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Association between Maternal Nutritional Status during Pregnancy and Low Birth Weight Delivery in Tikur Anbessa Hospital: A Case Control Study

Selamawit, Abate

BAHIR DAR UNIVERSITY

FACULTY OF CHEMICAL AND FOOD ENGINEERING

DEPARTMENT OF APPLIED HUMAN NUTRITION M.SC. PROGRAM

Association between Maternal Nutritional Status during Pregnancy and Low Birth Weight Delivery in Tikur Anbessa Hospital: A Case Control Study

A Thesis Submitted to Bahir Dar University Faculty of Chemical and Food Engineering Department in Partial Fulfillment of the Requirements for the Degree of Master of Applied Human Nutrition

By: Selamawit Abate

Advisor: Firehiwot Mesfin (Ph.D.)

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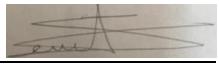
ADDIS ABABA, ETHIOPIA

Statement of Declaration

I, the undersigned, declare that this thesis is my original work, prepared under the guidance of Firehiwot Mesfin (Ph.D.). All sources of materials used for the thesis have been duly acknowledged. I further confirm that the thesis has not been submitted either in part or in full to any other higher learning Institution for earning any degree.

Name: **Selamawit Abate**

Signature: 

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Approval of thesis for defense result

I hereby confirm that the changes required by the examiners have been carried out and incorporated in the final thesis.

Name of Student Selamawit Abate Alemu Signature [redacted] Date 10/10/2016 E.C

As members of the board of examiners, we examined this thesis entitled "Association between maternal nutritional status during pregnancy and low birth weight delivery in Tikir Anbesa Hospital; A case of control study" by Selamawit Abate Alemu . We hereby certify that the thesis is accepted for fulfilling the requirements for the award of the degree of Masters of Science in "Applied Human Nutrition".

Board of Examiners

Name of Advisor	Signature	Date
Firehiwot Mesfin (Ph.D.)		10/10/2016 E.C
Name of External examiner	Signature	Date
Dr. Dereje Birhanu		12/10/2016 E.C
Name of Internal Examiner	Signature	Date
Fentanesh N.		12/10/2016 E.C
Name of Chairperson	Signature	Date
Mengist		12/10/2016 E.C
Name of Chair Holder	Signature	Date
Mengistu G.		14/10/2016 E.C
Name of Faculty Dean ፕሮ/ሰለሞን ወርቅነህ ፋንታ (ፋካልቲ ዲን) Prof. Solomon Workneh Fanta (Faculty Dean)	Signature	Date 12/10/2016 E.C

Faculty Stamp

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Finally, this thesis is the result of the collective efforts of various contributors, including data collectors, supervisors and Tikur Anbessa hospital and I am thankful for their contributions.

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List of abbreviations and Acronyms

ANC	Antenatal Care
Hb	Hemoglobin
HIC	High-Income Countries
IUGR	IntraUterine Growth Retardation
LBW	Low Birth Weight
LMP	Last Menstrual Period
MUAC	Mid-Upper Arm Circumference
SGA	Small-for-Gestational Age
SPSS	Statistical Package or Social Sciences
UN	United Nations
UNDP	United Nations Development Program
WHO	World Health Organization

Abstract

Background: *Low birth weight (LBW) is defined as a live born infant weight less than 2500 g regardless of gestational age. The world health organization estimates 25 million LBW babies are born worldwide annually and 95% occur in developing countries. A baby's birth weight can be affected by the mother's diet from birth to pregnancy, and her body composition at conception. LBW is the most important hospital concern worldwide and is still one of the leading causes of prenatal and neonatal deaths in Ethiopia.*

Objective: *To assess the association between maternal nutritional status during pregnancy and LBW among mothers who gave birth and visiting Tikur Anbessa Hospital.*

Methods: *A hospital-based unmatched case control study was conducted from October 1/2022 to December 30/2022 in Tikur Anbessa Hospital. 255 sample size was determined using Epi info 7 based on the assumptions 95% level of confidence, 80% power, 2:1 control to case ratio, 6% expected proportion among controls and 19.1% expected proportion among cases. Data was collected by interview using a pretested structured questionnaire and reviewing medical records. Newborns' birth weight was measured using a standard weight scale and mother's MUAC using a standard MUAC measuring tape. Data was cleaned and coded using Epi-data 7 and exported to SPSS 26. Variables having P-value < 0.25 in the bivariable model were entered into a multivariable regression model. Adjusted odds ratios were used to identify the association between the dependent and independent variable. Statistical significance was declared at P-value ≤ 0.05.*

Results: *A total of 192 (64 cases and 128 controls) were participated with the repose rate of 75.3%. The Multivariable logistic regression analysis showed a positive association between lower maternal nutritional status indicators and LBW. specifically, MUAC <23 cm [AOR=6.14; 95% CI: (2.17,17.3)], hemoglobin level <11 mg/dl [AOR = 4.58; 95% CI:(1.91,10.9)], absence of Nutritional Counseling [AOR = 2.28; 95% CI: (1.04,4.98)], lack of Iron/ Folic acid supplements [AOR = 6.02; 95% CI: (2.12,17.2)] and no Multiple*

micronutrient supplements [AOR = 6.44; 95% CI: (2.52,16.5)] were significantly associated with increased risk of low birth weight.

Conclusion: *this study showed a strong link between maternal nutritional status and LBW delivery. Thus, public health intervention in the field of maternal and child health should be addressed by strengthening multi-sectoral efforts, which improve women's adherence of iron-folate and multiple micronutrients, routine measurements of maternal MUAC and early detection and treatment of hemoglobin level during ANC visits.*

Key words: Low Birth Weight, Maternal Nutritional Status, Maternal MUAC, Hemoglobin Level

Chapter 1: Introduction

1.1 BACKGROUND OF THE STUDY

Low birth weight (LBW) is defined by the World Health Organization (Jemal) as weight at birth less than 2500 gram, while very low birth weight is considered as a birth weight less than 1500 gram, on the other hand very extremely low birth weight is a; birth weight less than 1000 gram, regardless of gestational age. The birth weight of an infant is an essential health status indicator and is a basic factor that determines the neonate's physical growth, mental development, and survival. It also indicates the previous and current health status of the mother (United Nations Children's Fund, 2004).

The health of the mother during pregnancy is very important to give birth to a healthy baby. Birth weight is a strong predictor of infant development and existence. Child born with low birth weight starts life with challenges and has a lower survival rate (Karim KH, 2013).

The global prevalence of low birth weight is estimated to be 15% to 20% of all births representing over 20 million births in a year.The regional estimates of low birth weight show 28% in south Asia, 6% east Asia and the Pacific, 13% in sub-Saharan Africa and 9% in Latin America (Marete I, 2020).

In a developing country, like Ethiopia, low birth weight is primarily caused by poor fetal growth linked to poor maternal nutrition before and during pregnancy. Mother's health, high prevalence of specific and non-specific infections, pregnancy complications, and physically demanding work during pregnancy also contributes to poor fetal growth (WHO, 2014) .

The nutritional status of women prior to conception and during pregnancy is important for fetal growth and development. Maternal undernutrition and insufficient gestational weight gain (GWG) are key contributors to increased incidence of low birth weight (JC, 2003).

While the association between maternal nutritional status during pregnancy and low birth weight, have not been adequately investigated, specifically in Tikur Anbessa Hospital Addis Ababa . To fill this gap, this study was aimed to examine the association between maternal nutritional status during pregnancy and low birth weight among pregnant mothers who delivered in Tikur Anbessa Hospital in Addis Ababa, Ethiopia.

1.2 STATEMENT OF THE PROBLEM

LBW is the most important public health concern worldwide and is still one of the leading causes of prenatal and neonatal deaths in Ethiopia. The global prevalence of low birth weight is estimated to be 15% to 20% of all births representing over 20 million births in a year.The regional estimates of low birth weight show 28% in south Asia, 6% east Asia and the Pacific, 13% in sub-Saharan Africa and 9% in Latin America (Marete I, 2020).

LMICs carry the highest burden of LBW infants. In 2015, three-quarters of the world's LBW newborns were born in three regions: south Asia (47%), eastern and southern Africa (13%) and west and central Africa (12%) (Marete I, 2020). Ethiopian Demographic and Health Surveys (EDHS) estimated that 14%-21% of all babies in the country are born at low birth weight. However, only 5% of children were weighed at birth (Central Statistical Agency, 2016). The prevalence of low birth weight has so far been reported as low as 11.2 to 28.3% across the country (Gebremedhin, 2015).

The health of the mother during pregnancy is very important to give birth to a healthy baby. Birth weight is a strong predictor of infant development and existence. Child born with low birth weight starts life with challenges and has a lower survival rate (Karim KH, 2013). The nutritional status of women prior to conception and during pregnancy is important for fetal growth and development. Maternal undernutrition and insufficient gestational weight gain (GWG) are key contributors to increased incidence of low birth weight (JC, 2003).

The World Health Assembly set a policy target to reduce LBW by 30% by the end of 2025. The packages give emphasis on care provided at the prenatal, ante-natal, intra-natal, and post-natal period interventions to prevent low birth weight, their associated morbidity and mortality in community settings (WHO, 2014). The Ethiopian government targeted to decrease neonatal mortality to 10 per 1000 live births by 2035 (WHO, 2011).

1.3 SIGNIFICANCE OF THE STUDY

Malnutrition in pregnancy is associated with a host of adverse maternal and infant outcomes, including gestational diabetes, pre-eclampsia, and preterm birth with over nutrition; small for gestational age (SGA), low birth weight (LBW), and neonatal death with undernutrition (Sutan, 2014). Therefore, the finding of this study will contribute in filling the gap in understanding the knowledge, attitude and practices regarding maternal nutrition among pregnant women in the study area.

The results of the study would inform design of the nutrition education intervention strategies targeting pregnant women due to their importance in reproductive and productive roles in the society. Besides the health providers and Ethiopian Ministry of Health, others who are interested in the field of maternal health in general would benefit from this research.

1.4 JUSTIFICATION OF THE STUDY

This study addresses a notable research gap in Ethiopia regarding the specific link between maternal nutritional status during pregnancy and low birth weight (LBW). Focused on Tikur Anbessa Hospital in Addis Ababa, the choice is informed by observed cases indicating the necessity for a comprehensive investigation within this healthcare setting. The study holds clinical significance by informing healthcare practices to develop targeted strategies for improving maternal nutrition and reducing the incidence of LBW, a critical health concern. Considering the local context in Addis Ababa recognizes variations in maternal health practices, nutritional habits, and healthcare infrastructure. The findings not only have local public health implications for Tikur Anbessa Hospital but also contribute to global knowledge on factors influencing birth weight, benefitting

researchers, policymakers, and healthcare practitioners worldwide focused on maternal and child health outcomes.

Chapter 2: Review of Related Literature

2.1 MATERNAL NUTRITION

Maternal nutrition during pregnancy is really important. Its effect is how the placenta grows and the baby grows and stays healthy. This interests women, their partners, and healthcare professionals. In developing countries, maternal undernutrition emerges as a prominent factor contributing to adverse pregnancy outcomes. (SACHIN, 2011).

Poor maternal nutritional intake after the preconception period during pregnancy can also negatively impact the fetus' genetic growth and can result in fetal growth restriction. Apart from what moms eat, how well the placenta works in sending nutrients and oxygen to the fetus is crucial for the fetus growth. Changes in placental development occur when the fetus isn't growing enough (S. M. Mahmud RA, Sarker AR, 2017) .

Maternal nutrition may predict nutrition available to the fetus after birth. The fetus responds and reacts to this prediction in various ways in order to maximize its chances of postnatal survival. The fetus immediate response to under nutrition is initially to break down substances to provide energy. If undernutrition is prolonged, the fetus changes its metabolic rate and changes the production of hormones as well as how tissue responds to them (Saraswathi, 2012).

2.1.1 Mid Upper Arm Circumference (MUAC)

Nutritional status of a woman is important for positive pregnancy outcomes (Lim Z., 2018). The nutritional status can be assessed using different parameters, one of them being the mid-upper arm circumference (MUAC) (Oliver E., 2014), a simple measurement used to evaluate the nutritional status of an individual (Benítez Brito, 2016) and serves as a surrogate of the body mass in pregnant women (Fakier A., 2017).

Mid-Upper Arm Circumference (MUAC) has been defined as, *"an anthropometric measurement which is used to assess nutritional status and determine eligibility for nutritional support among adolescents and adults in low–resource settings, especially among pregnant women*." (Tang AM, 2013).

There are several advantages that must be considered while looking into MUAC as a screening tool; it is easier to measure and more convenient, requiring less expertise than assessment of BMI. In the settings where resources and expertise are scarce, MUAC could be reliably surrogate for BMI to assess the nutritional status in pregnant women (Fakier A., 2017).

Although changes in MUAC are sometimes seen to be minimal during the entire duration of pregnancy, there is still a question of whether under certain circumstances MUAC could

possibly relate well with gestational weight gain. There is evidence of lower gestational weight gain during pregnancy among women with lower values for MUAC than with higher MUAC values (Dhivya Losini M, 2019). In spite of the convenience and ease of measurement of MUAC, it requires careful training and supervision in order to locate the tape on the proper position in the arm; to use the non-dominant arm; to measure while the arm is straight, not bent; and to prevent wrapping the measuring tape too tightly or too loosely, any of which could result in an erroneous estimate and some degree of observer variability (Dasgupta A, 2010).

2.1.2 **Dietary intake and micronutrient supplementation during pregnancy**

Maternal nutrition plays a key function in influencing fetal growth and birth outcomes. It is a changeable risk factor of public health significance in the effort to avert adverse birth outcomes, mostly among low-income populations (Abu-Saad, 2010). During pregnancy a a woman wants good nutritional status for a healthy outcome. Women who have a poor nutritional status at conception are at higher risk of disease and death (WHO, 2014). Optimal nutrition provided to the developing fetus is critical in achieving appropriate fetal growth and development (Allen, 2002). For instance, a systematic review and meta-analysis of 90 dietary studies among pregnant women in low-income countries reported lower energy and fiber intakes than optimal recommendations (Blumfield, 2012). Essential nutrients together with folic acid, iron, zinc, calcium, vitamin D, and essential fatty acids function to support bone development and brain development (Blumfield, 2013). It is obvious that intrauterine fetal growth is the placental supply of nutrients to the fetus reliant upon placental size and blood supply (Forehead, 2004).

Assessment of common practices of food intake during pregnancy informs the direction of preventative practice and interventions benefiting populations of pregnant women and their offspring. Being born with low birth weight (LBW) is generally recognized as a disadvantage for the infant, increasing the risk of early growth retardation, fast catch-up growth, infectious disease, developmental delay, and death during infancy and childhood (Englund, 2014). Earlier publications have shown that dietary practices characterized with nutrient-rich foods were linked with bigger birth size outcomes (Englund, 2014). This shows that proper dietary pattern during pregnancy is crucial for normal pregnancy outcome.

2.1.3 Nutrition counseling

Whole human beings require a balanced measure of foods for the proper performance of the body system. However, some factors can change nutrition requirements from individual to individual. For example, pregnancy is such a critical phase in a woman's lifetime when the mother needs optimal nutrients of superior qualities to hold the growing fetus (G Daba, 2013).

Additionally, optimal levels of micronutrients are highly essential for women's health during the childbearing years which is dependent on a mother's intake or consumption. Although poor dietary intake is a common cause of micronutrient deficiencies, the root cause is associated with a poor socioeconomic level, and decreased knowledge about appropriate feeding style (Zelalem, 2017).

Many factors hinder adequate dietary intake in pregnant and lactating women. Maternal food intake is usually dependent on individual choice, cultural beliefs; food taboos, beliefs surrounding pregnancy physiology, food aversions, household food availability, and economic constraints (de Diego-Cordero R, 2020). Maternal nutrition education and counseling (NEC) on diet and weight gain, as well as monitoring of progress in maternal nutrition, are areas of needed attention. With the exception of special populations, and specific diets, NEC is normally implemented to enhance maternal dietary activity (Amy Webb Girard, 2012).

For many pregnant women, dietary intake of vegetables, meat, dairy products, and fruit are often insufficient to meet these needs (Ali EA, 2020). Social and behavior change interventions to improve maternal nutrition including maternal diet counseling can also be integrated into community-level activities, such as supervision conducted by health extension workers, or participating male and female community leaders through each duty (Freeman PA, 2017).

As indicated by the Sustainable development Goals (SDGs) which is the United Nations (UN) agenda by the year 2030, nutrition is placed at the heart of the SDGs indeed, nutrition is vital for achieving twelve out of seventeen SDGs). The remaining five SDGs support improvements in nutrition (FMOH, 2015).

The Health Sector Transformation Plan of the Ethiopian government stated that the focus of the country is to improve the nutritional status of mothers and children. Improving the nutritional status of women (15–49 years) and adolescent girls (10–19 years) are one of the strategic objectives stated in NNP-II (ETHIOPIA, 2016).

Although healthcare practitioners perceive nutrition education to be important, because of many barriers to providing education to clients, generally, women are not receiving adequate nutrition education during AnteNatal Care follow-up (Catherine Lucas, 2014). Counseling given to pregnant women regarding nutrition was insufficient in opportunity and range. The counseling was characterized by a shortage of time, inadequate space, rare counseling, and interrupted documentation.

Furthermore, counseling was provided only once to the mothers throughout ANC follow-up, that is at their first visit only (Rameeza Kaleem, 2020). According to the study done in the Oromia region, Ethiopia, even though there is a significant relationship between nutrition information and nutrition practices of mothers during pregnancy, pregnant mothers' access to nutritional information is relatively low (G Daba, 2013).

In Addis Ababa, the proportion of mothers who have appropriate knowledge of maternal nutrition during pregnancy was found to be 53.9% after proper nutrition education has been provided to them (Zelalem, 2017).

Even so, maternal nutrition requires considerable attention during pregnancy; nutritional counseling provided by a health professional during antenatal care (Cátia Regina Branco da Fonseca) is not satisfactory (Rameeza Kaleem, 2020). Many studies conducted around the globe, particularly in Africa and Asia reported that; Counseling given to pregnant women regarding nutrition was insufficient in opportunity and range. The counseling was characterized by a shortage of time, inadequate space, rare counseling, and interrupted documentation. Previously conducted studies focus mainly on the maternal nutritional status and barriers of maternal education during pregnancy; which lacks to indicate the whole process of nutrition counseling and education, including interventions for barriers (Catherine Lucas, 2014).

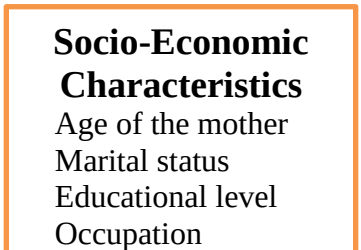
2.2 MATERNAL NUTRITION STATUS AND LOW BIRTH WEIGHT

Maternal nutritional status both before and during pregnancy is a well-recognized determinant of birth outcomes. Only two indicators, namely maternal pre pregnancy body mass index and weight gain during pregnancy have shown consistent positive associations with infant birth weight. Reports from developed and developing countries show that maternal anthropometric measurements are associated with birth outcome (Saraswathi, 2012). Maternal weight prior to conception reflects nutritional stores potentially available to the growing fetus. A study conducted in India had revealed pregnant women who weighed less than 60 kg gave birth to neonates with the mean birth weight of 2.7 kg, while subjects who weighed more than 75 kg gave birth to heavier neonates (3.6 kg). Similarly, pre pregnancy maternal weight of <45 Kg was important determinant of low birth weight with OR: 4.41, CI95% 2.30- 8.40. Weight gain during pregnancy would be expected to affect intrauterine growth. Studies from several developing countries report an average weight gain during pregnancy of 6 kg, compared with 11 kg in developed countries (Eltahir M Elshibly, 2008). A case-control study which was conducted in Botucatu city, Brazil showed that inadequate weight gain being less than 5 kg (OR: 2.63, 95% CI 1.35-5.00, p=0.004) was associated with LBW (Cátia Regina Branco da Fonseca, 2012). Meanwhile, women with normal weight gain gave birth to babies with the mean birth weight of 3.3 kg, while pregnant women with low gestational weight gain gave birth to babies with the mean birth weight of 2.5 kg

(Saraswathi, 2012). Similarly, a cohort study conducted in Kersa-Haromaya, Ethiopia has revealed that LBW was significantly associated with MUAC less than 23 cm (OR 1.6, 95% CI 1.19, 2.19).

2.3 CONCEPTUAL FRAMEWORK

This conceptual framework was developed after reviewing Ethiopian demographic health survey and different literatures. The diagram shows the association between low birth weight with socio-demographic factors, dietary intake, nutritional status indicators and supplementation.



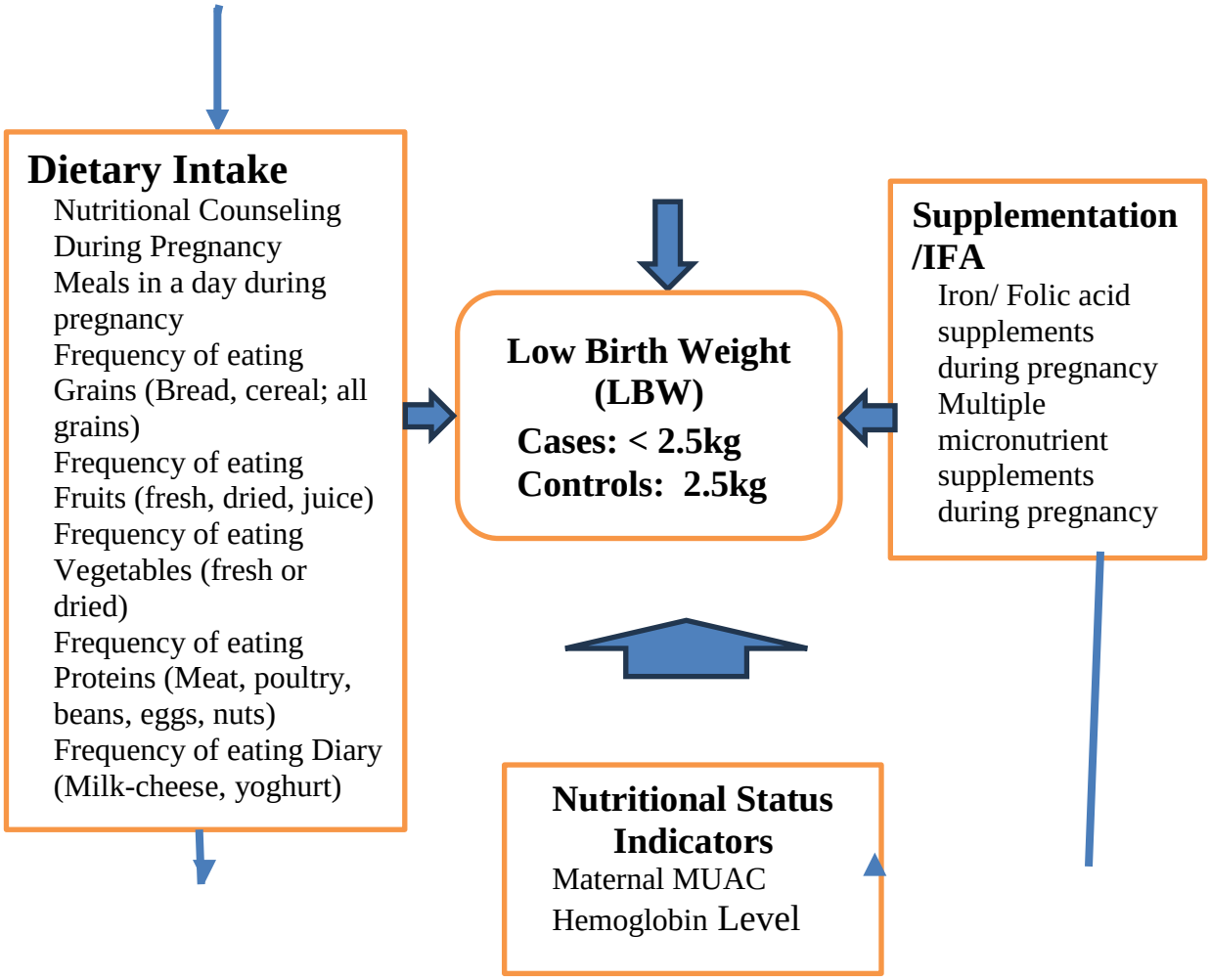


Figure 2-1: Conceptual Framework: Source: Reviewed literature

Chapter 3: Objectives of the Study

The general objective of this study is to assess the association between maternal nutritional status during pregnancy and low birth weight (LBW) among mothers who gave birth in Tikur Anbesa Hospital.

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Chapter 4: Methods and Materials

4.1 STUDY AREA AND PERIOD

This study was conducted in Tikur Anbessa Specialized Hospital (TASH). The Tikur Anbessa Specialized Hospital (TASH) is the teaching hospital of the College of Health Sciences (CHS), Addis Ababa University (AAU). TASH is the largest specialized hospital in Ethiopia, with over 700 beds. It offers diagnosis and treatment for approximately 370,000-400,000 patients per yearIt serves as a training center for undergraduate and postgraduate medical students, dentists, nurses, midwives, pharmacists, medical laboratory technologists, radiology technologists, and others who shoulder the health problems of the community and the country at large (https://www.ethiovisit.com). .

The study was conducted from October 1/2022 to December 30/2022 to determine the association between maternal nutritional status during pregnancy and the risk of low birth weight (LBW) in newborns at Tikur Anbessa Hospital.

4.2 STUDY DESIGN

This study employed a hospital-based unmatched case control study among women who deliver in Tikur Anbessa Hospital during the study period. A case-control study involves the identification of individuals with (‘cases’) and without (‘controls’) a particular condition. The prevalence (or level) of exposure to a factor is then measured in each group. If the prevalence of exposure among cases and controls is different, it is possible to infer that the exposure may be associated with an increased or decreased occurrence of the outcome of interest. In this study, cases were mothers who delivered alive low birth weight neonate (< 2500 g) and controls were mothers who deliver normal birth weight neonates (ε 2500 g.)

4.3 POPULATION OF THE STUDY

4.3.1 Source population

The source population of the study were all women of age 20 years and above who visit Tikur Anbessa Hospital for delivery service during the data collection period. New born weighing less than 2500 g were considered as cases and live term births weighed 2500 g up to 4g as controls.

4.3.2 Study population

The study population were mothers aged 20 and above who gave live term births weighing less than 2500 g were considered as cases and live term births weighed 2500 g up to 4g as controls.

4.3.3 Inclusion criteria

All mothers with term live newborns at Tikur Anbessa Hospital during the data collection period were included in the study

4.3.4 Exclusion criteria

Mothers suffered from severe medical or surgical conditions at the time of data collection period, twin delivery, newborn delivered with congenital anomalies, and unknown last normal menstrual period with absent early ultrasound evidence were excluded from the study.

4.4 SAMPLE SIZE AND SAMPLING TECHNIQUE

The sample size for this study was determined using Epi info version 7 statistical software package using the following assumptions of two population proportion formula for the unmatched case-control studies: level of confidence 95%, power 80%, 2:1 control to case ratio, 6% expected proportion among controls and 19.1% expected proportion among cases (Siyoum M, 2019). With the anticipation of a 5% non-response rate, the final sample size was 255, of which 85 cases and 170 controls. Both cases and controls were selected after delivery on an ongoing basis until the required sample size was fulfilled.

4.5 VARIABLES

4.5.1 Dependent variable

- Low Birth weight (LBW)

4.5.2 Independent variables:

- Nutritional status
  - Socio-Economic Characteristics
  - Maternal MUAC
  - Hemoglobin Level
  - Dietary Intake
  - Micronutrient Supplementation/IFA

4.6 OPERATIONAL DEFINITIONS

- **Maternal nutrition** is nutrient intake and dietary planning undertaken before, during and after pregnancy.
- **Low birth weight** is defined by the World Health organization as weight at birth less than 2500 gram, regardless of gestational age**.**
- **Mid upper arm circumference** is an anthropometric measurement which is used to assess nutritional status and determine eligibility for nutritional support among adolescents and adults in low–resource settings, especially among pregnant women." (Tang AM, 2013). measurement of MUAC, it requires careful training and supervision in order to locate the tape on the proper position in the arm; to use the non-dominant arm; to measure while the arm is straight, not bent; and to prevent wrapping the measuring tape too tightly or too loosely, any of which could result in an erroneous estimate and some degree of observer variability (Dasgupta A, 2010)
- **Dietary Intake,** refers to the quantity and types of foods an individual consumes over a specific period.it encompasses the variety of nutrients such as carbohydrate, proteins, vitamins and minerals.

4.7 DATA COLLECTION TOOLS AND PROCEDURES

The tools in this study were a pre-tested structured questionnaire and weight measurement. The newborns were weighted naked using a digital scale and the

questionnaire had a multiple-choice question and used to interview the mothers. Three data collectors and one supervisor had collected the data. Socio-economic status, dietary intake during pregnancy, nutrition status indicators and supplementation intake during pregnancy were included in the questionnaire. The weights of the newborn within 1 hour after delivery and the hemoglobin level of the mother were taken by the data collectors.

4.8 DATA QUALITY MANAGEMENT

To assure the quality of data, data collectors and supervisors were trained and regularly supervised and follow-ups were made by the supervisor and the principal investigator. In addition, regular check-up for completeness and consistency of the data was made on every other day basis. The questionnaire was translated to Amharic and back translated to English by translators to avoid language barrier.

Weight of the neonates was measured within one hour after delivery naked or in minimal clothing using standard, regularly calibrated scales. MUAC of the mothers was measured twice by an inelastic tape meter to the nearest millimeter and the averages of the two measurements were taken. The hemoglobin level of the mother was taken by the data collectors from ANC records.

4.9 DATA PROCESSING AND ANALYSIS

Data analysis was done based on data collected from the sample. Epi Info version 7.0 statistical software was used to clean and code the data. Statistical Package for Social Science (SPSS) software version 26 was used to analyze and present the data through the statistical tools used for this study.

Univariable Analysis: Frequencies and percentages were used for the categorical data to compare the distribution of the independent variables among cases and controls.

Bivariable Analysis: Binary logistic regression was done to determine association between independent variables and the dependent variable. Each independent variable was analyzed for its association with low birth weight and Crude odds ratios (de Diego-Cordero R 2020) with their subsequent 95% confidence intervals (CI) with the associated

p-values were obtained and interpreted. Those factors in the independent variables with p value of ≤ 0.25 were included as a candidate for multivariate logistic regression.

Multivariable Analysis: Binary Logistic Regression for all factors in the independent variables with p value of ≤ 0.25 and the results were expressed in terms of Adjusted Odds Ratios (AOR) with their subsequent 95% confidence intervals and p-values to determine proportion of low birth weight among newborns. In all analyses, associations with p-values of less than 0.05 ($p<0.05$) were considered statistically significant. Model fitness was checked by Hosmer and Lemeshow test and the p-value was 0.120, showing that the data set was a good fit for the model.

4.10 ETHICAL CONSIDERATIONS

The study was carried out after obtaining a supporting letter from Bahir Dar University Faculty of Chemical and Food Engineering. Then, data has been collected after necessary approval was obtained from Tikur Anbessa Hospitals prior to the commencement of the research. Written consent was obtained from all study participants. Consent forms were signed by the study participants. The purpose, possible risk and benefit of the study would be explained for the participants individually.

4.11 DISSEMINATION OF RESULT

The result of the study was presented to Bahir Dar University Faculty of Chemical and Food Engineering as part of Master of Science in Applied Human Nutrition and it will also get shared to the Hospital. Efforts will be made to present the results of scientific conferences and peer reviewed journal publications will also be considered.

Chapter 5: Results

5.1 SOCIO-ECONOMIC CHARACTERISTIC OF MOTHERS IN CASE AND CONTROL GROUP

A total of 192 participants with a repose rate of 75.3% participated in this study. Only socioeconomic characteristics of education level are significant. Other socio-economic characteristics of respondents show no significant difference between cases and controls. Refer table below for details.

Table 1: Socio-Economic Characteristics Among Case and Control Groups who gave birth to alive newborns and Visiting Tikur Anbessa Hospitals from October 1/2022 to December 30/2022, Addis Ababa.

Characteristics	Categories	Group		Total	P-Value
		Cases n (%)	Controls n (%)		
Age	20-30	20 (31.12)	39 (30.47)	59 (%)	.770
	31-40	30 (46.88)	66 (51.56)	96 (%)	
	ε 41	14 (21.9)	23 (18.0)	.794	
Marital status	Married	48 (75.0)	76 (59.4)	124 (64.58)	.794
	Divorced	7 (10.9)	26 (20.3)	33 (3.33)	
	Single	4 (6.3)	24 (18.8)	28 (14.58)	
	Widowed	5 (7.8)	2 (1.6)	.026*	
Educational level	No formal	10 (15.6)	25 (19.5)	35 (18.23)	.026*
	Primary	18 (28.1)	24 (18.8)	42 (21.88)	
	Secondary	27 (42.2)	33 (25.8)	60 (31.25)	
	College	9 (14.06)	46 (35.9)	.522	
Occupation	House wife	24 (37.5)	28 (21.9)	52 (27.08)	.522
	Gov't employee	22 (34.4)	34 (26.6)	56 (29.17)	
	Private employee	18 (28.1)	66 (51.6)	84 (43.75)	
Monthly income	< 5000 birr	32 (50.00)	26 (20.3)	58	.463

				(30.21)	
	5001 - 10000 birr	20 (31.1)	34 (26.6)	54 (28.13)	
	> 10000 birr	12 (18.75)	68 (53.1)	80 (41.67)	

**indicates candidate variables selected for multivariate*

5.2 MATERNAL MUAC AND HAEMOGLOBIN LEVEL OF RESPONDENTS

Out of 192 participant mothers, 29.7% (46.9% cases, 21.1% controls) had MUAC less than 23 cm with regard to hemoglobin level, 16.1 % (32.8% cases, 7.8% controls) had hemoglobin level less than 11 g/dl. Thus, there is a significant difference among cases and controls in terms of hemoglobin level and MUAC of the respondents. Refer table below for details.

Table 2: Maternal MUAC and Hemoglobin level Among Case and Control Groups who gave birth to alive newborns and Visiting Tikur Anbessa Hospitals from October 1/2022 to December 30/2022, Addis Ababa.

Variables	Categories	Groups		Total	P-Value
		Cases n (%)	Controls n (%)		
Maternal MUAC	< 23 cm	30 (46.9%)	27 (21.1%)	57 (29.7%)	.043*
	ε 23 cm	34 (53.1%)	101 (78.9%)	135 (70.3%)	
Maternal Hemoglobin level	< 11 g/dl	21 (32.8%)	10 (7.8%)	31 (16.1%)	.006*
	ε 11 g/dl	43 (67.2%)	118 (92.2%)	161 (83.9%)	

**indicates candidate variables selected for multivariate*

5.3 DIETARY INTAKE OF RESPONDENTS DURING PREGNANCY

Out of 192 participants, Mothers who did not get nutritional counseling during pregnancy were 49 (76.6%) cases. Thus, there is a significant difference among cases and controls in terms of nutritional counseling during pregnancy. However, there is not a significant difference among cases and controls in terms of the frequency of eating different types of food groups. Refer below table for details.

Table 3: Dietary Intake During Pregnancy Among Case and Control Groups who gave birth to alive newborns and Visiting Tikur Anbessa Hospitals from October 1/2022 to December 30/2022, Addis Ababa.

Variables	Categories	Group		Total	P-Value
		Cases n (%)	Controls n (%)		
During this pregnancy have you got nutritional counseling during pregnancy?	Yes	15 (23.4%)	78 (60.9%)	93 (48.4%)	.066*
	No	49 (76.6%)	50 (39.1%)	99 (51.6%)	
How many meals do you have in a day during pregnancy?	δ 2	22 (34.4%)	12 (9.4%)	34 (17.7%	.880
	3 times/day	25 (39.1%	66 (51.6%	91 (47.4%)	
	> 3	17 (26.6%)	50 (39.1%)	67 (34.9%)	
How often do you usually eat Grains (Bread, cereal; all grains)	Daily	40 (62.5%)	98 (76.6%)	138 (71.9%)	.281
	Every other day	16 (25.0%)	21 (16.4%	37 (19.3%)	
	1-2 times/week	7 (10.9%)	7 (5.5%)	14 (7.3%	
	Do not take	1 (1.6%)	2 (1.6%)	3 (1.6%)	
How often do you usually eat Fruits (fresh, dried, juice)	Daily	9 (14.1%	26 (20.3%	35 (18.2%)	.257
	Every other day	16 (25.0%)	48 (37.5%)	64 (33.3%)	
	1-2 times/week	17 (26.6%)	35 (27.3%)	52 (27.1%)	
	Do not take	22 (34.4%)	19 (14.8%)	41 (21.4%)	
How often do you usually eat Vegetables	Daily	4 (6.3%)	48 (37.5%)	52 (27.1%	.267
	Every other day	18 (28.1%	37 (28.9%	55 (28.6%)	

	1-2 times/week	26 (40.6%)	31 (24.2%)	57 (29.7%)	
	Do not take	16 (25.0%)	12 (9.4%)	28 (14.6%)	
How often do you usually eat Proteins (Meat, poultry, beans, eggs, nuts)	Daily	2 (3.1%	6 (4.7%)	8 (4.2%	.352
	Every other day	14 (21.9%	39 (30.5%	53 (27.6%	
	1-2 times/week	35 (54.7%	70 (54.7%	105 (54.7%	
	Do not take	13 (20.3%)	13 (10.2%)	26 (13.5%)	
How often do you usually eat Dairy (Milk-cheese, yogurt)	Daily	7 (10.9%)	21 (16.4%)	28 (14.6%)	.432
	Every other day	15 (23.4%)	37 (28.9%)	52 (27.1%)	
	1-2 times/week	40 (62.5%)	68 (53.1%)	108 (56.3%)	
	Do not take	2 (3.1%)	2 (1.6%	4 (2.1%)	

**indicates candidate variables selected for multivariate*

Table 4: Supplement Intake During Pregnancy Among Case and Control Groups who gave birth to alive newborns and Visiting Tikur Anbessa Hospitals from October 1/2022 to December 30/2022, Addis Ababa.

Variables	**Categories**	**Group**		**Total**	**P-Value**
		Cases n (%)	**Controls n (%)**		
Have you used Iron/ Folic acid supplements during this pregnancy?	Yes	40 (62.5%)	120 (93.8%)	160 (83.3%)	.005*
	No	24 (37.5%)	8 (6.3%)	32 (16.7%)	
Have you used Multiple micronutrient supplements during this pregnancy?	Yes	13 (20.3%)	81 (63.3%)	94 (49.0%)	.000*
	No	51 (79.7%)	47 (36.7%)	98 (51.0%)	

**indicates candidate variables selected for multivariate*

As Table 4 indicates, 40 (62.5%) cases 120 (93.8%) controls were supplemented with Iron/Folic acid supplements during their pregnancy. The remaining 24 (37.5%) of cases and only 8 (6.3%) controls were not supplemented with Iron/Folic acid supplements during their pregnancy. Regarding Multiple micronutrient supplements, the majority of cases, 51 (79.7%), were not supplemented with multiple micronutrient supplements during their pregnancy. Only 13 (20.3%) of cases were supplemented with multiple micronutrient supplements during their pregnancy. Whereas, 81 (63.3%) of controls were supplemented with multiple micronutrient supplements and 47 (36.7%) were not supplemented with multiple micronutrient supplements during their pregnancy. There is a significant difference among cases and controls in terms of Iron/Folic acid and multiple micronutrient supplements (Table 4).

5.4 ASSOCIATION BETWEEN NUTRITIONAL STATUS AND LOW BIRTH WEIGHT (LBW)

To assess the association between nutritional status and Low Birth Weight (LBW) among mothers who gave birth to alive newborns and visiting Tikur Anbessa Hospital, a bivariate and multivariable binary logistic regression analyses were used. Bivariable analysis was performed for each independent variable to determine the association between nutritional status of pregnant women during pregnancy and low-birth weight (LBW) of newborns. In the bivariate analysis, factors that had p-value < 0.25 were selected as candidate variables for the multivariable analysis. Educational level, MUAC, hemoglobin level, Nutritional counseling during pregnancy, Iron/ Folic acid supplements, and multiple micronutrient supplements were selected as a candidate variable for multivariate logistic regression model.

In the multivariate analysis MUAC, hemoglobin level, Nutritional counseling during pregnancy, Iron/ Folic acid supplements, and multiple micronutrient supplements was identified as factors associated with Low Birth Weight (LBW) among mothers who gave birth to alive newborns and visiting Tikur Anbessa Hospital.

Accordingly, Mothers who had MUAC <23 cm had 6.14 times higher odds of delivering LBW newborn compared to those who had MUAC ≥23 cm (AOR=6.14; 95% CI: 2.17-17.3). Similarly, anemic mothers (hemoglobin < 11 mg/dl) were 4.58 times more likely to deliver low birth weight babies than mothers who had hemoglobin level of ≥ 11 mg/dl during pregnancy (AOR = 4.58; 95%CI: 1.91-10.9).

Mothers unable to get nutritional counseling during pregnancy had 2.28 times higher odds of delivering LBW newborn compared to those who get nutritional counseling during pregnancy (AOR=2.28; 95% CI: 1.04-4.98).

Mothers who did not take Iron/ Folic acid supplements were 6.02 times more likely to deliver low birth weight babies than mothers who did take Iron/ Folic acid supplements during pregnancy (AOR =6.02, 6.02 to 17.2). Similarly, mothers who do not take multiple micronutrient supplements during pregnancy had 6.44 times higher odds of delivering LBW newborn compared to those who take multiple micronutrient supplements (AOR=6.44; 95% CI: 2.52-16.5) (Table 5).

Table5: Bivariate and multivariate logistic regression analysis of Low Birth Weight (LBW) among mothers who gave birth to alive newborns and visiting Tikur Anbessa Hospital, 2023 (n=192)

Variables	Category	Cases	Controls	COR (95%CI)	AOR (95%CI)
Educational level	Non formal	12(18.8)	39(30.5)	.410(.174,.969)	.370(.097,1.42)
	Primary	14(21.9)	34(26.6)	.549(.237,1.27)	1.16(.368,3.63)
	Secondary school	17(26.6)	27(21.1)	.840(.366,1.93)	1.04(.318,3.37)
	College	21(32.8)	28(21.9)	1	
MUAC	< 23cm	24 (37.5)	30 (23.4)	1.96(1.02,3.76)	6.14(2.17,17.3) *
	>_23cm	40(62.5)	98 (76.6)	1	
Hemoglobin level	<11g/dl	25(39.1)	26(20.3)	2.52(1.29,4.87)	4.58(1.91,10.9) *
	11g/dl and above	39(60.9)	102(79.7)	1	
Got Nutritional Counseling	Yes	29(45.3)	76(59.4)	1	
	No	52(40.6)	35(54.7)	1.76(.963,3.23)	2.28(1.04,4.98)*
Took Iron/	Yes	41(64.1)	106(82.8	1	

Folic acid supplements			)		
	No	23(35.9)	22(17.2)	2.70(1.36,5.37)	6.02(2.12,17.2)*
Consume Multiple micronutrient supplements	Yes	13(20.3)	72(56.3)	1	
	No	51(79.7)	56(43.8)	5.04(2.50,10.18)	6.44(2.52,16.5)*

**indicates significant variables (P-value<0.05), COR: Crude odd ratio, AOR: Adjusted odd ratio, 1: reference categories, CI: Confidence interval*

Chapter 6: Discussion

In this study an attempt was made to assess the association between maternal nutritional status during pregnancy and low birth weight (LBW) in the study area. Results of this study revealed that MUAC, hemoglobin level, Nutritional counseling during pregnancy, Iron/ Folic acid supplements, and multiple micronutrient supplements were identified as factors associated with Low Birth Weight (LBW) among mothers who gave birth to alive newborns and visiting Tikur Anbessa Hospital.

Women who had MUAC <23 cm have higher odds of delivering LBW neonates than those who had MUAC ≥23 cm. This finding was consistent with other studies conducted in Addis Ababa and other areas of the country. An institution based unmatched case-control study conducted by (Degemu Sahlu, 2020) on 468 mothers with term neonates at four governmental hospitals namely, Black Lion, Zewditu, Gandhi and St. Paulos Hospitals in Addis Ababa from February 1, 2017 to May 15, 2017, showed that mid-upper arm circumference (MUAC) had a statistically significant association with low birth weight. This result was also similar to studies conducted in North Shewa Zone, Ethiopia (Jemal, 2021), Dassie town, Ethiopia (Ahmed S, 2018), Guinea-Bissau (Stjernholm AD, 2021) and Bangladesh (S. M. Mahmud RA, Sarker AR, 2017) where maternal under-nutrition is positively associated with LBW. The reason behind this fact is that low nutritional status of the mother leads to different diseases that may cause LBW. Moreover, maternal under-nutrition may also cause fetal retardation because of the very low transfer of nutrients from the mother to her fetus, which leads to LBW (Triunfo S, 2015).

The odds of LBW among newborns from mothers who had hemoglobin < 11 mg/dl were more likely to deliver low birth weight babies than mothers who had hemoglobin level of ≥ 11 mg/dl during pregnancy. This finding was consistent with unmatched case-control study conducted by (Jemal, 2021) from February to June 2020 in five public hospitals and 14 health centers in the North Shewa zone showed that maternal Hgb had significant association with the occurrences of low birth weight. Similarly, this finding was also consistent with an institutional-based cross-sectional study conducted by (Negera, 2022)

design involving 269 participants pregnant mothers was conducted at Adama Hospital Medical College from September 15 to October 30, 2021 which showed that maternal Hgb <11g/dl had significant association with the occurrences of low birth weight. This finding is also in agreement with a case-control study conducted at Kambata (Alemu S, 2018), Dassie town (Ahmed S, 2018) Gahana (Adam Z, 2019) Nigeria (Oladeinde HB, 2015) and Nepal (Sharma SR, 2015) that found a statistically significant association between anemia and LBW. This is because anemia is caused due to the reduction of red blood cells (hemoglobin), and it can cause the amount of maternal blood production, which leads to the reduction of nutrients received by the fetus. This reduced amount of fetal nutrient causes restriction of fetal growth and leads to LBW.

Unable to get nutritional counseling during pregnancy was a significant determinant of low birth weight in this study. This finding is similar to a case-control study conducted in North Shewa Zone (Jemal, 2021) and Dassie town (Ahmed S, 2018) where nutritional counseling was an independent predictor of LBW. This might be because nutritional counseling enables and improves women's food intake, improves their nutritional status, and finally decreases the risk of giving LBW babies. In addition, the possible explanation could be that women during pregnancy got counseling about maternal diet and the importance of gestational weight gain. This type of counseling increased women's knowledge about the consequences of poor diet, the benefits of taking a balanced diet, food preparation, and weight gain (Nikièma L, 2017; Zelalem A, 2017).

This study also showed that mothers who did not take Iron/ Folic acid supplements were more likely to deliver low birth weight babies than mothers who did take Iron/ Folic acid supplements during pregnancy. This finding was consistent with an institution-based cross-sectional study conducted by (Teklay Tadesse, 2022) on 351 alive term newborns in selected public hospitals (Tikur Anbessa specialized hospital, Gandhi Memorial Hospital, Zewditu Memorial Hospital, and St. Petros hospital) of Addis Ababa Ethiopia from January-June 2021 which showed that iron/folic acid supplementation had significant association with low birth weight. Similarly this result was in line with a study conducted in Dassie town (Ahmed S, 2018), Kambata (Alemu S, 2018), Rural Ethiopia (Zerfu TA, 2016), Gahana (Adam Z, 2019), Auckland, New Zealand (Mitchell EA, 2004)

and Bangladesh (S. M. Mahmud RA, Sarker AR, 2017) that showed unable to take iron-folate during pregnancy associated positively with LBW. This might be due to intake of iron helps women not to develop anemia and risk of delivering LBW babies since the required amount of iron cannot be obtained from nutrients alone during pregnancy (Rizvi SA, 2007).

In addition, this result showed that mothers who do not take multiple micronutrient supplements during pregnancy had higher odds of delivering LBW newborn compared to those who take multiple micronutrient supplements. This result was supported by a randomized, double-blind controlled trial comparing standard iron supplementation with multiple micronutrients during pregnancy (Ramakrishnan U, 2003). Multiple micronutrients supplementation protects against low birth weight like Iron-alone supplementation (Ramakrishnan U, 2003). The use of multiple micronutrient supplements in pregnant women reduces rates of low birth weight (by 11% to 14%) and small-for-gestational-age infants (by 9% to 17%). However, the World Health Organization does not recommend multiple micronutrient supplementation because of the potential for increased neonatal mortality in some situations (Jennifer Pense, 2015).

Chapter 7: Strength and Limitations of the Study

7.1 STRENGTHS OF THE STUDY

- The study design used was relatively better (but not best) as low birth weight is multifactorial.

7.2 LIMITATIONS OF THE STUDY

- This study was hospital based, and therefore it may not be as good as population-based studies to generalize the results in the population.
- As the study design was a hospital-based case-control study selection and recall bias might be introduced.
- The design does not permit distinction between cause-and-effect relationships in the associations.
- As data on some variables were self-reported, to the extent that survey participants misreported and the results may be biased.
- Although, non-response becomes a critical issue when response rates fall below 70%, significant non-response bias can still occur even at 75.3% response rates(Martin prince ,2012).

Chapter 8: Conclusion and Recommendation

8.1 CONCLUSION

The aim of This identified mid-upper arm circumference (MUAC) of the mother, Hemoglobin level, nutritional counseling, iron/folic acid supplementation and multiple micronutrient supplementation had strong association with low birth weight of newborns at Tikur Anbessa Hospital. Maternal nutritional status had a significant impact on newborn birth weight as poorly nourished mothers had higher odds of delivering LBW babies when compared to those who were better nourished.

8.2 RECOMMENDATION

Public health intervention in the field of maternal health should be addressed by strengthening multi-sectorial efforts which improve women's adherence to iron-folate and multiple micronutrient supplementation, routine measurements of maternal MUAC and early detection and treatment of hemoglobin level during ANC visits. Stakeholders should better work together to reduce low birth weight by preparing appropriate intervention. Lack of iron folate supplementation, multiple micronutrient supplementation and low level of hemoglobin should be managed effectively by professionals and awareness shall be created before pregnancy. The importance of nutritional counseling during pregnancy and maternal undernutrition screening needs to be strengthened to reduce incidence of LBW infants.

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Annex I: Information sheet

Bahir Dar University Faculty of Chemical and Food Engineering

Principal Investigator: Selamawit Abate

Name of Organization: BUFCAFE Department of Nutrition.

Information sheet for the study on Association between Maternal Nutritional Status during Pregnancy and the Risk of Low Birth Weight (LBW) in Newborns at Tikur Anbessa Hospital Addis Ababa, Ethiopia.

Title: Association between maternal nutritional Status during Pregnancy and the Risk of Low Birth Weight (LBW) in Newborns at Tikur Anbessa hospitals in Addis Ababa, Ethiopia.

Aim: The aim of this study is to assess Association between maternal nutritional Status during Pregnancy and the Risk of Low Birth Weight (LBW) in Newborns at Tikur Anbessa Hospital Addis Ababa, Ethiopia. This will have great relevance in identifying children at risk designing appropriate measures, and undertaking timely interventions.

Procedures: For this study to be successful we need your participation. If you are voluntary to participate in this study, you are expected to understand and sign the informed consent. Then, socio demographic and economic, dietary habit information as well as physical measurements which are important for this study will be taken. Weight measurement will be taken by trained nurses.

Risks and/discomfort: By participating in this research project, you will not feel any discomfort except wasting some time which will be around 30 minutes. Every piece of information will be kept confidentially. There is no risk in participating in this research.

Expected benefits: The data collected will be analyzed using international WHO standards. Knowing the exact measurements of your body will help you to modify your nutritional habits. In this study, participants are not directly benefited however; the information provided will be an input for future plans.

Confidentiality: All of the personal information collected for the purpose of this study will be kept confidential.

Payment: No payment will be provided by participating in this study.

Compensation: treatments for any injury or harm during the data collection will be covered by the investigators.

Privacy: privacy will be protected during every session of the data collection procedures especially during weight measurement. Weight measurement will be taken individually one by one.

Right to Refusal or Withdraw: Any refusal to participate and withdrawal involves no penalty or loss of benefits to which participants are otherwise entitled. The study participants have a right to withhold information, decline to cooperate in the study and refuse to be physically measured.

Annex II: Consent Form

Consent

I have been requested to participate in this study, which plans to assess the Association between Maternal Nutritional Status during Pregnancy and the Risk of Low Birth Weight (LBW) in Newborns at Tikur Anbessa Hospital Addis Ababa, Ethiopia.

I have been informed that the data collection requires collection of personal information and physical measurements The study will be conducted through extracting information by

interviewers using questionnaires and measurement like weight, I have also read the information sheet or it has been read to me, I have been also informed that all information contained within

The questionnaire is to be kept confidential. Moreover, I have also been well informed of my right to keep hold of information, decline to cooperate and drop out of the study if I want and that none of my actions will have any bearing at all on my overall enrolment. It is therefore with full understanding of the situations that I agreed to give the informed consent voluntarily to the researcher to use the information I am providing. Moreover, I have had the opportunity to ask questions about the project and I have received clarification to my satisfaction. I was also told that results would be reported timely to the concerned bodies. I agree that I am contributing to the future of my fellows by participating in this project. 1 have asked some questions and clarification has been given to me. I have given my consent freely to participate in the study, and I hereby approve my agreement with my signature.

Participant name----------date----------signature----------

Invigilator's name ----------date----------signature----------

Principal name----------date----------signature----------

Annex III: Questionnaire

Checklist and Questionnaire for data collection on the association between maternal nutritional status during pregnancy and the risk of low-birth-weight Neonates in Tikur Anbessa Hospital, Addis Ababa.

Note the Exclusion criteria from clinical records:

- Is the child preterm? 1: YES 2: NO
- Is the child free of any visible major birth defect 1: YES 2: NO

If "Yes" to any of the exclusion criteria, stop the collection of data.

I. SOCIO-ECONOMIC STATUS

S.NO.	Questions	Responses	Code
101	Age at your last birth day?	1. 20-30 2. 31-40 3. 41 and above	
102	Marital status?	1. Married 2. Divorced 3. Single 4. Widowed	
103	Educational level	1. No formal learning 2. Primary school 3. Secondary school 4. College education	
104	Occupation	1. House wife 2. Gov.t employee 3. Private	
105	Monthly Income	1. < 5000 Birr/ month 2. 5000 – 10000 Birr/month 3. ε 10000 birr/month	

II. MEASUREMENT

S. No.	Coding Categories	Questions and filters	Code
201	Neonatal birth weight in grams?	1. < 2.5 kg 2. 2.5-4.0 kg	
202	MUAC (Take left hand if right handed, and right hand if left-handed)	1. < 23 cm 2. ε 23 cm	
203	Hemoglobin level	1. < 11 g/dl 2. ε 11 g/dl	Medical record

III. DIETARY INTAKE DURING PREGNANCY

S.NO.	Coding categories	Questions and filter	Code
301	How many meals do you have in a day during pregnancy?	1. δ 2 times/day 2. 3 times/day 3. > 3 times/day	
302	How often do you usually eat Grains (Bread, cereal; all grains)	1. Daily 2. Every other day 3. 1-2 times/week 4. Do not take	
303	How often do you usually eat Fruits (fresh, dried, juice)	1. Daily 2. Every other day 3. 1-2 times/week 4. Do not take	
304	How often do you usually eat Vegetables (fresh or dried)	1. Daily 2. Every other day 3. 1-2 times/week 4. Do not take	
305	How often do you usually eat Proteins (Meat, poultry, beans, eggs, nuts)	1. Daily 2. Every other day 3. 1-2 times/week 4. Do not take	

306	How often do you usually eat Dairy (Milk-cheese, yogurt)	1. Daily 2. Every other day 3. 1-2 times/week 4. Do not take	

IV. SUPPLEMENT INTAKE DURING PREGNANCY

S.NO.	**Coding categories**	**Questions and filter**	**Code**
401	During this pregnancy have you got nutritional counseling during pregnancy?	1. Yes 2. No	
402	Have you used Iron/ Folic acid supplements during this pregnancy?	1. Yes 2. No	
403	Have you used Multiple micronutrient supplements during this pregnancy?	1. Yes 2. No	