rao *et al*., 2007). Increased maternal parity, low

maternal educational level and decreased antenatal clinic care/visit are important factors associated with an increase in the incidence of low birth weight (Shah, 2010; Khan *et al*., 2013). Also, in the current study, a significantly higher mean Symphysio-fundal height was observed in mothers domiciled in the urban areas of Kano State as compared to those in the rural areas. This may also be attributed to the fact that mothers in urban settings get more pregnancy care i.e. utilization of antennal care services and higher maternal educational level than their rural counter parts. This is in line with a study conducted by Arif *et al*. (1998) which proved that women with higher education level give birth to normal birth weight babies (2.5 kg to 4.0 kg) more than what is obtainable in women with low education level. Similarly, Khan *et al*. (2013) reported that the frequency of low birth weight decreases with an increase in maternal educational level. Additionally, Metgud *et al*. (2012) revealed that maternal illiteracy form part of the risk factors that are significantly associated with the birth weight of newborn babies. Study by Currie and Moretti (2003) have also documented a fundamental effect of maternal education on birth weight which revealed that a strong relationship exists between maternal education and birth weight. It was shown that the maternal education affects birth weight by improving the probability and or productivity of health investment. In addition, maternal education improves the financial resources available to the child, directly and indirectly, through the choice of partner, timing of fertility, and number of offspring in developed countries (Behrman and Wolfe, 1989; World Bank, 1993).

The Apgar score (baby score at birth) is a comprehensive screening tool used in the evaluation of the newborn's condition at birth. It is one of the quantitative measurements used in assessing the health of a new-born baby. The evaluation is performed within the first and fifth minutes after delivery. A score of less than five is termed as low Apgar score. The low Apgar score has also been found to be an index of placental nutrient efficiency, which may lead to adverse perinatal outcomes, such as perinatal death (Molteni, 1984; Wallace *et al*., 2013). However, among the neonatal anthropometric parameters, the mean Apgar score values in this study at the first and fifth minutes were found to be above the risk level (i.e. above the scores of less than 7). Moreover, when urbanization was factored-in, a significant effect was observed at both the first and fifth minutes respectively. In a similar study conducted by Lao and Wong (2001), it was reported that there is an increase incidence of low Apgar score (a score of less than 7.0) among non-diabetic mothers. Additionally, Shehata *et al*. (2011) documented that high placental/birth weight ratio is associated with the increased risk of low Apgar score.

Anthropometric measurements were carried out on neonates from urban and rural areas separately to determine the discriminating variable against birth weight. In this study, among the urban neonates, the thigh circumference was found to be the best

discriminator between the low and high birth weight, while the least discriminator was the head circumference. Similarly, among the rural neonate, the best discriminator was found to be the birth length, and the least discriminator in this group of neonates was the head circumference. Achebe *et al*. (2014) conducted a study in Nnewi, Southeast Nigeria, on neonates to determine the cut-off values of low birth weight. The study suggested that the maximum thigh circumference was the best predictor of low birth weight. This is in line with the present study that found thigh circumference as the best discriminator between the low and high birth weight. Recently, Ndubuisi *et al*. (2018) conducted a prospective, cross-sectional, hospital-based study at the Maternity Unit, University of Nigeria Teaching Hospital, Enugu, involving newborn babies delivered in the unit. He found that the best discriminator for low birth weight is the chest circumference. In the present study, the best discriminator was the thigh circumference. This difference may be due to ethnic variations among the study groups. Another study by Hadush *et al*. (2017) to determine the cut-off value of low birth weight in Ayder Referral hospital (ARH), located in Mekelle city, Tigray region, north Ethiopia, suggested that chest and head circumferences had a better surrogates for detecting low birth weight neonates. In this study, both chest and head circumferences were found to be the least discriminators between low and high birth weight. The variations may be due to the geographical and racial differences that may exist among the study population. Other studies by (Lawoyin, 1993; Ikenna, 2013; Ndu *et al*., 2014) all found different cut-off values that discriminate against low and high birth weight. The differences in the values may be due to ethical, geographical, or genetic variations among the various study population.

Placenta has been identified as the most accurate record of the infant's prenatal experiences. It is derived from both foetal and maternal cells. It has been established

that factors such as socioeconomic status and the race of an individual affect the placental weight (Perry et al., 1995). An earlier study by Thomson *et al*. (1969) had revealed that different measurements of the placenta have been obtained in different countries with different placental preparations. The mean placental weight value in this current study has been found to be within the range reported in some literature (Sadler, 1995; Agboola, 1999; Inderbir and Pal, 2007; Kadasne, 2012). However, Adebami *et al*. (2007) reported a mean placental weight value for live singleton full term babies at the Wesley Guild Hospital Ilesa, Nigeria to be slightly higher than that obtained in this study. But, Sitti *et al*. (2015) reported a higher mean placental weight values among deliveries at Mother and Child Hospital Siti Fatimah Makassar City, Indonesia. These differences may be due to racial geographical location or the genetic differences that may exist between the study groups; as placental weight varies from area to area (Perry et al., 1995). However, when area of domicile (location) was considered, the placental weight among the rural populace was found to be higher than their urban counterparts. This may be chiefly explained by the fact that the placenta of mothers with lower haemoglobin level is heavier than of those who are not anaemic (Nkwabong *et al*., 2018). In this study, the haemoglobin concentration of mothers in the urban areas is discovered to be higher than that of their rural count parts among the parturient mothers. Nevertheless, the urban or rural site of the hospital for data collection plays a significant role in the weight of placenta; this shows a significant effect of urbanization on the placental weight. Thus, when urbanization was considered, a significant effect is observed in urban and rural areas respectively. However, recently, Nkwabong *et al*. (2018) reported a lower mean placental weight values for male and female neonates delivered from anaemic mothers at Yaoundé University Teaching Hospital, Cameroon. The variation between the two studies is ascribable to the fact that the Yaoundé experiment considered only anaemic parturient mothers, whereas this study considers this category of mothers regardless of their being anaemic or not.

The placental/birth weight ratio is used as an index of placental nutrient efficiency, which may lead to adverse perinatal outcomes, such as perinatal death. In the present study, the placental/birth weight ratio was gotten as 17.17% (1:5.9). Similarly, Agboola (1999), in Lagos, Nigeria, documented a placental/birth weight ratio of about one-sixth (1:6) of the normal weight of the newborn baby. A separate study conducted by Cunningham *et al*. (2005) has also documented the same value of placental/birth weight ratio of 1:6. Another study by Janthanaphan *et al*. (2006) found the ratio of placental weight to that of the birth weight in normal singleton pregnancies at term to be approximately 1/6 (or 17%) in Thailand. Furthermore, study conducted by Chandrakant *et al*. (2015) on placental weight and birth weight ratio and its effects on perinatal outcome revealed a value of 18.3%. These values obtained resemble those obtained in the present study when approximated. However, when urbanization was considered, a significant effect is observed between the urban and rural areas respectively. Furthermore, there is a significant difference in the placental weight between the male

and female neonates, which shows that the female neonatal placental/birth weight ratio being higher than their male counterparts.

The haemoglobin level (when urbanization was not considered) in the current study was observed to be 12.18 g/dl. The values of haemoglobin in the samples of study participants recruited from rural centres in the current study is recorded to have a mean value of 11.45 g/dl**,** which is significantly different from the overall mean values for haemoglobin observed for study participants from urban areas. Nevertheless, Goonewardene *et al*. (2012) reported haemoglobin level of less than 11 g/dl in the second trimester of gestation as anaemia in pregnancy. In addition, haemodilution may be markedly increased in early pregnancy. Thus, anaemia in pregnancy may include haemoglobin concentration of less than 10 g/dl (Levy *et al*., 2005; Grewal, 2010). The, maternal haemoglobin concentration among rural dwellers is discovered to be lower and this category of women are more prone to developing anaemia in pregnancy. The current findings among urban participants compared to rural participants are also in keeping with the explanation for the higher maternal anthropometric values among the urban participants compared to the rural participants. In the present study, considering the anaemic and non anaemic mothers, the placental weight was found to be heavier among the anaemic mothers, while the birth weight of the neonate born to the non anaemic mothers was found to be heavier. Therefore, in this study, the placental/birth weight ratio of the anaemic mothers was found to be heavier than that of the non anaemic mothers. This can be explained by the fact that several studies have reported that anaemia during pregnancy is capable of inducing hyperplasia and hypertrophy; thus the reason for the increase of placental weight and subsequently the higher placental/birth weight ratio among the anaemic parturient mothers (Beischer *et al*., 1970; Kosanke *et al*., 1998; Nkwabong *et al*., 2018).

The ponderal index (PI) is an effective and one of the simple anthropometric indices that can be used to determine intra-uterine foetal size. In developing nations, the significance of PI cannot be over emphasized especially because the nutritional status of pregnant mothers may be difficult to assess. Some alterations in body composition in-utero cannot identify some alterations in body composition that might be identified by the ponderal index (Caiza *et al*., 2003). The computation of PI and its role in determining neonatal size are similar to those of Body Mass Index (BMI) in adults. A PI of greater than 2.0 $g/cm^3$ is considered normal in term neonates (those born at 37 completed weeks) and a child with an index less than 2.0 $g/cm^3$ is classified as low ponderal index (Indrayan and Satyanarayana, 2000). The mean PI value among the neonates in this study is found to be within normal limit. A study conducted by Onubogu *et al*. (2017) on South-East Nigerian newborn infants recorded a PI value similar to that obtained in the present study. Similarly, a retrospective study conducted by Dure and Fehmina (2005) for determining the PI in the pregnancies of low birth

weight neonates delivered at term in Karachi revealed the value of less than normal limit in pregnancies of gestational age of 29 to 37 weeks as indicative of intrauterine foetal malnutrition among the neonates. In the current study as well as in the literature, PI values of normal limit have been reported (Muin *et al*., 1990; Indrayan and Satyanarayana, 2000; Roje *et al*., 2007). However, the mean PI among the neonates evaluated in the hospitals located in the urban centres is reported to be higher than the mean value from the rural centres and the difference is statistically significant. The reason for the differences may be due to supposed better living conditions found in the urban than the rural area. A study conducted by Roje *et al*. (2007) revealed that PI is significantly higher in female than in male newborns, and in multiparous than in nulliparous infants after 37 weeks of gestation. This is similar to the values obtained in this study. These similarities may be due to genetic factors. They further concluded that gestational age is the most important factor of neonatal PI, and the effect of sex and parity on PI should only be considered in term neonates. In addition, a significant effect of urbanization is observed on PI, with neonate from urban areas having higher mean value than their rural counterparts. Hence, generally, it can be said that the neonates delivered either in rural or urban areas did not encounter intra-uterine growth restriction in this study.

The correlation between variables can be measured in terms of level of significance (*P*-value), magnitude [from – 1 to + 1 (*r*-value)] or direction (either positive correlation, negative correlation or no correlation). However, the magnitude and direction are highly affected by the sample size. Thus, the level of significance is used for correlation between the variables in this study. In the current study, it is established that there exist a relationship (correlation) between birth weight and maternal as well as other neonatal anthropometric parameters. Among the maternal anthropometric parameters, birth weight shows a significant positive correlation with the maternal height and symphysio-fundal height. This is in agreement with a study conducted by Bothner *et al*. (2000) among a population in South Africa in which it was found that a good correlation of intrapartum symphysio-fundal height measurement exists with birth weight. Also, according to a study conducted by Hussain and Omololu (1983), there exists a strong correlation between the MH and BW. However, among the measured maternal anthropometric parameters in this study, the maternal arm circumference shows no correlation with the birth weight. Similarly, Nyaruhucha and Msimbe (1993) reported an existence of correlation between birth weight and the maternal anthropometric parameters (age of the mother, maternal parity and gestational age). Several studies have emphases that short maternal height is associated with reduced foetal growth and low birth weight (Kramer, 2003; Jananthan *et al*., 2009; Ozaltin *et al*., 2010; Wills *et al*., 2010). In another study conducted by Witter and Luke (1991), it was reported that new born babies born to shorter mothers (an obstetric height of less than 152 cm) are often symmetrically smaller than those born to taller mothers in the United States. Considering the relationship between birth weight and other selected neonatal anthropometric parameters in this current study, a strong correlation exists between the

birth weight, the placental weight and the other measured neonatal anthropometric parameters. In addition, there exists no correlation between birth weight with hand length and chest circumference. This is in accordance with a study conducted by Lo *et al*. (2002) which revealed a strong positive correlation between birth length and the placental weight. Furthermore, when gender is considered for the evaluation of the correlation between birth weight and placental weight in this study, a statistically significant correlation is observed, with the male neonates having a higher correlation value. Also, a significant correlation exists among the measured parameters in both male and female neonates. All these may be attributed to genetic factors that exist between the male and female participants.

Regression equations are important anthropometric models formed from anthropometric parameters that are used for estimating the relationships among variables. The equations are formed based on a straight line formula as $y = a + bx$ (Appendix VIII). The gold standard for BW measurement is the weighing scale, but in some areas (especially in the rural settings or busy delivery centres), the weighing scales are not readily available and where available, they are mainly faulty (Mullany *et al*., 2006) leading to non identification of LBW babies for immediate action/referral. In this study, an attempt has been made to estimate the BW using stepwise multiple regression equation models, formed from the measured neonatal anthropometric parameters. The overall model formulated for both male and female neonates is formed from the TC, the HB, the BL and the NAC as BW = - 358.17 + 78.87 × TC + 292.76 × HB + 20.17 × BL + 25.35 × NAC. By and large, among the male neonates in this study, the equation of BW estimation was formed from the TC, the HB, the NAC, the FB and the FL as BW = 82.34 + 58.27 × TC + 163.81 × HB + 54.50 × NAC + 118.95 × FB + 74.56 × FL. Considering the female neonates in this study, the overall models were formed from the BL in addition to the TC and the HB as BW = - 763.90 + 92.73 × TC + 317.76 × HB + 28.23 ×BL. In all the derived equations there is a significant correlation between the BW and the anthropometric parameters, thus the validity of the equations. A previous study among the neonates of the same population conducted by Modibbo and Taura (2013) formulated multiple linear regression equations for BW estimation using the anthropometric measurements of hand and foot among Hausa newborn babies in Kano, Nigeria. The chief difference between the regression equations formed in this study and the earlier one stems from the fact that stepwise regression models, not the linear regression equations, were used in the current study. In a prospective cohort study conducted by Mojgan *et al*. (2013) among full term neonates (taken 72 hours before birth), anthropometric parameters were measured sonographycally and the regression models that could be used to estimate BW was obtained as Log (BW) = 2.461 + 0.003 BPD + 0.001 AC + 0.007 STT + 0.005 FL. The measured anthropometric parameters significantly correlate with the parameters observed in the current study. Several studies have attempted estimating BW at term using regression equations formed from anthropometric parameters (Michael *et al*., 1999; Fei *et al*., 2009; Athena *et al*., 2014; Jili *et al*., 2015; Ozdamar *et al*., 2015). The anthropometric parameters used in

formulating these regression models were observed to correlate significantly with BW as stated in the present study.

# CHAPTER 6

## 6.0 CONCLUSION AND RECOMMENDATIONS

### 6.1 Conclusion

The study has determined the mean BW, PW, PW/BW ratio and the PI among the neonates in Kano State. A significant variation among the maternal and the neonatal anthropometric parameters in the urban and rural areas of Kano State has also been established. The study has proven the existence of positive influence of area of residence on maternal characteristics, Apgar score and PW/BW ratio among the neonates of Kano State. Furthermore, a strong correlation was established between the BW with the maternal and other neonatal anthropometric parameters among the maternal-neonatal pair (mother-child). Stepwise multiple regression models were formed for the estimation of BW. Similarly, ROC for the discrimination between low and high birth weight in tandem with the stepwise regression equation was constructed to further simplify the estimation of BW.

### 6.2 Recommendations

It is recommended that in any strategic health planning regarding neonates and or mothers, location (urban or rural) should be considered as a vital regulatory factor. Also, the Kano State Health Management Board should understudy the regression models and the ROC with a view at accepting it as a veritable tool for its rural and urban hospitals, so that low birth weight neonates are identified immediately for appropriate referral and or action. This will go a long way in reducing neonatal death in the State (and helps to achieve the fourth Millennium Development Goal). The ROC from this study can also be used in the various hospitals within the state so as to immediately estimate the birth weight even in the absence a weighing scale. In addition, health education should be provided for pregnant mothers (especially in the rural settings) on ANC visits on how to improve their haemoglobin (Hb) level. This is having realised that mothers domiciled in rural areas have low Hb levels. A new study should be under taken to consider the predictors of BW in other group of neonates that were excluded in the study (i.e. deformed or those with congenital anomalies). Lastly, it is also recommended that this study should also be carried out in other locations in Nigeria so as to get the Nigerian reference values.

### 6.3 Contribution to Knowledge

i. The mean values for BW, PW, PW/BW ratio and PI were determined for the neonates of Kano State, Nigeria.

ii. Cut-off values that discriminate between low and high birth weight among the urban and rural neonates in Kano State has been determined in this study.

iii. The mean PI value was found to be normal among the delivered neonates, this shows that babies born by the mothers in Kano State did not encounter intra-uterine foetal malnutrition [as their PI value was found to be >2.0 $g/cm^3$

iv. Stepwise multiple linear regression models were derived that can be used to estimate BW among neonates in the urban and rural areas of Kano State, especially the busy delivery centres or were weighing scale is not readily available.

v. Also, it was observed that area of resident significantly affects the neonatal and the maternal anthropometric characteristics.

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**APPENDIX I**

| | 0 (Points) | 1 | 2 |
|---|---|---|---|
| **Appearance** | Blue or pale all over | Blue extremities, but torso pink | Pink all over |
| **Pulse** | None | < 100 | ≥ 100 |
| **Grimace** | No response | Weak grimace when stimulated | Cries or pulls away when stimulated |
| **Activity** | None | Some flexion of arms | Arms flexed, legs resist extension |
| **Respirations** | None | Weak, irregular or gasping | Strong cry |

**Apgar scoring chart**

**Source:** https://www.bing.com/images/search

## APPENDIX II

13962 70992 65172 28053 02190 83634 66012 70305 66761 88344

43905 46941 72300 11641 43548 30455 07686 31840 03261 89139

00504 48658 38051 59408 16508 82979 92002 63606 41078 86326

61274 57238 47267 35303 29066 02140 60867 39847 50968 96719

43753 21159 16239 50595 62509 61207 86816 29902 23395 72640

83503 51662 21636 68192 84294 38754 84755 34053 94582 29215

36807 71420 35804 44862 23577 79551 42003 58684 09271 68396

19110 55680 18792 41487 16614 83053 00812 16749 45347 88199

82615 86984 93290 87971 60022 35415 20852 02909 99476 45568

05621 26584 36493 63013 68181 57702 49510 75304 38724 15712

06936 37293 55875 71213 83025 46063 74665 12178 10741 58362

84981 60458 16194 92403 80951 80068 47076 23310 74899 87929

66354 88441 96191 04794 14714 64749 43097 83976 83281 72038

49602 94109 36460 62353 00721 66980 82554 90270 12312 56299

78430 72391 96973 70437 97803 78683 04670 70667 58912 21883

33331 51803 15934 75807 46561 80188 78984 29317 27971 16440

62843 84445 56652 91797 45284 25842 96246 73504 21631 81223

19528 15445 77764 33446 41204 70067 33354 70680 66664 75486

16737 01887 50934 43306 75190 86997 56561 79018 34273 25196

99389 06685 45945 62000 76228 60645 87750 46329 46544 95665

36160 38196 77705 28891 12106 56281 86222 66116 39626 06080

05505 45420 44016 79662 92069 27628 50002 32540 19848 27319

85962 19758 92795 00458 71289 05884 37963 23322 73243 98185

28763 04900 54460 22083 89279 43492 00066 40857 86568 49336

42222 40446 82240 79159 44168 38213 46839 26598 29983 67645

43626 40039 51492 36488 70280 24218 14596 04744 89336 35630

97761 43444 95895 24102 07006 71923 04800 32062 41425 66862

49275 44270 52512 03951 21651 53867 73531 70073 45542 22831

15797 75134 39856 73527 78417 36208 59510 76913 22499 68467

04497 24853 43879 07613 26400 17180 18880 66083 02196 10638

95468 87411 30647 88711 01765 57688 60665 57636 36070 37285

01420 74218 71047 14401 74537 14820 45248 78007 65911 38583

74633 40171 97092 79137 30698 97915 36305 42613 87251 75608

46662 99688 59576 04887 02310 35508 69481 30300 94047 57096

10853 10393 03013 90372 89639 65800 88532 71789 59964 50681

68583 01032 67938 29733 71176 35699 10551 15091 52947 20134

75818 78982 24258 93051 02081 83890 66944 99856 87950 13952

16395 16837 00538 57133 89398 78205 72122 99655 25294 20941

53892 15105 40963 69267 85534 00533 27130 90420 72584 84576

66009 26869 91829 65078 89616 49016 14200 97469 88307 92282

45292 93427 92326 70206 15847 14302 60043 30530 57149 08642

34033 45008 41621 79437 98745 84455 66769 94729 17975 50963

13364 09937 00535 88122 47278 90758 23542 35273 67912 97670

03343 62593 93332 09921 25306 57483 98115 33460 55304 43572

46145 24476 62507 19530 41257 97919 02290 40357 38408 50031

37703 51658 17420 30593 39637 64220 45486 03698 80220 12139

12622 98083 17689 59677 56603 93316 79858 52548 67367 72416

56043 00251 70085 28067 78135 53000 18138 40564 77086 49557

43401 35924 28308 55140 07515 53854 23023 70268 80435 24269

18053 53460 32125 81357 26935 67234 78460 47833 20496 35645

**Random number table**

**Source:** From the rand corporation, *A million random digits with 100,000 normal deviates* (New York: The Free Press, 1955)

**APPENDIX III**

**Proforma of Data Collection for: The impact of urbanization and other anthropometric characteristics on birth weight among mother-child pair in Kano Nigeria**

**No…….. Code……. Senatorial Zone….....**

**SECTION A:**

Maternal Characteristics:

1. **Age**…… (*years*)
2. **Maternal Parity**…… *Multip.* [ ] *Primip.* [ ]
3. **Family Size**…….....
4. **Educational Level:** *Pri.* [ ] *Sec.* [ ] *Ter.* [ ] *Others* [ ]
5. **Antenatal Care:** *Attended* [ ] *Not Attended* [ ]
6. **Location/Residence:** *Urban* [ ] *Rural* [ ]

Maternal Anthropometric Parameters:

1. **Maternal Height**…….. (*cm*)
2. **Maternal Arm Circumference**…….. (*cm*)
3. **Symphysio-fundal Height**…… (*cm*)
4. **Haemoglobin Level**……. (*g/dl*)
5. **Urine Glucose Level**… $1^{+}$ [ ] $2^{++}$ [ ] $3^{+++}$ [ ] ***NEGATIVE*** [ ]
6. **Blood Pressure:** *Systolic B.P.* …… **mmHg /** *Diastolic B.P.* …**mmHg** (*supine*)

**SECTION B:**

Neonatal Parameters:

1. **Apgar score**…… ***1 min.***[ ] ***5 min.*** [ ] 10 min. [ ] 20 min [ ]
2. **Sex**……. *Male* [ ] *Female* [ ]
3. **Birth Weight**…… (*kg*).
4. **Placental Weight**……. (*kg*).
5. **Birth Length**…….. (*cm*).
6. **Foot Length**…… (*cm*).
7. **Foot Breadth**…… (*cm*).
8. **Thigh Circumference**…….. (*cm*).
9. **Hand Length**…… (*cm*).
10. **Hand Breadth**…….. (*cm*).
11. **Neonatal Arm Circumference**…… (*cm*).
12. **Chest Circumference**…… (*cm*).
13. **Head Circumference**…… (*cm*).

**APPENDIX IV**

**Delivery at Murtala Muhammad Special Hospital Kano from November 2017 to May 2018**

| **Months** | **Jan.** | **Feb.** | **Mar.** | **Apr.** | **May.** | **Jun.** | **Jul.** | **Aug.** | **Sept.** | **Oct.** | **Nov.** | **Dec.** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Deliveries 2017** | 1211 | 948 | 1005 | 1002 | 1205 | 1246 | 1231 | 1153 | 1267 | 1290 | ***1104*** | ***1249*** |
| **Deliveries 2018** | ***1106*** | ***1007*** | ***1071*** | ***989*** | ***1251*** | - | - | - | - | - | - | - |

**Labour Ward Statistics (November 2017 to May 2018)**

**Source:** Murtala Muhammad Specialist Hospital labour wards statistical records

**APPENDIX V**

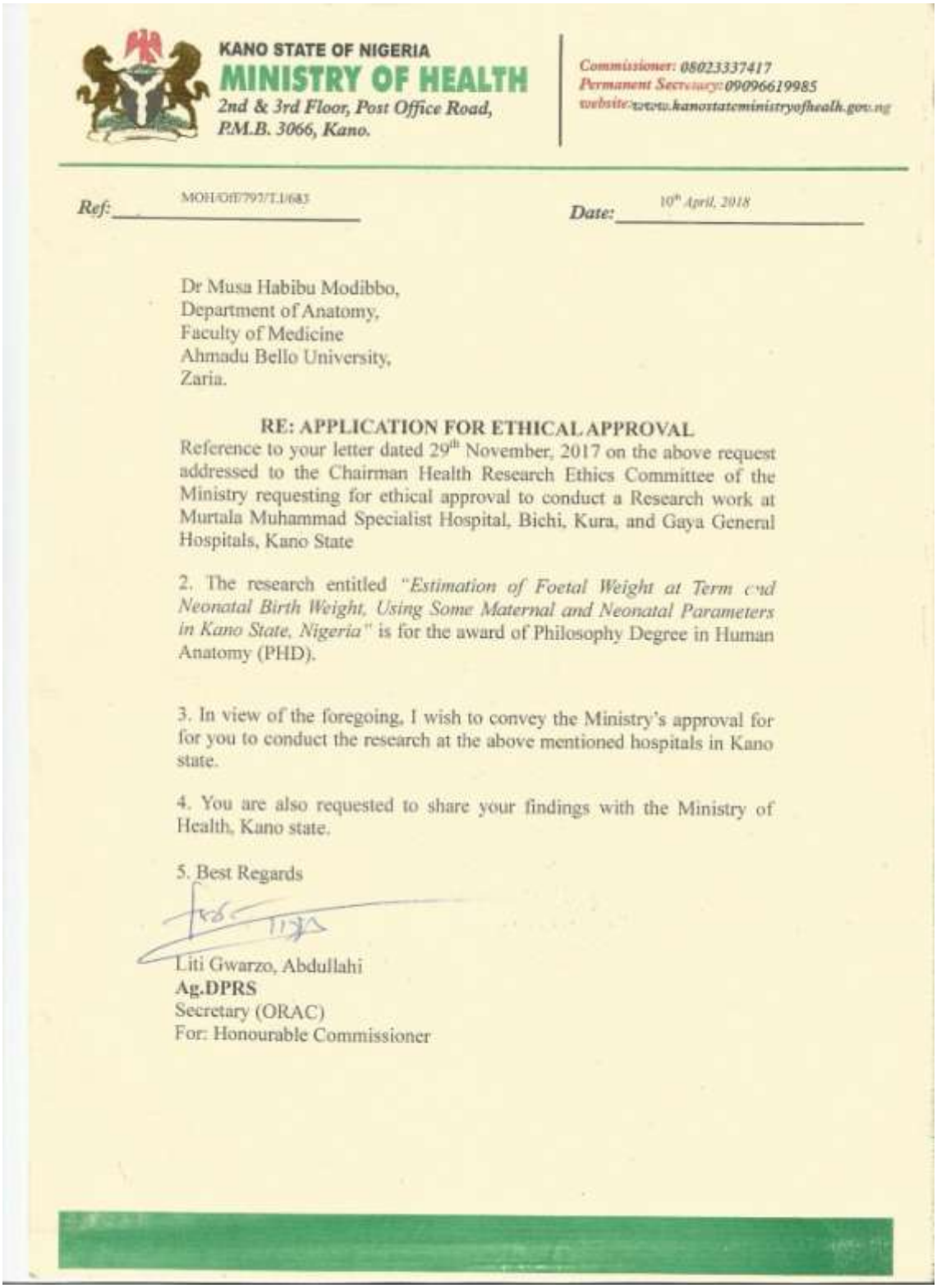
**Consent Form**

I am a Ph.D. student from the Department of Human Anatomy, Faculty of Basic Medical Sciences, Ahmadu Bello University, Zaria. I am conducting a research titled: ***"The impact of urbanization and other anthropometric characteristics on birth weight among mother-child pair in Kano, Nigeria"***. Some measurements will be carried out on you and your born baby. In addition, small blood sample will be taken from you for haemoglobin (Hb) measurement, thus small pain will be experienced while taking the sample. The study will be purely for research purposes as information given/gotten will be confidentially kept. However, no financial benefits will be attached for the information given. Be rest assured that acceptance or non acceptance of this consent will not in any way affect the quality of care to be rendered to you. Also, you can withdraw your consent at any moment you wish. By signing this consent form, it means you have read and understood it and you are willing to participate in the study.

---------- ----------

**Mother's signature/Thumb print** **Date**

**APPENDIX VI**



KANO STATE OF NIGERIA
MINISTRY OF HEALTH
2nd & 3rd Floor, Post Office Road,
P.M.B. 3066, Kano.

Commissioner: 08023337417
Permanent Secretary: 09096619985
website: www.kanostateministryofhealth.gov.ng

Ref: MOH/Off/797/T.I/683 Date: 10th April, 2018

Dr Musa Habibu Modibbo,
Department of Anatomy,
Faculty of Medicine
Ahmadu Bello University,
Zaria.

**RE: APPLICATION FOR ETHICAL APPROVAL**

Reference to your letter dated 29th November, 2017 on the above request addressed to the Chairman Health Research Ethics Committee of the Ministry requesting for ethical approval to conduct a Research work at Murtala Muhammad Specialist Hospital, Bichi, Kura, and Gaya General Hospitals, Kano State

2. The research entitled *"Estimation of Foetal Weight at Term and Neonatal Birth Weight, Using Some Maternal and Neonatal Parameters in Kano State, Nigeria"* is for the award of Philosophy Degree in Human Anatomy (PHD).

3. In view of the foregoing, I wish to convey the Ministry's approval for for you to conduct the research at the above mentioned hospitals in Kano state.

4. You are also requested to share your findings with the Ministry of Health, Kano state.

5. Best Regards

Liti Gwarzo, Abdullahi
**Ag.DPRS**
Secretary (ORAC)
For: Honourable Commissioner

Ethical clearance from the Ethical and Scientific Committee of Kano State Ministry of Health

**APPENDIX VII**

Those that declined consent to participate from the sampling hospitals are

**URBAN CENTRES:**

I. Murtala Muhammad Specialist Hospital = 7 persons.

II. Muhammad Abdullahi Wase Specialist Hospital = 16 persons.

III. Jakara Maternity Hospital = None

**RURAL CENTRES:**

I. Bichi General Hospital = None.

II. Kura General Hospital = 4 persons.

III. Gaya General Hospital = 1 person.

**TOTAL** = 28 persons (approximately 2%) of the participants declined consent.

## APPENDIX VIII

### Statistical Formulae

### (a). Minimum sample size

The minimum sample size ($n_o$) was determined using Cochran's formula (1957) as

$$n_o = \frac{Z^2Pq}{e^2}$$

Where:

Z = Standard normal deviation with confidence interval limit at 95% (that is ± 1.96).

P = is the prevalence of the study taken as 50% for an infinite population size with no published similar local study

q = is the complement of the prevalence (given as 1 – P)

*e* = Sampling error (the degree of accuracy desired) which is taken as 5% (0.05).

**(b). The regression equation formula is given as**

$y = a + bx$

Where,

$y$= Dependant variable **(the BW)**

$a$= Constant

$b$= Regression coefficient

$x$= Independent variable **(the selected anthropometric variables)**

Regression coefficient ***(b)*** is given as:

$b = r \frac{Sy}{Sx}$

Where,

$r$ = Coefficient of correlation

Sy = Standard deviation of the dependant variable

S$x$ = Standard deviation of the independent variable

**(c). Mean** $(\bar{x}) = \sum x/n$

x = Variance

n = Total number of observations

**(d). Standard Deviation** (S.D.) is given as the square root of the arithmetic average of the squares of the deviations from the mean

**S.D.** = $\sqrt{\sum} (x - \bar{x})^2/n - 1$

X = Variable

$\bar{x}$ = Mean

n = Total number of observations

**(e). Coefficient of correlation (*r*)**

$$r = \sqrt{\sum (x - \bar{x})^2 (y - \bar{y})^2} / \sum (x - \bar{x})^2 \sum (y - \bar{y})^2$$

$\sum (x - \bar{x})^2$ = the sum of squares of deviations of x from the mean ($\bar{x}$)

$\sum (y - \bar{y})^2$ = the sum of squares of deviations of y from the mean ($\bar{y}$)

$\sum (x - \bar{x})^2 \sum (y - \bar{y})^2$ = the sum of the product of the deviation of x and y from their means