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Influence of gestational weight gain on baby's birth weight in Addis Ababa, Central Ethiopia: a follow-up study

Fekede Asefa ,[1,2,3] Allison Cummins,[2] Yadeta Dessie,[1] Maralyn Foureur,[2,4] Andrew Hayen[3]

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[1]School of Public Health, College of Health and Medical Sciences, Haramaya University, Harar, Oromia, Ethiopia
[2]Centre for Midwifery, Child and Family Health, Faculty of Health, University of Technology Sydney, Sydney, NSW, Australia
[3]School of Public Health, Faculty of Health, University of Technology Sydney, Sydney, NSW, Australia
[4]Hunter New England Health, Nursing and Midwifery Research Centre, University of Newcastle, Newcastle, NSW, Australia

Correspondence to
Dr Fekede Asefa;
sinboona@gmail.com

ABSTRACT

Background Gestational weight gain (GWG) is an important indicator of fetal well-being during pregnancy. Inadequate or excessive GWG could have undesirable effects on birth weight. However, information regarding the influence of GWG on birth weight is lacking from the Ethiopian setting.

Objective This study aimed to determine the influence of GWG and other maternal-related factors on birth weight in Addis Ababa, Ethiopia.

Design and methods A cohort of pregnant women who received the first antenatal care before or at 16 weeks of gestation in health centres in Addis Ababa were followed from 10 January 2019 to 25 September 2019. Data were collected using a structured questionnaire and medical record reviews. We conducted a multivariable linear regression analysis to determine the independent effect of gestational weight on birth weight.

Results Of the 395 women enrolled in the study, the participants' pregnancy outcome was available for 329 (83.3%). The mean birth weight was 3130 (SD, 509) g. The proportion of low birth weight (<2500 g) was 7.5% (95% CI 4.8% to 11.0%). Babies born to underweight women were 150.9 g (95% CI 5.8 to 308.6 g, p=0.049) lighter than babies born to normal-weight women. Similarly, babies whose mothers gained inadequate weight were 248 g (95% CI 112.8 to 383.6 g, p<0.001) lighter than those who gained adequate weight. Moreover, babies whose mothers had a previous history of abortion or miscarriages or developed gestational hypertension in the current pregnancy were 147.2 g (95% CI 3.2 to 291.3 g, p=0.045) and 310.7 g (95% CI 62.7 to 552.8 g, p=0.012) lighter, respectively, compared with those whose mothers had not.

Conclusions Prepregnancy weight, GWG, having had a previous history of abortion or miscarriages, and developing gestational hypertension during a current pregnancy were independently associated with birth weight. Pregnancy-related weight management should be actively promoted through intensive counseling during routine antenatal care contacts.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ We prospectively followed the women's weight to assess gestational weight gain (GWG) and its influence on birth weight.
⇒ The US Institute of Medicine GWG recommendations are recommendations of high-income countries that may not be suitable in low-income settings such as Ethiopia.
⇒ We measured prepregnancy body mass index before or at 16 weeks of gestation, at which time there may already have been an increase or decrease in gestational weight.
⇒ This study was conducted in the capital city of Ethiopia in public health facilities; the situation in other parts of the country and private health facilities may be different.

INTRODUCTION

Gestational weight gain (GWG) is attributable to pregnancy-related changes that women experience, such as the increase in the size of the uterus and the developing fetus, placenta, amniotic fluid, an increase in breast size, extracellular fluid, and blood volume. The American Institute of Medicine (IOM) has published recommendations for a GWG of 12.5–18 kg for underweight women, 11.5–16 kg for normal-weight women, 7–11 kg for overweight women and 5–9 kg for obese women.[1]

GWG is a powerful indicator of maternal[2] and fetal[1] nutrition during pregnancy. Adequate GWG supports the growth and development of the fetus.[3] Both extremes, excessive or inadequate GWG, could result in undesirable pregnancy outcomes.[4–7] Excessive GWG is associated with pre-eclampsia,[8–10] caesarean birth,[8 10 11] macrosomia, large for gestation age and high birth weight.[7] On the other hand, inadequate weight gain is associated with intrauterine growth restriction,[12] low for gestational age, preterm birth[13–15] and low birth weight (LBW).[6 7]

Birth weight is one of the most important health indices in a newborn baby's growth, development and future survival.[16] Birth weight is high if it is >4000 g[17] or low if it is <2500 g.[18] LBW is a proxy indicator for intrauterine malnutrition. Intrauterine malnutrition has lifelong consequences for the fetus.[19]

Identifying the influence of GWG on birth weight at the local level is important to provide an appropriate nutrition intervention during the pregnancy to reduce the risk of intrauterine malnutrition and improve GWG and birth outcomes. This could help to break the vicious intergenerational cycle of malnutrition.[20]

Factors influencing birth weight have been reported as including but not limited to maternal characteristics such as maternal age,[21] prepregnancy body mass index,[22] nutritional status, smoking[23 24] and physical activity.[25–27] Factors related to the amount of growth and weight gain during pregnancy and the overall health of the mother and the fetus[28 29] also affect the amount of birth weight. In high-income settings, most pregnant women gain excessive gestational weight, and their babies are at a high risk of microsomia.[8 10 11] However, most pregnant women in low-income settings, including Ethiopia, gain inadequate gestational weight.[30–32] Hence, the effect of GWG on birth weight is expected to be different in these settings. While there are several studies on factors affecting birth weight in Ethiopia, the influence of GWG on birth weight is not well understood in this setting. This study aimed to determine the influence of GWG and other maternal-related factors on birth weight in Addis Ababa, a central Ethiopian population.

METHODS

Study setting and period

This study was conducted in Addis Ababa, Ethiopia's capital and the largest city. Participants were selected from nine health centres. The previously published paper reported details of the study setting and numbers of women recruited from each facility.[31] A cohort of pregnant women were followed from before or at their 16 th week of gestation until they gave birth to assess their GWG and the baby's birth weight from 10 January 2019 to 25 September 2019.

Sample size determination

Using the double proportion formula, we calculated the sample size using Open Epi V.2.3. The assumptions for the sample size calculation were alpha value 0.05; power 80%; exposed to non-exposed ratio 1:2 (proportion of adequate GWG=28% (exposure); and proportion of inadequate GWG=69% (non-exposure))[30]; proportion of LBW among women who gained adequate gestational weight=1.7%; proportion of LBW among women who gained inadequate gestational weight=17.5%,[21] lost to follow-up=20%. The required sample was 189 (exposed=63 and control (non-exposed)=126). However, since this study was part of another large study, we recruited a sample size of 395. The details of the sample size calculation assumptions were described in the study published elsewhere.[31]

Participants

Pregnant women who came to health centres before or at 16 weeks gestation for antenatal care were invited to participate, and those who agreed were recruited. We limited eligibility to women with a singleton pregnancy and no comorbidities such as diabetes and hypertension.

Measurements

We used structured questionnaires with trained interviewers and face-to-face semistructured interviews during the baseline data collection. Using the questionnaires, we collected information regarding sociodemographic characteristics, previous history of abortion (termination of pregnancy before the 28th week of gestation), LBW and stillbirth, pregnancy intention (planned/unplanned), gravidity, food insecurity, dietary diversity, physical activity, intimate partner violence and depression-related symptoms. Data collectors measured baseline weight and height of the women and mid-upper arm circumference. Women's medical records were also reviewed both during baseline data collection and after birth to collect data such as gestational age (ultrasound result), blood pressure, level of haemoglobin, random blood sugar result, weight at the 36th weeks of gestation, mode of birth, episiotomy, birth weight and sex of the baby. The primary author reviewed these data. Women were followed from before or at their 16th week of gestation until they gave birth to assess their GWG and the baby's birth weight. Sixteen women (5.2%) gave birth in a rural location, and we could not access the birth records. The birthweight information was ascertained for these women through a phone call to the mother.

The primary outcome variable in this study was birth weight. However, other pregnancy outcome variables such as the occurrence of gestational hypertension, modes of birth, episiotomy and birth outcomes (live birth, miscarriage or stillbirth) were also considered as outcome variables.

We assessed the household food insecurity using the Household Food Insecurity Access Scale[33] and the women's dietary diversity using the minimum dietary diversity-women tool.[34] Women's physical activity level was measured using the International Physical Activity Questionnaire-long form.[35] Perinatal depression symptoms were measured using the Edinburgh Postnatal Depression Scale[36] and intimate partner violence were measured using a questionnaire used by the WHO multicountry study on women's health and domestic violence.[37]

Statistical analysis

We double entered the data into Census and Survey Processing System (CSPro V.7.1). We exported data to STATA (V.14, StataCorp) for cleaning and analysis. Missing data were handled by performing pairwise deletion in the study. A particular variable was excluded when it had a missing value, but the case can still be used when analysing other variables with non-missing values. Hence, the analyses were performed on subsets of the data depending on where values are missing without completely omitting a case with missing some variables from the analyses.

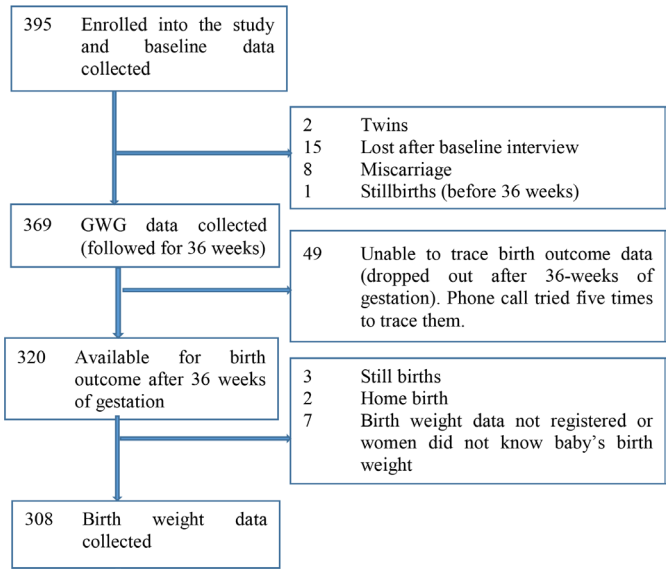

Figure 1 Flow chart showing data collection process from 10 January 2019 to 25 September 2019, Addis Ababa, Ethiopia. GWG, gestational weight gain.

Descriptive statistics, including frequencies, means and SD, were computed to describe the data. We calculated GWG by subtracting women's baseline weight from their weight at the 36th week of gestation. The adequacy of GWG (inadequate, adequate or excessive) was determined using the IOM criteria. Birth weight was analysed as a categorical and continuous variable. Birth weight was classified as <2.5 kg (LBW), 2.5 kg–3.9 kg (normal birth weight), ≥4.0 kg (macrosomia). The relationship between birth weight as a categorical variable (ie, LBW, normal birth weight or macrosomia) and other variables was reported descriptively using percentage. Since the number of LBW and macrosomic babies were small, we could not perform a regression analysis using birth weight as a categorical variable. Therefore, we assessed the influence of GWG and other variables on birth weight using a linear regression model. Variables with p<0.25 in the bivariable analysis were included in the multivariable analyses. However, some variable like food insecurity was considered important and forced into the multivariable model irrespective of the p value. The assumptions for linear regression were checked. Scatter plots showed that observations were linear. Multicollinearity was checked using the variance inflation factor (VIF). The mean VIF value was 1.44. The VIF value for each predictor variable was <3, which showed no multicollinearity among variables.

We performed multivariable linear regression analysis to determine the independent effect of GWG on birth weight, adjusting for other potential factors (educational status, average household monthly income, and previous history of abortion (termination of pregnancy before the 28th week of gestation), consuming meat or chicken in the last 24 hours, food insecurity, prepregnancy weight, maternal haemoglobin level, occurrence of gestational hypertension and sex of the baby).

RESULTS

Of the 395 women enrolled in the study, the participants' pregnancy outcome was available for 329 (83.3%). Eight of the 329 pregnancies ended in miscarriage (fetal loss before 28 weeks), three ended in stillbirths (fetal loss at or after 28 weeks) and the remaining were live births (figure 1).

The mean age of the women was 25.3 (SD, 3.9) years. Other sociodemographic and socio-economic variables of the participants were reported elsewhere.[31] As shown in table 1, half of the participants, 199 (50.4%), were multigravida, of which 40.7% had a previous history of abortion or miscarriage; 4.5% had a prior history of stillbirth and 3.3% had a prior history of LBW. Twenty-one (5.8%) developed gestational hypertension during pregnancy, while one woman developed gestational diabetes. Eighty-two per cent (82%) gave birth via spontaneous vaginal birth, with 47.5% assisted with episiotomy. Most infants had normal birth weight (89.6%) and 7.5% had LBW. Twelve babies (3.9%) were born preterm (table 1).

As shown in table 2, 85.6% of women who gained inadequate gestational weight gave birth vaginally, while 74.4% of women who gained adequate gestational weight gave birth vaginally; 9.3% of women who gained inadequate gestational weight gave birth to LBW babies, while 4.5% of women who gained adequate gestational weight gave birth to LBW babies. Four per cent (4.0%) of the women who gained inadequate gestational weight developed gestational hypertension, while 11% and 6% of women who gained adequate and excess gestational weight, respectively, developed gestational hypertension (table 2). The details for the participants' GWG status, including trimester-specific GWG, were reported elsewhere.[31]

The mean birth weight was 3.13 kg with a SD of 0.51 kg. It was 3.04 kg (SD=0.49 kg) among women who gained inadequate gestational weight; 3.30 kg (SD=0.52 kg) kg among women who gained adequate gestational weight; and 3.25 kg (SD=0.53 kg) among women who gained excessive gestational weight; 3.02 kg (SD=0.46 kg) among underweight women; and 3.14 kg (SD=0.53 kg) among normal-weight women. The proportion of LBW was 10.3% (95% CI 4.0% to 21.2%) among underweight women while it was 6.7% (95% CI 3.6% to 11.2%) among normal-weight women. Similarly, 27.8% of women who developed gestational hypertension gave birth to LBW babies while only 5.7% of women who did not develop gestational hypertension gave birth to LBW babies; 12.7% of women with low mid upper arm circumference (MUAC) (<23 cm) gave to LBW babies compared with women with high MUAC (6.5%) (table 3).

Predictors of infants' birth weight

Of the variables included the multivariable model, previous history of abortions or miscarriages, occurrence of gestational hypertension, prepregnancy weight and GWG were significantly associated with infants' birth weight at p<0.05.

Table 1 Pregnancy and pregnancy outcome-related data of the study participants, Addis Ababa, Ethiopia, 2019

Variable	Frequency	Percentage
Gravidity (n=395)		
Primi gravida	196	49.6
Gravida two	115	29.1
Gravida three	54	13.7
gravida four or above	30	7.6
Interpregnancy interval (n=192)		
<23 months	53	27.6
≥23 months	139	72.4
Previous history of abortion or miscarriages (n=199)		
Yes	81	40.7
No	118	59.3
A history of stillbirth (n=198)		
Yes	9	4.5
No	189	95.5
Mode of birth (n=314)		
Spontaneous vaginal birth	257	81.8
Caesarean section	57	18.2
Episiotomy (n=255)		
Yes	121	47.5
No	134	52.5
Sex of the baby (n=313)		
Male	146	46.6
Female	167	53.4
Gestational hypertension (n=359)		
Yes	21	5.8
No	338	94.2
Birth weight (n=308)		
Low birth weight	23	7.5
Normal birth weight	276	89.6
Macrosomia	9	2.9
Preterm birth (births before 37 weeks) (n=308)		
Yes	12	3.9
No	296	96.1

The ß-coefficient showed that infants born to underweight women were 150.9 g (95% CI 5.8 to 308.6 g, p=0.049) lighter than infants born to normal-weight women. Similarly, infants whose mothers had inadequate weight gain were 248.2 g (95% CI 112.8 to 383.6 g, p<0.001) lighter than those who gained adequate weight. In the same vein, infants whose mothers had a history of abortion or miscarriages and developed gestational hypertension during current pregnancy were 147.2 g (95% CI 3.2 to 291.3 g, p=0.045) and 311 g (95% CI 62.7 to 552.7 g, p=0.012), respectively, lighter compared with those whose mothers had not (table 4).

Maternal age, educational status, monthly income, haemoglobin level, pregnancy intention, gravidity, dietary diversity, food insecurity, physical activity, intimate partners' violence and perinatal depression were not significantly associated with birth weight.

DISCUSSION

A cohort of pregnant women who started their antenatal care follow-up before or at 16 weeks of gestation was followed until they gave birth to assess the influence of GWG and other factors on birth weight. The overall mean birth weight was 3130 g (SD, 509 g). The proportion of LBW was 7.5% (95% CI 4.8% to 11.0%); 9.3% (95% CI 5.7% to 14.2%) of women who gained inadequate gestational weight gave birth to LBW babies, while 4.5% (95% CI 1.2% to 11.1%) of women who gained adequate gestational weight gave birth to LBW babies. In addition, women's prepregnancy weight, GWG, having had a previous history of abortion or miscarriages, and the occurrence of gestational hypertension were the significant predictors of birth weight.

The proportion of babies born with LBW (7.5% (95% CI 4.8% to 11.0%)) was comparable with the findings from the nationwide study using the 2016 Ethiopia Demographic Health Survey data, which was 13.2% (95% CI 10.7% to 15.7%),[38] but lower than a finding from a meta-analysis conducted in 2018 in Ethiopia (pooled LBW data from 1995 to 2017), which was 17.3% (95% CI 14.1% to 20.4%).[39] Studies conducted in different parts of the country reported that maternal education,[38] employment status, income and maternal age[39] are significantly associated with a baby's birth weight. However, these factors were not significantly associated with birth weight in our study. This may be due to the sample size in our study being small because relatively a large number of women (64 women) lost from the study before their birth outcome was assessed. In addition, we were unable to access the birth records for sixteen women (5.2%) since they gave birth in a rural location, and birth weight information was ascertained through a phone call to the mother.

In our study, infants born to underweight women were 150.9 g lighter than infants born to normal-weight women. The proportion of LBW was higher (10.3%) among underweight women than that of normal-weight women (6.7%). Our findings were consistent with most prior reports that women's pre-pregnancy weight is associated with birth weight.[7 21 22 40] Maternal undernutrition, characterised by the low prepregnancy weight and inadequate GWG, can negatively influence fetal growth, leading to LBW.

GWG was found to have a significant influence on birth weight in our study. However, this finding needs to take account of a number of issues. First, the IOM GWG recommendations are the recommendations of high-income countries. These recommendations may

Table 2 Association between gestational weight gain (GWG) and pregnancy outcomes, Addis Ababa, Ethiopia, 2019

Variables	Gestational weight gain			P value for χ^2 test
	Inadequate GWG n (%)	Adequate GWG n (%)	Excess GWG n (%)	
Gestational hypertension (n=357)				
Yes	9 (3.8)	11 (11.0)	1 (5.9)	0.035
No	231 (96.2)	89 (89.0)	16 (94.1)	
Total	240 (100)	100 (100)	17 (100)	
Mode of birth (n=313)				
Spontaneous vaginal birth	179 (85.6)	67 (74.4)	11 (78.6)	0.064
Caesarean section	30 (14.4)	23 (25.5)	3 (21.4)	
Total	209 (100)	90 (100)	14 (100)	
Episiotomy (n=255)				
Yes	84 (47.5)	32 (47.8)	5 (45.5)	
No	93 (52.5)	35 (52.2)	6 (55.5)	0.990
Total	177 (100)	67 (100)	11 (100)	
Birth weight (n=307)				
LBW	19 (9.3)	4 (4.5)	0 (0.0)	
Normal birth weight	183 (89.7)	78 (87.6)	14 (100)	0.008
Macrosomia	2 (1.0)	7 (7.9)	0 (0.0)	
Total	204(100)	89(100)	14(100)	
Sex of the baby (n=312)				
Male	98 (46.9)	40 (44.9)	8 (57.1)	0.696
Female	111 (53.1)	49 (55.1)	6 (42.9)	
Total	209 (100)	87(100)	14(100)	
Preterm baby (n=270)				
Yes	9 (5.1)	3 (3.9)	0 (0)	0.651
No	169 (94.9)	74 (96.1)	14 (100)	
Total	178 (100)	77(100)	14 (100)	

LBW, low birth weight.

not be suitable in low-income settings such as Ethiopia. Second, we measured prepregnancy weight before or at 16 weeks of gestation, at which time there may already have been an increase or a decrease of gestational weight. Finally, women's last weight was measured at 36 weeks of gestation; hence there may be some weight gain after 36 weeks. Having those issues in mind, our study identified that babies whose mothers gained inadequate gestational weight were significantly lighter than infants of mothers who gained adequate weight. Moreover, 9.3% of women who gained inadequate gestational weight gave birth to LBW babies compared with women who gained adequate gestational weight (4.5%). Other studies in similar settings also reported that LBW was more common among women who gained inadequate gestational weight than among women who gained adequate weight.[21 41] While there is a strong need for extra nutritional intake during pregnancy, more than a quarter of pregnant women (27.3%) in Addis Ababa restrict their food intake to avoid weight gain.[42] This is primarily due to the perceived severity of birth complications due to large for gestational age babies making the birth more difficult and leading to caesarean birth.[43 44] Decreased nutrient intake due to poor dietary practices together with socioeconomic and environmental factors could affect fetal growth, which also leads to LBW.[45] Poor nutritional status among pregnant women may be associated with reduced placental size, which may lead to a reduction of nutrient transfer to the fetus from the placenta. Furthermore, the low nutritional status of mothers might reduce serum concentrations of hormones such as oestrogen and leptin, which could result in impairment of fetal growth.[39] Nutritional counselling during pregnancy may improve women's feeding behaviour and hence, their nutritional status, which may help mothers to decrease the risk of delivering LBW babies.[46 47]

We found that the birth weight of newborns whose mothers had a history of abortions or miscarriages was significantly lower than those whose mothers had no history of abortions or miscarriages, an average decrease of 147 g. This could be due to forty percent (40%) of multigravida women having had a history of abortions or

Table 3 Birth weight in relation to different factors in women of Addis Ababa, Ethiopia, 2019

Variable	LBW, n (%)	Normal birth weight, n (%)	Macrosomia, n (%)	Mean birth weight (SD) (kg)
Women's age category (n=308)				
<20 years	1 (7.1)	13 (92.9)	0 (0.0)	2.96 (0.50)
20–29 years	18 (7.3)	220 (89.4)	8 (3.3)	3.13 (0.51)
≥30 years	4 (8.3)	43 (89.6)	1 (2.1)	3.14 (0.53)
Marital status (n=308)				
Married	22 (7.4)	267 (89.9)	8 (2.7)	3.13 (0.51)
Single	1 (9.1)	9 (81.8)	1 (9.1)	3.15 (0.46)
Educational status (n=308)				
No formal education	2 (8.0)	23 (92.0)	0 (0.0)	3.17 (0.49)
Primary	12 (9.7)	111 (89.5)	1 (0.8)	3.01 (0.48)
Secondary	8 (9.0)	75 (84.3)	6 (6.7)	3.15 (0.58)
Tertiary	1 (1.4)	67 (95.7)	2 (2.9)	3.23 (0.45)
Occupational status (n=308)				
House duty	14 (9.2)	133 (87.5)	5 (3.3)	3.07 (0.54)
Employee	4 (4.0)	95 (94.0)	2 (2.0)	3.19 (0.44)
Merchant	2 (6.1)	29 (87.8)	2 (6.1)	3.26 (0.55)
Others*	3 (13.4)	19 (86.4)	0 (0.0)	3.00 (0.47)
Average monthly income (n=284)				
<ETB5000†	16 (8.3)	173 (90.1)	3 (1.6)	3.10 (0.51)
ETB5000–ETB10 000	5 (8.1)	54 (87.1)	3 (4.8)	3.10 (0.49)
≥ETB10 000	1 (3.3)	28 (93.4)	1 (3.3)	3.28 (0.46)
Pregnancy intention (n=304)				
Intended	22 (8.0)	246 (89.5)	7 (2.5)	3.12 (0.51)
Unintended	1 (3.4)	26 (89.7)	2 (6.9)	3.22 (0.48)
Gravidity (n=308)				
Primigravida	9 (6.2)	132 (91.0)	4 (2.8)	3.11 (0.50)
Multigravida	14 (8.6)	144 (88.3)	5 (3.1)	3.14 (0.52)
Time gap between pregnancy (n=252)				
<23 months	4 (9.8)	37 (90.2)	0 (0.0)	3.09 (0.51)
≥23 months	10 (8.6)	101 (87.1)	5 (4.3)	3.16 (0.53)
Dietary diversity (n=308)				
Low dietary diversity	1 (1.9)	50 (96.2)	1 (1.9)	3.09 (0.49)
High dietary diversity	22 (8.6)	226 (88.3)	8 (3.1)	3.13 (0.52)
Physical Activity (n=308)				
Low	13 (9.0)	127 (88.2)	4 (2.8)	3.10 (0.50)
Moderate	7 (5.5)	115 (90.6)	5 (3.9)	3.15 (0.52)
High	3 (8.1)	34 (91.9)	0 (0.0)	3.15 (0.53)
MUAC‡ (n=301)				
Low MUAC	7 (12.7)	46 (83.6)	2 (3.7)	3.02 (0.53)
High MUAC	16 (6.5)	223 (90.6)	7 (2.9)	3.15 (0.50)
Prepregnancy weight (n=307)				
Underweight	6 (10.3)	52 (89.7)	0 (0.0)	3.02 (0.46)
Normal weight	13 (6.7)	173 (89.2)	8 (4.1)	3.14 (0.53)
Overweight or obese	4 (7.1)	51 (91.1)	1 (1.8)	3.14 (0.50)

Continued

Table 3 Continued

Variable	LBW, n (%)	Normal birth weight, n (%)	Macrosomia, n (%)	Mean birth weight (SD) (kg)
Gestational hypertension (n=298)				
Yes	5 (27.8)	12 (66.7)	1 (5.5)	2.93 (0.69)
No	16 (5.7)	257 (91.8)	7 (2.5)	3.14 (0.49)
Intimate partners violence (n=308)				
Yes	2 (3.5)	53 (93.0)	2 (3.5)	3.13 (0.50)
No	21 (8.4)	223 (88.8)	7 (2.8)	3.12 (0.51)
Food insecurity (n=304)				
Food secure	19 (7.1)	239 (89.9)	8 (3.0)	3.12 (0.50)
Food insecure	4 (10.5)	33 (86.8)	1 (2.6)	3.12 (0.58)
Consuming meat or chicken in the last 24 hours (n=307)				
Yes	5 (5.7)	80 (92.0)	2 (2.3)	3.20 (0.50)
No	18 (8.2)	195 (88.6)	7 (3.2)	3.09 (0.51)
Perinatal depression (n=308)				
Yes	3 (9.1)	29 (87.9)	1 (3.0)	3.14 (0.51)
No	20 (7.3)	247 (89.8)	8 (2.9)	3.05 (0.49)

*Students, daily labourer, farmer.
†ETB=Ethiopian Birr.
‡MUAC=mid upper arm circumference.
LBW, low birth weight; SD, Standard deviation .

miscarriages; 22% of these women experienced abortions or miscarriages at least two times. This would indicate that women and their partners' reproductive health and family planning use is low. A study conducted by the DKT Ethiopia (a non-profit organisation that promotes family planning), in 2018, on 880 women who received post-abortion care showed that 83.4% of aborted pregnancies were unplanned, and 91.6% of the women intentionally aborted their pregnancy.[48] This would suggest that the Ethiopian government needs to improve access to information and knowledge of reproductive choices and access to family planning services for both men and women.

Consistent with other studies,[49–52] our study showed gestational hypertension was significantly associated with lower infant birth weights. Infants born to mothers with gestational hypertension were 311 g lighter than infants born to mothers without gestational hypertension. Similarly, 27.8% of women with gestational hypertension gave birth to LBW babies, while 5.7% of women without gestational hypertension gave birth to LBW babies. Although the relationship between gestational hypertension and an optimal intrauterine environment requires further exploration, some studies indicated that gestational hypertension is related to placental blood flow,[53 54] which affects fetal development, including birth weight.

Factors such as dietary diversity, food insecurity, physical activity, perinatal depression and intimate partners violence were not associated with birth weight in our study. This could be due to a number of reasons. First, these factors were captured before or at 16 weeks of gestations. The occurrence of these factors at a different stage of pregnancy would have different effects on GWG and birth weight. Future studies may need to measure the magnitude of dietary diversity, food insecurity, physical activity, perinatal depression and intimate partner violence at different trimesters of pregnancy and their effects on GWG and birth weight. Second, our sample size was relatively small because a significant number of women were lost during the follow-up before their birth outcome was captured. Finally, the effect of these factors may need to be checked in different settings, such as rural areas where a significant number of women suffer from household food insecurity.

Strengths and limitations of this study

The strength of this study was that women were prospectively followed to their GWG and birth weight. This study has some limitations. First, a relatively large number of women (64) lost from the study before their birth outcome was assessed. In addition, we were unable to access the birth records for sixteen women (5.2%) since they gave birth in a rural location, and birth weight information was ascertained through a phone call to the mother. Second, the IOM GWG recommendations are the recommendations of high-income countries. These recommendations may not be suitable in low-income settings such as Ethiopia. Third, we measured prepregnancy weight before or at 16 weeks of gestation, at which time there may already have been an increase or decrease of gestational weight. In addition, women's last weight was measured at 36 weeks

Table 4 Bivariable and multivariable linear regression analysis for predictors of birth weight (in gram) in Addis Ababa, Ethiopia 2019

	Bivariable regression			Multivariable regression		
Variable	**Crude-ß**	**95% CI**	**P value**	**Adjusted-ß**	**95% CI**	**P value**
Women's age			0.446			
<20 years	−176.0	−451.7 to 99.7	0.210	---	---	---
20–29 years	Ref					
≥30 years	6.0	−151.9 to 164.7	0.936	---	---	---
Educational status			0.065			
No formal education	−57.6	−289.6 to 174.5	0.626	−83.3	− 332.1 to 168.8	0.515
Primary	−194.8	−343.7 to −45.9	0.010	−152.2	− 315.9 to 11.5	0.068
Secondary	−84.1	−243.2 to 74.9	0.299	−59.4	−228.9 to 110.9	0.493
Tertiary	Ref			Ref		
Occupational status			0.258			
House duty	−116.57	−244.5 to 11.4	0.274	---	---	---
Employee	Ref					
Merchant	67.9	−131.9 to 267.8	0.504	---	---	---
Others	−185.1	−419.6 to 49.5	0.122	---	---	---
Average monthly income			0.190			
<ETB5000	−177.9	−372.5 to 16.6	0.073	−112.9	−323.9 to 99.0	0.293
ETB5000–ETB10 000	−175.9	−396.4 o 44.4	0.117	−161.9	−389.1 to 64.8	0.161
≥ETB10 000	Ref			Ref		
Pregnancy intention			0.294			
Intended	Ref					
Unintended	104.8	−91.4 to 301.1	0.294	---	---	---
Previous history of abortion or miscarriages			0.119			
Yes	−109.7	−247.8 to 28.5	0.119	−147.2	−291.3 to −3.2	0.045
No	Ref			Ref		
Gravidity	15.9	−36.6 to 68.4	0.552			
Dietary diversity			0.600			
Low	Ref					
High	−40.7	−193.4 to 112.0	0.600	---	---	---
Physical activity			0.641			
Low	−51.7	−236.9 to 133.4	0.583	---	---	---
Moderate	4.1	−183.6 to 191.8	0.966	---	---	---
High	Ref					
Consuming meat or chicken in the last 24 hours			0.085			
Yes	111.4	−15.4 to 238.2	0.085	130.6	5.5 to 266.7	0.060
No	Ref			Ref		
Prepregnancy weight			0.173			
Underweight	−114.9	−264.7 to 34.8	0.132	−150.9	−308.6 to −5.8	0.049
Normal weight	Ref			Ref		
Overweight or obese	57.2	−94.5 to 209.0	0.458	1.4	− 168.6 to 169.6	0.987
Gestational hypertension			0.076			
Yes	−216.7	−455.9 to 22.5	0.076	−310.7	−552.8 to −62.7	0.012
No	Ref			Ref		

Continued

Table 4 Continued

Variable	Bivariable regression			Multivariable regression		
	Crude-ß	95% CI	P value	Adjusted-ß	95% CI	P value
GWG			<0.001			
Inadequate	−252.9	−377.4 to −128.4	<0.001	−248.2	−383.6 to −112.8	<0.001
Adequate	Ref			Ref		
Excessive	47.8	−329.5 to 233.9	0.739	−58.5	−360.4 to 243.5	0.703
Sex of the baby			0.198			
Male	Ref			Ref		
Female	−75.0	−189.0 to 39.0	0.198	−111.6	−290.0 to 5.8	0.062
Maternal haemoglobin	−41.0	−81.2 to −0.9	0.045	−31.0	−72.4 to 10.3	0.141
Intimate partners violence			0.906			
Yes	8.8	−138.6 to 156.2	0.906	---	---	---
No	Ref					
Food insecurity			0.924			
Food secure	Ref			Ref		
Food insecure	−8.4	−183.5 to 166.6	0.924	52.8	−124.2 to 229.9	0.557
Perinatal depression			0.355			
Yes	−86.9	−271.8 to 97.8	0.355	---	---	---
No	Ref					

ETB, Ethiopian Birr; GWG, gestational weight gain.

of gestation; hence there may be some weight gain after 36 weeks of gestation. Finally, this study was conducted in the capital city of Ethiopia in the public health facilities; the situation in other parts of the country and private health facilities may be different.

CONCLUSION

We found that GWG was significantly associated with infants' birth weight. Infants whose mothers gained inadequate gestational weight were significantly lighter than the infants of mothers who gained adequate weight, an average decrease of 248 g. Moreover, the birth weight of newborns whose mothers were underweight had a previous history of abortion (termination of pregnancy before the 28th week of gestation) or miscarriages, and had gestational hypertension, was significantly lower than those whose mothers were without this history. Programme officers and policy-makers may need to design appropriate interventions to prevent LBW. Pregnancy-related weight management should be actively promoted through intensive counselling during routine antenatal care consultations. The practical applicability of the IOM guidelines and the effect of GWG (according to IOM recommendations) on pregnancy outcomes need further investigation in the Ethiopian context.

Contributors FA has conceived the study, performed data collection and analyses, and drafted the manuscript. AC, YD, MF and AH have critically revised the design of the study, participated in the analyses, interpretation of the findings and draft of the manuscript. All authors read this manuscript and finally approved it for submission. FA is the guarantor of the study.

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Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not applicable.

Ethics approval This study involves human participants and was approved by Ethics approval for the study was obtained from the Haramaya University Institutional Health Research Ethics Review Committee (IHRERC/200/2018), Addis Ababa Health Bureau Institutional Review Board (A/A/HB/2576/227) and the University of Technology Sydney, Human Research Ethics Committee (UTS HREC18-2610). Participants gave informed consent to participate in the study before taking part.

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ORCID iD

Fekede Asefa http://orcid.org/0000-0002-6700-4810

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