The Effect of Gestational Weight Gain on Low Birth Weight, Case-Control Study in Northeast Amhara Regional State, Ethiopia, 2019

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Abstract: *Background*: Intrauterine growth and development are one of the most vulnerable periods in the human life cycle that contribute to appropriate fetal development. Therefore, this study aimed to assess the effect of gestational weight on low birth weight (LBW).

Methods: A case-control study was conducted from June 30, 2018, to January 1, 2019, in seven governmental hospitals in the northeast Amhara region on 451 participants(150 cases and 301 controls).

Results: Inadequate gestational weight gain increases the risk of LBW by four times (AOR: 4.2, 95% CI: 2.4, 6.4). Anemic mothers were 3 times (AOR: 3.2, 95%CI: 2.5, 5.1) more likely to give birth to LBW newborns than non-anemic women. Mothers with a height of less than 150 cm were 2 times more likely to deliver low birth weight babies than their counterparts (AOR:2.1, 95% CI: 1.5,4.4). The odds of LBW delivery were 3.5 times (AOR: 3.5, 95% CI: 2.3, 5.3) higher for mothers with poor dietary diversity than for mothers with good dietary diversity.

Conclusion: Inadequate gestational weight gain during pregnancy was found to be a risk factor for LBW. Additionally, anemia, short stature, and poor dietary diversity were also risk factors for LBW. Therefore, selectively targeted interventions such as improving maternal nutrition, anemia prevention, and proper maternal weight monitoring during pregnancy are needed.

Keywords: Low birth weight, anemia, gestational weight gain, maternal nutrition, Amhara, Ethiopia.

INTRODUCTION

Intrauterine growth and development are one of the most vulnerable periods in the human life cycle that contribute to appropriate fetal development. Growth alteration in this stage can lead to low birth weight (LBW), which is a newborn weighing less than 2500 grams at birth [1,2]. LBW is one of the world's major public health problems, affecting nearly 16% of newborns. The burden is very high in developing countries, including Ethiopia, which was 13% in 2016 [3,4].

Maternal nutrition is one of the factors that affect the birth weight of newborns, in addition to the physical environment and other factors [5, 6]. Two aspects of the mother's weight change influence an infant's birth weight. These are mothers' pre-pregnancy weight and maternal weight gain during pregnancy. As maternal weight gain is important for fetal wellbeing, the Institute of Medicine (IOM) put the recommended pregnancy weight gain based on pre-pregnancy body mass index (BMI) [7].

LBW is among the leading causes of neonatal mortality in developing countries. In Ethiopia, it is responsible for 5% of total deaths (one of 17 causes of death) [6]. Those who survive are more likely to have impaired immune function, reduced IQ points, increased risk of infection, and reduced growth and development, including stunting during childhood. Adults are more likely to suffer from chronic diseases like diabetes mellitus (DM) and the intergenerational effects of malnutrition [2,8].

Ethiopia is one of the world countries with a higher prevalence of infant mortality and stunting. In the national nutritional program II of Ethiopia, as the window of opportunity (the first 1000 days), reduction in LBW is one component of 2020 targets [9].

Wollo District is one of the areas in Ethiopia which is frequently affected by drought, including in 2015/2016. Moreover, most of the people in the area are affected by different nutrition-related problems [10]. Identification of modifiable maternal nutrition-related risk factors associated with LBW is essential to alter the increasing trend of LBW, its consequence, and the intergenerational link of stunting in Ethiopia. However, studies that examine the effect of gestational weight on LBW are lacking in the study area. Therefore, this study aimed to assess the effects of gestational weight gain on the LBW northeast Amhara region.

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METHOD AND MATERIAL

Study Design, Area, and Period

An institutional-based case-control study was conducted in the northeast Amhara region from June 30, 2018, to January 1, 2019. The area is divided into two zones south and north Wollo zones. There are a total of 12 governmental hospitals in two zones, and the study was conducted in seven selected governmental hospitals [11, 12].

Source and Study Population

Source population: All mothers who gave birth in the northeast Amhara region governmental hospitals.

Study population: All mothers who gave birth in the seven selected governmental hospitals in the northeast Amhara region. Mothers who had antenatal care (ANC) follow-ups, who gave birth in the selected governmental hospitals, and whose newborn's weight was recorded were included in the study. Mothers who were critically ill and had DM, hypertension and twin delivery were excluded from the study. Mothers who gave birth to newborns weighing less than 2500 grams were cases, and mothers who gave birth to newborns weighing 2500 grams and above were controlled.

Sample Size Determination and Technique

The sample size was determined using the proportion difference approach with the assumption of 95 % confidence level (Zα/2 =1.96), 80 % power (Zβ=0.84), control to case ratio 1:2 (r=2), the odds ratio to be detected 2.8 and the 6.2 % control group will be exposed. By adding a 10% non-response rate, the final sample size was 451 (150 cases and 301 controls) [13]. The calculated sample size was proportionally allocated to the seven governmental hospitals based on the annual delivery caseload. The weight of all live births delivered in the selected hospitals during the study period was measured. Based on the case definition, those mothers who gave live births weighed less than 2500g were included in the study as cases. For each case, two consecutive controls were included.

Study Variables

The dependent variable is low Birth weight, and the independent variables are;

- Socio-demographic characteristics: Age of mother, mother's occupational status, marital status, mother's educational status, wealth index, and sex of the newborn
- Maternal nutritional status: pre-pregnancy BMI, maternal weight gain during pregnancy, height, mid-upper arm circumference (MUAC), anemia, extra meal during pregnancy, iron adherence, dietary diversity, meal number, nutrition education during ANC.

Definition of Terms

Low birth weight: Is the weight of a newborn less than 2500 g

Height: Maternal height less than 150 cm will be considered as short stature [14]

Maternal Anemia : Hemoglobin less than 12mg/dl [4].

Adequate gestational weight gain: underweight mothers, a recommended gestational weight gain of: 12.5–18 kg, for normal weight: 11.5–16 kg, overweight: 7–11.5 kg, and obese mothers: 5–9 kg [7].

Iron adherence: the taking of iron supplementation for ≥ 90 days during pregnancy

Data Collection Tools and Procedures

The data was collected using a structured, pretested interviewer-administered questionnaire. The data collection procedure was initiated after two days of training for data collectors and supervisors. The weight of the newborns was measured using beam balance. Maternal weight was measured by using the digital weight measuring scale and also reviewed in ANC charts. The pre-pregnancy BMI of the mothers were obtained by reviewing their first-trimester weight from ANC charts. The total pregnancy weight gain was calculated and categorized as adequate and inadequate based on the pre-pregnancy BMI. Dietary diversity score (DDS) was assessed by using the 24-hour recall method and categorized as adequate for more than and equal to five food groups and inadequate if less than five food groups. Non-stretchable MUAC tape was used to measure maternal MUAC, while maternal height was measured by using a stadiometer to the nearest 0.1cm in a barefoot standing position. The wealth index was assessed as a composite indicator of the living standard by considering variables related to ownership assets.

Data Quality Control

The training was given to data collectors' supervisors. The questionnaire was cross translated to check its consistency and modification done based on a pretest conducted in Tenta hospital. The scales were frequently validated and calibrated to increase their quality, and also data completeness was checked by the supervisors.

Data Management and Analysis

Data were entered into Epi Data 3.1 and then exported and analyzed using the Statistical Package for Social Sciences (SPSS) version 24. Descriptive statistics, including frequencies and proportions, were used to summarize the study variables based on cases and controls. Binary and multiple logistic regression analyses were conducted to determine the factors associated with the outcome variable. Variables with P≤ 0.25 in the binary logistic regression were entered into multiple regression models. The adjusted odds ratio (AOR) with a 95 % confidence interval (CI) was estimated to assess the strength of association, and a P value of <0.05 was used to declare the statistical significance in the multiple logistic regression analysis.

RESULTS

Socio-Demographic Characteristics of Study Participants

A total of 451 (150 cases and 301 controls) have participated in the study. The mean (±SD) birth weight of cases and controls were 2015 grams (±243) and 3101 grams (±463) grams, respectively. Nearly five percent of mothers among low birth weight newborns and 3% of mothers in normal birth weight newborns are less than 20 years, and more than 80% are between 24-35 years old. More than half of the newborns were females in cases and males in controls (60.7% and 52.2 %, respectively). Almost equal percent of mothers

Table 1: Socio-Demographic Characteristics of Study Participants in Northeast Amhara Regional State, Ethiopia, 2019

Variables		LBW		NBW	
		N	%	N	%
Sex of newborn	Female	91	60.7	144	47.8
	Male	59	39.3	157	52.2
Wealth Index	Poor	45	30.0	92	30.6
	Middle	81	54.0	144	47.8
	Rich	24	16.0	65	21.6
Marital status	Single	140	93.3	267	91.7
	Married	4	2.7	6	2.7
	Divorce	3	2.0	7	2.3
	Separated	3	2.0	10	3.3
Educational status of mother	Illiterate	45	30.0	47	15.6
	Elementary	48	32.0	84	27.9
	Read and Write	13	8.7	41	13.6
	Secondary	24	16	69	22.9
	College and Above	20	13.3	60	19.9
Occupation of mother	Housewife	35	23.3	48	15.9
	Private	38	25.3	51	16.9
	Government employee	18	12.0	40	13.3
	Farmer	32	21.3	65	21.6
	Daily Labour	27	18.0	97	32.2
Age of mother	Less than 20	8	5.3	9	3.0
	20 to 34	124	82.7	258	85.7
	35 and Above	18	12.0	34	11.3

[NBW = Normal birth weight].

among LBW and normal birth weight newborns had poor wealth index status (30% in both cases and controls). The majority of the mothers were married in both cases and controls, and most of the mothers completed primary education (Table **1**).

Nutritional Status and Feeding Study Participants

The magnitude of adequate gestational weight gain was 50% among the LBW group and 80.7% among the normal birth weight group. Fifty-four (36%) of mothers among cases and 45 (15%) among controls were anemic. Pre-pregnancy BMI of less than 18.5 kg/m^2 was almost similar in the two groups (21.3% and 22.3% in LBW and normal birth weight groups, respectively). The proportion of mothers with poor dietary diversity was 45.3% and 19% in LBW and normal birth weight birth groups, respectively. In addition, 69.8% (74% of cases and 67% of controls) of the mothers did not take iron supplementation for ≥90 days during their pregnancy. Regarding maternal MUAC, 41.3% of cases and 17% of controls had MUAC of < 23 cm (Table **2**).

Factors Associated with Low Birth Weight

In multivariable logistic regression analysis, gestational weight gain, maternal hemoglobin, DDS, maternal height, and MUAC were significantly associated with LBW.

Inadequate gestational weight gain increased the risk of giving birth to LBW newborns by four times (AOR: 4.2, 95% CI: 2.4, 6.4). Being anemic had three folds (AOR: 3.2, 95% CI: 2.5, 5.1) risk for LBW. Mothers with a height less than 150 cm are 2.5 times (AOR: 2.1, 95% CI: 1.5, 4.4) more likely to deliver LBW neonate than their counterparts. The odds of LBW

Table 2: Nutritional Status and Feeding Practice of Mothers in Northeast Amhara Regional State Ethiopia, 2019

Variables		LBW		NBW	
		N	%	N	%
Gestational weight gain	Inadequate	75	50.0	58	19.3
	Adequate	75	50.0	243	80.7
Hemoglobin	≤11.9	54	36.0	45	15.0
	≥12	96	64.0	256	85.0
Dietary diversity score	Poor	68	45.3	58	19.3
	Good	82	54.7	243	80.7
MUAC(cm)	<23	62	41.3	54	17.9
	≥23	88	58.7	247	82.1
Height(cm)	<150	32	21.3	29	9.6
	≥150	118	78.7	272	90.4
Iron adherence	No	112	74.7	203	67.4
	Yes	38	25.3	98	32.6
Nutrition education	Yes	85	56.7	177	58.8
	No	65	43.3	124	41.2
Meal number	<=3	113	75.3	204	67.8
	>=4	37	24.7	97	32.2
Pre-Pregnancy BMI(kg/m^2)	<18.5	32	21.3	67	22.3
	18.5 to 24.9	59	39.3	127	42.2
	25 to 29.9	34	22.7	74	24.6
	>=30	25	16.7	33	11.0

[NBW= Normal birth weight].

Table 3: Factors Associated with LBW among Mothers Delivered in Governmental Hospitals of Northeast Ethiopia, 2019

Variables		COR(95%CI)	AOR(95%CI)
Sex	Female	1.7 (1.2,2.5)	1.4(0.88,2.3)
	Male		
Gestational Weight Gain	Inadequate	4.2(2.7,6.4)	3.4(2.1,5.6)**
	Adequate		
Hemoglobin	≤11.9	3.2(2.0,5.1)	3.3(1.9,5.8)**
	≥12		
Dietary Diversity Score	Poor	3.5(2.3,5.3)	2.5(1.6,4.5)**
	Good		
MUAC	<23	3.2(2.1,5.0)	2.0(1.2,3.5)*
	≥23		
Height	<150	2.5(1.5,4.4)	2.9(1.5,5.6)*
	≥150		
Iron Adherence	No	1.4(0.8-2.6)	1.5(0.9,2.5)
	Yes		
Wealth Index	Poor	1.8(0.8,2.7)	1.4(0.7,2.8)
	Middle	1.5(0.9,2.6)	1.5(0.8,2.7)
	Rich		

(Hosmerlemeshow was fitted with value of 3.52, *=p<0.05, **=p<0.01).

delivery were 3.5 times (AOR: 3.5, 95% CI: 2.3, 5.3) higher for mothers with poor dietary diversity compared to mothers with good dietary diversity. Additionally, the odds of LBW delivery triples (AOR: 3.2, 95% CI: 2.1, 5.0) in mothers whose MUAC is less than 23cm compared to mothers whose MUAC ≥23 cm (Table **3**).

DISCUSSION

A mother's nutritional status is essential for the well-being of both herself and the developing fetus. Birth weight is one of the most important biologic predictors of the well-being of the newborn [2,15]. This study showed that poor maternal nutrition, either before or during pregnancy, is associated with LBW. Our study showed that mothers with inadequate gestational weight gain based on their pre-pregnancy BMI had a higher probability of giving LBW newborns. This finding was in agreement with the findings of the studies conducted in German, India, and Mekelle [16-18]. In the current study, maternal pre-pregnancy BMI did not show a significant association with LBW. This result was in contrast to findings of the studies conducted in Mekelle and China, where the risk of delivering LBW babies was found to be significantly higher in those mothers whose pre-pregnancy BMI was less than 18.5 kg/m^2 [18, 19]. This difference could be explained by the fact that the pre-pregnancy BMI alone cannot determine the occurrence of LBW. Rather, if a mother with low pre-pregnancy BMI gains adequate weight during pregnancy, the risk of LBW could be decreased.

Anemic mothers were more likely to deliver LBW neonate than mothers with normal hemoglobin levels. This result was in line with the findings of the studies conducted in Bharatpur and Adewa [20,21]. This could have resulted from the low level of oxygen found in anemic mothers. This might reduce the amount of oxygen delivered to the fetus and affect its growth [22,23].

In this study, mothers with a MUAC of <23 cm had a higher risk of LBW. This finding was similar to the findings of other studies [24,25]. The possible explanation could be the fact that there is a nutrient competition between the fetus and the mother. Therefore, if the mother is inadequately nourished, there is a probability for the fetus to be also inadequately nourished [22].

The sex of the newborn was associated with LBW in previously conducted studies [17,26-28]. However, it was not significantly associated with our study.

The odds of LBW delivery were almost three times higher in mothers with low DDS. This result was in line with the findings of other studies conducted in Ghana and Mekelle [18,29]. This could be explained by the fact that mothers with a good diet can provide adequate energy and nutrients essential for the normal growth and development of the fetus. Therefore, the fetus could have adequate nutrients to reach its normal weight [8].

The present study had a significant association between maternal height and LBW. Being a short stature (<150cm) mother, triple the risk of giving birth to LBW newborns [30]. This finding can be a good example of the intergenerational nature of growth failure [22].

This study had both strengths and limitations. The strength of this study was it assessed the less studied nutrition-related causes of low birth weight like DDS, maternal nutritional status, and household food security. The limitation was that it did not take into account the maternal energy consumption and micronutrient intake label, which might have a high effect on the weight of the newborn.

CONCLUSION

This study showed that inadequate gestational weight gain and poor maternal nutritional status (anemia, short stature, low MUAC) could significantly increase the risk of having an LBW neonate. This suggests that selectively targeted interventions such as improving maternal nutrition and preventing anemia, and also proper maternal weight monitoring are needed to improve maternal and neonatal health.

DECLARATIONS

Ethics Approval and Consent to Participate

Letter of Ethical approval was received from the University of Gondar Institutional Research Ethics Review Committee, and permission letters were secured from hospitals. The mothers were well informed about the aim of the study and procedure. Verbal consent was ascertained from the study participants.

ABBREVIATIONS

AOR = Adjusted Odds Ratio

CI = Confidence interval

COR = Crude Odds Ratio

DDS = Dietary diversity score

LBW = Low birth weight

MUAC = Mid-Upper Arm Circumference

SPSS = Statistical Package for Social Science

WHO = World Health Organization.

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AUTHORS' CONTRIBUTIONS

GAL, MKM, and YBB came up with the research idea, analyzed the results, and wrote the manuscript. They agreed to take the accountability regarding all aspects of the work. All authors read and approved the final manuscript.

COMPETING INTERESTS

No Commenting interest.

FUNDING

Not applicable.

AVAILABILITY OF DATA AND MATERIALS

All relevant data are within the paper and its Supporting Information.

CONSENT FOR PUBLICATION

Not applicable.

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