Factors associated with the rate of gestational weight gain in the rural Mangochi district of Malawi

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Supervisors:
Penjani Rhoda Kamudoni
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Master thesis submitted as a part of
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Abstract

Background: Inadequate and excessive gestational weight gain (GWG) is among the most important determinant of adverse pregnancy and birth outcomes. In most developing countries including Malawi, monitoring changes in pregnancy weight is challenging because of late Antenatal care (ANC) attendance. In addition, it is not a routine procedure to monitor and recommend appropriate gestational weight gain in Malawi.

Objectives: To identify factors associated with the rate of gestational weight gain and with other indicators of nutritional status in a rural setting of Malawi, and to compare if the weekly weight gain is in accordance to the Institute Of Medicine recommendations for pregnant women in different BMI categories of nutritional status.

Methodology: A longitudinal study was done on 257 pregnant women who were recruited in the first and second trimester of their pregnancies to participate in a cluster randomized controlled intervention study. Measurements of maternal weight were done at recruitment and at pregnancy midpoint check-up at local health clinics. Changes in weekly gestational weight over this period were compared to 2009 guidelines set by the IOM to determine whether the pregnant women were meeting these guidelines. Haemoglobin (Hb), Mid Upper Arm Circumference (MUAC) and skinfold thickness measurements were taken at the time of recruitment.

Analysis: Binary data (met IOM guidelines/ not met) were analyzed using the logistic regression model within the generalized linear regression model (GLM) framework to determine factors that were associated with the rate of gestational weight gain. Prevalence of inadequate gestational weight gain was also determined. The GLM was also used to identify factors associated with haemoglobin (Hb) status, MUAC and body fat percentage at recruitment.

Results: The study revealed that 19.8% of the pregnant mothers gained adequate GWG. The mean GWG per week was 0.26 (SD ± 0.2) kg. Starting pregnancy before harvest season was significantly associated with inadequate GWG, (AOR = 0.33, 95 % CI 0.16, 0.65) significantly predicted GWG. The factors that were associated with low Hb status on recruitment were malaria **β** and higher gestational age on recruitment. Maternal age was significantly associated with large MUAC whereas very poor socio economic status (SES) and large households significantly decreased the size of MUAC. Each one year increase in

age was associated with an increase in body fat percentage whereas lower body fat was common among women from very poor SES.

Conclusion: A small proportion of the pregnant women obtained adequate gestational weight gain. Season of recruitment significantly predicted GWG; before harvest season was associated with a lower weight gain.

Key words: pre gestational Body Mass Index (BMI), gestational weight gain, antenatal care, anthropometric status, morbidity, diet diversity, body fat %.

List of abbreviations

AIDS	Acquired Immune Deficiency Syndrome
ANC	Antenatal Care
ART	Antiretroviral Treatment
BMI	Body Mass Index
CHAM	Christian Health Association of Malawi
CRCT	Clustered Randomized Control Trial
DHS	Demographic Health Survey
FANC	Focused Antenatal Care
GWG	Gestational Weight Gain
HB	Haemoglobin
HCG	Human Chorionic Gonadotropin
HIV	Human Immuno-deficiency Virus
IMF	International Monetary Fund
IOM	Institute Of Medicine
IUGR	Intra Uterine Growth Retardation
LBW	Low Birth Weight
MDG	Millennium Development Goals
NGOs	Non-Governmental Organization
MUAC	Mid-Upper Arm Circumference
RBS	Random Blood Sugar
SES	Socio Economic Status
SFTM	Skinfold Thickness Measurement
USS	Ultra Sound Scanning
WHO	World Health Organization

Explanation of terms

Low birth weight	An infant weighing less than 2500
Gestational weight gain rate	Amount of gestational weight gain per week
Body Mass Index	Weight/(height)^2
Haemoglobin level	Protein molecule in red blood cells that carries oxygen from the lungs to the body's tissues and returns carbon dioxide from the tissues back to the lungs.
Body fat percentage	Percentage of fat the body contains
Skinfold thickness	An estimated size of the subcutaneous fat deposit
Mid-Upper arm circumference	The circumference of the left upper arm, measured at the mid- point between the tip of the shoulder and the tip of the elbow (olecranon process and the acromion
Trimester	A normal, full-term pregnancy ranges from 37-42 weeks and is divided into three trimesters
Health Volunteer	Local person from the village working as a volunteer to promote/improve health
Household	People eating from the same cooking pot

List of appendices

Table of contents

List of figures

List of tables

1 INTRODUCTION

1.1 Background of the study

In adequate weight gain during pregnancy is an important predictor of complications for the mother and infant (1). Gestational weight gain during pregnancy influence infant birth weight. A strong relationship between maternal pregnancy weight gain and birth weight has been consistently demonstrated, and low maternal weight gain is considered a preventable risk factor for Low Birth Weight (LBW) (2). In Malawi, gestational weight gain monitoring is not part of Antenatal Care (ANC) service in health facilities; most women do not achieve recommended weight gain according to official guidelines. Several studies have shown a strong association between poor gestational weight gain and birth outcomes including low birth weight, spontaneous preterm deliveries (1). This may be one of the reasons why Malawi still experiences poor birth outcomes especially low birth weight. Low birth weight is an important risk factor for neonatal deaths (3)and malnutrition. Very few studies have been done on gestational weight gain in Malawi (4-6).

Currently, there is an on-going research project (infant and maternal nutrition study) in Mangochi district aiming to develop community based delivered nutrition counselling to pregnant women and to measure its effect on birth weight. Some initial studies have already been done. As part of the large study, this study focused on exploring the factors that are associated with the rate of gestational weight gain given that gestational weight gain affects birth related outcomes in a rural setting in Malawi, this study compared weight gain according to IOM guidelines for pregnant women in different weight categories of BMI. This study also looked at factors associated with other indicators of nutritional status of pregnant women at recruitment including haemoglobin (Hb), MUAC and body fat % as secondary outcomes.

1.2 Gestational weight gain

Gestational weight gain is the amount of weight gained throughout pregnancy. Gestational weight gain is an essential determinant of maternal and neonatal health (3). The rate of gestational weight gain is the amount of weight gained per week in pregnancy. A unique and complex biological phenomenon that supports the functions of growth and development of the foetus (3). Maternal pre-gestational weight, BMI, gestational weight gain are factors determining offspring birth weight, weight for length, and adiposity(1).

Birth weight and adiposity are important because they have major impacts on neonatal morbidity and mortality, and also appear to affect early adult weight and long-term health(3). Gestational weigh gain is divided in three categories; gestation weight gain rate (weekly gain) pattern of gestational weight gain (gain between trimesters), and total gestational weight gain (gain throughout pregnancy) (7).

1.2.1 Changes in weight related to pregnancy

The body goes through many changes in pregnancy; below are some of the changes that a body goes through, which may apply in our study context.

Physiological changes related to pregnancy result in a weight gain of about 25 pounds (11kgs). As pregnancy progresses, protein, fat, water, and minerals are deposited in the fetus, in placenta, amniotic fluid, uterus, mammary gland, blood, and adipose tissue. The products of conception (placenta, fetus, amniotic fluid) comprise approximately 35 percent of the total weight. Average total water gain at term is distributed in the fetus (2,414 g), placenta (540 g), amniotic fluid (792 g), blood-free uterus (800 g), mammary gland (304 g), blood (1,267 g), and extra cellular fluid (ECF) (1,496 g) with no edema (1). Maternal plasma volume also increases and it correlates with birthweight (1). Fat deposition is unique to pregnancy; fat is deposited preferentially over the hips, back and upper thighs up to about 30 weeks gestation (3). Much of the variance in gestational weight gain is accounted in fat mass, because much of the increase in fat free mass will represent an increase in water (1).
Apart from physiological factors, psychological, behavioral, family, social, cultural, and environmental factors can also have an impact on gestational weight gain (7).

Societal/Institutional factors: media, culture and acculturation, health services

Cultural and acculturation: Cultural norms and beliefs may influence dietary behavior and physical activity, thereby affecting energy balance and gestational weight gain. Acculturation, the process in which members of one cultural group adopt the beliefs and behaviors of another, is often associated with adoption of unhealthy behaviors, including food choices.

Health Services: the type of advice that pregnant women receive at antenatal care clinics (ANC) about gestational weight gain, and policy.

Policy: principles, guidelines, or plans adopted by an organization to guide decisions, actions, and other matters, e.g. Institute of Medicine weight gain recommendations, World Health Organization guidelines and countries policies.

Environmental factors: Exposure to high altitude, exposure to environmental toxicants, and exposure to a natural or human-caused disaster.

Natural and Man-made Disasters: Disasters can affect GWG indirectly by influencing resource availability (including food supply), health care access, and stress levels(8).

Neighborhood/community factors: access to healthy foods and opportunities for physical activity.

1.2.2 Guidelines for gestational weight gain

In 2009, Institute of Medicine (IOM) published revised guidelines for total and weight gain rate during pregnancy from the 1990 guidelines. These guidelines are based on pre-gestational body mass index ranges for underweight, normal weight, overweight and obese women recommended by World Health Organization (9). To improve maternal and child health outcomes, women not only should be within a normal BMI range when they conceive but also should gain within the ranges recommended in the IOM guidelines. Meeting these challenges means that women need preconception counseling; both women and their care providers need to know and understand the recommendations (7). These recommendations are independent of age, parity, smoking history, race and ethnic background (7, 9) IOM also recommends that all women strive to be within the normal BMI range when they conceive (9). An important component of implementation of these guidelines is the need for individualized attention. The types of services needed to meet women's needs include recording pre-gestational height and weight, charting women's weight gain throughout pregnancy, and sharing the results with them so they are aware of their progress toward their weight gain goal (7).

Weight gains outside the IOM's recommended ranges are associated with twice as many poor pregnancy outcomes than are weight gains within the ranges(10). The pregnant woman is supposed to work with her health care provider on her weight gain goals at the beginning and regularly throughout her pregnancy. With the help of the health worker she needs to track her pregnancy weight gain at the beginning and regularly throughout pregnancy and compare her progress to recommended ranges of healthy weight gain (Centre Disease Control and prevention). Several studies have showed that gestational weight gain within IOM recommended ranges is associated with the best outcomes for both mothers and infants. **Table 1** shows guidelines for total and rate of gestational weight gain recommended by IOM.

Table 1: guidelines for total and rate of gestational weight gain recommended by IOM

	Total weight gain		Second and third trimesters	
Pre gestational BMI ((kg/m$^{2)}$	**Range (kg)**	**Range (lb)**	***Mean (Range) (kg/wk)**	***Mean (Range) (lb/wk)**
Underweight (less than 18.5)	12.5–18.0	28.0–40.0	0.51 (0.44–0.58)	1.0 (1.0–1.3)
Normal weight (18.5–24.9)	11.5–16.0	25.0–35.0	0.42 (0.35–0.50)	1.0 (0.8–1.0)
Overweight (25.0–29.9)	7.0–11.5	15.0–25.0	0.28 (0.23–0.33)	0.6 (0.5–0.7)
Obese (30.0 or higher)	5.0–9.0	11.0–20.0	0.22 (0.17–0.27)	0.5 (0.4–0.6)

BMI, body mass index.

*Calculations include a total first-trimester gain of 2 kg (1–3 kg) for all except obese women, who should gain 1.5 kg (0.5–2.0 kg).

Data from Institute of Medicine/National Research Council (Committee to Reexamine IOM Pregnancy Weight Guidelines, Food and Nutrition Board and Board on Children, Youth, and Families). Weight gain during pregnancy: reexamining the guidelines. Washington, DC: National Academies Press, 2009(9).

1.2.3 Relevance of gestational weight gain monitoring

Gestational weight gain monitoring is one of important aspects of preventive care in pregnancy. Excessive weight gain results in poor outcomes for both mother and child such as diabetes and large for age infants, while low total weight gain during pregnancy is a valid risk factor for low birth weight, spontaneous preterm deliveries and these are important risk factors for neonatal deaths (1).

Gestational weight gain also affects the mother in the prenatal and/or postnatal periods as excessive gestational weight gain increases her risk of complications in labor and delivery. In the postpartum period, weight retention can lead to higher weight status in subsequent pregnancies and other long-term maternal health consequences such as increased risk for type 2 diabetes and cardiovascular diseases (3).

Gestational weight gain monitoring helps detecting and managing conditions that may complicate pregnancy and childbirth and it improves the wellbeing of the mother and fetus.

Low birth weight babies who survive are likely to suffer growth retardation and illness throughout their childhood, adolescence and into adulthood. Apart from direct effects on her health and productivity, adult stunting and underweight increase the chance that her children will be born with low birthweight and so the cycle turns (11) as shown in **figure.1.**

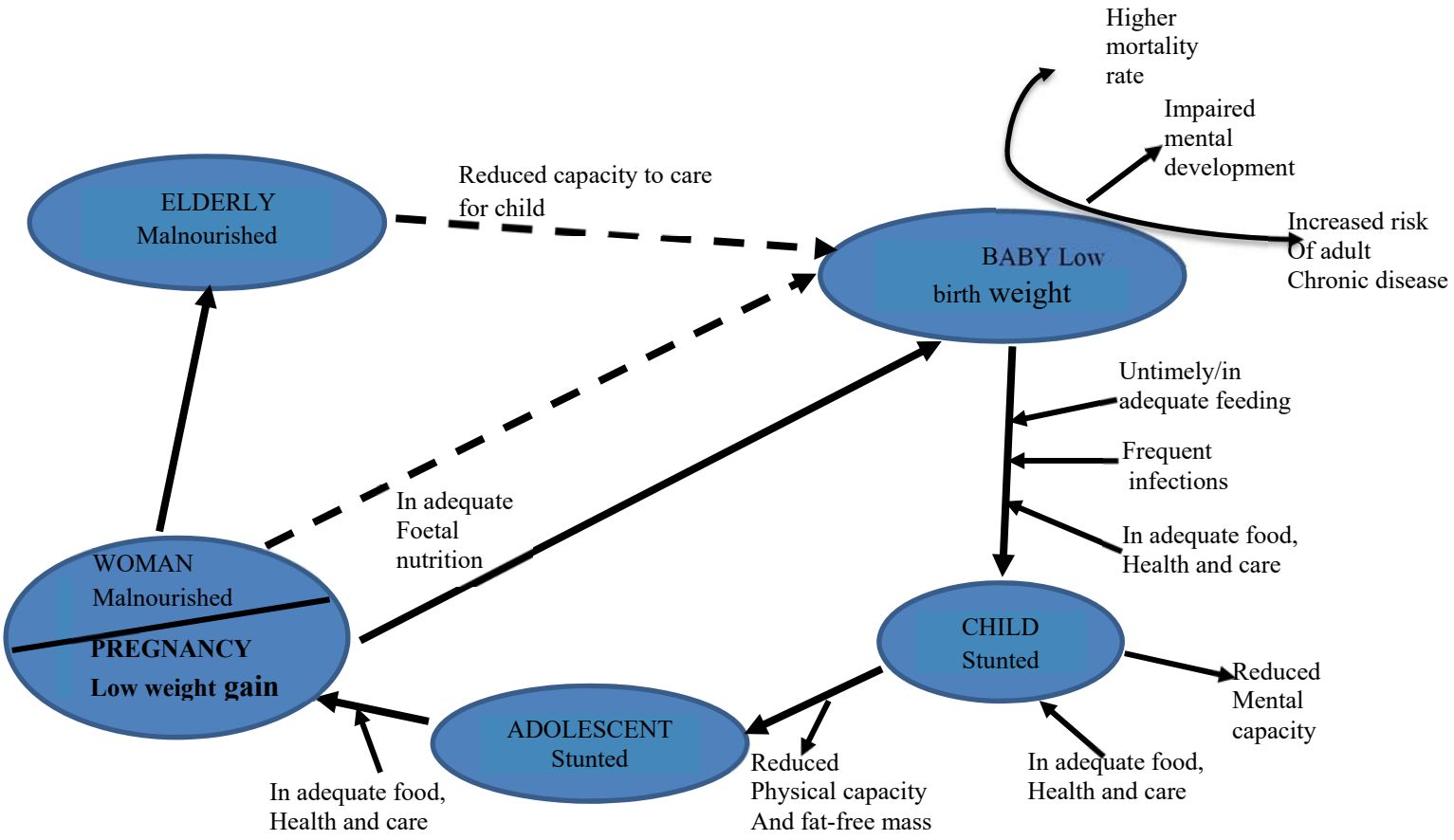

Figure 1: Pregnancy weight gain in the nutrition through the life cycle

1.2.4 Haemoglobin in pregnancy

Haemoglobin is the protein molecule in red blood cells that carries oxygen from the lungs to the body's tissues and returns carbon dioxide from the tissues back to the lungs.
Anaemia is a condition in which the number of red blood cells (and consequently their oxygen-carrying capacity) is insufficient to meet the body's physiologic needs Specific physiologic needs vary with a person's age, gender, residential elevation above sea level (altitude), smoking behaviour, and different stages of pregnancy (12). Several types of anemia can develop during pregnancy including; iron-deficiency, folate-deficiency and vitamin B12 deficiency. Maternal anemia is a common problem in pregnancy, particularly in developing countries(13). Anaemia is one of the most prevalent nutritional deficiency problems affecting a large proportion of people especially pregnant women. Anaemia affects almost two-thirds of pregnant women in developing countries and contributes to maternal morbidity and mortality and to low birthweight (4, 13-17).

1.2.5 Anthropometry in pregnancy

Anthropometry is the study of the measurement of the human body in terms of the dimensions of bone, muscle and adipose tissue (18). It provides the single most portable, universally applicable, in expensive and non-invasive technique for assessing the size proportions and composition of the human body (18). It reflects both health and nutritional status and predicts performance, health and survival (19, 20). The nutritional status of a woman before and during pregnancy is critical to both her infant's and her own health and survival (19). Maternal nutritional status both before and during pregnancy is a well-recognized determinant of birth outcomes (21).
MUAC is the circumference of the upper arm, measured at the mid- point between the tip of the shoulder and the tip of the elbow (olecranon process and the acromion. Several studies show that low Mid Upper Arm Circumference (MUAC) is associated with low birth weight and preterm delivery (4, 19, 22). It is relatively stable throughout pregnancy, even when measured relatively late in pregnancy, and it may be more reflective than weight of pre-pregnancy conditions (20).Wasting in pregnant women can be defined as a MUAC <22 cm (23, 24).

Body fat is the amount of fat the body contains, one of the simplest and easiest methods to understand body fat is through skinfold thickness (an estimated size of the subcutaneous fat deposit). Body fat percentage can be assessed by measuring the depth of a fold of skin at specific reference sites. Then comparing the results to researched reference tables, a measure of body fat percentage can be achieved (25).

1.3 Background Information of Malawi

1.3.1 Country profile

Malawi is a land locked sub-Saharan African country located south of the equator. The People's Republic of Mozambique; to the south, southwest and southeast borders. The north and northeast by the United Republic of Tanzania; and northwest by the Republic of Zambia. The country is 901 kilometres long and 80 to 161 kilometres wide. The total area is approximately 118,484 square kilometres of which 94,276square kilometres (80%) is land. The remaining area is mostly composed of Lake Malawi, which is about 475 kilometres long and delineates its eastern boundary with Mozambique (26).

Malawi's most striking topographic feature is the Rift Valley, which runs the entire length of the country, passing through Lake Malawi in the Northern and Central Regions to the Shire Valley in the south. The Shire River drains the water from Lake Malawi into the Zambezi River in Mozambique. To the west and south of Lake Malawi lay fertile plains and mountain ranges whose peaks range from 1,700 to 3,000 metres above sea level (26).

Malawi has a tropical continental climate with maritime influences. Rainfall and temperature vary depending on altitude and proximity to the lake. From May to August, the weather is cool and dry. From September to November, the weather becomes hot. The rainy season begins in October or November and continues until April. The most important staple is maize, which is normally harvested in April- May. Other important crops are sweet potato, cassava and rice (27).

The country is divided into three regions: the Northern, Central, and Southern Regions. There are 28 districts in the country. Six districts are in the Northern Region, nine are in the Central Region, and 13 are in the Southern Region. Administratively, the districts are subdivided into traditional authorities (TAs), presided over by chiefs. Each TA is composed of villages, which are the smallest administrative units, and the villages are presided over by village headmen (26, 27).

1.3.2 Population & demographic characteristics

According to the world fact book, Malawi's population was estimated at 17,964,697 in 2015 with a population growth rate of 3.32% (28). It has a population density of 188.3 persons per square metre as of 2016 (29). It has 41.56 births/1,000 population and 8.41 deaths/1,000 population. Malawi has urban population of only 16,3% of total population (28) this indicates that the rest of the population is rural. It has a median age of 16.4 years, this indicates that Malawi is constituted with more young people (28), according to 2008 population census 45.9% constituted of people under 15 years (30).

1.3.3 Economy

Malawi is defined as low income with a population that is mostly rural. Malawi ranked 171 out of 187 countries in the 2011 UNDP Human Development Index. Over 40 percent of the population live on less than US$1 per day according to 2010 DHS survey. The economy of Malawi is based primarily on agriculture, which accounts for 30 percent of the gross domestic product (GDP), The Gross Domestic Product per capita in Malawi was last recorded at 1,100 US dollars in 2015 (28). The country's major exports are tobacco, tea, and sugar, which account for approximately 85 percent of its domestic exports (26)**.** Other sources of income has been assistance from the IMF, the World Bank, and individual donor nations however since 2009, it has experienced some setbacks in aid due to a negative IMF review and governance issues (28); this affected government's efforts of improving the health status of the population and other areas like education.

1.3.4 Education

In Malawi more female than males have not attended school according to a recent demographic health survey (DHS), 12 percent of women have no education compared with 5 percent of their male counterparts. There are some urban-rural differences in educational attainment. More than 20 percent of the women in rural areas have no education at all in comparison with 9% of women in urban areas (31). The proportion of the population that has attained education varies greatly by region; Southern and Central Regions have higher proportions of women without education, 21 percent and 20 percent respectively, compared with 9 percent in the Northern Region (27). The study was conducted in southern region, rural area.

1.3.5 Health care system

A review of the health situation in Malawi shows that the health status of Malawians has seen improvement in some indicators over the past decades (27). Life expectancy at birth rose to around 55 years in the 2000s compared with 39 years in the 1990s when the nation was hard hit by the HIV epidemic. This substantial recent improvement resulted mainly from progress against the HIV/AIDS pandemic through the provision of life-prolonging drugs and other preventive measures. Despite these improvements, Malawi continues to carry a high burden of disease, including HIV/AIDS, respiratory infections, malaria, diarrheal diseases, and perinatal conditions (27).

The Ministry of Health and the Ministry of Local Government and Rural Development are jointly responsible for public health service delivery. There are three major categories of health service providers in the country: public-sector facilities, not-for-profit private-sector facilities, and for-profit private-sector facilities. Approximately half of all facilities in Malawi are public facilities; around 15 percent are faith-based organizations that work under the umbrella of the Christian Health Association of Malawi (CHAM), and the rest belong to other nongovernmental organizations (NGOs) or to the private for-profit sector (27).

The health system has been largely dependent on donor aid ranging from 57% to 62% of the total health expenditure between 2006 and 2009 raising the issue of sustainability and predictability. During the same period, government expenditure on health ranged from 13.5% to 22.4% (32).

1.3.6 Maternal and child health

Fertility in Malawi has been declining since the 1990s. The total fertility (TFR) has declined from 6.7 children per woman in 1992 to 6.3 children per woman in 2000, to 6.0 children per woman in 2004 and to 5.7 children per woman in 2010. Following a two-decade-long steady decline in fertility since the 1990s, TFR declined sharply in the last three years and reached 4.4 children per woman in 2015 DHS (31). It also indicates that fertility is notably higher among rural women than among urban women.

The antenatal care policy in Malawi follows the newest WHO antenatal care approach; Focused Antenatal Care (FANC) to promote safe pregnancies (26). WHO's FANC approach encourages women to have four goal oriented ANC visits and that first ANC visit should be as early as possible in pregnancy, preferably in the first trimester. The last visit should be at around 37 weeks or near the expected date of birth to ensure that appropriate advice and care have been provided to prevent and manage problems (26). Antenatal care from a skilled provider is important to monitor pregnancy and reduce morbidity and mortality risks for the mother and child during pregnancy, delivery, and the postnatal period (within 42 days after delivery). The 2015-16 MDHS results show that 95 percent of women who gave birth from 2010 received antenatal care from a skilled provider at least once for their last delivery. Half of women had four or more ANC visits (51 percent). Urban women were more likely than rural women to have received ANC from a skilled provider (97 percent versus 94 percent, respectively) and to have had four or more ANC visits (59 percent versus 49 percent, respectively) (31).

Low birth weight (LBW) is defined by WHO as weight less than 2.5kg (33). LBW is a leading cause of neonatal deaths as such it is one of the most important public health problems. According to United Nations International Children's Emergency Fund (UNICEF) and WHO, half of low birth weight children are in the South Central Asia where more than a quarter of all born children are less than 2.5kg, representing 27% of all new births with LBW (34). Sub-Saharan Africa has the second highest incidence of LBW, pegged at 15% (33).

In 2004, infant mortality rate in Malawi was 42 deaths per 1,000 live births. The child mortality rate was 23 deaths per 1,000 children surviving to age 12 months, while the overall under-5 mortality rate was 64 deaths per 1,000 live births. The neonatal mortality rate was 27 deaths per 1,000 live births. The post neonatal mortality rate was 15 deaths per 1,000 live births. The 2015-16 MDHS indicates that under-5 mortality rates have declined from 112 deaths per1,000 live births in 2001-2005 to 64 deaths per 1,000 live births in the 5 years prior to the 2015-16 MDHS survey (31).

2 LITERATURE REVIEW

Pubmed, up to date and google scholar databases were used to search relevant review articles and original reports on the area of the study. Additionally, textbooks on gestation weight gain were used.

2.1 Overview of gestational weight gain

In 2010/2011, nearly 4.5 million mothers, newborns, and children under five died in Africa, south of the Sahara. 80% of those deaths could be have been prevented by simple, low-cost interventions and quality obstetrical care (35). Most of the causes of neonatal mortality are intertwined with the health, nutrition, economic and social status of the mother during and after pregnancy (35). It is estimated that babies who die before the onset of labour, or antepartum stillbirths, account for two-thirds of all stillbirths in countries where the mortality rate is greater than 22 per 1,000 births – nearly all African countries (36). Antepartum stillbirths have a number of causes, including maternal infections i.e syphilis and pregnancy complications. Newborns are affected by problems during pregnancy including preterm birth and restricted fetal growth. The social, family, and community context and beliefs affect health during pregnancy (36).

Gestational weight gain is one of the critical factors that is supposed to be monitored in prenatal clinics as part of maternal care. Gestational weight gain during pregnancy is one of the factors that is associated with a variety of stresses affecting fetal growth. It has been shown repeatedly to be a strong predictor of birth weight (7). Excessive weight gain results is associated with poor outcomes for both mother and child such as diabetes, large for age infants, while low total weight gain during pregnancy is a valid risk factor for low birth weight, spontaneous preterm deliveries, small for age infants and these are important risk factors for neonatal deaths. Several studies have found strong evidence supporting these associations (1, 3, 4, 9, 23, 33, 37-41). A systematic review including 35 studies, of which 10 that examined gestational weight gain found the same strong evidence supporting the associations, and all of the studies found an association between inadequate gestational weight gain and lower birth weight despite various methods of characterizing GWG (total, rate or by trimester) (1).

Other studies have indicated importance of GWG in a specific trimester. Sekiya *et al* and Abrams *et al* found the rate of GWG during 2nd trimester to be a strong risk factor for low birth weight and premature infant deliveries as it showed a strong association with foetal growth than was weight gain in first or third trimester (37, 39). The importance of the weight gain pattern for birth weight and preterm delivery was also shown in other populations including black and white and Hispanic populations, (Siega *et al* and Hickey *et al* found that inadequate weight gain during third trimesters was predictive of preterm birth) (42, 43). The pattern of weight gain is as important as the total amount of GWG (37, 39). This means that GWG monitoring is important throughout pregnancy. The committee that revised GWG guidelines discussed multiple factors that affect gestational weight gain according to various studies; these are environmental factors i.e social factors (living standards, cultural factors, and mass media), community factors (public health programs, prenatal care) and family determinants (violence, marital status, family support) (7). There are also maternal factors that affect GWG: demographic (age, parity), genetic, physiological and anthropometric (pre-gestational BMI, metabolic and hormonal changes), psychological and behavioral factors (food consumption and physical exercise) (7, 44). In addition, some studies have shown that pre-gestational weight, morbidity, nutrition, social demographic characteristics, stress, antenatal care, age, parity and birth interval are associated with GWG (4, 10, 45).

2.1.1 Epidemiological patterns of gestational weight gain

Most women in developing countries especially Africa do not gain recommended weight according to their BMI (4). A study done in Nigeria (2014) showed that 96.6% gained less than recommended weight and only 3.1% gained the IOM recommended weight gain while 0.3% gained more than recommended weight (46). Another study done in Ethiopia found that 69%, 28% and 2.7% of the women gained inadequate, adequate and excess gestational weight, respectively (47). In a longitudinal study done in Malawi, Xu *et al* found that weight gain during pregnancy was substantially slower in their cohort than the US IOM's recommendation (5). These studies support the fact that most women in developing countries gain less than recommended gestational weight although this is supported by few studies done in Africa (4, 5, 46, 47).

Few studies have been done on gestational weight gain in developing countries, especially Africa compared to developed countries and some middle-income countries. Most studies done in developed countries reveal the problem of excessive weight gains (48) while inadequate gestational weight gains seems to be a problem in developing countries.

There is a difference between white and black women; studies reveal that black people do not gain adequate weight compared with white women. In a study done on black and white women Caulfield *et al* found that black women were likely to under-gain than over-gain as compared to white women (10).

2.1.2 The challenge

The challenge is that the proportion of women receiving adequate numbers of ANC services in developing regions remains low and women start antenatal care late (23), although there are some improvements in ANC coverage in developing countries, especially Malawi. Gestational weight gain monitoring is supposed to be part of ANC.

In Africa 69 %of pregnant women have at least one antenatal care (ANC) contact while in industrialized countries, more than 95 percent of pregnant women have access to ANC (36). However, to achieve the full life-saving potential that ANC promises for women and babies, four visits provide essential evidence based intervention a package often called focused antenatal care (FANC) – are required (36). This is only to be achieved if women start ANC early and attends four or more ANC visits. Repeated contacts between the woman and the health services offer many opportunities for providing evidence based interventions likely to affect maternal, fetal, and neonatal health and survival (36). However, gestational weight gain is not a focus of FANC and health education at antenatal clinics is not individualized, pregnant women are given health talks in groups before consultation. The midwife/clinician and the pregnant woman do not discuss about her recommended gestational weight gain goal, as it is not properly monitored (a reflection of what happens in the Malawian clinic setting). Abrams *et al* suggested that gestational weight gain monitoring might help clinicians to target nutritional, medical and social services to women at high risk of poor pregnancy outcomes (37) especially underweight women in our context.

Health education, advice, and counselling are a focus of FANC; but specifying gestational weight gain counselling and monitoring in FANC package would be important. However according to the FANC package, the counselling is about self-care, alcohol and tobacco use, nutrition, safe sex, rest, sleeping under ITN, Birth and emergency plan, infant feeding, postpartum/postnatal care, pregnancy spacing. Some of these activities could have the effect of improving weight gain, but a woman is supposed to know how much she is supposed to gain throughout her pregnancy according to her BMI for both good maternal and child outcome.

2.2 Overview of GWG in Malawi

Few studies have been done in Malawi on gestational weight gain. A study done on gestational health and predictors of newborn weight amongst pregnant women in rural Malawi Kulmala *et al* found out that maternal parity, initial weight, duration of pregnancy and gestational weight gain were associated with newborn weights (49).

Another study that was done in rural southern Malawi on the effect of chronic and preexisting conditions on weight gain and its association with birth weights, where it showed that mothers with placental or peripheral malaria on delivery or HIV infection had a lower mean weight gain (4) .

Reference values are well established for white women (9) as well as for some southern American countries and China (5). In the mid-90s, a Malawian cohort study estimated a mean GWG of 259g/week as a reference value for normal weight gain, from this time no study has been done in Malawi on this subject (5). Malawi adopted Focused Antenatal Care (FANC) and women are encouraged to start ANC early at least during first trimester (26). Gestational weight gain monitoring is a challenge as it is not part of the focused antenatal care; this might be one of the reasons why Malawi still experiences low birth weight rates.

From my experience in Malawian clinics gestational weight gain monitoring not part of ANC; women are only encouraged to eat balanced food, do exercises, recognition and management of pregnancy-related complications, particularly pre-eclampsia, anaemia during group health education. BMI is not determined, weight and height are measured; height is measured to determine the type of facility to give birth; either health center or district hospital, as short women (<150cm) most likely have difficulties during delivery and are at risk of caesarian section delivery if spontaneous delivery fails.

2.3 Summary of literature review

Few studies have been done on gestational weight gain in developing countries, including Malawi. Weight gain within IOM's recommended ranges are associated with better pregnancy outcomes than are weight gains outside these ranges. Gestational weight gain is not properly monitored in pregnant women and it is not individualized in Malawi. Women start visiting ANC late in pregnancy in most developing countries including Malawi, hence its difficult too. to monitor gestational weight gain throughout the pregnancy.

3 PROBLEM STATEMENT, RATIONALE, OBJECTIVES

3.1 Problem statement

High neonatal mortality rates accounts for a substantial early loss of lives in Malawi; and has thus been a hindrance for Malawi to eradicate child deaths. From 2000 to 2011, Malawi achieved an overall reduction of 23% in under-five child mortality (26, 50). The reduction was more substantial between the second and the fifth year of life, being 28%. According to Demographic Health Survey (DHS) 2000, 2004 and 2010 under five mortality decreased from 189 to 133 and then 112 respectively. However, in the neonatal period the reduction was half, at 14%. Neonatal infections and deaths, child mortality, child and adult malnutrition in developing countries are due to prematurity or low birth weight, neonatal infections, birth trauma related conditions and congenital anomalies (3). Being of low birth weight increases the risk of death four fold in the neonatal period. Even when low birth weight infants survive, their poorly developed immune function exposes them to increased morbidity in early life. More studies have shown a strong association between poor gestational weight gain and birth outcomes including low birth weight, and spontaneous preterm deliveries. Gaining less than the recommended amount of weight in pregnancy is associated with delivering a small baby. Some babies born too small may have difficulties in starting breastfeeding, may be at increased risk for illness, and may experience developmental delays (not meeting the milestones for his or her age. However, in Malawi gestational weight monitoring gain is not part of routine ANC, hence it has not been considered yet as one of the interventions to prevent low birth weight, preterm births. Very few studies on gestational weight gain have been done in developing countries including Malawi.

3.2 Rationale of the study

Weight gain during pregnancy is an important predictor of complications for the mother and infant. As it is not part of ANC in Malawi, most women do not achieve recommended weight gain according GWG guidelines. Health workers too have limited knowledge about the importance of adequate GWG. The pregnant woman is supposed to discuss her weight gain goals at the beginning and regularly throughout her pregnancy with her health care provider to achieve her recommended weight gain according to her BMI. More studies have shown a strong association between poor gestational weight gain and birth outcomes including low birth weight, spontaneous preterm deliveries.

The present study is part of an on-going research project in Mangochi district aiming to develop community based delivered nutrition counselling to pregnant women and measure its effect on birth weight. Some initial studies have already been done. This study focuses on exploring the factors that are associated with the rate of gestational weight gain, given that it affects birth related outcomes. This study also identified factors associated haemoglobin status, MUAC and body fat percentage at recruitment as these are nutritional indicators that have impact on pregnancy outcomes.

The study underlines the importance of monitoring individualized gestational weight gain in antenatal care clinics in Malawi and importance of achieving recommended gestational weight gain.

3.3 Study objectives

3.3.1 Main objective

To identify factors that affect the rate of gestational weight gain and other nutritional indicators (Hb, MUAC and body fat %) among pregnant women in a rural district of Malawi.

3.3.2 Specific objectives

- To determine the prevalence of women meeting the IOM GWG guidelines
- To determine how socio economic status/situation among pregnant women affects the rate of gestational weight gain
- To assess the effect of morbidity during pregnancy on the rate of gestational weight gain
- To determine how food security among pregnant women affects gestational weight gain rate
- To determine factors that are associated with haemoglobin status among pregnant women at recruitment (during the first trimesters)
- To determine factors that are associated with anthropometric status (MUAC, body fat percentage) among pregnancy women at recruitment (during the first two trimesters)

3.3.3 Research questions

- How does socio economic status among pregnant women affects the rate of gestational weight gain (i.*e. occupation of household head, mother's literacy level, ownership of household amenities, and access to safe drinking water)*?

- How does morbidity affects gestational weight gain from the onset of pregnancy *(i.e. infections she has suffered from, whether HIV negative or positive)?*

- How does food security during pregnancy affects gestational weight gain rate *(i.e. facing food shortage throughout the year, number of months of food shortage*, *recruitment* season)*?*
- If the women met IOM GWG guidelines- *(i.e. Guidelines based on their initial ANC visit BMI).*
- Which factors were associated with hemoglobin status at recruitment *(i.e. haemoglobin test during initial ANC visit)?*
- Which factors were associated with MUAC and body fat percentage of the women at recruitment *(i.e. body fat percentage calculated from skinfold thickness measurements; biceps, triceps, subscapular and suprailliac)?*

4 SUBJECTS AND METHODS

4.1 The infant and maternal nutrition study (Main study)

4.1.1 Background

The current study was conducted as part of a cluster Randomized Controlled Trial (cRCT) going on in Malawi which is aiming to develop community based nutrition counselling to mothers during pregnancy and measuring its effectiveness in improving birth weight in the Malawian context given that use of lay health workers has been identified as one of the effective strategies to meet the health workforce shortage challenges in low resource settings (51, 52).

Participants for the current study were primarily recruited for the trial. However prior to the trial interventions (treatments & placebo) the current study's data were collected. The objective of the cRCT was to measure the effect of dietary counseling during pregnancy on infant birth weight in Nankumba area, Mangochi district. The primary outcome being infant birth weight. Secondary outcomes were: other infant birth size parameters (length, head and abdomen circumference); maternal dietary intake (actual diet intake & related knowledge & attitudes); **relative pregnancy weight gain (and maternal anthropometric status); maternal biochemical nutritional status (current study).**

4.1.2 Sampling method (main study)

The study was conducted as a pragmatic cluster Randomized controlled trial (cRCT) design with two arms. The cluster randomization was chosen given that that the intervention to be evaluated would be community based, thus posing a risk for contamination if individual randomization could have been chosen instead. The designation of clusters was based on previous boundaries of allocation of clusters by the national census where a cluster has an approximate population of 8000. Each cluster was surrounded by a buffer zone to reduce contamination between treatment and control clusters. Thus, the study area was divided into approximately 40 clusters.

The 40 clusters were stratified into two groups based on their residential terrain (proximity to seashore); into either low land (close to the seashore) or upper land (off seashore). There is a difference in livelihood formats between lakeshore dwellers and those who reside off shore. The former group is more dependent on fishing for a living while the latter relies more on farming. Thus, all clusters in the two strata (close lakeshore and upper shore) of the study area were randomized into either control or intervention clusters to ensure similarity in socioeconomic context between the intervention and control clusters.

Random numbers were generated using STATA and allocated to the clusters. Clusters in each stratum were block randomized in blocks of two into either control or intervention arms. Allocation into either control or intervention arms were concealed. Different study team members who were not directly involved in data collection carried out the randomization process.

The current researcher and data collectors of anthropometrical measurements did not know the cluster arms because they were working independently from the intervention delivery team and the researcher analyzed the data of the cohort of all pregnant women together regardless of cluster arms (intervention/control) as there was a delay in intervention initiation.

4.1.3 Study area

The study was conducted in one of the 7 Traditional Authority (TA) areas of Mangochi district, Namkumba. A traditional authority area is a division of district ruled by chiefs. Nankumba TA is 70 km from Mangochi District/Town in Southern Malawi. The population is a mixture of Yao, Tumbuka and Chewa tribes and is both Muslim and Christian. The population size of this area is approximately 150 000 people. There are six primary health facilities surrounding TA Nankumba. Of the five one is a community rural hospital, one mission health center and three government health centres. These facilities provide the local population with free preventive and curative modern health services such as family planning, antenatal and delivery care, and treatment of common illnesses. Only 19 villages were selected because of the trial protocol. *i.e.* Selected villages were supposed not to share boundaries hence few villages could be selected. (**Appendix 1**).

Figure 2: Malawi map showing Mangochi district and neighbouring countries

4.2 Study population

Pregnant women who participated in the current study were recruited from end November 2015 until end of July 2016. However in the ongoing cRCT, participants were recruited until-September 2016.

Inclusion criteria

1. Pregnant at ≥ 8 weeks but ≤ 24 weeks of gestation
2. Available during the period of the study.
3. Intention to give birth at the health facilities within the study area
4. Consented to participate (indicated by a signature or fingerprint)

The intention was to recruit the women as early in the pregnancy as possible; however, women are less likely to identify themselves as pregnant within the first trimester therefore women were also recruited in second trimester.

NB: **Loss to follow up** was defined as participants moving out of the study zone where it was impossible to follow them up.

Exclusion criteria

1. Severe illness, where the mother is bed ridden
2. Twin pregnancy
3. Mental illness

4.3 Study design

A longitudinal study was conducted on pregnant women who met the inclusion criteria. The study used quantitative methodology.

At the onset of the study, leadership (chiefs, village committees etc.) in the selected clusters were notified about the study. Female community volunteers who are already involved in the delivery of community based health services were chosen from each cluster. Their task was to identify pregnant women early in their pregnancies.

Participants were recruited through the following process:

1. Door-to-door visits were made by a female member of the village health committee (in liaison with the Health Surveillance Assistants (HSAs), where interested pregnant mothers were enlisted. After identification, the pregnant woman was given a referral letter **(Appendix 2)** to the nearest clinic for screening and recruitment.
2. An Abdominal Ultra Sound (USS) for gestation was conducted for gestation age. Human Chorionic Gonadotropin (HCG) test was done where necessary (to rule out pregnancy).
3. The woman attended normal Antenatal Care Clinic (ANC) after USS, before recruitment because: (1). ANC service is offered in the morning and this helped the woman not to miss the routine ANC service as our procedure took much time, (2). We needed HIV status data from the ANC visit and (3). Our USS results also helped the midwife with data for the particular ANC visit.
4. Interviews: SES and morbidity questionnaires **(Appendix 3 and 4)** were administered.
5. Anthropometric measurements: skinfold thickness measurements (biceps, triceps, subscapular and suprailliac), Mid Upper Arm Circumference, weight and height **(Appendix 5)**; Blood tests: Random blood sugar (RBS) and Haemoglobin (Hb) **(Appendix 6)**.

4.4 Sample size and statistical power

The majority of expecting mothers in poor rural settings of Malawi have BMIs that ranges from ≤ 18.5 kg/ m^2 (underweight) to (18.5 – 24.9 kg/ m^2) or normal weight. The sample size is based on having a power of 80% to detect a difference in mean BMI of approximately 0.5 units using a critical level of significance of 5%. The difference was intended to be measured in first trimester (at recruitment) and at the end of second trimester (follow up).

$$n = \frac{2\delta^2(z_{\alpha/2} + z_{\beta})^2}{\Delta^2}$$

Here, δ is the standard deviation (I assumed that the standard deviation of observations in each group would be equal to 2 BMI units), α is the desired level of significance (typically 1.96 for a 95% confidence interval), β is the desired power (typically 0.84 for a power of 80%) and Δ is the effect size (the difference between an underweight mother and a mother of normal weight)

Therefore, $n = \frac{2 \times 2^2 \times (1.96 + 0.84)^2}{0.5^2} = 125.44$

Approximately, a total sample size of **252 participants** (126 women in each group – underweight and normal weight (The sample size which was calculated during protocol writing).

Two hundred and fifty seven participants were included in the study in under-, normal- and overweight BMI categories according to WHO; 18, 201 and 38 women respectively.

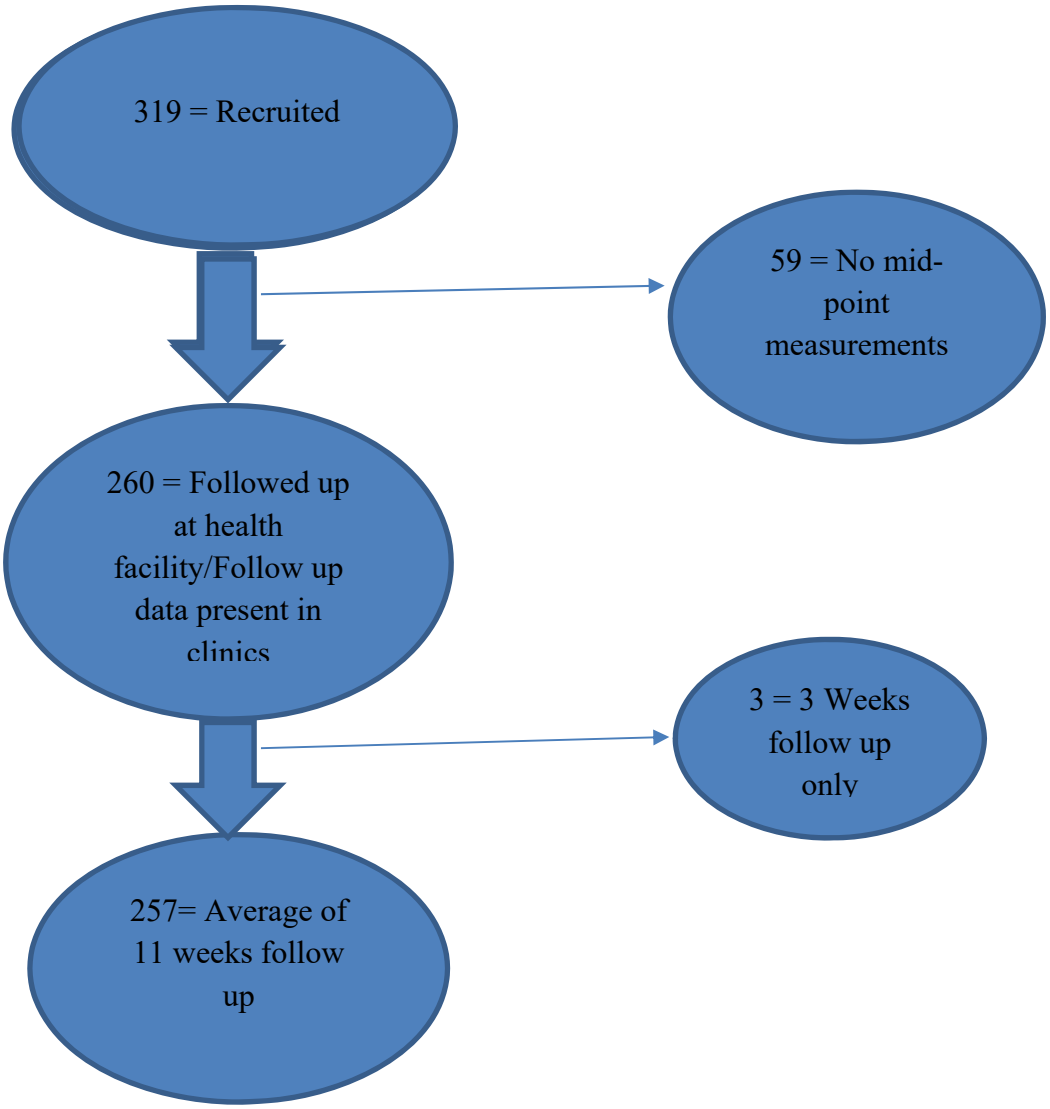

Figure 3: Flow chart of participants included in the study.

A total of 319 pregnant women were recruited in first and second trimesters. 59 women were lost in the course of retrieving follow up data in health centres and others did not come to mid-point measurements after being called. 3 women had a short follow up period (3-5 weeks).

4.5 Ethical considerations

4.5.1 General principles

Ethical clearance for conducting the study was obtained from the ethical clearance committees in Norway and Malawi **(Appendix 7 and 8)**. Confidentiality of the data being collected was observed throughout the process of the research. The study adhered to the principles of Helsinki declaration and regulatory guidelines in Malawi. In order to sensitize the local community to the project the chiefs from all villages of the Nankumba traditional authority were invited to an information meeting held by the study coordinator. The chiefs were informed about the purpose of the study; how it would be conducted, the importance and potential benefits of the project. They were given the chance to raise questions and concerns. The hospital staff was informed too and consent was given. The study coordinator introduced the researcher and the data collectors to the in charge of the community hospital who further introduced the researcher to other concerned staff.

4.5.2 Informed consent

All potential participants received information about the study during an initial visit to the participants' homes (through volunteers). Before Ultra Sound Scanning (USS), the participants were given information about the study by either the researcher or the research assistants. All eligible women who wished to participate signed consent form or left a fingerprint on the consent form, indicating the voluntary nature of the study and the participants' right to discontinue from participating at any point in the course of the study **(Appendix 9 and 10).** Amount of blood collected through drops of blood was approximately equivalent to 70 microliters, a negligible amount of an individual's blood. The collection of the sample caused the mothers some discomfort, but it had no biological significance to them and the pain was for short time. Data on HIV status of the participants was treated with confidentiality and anonymity. All answers given by the participants were treated with confidentiality and the data was kept in a secure place. As a compensation for their time, the participants received a lunch allowance of 250 Malawi kwacha (around 3kr) and transport refund (exact amount she spent on transport).

4.6 Data collection

4.6.1 Preparation for data collection

In July, the Principle Investigator (PI) introduced the researcher to the director of the Monkey Bay Community Hospital (MBCH), the health facility which was the main data collection site. The hospital director later introduced the researcher to other concerned hospital staff including Antenatal care clinic staff, labour ward staff.

4.6.2 Anthropometric measurements and blood tests

Following ethical clearance, the researcher had to become familiar with performing anthropometric measurements.

- Firstly, research nurses from the previous study of the same project were invited for training where they showed the researcher and PI how they were conducting anthropometric measurements in the previous study.
- The researcher compared articles, guidelines, and books and watched videos to come up with training materials on anthropometric measurements. At the same time, she also attended antenatal care clinic for observation (approximately two weeks).
- She later practiced taking skinfold thickness measurements and blood tests for Hb and RBS (hemacues for Hb and RBS used were different with those used in Malawi which the researcher was familiar with) on women attending antenatal care clinic – consent was sought from these women and it helped too in diagnosing anaemia, low or high glucose levels

NB: These women were not study participants and the researcher is a licensed nursing officer in Malawi

4.6.3 Ultra sound scanning for gestational age

Previously experienced research nurses trained the researcher and two research assistants (nurses) on how to do abdominal ultra sound scanning for gestational age; this was both theory and practice. The training took two weeks (in September).

4.6.4 Research Assistants

Two research assistants (nurse - midwife technicians) were employed. The principle investigator recruited them. These nurses worked together with the researcher. One more research assistant (ordinary level) was employed a month later to help the nurses and the researcher with the interviews. All of them were fluent in English and in Chichewa.

The principal investigator and the researcher developed a training schedule for the other data collectors on how to perform the measurements. The researcher and the principle investigator understood the concepts before training the assistants (as said earlier). The researcher consulted anthropometry expert in Australia (Timothy Olds) for clarifications where not clear. After one month of practicing the measurements at Monkey bay community hospital ANC clinic, standardization of the measurements was done for consistencies in the readings (different measurers on one patient), including the Principal Investigator (PI).

4.6.5 Questionnaire development

Two structured precoded questionnaires previously developed and used in the study area, was used for data collection on socio demography and morbidity.

The PI gave a detailed training using the questionnaires, on how to conduct the interviews. Each part of the interview was demonstrated before practicing on each other.

The questionnaire captured information on the following:

Socio-demographic characteristics: age, sex, marital status, literacy, profession, parity, assets owned, type of house roofing, floor, household size, number of children under five years in a household, child spacing, food security, source of drinking water, source of food, place of birth **(Appendix 3).**

Morbidity: First section was for measurements readings, blood tests results and ultra sound scanning results. Medical history in the current pregnancy, past medical/surgical history, chronic illness history, iron supplementation history of the current pregnancy. Data on maternal HIV sero-status was collected, due to the sensitivity of information pertaining to an individual's HIV status, the data was collected as secondary data from their health passport books or hospital records **(Appendix 4)**

4.6.6 Pre-testing

The questionnaires were later tested on women attending antenatal care clinic at Mangochi district hospital. These women were not from the study area. Based on the responses during the pre-testing, changes on the questionnaire were made. Changes and corrections were made following pretesting in both English and Chichewa questionnaire. Translational changes were also made.

4.7 Data collection logistics

The data collection study site where more women were expected to utilize the health services, MBCH was stationed by the researcher and the two research assistants. One study nurse was responsible for the relatively minor site, Nankumba health centre. The researcher also worked at this site occasionally.

Through door-to-door visits, volunteers identified pregnant women early in their pregnancies. The volunteers gave each woman a referral letter to either Namkumba health Centre or Monkey bay community hospital depending on which village she was from. At the clinic, the researcher or the nurses or radiology technician (only at Monkey bay hospital|) conducted abdominal ultrasound scanning (USS) for pregnancy confirmation and gestational age. Where USS was not clear, urine for Human Chorionic Gonadotropin (HCG) test was taken to rule out pregnancy. Only eligible pregnant women were recruited after USS. USS results were also documented in the health passport book. The researcher together with the research assistants conducted all the interviews and anthropometric measurements. The nurse at Namkumba health centre was responsible for all procedures.

4.8 Data handling

Questionnaires were checked at the end of each interview by the interviewer, they were also re-checked by the data entry clerk and the researcher for inconsistencies. Data entry clerk and the researcher allocated serial numbers to the questionnaires (serial numbers were given according to date of interview after combining questionnaires from both health facilities). Where data was missing or any confusion about responses written in the questionnaires, the researcher or the data entry clerk would contact the participant through the community volunteers (those who referred them), the volunteers know every study participant in their villages.

4.9 Data analysis

Data was entered in SPSS by the researcher herself whilst in Malawi and exported later into, Stata in Norway. All analyses were done using Stata SE14 and IBM SPSS 24. The variables were classified as below:

Dependent variables

Gestational weight gain, haemoglobin, MUAC and body fat percentage.

Explanatory variables

BMI at recruitment, age, season of recruitment, mother's education level, HIV status, house hold head profession, malaria, assets owned, diarrhea, house hold size, appetite loss, food security; number of eating times and food shortage months.

Gestational age: Women were recruited at different gestational ages; others were recruited in first trimester and others in second trimester. It is expected that as a pregnancy progresses, physiological changes happen. Due to variation in gestational age at recruitment, (we treated gestation age on recruitment as an independent variable in all regression models (GWG, hb, MUAC and body fat percent).

4.10 Operational definitions of important variables

Rate of Gestational weight gain: Amount of gestational weight gain per week. According IOM guidelines every woman has her weekly recommended rate according to her BMI and which trimester she is in. It was calculated from the difference of weight between mid-point weight measurement and weight measured at the time of recruitment.

BMI at recruitment: BMI was calculated using weight at recruitment and height (weight/height^2). We were supposed to use Pre gestational BMI; unfortunately, pre gestational weights could not be retrieved from health passport books since women start ANC late and do not go to pre conception counselling. Other studies have used reported pre gestational weights and others have used initial ANC weight (especially early months) to establish BMI for determining gestational weight gain (44, 47).

Haemoglobin level: Haemoglobin was used detect and measure the severity of anaemia in this study. Normal Hb cut off (g/dl) according to WHO (12).

First trimester: 11.6 – 13.9

Second trimester: 9.7 – 14.8

Third trimester: 9.5 – 15.0 (53)

Haemoglobin and glucose levels were tested using **Hemocue Hb 301** and **Hemocue Glucose 201** respectively**.** The middle or ring finger was used. Sample was taken at the side of the fingertip **(appendix 6).**

Anthropometric measurements **(Appendix 5)**

All the measurements were taken at the time of recruitment excluding mother's weights, which were measured at mid -point too**.**

Mothers' weights: Weight of the mother in kilogram. Weights were taken using a Seca digital weight scale in kilogram mode, the woman was asked to remove shoes and remove extra clothes (wrapper, cardigan) to be in light/thin clothes (all data collectors were ladies and no woman felt offended to remove clothes when necessary).

Mothers' heights*:* Stadiometer with a fixed vertical backboard and an adjustable headpiece was used to measure standing height; it was with a minimum range of measurement of 60 cm to 220cm and placed on a hard and level floor.

Skinfold thickness measurements (SFTM): A Harpenden skinfold caliper was used to measure SFTM (triceps, biceps, suprailliac and subscapular) to the nearest 0.1mm and it was calibrated to zero. The sum of SFTM was used to calculate body fat percentage.

MUAC: The circumference of the upper arm, measured at the mid-point between the tip of the shoulder and the tip of the elbow (olecranon process and the acromion). It was measured using a tape measure (Seca tape measure).

Body fat percentage: Percentage of fat the body contains, in this study, body fat percentage was calculated using the sum of four skinfold thicknesses (biceps, triceps, subscapular and suprailiac) and the body fat percentage look up table (25) **(appendix 11).**

Trimester: A normal, full-term pregnancy ranges from 37-42 weeks and is divided into three trimesters. Each trimester lasts between 12 and 14 weeks. The first trimester lasts from the first through the 13th week of pregnancy. The second trimester lasts from 13th week through 27th. The third trimester lasts from the 28th week through delivery.

SES : Income is an important indicator of SES as it influences other factors that also predict health (48). Given the resource constraints to measuring household income or expenditure in low- and middle-income country settings, other methods of developing SES indices are being used which streamline the variables required, enabling data to be collected more rapidly. Rather than income or expenditure, SES data can be collected from variables that capture living standards, such as household ownership of durable assets(54). An asset index was calculated as a proxy for the household's economic status by adding the household's asset scores. Each asset was given a score relative to its monetary value and functionality as follows: Car = 8; Fridge or TV or motorcycle or fishing canoe = 4.0; Mattress or bicycle = 2.0; Radio = 1.0; Blankets = 0.5; Mosquito net = 0.25; Mobile phone = 2.0. These values have previously been used in studies in rural areas in Malawi (55-58).

SES was calculated using assets owned where each asset was given a score (previously used in different studies in rural Malawi) and then all the scores added of each individual, SES was then categorized using percentiles as follows.

Percentile	Score	Category
≤ 25th percentile	≤ 1.25	Very poor
>25th to 75th percentile	1.251 to 6.75	Poor
>75th percentile	> 6.75	Well off

4.11 Statistical methods

The Institute of Medicine (IOM) recommends different weight gains for expecting mothers depending on their body mass indices (BMI) regardless of race/ ethnicity. In this study, it was also necessary to establish the prevalence of expecting mothers meeting the recommended pregnancy weight gain (rate of weight gain). The women were followed for approximately eleven weeks (SD: 4.12).

Data on changes in gestational weight between the time of recruitment and the mid-point were measured on a continuous scale and then categorized according to whether the women met the IOM guidelines or not during this period. These binary data (met/ not met) were analyzed using the logistic regression model within the Generalized Linear Regression Model (GLM) framework. Using this model, factors that were associated with the binary responses were identified and explained. The modeling process proceeded in two steps; first, bivariate models were fitted to the data in order to find significant variables. Secondly, variables that were significant in the bivariate analysis together with the clinically relevant variables were then used to fit the multiple regression models. We were also able to compare the changes in pregnancy weight between the two groups of women (recruited in first and second trimester).

Generalized Linear Regression Model (GLM) was also used to identify factors associated with haemoglobin status, MUAC and body fat percent at recruitment.

All analyses were performed using Stata SE 14 and IBM statistics 22 and significance level was set at $\alpha = 0.05$.

5 RESULTS

5.1 Sociodemographic characteristics of the study participants

There were no significant differences between the characteristics of women recruited in the first and second trimester. Two hundred and fifty seven participants were included in the study of which 52.5% were recruited in the first trimester and the rest in the second trimester of pregnancy. Demographic characteristics of the study participants are shown in **Table 2.** The mean age of the women was 24.7. Mean number of household size was 4.7. On average, the women had undergone two previous deliveries. More than half of the sample had only two meals per day (56.4). A day passing without food during food shortage months occurred in 37.0% of the whole sample.

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Table 2: Sociodemographic characteristics of the participants

	Stage of recruitment			
Demographic factor	First trimester	Second trimester	Total	*P*-value
Sample size (n %)	135 (52.5)	122 (47.5)	257(100)	0.16
Age (Mean± SD)	25.12 ± 6.64)	24.11 ± 5.78	24.66 ± 6.26	0.14
Marital status				
Unmarried/divorced	11 (8.1)	15 (12.3)	26 (10.1)	0.36
Married	124 (91.9)	107 (87.7)	231 (89.9)	0.14
Number of children alive				
Null	40 (29.6)	38 (31.1)	78 (30.4)	0.42
1-3	69 (51.1)	63 (51.6)	132 (51.4)	0.51
4+	26 (19.3)	21 (17.2)	47 (18.3)	0.42
Household size				
≤ 4	59 (43.7)	65 (53.3)	124 (48.2)	0.10
≥ 5	76 (56.3)	57 (46.7)	133 (51.8)	0.10
Household head				
Study participant	2 (1.5)	5 (4.1)	7 (2.7)	0.43
Husband	116 (85.9)	111 (91.1)	227 (88.3)	0.06
Parents	9 (6.7)	5 (4.1)	14 (5.4)	0.84
Parent in-law	2 (1.5)	0 (0)	2 (0.8)	
Other	5 (3.7)	0 (0)	5 (1.9)	
Education of mother				
Primary 1-4/ No school	45 (33.3)	38 (31.1)	83 (32.3)	0.38
Primary 5-8	70 (51.9)	62 (50.8)	132 (51.4)	0.47
Secondary/ tertiary	20 (14.8)	22 (18.0)	42 (16.3)	0.38
Profession of the mother				
Unemployed	94 (69.6)	83 (68.0)	177 (68.9)	0.45
Employed	41 (30.4)	39 (32.0)	80 (31.1)	0.47
Profession of household head				
Subsistence farmer/ Labourer	53 (39.3)	47 (38.5)	100 (38.9)	0.48
Fisherman/trader/paid professional	82 (60.7)	75 (61.5)	157 (61.1)	0.47
Socioeconomic status				
Very poor	37 (27.4)	33 (27.0)	70 (27.2)	0.52
Poor	70 (51.9)	55 (45.1)	125 (48.6)	0.88
Well off	28 (20.7)	34 (27.9)	62 (24.1)	0.53
Food source				
Direct harvest	66 (48.9)	66 (54.1)	132 (51.4)	0.28
Family assistance	3 (2.2)	3 (2.5)	6 (2.3)	0.49
Purchasing	64 (47.4)	52 (42.6)	116 (45.1)	0.30
Food for work	2 (1.5)	1 (0.8)	3 (1.2)	0.48
Number of daily meals				
1	4 (3.0)	8 (6.6)	12 (4.7)	0.40
2	78 (57.8)	67 (54.9)	145 (56.4)	0.36
3	53 (39.3)	47 (38.5)	100 (38.9)	0.53
Food shortage				
Yes	29 (21.5)	34 (27.9)	63 (24.5)	0.26
No	106 (78.5)	88 (72.1)	194 (75.5)	0.13
Whole day without food				
No	84 (62.2)	78 (63.9)	162 (63.0)	0.41
Yes	51 (37.8)	44 (36.1)	95 (37.0)	0.43

5.2 Anthropometric measures, haemoglobin (Hb), glucose and HIV status.

Anthropometric measures, Hb and glucose at the time of recruitment of participants are shown in **table 3**. The results showed that women in the second trimester had a mean BMI of 22.4 kg/ m^2 whereas women in the first trimester had a mean BMI of 21.7 kg/ m^2 ($P = 0.02$). Women in the first trimester had a higher Hb level of 11.7 g/dl compared to 11.1 g/dl for women in the second trimester ($P < 0.01$). Women in the first trimester had a mean weight of 53.0 kg while women who were recruited in second trimester had a mean weight of 55.3 kg ($P = 0.02$. 14.8% of the women recruited in the first trimester were HIV positive compared to 9% of the women recruited in the second trimester.

Table 3: Anthropometric measures, Hb, and glucose and HIV status at recruitment

	Stage of recruitment			
Measurements (mean ± SD)	First trimester	Second trimester	Total	*P*-value
Sample size, n (%)	135 (52.5)	122 (47.5)	257 (100)	0.16
BMI, Kg/m^2 (Mean ± SD)	21.7 ± 2.5	22.4 ± 2.8	22.0 ± 2.7	
Weight, kg (Mean ± SD)	53.0 ± 7.1	55.3 ± 7.7	54.1 ± 7.5	0.02
Height, cm (Mean ± SD)	156.6 ± 5.7	157.2 ± 6.8	156.3 ± 10.8	0.28
MUAC, cm (Mean ± SD)	26.8 ± 2.5	27.2 ± 2.6	27.0 ± 2.5	0.15
Body fat, % (Mean ± SD)	22.9 ± 3.9	23.1 ± 4.2	23.0 ± 4.0	
Blood tests				
Glucose, mmol/l (Mean ± SD)	6.4 ± 1.1	5.8 ± 1.0	6.1 ± 1.1	0.01
Haemoglobin ,g/dl,(Mean ± SD)	11.7± 1.4	11.1 ± 1.6	11.4 ± 1.5	< 0.01
Morbidity				
HIV status				
Positive, n (%)	20 (14.8)	11 (9.0)	31 (12.1)	0.3
Negative, n (%)	106 (78.5)	107 (87.7)	213 (82.9)	0.4
Unknown, n (%)	9 (6.7)	4 (3.3)	13 (5.1)	0.4

Table 4: Recruited women according to BMI categories

BMI Category	n (%)	Mean BMI ± SD
Underweight	18 (7.0)	17.7 ± 0.8
Normal weight	201 (78.2)	21.5 ±1.7)
Overweight	38 (14.8)	26.6 ± 1.4)

Haemoglobin status according to World Health Organization cut-off points is shown in **Figure 4**. The study showed that 0.4%, 15.6% and 21.8% of the mothers had severe, moderate and mild anaemia respectively. The rest had normal level of haemoglobin at recruitment.

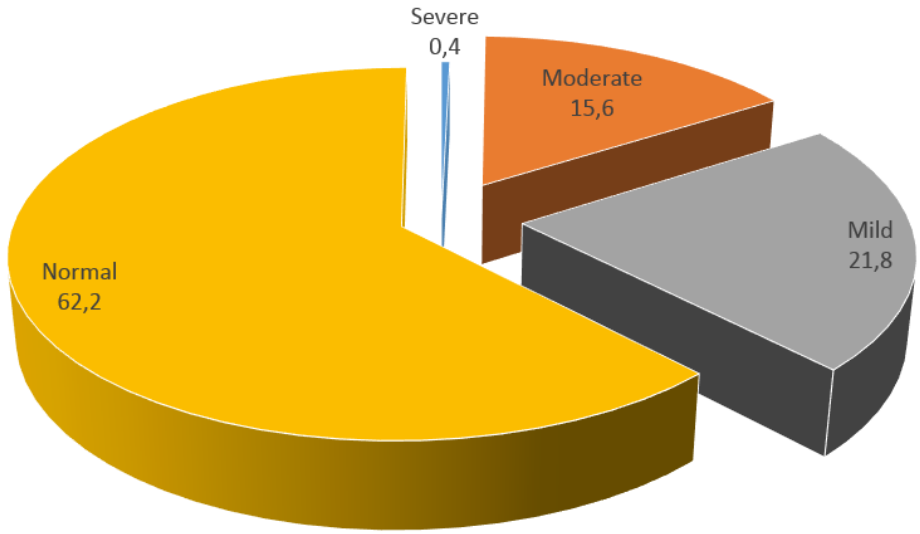

Figure 4: Haemoglobin status at recruitment according to WHO cut off points in pregnancy

5.3 Prevalence of women meeting adequate GWG

5.3.1 Percent of women meeting IOM's gestational weight gain guidelines compared to those who did not

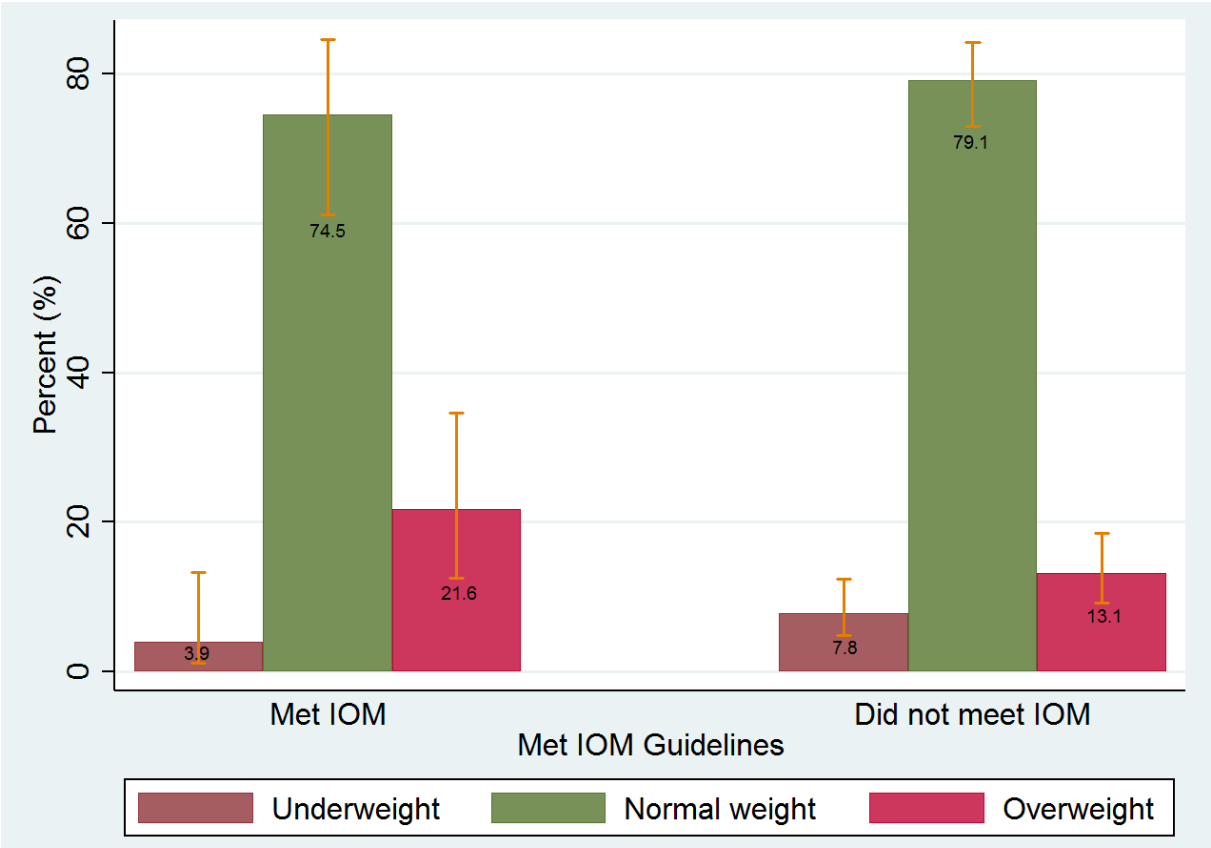

Figure 5: Percent women meeting IOM's gestational weight gain guidelines

The results showed that, 19.8% of all the women gained according to IOM's recommendations. Of these, 3.9% were in the underweight category, 74.5% in the normal and 21.6% were in overweight category.

In total, 80.2% of the women undergained and none overgained during this period.

5.3.2 Percent of women meeting IOM's gestational weight gain guidelines within three BMI categories

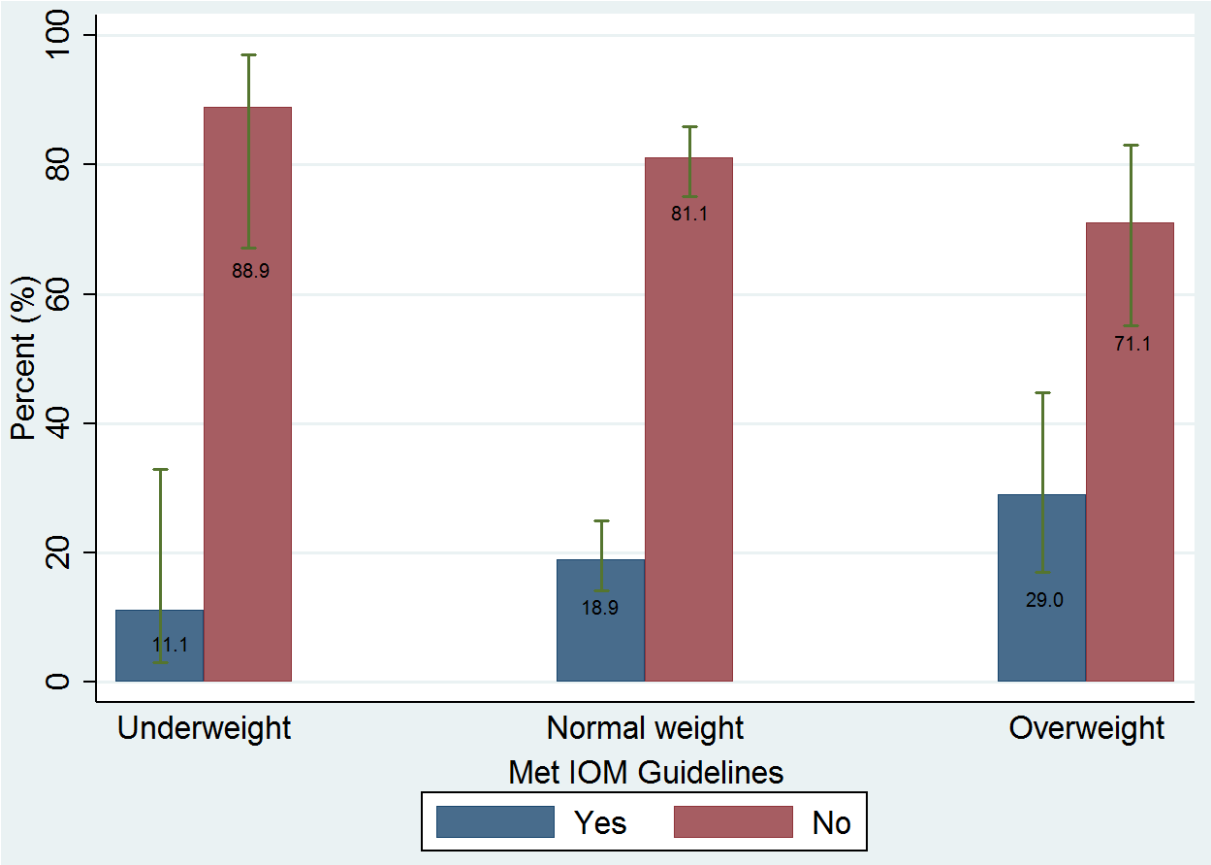

Figure 6: Percent of women meeting IOM's gestational weight gain guidelines within each BMI category versus those who did not

The study showed that the percentage of women meeting the IOMs guidelines increased for each increase in weight category; 11.1%, 18.9% and 29.0% of the women in underweight, normal and overweight BMI categories.

5.3.3 Comparison of GWG rate between IOM guidelines and our study results

Table 5: Comparison of GWG per week between IOM guidelines and our study results

Weight categories	Pre-gestational BMI (kg/m^2)	IOM mean gwg/wk (kg)	Study mean gwg/wk (kg)
Under weight	< 18.5	0.51 (0.44- 0.58)	0.31 (0.21 -0.39)
Normal weight	18.5 – 24.9	0.42 (0.35- 0.50)	0.26 (0.24 -0.28)
Over weight	25.0 – 29.9	0.28 (0.23 – 0.33)	0.22 (0.14 – 0.30

The results showed that the women on average were gaining below IOM guidelines per week in all three BMI categories as shown in **table 5**. The mean gestation weight gain rate was 0.26kg (SD ± 0.2).

5.4 Changes in pattern gestational weight

5.5 Changes in pattern gestational weight

The mean gestational weight gain for the whole group at follow up (an average of 11 weeks) was 2.89kg (SD ± 2.03). Changes in mean gestational weight are shown in **figure 7.** The results show that women recruited in the first trimester gained on average 3.22 kg, ($P < 0.01$) whereas women recruited in the second trimester gained an average of 2.58 kg ,($P < 0.01$) from recruitment to midpoint (average of 11 weeks). There is a difference between pattern GWG of the sample and a week-by-week IOM weight gain curve (**Appendix 12**) as these women were recruited at different gestational ages in their specific trimesters.

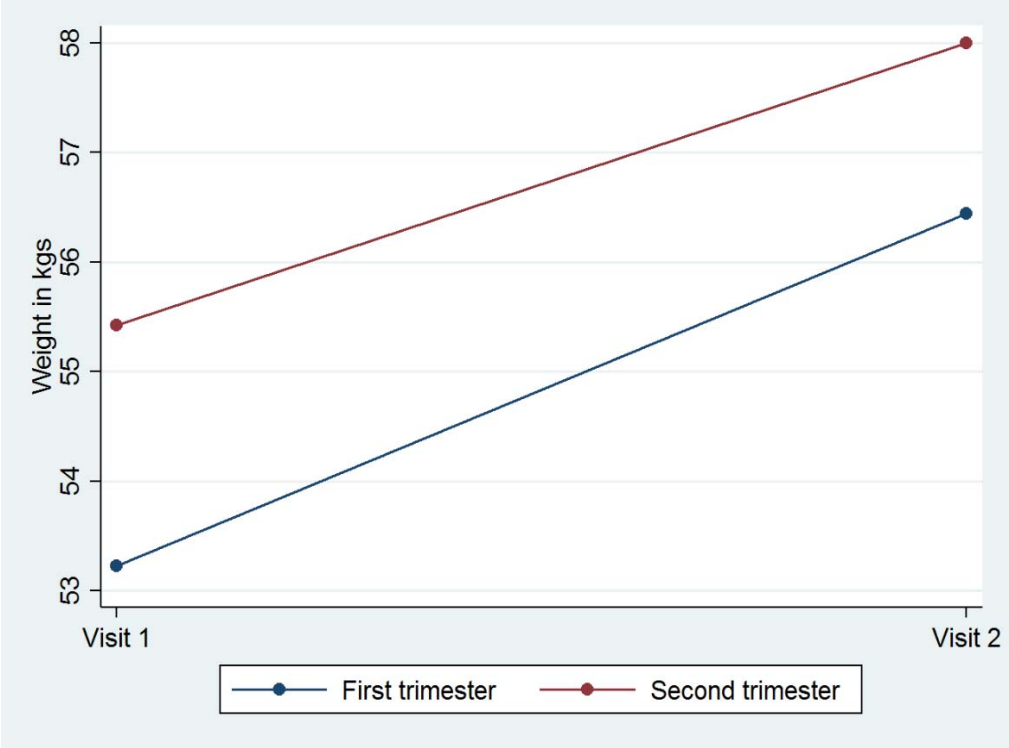

Figure 7: Patterns of gestational weight gain in women recruited in first trimester versus second trimester

5.6 Factors associated with the rate of gestational weight gain

A total of 206 women representing 80.2 % did not gain according to the IOM guidelines. The analysis showed that 85.6 % of the 180 women who were recruited before the harvest season failed to gain accordingly whereas 67.5 % of the 77 women who were recruited in the harvest season also failed to gain according to the IOM guidelines.

Figure 8 is a forest plot showing the relative risk (RR) for the effect of season on GWG by social demographic factors. The likelihood of failing to gain according to IOM was 33% higher among HIV negative women who were recruited before harvest compared to HIV negative women who were recruited after the harvest season. For women who were recruited before the harvest season, the risk of failing to meet IOM guideline increased by 56% in the normal BMI category, by 39% among multiparous and by 69% among women whose HH were subsistence farmers.

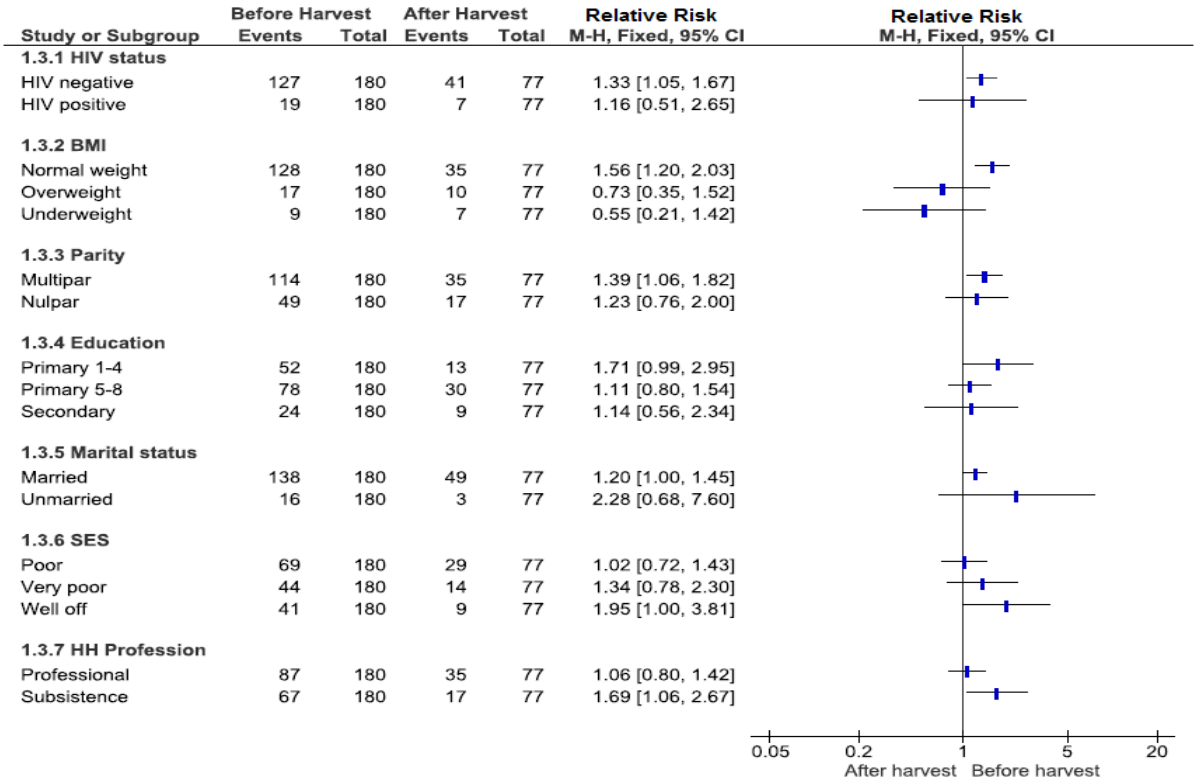

Figure 8: Forest plot showing RR for the effect of season on GWG by socio demographic factors

Factors that are associated with rate of gestational weight gain are presented as unadjusted and adjusted estimates in **Table 6.** Based on a $P \leq 0.05$ in the bivariate analysis; season was considered for the multiple logistic regression analysis. The multiple logistic regression analysis also included clinically relevant variables; HIV status, marital status, parity and mother's education, SES, BMI and household head profession.

Women who were recruited before the harvest season were more likely to gain inadequately as compared to women who were recruited after the harvest season. The odds of gaining according to the IOM guidelines significantly decreased by 67% among those who were recruited before the harvest season compared to those who were recruited after the harvest season. No further explanatory variables were significantly associated with the rate of gestational weight gain.

Table 6: Factors associated with the rate of gestational weight gain

	Sub-optimal GWG	Bivariate Analysis		Multiple Logistic Regression Analysis	
Exaplanatory variables	**n (%)**	**OR (95 % CI)**	***P*-Value**	**AOR (95 % CI)**	***P*-Value**
Gestational age on recruitment		1.07 (0.99, 1.16)	0.09	1.01 (0.93, 1.11)	0.77
BMI at recruitment (Ref: Normal)					
Underweight	2 (3.9)	0.54 (0.12, 2.43	0.42	0.43 (0.09, 2.11)	0.30
Overweight	11 (21.6)	1.74 (0.80, 3.83)	0.16	1.31 (0.55, 3.10)	0.54
HIV status (Ref: Negative)					
Positive	5 (10.0)	0.72 (0.26, 1.98)	0.52	0.79 (0.27, 2.35)	0.68
Number of live children (Ref: 0)					
1+	30 (58.8)	0.55 (0.29, 1.03)	0.06	0.50 (0.24, 1.02)	0.057
Marital status (ref: Married)					
Unmarried/separated/divorced	7 (13.7)	1.57 (0.62, 3.96)	0.34	1.47 (0.50, 4.32)	0.48
SES (ref: Well-Off)					
Very poor	12 (23.5)	0.86 (0.36, 2.09)	0.74	0.96 (0.36, 2.48)	0.93
Poor	27 (52.9)	1.15 (0.54, 2.46)	0.72	1.12 (0.48, 2.61)	0.80
Mother's education (ref: Secondary/ tertiary)					
Primary 1-4/ no school	18 (35.3)	0.80 (0.40, 1.59)	0.59	0.68 (0.32,1.44)	0.32
Primary 5-8	24 (47.1)	0.98 (0.40, 2.43)	0.97	1.09(0.41,2.87)	0.87
HH head profession (ref: Fisherman/trader/paid professional)					
Subsistence farmer/paid labourer	16 (31.4)	0.66 (0.35, 1.28)	0.22	0.81 (0.40, 1.65)	0.56
Season of recruitment (ref: after harvest)					
Before harvest	26 (51.0)	0.35 (0.19, 0.66)	**< 0.01**	0.33 (0.16, 0.65)	**< 0.01**

5.7 Factors that are associated with haemoglobin status at recruitment

Factors that are associated with Hb levels at recruitment are presented as unadjusted and adjusted estimates in **Table 7**. Based on a significance level of $P \leq 0.05$ in the bivariate analysis; household size, malaria, gestation age and mother's education were considered for the multiple linear regression analysis. The multiple regression analysis also included clinically relevant variables; diarrhoea and HIV status, parity, marital status, SES and season of recruitment.

For each increase in a woman's gestation age at baseline (at recruitment), there was a decrease in Hb of 0.07g/dl ($P = 0.01$). The results also showed that women who suffered from malaria (once or more) between conception and recruitment day had a decrease in Hb of 0.47g/dl ($P = 0.04$). No further explanatory variables were significantly associated with Hb levels at recruitment.

Table 7: Factors associated with level of haemoglobin (Hb) at recruitment

	Bivariate Analysis		Multiple Linear Regression Analysis	
Explanatory variables	**β (95%CI)**	***P*-Value**	**β (95%CI)**	***P*-Value**
Gestational age at recruitment (in weeks)	-0.06 (-0.11, -0.01)	**0.01**	-0.07 (-0.12, -0.02)	**0.01**
Diarrhea (Ref: No)				
Yes	-0.27 (-0.71, 0.16)	0.22	-0.11 (-0.56, 0.35)	0.65
HIV status (Ref: Negative)				
Positive	-0.22 (-0.80, 0.35)	0.45	-0.35 (-0.93, 0.22)	0.23
Malaria (Ref: Negative)				
Yes	-0.47 (-0.89, -0.05)	**0.03**	-0.47 (-0.92, -0.03)	**0.04**
Number of live children (Ref: 0)				
1+	0.51 (0.11, 0.91)	0.01	0.24 (-0.22, 0.71)	0.31
Marital status (ref: Married)				
Unmarried	-0.11 (-0.72, 0.51)	0.74	-0.05(-0.73, 0.63)	0.88
SES (ref: Well off)				
Very Poor	-0.31 (0.83, 0.20)	0.23	-0.27 (-0.81, 0.28)	0.34
Poor	-0.10 (-0.56, 0.36)	0.67	-0.22 (-0.70, 0.27)	0.38
Household size (ref: less than 4)				
4 and above	0.48 (0.12, 0.85)	**0.01**	0.35 (-0.06, 0.77)	0.10
Mother's education (ref: primary 1-4/ no sch)				
Primary 5-8	-0.51 (0.92, -0.09)	**0.02**	-0.42 (-0.84, 0.01)	0.06
Secondary/ tertiary	-0.03 (-0.59, 0.52)	0.91	-0.01 (-0.59, 0.56)	0.97
Season				
Before harvest	0.05 (-0.35, 0.46)	0.80	-0.11 (-0.54, 0.31)	0.60

5.8 Factors associated with Mid-Upper Arm Circumference (MUAC) at baseline

Factors that are associated with MUAC in centimeters at recruitment are presented as unadjusted and adjusted estimates in **Table 8.** Based on a $P \leq 0.05$ in the bivariate analysis; mother's age and parity were considered for the multiple linear regression analysis. The multiple regression analysis also included clinically relevant variables; HIV status, gestational age, marital status, household size, mother's education, SES, season of recruitment. For each increase in a mother's age, there was an increase in MUAC of 0.08 centimeters ($P = 0.03$). The results showed that there was a decrease in MUAC with 1.06 centimeters in mothers belonging to the very poor category at recruitment as compared to mothers who were well off ($P = 0.02$). Women belonging to a household of 4 or more household members had a decreased MUAC with 0.85 centimeters as compared to those women belonging to a household with less than 4 ($P = 0.03$). No further explanatory variables were significantly associated with MUAC at recruitment.

Table 8: Factors associated with Mid-Upper Arm Circumference (MUAC) at recruitment

	Bivariate Analysis		Multiple Linear Regression Analysis	
Exaplanatory variables	**β (95%CI)**	***P*-Value**	**β (95%CI)**	***P*-Value**
Gestational age at recruitment (in wks)	0.03 (-0.05, 0.12)	0.47	0.01 (-0.08, 0.10)	0.80
HIV status (Ref: Negative)				
Positive	-0.43 (-1.39, 0.53)	0.38	-0.67 (-1.65, 0.30)	0.18
Mother age	0.06 (0.01, 0.11)	**0.01**	0.08 (0.01, 0.15)	**0.03**
Number of live children (Ref: 0)				
1+	0.75 (0.08, 0.42)	**0.03**	0.30 (-0.60, 1.20)	0.52
Marital status (ref: Married)				
Unmarried	-0.86 (-1.89, 1.16)	0.10	-0.55 (-1.71, 0.60)	0.35
SES (ref: Well off)				
Very Poor	-0.76 (-1.63, 0.11)	0.09	-1.06 (-1.98, -0.14)	**0.02**
Poor	-0.65 (-1.42, 0.12)	0.10	-0.80 (-1.62, 0.01)	0.053
Household size (ref: less than 4)				
4 and above	-0.15 (-0.77, 0.47)	0.64	-0.85 (-1.61, -0.09)	**0.03**
Mother's education (ref: primary 1-4/ no sch)				
Primary 5-8	0.10 (-0.60, 0.79)	0.79	0.07 (-0.65, 0.79)	0.85
Sec/ tertiary	0.51 (-0.43, 1.45)	0.29	0.42 (-0.55, 1.39)	0.40
Season				
Before harvest	-0.47 (-1.15, 0.20)	0.18	-0.49(-1.21, 0.23)	0.18

5.9 Factors associated with body fat % (from 4 skinfold thickness measurements (SFTM): triceps, biceps, sub scapular and suprailliac) at baseline

Factors that are associated with body fat percent at recruitment are presented as unadjusted and adjusted estimates in **Table 9**. Based on a $P \leq 0.05$ in the bivariate analysis; season of recruitment and SES were considered for the multiple linear regression analysis. The multiple regression analysis also included clinically relevant variables; diarrhoea, HIV and gestation age. The study also included socio-demographically relevant variables; parity, marital status, household size, and mother's education, eating times. For each increase in a mother's age, there was an increase in body fat percentage of 0.15 ($P = 0.01$). The results showed that mothers in the very poor SES category had a decreased body fat percentage of 1.69 at recruitment as compared to mothers who were well off ($P = 0.02$). No further explanatory variables were significantly associated with body fat percent at recruitment.

Table 9: Factors associated with Body fat % at recruitment

	Bivariate Analysis		Multiple Linear Regression Analysis	
Exaplanatory variables	**β (95%CI)**	***P*-Value**	**β (95%CI)**	***P*-Value**
Gestational age at baseline (in wks)	0.02 (-0.12, 0.16)	0.77	-0.04 (-0.18, 0.10)	0.59
Diarrhea (Ref: No)				
Yes	-0.70 (-1.85, 0.46)	0.37	-0.56 (-1.76, 0.64)	0.36
HIV status (Ref: Negative)				
Positive	-0.41 (-1.94, 1.12)	0.60	-0.69 (-2.24, 0.87)	0.39
Mother age	0.05 (-0.03, 0.13)	0.19	0.15 (0.03, 0.26)	**0.01**
Number of live children (Ref: 0)				
1+	-0.38 (-1.45, 0.69)	0.48	-1.31 (-2.76, 0.14)	0.08
Marital status (ref: Married)				
Unmarried	-0.28 (-1.91, 1.34)	0.73	-0.09 (-1.93, 1.75)	0.92
SES (ref: Well off)				
Very Poor	-1.74 (-3.09, -0.38)	**0.01**	-1.69 (-3.15, -0.23)	**0.02**
Poor	-0.56 (-1.78, 0.64)	0.36	-0.37 (-1.67, 0.93)	0.58
Household size (ref: less than 4)				
4 and above	-0.18 (-1.16, 0.81)	0.73	-1.05 (-2.25, 0.16)	0.09
Mother's education (ref: primary 1-4/ no sch)				
Primary 5-8	0.44 (-0.66, 1.55)	0.43	0.45 (-0.69, 1.59)	0.44
Secondary/ tertiary	0.87 (-0.62, 2.36)	0.25	0.91 (-0.63, 2.46)	0.25
Season				
Before harvest	-1.07 (-2.14, -0.01)	**0.05**	-1.11 (-2.25, 0.04)	0.06

6 DISCUSSION OF RESULTS

6.1 Overview

In the present study, we examined factors that affect the rate of gestational weight gain in a rural setting. We further assessed factors that are associated with haemoglobin and anthropometric status (MUAC and body fat percent) at recruitment. The prevalence of adequate gestational weight gain according to 2009 IOM guidelines and anaemia according to WHO was also determined.

The study found that 19.8% of the pregnant mothers gained according to IOM. We also found that season of recruitment, especially among subsistence farmers was significantly associated with the rate of gestational weight gain in both bivariate and adjusted logistic regression. In addition, malaria and gestational age were significantly associated with haemoglobin status at recruitment. Furthermore, we found that SES, mothers' age and household size were independently associated with Mid-Upper Arm Circumference of the pregnant mother on recruitment and finally age of the mother and SES were significantly associated with body fat percent of the mother on recruitment.

6.2 Sample characteristics

A majority of young women of less than 25 years (55.6%) characterized our sample with a mean age of 24.7 years. Results of MDHS 2015/2016 showed that 29 % of adolescents aged 15-19 had begun child bearing, of whom 22% had given birth once or more often, whereas 7% were pregnant with their first child at the time of interview (31). These findings are slightly different from our findings, where 24.5% of the women were aged 15-19 years; 21% of these were pregnant with their first child while 3.5% had given birth once or more. This slight difference may be due to a much smaller sample size as compared with the national survey, or that our sample was taken from only one district in Malawi. Nevertheless, this shows that Malawi still has the problem of teen pregnancies.

The 2010 MDHS results indicate that the average household size is 4.6 people, with rural households having 4.7 people (26) - the same as in our findings. Mangochi is one of the districts with high rates of fertility and early marriages.

There was a higher percentage of male-headed household in our sample (88.3%) than those reported in DHS 2010 (72%). Given that the sample were particularly pregnant women it is plausible that a higher percentage of male-headed households was observed than would in an ordinary sample of women. Only 3.1% of our sample had no schooling, whereas the majority had at least reached primary school (79.4%). There has been progress in educational attainment between 2004 MDHS and 2010 MDHS: the proportion with no education has decreased, from 30 % to 19% (26). This could support our findings despite the fact that the majority of our women could not read or write even though they had at least reached primary school.

Fifty two % of the women in our sample started attending antenatal care services in first trimester and 47.5% in second trimester. WHO's focused antenatal care approach encourages women to have four goal oriented ANC visits, recommending that the first ANC visit should be as early as possible in pregnancy, preferably in the first trimester. The last visit should be at around 37 weeks or near the expected date of birth to ensure that appropriate advice and care have been provided to prevent and manage problems (26). We managed to get these women fairly early because of the volunteers who visited them in their respective houses. Most health facilities including Mangochi, offer gifts (wraps, soap) to women who come for their first ANC at ≤ 12 weeks gestation to promote early ANC attendance.

There has been an improvement from 2010 MDHS 2015: from 46% to 51% of the women reported visiting antenatal clinics at least four times during pregnancy, which is one of the goals of the focused ANC approach. ANC policy in Malawi follows this new approach(26) and the country is trying the best for women to start ANC early.

6.3 Methodological discussion

6.3.1 Design

To detect changes in weight, a longitudinal study was used. One of the advantages is the ability to show patterns of a variable over time. This was the objective of the present study to find out factors, which were associated with the rate of gestational weight gain.

6.3.2 Sampling design

One stage cluster randomized sampling was used where all eligible pregnant women willing to participate (from the random selected clusters) were recruited. Cluster random sampling was appropriate, as random sampling of women would have reduced the likelihood of finding pregnant women in the clusters, since cluster sampling include all eligible members of the population.

6.3.3 Sampling error

The fact that only a sample was studied not the entire population, sampling error may be present. This study was conducted in a rural area which may restrict the results; combined with women from an urban area would have captured more variation in the information about gestational weight gain. The results cannot be generalized to the entire population of pregnant women in Malawi. We might have missed other factors that are associated with gestational weight gain that are present in urban women as they are different. Selection bias in the sample maybe present as well, e.g. women who refused to participate or did not go to check-up at the health station could have different characteristics from those who participate.

6.3.4 Non sampling error

Error arises in data collection because of factors other than taking a sample; these errors can arise from or measurement and behavioural effects (during interview). Despite standardization of measuring tools and data collectors, errors may be present due to significant potential for measurement inaccuracies (20). Three different people including the researcher herself conducted the measurements. Two people can find different readings of a person despite standardization. The questionnaire was pretested before recruitment commenced and all the interviewers including the researcher herself all come from Malawi and understood the local language, so probability of errors arising from questionnaire was minimized and all the questionnaires were in Chichewa.

6.3.5 Confounding factors

Diet diversity

The period allowed for executing the masters' study ended before diet diversity data was collected from the cohort, which limited the inclusion of dietary data in the current study. Evidence from a multi-country analysis suggests that household-level dietary diversity is strongly associated with per capita consumption (a proxy for income) and energy availability, suggesting that dietary diversity could be a useful indicator of household food security and vice versa (59).

Diet and socioeconomic status affect gestational weight gain; literature also shows these factors are related. Diet follows a socioeconomic gradient whereas higher-quality diets are associated with greater affluence and persons of lower SES preferentially consume energy-dense diets that are nutrient-poor (60). Studies show that diet is associated with other variables i.e. morbidity, household size, household head profession, marital status, haemoglobin status, anthropometric status (48, 61, 62). Although we included data on SES, household food security, data on diet diversity in the current study would have been important too.

6.3.6 Internal and external validity

As anthropometric measurements are prone to different types of errors, those errors maybe present in the current study. Some of these errors may affect internal validity, which implies that what was done in the study caused what was observed (i.e., the outcome). These can also affect external validity which is the extent to which the results of a study can be generalized (63). Measurements were repeated thrice and an average was taken to minimize measurement error. However, skinfold measurements may have posed a challenge of generally lowering the final measurement used in analysis given the shrinking of body fat in repeated consecutive measurements. External validity can also be affected by what confounding variables were put in the model.

6.4 Discussion of main findings

6.4.1 Prevalence of GWG according to IOM guidelines

Adequate gestational weight gain is required for optimal pregnancy outcome. Less than a quarter (19.8 %) of the pregnant women in this study gained adequate gestational weight according IOM guidelines. Two studies done in Africa show a lower prevalence of adequate GWG in their studies; a study done in Nigeria found that only 3.1% of the pregnant women gained according to the guidelines (46). The other study from Ethiopia found that 28% of the pregnant women gained weight according to IOM guidelines (47). In a longitudinal study done in Malawi, Jiajun Xu *et a*l found that the percentage of weight gain during pregnancy was substantially slower in their cohort than the US Institute of Medicine recommendation(5). In a study done in Pakistan, adequate weight gain was reported in 34.1% of the women (64). Inadequate gestational weight gain in our study is most likely related to the nutritional condition of the women, given that 61.1% of the women had less than three meals per day and the fact that women who were recruited before harvest season were more likely to gain inadequately. In a systematic review of 35 studies, Anna Marie Siega- Riz *et al* found a strong evidence supporting associations between inadequate gestational weight gain (according to IOM guidelines) and decreased birth weight and fetal growth (1). The present study did not evaluate the association between GWG and birth weight.

Limitations of gestational weight gain

IOM: The lack of formally acknowledged pregnancy weight gain trajectories, showing weight to be gained at a particular gestational point more so attuned for specific population groups/BMI categories. Studies in multiethnic societies suggest that African and white women may have different patterns in weight gain during pregnancy (5, 65, 66) despite the fact that IOM guidelines are regardless of race and ethnicity (9).

6.4.2 Factors associated with rate of gestational weight gain

Food security

Our study found a significant association between gestational weight gain and season of recruitment in both bivariate and multiple logistic regressions, women who were recruited before harvest season were more likely to gain inadequately compared to those who were recruited after harvest. This means women were least food secure after harvest. This is consistent with a study that was done in Malawi on seasonal variation of maternal anthropometry, where the authors found that maternal weight gain during pregnancy followed a seasonal pattern (6). A study done in the US suggested that food insecurity plays a role in gestational weight gain as they found that women who were food insecure in early pregnancy were at greatest risk of *excessive* gestational and postpartum weight gain (67).

Food-insecure households in developed countries often purchase calorie-dense foods that are high in fats and added sugars in adaptation to their food insecurity (7). Food security is related to SES of the household, as the income of the household influences the type of food to purchase and ability to purchase food.

Our study was conducted in a rural area, only 24.5% of the women did not face food shortage from the previous harvest, and only 38.9% managed three meals a day whereas the rest had only one or two meals a day. However, number of meals did not seem to have any effect on weight gain. The effect is of course also dependent on the size and nutrient content of each meal and could mean that those women having only one or two meals compensated by eating more in each meal or by eating more snacks.

In any case, food insecurity prevent pregnant mothers from eating a balanced diet as they struggle to find food regardless of the nutrient and energy content, and hence negative impacts on weight gain. Our result has shown that women in our area are food insecure as they depend on harvests which do not last for the whole year, which affects gestational weight gain.

BMI at recruitment

Many studies have shown an association between pre-gestational BMI and GWG. In the current study, we used BMI calculated on recruitment day to find out the prevalence of those attaining recommended weight gains. In the present study, BMI showed some effect on gestational weight gain even though it was not significant, overweight women were more likely to gain according to IOM guidelines and underweight women were more likely to under gain compared to women in normal weight BMI category. More than half of the women had normal BMI, these women were recruited at ≤ 24 weeks at the time there may already have been an increase or decrease in gestational weight, and the results show that overall, these women were not gaining according to IOM recommendations, these can be possible reasons why our result was not significant. Similar results (under gain in underweight BMI category) were found in non- Hispanic, white, black and Asian populations (44, 46, 47, 68-75). Two studies done in Malawi and Tanzania showed that women with higher BMI gained less than those who were underweight (4, 61). It is not clear why results are different. One possible explanation could be that the women in the other studies had better ANC counselling comparing to the Malawi and Tanzania studies. Women who are underweight are required to gain more weight to achieve a good GWG compared to normal and overweight women (as normal and overweight women are be able to support the growth of fetus with the portion of their stored energy) (47).

Socio demographic factors

Socio economic status

Some studies show that women with low income have an increased risk for inadequate GWG (40, 47, 67) Women with low income and in rural areas are likely to have limited access to healthy food; limited access to good groceries and the transportation costs to good markets - all these can explain low weight gain in economically disadvantaged women in this area. However, most studies done in developed countries show that poor women are at an increased risk for excessive GWG (48, 67, 76-78) as they consume energy dense food which are not necessarily nutrient dense (empty calories) (48, 67), however SES did not show any significant effect on our sample. This may be due to homogeneity of the sample in relation to SES, as it was a rural setting.

Other demographic factors

Our study found no association between gestational weight gain, parity, marital status and education of the mother; however, other studies done in both developing and developed countries found some associations between these factors and gestational weight gain.
Marital status: According to US national data Hickey C reported that unmarried mothers were more likely than married mothers to gain < 7.3 kg (79). In a Hispanic population, Siega- Riz *etal* (1997) found that those women who received support from their baby's father gained more weight as compared to those who did not (80). However, Strychar *et al* (2000) found marital status as a non-significant predictor of GWG in a French-Quebec population (81) just like our findings.

Education: Some studies found that lower education was associated with increased risk of insufficient gestational weight gain, this may be expected as higher education levels is associated with better nutritional habits and higher socio economic status (79).

Parity: Brawsky et al found that women who were nulliparous had a risk of inadequate GWG (82). However, some studies show that being multiparous influenced the risk for low weight gain (10, 46, 67, 68, 80, 83); this is consistent with our results as multiparous women gained inadequately compared to nulliparous women though it was not significant in our study (P = 0.057). Only one of these studies was done in Africa (46) (Nigeria) where multiparous women had lower gestational weight gain compared to nulliparous women.

Morbidity

Our study did not find any association between morbidity and gestational weight gain. Studies done in Malawi, Tanzania and Kenya (4, 84, 85) showed that HIV sero-positive women had lower rates of gestational weight gain; our study found almost a similar finding with these studies but it was not significant. This could this be due to AntiRetro viral Treatment (ART) and only few women were HIV positive in our sample.

6.4.3 Factors associated with Hb status on recruitment

Malaria was an important determinant of anaemia in both bivariate and multiple regression analyses, as those who had malaria in the current pregnancy had reduced haemoglobin (Hb) level compared to those who had no malaria. Our result is consistent with studies done in Ethiopia and Malawi; where they found that pregnant women who had malaria infection in the past year had reduced Hb at recruitment (4, 15, 86). Anaemia affects almost two-thirds of pregnant women in developing countries and contributes to maternal morbidity and mortality and to low birthweight (4, 13-17). Malaria due to Plasmodium falciparum may cause severe anaemia in pregnancy and is common in Malawi. Malaria is common in Africa as a whole and common in pregnant women in general. In the present study, 25.7% of the women had malaria. 37.7% of the women had anaemia (severe, mild and moderate according to WHO) (12).

We also found that gestational age at recruitment was associated with haemoglobin status; Hb decreased as the gestational age at which one was recruited increased. This is probably due to increasing requirement of iron as the pregnancy progresses. This is expected since healthy pregnancy is associated with a modest decrease in hemoglobin levels (physiological or dilutional anemia of pregnancy). This decrease is due to a greater expansion of plasma volume relative to the increase in RBC mass. (40)

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6.4.4 Factors associated with Mid-Upper Arm Circumference (MUAC) on recruitment

MUAC reflects more of one's nutritional status. Just like GWG, several studies show that low MUAC is associated with low birth weight and preterm delivery (4, 22). Our study found that mother's age, SES and household size were independently associated with MUAC at baseline. This is consistent with results from a study done in Malawi where they found that mothers' exposure to famine season, age and wealth index were associated with MUAC in HIV infected pregnant women. In another study done in Tanzania, it was found that HIV positive status was associated with wasting especially in groups of low socio economic status (24). Another study done in Nepal; wealth, age and women's education were associated with a higher mean MUAC in pregnancy. Our study also found that there was an increase of 0.67cm in MUAC in HIV negative women but this was not significant (*P*= 0.18). These studies show that poor nutritional status is highly linked with low economic status of the woman

6.4.5 Factors associated with body fat percentage on recruitment

Just like MUAC, body fat reflects one's nutrition status. In the current study, body fat percentage was calculated from the sum of four skinfold thicknesses (triceps, biceps, subscapular and suprailliac) (25). There are limited studies in this area. Our study found that age and SES were associated with body fat percentage at baseline. SES is related with nutrition as those who are economically disadvantaged eat whatever is found regardless of food nutrient content, which in turn affect their nutrition status. This may explain the difference in the SES categories on body fat in our study findings. A study done in US found that subcutaneous body fat change in pregnancy was independently associated with pre-gestational BMI, parity and newborn gender (87). Another study done in Scotland found an association between Skinfold Thickness (SFT) and parity; Increase of SFT during pregnancy was greater, on average, among primiparae than among multiparae (88). However our study found almost same association but with body fat percentage and it was not significant (*P*=0.09).This difference may be due to small sample. Our study also evaluated determinants at recruitment only not throughout pregnancy.

7 CONCLUSION

The study revealed that pregnant women from the study area are failing to comply with IOM guidelines for gestational weight gain. Less than a quarter of the women gained below the GWG guidelines. This may imply low total weight gain at delivery - hence low birth weight babies.

Although the reasons may be multi-facetted, season of recruitment significantly predicted GWG in both bivariate and multiple logistic regression. We did not find any significant association, neither in the bivariate nor in the multiple regression analysis, between BMI categories, SES, marital status, education, occupation and GWG, just like most studies done in this pregnancy weight gain.

We did not find any significant association between morbidity and GWG

The study also revealed a high prevalence of anemia (37.8%) among pregnant women at recruitment. Malaria and gestational age at recruitment were independently negatively associated with haemoglobin at recruitment.

The study also showed that mother's age, SES and household size were independently associated with MUAC at the time of recruitment. Mother's age and SES significantly predicted body fat percentage at recruitment.

Season of recruitment is the main common determinant of GWG, this shows the role that dietary intake may likely have on gestational weight gain pattern; most people are poor so that harvested food does not last long enough to reach next harvest and this has negative effects on their nutritional status and health.

8 RECOMMENDATIONS

The study has highlighted the importance of monitoring GWG among pregnant women during ANC, as it would help to identify women at risk for low weight gain. It reveals that it is important to study determinants of gestational weight gain to develop and implement public health strategies to eradicate risk for inadequate weight gain.

There is thus a need to monitor GWG in Malawi, which is a challenge at present. Health workers have limited knowledge on how this can be done. Health care providers need to be assessing the pregnant woman's BMI during the first prenatal visit and monitor weight gain closely throughout pregnancy. Women at risk of inadequate weight gain may benefit from interventions directed towards modifiable factors during pregnancy.

GWG is one of the modifiable factors that should be considered when developing maternal-infant health policy and programs.

Aside of GWG, it is very important to take into consideration anthropometric status of the mothers throughout pregnancy as they reflect more fully one's nutritional status. This could help to improve both maternal and neonatal outcomes, and would be possible since the woman is to receive antenatal care before she gives birth (simple and inexpensive instead of complicated and expensive curative services).

Developing countries need their own GWG reference values based on their population characteristics, as most GWG in low income countries is evaluated against IOM guidelines, which may overestimate the proportion of women with GWG below the guidelines in developing countries.

Nutrition interventions using locally available foods can help eradicate risk for inadequate weight gain hence improving birth outcomes.

9 FUTURE RESEARCH

Use of quantitative methods has missed cognitive and psychological factors explaining low GWG. This would have been better studied using qualitative methods. Studies in developed countries have established the importance of such factors through employing qualitative approaches. There is a paucity of such type of studies in developing countries.

Our study was done in a rural area only, but in order to generalize the findings on factors affecting gestational weight gain and other indicators of nutritional status of pregnant women in Malawi, a larger study including both rural and urban areas is needed, evaluating total gestational weight gain through pregnancy in Malawi and develop reference values for GWG according to Malawi's population.

There is a need to develop GWG guidelines for improved both maternal and birth outcomes in low- and middle- income countries through research.

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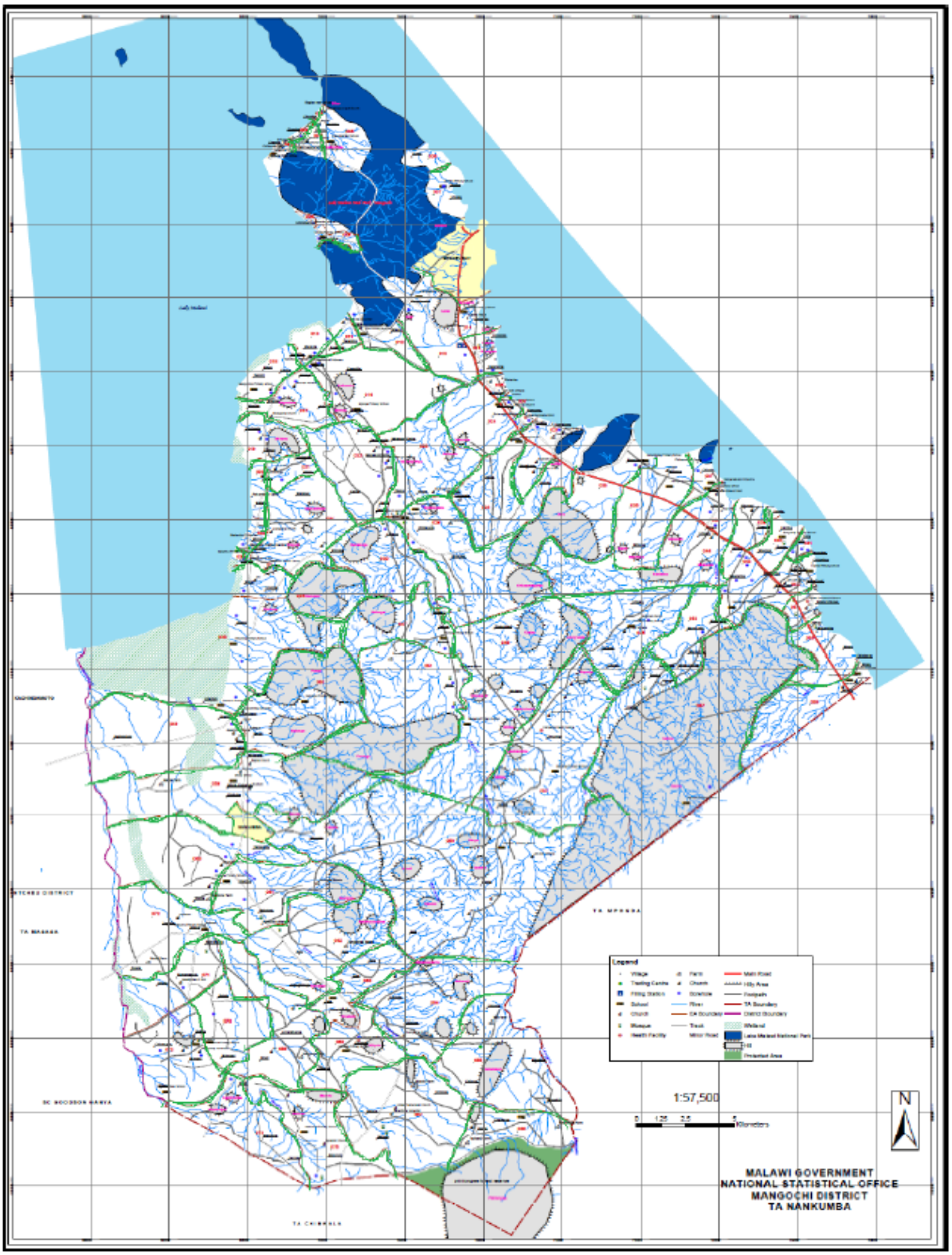
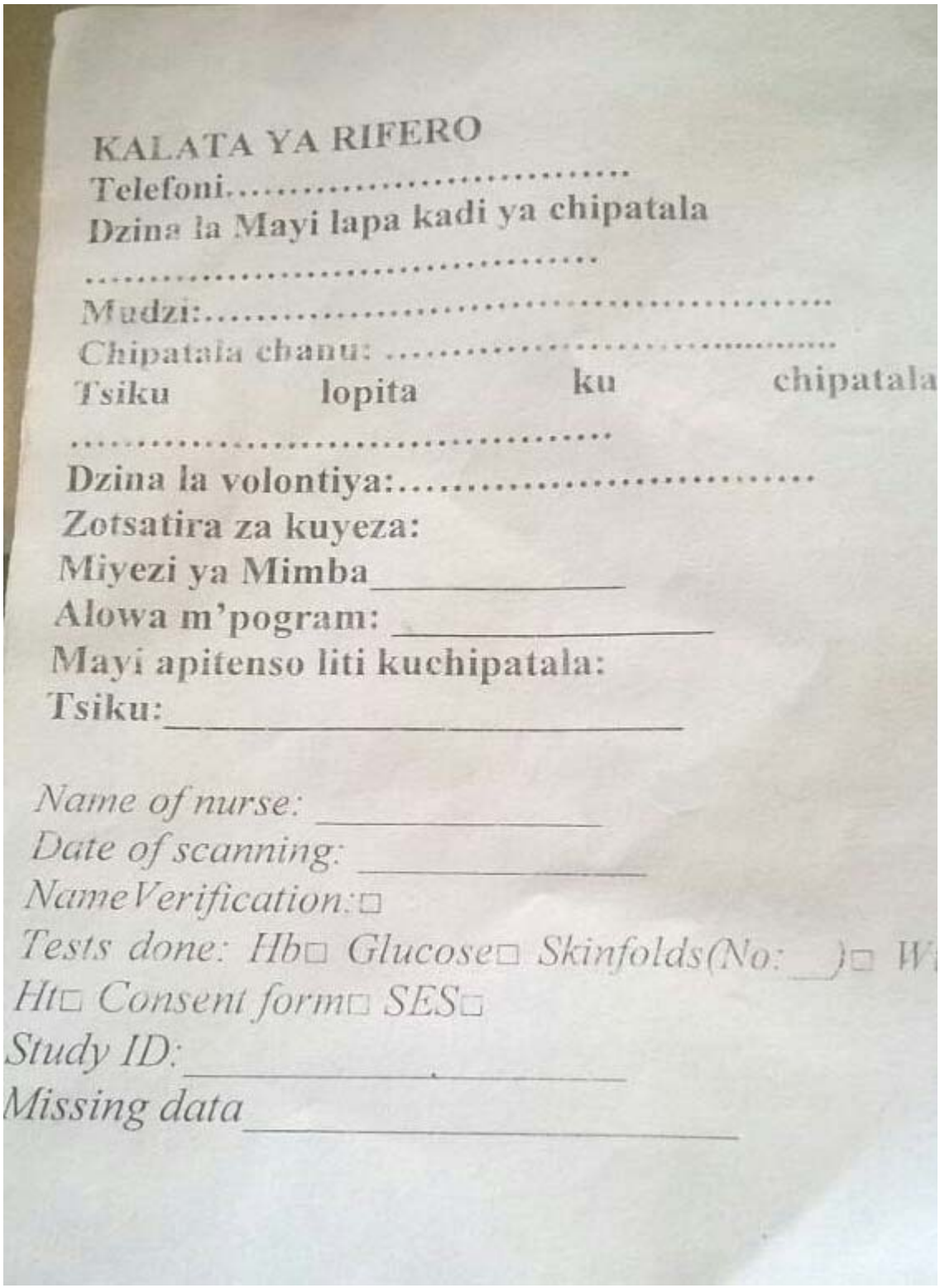
APPENDIX

Appendix I: Map of Mangochi



Appendix II: Referral letter to clinic



KALATA YA RIFERO

Telefoni.....

Dzina la Mayi lapa kadi ya chipatala

.....

Mudzi:.....

Chipatala chanu: .....

Tsiku lopita ku chipatala

.....

Dzina la volontiya:.....

Zotsatira za kuyeza:

Miyezi ya Mimba_____

Alowa m'pogram: _____

Mayi apitenso liti kuchipatala:

Tsiku:_____

Name of nurse: _____

Date of scanning: _____

NameVerification:□

Tests done: Hb□ *Glucose*□ *Skinfolds(No:*)□ W

Ht□ *Consent form*□ *SES*□

Study ID: _____

Missing data _____

Appendix III: SES Questionnaire

FORM 2A: SOCIO DEMOGRAPHIC QUESTIONNAIRE

TO BE ADMINISTERED ON 1ST 2ND & 3RD VISIT

IDENTIFICATION INTERVIEWERS NAMES

QUESTIONNAIRE NUMBER:_____

DATE OF INTERVIEW (DoI):_____ _____/____ _____/_____ _____ _____ ____

NAME OF WOMAN:_____

NAME OF HOUSEHOLD HEAD

Surname:_____

First Name:_____

Middle Name:_____

Other Name:_____

NAME OF VILLAGE_____

T/A:_____

SEASON (TICK CORRECT SEASON)

1. AFTER HARVESTING (JUNE – SEPTEMBER)
2. BEFORE PLANTING (DECEMBER – FEBRUARY' 15)

STUDY ID: ____ ____ _____ _____ _____ _____ _____ ____ ____ ____ ___ ____
Centre Village Date Actual Number

Nanumba (1); Monkey-Bay (2);- Circle and use in above study ID

USUAL CLINIC_____

WALKING TIME FROM VILLAGE TO USUAL CLINIC_____

Date of birth of Mother ____ ____/____ ___/___ ___ ___ ___

☐Health card ☐Reported ☐Voter registration ☐Other (specify)

Previous number of births_____

[*Kodi munabelekapo kangati, kuwerengera ndi amene angakhale kuti anapitilira?*]

If previous birth is 0, skip to page 2 the Sociodemographic table

Number of Children a live _____

[*nanga amoyo ndi angati*]

Mother's birth (if information is available) ☐Available (*Record*) _____

☐Not Available

1. Where did you deliver during your last delivery? [*kodi mimba yanu yomaliza musanatenge iyi munachulira kuti?*]
    0. Home
    1. Clinic
    2. On the way to clinic
2. In case if last birth was home delivery – did you go to the clinic after birth? *If yes, after how long? [Kodi munapita kuchipatala mutabereka? Ndipo patapita nthawi yaitali bwanji]*
    0. No
    1. Yes
3. What was the method of delivery of last birth? [*Kodi munachilira njira yanji mimba yanu yomaliza musanatenge iyi?*]
    0. Forceps assisted
    1. Vaccum assisted
    2. C-section
    3. Normal
4. What was the weight of the last child (if multigravida) (check in health passport book if she can't remember) [Kodi mwana wanu omaliza analemera bwanji?]
    _____ (*if not available, make alternative arrangement to have the data collected*)

USUAL RESIDENTS	RELATIONSHIP TO H/HOLD HEAD	SEX	AGE	MAIN PROFESSION	LITERACY	EDUCATION
What are names of pple living in this h/hold? [*Tchulani mayina a anthu omwe akukhala pakhomo pano?]* PROBE 8 (*ndikutanthauza amene mumadyera limodzi*)	What is relationship of (name) to h/hold head? [*Kodi pali ubale otani pakati pa (dzina) ndi mwini khomo?*]	Is (name) male or female? [*Kodi (dzina) ndi wam'muna kapena wamkazi*]	When was (name) born? [*Kodi (dzina) anabadwa liti?*]	What does (name) do for aliving? [*Kdi (dzina) amapanga chani?*]	Can (name) read or write [*Kodi (dzina) amatha kuwerenga ndi kulemba?*]	Has (name) ever been to school? If yes what is the highet qualification? [*Kodi (dzina) anapitako kusukulu? Kodi analekezera kalasi yanji*]
Question 1	**Q2**	**Q3**	**Q4**	**Q5**	**Q7**	**Q8**
Q9a Total household size:						
Q 9b. total number of children under 5:				**Q11b. Gender of Household head**		
Q 10a. Total number of literate people in the house:				**Q12a. Relationship of mother to household head**		
Q10b. Number of males above 14 yrs:				**Q13: age of mother**		
Q11a. Main profession of household head:						
	CODES FOR ANSWERS Head of h/hold 1 Wife 2 Son or daughter 3 Brother or sister 4 Niece or nephew 5 Son/daughter –in-law 6 Grandchild 7 Others (specify) 8 Just in case they will be others like workers, longterm visitors, who are not relatives, etc	CODES FOR ANSWERS Male 0 Female		CODES FOR ANSWERS Small scale farmer 1 Small scale fishermen 1 Small trader 3 Medium scale trader 4 Paid laborer 5 Big scale fisherman 6 Big scale farmer 7 Big scale business 8 Paid professional 9 Student 10 Unemployed 11 Not applicable 12 Other (specify) 13	CODES No 0 Yes 1	CODES Pre-school/Primary 1-4 Primary 5-8 2 Junior sec 3 Senior sec 4 Post sec 5 Adult school 6 No school 7 n/a 8

SECTION 1: SOCIO-DEMOGRAPHIC CHARACTERISTICS (FORM 2)

Q14. What is your marital Status? [*Kodi muli pa banja?*]

0. Unmarried
1. Divorced / separated
2. Cohabiting / married

Q15a. **If married,** does the husband live with her? [*kodi bambo amakhala kuti?*]

0. Married woman lives alone
1. Married husband visits occasionally (once a week)
2. Married husband visits occasionally (once a month)
3. Married – husband lives with wife (all the time)
4. Other (specify)

Q18. Do you have the following property? If yes, how much? *Indicate number eg 0, 1, 2 etc [kodi muli ndi katundu? **Ife yes;** mulinaye ochulua bwanji]*

Car	_____
TV	_____
Refrigerator	_____
Mobile Phone	_____
Radio	_____
Bicycle	_____
Motorcycle	_____
Ox-cart	_____
Boats	_____
Blankets	_____
Mattresses	_____
Mosquito nets	_____

Q19. What is the main material for the roof of your house? [*kodi denga la nyumba yani ndi lofolera ndi chani?*]

Grass thatch	0
Iron sheets/tiles	1
Other (specify)	2

Q20. What is the main material for the floor of your house? [*Kodi pansi pa mkati mwa m'nyuma yanu mpotani*]

Earth	0
Cement	1
Other (specify)	2

Q21. What is the main source of water for domestic uses? [*Kodi madzi omwe mumagwiritsa ntchito pakhomo mumatunga kuti?*]

Tap water (chlorinated)	1
Borehole	2
Protected well	3
Unprotected well	4
River/stream/lake	5
Other (specify)	6

Q22. What is the main source of water for drinking in the household? [*Kodi madzi omwe mumamwa pakhomo pano mumatunga kuti?*]

Tap water (chlorinated)	1
Borehole	2
Protected well	3
Unprotected well	4
River/stream/lake	5
Other (specify)	6

Q23. What are the ways in which you acquire food in your household? What is the main way in which you acquire food? [*Kodi chakudya pakhomo pano mumachipeza munjira zanji? Panjira zomwe mwachulazo kodi njira yomwe mumayidalira ndi iti?*]

Direct harvest from garden	1
Assistance from family	2
Purchasing	3
Battering of food for work	4
Food aid	5
Food for work projects	6
Other (specify)	7

Q24a. How many times do you normally eat in a day? [*Kodi nthawi zambiri mumadya kangati pa tsiku pakhomo pano?*] _____ (*record number*)

Q24b. Do you ever face food shortages? [*Kodi munayamba mwakumanapo ndi vuto lopelewera chakudya pakhomo pano?*]

No	0
Yes	1

If NO, skip Q25-Q31, and go to 32

Q25. Starting from last year's harvest, until this year's harvest; which months did you face food shortage? [*kuyambira kukolola ndi vuto lakuperewera chakudya?*] *Record of month's*

_____

Q25b. Number of months in which food shortage was faced was (Count and put no of monthly) _____

I will ask some question regarding the months when you face food shortages:
Q26. Did you or any household eat a small meal than you felt you needed because there was not enough food? [*pamiyezi imene mwandichulila ija _____,_____,_____ kodi inuyo kapena wna aliyese pakhomo pano amadya chokudya chochepa osati mmene amadyera chifukwa choti panali chokudya chopelewela?*]

No	0
Yes	1

Q28. Did you or any household member eat fewer meals than you needed to because there was not enough food? [*munanena kuti mumadya_____. Kodi munthawi yosowekera, zinachitikapo kuti inuyo kapena wina aliyense pakhomo pano amadya mochepela ka _____ pa tsiku*]

No 0
Yes 1

Q29. If yes, how often [*Nanga zimenezo zimachitika kangati pa sabata?*]

0. Often (daily)
1. Sometimes (2 or more times a week)
2. Rarely (once a week)

Q30. Did you or any household member go a whole day without eating because there was not enough food? [*Kodi munthawi imeneyi, zimachitika kuti mwina inuyo kapena wina pakhomo pano kuswera tsiku lonse osadya chifukwa cha vuto lakupelewera chokudya?*]

No 0
Yes 1

Q31. If yes, how often [*Nanga zimenezo zimachitika kangati pa sabata?*]

0. Often (daily)
1. Sometimes (2 or more times a week)
2. Rarely (once a week)

Appendix IV: Morbidity questionnaire

FORM 2B: MATERNAL ANTHOTOPOMETRY & MORBIDITY TO BE ADMINISTERED ON 1ST 2ND & 3RD VISIT

IDENTIFICATION INTERVIEWERS NAME
QUESTIONNAIRE NUMBER:_____ DATE OF INTERVIEW (Dol):_____ _____/____ _____/_____ _____ _____ ____ NAME OF WOMAN:_____ NAME OF HOUSEHOLD HEAD Surname:_____ First Name:_____ Middle Name:_____ Other Name:_____ NAME OF VILLAGE_____ T/A:_____ SEASON (TICK CORRECT SEASON) 3. AFTER HARVESTING (JUNE – SEPTEMBER) 4. BEFORE PLANTING (DECEMBER – FEBRUARY' 15) STUDY ID: ____ ____ _____ _____ _____ _____ _____ ____ ____ ____ ___ ____ Centre Village Date Actual Number *Nankumba (1); Monkey-Bay (2);*

Gestation in weeks:

_____

SECTION 1: ANTHROPOMETRY

Weight 1) _____ 2) _____Kg

Weight Measurer: 1) Shyreen 2) Saukani 3) Phallece 4) Mbumba 5) Other (Specify) _____6) Other (Specify) _____

Height 1) _____ 2) _____cm

Height Measurer: 1) Shyreen 2) Saukani 3) Phallece 4) Mbumba 5) Other (Specify) _____6) Other (Specify) _____

Mid-upper arm circumference: 1) _____ 2) _____cm

MUAC Measurer: 1) Shyreen 2) Saukani 3) Phallece 4) Mbumba 5) Other (Specify) _____6) Other (Specify) _____

Skinfold

1. Biceps 1)_____mm+____cm 2) _____mm+____cm 3) _____mm+____cm

   Biceps Measurer 1) Shyreen 2) Saukani 3) Phallece 4) Mbumba 5) Other (Specify) _____6) Other (Specify) _____

2. Triceps 1)_____mm+____cm 2) _____mm+____cm 3) _____mm+____cm

   Triceps Measurer 1) Shyreen 2) Saukani 3) Phallece 4) Mbumba 5) Other (Specify) _____6) Other (Specify) _____

3. Subcapular 1)_____mm+____cm2) _____mm+____cm 3) _____mm+____cm

   Subcapular Measurer 1) Shyreen 2) Saukani 3) Phallece 4) Mbumba 5) Other (Specify) _____6) Other (Specify) ____

4. Supra iliac 1)_____mm+____cm 2) _____mm+____cm 3) _____mm+____cm

   Suprailiac Measurer 1) Shyreen 2) Saukani 3) Phallece 4) Mbumba 5) Other (Specify) _____6) Other (Specify) ____

Blood tests

Haemoglobin: _____g/L Glucose:

_____mmol/L

Blood Test Measure 1) Shyreen 2) Saukani 3) Phallece 4) Mbumba 5) Other (Specify) _____6)

Other (Specify) _____

Time of Glucose test: _____:_____ am/pm (*Circle am or pm*)

The mother's last meal was: Breakfast / Lunch / Dinner (*Circle*)

Time of the last meal: _____:_____ am / pm (*Circle am or pm*) _____/_____/

2016

Number of hours from last meal to Glucose

test_____

SECTION 3 MORBIDITY

Q32. Have you experienced any of the following signs in the past 2 months/3months (state duration of gestation)? [*Lero ndi _____, kubwelera mmbuyo tsiku la_____ omwe lapitalo, ndikubwelera mbuyo tsiku la _____ linalo; pamodzi ngati miyezi yiwiri yomwe yapitayo. Kodi munamva zizindikiro izi mthupi mwanu?*]

*If on 2nd and 3rd visit, the question should refer to the period between the last visit and the time of the interview

	Yes	No	No. of days
1. Fever [*kutentha mthupi*]	_____	_____	_____
2. Open bowels [*kusegula mmimba]*	_____	_____	_____
3. Difficulty/fast breathing [*kupuma mobanika*]	_____	_____	_____
4. Pain in urinating [*kumva kuwawa pokoza*]	_____	_____	_____
5. Drowsiness/fatigue [*Chizungulire / kutopa*]	_____	_____	_____
6. General body pain [*kuphwanya mthupi*]	_____	_____	_____
7. Loss of appetite [*kusowa chilakolako chofuna chokudya*]	_____	_____	_____
8. Foul smelling or unusual colored vaginal discharge [*Chikazi chonunkha kapena cha mtundu wachikasu*]	_____	_____	_____

Q33. Medical / Surgical History

Have you had any of the following illness from the time since you got pregnant? [*Kodi mwadwalako matenda awa*

Pa nthawi yomwe mwakhala muli oyembekezela panopa?]

If on 2nd visit or 3rd visit ask as below:

Have you had any of the following illness from the time since you were scanned (or from your second visit) and now?

[*Kodi mwadalako matenda awa pa kuyambila panthawi yomwe munabwela kodzaunikidwa (kapena nthawi vachiwili) kufikila panopa*?]

Check the Health Passport at same time.

	No (0)	Yes (1)
1. Diarrhoea	_____	_____
2. Malaria	_____	_____
3. High Blood Pressure	_____	_____
4. Diabetes	_____	_____
5. Epilepsy	_____	_____
6. Fistula Repair	_____	_____
7. Anaemia	_____	_____
8. Asthma	_____	_____
9. STIs	_____	_____

Q34. Have you been tested for HIV before? [*Kodi munayezetsako HIV mbuyomu?]* 0. No

1. Yes

Q34b. HIV Status 0. Sero – Positive (**not verified in health passport/register**)

1. Sero-Positive (**verified in health passport/register**)
2. Sero-Negative (**not verified in health passport/register**)
3. Sero-Negative (**verified in health passport/register**)

Q34d. Are you on ART 0. No

1. Yes (Write down the ART Reg. No) ART Reg. No

_____

35. Do you suffer from any chronic diseases? [*Kodi mumadwalamatenda aliwonse am'gonagona?*]

0. No

1. Yes

36. Is there medication that you are obliged to take daily due to any illness? [*Kodi pali mankhwala amene munauzidwa kuti muzimwa tsiku lililonse chifukwa cha vuto linalilonse?]*

0. No

1. Yes

Q37a. ***If Yes***, what kind of medication? [Kodi ndi mankhwala anji?]

_____

Q38. Compared to other adults, are you more often sick or not? [*Kodi inuyo mukadzifanizira ndi anthu ena m'sinkhu wanu mumadziona kuti mumadwaladwala?]* 0. No

1. Yes?

Q39. Did you have the opportunity to take Iron tablets during this pregnancy?
[Kodi Munali ndi mwayi womwe mankhwala oonjezela magazi pa nthawi yomwe Munali oyembekezera

0. No

1. Yes

Q39b. ***If Yes***, which months during pregnancy were you taking the Iron tablets? Circle the right number [*Kodi ndi miyezi iti yomwe munakhala mukumwa mankhwala oonjezela magazi?]*

0. 1st month of pregnancy
1. 2nd month of pregnancy
2. 3rd month of pregnancy
3. 4th month of pregnancy
4. 5th month of pregnancy
5. 6th month of pregnancy
6. 7th month of pregnancy
7. 8th month of pregnancy
8. 9th month of pregnancy

How frequently in a week in that month did she take the tablets?

1st month	**2nd month**	**3rd month**	**4th month**	**5th month**	**6th month**	**7th month**	**8th month**	**9th month**
0-Once a wk	0-Once a wk	0-Once a wk	0-Once a wk	0-Once a wk	0-Once a wk	0-Once a wk	0-Once a wk	0-Once a wk
1-Two-Three Times a wk	1-Two-Three Times a wk	1-Two-Three Times a wk	1-Two-Three Times a wk	1-Two-Three Times a wk	1-Two-Three Times a wk	1-Two-Three Times a wk	1-Two-Three Times a wk	1-Two-Three Times a wk
2-Daily	2-Daily	2-Daily	2-Daily	2-Daily	2-Daily	2-Daily	2-Daily	2-Daily

Q37. Have you ever attended ANC for this pregnancy? [*Kodi munayamba mwapitako ku sikelo ya apathupi?*]

No

1. Yes

Q37a. **Ask on 2nd visit**

How many sessions have you attended since when were scanned and now? [*Mwapitako kangati kuyambila pa nthawi yomwe Munali munapita kokaunikidwa kufikila panopa?]*

_____

Q37b. **Ask on 3rd visit**

How many sessions have you attended since when you last visited and now? [*Mwapitako kangati kuyambila ulendo watha kufikila panopa?]* _____

Appendix V: Anthropometric measurements guidelines

Weight

Equipment:

1. Analog weight scale in kilogram mode

Participant:

1. Remove shoes
2. Put on light/thin clothes

Examiner:

1. Introduce the exam to the participant
2. press the zero key on the keyboard scale to zero the scale
3. Direct the participant to stand on the center of the weight scale platform facing the recorder at 90 degrees, hands at sides, and looking straight ahead.
4. Stand to the left side of the patient for better visualization when recording the measurement
5. After the participant is correctly positioned and the readout on the measurement device becomes stable, record the measurement on the form.
6. Repeat step 2,3, 4 and 5 (2 measurements needed)

Standing height

Equipment:

1. Stadiometer with a fixed vertical backboard and an adjustable head piece.
    - The stadiometer with a minimum range of measurement of 60 cm to 220cm.
    - The head board be constructed with a locking device.
    - The floor should be hard and level.

Participant:

1. Remove hair ornaments, jewelry, buns, or braids from the top of the head

Examiner:

1. Introduce the exam to the participant
2. Direct participant to the stadiometer platform
3. Instruct participant to stand up straight against the backboard with the body weight evenly distributed and both feet flat on the platform
4. Instruct her to stand with the heels together and toes apart (The toes should point slightly outward at approximately a 60ºangle. The back of the head, shoulder blades, buttocks, calf muscle and heels have to be checked making sure they are in contact with the backboard).
5. Align the head in the Frankfort horizontal plane (The head is in the Frankfort plane when the horizontal line from the ear canal to the lower border of the orbit of the eye is parallel to the floor and perpendicular to the vertical backboard)
6. If she will not assume the position (5) naturally; help her to tilt her head up or down gently to achieve the proper alignment.
7. Instruct the woman to look straight ahead.
8. Lower the stadiometer head piece so that it rests firmly on top of the participant's head, with sufficient pressure to compress the hair
9. Instruct her to stand as tall as possible, take a deep breath, and hold that position (The act of taking a deep breath helps straighten the spine to yield a more consistent and reproducible stature measurement, the inhalation will cause the headpiece to rise slightly).
10. While the participant is correctly positioned and holding the breath, record the value on the form.
11. Repeat steps 2 to 10 to capture a second reading.
12.

NOTE:

Depending on the overall body conformation of the individual, all five contact points – head, shoulders, buttocks, calf muscles and heels – may not touch the stadiometer backboard. For example, some women may have kyphosis, a forward curvature of the spine that appears as a hump at the upper back.

Mid-Upper Arm Circumference

Equipment

Store in a cylindrical container or hang

Participant:

1. stands with arms relaxed

Examiner:

1. Introduce the exam to the participant
2. Determine the midpoint between the most superior and lateral point of the acromion border and the most proximal and lateral border of the head of the radius
3. Wrap tape clockwise + upright around center point
4. Tuck in tape
5. Adjust to 0 cm on the center point
6. Tighten tape and loosen it
7. Take reading
8. Repeat step 3 to step 7 two times to capture second and third reading

SKINFOLDS

Equipment:

- Harpenden skinfold caliper
  - Calibrate to 0 mm
- Cosmetic pencil marker
- Tape measure

Triceps

Participant:

1. Assumes a relaxed standing position
2. Stands erect with feet together, shoulders relaxed, arms hanging freely at the sides.
3. Relax the shoulder joint slightly externally rotated and elbow extended by the side of the body.

Examiner:

1. Introduce the exam to the participant
2. Stands behind the participant's right side
   Locate landmarks (milestones).
3. **Triceps center point (tape is vertical)**

   a. Landmarks for triceps vertical line (acromion process + elbow
   b. Mark vertically on the left
   c. Mark mid-point
   d. Draw a horizontal line on the mid-point around the arm

4. **Pinching line**
   a. Place MUAC tape 2cm above the mid-point and mark its top line
   b. Mark a 90˚ point from triceps center point onto pinching line

5. **Triceps finger pinching points**
   a. Using 5cm points on the tape, mark 5 cm points from the triceps center point (on both sides of the center point that's left and right).

6. **Skin fold holding**
   a. Left hand in opposite side of a beggar position
   b. Thumb on one finger pinching point and the rest of fingers on the other point
   b. Grasp and let loose of muscles

7. **Caliper pinching**
   a. Hold caliper and open wide to the same degree as the pitch
   2. Bring caliper on the MUAC line at the pitching point, placing jaws under the fingers
   3. Pitch vertically and take reading within 3 seconds and release lower hold of caliper

8. **Repeat** step 6 and 7 two times to capture second and third reading

Biceps

Participant:

1. Assumes a relaxed standing position
2. Stands erect with feet together, shoulders relaxed, arms hanging freely at the sides.
3. Relax the shoulder joint slightly externally rotated and elbow extended by the side of the body.
4. Relax the arm with the palm of the hand facing forwards.

Examiner:

1. Introduce the exam to the participant
2. Stands behind the participant's right side
   Locate landmarks

3. **Biceps center point (tape is vertical)**
   a. Landmarks for biceps vertical line (between the acromiale (lateral edge of the acromion process, e.g. bony tip of shoulder) and the radiale (proximal and lateral border of the radius bone, approximately the elbow joint), on the mid-line of the anterior (front) surface of the arm (over the biceps muscle).
   b. Mark vertically on the left
   c. Mark mid-point
   d. Draw a horizontal line on the mid-point around the arm

4. **Pinching line**
   c. Place MUAC tape 2cm above the mid-point and mark its top line
   d. Mark a 90˚ point from biceps center point onto pinching line

5. **Biceps finger pinching points**
   b. Using 5cm points on the tape, mark 5 cm points from the biceps center point (on both sides of the center point that's left and right).

6. **Skin fold holding**
   a. Left hand in opposite side of a beggar position
   b. Thumb on one finger pinching point and the rest of fingers on the other point
   b. Grasp and let loose of muscles

7. **Caliper pinching**
   a. Hold caliper and open wide to the same degree as the pinch
   b. Bring caliper on the horizontal line drawn in step 3d, placing jaws under the fingers
   c. Pinch vertically and take reading within 3 seconds and release lower hold of caliper

8. **Repeat** step 6 and 7 two times to capture second and third reading

Subscapular

Participant:

1. Assumes a relaxed standing position
2. Stands erect with feet together, shoulders relaxed, arms hanging freely at the sides.
3. Relax the shoulder joint slightly externally rotated and elbow extended by the side of the body.

Examiner:

1. Introduce the exam to the participant
2. Open the back of the blouse and palpate for the inferior angle (or triangle portion) of the right scapula
3. To mark the landmark stand 50cm away from the patient ;(+ sign) on the inferior angle of the scapula
4. Examiners right leg to be at almost in a straight line behind the left leg of the participant
5. If required, ask the woman to reach behind her back with her right arm to better expose the scapula.
6. To draw a 90 degree line from the landmark, examiner's left leg to be 16cm away behind the participant and right leg to be 23cm away behind the left leg of the participant
7. Draw a bottom line towards vertebral column from the bottom point of line drawn in step 6 (caliper pitching line)
8. On the same position draw a 45 degree angle from the line drawn in step 6 and 7, inferior to the shoulder blade.
9. Mark 2 cm above, on the line drawn in step 8 and draw a horizontal line towards vertebral column adjacent to the caliper pitching line (finger pitching points)
10. Skin fold holding
    a. Left hand in opposite side of a beggar position
    b. Thumb on one finger pinching point and the rest of fingers on the other point
    b. Grasp and let loose of muscles
11. Caliper pinching
    a. Hold caliper and open wide to the same degree as the pinch
    b. Bring caliper on the horizontal line drawn in step 7, placing jaws under the fingers
    c. Pinch vertically and take reading within 3 seconds and release lower hold of caliper

12. **Repeat** step 10 and 11 two times to capture second and third reading

Suprailliac

Participant:

1. Stands and holds the right side of her cloth up so that the right hip area is exposed
2. Lower the exam pants slightly to expose the area

Examiner:

1. Introduce the exam to the participant
2. Make a (+) one inch above the right hip bone.
3. Draw a 90˚ angle on the marked point facing the stomach (vertical and horizontal lines from the marked point) then draw a 45˚ line from the marked point inside the 90˚ angle already drawn
4. Mark 2 cm on the 45˚ line from the marked point and join to the horizontal line already drawn in step 3
5. Mark 4cm from the 2cm point and join again to the horizontal line (the 4 cm on the 45˚ line will be pinching points and the 4 cm on the horizontal line will be for caliper pinching
6. Left hand in opposite side of a beggar position
7. Place left thumb on the 1cm point of the 4cm and rest of the fingers at the 4cm point(on the 45˚ line)
8. Hold caliper and open wide to the same degree as the pinch
9. Bring caliper on the horizontal line from the 90˚angle placing jaws under the fingers
10. Pinch horizontally and take reading within 3 seconds and release lower hold of caliper
11. Repeat step 6 to step 10 to capture second and third reading.

Appendix VI: Blood tests guidelines

Measuring Hemoglobin using Hemocue Hb 301 (according to the manual)

1. Put the cuvette holder in its loading position. The display will show three flashing dashes and the hemocue symbol
2. Remove a hemocue Hb 301 microcuvette from the vial.
3. Make sure the patient's hand is warm and relaxed. Use only the middle or ring finger for sampling, avoid fingers with ring on
4. Clean with disinfectant and allow to dry completely or wipe off with a dry, lint-free wipe.
5. Using examiner's thumb, lightly press the finger from the top of the knuckle towards the tip.
6. Sample at the side of the finger tip
7. While applying light pressure towards the fingertip, puncture the finger using a lancet
8. Wipe away the first 2 or 3 drops of blood.
9. Re apply light pressure towards the fingertip until another drop of blood appears.
10. When the blood drop is large enough, fill the microcuvette in one continuous process. **DO NOT** refill!!If a second sample is to be taken, fill a new cuvette from a new drop of blood. This should not be done until the measurement of the first sample is completed.
11. Wipe off excess blood from the outside of the microcuvette with a clean, lint-free wipe. Do not touch the open end of the microcuvette.
12. Look for air bubbles in the filled microcuvette. If present, discard the microcuvette and fill a new microcuvette from anew drop of blood. Small bubbles around the edge can be ignored.
13. Place the filled microcuvette in the cuvette holder within 40 seconds after filling
14. Gently touch the cuvette holder, it will automatically slide to the measuring position
15. During the measurement "  " will be shown.
16. After approximately 10 seconds, the hemoglobin value is displayed. The result will remain on the display as long as the cuvette holder is in the measuring position. Do not remeasure the cuvette. When operating on battery power, the analyzer will automatically turn off after approximately 5 minutes
17. Always handle blood specimens with care, as they might be infectious. Consult local environmental authorities for proper disposal.

Measuring blood glucose using Hemocue Glucose 201(according to the manual)

1. Put the cuvette holder in its loading position. The display will show three flashing dashes and the hemocue symbol
2. Make sure the patient's hand is warm and relaxed. Use only the middle or ring finger for sampling, avoid fingers with ring on
3. Clean with disinfectant and allow to dry completely or wipe off with a dry, lint-free wipe.
4. Using examiner's thumb, lightly press the finger from the top of the knuckle towards the tip.
5. Sample at the side of the finger tip
6. While applying light pressure towards the fingertip, puncture the finger using a lancet
7. Wipe away the first 2 or 3 drops of blood.
8. Re apply light pressure towards the fingertip until another drop of blood appears.
9. When the blood drop is large enough, fill the microcuvette at the filling end in one continuous process. **DO NOT** refill!!If a second sample is to be taken, fill a new cuvette from a new drop of blood. This should not be done until the measurement of the first sample is completed.
10. Wipe off excess blood from the outside of the microcuvette with a clean, lint-free wipe being careful not to touch the filling end of the microcuvette, which could result in blood being drawn out of the microcuvette.
11. Make sure that the microcuvette is completely filled and has no air bubbles. If air bubbles are present, discard the microcuvette and fill a new microcuvette from anew drop of blood. Small bubbles around the filling end can be ignored.
12. Place the microcuvette into the cuvette holder and start measurement as soon as possible but not later than 40 seconds after filling the microcuvette, by gently sliding the cuvette holder to the measuring position.
13. During the measurement "⧗" will be shown and three fixed dashes will be shown.
14. Most results will appear on the display within 1 minute for glucose levels ≤ 7mmols/L (≤126 mg/dl). The result will remain on the display as long as the cuvette holder is in the measuring position. An analyzer with plasma conversion will show p- equiv on the display. When operating on battery power the analyzer will automatically turn off after 5 minutes. Do not remeasure the cuvette.
15. Always handle blood specimens with care, as they might be infectious. Consult local environmental authorities for proper disposal.

Appendix VII: Ethical clearance - Norway

REK
REGIONALE KOMITEER FOR MEDISINSK OG HELSEFAGLIG FORSKNINGSETIKK

Region:	Administrator:	Telephone:	Our date:	Our ref:
REK sør-øst	Tor Even Svanes	22845521	09.09.2015	2015/1286/REK sør-øst C
			Your date:	Your referanse:
			16.06.2015	

Penjani Kamudoni
Institute for health and Society

2015/1286 Maternal and child health

Institution responsible for Research: Institute for health and Society
Project Manager: Penjani Kamudoni

We are writing in reference to your application for approval for the above mentioned Research Project. The Committee reviewed the application during its meeting on the 28th of August 2015. The project was assessed in accordance to the Health Research Act (2008) § 10, and Norwegian Research Ethics Act (2008) §
4.

Project Description
Maternal nutrition represents by far, the greatest influence amongst pregnancy environmental factors on birth weight in developing countries. It is against the above background, that a cluster Randomized Controlled Trial (cRCT) aimed at measuring the effect of dietary counseling during pregnancy on infant birth weight in Nankumba area, Mangochi district, Malawi has been planned. The counselling intervention will be developed from findings from earlier studies (a cross-sectional dietary intake survey & formative study) which will be undertaken as part of an independent sub-project, by a PhD fellow. The primary outcome in the cRCT will be infant birth weight. Secondary outcomes will be: other infant birth size parameters (length, head and abdomen circumference); maternal dietary intake (actual diet intake & related knowledge & attitudes); relative pregnancy weight gain (and maternal anthropometric status); maternal biochemical nutritional status.

We are writing in reference to your Application for Preliminary Approval for the above-mentioned Research Project. The Regional Committee for Medical and Health Research Ethics, Section C, South East Norway, reviewed your Application during its meeting on the 20th of August 2015. The Project was assessed in accordance to the Norwegian Research Ethics Act § 4 (2006), and the Health Research Act § 10 (2009), for Regional Committees for Medical and Health Research Ethics.

Review
The Committee has no objections to implementation of the Research Project.

Decision
The project is approved on the condition that it is conducted as described on the Application Form, and in the Research Protocol.

The approval is valid until 31.12.2016. For documentation and follow-up purposes, the data will need to be

kept until 31.12.2026. The data must be stored as de-identified data, i.e. a file with key identifiable information stored separately from the file containing other data. The data must, either be deleted or anonymised within 6 months after this date.

Appeals process
The decision of the Committee may be appealed to the National Committee for Research Ethics in Norway. The appeal will need to be sent to the Regional Committee for Research Ethics, Section B, South East Norway, The deadline for appeal is three weeks from the date on which you receive this letter.

With kind regards

Britt-Ingjerd Nesheim
Chair of the Regional Committee for Medical
& Health Research Ethics of South East Norway,
Section C

Tor Even Svanes
Senior Advicer

Copy::k.t.stokke@mesidisin.uio.no

Appendix VIII: Ethical clearance - Malawi

CERTIFICATE OF ETHICS APPROVAL

This is to certify that the College of Medicine Research and Ethics Committee (COMREC) has reviewed and approved a study entitled:

P.06/13/1406 – A Cross-sectional Study on Maternal Dietary intake and its Association with Infant's Birth Weight by Dr. P. Kamudoni

On 4th July 2013

As you proceed with the implementation of your study, we would like you to adhere to international ethical guidelines, national guidelines and all requirements by COMREC as indicated on the next page

Dr. G. Kalanda – Chairperson (COMREC)

Approved by College of Medicine
04 JUL 2013
(COMREC)
Research & Ethics Committee

Date: 04 July 2013

Appendix IX: Consent form in Chichewa

CONSENT FORM (THUMB PRINT) FOR PARTICIPATION IN THE STUDY ON FACTORS AFFECTING PREGNACY WEIGHT GAIN

Kwa amayi omwe angakonde kutenga mbali mu mkafukufuku:

Ine ndine ----------(dzina la mlendo wa za kafukufuku), ndabwera kuno ngati wogwira ntchito mu mprojekiti ya kafukufuku pakati pa sukulu ya zaumoyo yaku Norway ndi sukulu ya za umoyo kuno kwathu ku Blantyre. Ndabwera kuno kudzachita kafukufuku wokhudza thanzi la amayo oyembekezela. Cholinga cha kafukufuku ameneyu ndichakuti ana ambiri kwathu kuno amabadwa ndi sikelo yotsika. Thanzi la mayi m'thawi yoyembekezela ndi chimodzi mwazifukwa zomwe zimapangitsa mwana kubadwa ndi sikelo yotsika. Choncho, pofuna kuthetsa vuto ili, nkofunika kuti tidwiwe zinthu zomwe zimapangitsa mimba kuti izikula. Kafukufuku ameneyu ndi nthambi ya kafukuku yemwe akuchitika okhudzana ndi malangizo a zakudya kwa amayi oyembekezera ndi momwe amakhudzilana ndi sikelo ya mwana pobabdwa.

Chifukwa chachimenechi ndikupempha amayi omwe ali oyembekezela ndipo ndiosangalatsidwa kuti atenge nao mbali m'kafukufukuyi; Choncho ngati muli osanangalatsidwa ndipo mukufuna, mukhoza kulowa nao m'kafukufukuyi. Ngati muvomere kutenga mbali mkafukufukuyu, dzikufunsani mafunso okhudzana ndi zinthu izi: banja lanu, komanso maganizo anu pa nkhani ya zakudya. Komanso kagwiridwe kanu ka ntchito za pakhomo komanso ntchito zina zili zonse. Kuonjezera apo ndikuyesani sikelo ndi msinkhu, komaso oyesa magazi akakutengani madontho asanu ndi limodzi a magazi. Magaziwo akawayesa kuti aone ngati muli ndi ma vitamin okwanira mthupi komanso ngati muli ndi magazi okwanila. Kafukufukuyi ndi wa nthawi yosapitilira miyezi inayi kuyambila mukalowa panopa.

Palibe vuto linalilonse lomwe mungapezane nalo potenga m'bali m'kafufukuyi. Panthawi yomwe adzakutengeni madontho amagazi, mudzamva kaululu kwa kanthawi yochepa. Pakutenga mbali mkafukufukuyu mupeza phindu lakuti madzatha kudziwa ngati muli ndimagazi okwanila kapena ayi pokabeleka, komanso ngati muli onyetchela kapena ayi. Komanso pakutenga mmbali mkafukufukuyi mudzathandiza kubweletsa m'dela lino phindu

lakuti akuluakulu azaumoyo adzakhala odziwa za zomwe zimapangitsa mimba kuti zizikula, zomwe zidzawathandiza kuti akamachita mapologalamu adziganizila za izi.

Muli ndi ufula okana kutenga mbali mkafukufukuyu. Ndipo simuyimbidwa mlandu ulionse chifukwa chokana. Ndipo ngakhale mutavomera kutenga mbali muli ndi ufulu osintha maganizo ndikusiya ngati mwafuna kutero. Dzina lanu silikaululidwa kapena kutchulidwa kwina kuli konse, kupatula pa nthawi ino pofuna kulankhula nanu. Chithu chimodzi chomwe chilipo m'chakuti iwo amene atenge mbali m'kafukufukuyo, akuyenela kukhala azimayi omwe adzafune kukachilila kuchipatala.

Komaliza mayankho, komanso zoyesedwa zanu zakuchipatatala adzazisunga, ndipo patsogolo adzazigwiritsa ntchito kuti afufuze ngati nthanzi la mayi m'nthawi yoyembekezela lingathandize kuketeza mwana ku matenda ena akakula

Chidindo/Siginetcha cha otenga mbali mkafukufuku_____
Tsiku_____

Chidindo/Siginetcha cha mboni _____ Tsiku _____

Ngati muli ndi mafunso kapena pali zovuta zina zilizonse dziwitsani:

Abungwe loyanganira kuti akafukufuku m'dziko muno adzilemekeza ufulu wa anthu pa addressi ndi numbala iyi:
Mr F. Masiye, College of Medicine, Private Bag 360, Chichiri, Blantyre 3. Tel: 01 877 245
Kapena:
Oyang'anira za kafukufukuyi:
Dr P. Kamudoni, University of Oslo, Norway

Appendix X: Consent form in English

CONSENT FORM (THUMB PRINT) FOR PARTICIPATING IN THE STUDY ON FACTORS AFFECTING PREGNANCY WEIGHT GAIN

Dear prospective participant:

My name is …… (Researcher's name) and I am a researcher and working within a collaborative research project between the University of Oslo and the Malawi College of Medicine. I am here as part of the process of conducting a study determining factors that affect pregnancy weight gain. The reason why we are conducting this study is that a significant proportion of children in Malawi are born with low birth weight, pregnancy weight gain is one of the factors which is associated with birth weight; in adequate or excess have effects in birth weight. Therefore in order for health planners to prevent the problem of low birth weight, it is important understand the factors that affect pregnancy weight gain. This study is part of an on-going research project on community based delivered nutrition counselling on pregnant women and measure its effects on birth weight.

It is because of the above highlighted plans that I am requesting interested pregnant women to participate in this study. And thus, I would like to request you to participate. If you agree to participate in this research, we will visit you and ask you questions about your family background, the situation in your household. Furthermore we will also measure your weight, height, mid-upper arm muscle circumference. In addition, the laboratory technician will take six drops of blood from you by pricking your finger. The blood spots will be analyzed in a laboratory to assess if your body has adequate vitamins and blood, and also if you have enough blood. The study will go on for a maximum of 6 months i.e. starting from now.

There are no major risks as a result of participating in the study. A minor risk is the feeling of pain during the taking of blood spots; however, this pain is for a short time. The benefit that you can get by participating in the study is that you will be able to know at the time of giving birth whether you shall have enough blood or not; and also whether your body is underweight, normal or overweight. In addition by participating in the study you will help bring the benefit in this area that the health planners will be helped to better understand factors affecting pregnancy weight gain.

Your participation is voluntary and you do not have to answer if you don't want to. You can withdraw from the interview at any time if you wish to, without this having any negative consequences on you. Your name will not be used in any way after the interviewing is finished. The information you give me will be treated with confidentiality. However, in order to participate one needs to agree that they shall give birth at the hospital.

Lastly the information of those who shall participate in the study will be stored and utilized in future to examine if a mother's nutrition during pregnancy is a risk factor for diseases her child may get later on in life.

Signature / Thumb print: _____ Date: _____

Witness_____ Date_____

In case of any questions or problems please contact the College of Medicine Ethical Clearance contact at the below address or phone number:
Mr F. Masiye, College of Medicine, Private Bag 360, Chichiri, Blantyre 3. Tel: 01 877 245

OR:

The lead investigator in Malawi:
Dr P. kamudoni, University of Oslo, Norway

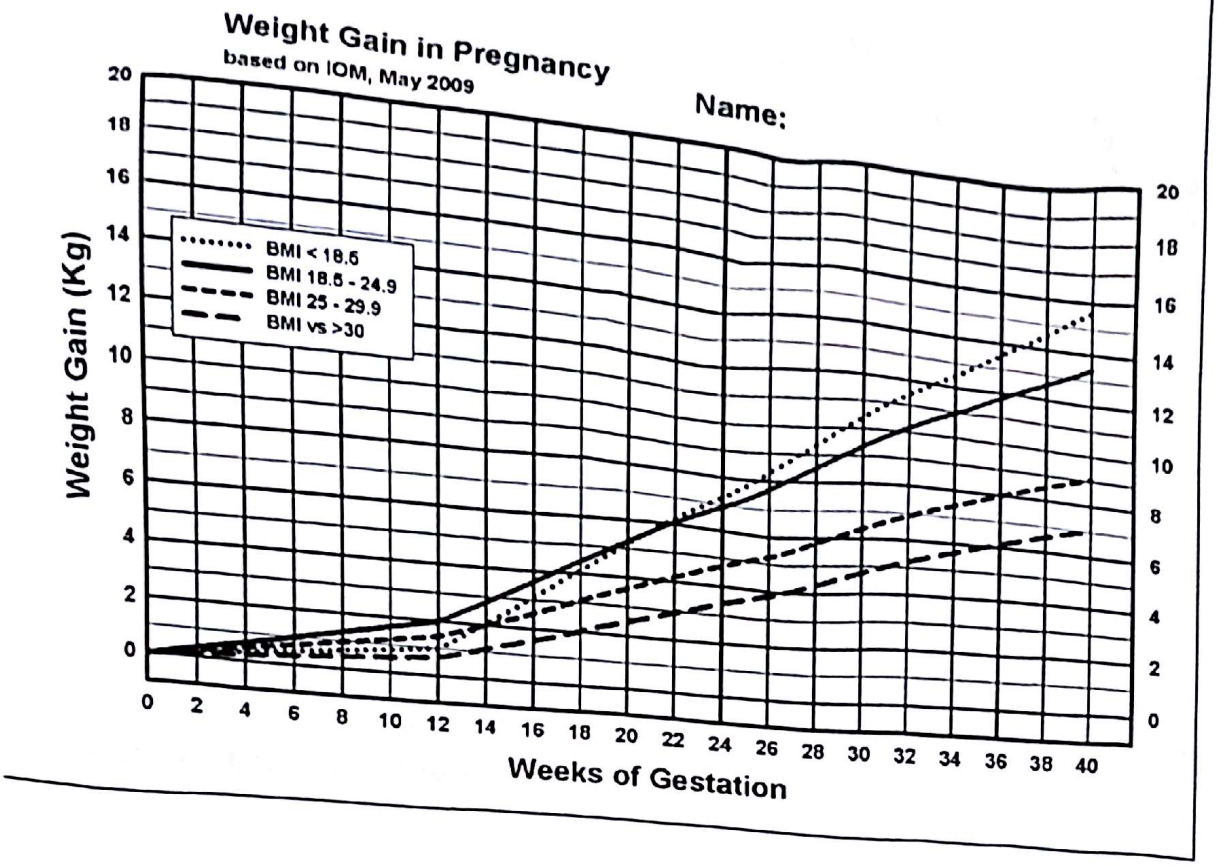
Appendix XI : Look up table for body fat calculation

UK

Calculation of body fat Percentage

Male	Age				Female	Age			
Sum	17-29	30-39	40-49	50+	Sum	16-29	30-39	40-49	50+
15	4.8	8.00	8.29	8.60	15	10.5	14.7	15.9	17.8
20	8.1	12.2	12.2	12.5	20	14.1	17.0	19.8	21.4
22	9.2	13.0	13.4	13.9	22	15.4	18.0	20.0	22.6
24	10.2	13.8	14.4	15.1	24	16.5	18.9	21.2	23.7
26	11.2	14.6	15.5	16.3	26	17.6	19.9	22.3	24.8
28	12.1	15.4	16.6	17.4	28	18.6	20.8	23.4	25.7
30	12.9	16.2	17.7	18.6	30	19.5	21.8	24.5	26.6
35	14.7	17.7	19.8	20.8	35	21.6	23.7	26.4	28.6
40	16.4	19.2	21.4	22.9	40	23.4	25.5	28.2	30.3
45	17.7	20.4	23.0	24.7	45	25.0	26.9	29.6	31.9
50	19.0	21.5	24.6	26.5	50	26.5	28.2	31.0	33.4
55	20.1	22.5	25.9	27.9	55	27.8	29.4	32.1	34.6
60	21.2	23.5	27.1	29.2	60	29.1	30.6	33.2	35.7
65	22.2	24.3	28.2	30.4	65	30.2	31.6	34.1	36.7
70	23.1	25.1	29.3	31.6	70	31.2	32.5	35.0	37.7
75	24.0	25.9	30.3	32.7	75	32.2	33.4	35.9	38.7
80	24.8	26.6	31.2	33.8	80	33.1	34.3	36.7	39.6
85	25.5	27.2	32.1	34.8	85	34.0	35.1	37.5	40.4
90	26.2	27.8	33.0	35.8	90	34.8	35.8	38.3	41.2
95	26.9	28.4	33.7	36.6	95	35.6	36.5	39.0	41.9
100	27.6	29.0	34.4	37.4	100	36.4	37.2	39.7	42.6
110	28.8	30.1	35.8	39.0	110	37.8	38.6	41.0	43.9
120	30.0	31.1	37.0	40.1	120	39.0	39.6	42.0	45.1
130	31.0	31.9	38.2	41.8	130	40.2	40.6	43.0	46.2
140	32.0	32.7	39.2	40.3	140	41.3	41.6	44.0	47.2
150	32.9	33.5	40.2	44.1	150	42.3	42.6	45.0	48.2
160	33.7	34.3	41.2	45.1	160	43.3	43.6	45.8	49.2
170	34.5	34.8	42.0	46.1	170	44.1	44.4	46.6	50.0
180	35.3	35.4	42.7	47.0	180	45.0	45.2	47.4	50.8
190	35.9	35.9	43.5	47.9	190	45.8	45.9	48.2	51.6
200	36.5	36.7	44.5	48.8	200	46.5	46.5	48.8	52.4

Appendix XII: Week by week recommended weight gain curve



http://www.pregnancy-week-by-week.info/pregnancy-wellness/weight-gain.html