Effect of pregnancy under-nutrition on low birth weight incidence in Tigrai Regional State, Ethiopia; A prospective cohort study

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Abstract

Background: Maternal nutrition affects the growth and development of the fetus and later health outcomes of the offspring. Worldwide, 20.5 million children were low birth weight in 2015 that were mainly from low and middle-income countries. However, there is no longitudinal-based evidence to depict the effect of pregnancy under-nutrition on birth weight incidence nationally in Ethiopia and Tigrai Regional State as well. Hence, this study aimed at determining the effect of pregnancy under-nutrition on low birth weight incidence in the Tigrai Regional State.

Methods: We conducted a prospective cohort study among consecutively selected 500 pregnant women attending ANC in hospitals from October 2019 to June 2020. Data were collected using pretested and structured questionnaires. SPSS version 25 was used for analysis. A Chi-square test was used to assess the difference in the incidence of low birth weight between the groups. A log-binomial model was used to estimate the adjusted risk ratio and its 95% CI of the risk factors for low birth weight. Multi-collinearity was checked using the variance inflation factor (VIF) at a cut-off point of 8 and there was no multi-collinearity.

Result: The overall cumulative incidence of low birth weight was 14% (95%CI: 11.1%, 17.4%). The difference in low birth weight incidence between the exposed and unexposed groups was statistically significant (p-value=0.006) along with risk factors of maternal illiteracy (ARR: 1.8, 95%CI: 1.01, 3.3), monthly family income <1500 Ethiopian birr (ARR: 1.6, 95%CI: 1.07, 2.2), latrine utilization (ARR: 0.47, 95%CI: 0.28, 0.78), and low diet diversity score <5 (ARR: 1.9, 95%CI: 1.05, 2.61).

Conclusion: The incidence of low birth weight in Tigrai regional state was high and the risk factors for low birth weight were maternal illiteracy, low monthly income, utilization of latrine, and low diet diversity score. It is then important to strengthen the nutritional assessment and intervention both during pre-conception and pregnancy periods with a special focus for illiterate and low-income pregnant women; together with promoting latrine utilization and consumption of diversified diets to reduce the risk of low birth weight incidence.

Background

Maternal nutrition affects the growth and development of the fetus and later health outcomes of the offspring(1–3). Maternal under-nutrition affects pregnancy outcomes especially newborns and neonatal outcomes (4). Maternal under-nutrition is a public health problem in Ethiopia. Based on the demographic and health survey (DHS) conducted between 1998 and 2008; the prevalence of maternal under-nutrition in Ethiopia was higher than in any other sub-Saharan African country(5). According to the Ethiopian demographic and health survey (EDHS) 2016, 22% of reproductive age (15 to 49 years) women in Ethiopia and 34% in Tigrai regional state were undernourished (body mass index < 18.5 kg/m^2). When these women enter pregnancy, the fetus has an increased risk of intrauterine growth restriction and low

birth weight (< 2.5 kg). Again, girls who were born small are later more likely to give birth to small children and under-nutrition continued to transferred through generations (6).

According to the World Health Organization (WHO), low birth weight has been defined as weight at birth of less than 2,500 grams(7). In 2015, an estimated 20·5 million live births were low birth weight (LBW), 91% from low-and- middle-income countries, mainly southern Asia (48%) and sub-Saharan Africa (24%) (8). About 3.6 million infants die during the neonatal period (9). Two-thirds of these deaths occur in southern Asia and sub-Saharan Africa and more than one-third of child deaths are thought to be attributable to maternal and child under-nutrition (10). The consequences of low birth weight are increased fetal and neonatal mortality and morbidity, poor growth, impaired cognitive development, and chronic disease later in life (7,10). Low birth weight can be affected by many factors which include infant, mother and physical environment relate factors(7).

The government of Ethiopia has launched a new food and nutrition policy in 2018 (11) and implemented a national nutrition program since 2008 (12) but still the nutritional problems during pregnancy and its consequences are high. Currently, in Ethiopia, neonatal mortality, infant mortality, and under-five mortality are high which are 30, 43, and 55 per 1000 live births, respectively (13). And in Tigrai Regional State (the study area), neonatal mortality, infant mortality, and under-five mortality are again high which were 34, 43, and 59 per 1000 live births, respectively (6). However, the national target (to be achieved by 2020) for neonatal mortality, infant mortality, and under-five mortality reduction is 10%, 20%, and 30% respectively (14). Yet, to our knowledge, no longitudinal based evidence indicates the effect of pregnancy under-nutrition on low birth weight incidence in Ethiopia as well as in the study area (Tigrai Regional State). Therefore, this study was conducted to address this gap by applying a prospective cohort study design on pregnant women, and the findings of this study could be used as part of nutrition evidence in the critical first 1,000 days of life (window of opportunity).

Methods

Study area, study design, and population

The study was conducted in Tigrai Regional State, Ethiopia. It is located at 780 km from the capital of Ethiopia, Addis Ababa. According to the 2010 EFY Tigrai Regional Health Bureau report, there are 7 zones, 52 woredas/districts, 780 health posts, 227 health centers, 16 general hospitals, and 2 referral and teaching hospitals. The major agricultural products found in Tigrai regional state are cereals (Taff, barley, maize, and wheat), grains (bean, soya bean, and pea), vegetables, fruits, honey, and roots, animal products like meat, poultry and milk, and milk products. We applied a prospective cohort study design from October 2019 to June 2020. The source population was all pregnant women attending antenatal care (ANC) in hospitals of Tigrai Regional State whereas the study population was all pregnant women attending ANC in the selected hospitals of Tigrai Regional State. The inclusion criteria were first ANC visits with gestational age, not more than 16 weeks, willing to attend routine ANC visits and permanent

residence, and address (≥ 6 months) in Tigrai regional state. Pregnant women with severe illness, overweight or obesity (BMI ≥ 25 kg/m^2), and twin and above pregnancies were excluded from the study.

Sample size determination

In this prospective cohort study, we used a ratio of 1:1 well-nourished (unexposed) to under-nourished (exposed) group of pregnant women. We calculated the sample size using Epi-Info version 7.2.4 with the assumptions of 95% significance level (2-sided), 80% power. Besides, we took the incidence of low birth weight for exposed (11.8%) and unexposed (10.4%) pregnant women, and relative risk of 1.9 from a study conducted in Tigrai Regional State in 2014 (15). Then, we considered a 10% loss to follow up and our total sample size for this study was 540 (270 for exposed and 270 for the unexposed group) pregnant women.

Sampling technique

Firstly, we used a simple random method to select a total of 6 hospitals from a total of 18 hospitals in Tigrai Regional State. Next, we took a total number of study participants from each hospital based on their proportion to population size (PPS) i.e. proportional to their average client size attended per month by referring the registration books of each antenatal care unit. Finally, we recruited participants at the antenatal care unit using a consecutive sampling technique until the required sample size was attained and we followed them until they gave birth.

Study variables

The dependent variable was the incidence of low birth weight and the independent variables include socio-demographic and economic factors (age, educational status, marital status, parity, income, residence, and religion), dietary-related factors (DDS, daily drinking of tea/coffee), hygiene and sanitation-related factors (latrine, hand washing, and access to safe water), and anthropometry measurements (maternal height and weight, Mid-Upper-Arm Circumference (MUAC), gestational weight gain, and newborn weight).

Standard definitions

Low birth weight is (< 2.5 kg)(7). The exposed group were pregnant women with Mid-Upper-Arm Circumference (MUAC) < 23 cm and the unexposed group were pregnant women with MUAC ≥ 23 cm (16,17).

Data collection tools, procedures, and recruitment

Data were collected by face to face interview using a structured questionnaire developed from previous similar literature (4,6,13,18,19). The questionnaire had baseline questions concerning socio-demographic and economic, dietary and lifestyle, hygiene, and sanitation-related factors and anthropometry measurements. Gestational age at first visit was determined by the last normal menstruation period (LNMP), fundal height measurement, and or ultrasound. Next to the baseline questions, the questionnaire had followed up questions like MUAC, diet diversity score (DDS), Gestational weight gain, Iron folate

supplementation adherence. Finally, the questionnaire had questions about birth outcomes like the sex of the newborn and birth weight.

MUAC was used to assess the nutritional status of pregnant women. Those with a MUAC value less than 23 cm were considered as undernourished and those with MUAC > 23 cm were normal nourished [16, 17]. The weight of the mother was measured in kilograms with a weighing scale (Seca designed by Germany) and rounded off to the nearest 0.1 kg. The height of the mother was measured with a stadiometer (Seca-2000, mechanical height meter), without shoes and rounded off to the nearest 0.1 cm. Maternal mid-upper-arm circumference (MUAC) was measured by non-stretchable measuring tape. A tape was fixed at the mid-point between the elbow and the shoulder (acromion and olecranon) and places the tape measure around the left arm (the arm should be relaxed and hang down the side of the body). The weight of the baby at birth was measured in kilograms on digital baby scales (Seca 354 Hamburg, Germany). The infants were weighed wearing no clothing. Standard procedures were used in anthropometry measurements. All measurements were taken three times and the average was calculated to ensure reliability.

The respondents' dietary intake was assessed using a 24-hour dietary recall method and Dietary Diversity Scores (DDS) was calculated. All the foods and the liquids consumed a day before the data collection were categorized into 10 food groups (Cereals, Pulses, Nuts and Seeds, Dairy, Meat, Eggs, Dark green leafy vegetables, Other vitamin A-rich fruits and vegetables, Other vegetables, and Other fruits). Consuming a food item from any of the groups was assigned a score of "1" and if no food was taken a score of "0" was given. Accordingly, a DDS out of 10 points was computed by combining the values of all the groups. The DDS was categorized as low (< 5) and recommended (≥ 5)(19). At least three follow up (three ANC visits) and institutional delivery was required to complete the study.

Data quality control

Initially, the questionnaire was prepared in English and then translated into Tigrigna (local language) and back to English to check for consistency. A pre-test was conducted in 5% of the sample size before the actual data collection and modification on the flow of the questions and some words were taken. Data collectors have experienced BSc midwives. Two days' training was given for data collectors and supervisors. All instruments were calibrated regularly using standard measurements. Moreover, data collectors were strictly supervised. Supervisors checked out the completeness of filled questionnaires. Any error, ambiguity, incompleteness, or other encountered problems were addressed accordingly. Overall, the data collection process was controlled and supervised by the corresponding author and coauthors.

Data analysis

We used a statistical package for social sciences (SPSS) version 25 to analyze. And we cleaned the data by sorting and tabulating simple frequency tables. Low birth weight was dichotomized into 1 = Yes and 0 = No. Then, we computed descriptive statistics for the study variables and categorical variables were reported using frequencies and percentages. We also checked the normality for the distribution of continuous variables using the Shapiro-Wilk test. We further applied crosstabs to estimate the cumulative

incidence of low birth weight and the chi-square test was used to assess the significant differences in the cumulative incidence of low birth weight. Accordingly, the difference was considered statistically significant at P-value < 0.05. Finally, we used a log-binomial model to estimate the adjusted risk ratio and its 95% CI of the risk factors for low birth weight. During the analysis, we also checked the multi-collinearity effect using a variance inflation factor (VIF) at a cut-off point of 8 and there was no multi-collinearity effect.

Result

Socio-demographic and economic characteristics of pregnant women

Out of 540 participants, 500 (245 exposed and 255 unexposed) had completed and included in this study, with a total loss to follow up of 40 (7%) as shown in (Fig. 1) below.

Figure 1: *Study participants' flow during the prospective cohort study of pregnant women in Tigrai Regional State, Ethiopia, 2020. [ANC: antenatal care]*

Majority of the pregnant women in unexposed (91.4%) and exposed groups (95%) were married. The mean (± standard deviation) age of the participants was 28.05 ± 5.13 years. All the pregnant women in both groups were Tigrean in ethnicity. Majority of the pregnant women in the exposed group (84%) and almost all pregnant women in the unexposed group (96%) were Orthodox Christian in religion. Three-fourth (74.7%) of pregnant women among the exposed group and 218(85.5%) pregnant women among the unexposed group lived in urban areas. Majority of the pregnant women in both groups (95.1% from exposed and 91.4% from unexposed) were married (Table 1).

Table 1
Socio-demographic and economic characteristics of pregnant women in Tigrai Regional State, Ethiopia, 2020.

Variables		Exposed group n = 245(%)	Unexposed group n = 255(%)
Age of the pregnant women	19–24 years	71(29%)	53(20.8%)
	25–29 years	56(22.9%)	68(26.7%)
	30–35 years	80(32.7%)	109(42.7%)
	Above 35 years	38(15.5%)	25(9.8%)
Educational status of pregnant women	Illiterate	84(34.3%)	43(16.9%)
	Elementary (1–8 grades)	60(24.5%)	65(25.5%)
	High school (9–10 grades)	57(23.3%)	71(27.8%)
	Above high school	44(18%)	76(29.8%)
Educational status of husbands	Illiterate	46(19.7%)	26(11.2%)
	Elementary (1–8 grades)	86(36.9%)	57(24.5%)
	High school (9–10 grades)	51(21.9%	66(28.3%)
	Above high school	50(21.5%)	84(36.1%)
Occupation of pregnant women	Civil servant	15(6.1%)	94(38.5%)
	Daily worker/waitress/farmer	39(15.9%)	11(4.5%)
	Own business	65(26.5%)	13(5.3%)
	Housewife	126(51.4%)	126(51.6%)
Occupation of husbands	Civil servant	72(30.9%)	119(51.1%)
	Own business	135(57.9%)	92(39.5%)
	Daily worker/waitress/farmer	26(11.2%)	22(9.4%)
Monthly family income	< 1500 Ethiopian Birr	78(31.8%)	44(17.3%)
	1500–5000 Ethiopian Birr	75(30.6%)	106(41.6%)
	> 5000 Ethiopian Birr	92(37.6%)	105(41.2%)

Hygiene And Sanitation-related Factors

One-third (68.4%) of the exposed group and three-fourth (74.9%) of the unexposed group of pregnant women were utilizing latrine. Whereas one fourth (27.4%) pregnant women from the exposed group and 31(12.2%) of the unexposed group had no latrine. Almost all pregnant women in both groups (94.7% in exposed and 98.1% in unexposed) were washing their hands at all critical conditions (after toilet, before food preparation, before eating, after cleaning child). Tap water was the water source for drinking for 87.8% of exposed pregnant women and 91.2% of unexposed pregnant women.

Dietary Related Factors

In both groups, the staple food was Injera prepared from Taff or sorghum or maize with

Shiro Tsebhi. Half (50.6%) of the pregnant women from exposed women and more than one-third (38.4%) of pregnant women from the unexposed group were in fast during the fasting period. Twenty-eight (11.4%) pregnant women from the exposed group and 5(1.9%) pregnant women from the unexposed group reported foods forbidden to them (taboo) like meat, vegetable, and coffee. The reasons why the foods are forbidden are fear of infection, to prevent large babies, not to change the color (black mark on the body part) of the baby. Only two third pregnant women in both groups utilize iron-folate supplementation. Women's diet diversity score was low (< 5) in 160(65.3%) and 101(39.6%) pregnant women of exposed and unexposed groups, respectively. One-fourth (27.8%) from exposed and 22(8.6%) from unexposed pregnant women had a history of alcohol drinking. All pregnant women in both groups didn’t receive nutritional counseling during ANC visit one (Table 2).

Table 2
Dietary related factors of pregnant women in Tigrai Regional State, Ethiopia, 2020

Variables			Exposed group (n = 245)	Unexposed group (n = 255)
Number of meals per day	3 times		203(82.9%)	171(67.1%)
	4 times and above		42(17.1%)	84(32.9%)
Number of additional meals per day during pregnancy	No additional meals (as usual)		35(14.3%)	78(30.6%)
	Once		81(33.1%)	46(18%)
	Twice		94(38.4%)	72(28.2%)
	Three times and above		35(14.3%)	59(23.1%)
Drinking of coffee/tea with meals or within 2 hours of meal	No drinking of coffee or tea		58(23.7%)	94(36.9%)
	1–2 cups		99(40.4%)	80(31.4%)
	≥ 3 cups		88(35.9%)	81(31.8%)
Nutritional counseling during ANC follow up	ANC 1	Yes	0(0%)	0 (0%)
		No	245(100%)	255(100%)
	ANC 2	Yes	37(15.1%)	32(12.3%)
		No	208(84.9%)	223(87.7%)
	ANC 3 or 4	Yes	22(9%)	25(9.8%)
		No	223(91%)	230(90.2%)
Food security	Moderate food insecure with hunger		17(6.9%)	10(3.9%)
	Mild food insecure without hunger		80(32.7%)	72(28.2%)
	Food secured		148(60.4%)	173(67.8%)

Gynecological And Obstetric Related Variables

Three fourth of the pregnant women in both groups (79.6% in the exposed group and 76.9% in the unexposed group) had no history of abortion in their previous pregnancies. More than half (55.5%) of the pregnant women in the exposed group and three-fourth (76.1%)) of the pregnant women in the unexposed group had vaginal bleeding in the index pregnancy. Thirty-nine (15.9%) pregnant women from

the exposed group and 21(8.2%) pregnant women from the unexposed group had urinary tract infection (Table 3).

Table 3
Gynecological and obstetric related factors of pregnant women in Tigrai Regional State, Ethiopia, 2020

Variables		Exposed group (n = 245)	Unexposed group (n = 255)
Type of modern family planning used before got pregnant	Not used	84(34.3%)	42(16.5%)
	Pills	0(0%)	58(22.7%)
	Injectable	146(59.6%)	118(46.3%)
	IUCD	0(0%)	11(4.3%)
	Implant	15(6.1%)	26(10.2%)
Total pregnancies including the index pregnancy	1	86(35.1%)	46(18%)
	2	58(23.7%)	70(27.5%)
	3–5	73(29.8%)	117(45.9%)
	≥ 6	28(11.4%)	22(8.6%)
Type of pregnancy	Unplanned and unwanted	40(16.3%)	36(14.1%)
	Unplanned but wanted	55(22.4%)	62(24.3%)
	Planned and wand wanted	150(61.2%)	157(61.6%)
Previous uterus problems	No problem	210(85.7%)	236(92.5%)
	Discharge	15(6.1%)	10(3.9%)
	Pelvic inflammatory pain	20(8.2%)	9(3.5%)

IUCD = intra-uterine contraceptive device

Anthropometry Measurements, Laboratory Findings, And Delivery Outcomes

Almost two-thirds (73.5%) of pregnant women from the exposed group and half (52.2%) of the pregnant women from the unexposed group had low total gestational weight gain. The height of the pregnant women was < 1.45 meter in 11.5% and 6.3% of the exposed and unexposed group, respectively. Thirty-six (14.7%) and 21(8.2%) pregnant women had intestinal parasites in the exposed and unexposed groups, respectively. All pregnant women in both groups were non-reactive for syphilis and Hepatitis B virus but

11(4.5%) from the exposed group and 5(1.9%) pregnant women from unexposed groups were reactive for HIV test. Furthermore, 60 (24.5%) from the exposed group and 32 (12.5%) pregnant women from the unexposed group had anemia (Hemoglobin < 11 gm/dl) during antenatal care visit one. Concerning the mode of delivery for the index pregnancy; half of the pregnant women in both groups gave delivery via vaginal normal delivery, the rests were through cesarean section and instrumental. More than half (52.2%) of the newborns from the exposed group and two-third (64.7%) of the newborns among the unexposed group were females.

Incidence And Risk Factors Of Low Birth Weight

In this study, the mean (± standard deviation) of birth weight was 2.96 (SD ± 0.45). The overall cumulative incidence of low birth weight was 14% (95%CI: 11.1%, 17.4%). The cumulative incidence of low birth weight among the exposed was 18.4% (95%CI: 14.1%, 23.9%) and among the unexposed women, it was 9.8% (95%CI: 6.8%, 14.2%). The difference in incidence among these two groups was assessed using the chi-square (X^2)-test and it was found that the difference in low birth weight incidence between the exposed and unexposed groups was statistically significant (p-value = 0.006).

Based on the log-binomial model; maternal educational status, monthly family income, latrine utilization, and diet diversity score were statistically significant risk factors of low birth weight. Illiterate pregnant women were 1.8 times more likely to give birth to newborns with low birth weight as compared to pregnant women with the educational status of above secondary school (ARR:1.8, 95%CI: 1.01, 3.3). Pregnant women who had monthly family income less than 1500 Ethiopian birr were 1.6 times higher to have newborns with low birth weight as compared to pregnant women with a monthly income of more than 5000 Ethiopian birrs (ARR: 1.6, 95%CI: 1.07, 2.2). The utilization of latrine was a statistically significant factor for low birth weight. Pregnant women who utilized latrine were 53% less likely to have low birth weighted newborns (ARR: 0.47, 95%CI: 0.28, 0.78). Pregnant women who had a diet diversity score of less than five were 1.9 times more likely to have newborns with low birth weight as compared to pregnant women who had five and above diet diversity scores (ARR:1.9, 95%CI: 1.05,2.61) (Table 4).

Multi-collinearity was checked using variance inflation factor (VIF) at < 8 but the VIF of all variables was less than two which means no multi-collinearity. Moreover, the interaction of the variables at a p-value of < 0.05 was assessed and there was no interaction. In the omnibus test, the likelihood ratio chi-square test indicates that the full model was a significant improvement in fit over a null (no factor) model (p-value < 0.001).

Table 4
Result of Log-binomial model to identify risk factors for low birth weight in Tigrai Regional State, Ethiopia, 2020

Variables		Low birth weight		CRR (95%CI)	ARR(95%CI)
		Yes (%)	No (%)		
Maternal height	≤ 1.45 meter	3(4.3)	41(9.5)	0.15(0.12, 1.8)	0.56(0.19,1.64)
	1.45 meter (ref.)	67(95.7)	389(90.5)	1	1
Maternal educational status*	Illiterate	18(25.7)	109(25.3)	0.06(0.57,1.99)	1.8(1.01, 3.3)*
	Elementary school	16(22.9)	109(25.3)	0.96(0.5,1.8)	1.89(0.89,4.04)
	High school	20(28.6)	108(25.1)	1.17(0.64,2.5)	1.86(0.98,3.44)
	Above high school (ref.)	16(22.9)	104(24.2)	1	1
Maternal occupational status	Civil servant	25(35.7)	84(20)	2.63(1.55,4.45)	2.69(1.56,4.68)
	Farmer/daily worker	5(7.1)	45(10.7)	1.15(0.46,2.88)	1.08(0.43,2.69)
	Own business	18(25.7)	60(14.3)	2.64(1.49,4.67)	1.75(0.98,2.32)
	Housewife (ref.)	22(31.4)	230(54.9)	1	1
Monthly family income**	< 1500 Ethiopian birr	23(32.9)	99(23)	1.09(0.68,1.76)	1.6(1.07,2.2)**
	1500–5000 Ethiopian birr	13(18.6)	168(39.1)	0.42(0.23,0.76)	0.47(0.28, 0.78)
	> 5000 Ethiopian birrs (ref.)	34(48.6)	163(37.9)	1	1
Family size	≤ 4	50(71.4)	267(62.1)	1.44(0.89,2.35)	1.44(0.88,2.34)
	> 4 (ref.)	20(28.6)	163(37.9)	1	1
Utilization of latrine*	Yes	34 (48.6)	319(75.6)	0.37(0.24,0.57)	0.47(0.28, 0.78)*
	No (ref.)	36(51.4)	103(24.4)	1	1
Fasting during pregnancy during a fasting period	Yes	27(38.6)	195(45.3)	0.79(0.5,1.23)	1.12(0.71,1.75)
	No (ref.)	43(61.4)	235(54.7)	1	1

**<0.05, **<0.01CRR = Crude Risk Ratio, ARR = Adjusted Risk Ratio, CI = Confidence Interval, ref. =reference category*

Presence of diseases	Yes	2 (2.9%)	58(13.5)	0.22(0.05,0.86)	0.25(0.06,0.98)
	No (ref.)	68(97.1)	372(86.5)	1	1
DDS*	Low (< 5)	35(50)	226(52.6)	0.92(0.59,1.4)	1.9(1.05,2.61)*
	Adequate (≥ 5) (ref.)	35(50)	204(47.4)	1	1
Alcohol drinking during pregnancy	Yes	6(8.6)	84(19.5)	0.43(0.19,0.96)	0.42(0.18,0.95)
	No (ref.)	64(91.4)	346(80.5)	1	1
Total gestational weight gain	Low	51(72.9)	262(60.9)	1.6(0.98,2.6)	1.45(0.9,2.32)
	Adequate (ref.)	19(27.1)	168(39.1)	1	1

**<0.05, **<0.01CRR = Crude Risk Ratio, ARR = Adjusted Risk Ratio, CI = Confidence Interval, ref. =reference category*

Discussion

This study was conducted to investigate the effect of pregnancy under-nutrition on low birth weight incidence in Tigrai Regional State, Ethiopia. The overall cumulative incidence of low birth weight was 14% (95%CI: 11.1%, 17.4%). The incidence of low birth weight was 18.4% (95%CI: 14.1%, 23.9%) among the exposed group and 9.8% (95%CI: 6.8%, 14.2%) among the unexposed group. The difference in low birth weight incidence between the exposed and unexposed groups was statistically significant (p-value = 0.006). Low birth weight incidence of this study was consistent with the low birth weight in Wolaita Sodo Referral Hospital 15.8%(20), Felege Hiwot referral hospital 11.6%(21), Jimma University Specialized Hospital 14.6%(22), Debre Tabor Hospital(23), EDHS 2016 Ethiopia 13%(6), systematic review and meta-analysis in Ethiopia 17.3%(24), selected countries in Africa(25), and Africa level 13.7%(26).

On the other hand, this incidence of low birth weight in our study is lower than the incidence reported from studies conducted in Debre Markos Referral Hospital 21.6%(27), Northeast India 26%(28), and Nepal 23.6%(29). Whereas, it is higher as compared to incidences reported from studies conducted in Aksum town 8.8%(30), Adwa town 10%(31), Tigrai Region 10.5%(32), Butajira General Hospital 8.9% (33), Southwest Ethiopia 10%(34), Ghana 9.7%(35), Nigeria 7.3%(36), and Iran 9%(37). The difference in incidence could be due to study design, study setting, study period, and source of information. Overall this study showed a high incidence of low birth weight which indicates poor progress to achieve the World Health Assembly (WHA) target of reducing the prevalence of low birth weight to 10.5% or below by 2025(26). It is strongly supported that a newborn's weight at birth is an important marker of fetal health and nutrition. For instance, low birth weight newborns have a higher risk of dying in the first 28 days of life and even those who survive are more likely to suffer from stunted growth, lower intelligence quotient (IQ), and poor quality of life. Moreover, the consequences of low birth weight continue into adulthood,

increasing the risk of adult-onset chronic conditions such as obesity and diabetes(26,38,39). Hence, our finding could set an alarm in seeing back to the outcome being obtained through nutrition related programs and initiatives being implemented during the critical first 1,000 days of life (window of opportunity) both regionally (Tigrai) and nationally in Ethiopia, by different stakeholders and the government sectors.

Furthermore, this study revealed that illiterate pregnant women were 1.8 times more likely to give birth to newborns with low birth weight as compared to pregnant women with the educational status of above secondary school. This finding was supported by studies conducted in South-East Ethiopia(40), North Wello zone (41), Addis Ababa(42), Ethiopia(43), Tanzania(44), Indonesia(45), and India (46). This might be because maternal education promotes a positive attitude towards health-seeking behavior, acquisition of health and nutrition knowledge, and adherence to recommended feeding practices during pregnancy (47). Again, educated mothers might have greater knowledge and utilization of modern health care services and the ability to communicate with health professionals.

Our study further indicated that pregnant women who had monthly family income less than 1500 Ethiopian birr were 1.6 times higher to have newborns with low birth weight as compared to pregnant women with a monthly income of more than 5000 Ethiopian birrs. This finding was consistent with studies conducted in South-East Ethiopia (40), Southwest Ethiopia (34), LAO (48), Ethiopia (43), North West Ethiopia (21), Southern India (46), and Bangladesh(49). Pregnant women with low income could be in a high level of stress, fatigue, and psychological distress during pregnancy which in turn could be associated with low birth weight(50). Pregnant women need two extra meals in addition to the basic three meals but pregnant women with low monthly income may not get the extra meals and their diet could be poor in terms of quantity and nutrient quality.

In our study, utilization of latrine was also a statistically significant factor for low birth weight in which pregnant women who utilized latrine were 53% less likely to have low birth weighted newborns compared to their counterparts. Similar findings were reported from other studies conducted in Southwest Ethiopia(34), India(51). Poor or no utilization of latrine could reflect fecal contamination of the local environment which in turn could result in a high incidence of infectious disease and intestinal parasites, thus high levels of nutrient mal-absorption in pregnant women and possibility to have low birth weight newborns.

Finally, our study showed that pregnant women who had a diet diversity score of less than five were 1.9 times more likely to have newborns with low birth weight as compared to pregnant women who had five and above diet diversity scores. This finding was consistent with findings of other studies conducted in rural Ethiopia (18), LAO (48), West Ethiopia (52), Mumbai(53), and Ghana(54). This could be justified with the diets of pregnant women in low and middle-income countries (LMICs) that are monotonous and predominantly plant-based with little consumption of micronutrient dense animal source foods, fruits, and vegetables. Hence, such poor diets diversity is likely to be deficient in multiple micronutrients which in turn affects women’s health and nutrition which can result in a negative impact of birth weight (55).

The strength of our study was its prospective nature, control of confounding factors, and low loss to follow up. Nevertheless, limitations observed in this study include; micronutrients were not measured except hemoglobin for anemia, the possibility of recall bias during the assessment of the diet diversity score using previous 24 hours recall method, caffeine from chocolate, and soft drink was not considered, and private health facilities were not included. Besides, it does not provide evidence for a causal relation. Considering these limitations, we recommend that further inference of our findings should be with caution.

Conclusion

The incidence of low birth weight in Tigrai Regional State was high entangled with risk factors maternal illiteracy, low monthly income, latrine utilization, and low diet diversity score. It is then important to strengthen nutritional assessment and intervention during pre-conception and pregnancy periods with a special focus for illiterate and low monthly income pregnant women; together with promoting latrine utilization and consumption of diversified diets to reduce the high risk of low birth weight incidence.

Abbreviations

ANC Ante-Natal Care

CI Confidence Interval

DDS Dietary Diversity Scores

EDHS Ethiopia Demographic Health Survey

LBW Low Birth Weight

SPSS Statistical Package for Social Science

VIF Variance Inflation Factor

WHO World Health Organization

Declarations

Ethical approval and consent to participate

An ethical clearance letter was obtained from the Institutional Review Board (IRB) of Mekelle University, College of Health Sciences before the beginning of data collection. The registration number of the ethical clearance for this paper was MU/CHS/SC/20/2019. Written permission was obtained from the Tigrai Regional Health Bureau and selected hospitals. Further, study participants were briefed about the objective of the study by data collectors. Participants were informed that they had the full right to refuse

to participate in the study and can interrupt the study if not comfortable. Confidentiality of the information was assured and the privacy of the study population was respected and kept as well. Written informed consent was obtained from each study participant. There was no procedure that could harm pregnant women and they have received all the necessary routine nutritional and health services regardless of their participation in this study. At the end of data collection, pregnant women were counseled about nutrition and hygiene.

Consent for publication: Not applicable

Availability of data and materials: All data generated or analyzed during this study are included in this published article.

Competing of interest: The authors declare that they have no competing interests

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Authors' contributions

KB, LM, FG, AT, and MR were involved in conceptualization, data collection, analysis, and manuscript writing. KB, AK, and BG were involved in data cleaning, analysis, manuscript writing, and reviewing. All authors read and approved the manuscript.

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Figures

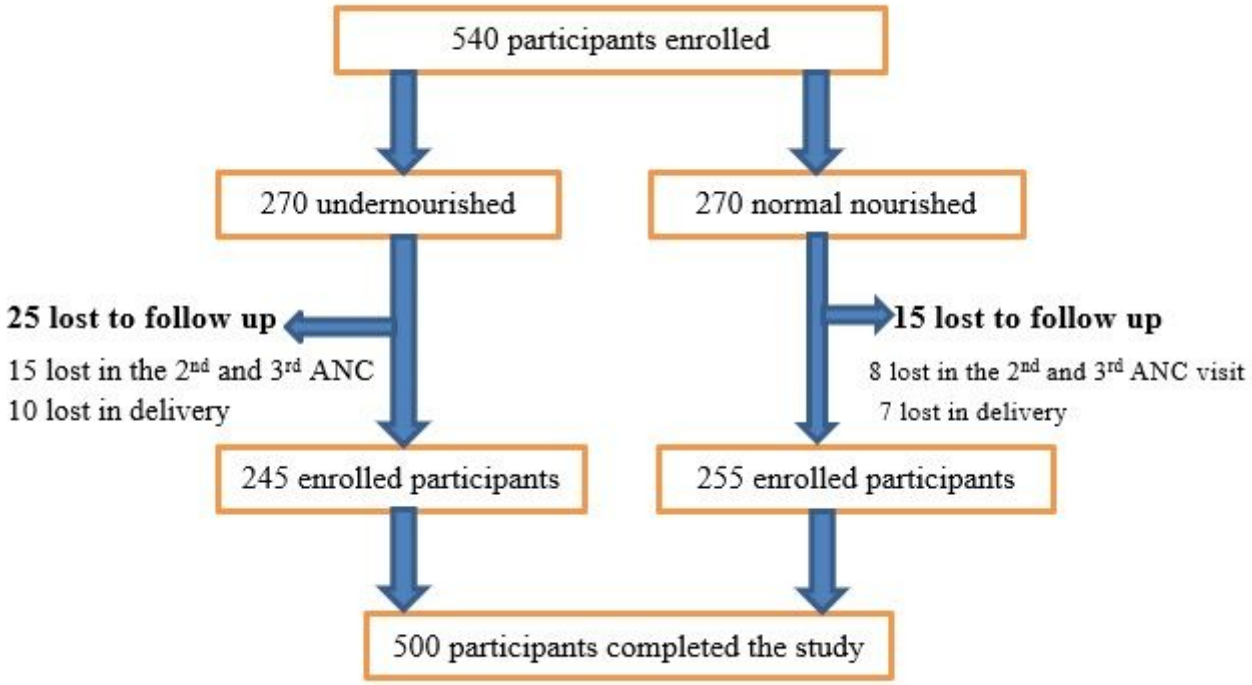

Figure 1

Study participants' flow during the prospective cohort study of pregnant women in Tigrai Regional State, Ethiopia, 2020. [ANC: antenatal care]

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