

**COMPARATIVE STUDY OF PREGNANCY DATING BY SYMPHYSIS-
FUNDAL HEIGHT MEASUREMENT AND ULTRASOUND SCANNING
IN KUMASI METROPOLIS**

LINDA NYARKO ANTWI

(10556964)

DEPARTMENT OF RADIOGRAPHY

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DECLARATION

I, **LINDA NYARKO ANTWI**, do hereby declare that this thesis which is being submitted in fulfilment of the requirement for the degree of MSc in Medical Ultrasonography is the result of my own research performed under supervision, and that except where otherwise other sources are acknowledged and duly referenced, this work has not previously been accepted in substance for any degree and is not being concurrently submitted in candidature for any degree. I hereby give permission for the Department of Radiography to seek dissemination of the dissertation in any appropriate format.

Signed.....

Date.....

LINDA NYARKO ANTWI

(10556964)

Signed.....

Date.....

DR. SAMUEL YAW OPOKU

(SUPERVISOR)

Signed.....

Date.....

DR. VINCENT HEWLETT

(SUPERVISOR)

Signed.....

Date.....

DR. ANIM-SAMPONG

(HEAD OF DEPARTMENT)

DEDICATION

I dedicate this work to my beloved husband Rev. Joseph Antwi and my caring mother, Madam Comfort Sekyere. This work is also dedicated to my dear sister DSP. Genevieve Hagan. Their total support made this dream come true.



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LIST OF ABBREVIATIONS

AC	Abdominal circumference
ACOG	American College of Obstetricians and Gynecologists
AIDS	Acquired Immune Deficiency Syndrome
ANC	Antenatal care
BPD	Biparietal diameter
CRL	Crown rump length
EDD	Expected delivery date
FL	Femur length
GA	Gestational age
HC	Head circumference
IUGR	Intrauterine growth restriction
LMP	Last menstrual period
SFH	Symphysis-fundal height
SPD	Swiss precision diagnostics
SPSS	Statistical Package for Social Sciences software
US	Ultrasound scan
USCBP	Ultrasound scan of combined biometric parameters

ABSTRACT

Background: Gestational age (GA) assessment is an essential tool used to monitor the proper growth and development of fetuses. Obstetricians therefore depend on estimated GA to correctly diagnose either pre-term or post-term labour and to distinguish between preterm birth and intrauterine growth restriction.

Aim: The aim of study was to evaluate the accuracy of symphysis-fundal height (SFH) in comparison to ultrasound scan for the assessment of gestational age.

Methodology: The cross-sectional method was utilized in this prospective study involving 313 pregnant women with singleton uncomplicated pregnancies and presenting between 17 to 28 weeks of gestation. Convenient sampling method was used and an ultrasound machine was used to assess the biparietal diameter (BPD), head circumference (HC), abdominal circumference (AC), fetal length (FL). Ultrasound scans of combined biometric parameters (USCBP) and their corresponding GAs were estimated using the Hadlock method. The SFH of participants were recorded (emptied bladder) and estimates of the GA were made.

Results: Statistically there were no significant differences between the crown rumped length (CRL) and USCBP. No significant differences were also observed between the other US foetal biometrics parameters; (BPD, HC, FL and AC). However, there were significant differences ($p < 0.05$) between SFH and USCBP, and also between other US foetal biometrics parameters in the estimation of GA.

Conclusion: From the results of the study, it may be known that apart from the CRL scans, the next accurate measure of GA is the use of the US biometric parameters in second trimester.

Keywords: Gestational age, ultrasound scan, crown rump length, symphysis-fundalheight, antenatal care



CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND

Gestational age (GA) assessment is an essential tool for every obstetrician to monitor the proper growth and development of foetuses. It thus serves as aid to managing pregnancies (Scrudder, 2012). For this reason diagnoses of foetuses born before time or born after required date of delivery and intrauterine growth restriction depend largely on the estimated GA. There are several negative pregnancy outcomes such as unnecessary hospitalization, induction of labor and holistic treatment, which mostly result from wrong due dates. These affect both pregnant woman and clinicians.

The last menstrual period (LMP) has been used over several decades in determining the GA and this has given some significantly reliable clinical estimation of actual GA. Although the establishment of GA via the LMP is usable, many studies have proven its unreliability, especially, in the least developed countries largely due to high illiteracy among obstetric patients (Brakohiapa, Coleman, Ofori, Ndanu, & Antwi, 2012). As a consequence of this, the symphysis fundal height (SFH) for estimating GA was established to augment the LMP especially where there is multiple measure of SFH (White *et al.*, 2012).

A previous study by Ogbe, Ekwempu, Musa, & Anzaku, (2015) reported that SFH is an important and reliable tool in assessing GA with some limitations in some of the pregnancies. A recent method for estimating GA is the use of ultrasound (US) dating. In particular, GA assessment by ultrasound has by far shown to minimize instances where foetuses are inappropriately diagnosed with intrauterine growth restrictions and confirms the proper growth of the foetus, Adewale & Munir'deen (2015) however, found that there was no

significant difference between SFH and US parameters in assessing GA or predicting date of delivery in the first half of pregnancy. Therefore where US are not readily available, SFH measurement could be a good alternative, most especially, in low resourced countries. Currently these three methods; US, SFH, and LMP are being used for estimating date of pregnancies in Ghana.

In estimating the GA using the LMP, many studies have proven it as inferior relative to SFH and US dating. In study pregnancy dating methods, Ogbe, Ekwempu, Musa, & Anzaku (2015) examined the reliability and significance of each method to the health profession. Hence, health professionals can thus use SFH in determining GA where US dating is not available or accessible (Ogbe *et al.*, 2015). It is however generally confirmed from studies, that US dating is the most reliable standard of establishing GA (Jehan *et al.*, 2010; Mongelli, 2015). It is most useful in the first trimester where biological variation in fetal size and the effects of growth restrictions are negligible (Kalish & Chervenak, 2005; Mongelli, 2015).

1.2 PROBLEM STATEMENT

In a study by Brakohiapa *et al* (2012), it was revealed that maternal mortality is a large and un-abating problem, occurring mainly in the developing world. Accuracy of pregnancy dating therefore cannot be overemphasized because wrong due dates are also associated with high induction rates with resultant failed inductions, increased caesarean sections and increased prenatal morbidity and mortality (Brakohiapa *et al.*, 2012). During field observation at various ultrasound departments, it was found that many discrepancies in relation to pregnancy dating were common occurrences due to the different methods being used to estimate GA.

The use of LMP is not easily reliable which may be due to poor recollection, irregular menstrual cycles of varying duration, lactational amenorrhea, bleeding in early pregnancy, or

hormonal contraceptive use prior to conception (Kalish & Chervenak, 2005). More so, it is dependent on the self-information given by the pregnant women who in this context are mostly ignorant about this LMP (Babuta *et al.*, 2013). This has become imperative to evaluate the accuracy of SFH in comparison to US for the assessment of GA in Ghana. Moreover, SFH is well assessed during second trimester.

1.3 SIGNIFICANCE OF THE STUDY

Accurate determination of GA is very crucial for proper medical management in the antenatal, delivery and postnatal stages of pregnancy. Thus, improper management could lead to an increase in infant and maternal mortality. Inaccuracies in the timing of deliveries as a result of wrong due dates give rise to increased overall costs of antenatal and delivery services (Jehan *et al.*, 2010). A foetal US is accepted as the best standard for establishing GA if it is done in the first and second trimesters, especially using the crown rump length (CRL) biometry in the first trimester (Karl *et al.*, 2015; Kalish & Chervenak, 2005; Taipale & Hiilesmaa, 2001) However, in Ghana most pregnant women do not attend antenatal clinic during the first trimester; hence there is the need to embark on this research to investigate other methods for gestation such as the SFH and foetal US in the second trimester.

A study like this is necessary in Ghana to help obstetricians, gynaecologist and midwives to qualitatively manage pregnant women. This study in Ghana may also inform policy makers to design training programmes to train more sonographers. All of these may contribute to reducing maternal morbidity and mortality.

1.4 HYPOTHESIS

There is no statistically significant difference between SFH measurement and ultrasound scan in the estimation of GA.

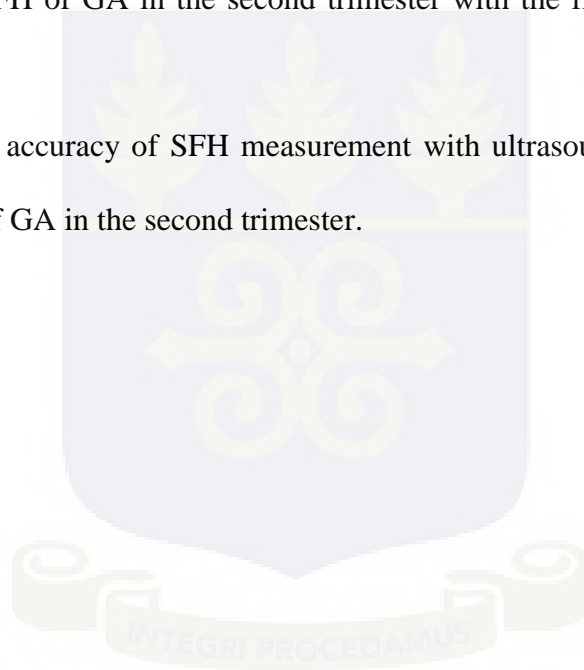
1.5 AIM

The aim of study is to evaluate the accuracy of SFH in comparison to ultrasound scan for the assessment of GA.

1.6 SPECIFIC OBJECTIVES

The objectives for this study are:

- i. To assess the ultrasound foetal biometry estimation of gestational age in the second trimester with the first trimester ultrasound dating by CRL.
- ii. To assess the SFH of GA in the second trimester with the first trimester ultrasound dating by CRL.
- iii. To compare the accuracy of SFH measurement with ultrasound foetal biometrics in the estimation of GA in the second trimester.



CHAPTER TWO

REVIEW OF LITERATURE

2.1 INTRODUCTION

This Chapter entails extant literature on the topic under discussion. Over here, various explanations are provided to the terms used in the study. Afterwards the various circumstances that led to the springing up of the ultrasound techniques in assessing the GA are brought up in this Chapter. It would be noticed further in the review of literature that, the use of the various methods in assessment of GA and subsequently the expected delivery date (EDD) would be discussed, highlighting the pros and cons of each of the techniques. Another important factor that is well pointed out in this review of literature is the time considered to be appropriate for the utilization of each of the techniques.

2.2 GESTATIONAL AGE

Gestational age is also referred to as the age of the “baby” (American Pregnancy Association, 2017). Bottomley *et al.* (2009), defines GA as the number of days from the LMP. Similarly, according to the American Pregnancy Association (2017), GA refers to a period between the first day of the LMP of a pregnant woman to the day on which an assessment of gestation period is being made. This means GA is the age of an unborn baby (Babuta *et al.*, 2013). It is worth noting that the GA is not calculated from the date of conception but from the first day of the LMP and is usually defined in weeks (Falatah *et al.*, 2014).

Gestational age is very important (appropriate obstetric care) in prenatal care as highlighted by a number of studies (Deputy, Nguyen, Pham, Nguyen, & Neufeld, 2017; Goldberg & El-sayed, 2017; Babuta *et al.*, 2013; Loughna, Chitty, Evans, & Chudleigh, 2009). According to Ohuma, Papageorghiou, Villar, & Altman (2013), accurate estimate on the GA of a foetus is

imperative to antenatal care and estimation of the EDD. As a matter of fact, all measurements in assessing pregnancy dating are dependent on the GA (Loughna *et al.*, 2009). This assertion therefore highlights how important and unescapably knowledge about the GA is in determining pregnancy dates.

According to the literature there are various ways of finding out the GA of the pregnant woman. The methods available include the use of the LMP, US dating and a combination of both (INTERGROWTH-21st, 2010; Ohuma *et al.*, 2013). With the exception of the US method, the other two are subject to considerable error and therefore need to be used only when ultrasonography facilities are not available (Mongelli, 2015).

However, other studies (White *et al.*, 2011; Women and Newborn Health Service, 2016) include the use of the SFH in estimating the GA which more or less is preferred in deprived settings. The SFH is a physical examination and measurement of certain characteristics to and in estimating GA (Department of Health & International Center for AIDS Care and Treatment Programs, 2009).

2.3 LAST MENSTRUAL PERIOD

In female humans, one characteristic that connotes one to be fertile is menstruation. Menstruation simply refers to a woman's monthly bleeding (U.S Department of Health and Human Services, 2017). On the average, menstrual periods are supposed to last for three to five days. The cycles of menstruation re-occurring is called the menstrual cycle. On the average, a menstrual cycle lasts for 28 days (U.S Department of Health and Human Services, 2017). It can therefore be inferred that, the LMP is the woman's first day of the last menstrual period.

The LMP is a method which has long been used in estimating the GA of an unborn baby and has extensively been documented to be unreliable (Martin *et al.*, 2015; SPD Swiss Precision Diagnostics GmbH, 2008). However, people without imagery diagnosis have no other choice than to use the LMP or other less sophisticated techniques. It has been realized that few women normally remember or provide accurate information regarding their LMP and more so dating the LMP may be difficult due to poor memory, inconsistency in menstrual periods of varying duration, lactational amenorrhea, bleeding in early pregnancy, or hormonal contraceptive use before conception (Neufeld, Haas, Grajeda, & Martorell, 2006; Kalish & Chervenak, 2005; Savitz *et al.*, 2002; Mongelli, Wilcox, & Gardosi, 1996; Alexander, Tompkins, Petersen, Hulsey, & Mor, 1995; Kramer, McLean, Boyd, & Usher, 1988).

One is expected to deliver a baby 280 days after the LMP (Goldberg & El-sayed, 2017). Researchers and clinicians continue to debate the validity and accuracy of LMP in high- and low-resource settings (Wingate, Alexander, Buekens, & Vahratian, 2007; Wegienka & Baird, 2005; Andersen, Johnson, Barclay, & Flora, 1981). In both situations, reliance on LMP alone has shown a tendency to overestimate GA at the extremes of gestation due to recall bias, thereby overestimating the proportion of post-date pregnancies and underestimating preterm deliveries (Wingate *et al.*, 2007; Savitz *et al.*, 2002; Taipale & Hiilesmaa, 2001; Mongelli M, 1997; Alexander *et al.*, 1995; Ballard *et al.*, 1991). Results of some recent studies in low- and middle-income settings, such as South Africa and Guatemala, suggest that LMP may differ from ultrasound estimates by a range of $\pm 2-14$ days (Blanchard *et al.*, 2007; Neufeld *et al.*, 2006). For guiding postnatal care at the individual level, a discrepancy of 1-2 week(s) may not be harmful. The same margin of error, however, may be unacceptable for administrative and statistical purposes (Rosenberg *et al.*, 2009). However, in low-resource countries such as Bangladesh where limited information or technical knowledge is routinely available, health workers often determine GA by relying on LMP or neonatal birth weight and on available

obstetric clinical estimates, such as SFH measurement and timing of first quickening (Blanchard *et al.*, 2007; Neufeld *et al.*, 2006; Andersen, Johnson, Flora, *et al.*, 1981).

Rosenberg *et al.* (2009) also outlined the difficulties involved in assessing GA in areas with high prevalence of maternal malnutrition and intrauterine growth restriction (IUGR). However, Gardosi (1999) emphasized the unreliability of pregnancy dating methods like LMP and further urged clinicians to rely on routine measurement of the SFH especially in communities where US are not readily available. In another study Gardosi (1997) showed ample evidence that routine US in the first half of pregnancy had more precise GA assessment than solely LMP or in combination with ultrasound, further suggested that, obstetricians, sonographers, midwives and general practitioners should not use LMP in determining the EDD. Rather LMP should only be used to calculate the approximate date when the dating scan should be registered. If that is not the case, it should be considered as a substitute measure, alongside other measures such as the clinical assessment of uterine size, 'Dubowitz scores and Quickening'.

2.4 ULTRASOUND SCAN

The use of ultrasound technology in assessing the GA harnesses foetal biometry which is a methodology devoted to taking measurements of several parts of foetal anatomy and their growth (Babuta *et al.*, 2013). The ultrasound technology provides imagery diagnosis of the foetus which makes it possible to measure certain parameters on the unborn baby. Images produced from the ultrasound technology are described as tomographic images- showing slices of a body part (Wilhjelm, Illum, Kristensson, & Andersen, 2016). Antenatal care took a different turn with the introduction of the ultrasound as gender of unborn babies could even be determined (Efrat, Akinfenwa, & Nicolaides, 1999).

The accuracy of SFH measurements to determine GA is low, but may provide a reasonable alternative during the second trimester in areas where ultrasound is unavailable, and when LMP may be inaccurate, especially where multiple measurements are performed during pregnancy (Neufeld *et al.*, 2006; Turney, 2005; White *et al.*, 2012). In dating pregnancies, Hunter, (2009) commented on the limitations of ultrasound as well, and indicated that the accuracy of US scan depend greatly on the skill of the person performing the examination and the quality of the images, not to mention the size of the patient and the fetal position (Callen, 2011). Cost-benefit ratios of routine ultrasound use have still not been completely resolved in every practice setting, with one study suggesting that community based hospitals would actually lose money if routine ultrasound screening is performed (Vintzileos, Ananth, Smulian, Beazoglou, & Knuppel, 2000).

American College of Obstetricians and Gynecologists (ACOG) has further stated that, ultrasound sensitivity in detecting fetal anomalies remains controversial, with higher detection rates reported at tertiary centers and higher sensitivity rates overall for central nervous system and urinary versus cardiac anomalies (Abuhamad, 2008). The safety of ultrasound has come into question, and these concerns have been addressed by the American Institute of Ultrasound in Medicine (AIUM)(2009). Ultrasound energy generates sound waves in a pulsed fashion that can theoretically raise the temperature of body tissues and this vibration effect, commonly referred to as cavitation, has been cited in some studies as potentially causing harm to developing fetuses (Callen, 2011).

Various studies acknowledge biometric parameters in ultrasonic imaging and these include the biparietal diameter (BPD), head circumference (HC), fetal length (FL) and the abdominal circumference (AC)(Babuta *et al.*, 2013; Falatah *et al.*, 2014). However, in the study of Shan

& Madheswaran (2010), another ultrasonic parameter was included which is crown rump length(CRL).

One of the numerous measurements taken during pregnancy is the BPD (Danielsson, 2017b).The BPD is the standard against which the other foetal biometry parameters of GA estimation is compared with (Woo, 2017). Every human and as a matter of fact, every unborn baby has two parietal bones; one on the right and the other on the left side of the skull (Danielsson, 2017b). The BPD is the length from the right parietal bone to the left parietal bone which is the diameter across the skull (Danielsson, 2017b).

The HC is usually measured in the course of taking measurements from the BPD (Military Obstetrics & Gynecology, 2017). The HC is simply the perimeter around the head of the unborn baby (like measuring the circumference of a circle) (Military Obstetrics & Gynecology, 2017).

Femur implies the thigh bone. The length of the thigh bone (which is the longest bone) of an unborn baby can provide adequate information for estimation of GA (Danielsson, 2017b). The femur bone is measured from where it starts in the hip to its end in the kneecap.

According to the Military Obstetrics & Gynecology (2017), The AC refers to the:

“...transverse section (coronal) through the foetal abdomen at the level where the umbilical vein enters the liver.”

The AC and FL are not only useful in estimating GA but also foetal weight (Military Obstetrics & Gynecology, 2017). It is observed that all these foetal biometric parameters can provide reliable estimations with appropriate formulas solely or when combined with other parameters. Another common objective that all these methods seek to achieve is not only to give an idea of the GA but to help predict the EDD.

Lastly, the CRL is an ultrasonic parameter which is described by a number of researchers as the most reliable predictor is accepted as the best standard for establishing GA when done in the first and second trimester, especially using the CRL biometry in the first trimester (Karl et al., 2015; Shan & Madheswaran, 2010; Taipale & Hiilesmaa, 2001).

According to Shan & Madheswaran (2010), CRL is the taken at sitting height, in a neutral position, from the middle of the brain to the lowest point of breech. It is the measurement in length from the top of the head (crown) to the buttocks (rump) of the unborn baby excluding the limbs and yolk sac (Danielsson, 2017a).

2.5 SYMPHYSIS-PUBIS FUNDAL HEIGHT

In other studies, the Symphysis-pubis Fundal Height (for example White *et al.*, 2011) is known as the SFH (for example Freire, Cecatti, & Paiva, 2010). They all connote the same thing. According to the Women and Newborn Health Service (2016) SFH refers to the

“...distance measured in centimetres on the longitudinal axis of the abdomen from the top of the fundus to the upper border of the symphysis pubis”.

The SFH is one method of estimating GA especially in less resourced areas (White *et al.*, 2011). This is because all that is needed is a tape measure to measure the longitudinal axis in centimetres. This requires high expertise in the interpretation of results but less sophisticated materials in measurements. For the purposes of accurate measurements and biases, Belizan & Villar (1978), proposed that measurements should be done blind by turning the tape measure and marking the tape from behind.

Research has shown little evidence to the benefits or harm associated with the routine measurement of SFH during pregnancy (Neilson, 2009). Notwithstanding, available literature indicates that routine SFH measurement is a sound method for detecting small-for-gestational-age babies in developing countries. Moreover, It has been indicated that after the

first sixteen weeks of pregnancy, the fundal measurement matches the number of weeks of pregnancy (Harms, 2014). This also corresponds with the ultrasound dating. Knowledge about GA accuracy is important for prenatal, delivery, and postnatal care (Abdalla, 2015)

However, because of various differences in SFH across populations, local standards are required for optimal pregnancy dating using SFH (Limpanyalert & Manotaya, 2001; Andersson & Bergström, 1995; Mathai, Jaira, & Muthurathnam, 1987; Ogunranti, 1990; Rai, Kurien, & Kumar, 1995). The size of the uterus, estimated through pelvic or abdominal examination, can be roughly correlated with gestational age; however, factors that affect uterine size (such as fibroids) and maternal body characteristics (such as obesity) will affect such estimates. At 20 weeks the fundus reaches the umbilicus. After 20 weeks, the SFH (in cm) should correlate with the weeks of gestation (Andersen, Johnson, Flora, & Barclay, 1981; Beazley & Underhill, 1970; Limpanyalert & Manotaya, 2001).

Rosenberg has also described how in many settings, SFH had replaced clinical assessment of fetal size by abdominal palpation because the latter had been reported to perform poorly in observational studies during routine antenatal care, in detecting foetuses that were small for GA at delivery (Rosenberg K, 1982). Neilson (2007) emphasised that, *“It would seem unwise to abandon the use of SFH measurements unless a much larger trial likewise suggests that it is unhelpful”*. Clear guidance about the value of SFH in routine antenatal care requires a much larger trial than has been performed to date.

The main problem with ascertaining the reliability of the SFH measurement is that, there are no published standards that describe the technique (McGeown, 2001). A valid date of delivery can only be estimated from the LMP if the menstrual date is accurate. However, the unreliability of this method has been demonstrated by various authors, who observed that 10%–45% of women did not have a reliable date for their LMP as a result of an irregular

menstrual cycle, use of oral contraceptive pills, or bleeding during pregnancy (Jehan *et al.*, 2010; Taipale & Hiilesmaa, 2001).

2.6 HISTORY OF TECHNIQUES IN GESTATIONAL AGE ESTIMATION

According to Tsung (2011), the Italian physiologist Lazzaro Spallanzani was the first person to study ultrasound physics. This was after the basis of sound waves had been studied and published by Lord Rayleigh in 1877 (Woo, 2008). Lazzaro Spallanzani demonstrated how bats utilized ultrasound to navigate their way in dark places accurately (Woo, 2008). He vividly asserted that the ultrasound emitted by the bats is inaudible to the human ear due to the very high frequency it possesses. Further to prove this was the invention of the Galton Whistle by English scientist Francis Galton in 1876 whose device could produce sound waves which were inaudible to the human ear. During that time, the use of ultrasound for medical purposes had not been established. During this period, efforts were geared towards establishing the fundamentals and proving the existence of inaudible ultrasound.

Later developments in ultrasound involved deploying it into devices. This was spurred by war and the event of the titanic sinking in the 1912(Woo, 2008). This was for the purpose of navigation in the waters by submarines and ships. Reginald Fessenden in 1914 was the first to develop a sonar system (which could only detect the iceberg but not the direction due to the low frequency) to detect underwater icebergs from two miles away (Woo, 2008). This then called for the discovery of materials which could emit and withstand high frequency ultrasound. The breakthrough to this was the discovery of the diode and triode which allowed powerful electronic amplifications. Hence the hydrophone was developed and deployed in submarines quickly and this was used in the World War 1. According to literature the first known sinking of a submarine which was detected by a hydrophone was in 1916 during World War 1 (Woo, 2008). On the other hand, ultrasound effects were being developed to

asses flaws in metals and this was also pioneered by soviet scientist Sergei Y. Sokolov in 1928 (Woo, 2008). This use of ultrasound came to stay as it was further developed for better metal flaw detection.

It was after these series of events that ultrasound was thought to be able to be used in the field of medicine. However in the early use of ultrasound application in medicine, focus was on its use for therapy other than diagnosis (Woo, 2008). There were concerns in the use of ultrasound in the field of medicine as the issues had been raised in the 1920s about its destructive power and the ability to cause induced pain in the hand (Woo, 2008). Eventually it became a neuro-surgical tool which was used by scientist to destroy basal ganglia in patients with Parkinsonism. In the 1940s ultrasound was regarded as an almost “cure all” medicine for asthma, gastric ulcers, arthritic pains, haemorrhoids, urinary incontinence and others but there was no evidence to back all these claims (Woo, 2008).

The breakthrough in the use of ultrasound for medical diagnosis was realised by Karl Dussik, a neurologist and psychiatrist, who first used ultrasound in the detection and diagnosis of tumours, abscesses or exudates (Tsung, 2011). The method used was based on echo-reflections similar to the use of ultrasound in the detection of metal flaws. Dussik’s procedure was called the “Hyperphonography” as imagery of tumours could be seen also. Dussik performed the earliest form of ‘scanning’ as results (photograph) was captured on heat-sensitive paper as spots of light (Woo, 2008). This was the beginning of ultrasound imagery as there were improvements in the imagery over the course of time. Scientists interested in the emerging and growing field of ultrasound technology then joined the course of its development. Ultrasound technology finally made a splash in the late 1940s by George Ludwig who designed equipment to detect foreign bodies in animal tissues and gallstones. However, his research was concealed by the United States Department of Defence until after

the war was over. Next on the discovery list was John Julian Wild who also investigated how ultrasound waves can be used to detect the thickness of bowel walls in surgical conditions. Wild built the uni-directional A-mode apparatus to aid this detection (Woo, 2008).

Another scientist named Ian Donald from Scotland was present at a lecture by John Wild in 1954. While Wild had concentrated his research on the detection of tumours of the colon and the breast and had popularized his findings, Ian Donald saw an opportunity for ultrasound diagnosis in obstetrics and gynaecology (Woo, 2008). This was the beginning of ultrasound technology in obstetrics and gynaecology. Ian Donald asserted that clear echoes can be gotten from the head of the foetus and later tests proved true and then foetal growth could be assessed subsequently. This resulted in foetal cephalometry (Woo, 2008). Hence, research on ultrasound technology in obstetrics and gynaecology experienced a boom several others like Tom Brown, Alfred Kratochwil, Peter NT Wells, and Stuart Campbell joined the emerging field (Tsung, 2011).

Subsequent improvements in ultrasound technology lead to the development of an A mode scan, B-mode scan and the M-mode scan. Based on the A-mode scan, Ian Donald was the first to invent the BPD of a foetus (Woo, 2008). A researcher named Hugh Robinson taking advantage of improved gadgets, reported a 100% detection of foetus cardiac after 7 weeks of conception (Woo, 2008). Hugh Robinson was the first to bring about the idea of measuring the foetal CRL (Woo, 2008). On the other hand using the B-scan Stuart Campbell (Campbell Group) brought about the measurement of the AC which is still the most important parameter in assessing foetal weight and nutrition (Woo, 2008). According to Ohuma *et al.* (2013), Campbell in 1969 was the first to use ultrasound biometry to assess the GA and this has become the preferred method for pregnancy dating. Later in 1979, John Hobbins introduced another ultrasound biometric parameter - the foetal femur length (FL). According to Woo

(2008), foetal biometry gained more prominence in the 1980s and by the mid1980s the few foetal biometric parameters that were considered standard are the CRL, BPD, HC , AC, and FL. Up to date, these foetal biometrics are still the standard parameters in assessing the gestational age and expected date of delivery (Ohuma *et al.*, 2013; Salomon *et al.*, 2010; Shah, Teismann, Zaia, & Vahidnia, 2010).

2.7 ESTIMATIONS FROM THE GESTATIONAL AGE TECHNIQUES

Making estimations from all of the techniques in estimating the GA and ultimately the EDD is something all the techniques seek to achieve. However, knowledge about the GA is vital to predicting the EDD. It is worth noting that all these techniques possess appropriate GA where their predictions are more accurate and at other times in the gestational ages, their predictions are massively flawed. In this section, the ways in which the various techniques are used in making estimations on the GA and the EDD are described. Moreover, the conclusions drawn on the accuracy of these techniques are presented.

2.7.1 LMP Estimations

Starting from the LMP which is the traditional way of estimating the GA and EDD, it is the oldest technique (Papageorghiou *et al.*, 2016). The LMP is the most used technique in estimating GA in epidemiological research and clinical care (Hoffman *et al.*, 2008). As already noted that EDD after establishing the LMP is 280 days (Goldberg & El-sayed, 2017). This assertion is per the assumption of a woman with menstrual cycle of 28 days with ovulation happening on the 14th day after a new menstrual cycle (Papageorghiou *et al.*, 2016).

However, the estimated 280 days (Soltani, 2007) can be completely flawed because in some cases women do not recall the accurate date of LMP, some experience irregular menses, there can be misinterpretation of early pregnancy bleeding or a variability in the timing of ovulation (Goldberg & El-sayed, 2017; Papageorghiou *et al.*, 2016; Hoffman *et al.*, 2008;

Swiss Precision Diagnostics (SPD) GmbH, 2008). To affirm this, a study done by the (Swiss Precision Diagnostics (SPD) GmbH (2008), revealed that 56% of women were able to recall their LMP whilst Ohuma *et al.* (2013) found the 50% of women cannot recall their LMP. Still, another study by Babuta *et al.* (2013), suggested that between 10 to 40% of patients (pregnant women) have no knowledge, have irregular history of menstrual cycle or have been on oral contraception which distorts menstrual cycle. The LMP is used in estimation of EDD by applying the 280 days rule as soon as the LMP is known. Knowledge of the LMP is also needed to carry forth with the estimation of the GA.

Due to these distortions and even other more which may be genetically related, the use of LMP to make predictions as per the GA and the EDD has been declared unreliable by a number of research works (Papageorghiou *et al.*, 2016; Simic, 2012; Hoffman *et al.*, 2008). At best, LMP is an approximation of the GA which is derived from a first trimester ultrasound scan. Despite these anomalies, if GA approximation using the CRL is within 7 days of that calculated from LMP, the LMP is considered to be reliable and taken as the true biological date (INTERGROWTH-21st, 2010).

2.7.2 Ultrasound Estimations

As explained earlier, the use of the ultrasound Scan to make estimations regarding GA and EDD usually centres on the BPD, HC, AC and FL (known as the foetal biometrics according to Babuta *et al.*, 2013). A pregnancy is expected to last for 9 months and it is divided into three trimesters (each division is made of three months). Generally, many authors argue that, ultrasound scan estimation of GA and subsequently EDD are much more accurate in the first trimester (Hoffman *et al.*, 2008; Kalish & Chervenak, 2009). In contrast to this, Babuta *et al.* (2013), also found that ultrasound Scan in subsequent trimesters could also be accurate in determining the GA and the EDD, but it is rather a matter of which foetal biometric

parameter being used at the appropriate trimester. Based on this, it can be concluded that, ultrasound Scan can be used in various trimesters with some level of accuracy; however it is most preferred in the first trimester. Evidence from Babuta *et al.* (2013) study provided some interesting evidence to why ultrasound Scan is established to be much accurate in the first trimester: It was realized that, the accuracy of the foetal biometric parameters in the subsequent trimesters other than the first, were consistently decreasing in their accuracy. In spite of these, Falatah *et al.*, (2014) explained that performing ultrasound scans with precision and quality can render ultrasound alone more accurate than the use of a menstrual dates.

Delving deeper into the foetal biometrics, the BPD has been singled out to make predictions of about 95% confidence of 10 to 14 days (Military Obstetrics & Gynecology, 2017). Due to this, Woo, (2017) claims that the use of the BPD should be the standard to which other parameters are compared. However, Falatah *et al.*, (2014) unveiled some conditions which could render BPD useless and very unreliable. They claimed that when there is IUGR, biparietal growth becomes slow. The BPD is dependent on the shape of the head and hence the cephalic index is used to adjust measurements when necessary (Loughna *et al.*, 2009). Moreover, as the GA increases, the BPD becomes less reliable as evidenced in Babuta *et al.*'s. (2013) study and that of Danielsson, (2017b). It is difficult to detect the cut off week for the accuracy of using the BPD in estimations. According to Danielsson (2017b), some studies showed forth that BPD is most accurate between week 12 and 26 of pregnancy whereas other studies reported that BPD became less reliable after the 20th week of pregnancy. Similarly, Falatah *et al.*, (2014) asserted that BPD after week 30 becomes useless and hence other parameters were required to commensurate the discrepancies. Woo (2017) posits that BPD should be taken after the 13th week of pregnancy. What is unclear throughout literature is the actual cut off week at which BPD reduces in reliability or is most accurate.

The AC is seen by Babuta *et al.*, (2013) to be the least accurate in the estimation of GA. It is not well established why, but this event could have been explained by Falatah *et al.*, (2014) who claimed the measuring of foetal AC is the most challenging as compared to other parameters. It was explained that due to the lack of bones in the abdomen, taking measurements posed challenges due to the vague image produced on the screen. Moreover, the positioning of the baby normal occurrence of respiration distorts the measuring of the AC. According to the Military Obstetrics & Gynaecology (2017), taking good measurements on the AC is accurate in estimating the GA, however, it is much more useful in estimating the foetal weight. Due to the difficulty in the measurement of AC in some cases, it is estimated from other parameters (indirectly) especially after the GA has been established. Estimation of the AC from the GA according to Loughna *et al.*, (2009) can be done with the formula:

$$AC = -85.84 + 11.92(GA) + 0.0007902(GA)^3 \dots\dots\dots(2.1)$$

Femur length also comes in handy in the estimation of GA. Deductions from Falatah *et al.*, (2014) suggests that the FL should be easier to spot on the screen of an ultrasonic machine because it is a bone and would therefore be visible on the screen. In measuring the FL, the ideal situation is to make sure the femur is imaged at an horizontal plane, precisely the femur should be 90 degrees to the ultrasound beam (Loughna *et al.*, 2009). Loughna *et al.*, (2009) suggests that the FL be used to make estimations starting from week 13 to week 25 as it can provide accurate estimations of GA in those weeks. Out of the ideal time of measurement Falatah *et al.* (2014), set out to assess the accuracy of the foetal biometrics after the 1st trimester. It came to the realization that FL was a more accurate measure of GA than the BPD after week 28 (third trimester). This spurred the recommendation that in the later stages of pregnancies, BPD should be used in conjunction with other parameters including the FL. The formula according to Loughna *et al.*, (2009) for obtaining the GA from the FL is:

$$\log_e(GA) = 0.034375FL - 0.0037254FL \times \log_e(FL) + 2.306\dots\dots(2.2)$$

The HC, unlike the BPD is independent of the shape of the head (Loughna *et al.*, 2009). This suggests that an anomaly in the shape of the head hardly affects measurements pertaining to the HC. HC measurements for GA estimations are preferably performed between weeks 13 and 25 of pregnancy. According to Loughna *et al.*, (2009), GA can be calculated from the HC using the formula:

$$\log_e(GA) = 0.010611HC - 0.000030321HC^2 + 0.43498 \times 10^{-7}HC^3 + 1.848.....(2.3)$$

2.7.3 Ultrasound CRL Estimations

The CRL is the most trusted foetal biometric parameter for the estimation of GA in the first trimester (Shan & Madheswaran, 2010). As reported by INTERGROWTH-21st, (2010), the CRL is the ideal foetal biometric parameter for predicting EDD and GA. Loughna *et al.* (2009), shares the same opinion that the CRL should be the recommended practice for estimating the GA other than the use of menstrual dates. One would wonder why the use of CRL is most recommended and seems to have the backing of many health institutions. This is because the use of the CRL has been realized to overlook anomalies which distort the use of the LMP for estimation. Papageorghiou *et al.* (2016) recommended that, CRL is much more reliable to use in cases of uncertain or unknown dates, irregular menses, oral contraception, breastfeeding or recent pregnancy which is known to flaw the use of the LMP.

The CRL is most reliable: from week six or seven to the 14th week, CRL can be taken and can produce reliable estimates about the GA (Danielsson, 2017a). It is no surprise that the ISUOG (2013) reports that the CRL and the BPD are the most commonly measured parameters in pregnancy dating between the 11th and 13th + 6 weeks. Ohuma *et al.*, (2013) opine the CRL is most reliable between week 9+0 to 13+6 weeks gestations but not beyond. It can be realized that, this rather has a lower range compared to that of Danielsson, (2017a) but there is an intersection point. Similar to the assertion of Danielsson (2017a), Shan &

Madheswaran, (2010) stated that CRL is measured reliably between week 5 and 14 of gestation. Loughna *et al.* (2009) also suggested CRL records within weeks 6 and 13. According to Goldberg & El-sayed (2017), CRL is the first ultrasound foetal biometric parameter which should be measured in early pregnancy. Other parameters come in at subsequent check-ups. This further highlights the importance of the CRL.

In all cases of such estimation the word ‘early’ is used to depict when ultrasound scan CRL should be taken. It brings to mind that CRL should be the first ultrasound method to rely on during GA and EDD estimations. Shan & Madheswaran (2010) posits that even though CRL may be the most reliable in the early stages, it should be keenly measured as defects in foetal position such as the foetal flexion can trigger variations of up to 7 days. The CRL is also easier to measure compared to the AC because areas of measures are much clearer on the screen due to the presence of bones at the measurement areas. In CRL measurements, the ISUOG (2013) posits that if CRL is over 84 mm (8.4 cm), then the HC parameter should be used since it more precise at that point than even the BPD. Loughna *et al.* (2009) recommends the use of the formula below in using CRL to estimate the GA.

$$GA = 8.052 \times (CRL \times 1.037)^{1/2} + 23.73 \dots\dots\dots(2.4)$$

The INTERGROWTH-21st, (2010) reported an extensive study about CRL and created a dating chart for the Gestational Ages of unborn babies using the CRL (Table 2.1). Due to the level of accuracy achieved with this the INTERGROWTH-21st, (2010) recommend that the use of CRL in early antenatal care for the estimation of GA.

Table 2.1: Dating chart for foetal CRL

Mm	GA(Weeks)	GA(days)	Mm	GA(Weeks)	GA(days)	Mm	GA(Weeks)	GA(days)
10	7	2	40	10	6	70	13	2
11	7	3	41	11	0	71	13	2
12	7	4	42	11	0	72	13	3
13	7	5	43	11	1	73	13	3
14	7	6	44	11	2	74	13	4
15	8	1	45	11	2	75	13	4
16	8	2	46	11	3	76	13	5
17	8	3	47	11	4	77	13	5
18	8	3	48	11	4	78	13	6
19	8	4	49	11	5	79	13	6
20	8	5	50	11	5	80	14	0
21	8	6	51	11	6	81	14	0
22	9	0	52	11	6	82	14	0
23	9	1	53	12	0	83	14	1
24	9	2	54	12	1	84	14	1
25	9	3	55	12	1	85	14	2
26	9	4	56	12	2	86	14	2
27	9	4	57	12	2	87	14	3
28	9	5	58	12	3	88	14	3
29	9	6	59	12	3	89	14	4
30	9	6	60	12	4	90	14	4
31	10	0	61	12	4	91	14	4
32	10	1	62	12	5	92	14	5
33	10	2	63	12	5	93	14	5
34	10	2	64	12	6	94	14	6
35	10	3	65	12	6	95	14	6
36	10	4	66	13	0	96	14	6
37	10	4	67	13	0	97	15	0
38	10	5	68	13	1			
39	10	6	69	13	1			

Source: INTERGROWTH-21st, (2010)

2.7.4 Symphysis Fundal Height estimations

The standard style for measuring the SFH is via tape measurement from the symphysis pubis to the palpable superior portion of the uterus (Shah *et al.*, 2010). The SHS is a reflection of the CRL (Shobeiril & Nazari, 2006). This means that the CRL is measured internally from the crown to the rump, while its corresponding bulge on the outside is measured and termed as the SFH just like the LMP is used in less resourced areas. In the poorly resourced facilities, SHF is the proxy for estimating the GA (White *et al.*, 2011).

The SFH is a simple, non-invasive and inexpensive method (Pay *et al.*, 2015; White *et al.*, 2011). According to Tsung (2011), WHO estimated that up to 75% of the world's population has no access to diagnostic imaging. It is interesting to note that, despite the crudeness of this technique, it is also important in determining low birth weight infants. This is mostly detected in the second trimester (Shobeiril & Nazari, 2006). According to Shobeiril & Nazari (2006), there is a high likelihood that the baby could be underweight if results obtained from SFH measures less than 25 cm in the second trimester. In White *et al's* (2011) study, the SFH measures were not taken until week 34 onwards after the bladder was emptied.

2.8 APPROPRIATE GAS FOR THE FOETAL BIOMETRIC PARAMETERS

The appropriate GAs for assessing foetal biometric parameters is presented in Table 2.2.

Table 2.2: Appropriate GAs for undertaking the foetal biometric parameters

GA range	Foetal biometric parameter
From 8 weeks 6 days to 13 weeks 6 days	CRL
From 14 weeks 0 days to 15 weeks 6 days	BPD, HC, AC, FL
From 16 weeks 0 days to 21 weeks 6 days	BPD, HC, AC, FL
From 22 weeks 0 days to 27 weeks 6 days	BPD, HC, AC, FL
From 28 weeks 0 days and beyond	BPD, HC, AC, FL

Source: Goldberg & El-sayed, (2017).

The GA is taken from the initial estimations of the LMP but as time goes on, the foetal biometrics take over. It can be realized that the CRL is the first foetal biometric parameter which comes to play in the early part of pregnancy until week 14 where the other foetal biometric parameters can be used for predictions (Table 2.2). In extreme cases, there would be a need for re-dating if some levels of discrepancy between the LMP and the foetal biometrics are realized.

2.9 APPROXIMATE FOETAL BIOMETRIC PARAMETERS BY GA

The work of Babuta *et al.* (2013) was done with the view that a combinations of the foetal biometric parameters would provide better estimates than one single parameter. Hence Babuta *et al.* (2013) concentrated on the mean GA arrived from the individual parameters and this proved true. Prior to that study an earlier one known as the Hadlock study had already been done with the same notion. It is interesting to note that Babuta *et al's.* (2013) study is consistent with Hadlock's (Hadlock *et al.*, 1984). The presentations of mean foetal biometric parameters and their corresponding GA by both Babuta *et al* and Hadlock *et al* are shown in Table 2.3.

The findings of the two studies depicts that any normal measurement of the foetal biometric parameters should not significantly deviate from this. Moreover measurements of the foetal biometric parameters in reference to Table 2.3 could aid in predicting the gestational age of a foetus.

Table 2.3 Mean foetal biometric parameters and their corresponding GA

GA (wks) (via LMP)	BPD (mm)		HC (mm)		AC (mm)		FL (mm)	
	Babuta	Hadlock	Babuta	Hadlock	Babuta	Hadlock	Babuta	Hadlock
13	22.50	21	74.50	82	60.50	60	9.50	11
14	25.25	25	91.50	97	73.63	73	12.38	14
15	28.09	29	105.18	111	81.36	86	15.18	17
16	32.36	32	122.82	124	99.91	99	18.73	20
17	36.00	36	129.00	138	106.50	112	21.90	24
18	37.87	39	141.93	151	119.00	125	24.80	27
19	40.73	43	154.18	164	130.82	137	27.55	30
20	44.10	46	163.40	177	143.10	150	30.20	33
21	47.90	50	178.50	189	150.70	162	33.10	35
22	50.19	53	183.63	201	158.13	174	35.13	38
23	55.06	56	202.50	213	174.19	185	38.31	41
24	58.25	59	218.88	224	185.75	197	41.50	44
25	61.38	62	227.13	235	193.88	208	43.63	46
26	63.50	65	235.58	246	206.00	219	45.42	49
27	66.00	68	244.10	256	212.00	230	47.70	51
28	67.86	71	252.86	266	225.29	240	49.86	54
29	70.60	73	262.20	275	222.80	251	52.40	56
30	73.93	76	272.93	284	239.93	261	54.79	58
31	75.71	78	279.36	293	253.64	271	57.50	60
32	77.33	81	290.87	301	266.53	281	60.40	62
33	81.10	83	297.00	304	274.43	291	62.14	64
34	82.08	85	299.50	308	280.92	300	63.08	66
35	84.20	87	310.40	315	288.20	309	65.85	68
36	84.88	89	310.47	328	290.88	318	66.59	70
37	87.07	90	319.50	333	296.50	327	68.14	72
38	85.86	92	322.14	338	305.57	336	69.14	74
39	88.17	93	327.06	342	313.67	344	71.78	75
40	89.75	94	330.38	346	321.13	353	72.00	77

Source: Babuta *et al.* (2013)

CHAPTER THREE

METHODOLOGY

3.1 INTRODUCTION

This Chapter entails the methodology employed in the study. The methodology describes the study design, study variables, study site, sample population, the sample size, sampling techniques, and procedure for data collection, data extraction, validity, data analysis, data management and ethical issues.

3.2 STUDY DESIGN

A cross-sectional study involving 1301 second trimester pregnant women with uncomplicated singleton pregnancies and presenting between 17weeks and 28weeks of gestation was adopted. A prospective design was applied because existing data for the study was not adequate. A cross-sectional design was used because the study was aimed at evaluating the accuracy of SFH in comparison to ultrasound scan for GA assessments at a given period. This design allowed for the collection of data within the given time.

A number of tools and techniques were utilized in order to attain valid responses from respondents. One tool used on the field was the structured questionnaire. In this way both open and close ended questions were asked to allow flexibility in the response but precision in answering questions. Administering questionnaires was complemented with the one-on-one interview technique with the respondents. These techniques allowed for guiding respondents through the questionnaire and for asking further questions which become necessary in the course of the interview. The observation technique was used on the field as well to record and validate responses from the respondents. This meant that, responses were compared with printouts from ultrasound scan machines to validate results.

Two sources of data (primary and secondary) were used for the study. The primary data refers to all data gathered from the field and includes the responses of interviewees and data captured through the use of the observation technique. This was vital to the study as it enabled achievement of the study objectives. The use of secondary data was also equally important in this research. In particular the secondary data aided the structuring or conceptualization of the whole research and provided adequate information for the calculation of the sample size. Secondary data was also used to affirm the results of the study. This was attained by comparing the results with other research works. Secondary data was sort from journal articles, reports from institutions, books and other documented sources.

3.2.1 Study Variables

In order to adequately achieve the objectives of the study, variables were needed. The variables acted as the facets of the objectives of the study which made the objectives easier to assess in the long run. The study variables to assess the objectives are shown in table 3.1.

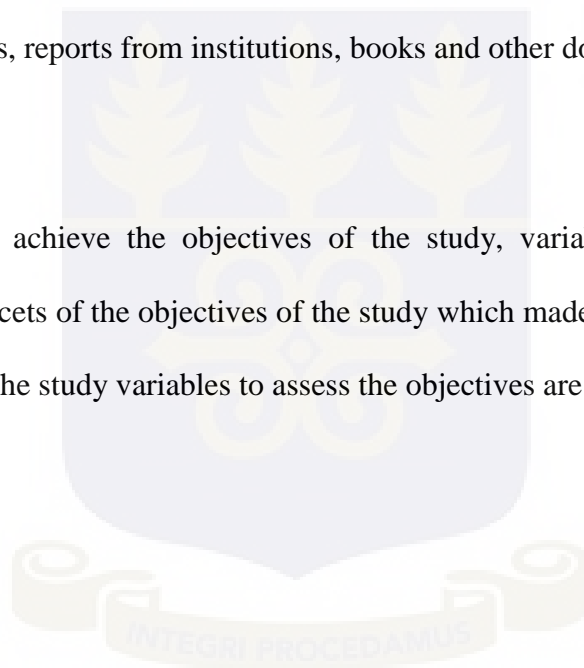


Table 3.1 Study Variables

Objectives	Variables	Definition & Purpose	Unit of Inquiry
To assess the US foetal biometry estimation of GA in the second trimester with the first trimester ultrasound dating by CRL.	BPD GA	The GA is by BPD. This variable aided in assessing the difference between CRL GA and BPD GA and subsequently in calculating the GA by the combined US parameters.	Pregnant women & US scan report
	FL GA	The GA is by FL. This variable aided in assessing the difference between CRL GA and FL GA and subsequently in calculating the GA by the combined US parameters.	Pregnant women & US scan report
	HC GA	The GA is by HC. This variable aided in assessing the difference between CRL GA and HC GA and subsequently in calculating the GA by the combined US parameters.	Pregnant women & US scan report
	AC GA	The GA is by AC. This variable aided in assessing the difference between CRL GA and AC GA and subsequently in calculating the GA by the combined US parameters.	Pregnant women & US scan report
	USCBP GA	This is GA arrived at after combining the BPD, FL, HC, and AC. This variable aided the assessment of the difference between USCBP GA and the GA by CRL	Pregnant women & US scan report
	EDD by CRL	The EDD by CRL is the expected date of delivery by the CRL scan. This variable was the standard of assessment of the accuracy of the ultrasound fetal biometry parameters in terms of EDD.	Pregnant women & US scan report
	GA by CRL	The GA by CRL is the age of the unborn baby by CRL scans. This variable was used as the standard for assessing the accuracy of the GA of the other ultrasound fetal biometry parameters.	Pregnant women & US scan report
To assess the SFH estimation of GA age in the second trimester with the first trimester ultrasound dating by CRL.	GA by SFH	The GA is via SFH. This variable aided in assessing the difference between CRL GA and SFH GA.	Pregnant women & US scan report
	EDD by SFH	The EDD by SFH is the expected date of delivery by the SFH	Pregnant women & US scan report & SFH

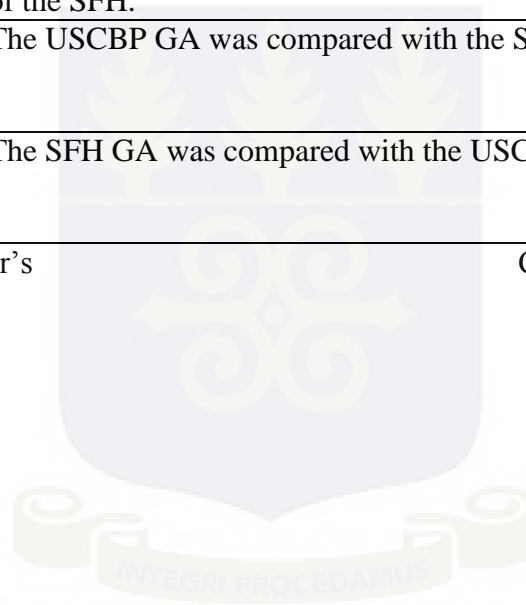
		calculation. This variable aided in assessing the difference between EDD by CRL and EDD by SFH.	Report
	EDD by CRL	The EDD by CRL is the expected date of delivery by the CRL scan. This variable was the standard of assessment of the accuracy of the SFH in terms of EDD.	Pregnant women & US scan report & SFH Report
	GA by CRL	The GA by CRL is the age of the unborn baby by CRL scans. This variable was used as the standard for assessing the accuracy of the GA of the SFH.	Pregnant women & US scan report
To compare the accuracy of SFH with ultrasound foetal biometrics in the estimation of GA in the second trimester.	USCBP GA	The USCBP GA was compared with the SFH GA	Pregnant women & US scan report & SFH report
	SFH GA	The SFH GA was compared with the USCBP Gestational Age	Pregnant women & US scan report & SFH report

Source:

Author's

Construct,

2017



3.3 STUDY SITE

The Suntreso Government Hospital was purposively chosen for the study. This is because it is one of the most patronized hospitals in the Ashanti Region for purpose of antenatal care. The Obstetrics and Gynaecology Department is furnished with adequate equipment to undertake US and SFH prediction of gestational age which are vital to the study. Moreover, the staff at the study site could adequately utilize the needed equipment to provide results from US and SFH methods.

3.4 STUDY POPULATION

The population for this study consisted of pregnant women aged 18–49 years attending an antenatal care (ANC) at Suntreso Government Hospital in the Kumasi Metropolis, from March to May 2017.

3.5 SAMPLE SIZE

The sample for the study was obtained from the population of pregnant women attending antenatal care (ANC) in the hospital. The ANC currently holds close to 180 pregnant women daily. Available data from the Obstetrics and Gynecology Department at the study hospital revealed a number of expected 3453 attendants. Based on this, the sample size of the study was calculated with the formula by Yamane (1967) as cited in Kasiulevičius, Šapoka, & Filipavičiūtė (2006) 225 using a 95% confidence level and an error margin of 5% as follows:

$$n = \frac{N}{1 + N(\infty^2)} = \frac{3453}{1 + 3453(0.05^2)} = 358$$

where N = sample frame (3453) n = sample size, and ∞ = margin error (0.05).

Despite the calculated sample size being 360, the actual sample obtained from the field was 313 pregnant women. This was because the stipulated time frame for the study was over.

Moreover due to the inclusion criteria, many potential sample units were not eligible to take the survey and that slowed down the data collection process. Therefore 87.4 per cent of the proposed sample size was taken from the field.

3.6 INCLUSION CRITERIA AND EXCLUSION CRITERIA

3.6.1 Inclusion Criteria

All pregnant women aged 18–49 years were considered eligible for inclusion provided all the following conditions were met.

1. Pregnant women with no a histories of pregnancy related complications in their second trimester attending antenatal care services at Suntreso Government Hospital.
2. Pregnant women presenting with singleton pregnancy in their second trimester attending antenatal care services at Suntreso Government Hospital.
3. Pregnant women with Suntreso Government Hospital reports on early first trimester ultrasound scan by crown-rump length.
4. Pregnant women attending antenatal care services at Suntreso Government Hospital who consented to participate in the study.

3.6.2 Exclusion Criteria

1. Non-pregnant women attending US at Suntreso Government Hospital.
2. Pregnant women below 18 weeks of gestation, as well as those beyond 27 weeks of gestation.

3.7 DATA COLLECTION PROCEDURE

The aims and purpose of the study was explained to pregnant women within their 2nd trimester attending ANC at the Suntreso Government Hospital. Their consent and voluntary participation was solicited for the study. Eligible participants were identified and recruited by

trained fieldworkers and local resource persons. Convenient sampling technique was used to select participants. Sampling units for the study were thoroughly assessed to make sure samples fitted into the inclusion criteria.

Data was collected using the paper questionnaires in conjunction with the technique of one - on -one interview with respondents. A qualified sonographer performed the second trimester US of all the eligible pregnant women. The scan process was explained to the participant before commencement. With the help of chaperon, participants were assisted onto the couch for partial lower abdominal exposures. A coupling gel was applied and scans were performed in sagittal, transverse and oblique plans. The first ten scans were reviewed by the resident obstetrician to check for consistency with the protocol. To prevent bias, the sonographer was blinded from the first trimester US findings.

The US was performed by means of a real-time on 'GE Voluson I' ultrasound machine with a low-frequency 2-5 MHz using curvilinear transducer. The biometric parameters such as the BPD, HC, AC and FL were assessed using reliable landmarks and planes and GA was estimated using the Hadlock method (Hadlock *et al*, 1984).

After the ultrasound scan, participants emptied their bladder as maternal bladder volume is known to have an effect on fundal height measurement. This is because the pre-void fundal height is significantly larger than at post-void. Participants then lay down in supine position; each fundus of the uterus was outlined for gentle palpation. A certified midwife used a non-elastic tape (graduated in centimeters) facing the maternal abdomen to make the measurements in the midline from the fundus to the upper part of the pubic symphysis. The SFH measurements (to the nearest cm) were then recorded for each subject. The average of two measurements was determined as the gestational age in weeks. A follow up interview

was conducted using structured questionnaire to collect information on socio-demographic and reproductive variables including duration of their pregnancies as illustrated in figure 3.1.

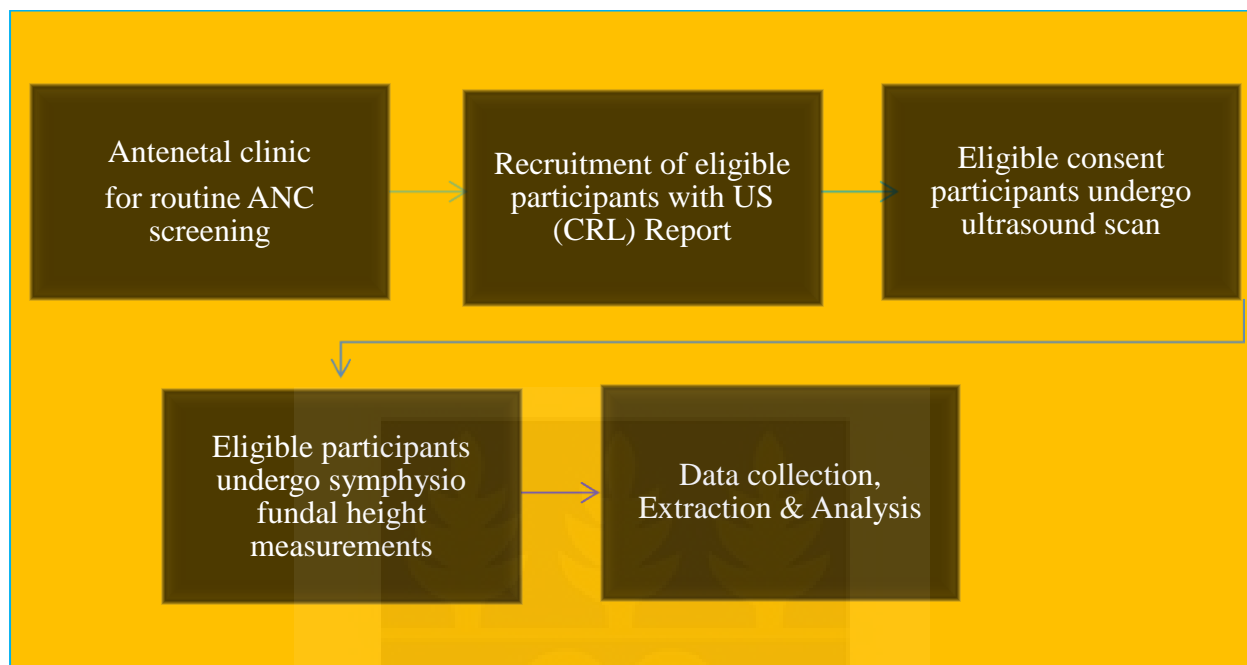


Figure 3.1: A flow chart showing recruitment and sampling procedures

3.7.1 Data Extraction

The data collected was then processed alongside the data collection exercise into database. Captured data was checked for completeness, correctness and inconsistencies and entered twice into an MS Excel.

3.7.2 Validity

Some of the errors could include questions that did not produce intended measurements. For this reason a pre-test was conducted in order to test the questionnaire, and rectify errors by changing the sequence of questions and also wording the questions in order to allow for respondents to understand the questions as intended.

The captured CRLs from participants ANC books were of no difference to the INTERGROWTH-21st (2010) report on CRL in terms of their corresponding GAs (Table

2.1). This made the captured CRLs from the field became the standard for comparison during data analysis.

Moreover, the observation technique was used to validate some of the responses captured on the field. Observation technique was used to triangulate the data thereby increasing the quality of data collected on the field. Lastly, in order to tackle errors that may have been introduced at the data entry section, the completed questionnaires were numbered and entered in a sequential order corresponding to the row numbers in the SPSS. This allowed for cross check of entered data which was done by the researcher. This was to ensure that, data entered into the SPSS was a true reflection of what was captured in the questionnaire.

3.8 DATA ANALYSIS

The Statistical Package for Social Sciences software and Microsoft Excel were jointly used to analyse the data. First of all the responses were entered into the SPSS. This allowed the generation of the needed statistics for communicating the results of the study. The SPSS also allowed for cross tabulation of data. This increased the depth of the analysis. Microsoft Excel was used to perform simple arithmetic calculations and also the generation of charts to communicate the results of the study.

Data entered was double checked for consistency. The relevant data was analyzed using the SPSS version 20 and Microsoft Excel 2013. Descriptive statistics was generated to reveal the general nature of the data collected. The gestational mean ages was use to assess the level of difference between the figures obtained by the various techniques of assessing the GA and subsequently the EDD of the various techniques. The CRL was by the standard for determining the level of accuracy of these various methods.

3.9 DATA MANAGEMENT

All information received from participants was stored on computers encrypted in a code which was to be made accessible only to the researcher and the supervisors.

3.8 ETHICAL ISSUES

Approval was received from the Ethical and Protocol Review Committee of the School of Allied Health Sciences, University of Ghana. Permission was sought from the Health Directorates and the Medical Director of the Sunreso Government Hospital. Consent was sought from the individual participants and their confidentiality and anonymity was assured. A comfortable and secured place was provided for the participants' privacy during US scanning, SFH measurements, and data collection procedures. Data collected was given code numbers and no name was linked to the individual participants in any reports from this study. The participants were informed that their participation was voluntary and that they were not under any obligation to participate in the study; and that they could choose to withdraw from the research at any time and that could not affect their Antenatal Care, treatment in the hospital or any health care institution.

CHAPTER FOUR

RESULTS AND ANALYSIS

4.1 INTRODUCTION

This Chapter presents the results and analyses of the data collected. The chapter was divided into sub-headings to throw more light on the objectives of the study. Analytical tools used were frequency with percentages, descriptive statistics (mean and standard deviation) and independence t-test.

4.2 DEMOGRAPHIC CHARACTERISTICS OF THE PARTICIPANTS

This section analysed the demographic characteristics of the study participants. The emphasis was made on response rate, age, height, weight, educational level, marital status and main occupation. The distribution of participants is presented in Table 4.1

Table 4.1: Distribution of participating and non-participating pregnant women

Category of participants	Number of participants	Percentage, %
Included participants	313	24
Excluded participants	988	76
Total	1301	100

Source: Field Study, 2017

A total of 1301 pregnant women within their second trimester with singleton uncomplicated pregnancies were initially interviewed purposefully for this study. However, in respect of the condition of providing report on first trimester US of CRL which was listed in the inclusion criteria, only 313 pregnant women qualified to participate in the study.

Figure 4.1 shows that participants with SHS level of education formed the majority (38%). There were 32% of the participants with JHS level of education and about 15% of the participants had tertiary education. The study population was dominated by SHS and JHS.

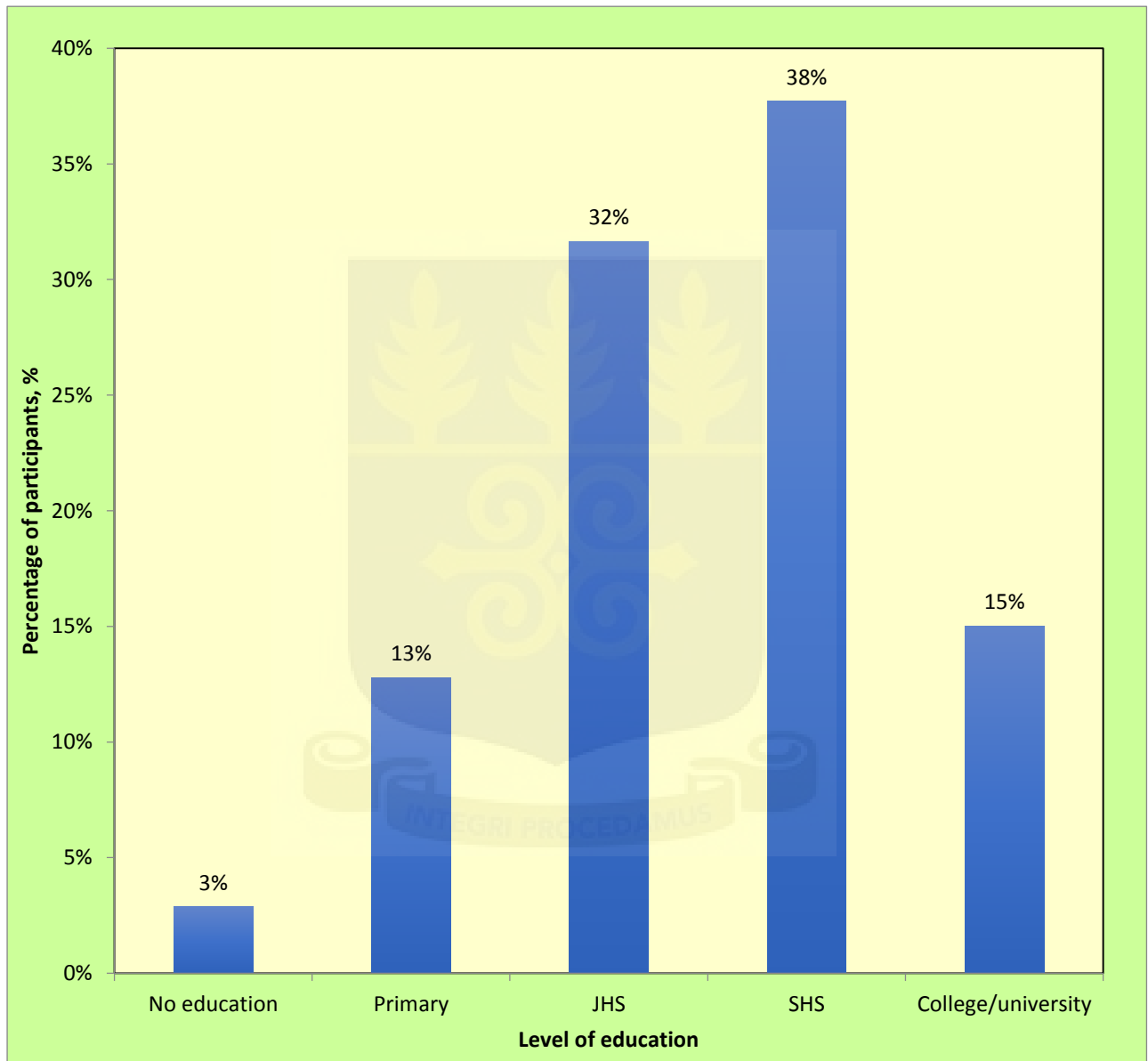


Figure 4.1: Educational Level **Source: Field Study, 2017**

The age, height, and the weight measurement of participants is presented in Table 4.2

Table 4.2: Age, height and weight statistics of the study participants

Demographic	Number	Mean \pm SD	Minimum	Maximum
Age	313	28.33 \pm 5.24	18	43
Height	313	158.22 \pm 7.9	140	175
Weight	313	67.62 \pm 13.29	45	164

Source: Field Study, 2017

The average age of the participants was averagely 28 \pm 5.24years. The minimum and maximum ages were respectively 18 years and 43 years. The study recorded average height of 158.22cm \pm 7.9cm, minimum height was 140cm and maximum height was 175cm. The average weight for the study population was 67.62kg \pm 13.29 kg. The extreme weight recorded were respectively 45kg and 164kg for minimum and maximum.

The marital status of participants is shown in Figure 4.2. Most participants (62%) were married while 9% were singles and 2% cohabited.

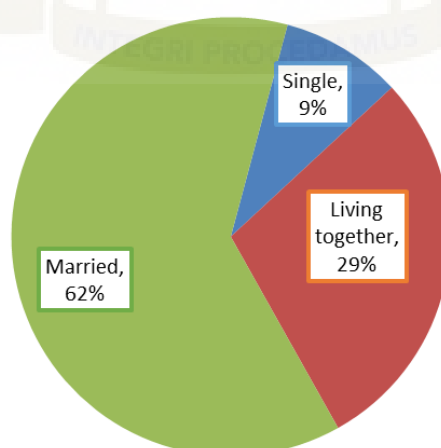


Figure 4.2: Marital Status Source: Field data, 2017

The occupations of the participants are presented in figure 4.3

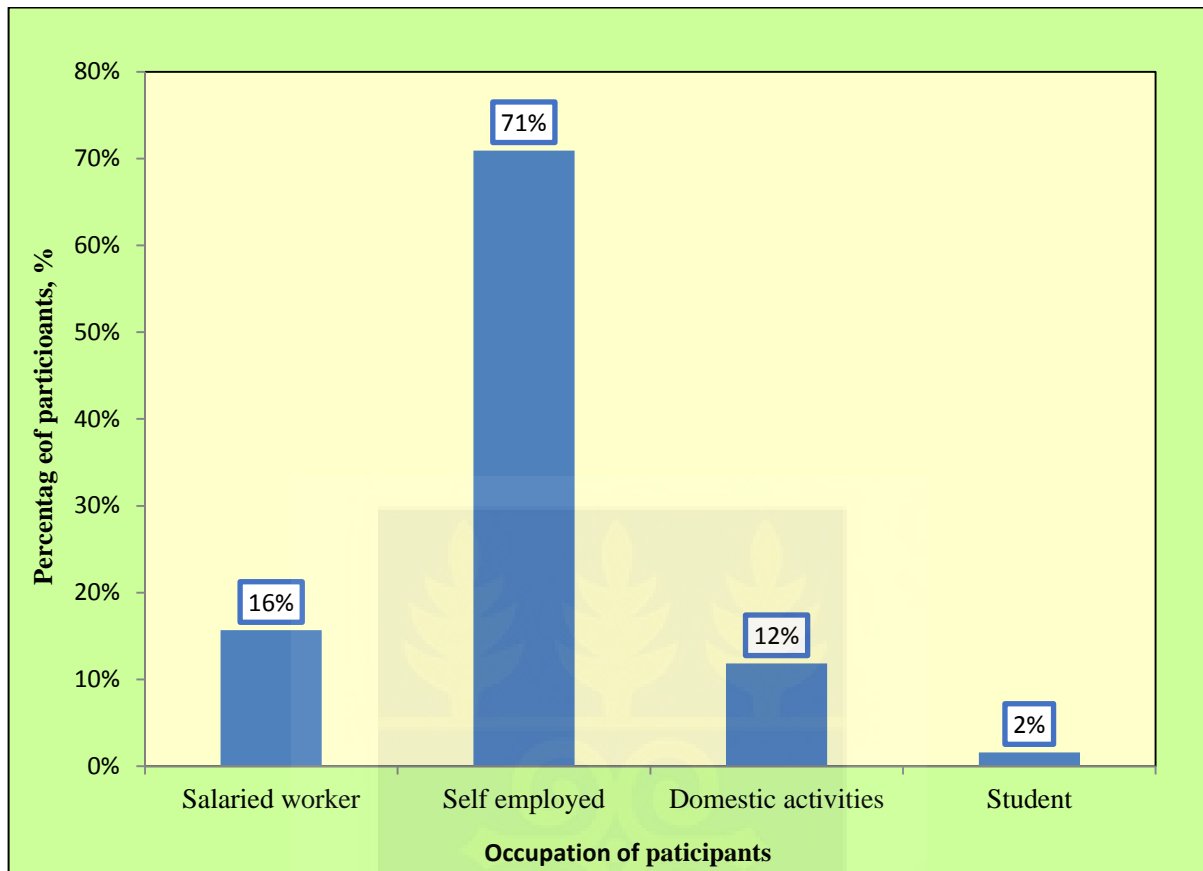


Figure 4.3: Occupation of participants Source: Field Study, 2017

Most of the participants were mainly self-employed (71%). There were 16% salaried workers. 12% domestic activity workers. Only 2% were students.

As shown in Table 4.3, it was observed from Table 4.3 that, the demographic characteristics (age, height, weight, educational level, occupation and marital status) had no significant association with any of the measuring instruments used for the estimation of GA in both 1st trimester and second trimester as indicated from the correlational analysis.

Table 4.3: Correlations

	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Age	1	.089	.136*	-.103	-.058	-.055	-.065	-.058	-.054	-.052	-.040	-.011	.010
2. Height	.089	1	.247**	.050	.052	.062	.055	.035	.075	.059	.089	.007	-.041
3. Weight	.136*	.247**	1	-.018	.006	.022	.025	.014	.000	.026	.067	.015	-.126*
4. Educational Level	-.103	.050	-.018	1	-.066	-.044	-.041	-.047	-.036	-.048	-.073	.014	.037
5. GA by CRL	-.058	.052	.006	-.066	1	.968**	.973**	.949**	.859**	.982**	.864**	.064	.199**
6. GA by BPD	-.055	.062	.022	-.044	.968**	1	.980**	.933**	.844**	.980**	.868**	-.028	.163**
7. GA by HC	-.065	.055	.025	-.041	.973**	.980**	1	.945**	.852**	.987**	.877**	-.023	.155**
8. GA by FL	-.058	.035	.014	-.047	.949**	.933**	.945**	1	.835**	.971**	.853**	-.051	.164**
9. GA by AC	-.054	.075	.000	-.036	.859**	.844**	.852**	.835**	1	.873**	.761**	-.066	.148**
10. GA by 2nd US	-.052	.059	.026	-.048	.982**	.980**	.987**	.971**	.873**	1	.880**	-.036	.165**
11. SFH Average	-.040	.089	.067	-.073	.864**	.868**	.877**	.853**	.761**	.880**	1	.009	-.210**
12. EDD 2nd US	-.011	.007	.015	.014	.064	-.028	-.023	-.051	-.066	-.036	.009	1	.196**
13. EDD by SHF	.010	-.041	-.126*	.037	.199**	.163**	.155**	.164**	.148**	.165**	-.210**	.196**	1

*

Correlation is significant at the 0.05 level (2-tailed). & **. Correlation is significant at the 0.01 level (2-tailed).

4.3 ASSESSING ULTRASOUND FOETAL BIOMETRY ESTIMATION OF GESTATIONAL AGE

An assessment of the ultrasound foetal biometric estimation of GA in the second trimester with the US of CRL estimations in the first trimester, was done separately. This was done to know the most accurate ultrasound parameter. Moreover, the USCBP was also assessed to know how best the USCBP predicted the GA and the EDD.

For the best outcome of the various ultrasound parameters, the timing of the various scans were made at the appropriate times within the ranges as suggested by Goldberg & El-sayed, (2017). Moreover since the time for the CRL scan was different from the other foetal biometric parameters assessing the GA needed some adjusting. The time difference in the GA assessment of the CRL and the other biometric parameters were commensurate by adding the difference in days apart to the CRL estimation of GA. This showed the CRL estimations of the GA at the time when the other ultrasound biometric parameters were measured and allowed for direct comparison.

Using the CRL as the benchmark for accuracy of GA, the other ultrasound foetal biometrics parameters were assessed. This was done in order to know how many days apart these methods could go in assessing the GA of an unborn baby as shown in Table 4.4

Table 4.4: Assessing ultrasound foetal biometry parameters estimation of GA with CRL

Difference in GA (in weeks)	BPD		HC		AC		FL		US	
	No.	%	No.	%	No.	%	No.	%	No.	%
-3	1	0.32	1	0.32	2	0.64	2	0.64	0	0.00
-2	14	4.47	9	2.88	12	3.83	30	9.58	6	1.92
-1	125	39.94	86	27.48	114	36.42	142	45.37	62	19.81
0	35	11.18	36	11.5	35	11.18	22	7.03	175	55.90
+1	122	38.98	167	53.35	128	40.89	94	30.03	63	20.13
+2	13	4.15	12	3.83	18	5.75	21	6.71	7	2.24
+3	3	0.96	2	0.64	4	1.28	2	0.64	0	0.00
Total	313	100.00	313	100.00	313	99.99	313	100.00	313	100.00

Source: Field Study, 2017

Table 4.4 suggests that the USCBP are most likely to give estimates which are closer or even same as that of the CRL. Based on the results from Table 4.4, the number of weeks' difference from CRL estimates of GA in each method was presented in percentages as shown in Table 4.5.

Table 4.5: Discrepancies between CRL and US biometric parameters GA estimates

Discrepancy from CRL estimations	BPD (%)	HC (%)	FL (%)	AC (%)	USCBP (%)
In 1 week	90.1	92.3	82.4	88.5	95.8
Between 1 week to 2 weeks	8.6	7.0	16.3	9.6	4.2
Between 2 weeks to 3 weeks	1.3	0.6	1.3	1.9	0.0

Source: Field Survey, 2017

Table 4.5 suggests the percentage of estimates from each technique which falls within one week and more of CRL estimates of GA. It could be observed that the maximum weeks USCBP estimates of GA could be away from CRL was 2 weeks.

Table 4.6 shows level of significance of the US biometric parameters.

Table 4.6: Assessment of US Biometric Parameters in GA estimations by CRL

Comparison	Diff-Mean	Std. dev.	95% CI	<i>p-value</i>
CRL by BPD	0.14	1.43	-2.67-2.95	0.924
CRL by HC	0.73	1.45	-2.12-3.59	0.613
CRL by AC	0.28	1.40	-2.47-3.03	0.841
CRL by FL	-0.92	1.43	-3.72-1.89	0.521
CRL by USCBP	0.05	1.41	-2.72-2.81	0.973

Source: Field Study, 2017.

Here, the ultrasound biometric parameters were assessed statistically to find out how different they are from the CRL. Statistically, all the US biometric parameters did not vary much from the CRL ($p > 0.05$). This suggests that the US parameters in its estimate of GA display no significant difference from that of the CRL.

4.4 ASSESSMENT OF SFH BY CRL IN GA ESTIMATIONS

From Table 4.7, it may be observed that the SFH has more estimation away from the exact date of GA. This tells how scattered away GA estimates of SFH are from the GA estimates of CRL. Only 8 participants had their GA estimates of SFH exactly as the GA estimates of CRL, and this constituted only 2.56%.

Table 4.7: Assessment of SFH with CRL GA Estimates

Difference in GA (in weeks)	Symphysis Fundal Height	
	No.	%
-4	1	0.32
-3	9	2.88
-2	17	5.43
-1	36	11.5
0	8	2.56
+1	85	27.16
+2	99	31.63
+3	52	16.60
+4	6	1.92
Total	313	100.00

Source: Field Study, 2017.

It may be seen from Table 4.7 that many of the estimates from the SFH lie one week outside the CRL compared to the other methods. This implies that the use of the SFH provides a vague estimate of GA. Moreover, it may be realized from Table 4.8 that over 50% of GA estimates using the SFH are more than a week away from the CRL estimates.

Table 4.8: Level of discrepancy between GA estimates of SFH and CRL

Discrepancy from CRL Estimations	No.	SFH (%)
In a week	129	41.2
Between 1 week to 2 weeks	116	37.1
Between 2 weeks to 3 weeks	61	19.5
Between 3 weeks to 4 weeks	7	2.2
Total	313	100

Source: Field Study, 2017

From Table 4.9 the significance value in GA estimation is 0.000 ($p=0.000 < 0.05$) and this suggests that there is a significant difference between the two in terms of GA estimation.

Table 4.9 Significance level between SFH and CRL

Comparison	Diff-Mean	Std. dev.	95% CI	<i>p</i> -value
CRL by SFH	6.25	1.41	3.47-9.02	0.000

Source: Field Study, 2017.

4.5 COMPARISON BETWEEN GA ESTIMATES OF SFH AND USCBP

Statistically, the significance level between GA estimates of SFH and USCBP was assessed to determine the level of difference between them. The result in Table 4.10 shows the significance difference between the two techniques ($p=0.001$).

Table 4.10: Significant level between SFH and USCBP

Comparison	Diff-Mean	Std. dev.	95% CI	<i>p</i> -value
SFH with USCBP	6.20	0.49	5.23-7.16	0.001

Source: Field Study, 2017

Moreover, the EDD variation between USCBP and SFH were assessed to determine any statistical difference. (Table 4.11)

Table 4.11 EDD variation of USCBP and SFH with CRL test value=0

Comparison	Diff-Mean	Std. dev.	Sig.(2tailed)
EDD by USCBP	-1.77	3.819	0.000
EDD by SFH	3.80	9.231	0.000

Source: Field Study, 2017

The result from Table 4.11 indicated that there were significant differences in the second trimester EDD estimation and the estimation of EED by CRL in the first trimester. The EDD by USCBP was underestimated by mean difference of 1.77 day, approximately 2 days than EDD estimation by CRL in the first trimester. On the other hand EDD by SFH was overestimated by mean difference of 3.8 days, approximately 4 days than EDD estimation by CRL in the first trimester. The significance difference for the two methods in comparison with the CRL was the same, ($p\text{-value}=0.000<0.05$).



CHAPTER FIVE

DISCUSSION, CONCLUSION AND RECOMMENDATIONS

5.1 INTRODUCTION

This chapter, a discussion of major findings of this study is presented. A comparison with literature and findings of other studies, as well as the clinical relevance of these findings are made. The conclusions, recommendations and some of the limitations encountered in the research are as well presented.

5.2 RESPONSE RATE OF THE POPULATION

The response rate was 24% giving a final sample size of 313 which was not as large as that used in other works (Jehan *et al.*, 2010). This was however similar to that used by Savitz *et al.*, (2002) and larger than that used by Okonofua *et al.*, (1986). The sample size was limited by the fact that many of the pregnant women did not have US of CRL reports which were considered in this work as the reference for computing the GA of the foetuses.

5.3 DEMOGRAPHIC CHARACTERISTICS OF THE PARTICIPANTS

From Table 4.3, it was statistically proven that all the demographic factors did not influence the results of the study. This is to say that the demographic category of a sample has no relation to the results from the SFH, CRL and other US biometric parameters.

5.4 ASSESSING ULTRASOUND FOETAL BIOMETRY ESTIMATION OF GESTATIONAL AGE

The first objective of the study sought to assess the ultrasound foetal biometric estimation of GA in the second trimester with the ultrasound CRL estimations in the first trimester. This was done by assessing the ultrasound biometric parameters estimation of the GA individually

in order to know the most accurate ultrasound parameter. Moreover, the ultrasound scan of combined biometric parameters in assessing GA was also assessed to know how best the combined use of the parameters predicts the GA and the EDD.

It is imperative to note this current study is similar to the of Babuta *et al.* (2013) who used LMP to compare the accuracy of individual biometric parameters as well as their combined effect with the LMP. However, in this current study, due to the inability of the population to provide accurate LMPs, CRL which is accepted as the standard in pregnancy dating (Karl *et al.*, 2015; Kalish & Chervenak, 2005; Taipale & Hiilesmaa, 2001) was adopted in place of the LMP as the basis of comparison in GA estimates. The results of the study are similar to that obtained by Babuta *et al.* (2013).

5.4.1 Accuracy of BPD in Assessing Gestational Age

The estimation of GA using the BPD in comparison to the CRL showed some level of discrepancy. There were 11.2% cases where BPD and CRL measured GA were the same. The range of discrepancy observed was 3 weeks 2 days apart. In most cases (90.1%) BPD estimations were within 1 week range of the CRL estimations with only 9.9 % of estimations above 1 week (Table 4.5). This is consistent with literature. According to Babuta *et al.*, (2013) 91.51% of GA estimates using BPD were within one week of the standard used. This consistency is surprising as the two studies employed different methods of measurements of assessing the accuracy of the parameters.

Graphical display of these findings shows how BPD estimations of GA for various pregnant women were around the CRL GA estimations (Figure 4.4). figures closer to the zero line depicts BPD estimates closer to the CRL estimates whiles figures farther from the zero line depicts BPD estimates to be far away from the standard CRL estimates.

From the inferential results, there was no statistically significant difference between BPD measured GA in the second trimester and CRL ultrasound dating in the first trimester. The significance value was $0.924 > 0.05$ showing no significant difference. The mean difference was 0.14 day which is approximately the same day as that of the CRL (Table 4.6). This suggested that, BPD estimation of GA in the second trimester and the CRL in the first trimester was statistically the same.

5.4.2 Accuracy of Head Circumference in Assessing Gestational Age

Estimation of GA using the HC in comparison to standard CRL measurement of GA also displayed some level of discrepancy. In some (11.5%) instances HC estimates of GA were no different from the CRL estimates. The range of discrepancy observed was 2 weeks 2 days, which is a shorter range than the BPD to CRL estimations of GA. This depicts that, the farthest days HC estimations of GA could veer off that of CRL's was 16 days. The HC recorded 92.3% of GA estimates within one week of CRL estimates however, the work of Babuta *et al.*, (2013), recorded 81.21% of estimates within one week. This inconsistency may be attributed to the fact that the latter work used the LMP as the standard of accuracy.

A graphical display of the level of discrepancy of the HC estimation of GA and that of the CRL presents a similar chart as that of the BPD (Figure 4.5). The notable display difference is that the highest figure of the HC is lower than that of the BPD and this highlights the lower range in discrepancy for that of the HC.

From the inferential results, the GA by HC in the second trimester and CRL estimates of GA was statistically insignificant. The $p\text{-value} = 0.613 > 0.05$ and the mean difference was 0.73 day approximately 1 day (Table 4.6). This meant that the HC estimation of GA in the second trimester was statistically the same as the estimation of GA by using the CRL at first trimester.

5.4.3 Accuracy of Femur Length in Assessing Gestational Age

The results of FL estimates of the GA were compared to that of the CRL. Again, there were discrepancies just as expected. The range of the difference in estimates ranged from 1 to 19 days (See figure 4.6). This is highest range (19 days) in difference recorded so far. In 7.0% of estimates, the FL predicted the same GA as the CRL. The FL estimates has a lesser percentage (82.4%) of cases within 1 week range of the CRL GA estimates which is lesser than the HC and BPD estimates (Table 4.5), this is inconsistent with what was discovered in literature. Babuta *et al.*, (2013) realized that 94.55% of FL GA estimates were within one week of the standard used. This inconsistency can be attributed to the latter work using the LMP as the standard of measurement.

There were more cases which estimates exceed 1 week in the FL (17.6%) estimation of GA than the BPD (9.9%) and HC (7.7%) estimates (Figure 4.6, Table 4.5). A graphical display of the level of discrepancy of the FL estimation of GA and that of the CRL was presented (Figure 4.5).

From the inferential results, the estimation of GA by FL was not statistically different from that of the CRL in the first trimester. The significant value was $0.521 > 0.05$. The mean difference was 0.92 approximately 1 day different from the CRL in the 1st trimester (Table 4.6). This suggested FL in the 2nd trimester estimated GA statistically the same as the CRL at first trimester.

5.4.4 Accuracy of AC in Assessing Gestational Age

The AC which is also an ultrasound biometric parameter was assessed against the CRL in the estimation of the GA. Estimations using these two methods displayed some level of differences. The range of difference between AC estimates of GA and that of CRL 2 weeks 5

days which is the widest range recorded so far. This suggests that AC estimates in the worst case scenario would be approximately 19 days difference from estimates of CRL (figure 4.7). It is no surprise that AC estimates can go that wide. This observation is consistent with literature where it has been reported that GA measurements can be challenging due to lack of bones in the area (Falatah *et al.*, 2014).

AC estimation of GA was less likely to be within 1 week of CRL estimates as compared to BPD and HC estimates. However, there were more AC estimate cases within 1 week range of CRL estimates than FL. This phenomenon was also realized in the work of Babuta *et al.*, (2013). FL estimates of GA recorded 91.51% of cases within 1 week of the standard used.

From the inferential results, the AC estimation of GA was not statistically different from that of CRL in the first trimester. The *p-value* $0.841 > 0.05$ and mean difference was 0.28 (Table 4.6). This result indicated that AC estimated GA in the second trimester is the same as the CRL estimation in the first trimester.

5.4.5 Accuracy of USCBP in Assessing Gestational Age

After individual assessment of the ultrasound foetal biometry parameters individually against the standard CRL estimates, the output of the USCBP was also assessed against the GA estimates of CRL. The field data proved that the combination of the biometric parameters produced the best results in comparison to the CRL estimates and this affirms the research of Babuta *et al.* (2013) and Military Obstetrics & Gynaecology (2017). The combination of the US biometric parameters had more (95.8 %) cases of pregnant women within a week range of CRL estimates than any individual parameter (Table 4.5). This is consistent with literature as Babuta *et al.*, (2013) recorded 96.96% of the GA estimates with the combined parameters within a week.

Moreover, the USCBP revealed that fewer cases produced results more than 1 week (4.2 % of cases) from CRL estimates compared to any other single parameter. The observed range of the discrepancy was from 1 to 2 weeks, lower than any other single parameter. As those wider ranges seem to be a rare case for all the parameters, the same applies to the results of the combination of the parameters in estimating the GA. This suggests that, at worst, the combination of the US parameters in predicting the GA would be 2 weeks difference from GA estimates of CRL (Babuta *et al.*, 2013). In addition, the USCBP estimates of GA produced more cases where CRL estimates of GA were exactly equal to that of the combined results. As much as 55.9 % produced exactly the same GA estimates as the CRL (Table 4.4).

From the inferential results, the GA estimation via USCBP in the second trimester, by CRL in the first trimester was statistically the same. From the result, the *p-value* was $0.973 > 0.05$ and the mean difference was 0.05 approximately the same day as the CRL (Table 5.1).

This suggested that CRL and USCBP estimation of GA were the same.

The table below summarized both descriptive and inferential statistics for objective one.

Table 5.1 Summary of Findings for Objective One

US biometric parameters	Range of difference from CRL GA (Days)	Mean difference in GA from CRL (days)	Within one week of CRL GA (%)	Exact estimation as the CRL GA (%)	<i>p-value</i> in comparison to CRL GA
BPD	17	0.14(0)	90.1	11.2	0.924
HC	16	0.73(1)	92.3	11.5	0.613
FL	19	0.92(1)	82.4	7.0	0.521
AC	19	0.28(0)	88.5	10.5	0.841
US combined	14	0.05(0)	95.8	55.8	0.973

Source: Researchers Field Survey, 2017.

5.5 ASSESSING SFH ESTIMATION OF GESTATION AGE

The SFH, approach to estimating the GA was also assessed against figures recorded from the CRL scans. The assessment showed that the range of difference between the SFH and CRL estimates is from 1 to 26 days (3 weeks 5 days). This suggests that in the worst case scenario, SFH estimation of GA could be at most 26 days apart from CRL estimates (figure 4.9). Subsequently, the fraction of estimates that were exactly equal to CRL estimates of GA were only 2.5% of cases.

It can be inferred from Figure 4.9 that, the estimates are scattered between zero and 21 days range field and then sparse from 21 onwards. From the inferential results (Table 4.9), there was a statistically significant difference between GA by SFH taken in the second trimester and first trimester ultrasound dating by CRL. The significance value was $0.000 < 0.05$. This result showed significant difference GA estimation between SFH in the second trimester and the CRL in the first trimester. The mean difference was 6.25, approximately 6days.

5.6 COMPARING THE ACCURACY OF SFH AND USCBP IN ESTIMATING GA

After the assessment of the SFH and USCBP, the result from Table 4.4 and Table 4.7 suggest that the use of the USCBP was better than the SFH in the assessment of GA. In instances where both measurements may give absurd estimates, it is much more likely that the SFH estimates would be worse off. Moreover, in terms of cases where estimates were exactly the same as that of the CRL, the USCBP produced better results than the SFH, which had only 2.56 % exactly matching results from the CRL estimation of GA. On the other hand, the USCBP produced results where as much as 55.9% of GA estimates matched the CRL results.

Subsequently, the USCBP realized as much as 95.8 % of estimates to be at most 1 week within CRL estimates of GA. However SFH estimates produced results with 41.2 per cent of GA estimates within 1 week of CRL estimates (Table 4.5 and 4.8). From the inferential results, the significance level between SFH and USCBP estimates of GA was assessed to determine the level of difference between the two. The result in Table 4.10 showed the significance value of $0.001 < 0.05$. This suggest that, the use of USCBP differ significantly from SFH in assessing GA

5.6 CONCLUSION

The main aim of the study was to evaluate the accuracy of SFH in comparison to ultrasound scan for the assessment of GA.

From the result of the study, there is a statistically significant difference between SFH measurement and ultrasound scan in the estimation of GA. This goes further to suggest that second trimester ultrasound scans are reliable in assessing GA in cases where CRL scan reports are not available.

However, in order to detect early disorders, the first trimester scans are still needed.

5.7 RECOMMENDATION

The recommendations emanating from the study are:

- From the conclusion of the study, the health institutions may be advised to consider providing awareness on the importance of attending ANC in the first trimester where pregnant women can undergo CRL scans. This is because CRL scans are the standard and the most accurate method of assessing the GA and the EDD. This will help the obstetrician and midwives to qualitatively manage pregnant women in order to reduce maternal morbidity and mortality.

- Considering the point above, it is also recommended that every ANC health facility should have access to ultrasound machine with qualified Sonographers to work hand in hand with the Obstetricians and midwives in providing a common goal of reducing maternal morbidity and mortality.
- It is also recommended that policy makers in health institution may consider designing training programmes to generate more qualified Sonographers who may provide quality work.
- Obstetrician and midwives may consider SFH as the last resort; however, the use of the SFH method in the assessment of GA should be done bearing in mind that results could be 41% accurate within one week from the actual date.

5.8 LIMITATIONS

The study has certain limitations.

- **Time constraints.** This research was performed within a short time period of six months. A longer time schedule could have enabled the researcher increase the sample size, since most of the pregnant women did not have report on CRL scans.
- **Financial constraints.** Financial sponsorship could have provided a great support in conducting the research in more facilities and expanded the study population size.

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APPENDIX I

PARTICIPANT INFORMATION LEAFLET

Researcher: Linda Nyarko Antwi
Address: Department of Radiography
School of Allied Health Sciences
College of Health Sciences
University of Ghana
Telephone: 0266794499
E-mail: zetlindaj@gmail.com

Thank you for agreeing to participate in this study which will take place between March 2017 and May 2017. This form outlines the purposes of the study and provides a description of your involvement and rights as a participant.

Purposes of this research: To partially fulfill the requirement for the award of a Masters' degree in Medical Ultrasonography from the University of Ghana.

More so, to evaluate the accuracy of Symphysis Fundal Height in comparison to Ultrasound Scan for the assessment of gestational age so that the outcome of the study may assist obstetricians and midwives to rely on accurate method in assessing gestational age.

Risk(s): There are no risks involved with measurement of SFH, other than the inconvenience of having to lie still while the measurement is recorded by a midwife. In regards to risks from US, there are no confirmed ill effects from having an ultrasound exam at a low-frequency 2-5 MHz levels and the time exposure required to conduct this study on a participant is about 30-45 minutes.

Benefit(s): There are no financial benefits to you as a participant. The results of this study will encourage medical professionals to rely on SFH for accurate GA in the absence of (US) in managing their clients especially in the areas where the use of US are not available or to recommend the use of US for all maternity Units at health facilities to avoid maternal morbidity and mortality.

Confidentiality: All information that would be collected in this study will be given code numbers. No name will be recorded. Data collected would not be linked to any individual in any way. No name or identifier will be used in any publication or reports from this study. However, as part of the responsibility for the researcher to conduct this research properly, officials from the ethics committee may be allowed to have access to your records.

Privacy: A comfortable and secured place will be assured for your privacy.

Voluntariness: Taking part in this study should be out of your own free will. You are not under obligation to participate. Research is entirely voluntary.

Alternatives to participation: If you choose not to participate, this will not affect your Antenatal care, treatment in this hospital or any institution in any way.

Withdrawal from the research: You may choose to withdraw from the research at any time without having to explain yourself. You may also choose not to answer any question you find uncomfortable or private.

Consequence of Withdrawal: There will be no consequence, loss of benefit or care to you if you choose to withdraw from the study. Please note, however, that some of the information that may have been obtained from you without identifiers (name etc), before you chose to withdraw, may have been modified or used in analysis reports and publications and cannot be removed anymore. We do promise to make good faith effort to comply with your wishes as much as practicable.

Costs/Compensation: No compensation will be provided for your participation in this study and no cost to you either.

In pursuance of the above, I would be grateful if you could complete the attached informed consent form before any data is taken from you and the foetus.

APPENDIX II

CONSENT FORM

STATEMENT OF PERSON GIVING CONSENT:

I have read the information on this study or have had it translated into a language I understand. I have also talked it over with the interviewer to my satisfaction.

I understand that my participation is voluntary.

I know enough about the purpose, methods, risks and benefits of the research study to decide that I want to take part in it.

I understand that I may freely withdraw being part of this study at any time without having to explain myself.

I have received a copy of this information leaflet and consent form to keep for myself.

NAME OF PARTICIPANT: _____

SIGNATURE/THUMB PRINT OF PARTICIPANT: _____

DATE: _____

WITNESS' SIGNATURE (for non-literate participants): _____

WITNESS' NAME (print): _____

NAME OF RESEARCHER: _____

DATE: _____

RESEARCHER' SIGNATURE: _____

APPENDIX III

Data Collection Sheet

Participant Code Number: _____

Comparative study of Pregnancy Dating by Symphysis-Fundal Height Measurements and Ultrasound Scanning

Demographic and Observational Data

Date of Data Collection: _____

Date of Birth: _____ Age: _____ yrs Height: _____ cm Weight: _____ kg

Educational Level: No Education , Primary , JHS , SHS , college/university , graduate school .

Marital Status: Single , Widowed , Divorce , Living together , Married ,

Main Occupation: Salaried Worker , Self Employed , Domestic Activities ,

Others, Specify: _____

Date of LMP		GA by LMP (weeks):
Date of 1 st Trimester US		
CRL at 1 st Trimester US(mm)		
GA by CRL at 1st Trimester US (weeks)		EDD:
Date of 2 nd Trimester US		
BPD (cm)		GA:
HC (cm)		GA:
FL (cm)		GA:
AC(cm)		GA:
GA by 2 nd Trimester US (weeks)		EDD:
Symphysis Fundal Height (cm)		
1st measurement (cm)		
2 nd measurement (cm)		
Average (cm)		
GA by SFH (weeks)		EDD:



UNIVERSITY OF GHANA
SCHOOL OF BIOMEDICAL AND ALLIED HEALTH SCIENCES

14th March, 2017.

Ref. No.:

Ms. Antwi, Linda,
Dept. of Radiography,
SBAHS,
Korle Bu.

Dear Ms. Antwi,

ETHICS CLEARANCE

Ethics Identification Number: SBAHS – RD./10556964/AA/5A/2016-2017.

Following a meeting of the Ethics and Protocol Review Committee of the School of Biomedical and Allied Health Sciences held on Tuesday 14th March, 2017. I write on behalf of the Committee to approve your research proposal as follows:

TITLE OF RESEARCH PROPOSAL: COMPARATIVE STUDY OF PREGNANCY DATING BY SYMPHYSIS-FUNDAL HEIGHT MEASUREMENT AND ULTRASOUND SCANNING IN KUMASI METROPOLIS

This approval requires that you submit three-monthly review reports of the protocol to the Committee and a final full review to the Committee on completion of the research. The Committee may observe the procedures and records of the research during and after implementation.

Please note that any significant modification of the research must be submitted to the Committee for review and approval before its implementation.

You are required to report all serious adverse events related to this research to the Committee within seven (7) days verbally and fourteen (14) days in writing.

As part of the review process, it is the Committee's duty to review the ethical aspects of any manuscript that may be produced from this research. You will therefore, be required to furnish the Committee with any manuscript for publication.

This reviewed report is valid till 31st. August, 2017. Please always quote the ethical identification number in all future correspondence in relation to this protocol.

Thank you.

Yours sincerely,

Dr. M.M. Addae

For : **Dr. S. D. Amanquah**
(Chairman, Ethics and Protocol Review Committee)

Cc: Dean
Head, Dept. of Radiography
School Administrator

COLLEGE OF HEALTH SCIENCES

In case of the reply the number
and the date of this letter
should be quoted

My Ref. No: SGH-26/2013
Your Ref. No:

E-mail: suntresogovhospital@yahoo.com
suntresogovhospital@hotmail.com

Tel: 03220-22253



GHANA HEALTH SERVICE
SUNTRESO GOVT. HOSPITAL
P. O. BOX 14775
KUMASI

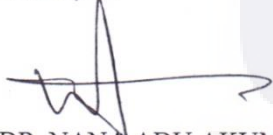
20th March 2017

THE CHAIRMAN
ETHICS AND PROTOCOL REVIEW COMMITTEE
SCHOOL OF BIOMEDICAL AND ALLIED HEALTH SCIENCES
UNIVERSITY OF GHANA
LEGON - ACCRA

LETTER OF APPROVAL TO UNDERTAKE RESEARCH
MRS. LINDA NYARKO ANTWI

I write to inform you that approval has been given to Mrs. Linda Nyarko Antwi to undertake a research on Comparative study of pregnancy dating by symphysis-fundal height ultrasound measurement in Kumasi Metropolis in this facility.

Thank you.



DR. NANA ADU AKUMIA
MEDICAL SUPERINTENDENT

CC: DEAN

HEAD OF DEPT OF RADIOGRAPY

ADMINISTRATOR

