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Anemia during pregnancy and neonatal birth weight: Comparison of maternal dietary intake in Sri Lanka

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Abstract Anemia in pregnancy is a key public health problem in both developing and industrialized countries that contributes to poor maternal and fetal outcomes. This longitudinal study aimed to assess maternal anemia and its association with maternal dietary intake and neonatal birth weight at a tertiary care hospital in Sri Lanka. Secondary data of first and third-trimester maternal hemoglobin concentrations were used. Dietary intake was assessed using a food frequency questionnaire, performed once in the second and third-trimesters. Birth weight was obtained from the hospital records. The chi-square test and the two-sample t-test were used to compare the anemic and non-anemic groups. Both univariate analysis of variance and generalized linear model were used to identify the effects of hemoglobin levels on birth weight. No difference in birth weight was found between first-trimester anemic and non-anemic women ($p > 0.05$). The babies whose mothers were anemic during the third trimester were 350 g lighter than those born to women who were not anemic during the third-trimester (95% CI: 66 to 634; $p = 0.017$). No differences in dietary intake were found between third-trimester anemic and non-anemic women ($p > 0.05$). The results suggest that third-trimester maternal anemia is associated with a low mean birth weight. The high prevalence of third-trimester maternal anemia among Sri Lankan women cannot be explained solely by macro and micronutrient deficiencies.

Background

Anemia is a major nutritional disorder defined as a low blood hemoglobin concentration and has been identified as a significant public health problem in both developing and industrialized countries. The global prevalence of anemia was reported as 32.9% in 2010.[1)] The most recent World Health Organization (WHO) data revealed that 25-36% of Sri Lankan people have anemia at various life stages.[2)] Among the multiple causative factors of anemia, iron deficiency is the most common cause worldwide. Additionally, vitamin and folate deficiencies, malaria and helminth diseases are mostly attributable to anemia in developing countries.

Anemia in pregnancy is a widespread health problem in Sri Lanka that must be addressed. In Sri Lanka, the prevalence of maternal anemia among pregnant women was reported as 34% in 2006/2007.[3)] Anemia during pregnancy can lead to poor fetal outcomes [4) 5)] and increased risk of maternal and child morbidity and mortality.[6)] Many researchers have debated the correlation between maternal anemia in various trimesters and low birth weight (LBW) and preterm

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deliveries [5)7)] and these findings remain controversial. A woman's iron needs triple during pregnancy compared to non-pregnancy to support the growing fetus, placenta and increased red blood cell mass. [8)] Although the most suitable strategy to overcome this physiological demand is to have good nutrition during pregnancy, women in most developing countries are unable to access good nutrition even during pregnancy. Therefore, iron supplementation during pregnancy is advisable in developing countries where women often enter pregnancy with low iron stores. [9)]

Many industrialized countries, including the United Kingdom, have advised against universal supplementation in their clinical guidelines [10)] because of a low prevalence of anemia due to a universal iron fortification program.[11)] However, the iron fortification programs in developing countries are not effective due to several factors. [8)]

Pregnancy is measured in trimesters from the first day of the last menstrual period, totaling 40 weeks. The first trimester of pregnancy is week 1 through week 12, the second trimester is week 13 to week 27, and the third trimester of pregnancy spans from week 28 to the birth. As a country with a moderate prevalence of anemia, Sri Lanka maternal health care policies recommend daily supplementation of 60 mg of oral iron and 400 μg of folic acid beginning soon after completion of 12 weeks of gestation and continuing until 6 months postpartum. [12)] These supplements are freely distributed to all pregnant women through community and hospital-based antenatal clinics to combat maternal anemia and thereby improve pregnancy outcomes. Routine blood hemoglobin measurements at the first antenatal clinic visit and at 28 weeks' gestation are also recommended.[12)] Although universal iron supplementation programs have been implemented for several decades in Sri Lanka, the prevalence of maternal anemia among pregnant women is still quite high. The LBW rate in 2014 was 16% [13)], and this rate has fluctuated between 16 and 17% for many years. The negative health consequences of anemia and LBW have real impacts on the country`s health care and future plans. However, studies on maternal anemia and birth weight are scarce in Sri Lanka. Although some South Asian researchers [5)] have revealed the effect of maternal anemia in different trimesters on neonatal birth weight, this is the first study to assess maternal anemia and its relation to maternal dietary intake and newborn birth weight.

Methods

This study was a prospective observational study that was conducted in a large tertiary care hospital in Sri Lanka from October 2015 to June 2016. A detailed description of the subject recruitment procedure was published elsewhere. [14)] In brief, 150 pregnant women who were between 18-24 weeks of gestation were initially included in the study. Exclusion criteria were risk factors according to obstetrical history (e.g., miscarriages/abortions, multiple fetuses, pregnancy-induced hypertension, and gestational diabetes mellitus) and medical history (e.g., psychiatric disorders or long-term cardiac, renal, lung, or gastrointestinal disease). Additionally, neonates with a 5-minute Apgar score less than 5 were excluded. A sub-sample of women who fulfilled the criteria of having undergone anemia screening tests at both their booking visit (first antenatal clinic visit; usually approximately 6-8 weeks gestation) and at 28-30 weeks gestation and having delivered a term singleton neonate was selected for this particular analysis (n = 52). An interviewer-administered questionnaire was used to collect socio-economic and demographic data. Information on maternal hemoglobin concentration at the booking visit and at 28-30 weeks gestation was obtained directly from the individual pregnancy records. Subjects were grouped into categories of hemoglobin based on the WHO guidelines of hemoglobin levels to diagnose anemia at sea level during pregnancy; non-anemia: greater than or equal to 110 g/l; mild: 100-109 g/l; moderate: 70-99 g/l; and severe: lower than 70 g/dl. [15)] Maternal dietary intake was assessed once during the second (approximately 22weeks gestation) and third (approximately 34 weeks gestation) trimesters using a validated food frequency questionnaire (FFQ) [16)], which was developed for Sri Lankan adults. Energy, macro nutrient and micro nutrient values of the maternal diets were calculated using Nutrisurvey2007 (EBISpro, German), anutrient analysis software, after modifying for Sri Lankan food items. More detailed and concise descriptions of the nutrient analysis software modification were published elsewhere. [14)] Neonatal data on birth weight and sex were obtained directly from the hospital records following birth.

Ethics approval and consent to participate

The study was approved by the ethical review committees of the Graduate School of Health Sciences, Niigata University, Japan(No: 125); Faculty of Allied Health Sciences, University of Peradeniya; and the Institutional Ethical Review Committee of the Teaching Hospital, Kurunegala, Sri Lanka(ERC/2015/06). The study was conducted in compliance with the principles of the Declaration of Helsinki. Informed written consent was obtained from all subjects prior to data collection.

Statistical analysis

The statistical analysis was performed using Minitab version 17 (Minitab, Inc., State College, Pennsylvania, United States). One-way analysis of variance (ANOVA) was performed to test the effect of different maternal hemoglobin levels on neonatal birth weight. Firstly, the effect of first trimester non-anemic (Hb ≥ 110 g/l), moderate anemic (Hb 70-99 g/l) and mild anemic (Hb 100-109 g/l) status on neonatal birth weight was assessed using one way ANOVA test. Then two sample t-test was used to compare the neonatal birth weight between first trimester anemic (Hb < 110 g/l) and non-anemic (Hb ≥ 110 g/l) group. The same procedure was carried out to test the effect of third trimester maternal hemoglobin levels on neonatal birth weight.

Participants`characteristics were compared between third trimester anemic (Hb < 110 g/l) and non-anemic groups using chi-square test and two sample t-test while only the two sample t-test was used to compare the dietary intake between two groups. Paired t-test was used to compare the second- and third-trimester dietary intakes of the followed subjects in both the anemic (Hb < 110 g/l) and non-anemic groups. Generalized linear model was performed to test the independent effects of hemoglobin levels on neonatal birth weight by controlling possible confounding effects. All of the continuous variables were first assessed using numerical and graphical techniques, including scatter plots, to determine whether they met the distributional assumption of the statistical tests used to analyze them. Equal variances are confirmed. The descriptive statistics are expressed as the mean ± standard deviation. A p value of 0.05 was set as the cutoff for statistical significance.

Results

Anemia prevalence and its effect on neonatal birth weight

There were no subjects with severe anemia (hemoglobin < 70 g/l) in either the first or third trimester. Of the total sample, 28.8% and 46.1% were anemic (hemoglobin < 110 g/l) when they became pregnant and at 28-30 weeks gestation, respectively. No significant difference in the mean birth weight was captured based on the first-trimester maternal hemoglobin level (p > 0.05). Although it did not reach the level of significance, the lowest mean birth weight (2,822 ± 357 g) was reported in women with moderate anemia during the third trimester (p = 0.119).Univariate analysis revealed that the babies whose mothers were anemic during the third trimester had a significantly lower mean birth weight (2,835 ± 506 g) than the babies with non-anemic mothers (3,135 ± 506; 95% CI for the difference: 16 to 582; p = 0.038; Table 1).

Similarly, the fitted general linear model ($R^2_{(adj)}$ = 19.9%) showed that the babies of mothers who were anemic during their third trimester of pregnancy were 350 g lighter than those whose mothers were non-anemic during the third trimester (95% CI for the difference: 66 to 634; p = 0.017) by controlling for pre-pregnancy body mass index (BMI; p = 0.455), area of residence (p = 0.036), history of low birth weight (p = 0.117) and sex of the newborn (p = 0.087).

Participants' characteristics based on third-trimester anemic and non-anemic status

The women in the anemic group were relatively younger than those in the non-anemic group; however, the difference in mean maternal age did not reach the level of significance (p > 0.05). Among the six factors assessed (maternal age, education level, monthly household income, area of residence, pre-pregnancy BMI category and sex of the newborn), only the sex of the newborn showed a significant relationship with third-trimester anemic and non-anemic status (odds ratio: 3.75; 95% CI: 1.1744 to 11.995; p = 0.022; Table 2).

Maternal dietary intake

Maternal dietary intake during the second and third trimesters was compared between the anemic and non-anemic groups based on third-trimester hemoglobin values. No significant difference was found between the third-trimester anemic and non-anemic groups in terms of daily energy, carbohydrate, protein or dietary iron intake in either the second or third trimester (p > 0.05; Table 3). The comparison of second- and third-trimester dietary intake revealed that the mean daily intake of energy, carbohydrate, total protein, animal

Table 1: Relationship between maternal anemia and neonatal birth weight

Trimester	Classification of anemia		n (%)	Hemoglobin concentration (g/l) (Mean ± SD)	Birth weight (g) (Mean ± SD)	P value
First trimester[a]	Anemic group	All (Hb < 110 g/l)	15 (28.8%)	99.9 ± 12.4	2997 ± 652	0.903[c]
		Moderate (Hb 70-99 g/l)	4 (7.7%)	81.2 ± 8.4	3100 ± 745	0.999[d]
		Mild (Hb 100-109 g/l)	11(21.1%)	106.6 ± 2.4	2959 ± 650	
	Non-anemic group (Hb ≥ 110 g/l)		37 (71.2%)	121.7 ± 8.2	2997 ± 472	
Third trimester[b]	Anemic group	All (Hb < 110 g/l)	24 (46.1%)	99.1 ± 9.3	2835 ± 506	0.119[e]
		Moderate (Hb 70-99 g/l)	9(17.3%)	89.9 ± 9.0	2822 ± 357	0.038[f**]
		Mild (Hb 100-109 g/l)	15(28.8%)	104.7 ± 3.0	2843 ± 589	
	Non-anemic group (Hb ≥ 110 g/l)		28 (53.9%)	117.0 ± 6.5	3135 ± 506	

SD, Standard deviation; Hb, Hemoglobin.

[a] At first antenatal clinic visit (6-8 gestation week)

[b] At 28-30 gestation weeks

[c] Comparison of neonatal birth weight among first trimester moderate anemic (Hb 70-99 g/l) , mild anemic (Hb 100-109 g/l) and non-anemic (Hb ≥ 110 g/l) groups

[d] Comparison of neonatal birth weight between first trimester anemic (Hb < 110 g/l) and non-anemic groups

[e] Comparison of neonatal birth weight among third trimester moderate anemic (Hb 70-99 g/l) , mild anemic (Hb 100-109 g/l) and non-anemic (Hb ≥ 110 g/l) groups

[f] Comparison of neonatal birth weight between third trimester anemic (Hb < 110 g/l) and non-anemic groups

**$p < 0.05$

Table 2 : Participant characteristics (n=52)

Variable	All	Third trimester	
		Anemic group (n=24)	Non-anemic group (n=28)
Maternal age	29.2 ± 6.1	27.6 ± 6.4	30.7 ± 5.5
Level of education n (%)			
Primary	9 (17.7%)	5 (20.8%)	4 (14.8%)
Secondary	41 (80.4%)	18 (75.0%)	23 (85.2%)
Higher	1 (1.9%)	1 (4.2%)	0 (0.0%)
Monthly household income n (%)			
Up to 14000 LKR	10 (19.6%)	6 (25.0%)	4 (14.8%)
14000 to 32000 LKR	35 (68.6%)	18 (75.0%)	17 (63.0%)
>= 32000 LKR	6 (11.8%)	0 (0.0%)	6 (22.2%)
Area of residence n (%)			
Urban	5 (9.8%)	1 (4.2%)	4 (14.8%)
Sub-urban	22 (43.1%)	11 (45.8%)	11 (40.7%)
Rural	24 (47.1%)	12 (50.0%)	12 (44.4%)
Pre-pregnancy BMI category n (%)			
Underweight	10 (19.2%)	5 (20.8%)	5 (17.9%)
Normal	29 (55.8%)	15 (62.5%)	14 (50.0%)
Overweight	10 (19.2%)	4 (16.7%)	6 (21.4%)
Obese	3 (5.8%)	0 (0.0%)	3 (10.7%)
Sex of the newborn**			
Male	24 (46.1%)	7 (13.5%)	17 (32.7%)
Female	28 (53.8 %)	17 (32.7%)	11 (21.1%)

Compared using chi-square test and two-sample t-test.

**Odds ratio: 3.75; 95% CI: 1.1744 to 11.995; p = 0.022)

Table 3 : Maternal energy, macronutrient and micronutrient intake based on third-trimester anemia status

Trimester	Factor	Third trimester		P value[a]
		Anemic group; (n=22)	Non-anemic group; (n=28)	
Second trimester	Energy intake (kcal/day)	2894±628	2823 ± 738	0.717
	Carbohydrate (g/day)	529± 116	520 ± 147	0.820
	Plant protein (g/day)	54.7± 15.2	51.5 ± 15.1	0.463
	Animal protein (g/day)	9.7 ± 6.5	7.7 ± 5.6	0.259
	Total protein (g/day)	71.1± 17.5	66.5 ± 17.5	0.362
	Iron (mg/day)	24.3 ± 7.7	22.8 ± 7.0	0.472
Third trimester	Energy intake (kcal/day)	3047± 669	2987 ± 745	0.793
	Carbohydrate (g/day)	553± 136	547 ± 134	0.877
	Plant protein (g/day)	56.5± 11.8	56.7 ± 13.8	0.965
	Animal protein (g/day)	16.6± 7.0	13.0 ± 7.2	0.123
	Total protein (g/day)	77.0± 14.2	73.2 ± 19.8	0.496
	Iron (mg/day)	27.7 ± 5.9	24.1 ± 7.3	0.098

SD: Standard deviation.

[a] Comparison of dietary intake of the third-trimester anemic- and non-anemic groups using two sample t-test

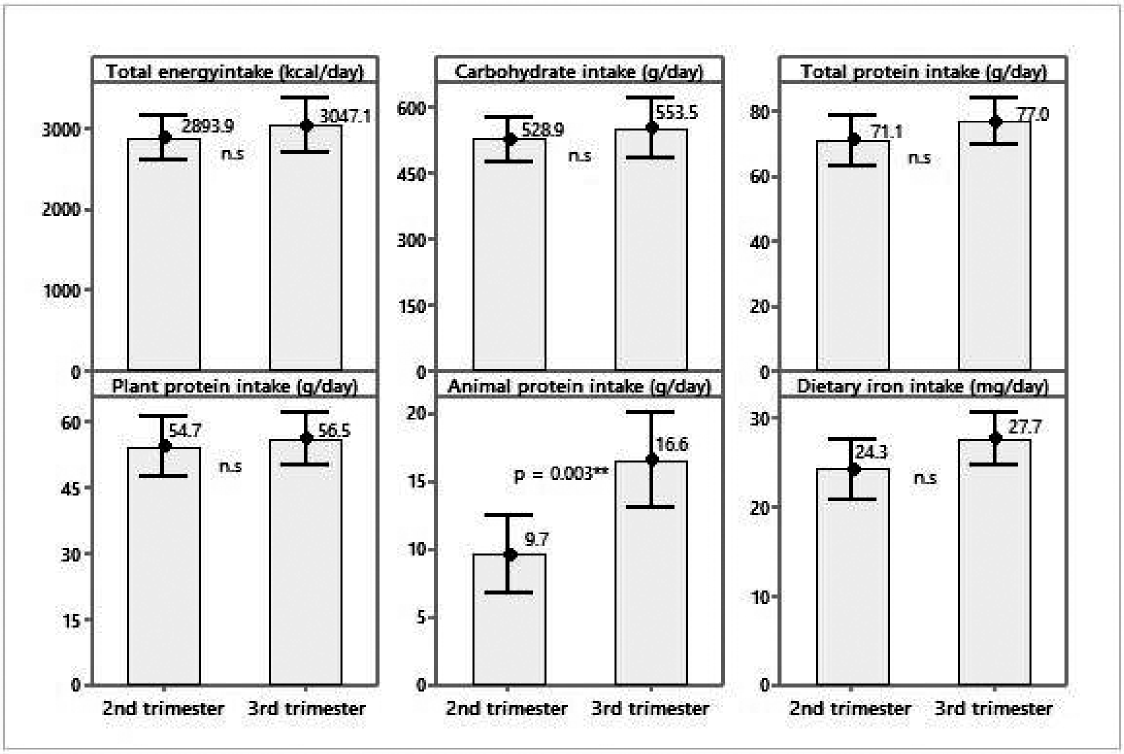

Figure 1 (a)

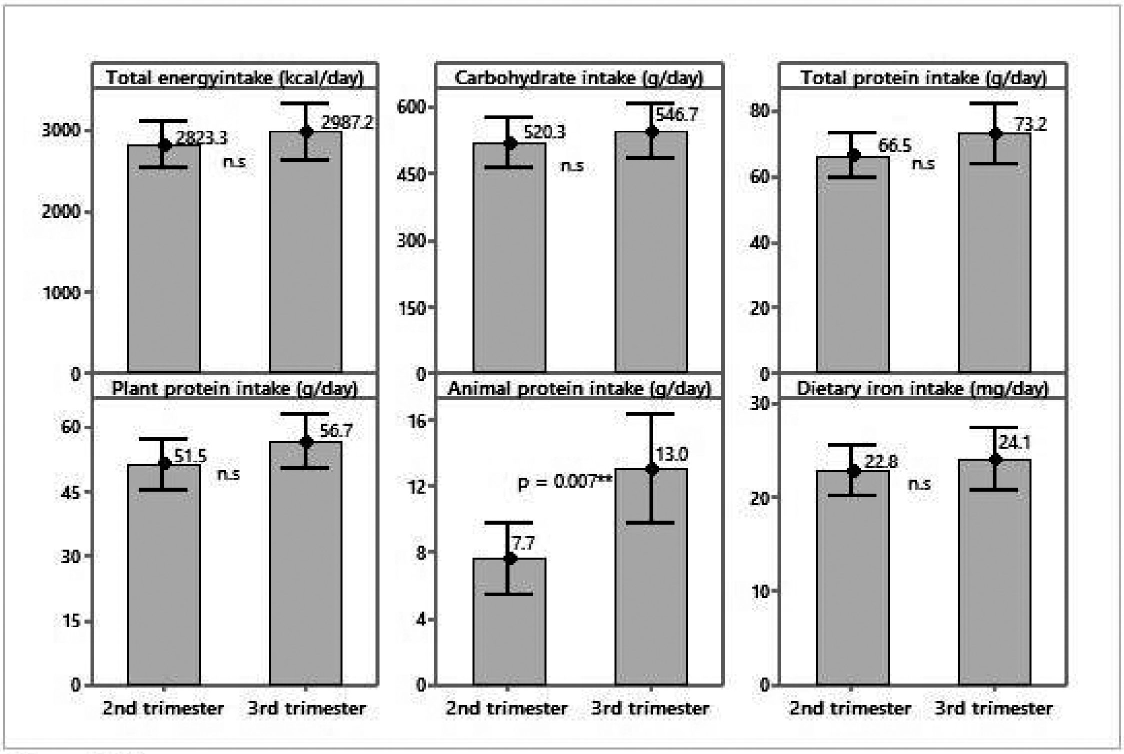

Figure 1 (b)

Figure 1: Comparison of second- and third-trimester dietary intake; between third-trimester (a) anemic and (b) non-anemic group

Both the anemic and non-anemic groups showed significantly higher animal protein intake during the third trimester of pregnancy compared with the second trimester.

protein and dietary iron was higher during the third trimester than during the second trimester for both the anemic and non-anemic groups. In both groups, daily animal protein intake was significantly higher in the third trimester ($p < 0.01$; Fig. 1).

Discussion

The present study showed an anemia prevalence of 28.8% and 46.1% in the first and third trimesters, respectively. The national statistics in 2006/07 showed a 34% prevalence of anemia among pregnant women.[3] However, the gestational age at the time of hemoglobin measurement was not specified in the national statistics, which made it difficult to perform a fair comparison. Level of education, monthly household income and area of residence were not related to maternal blood hemoglobin levels in third trimester, and this result was consistent with previous studies.[17)18] The current guidelines of the maternal health care programs in Sri Lanka recommend screening for anemia twice – at the first antenatal clinic visit and in the third trimester. However, due to resource limitations, the second screening is done only for women who show anemic symptoms and/or low hemoglobin concentrations in the first trimester. The current study showed that third-trimester maternal anemia is associated with low mean birth weight. These results are consistent with previous studies.[5) 19] In the current study, 10 (19.2%) subjects continued to have anemia from the first trimester, and 14 (26.9%) new anemia cases were detected at 28-30 weeks gestation. As the pregnant women enter to antenatal care at around 6-8 weeks of gestation, there were no data regarding the pre-pregnancy maternal hemoglobin concentrations. Since the first hemoglobin test is carried out in the very first antenatal clinic visit (6-8 weeks gestation), it may consider as the pre-pregnancy maternal hemoglobin concentration of each women. However, no relationship was found between first trimester anemic/non-anemic status (based 6-8 week hemoglobin concentration) and neonatal birth weight. Based on the results of the current study, we emphasize the importance of third-trimester anemia screening for all pregnant women regardless of their first-trimester results and anemic symptoms.

The mean dietary iron intake of the study sample was below the recommended dietary allowance for iron during pregnancy, which 27 mg/day[20] during both the second (23.5 ± 7.3 mg) and third trimesters (25.8 ± 6.8 mg).This result indicates the poor dietary iron intake of this study group. This shortcoming can be considered a problem in many developing countries and is due to consumption of cereal and legume–based diets containing low amounts of bio-available iron, which may increase the risk of iron deficiency.[21] However, similar results were also found in a study conducted in a developed country to assess first- and second-trimester maternal nutrition.[22] The dietary assessment of the third-trimester anemic and non-anemic groups revealed no difference in energy, carbohydrate, protein or dietary iron intake between the two groups during both the second and third trimesters. However, the animal protein intake was higher in the anemic group both in the second and third trimesters. The third-trimester anemia group showed higher mean dietary iron intake both in the second and third trimesters, but the difference from the non-anemia group was not significant. This finding may be due to the individualized nutritional education that the anemic women received from their primary health care providers along with their hemoglobin test results. Although the difference was not statistically significant, there was a higher energy, carbohydrate, plant protein and total protein intake during the third trimester than during the second trimester. However, both the anemic and non-anemic women showed significantly higher animal protein intake during the third trimester. The Sri Lankan culture of relatives and neighbors offering nutritious meals to pregnant women may be one reason for the higher animal protein consumption during the third trimester as meal presents are more common during the third trimester. Although all the pregnant women showed an increased animal protein intake during the third trimester, the mean animal protein intake remained quite low compared with western figures, which can be explained by cultural and economical factors in Sri Lankan context.[14] The Family Health Bureau of Sri Lanka[12] recommends that all pregnant women receive advice on iron-rich food items for their meals. Specifically, the meals of pregnant women should consist of animal as well as non-animal foods rich in dietary iron. These women are advised to consume iron together with citrus fruit or juice and should be discouraged to consume food such as tea and coffee, which inhibit the absorption of iron from plant sources. However, it should be noted that Sri Lanka is a country with traditional black tea drinkers, and black tea can interfere with the absorption of iron from food. A study performed in Sri Lanka revealed that

88.7% of the respondents were tea consumers.[23] Although the frequency and pattern of tea consumption were not assessed in detail in the current study, this factor may be a possible confounder for the high incidence of anemia. In the current study, there was no difference in the dietary intake between the anemic and non-anemic groups. Therefore, the difference in blood hemoglobin levels may be due to the compliance with antenatal iron and folic acid supplementation. Although all the participants reported that they had commenced iron supplementation soon after the first trimester, compliance was not assessed in this study.

A recent study performed in Colombo, Sri Lanka revealed that only 4% of pregnant women received advice about their hemoglobin test results.[24] This finding may indicate the gaps in antenatal education, especially in providing supplementation in antenatal clinics. The poor efficacy of iron supplementation was found to be due to poor compliance and unsatisfactory methods of supplement intake.[25] Palihawadana et al.[26] suggested that a simple education intervention could improve the effectiveness of iron supplementation programs in Sri Lanka. Antenatal oral iron supplements should be taken one hour before a main meal together with vitamin C or citrus fruit juice. Calcium supplementation should be taken at a different time of day, as calcium inhibits both heme and non-heme iron absorption. Moreover, the proper storage of supplements should be a main part of this education, as improper storage can lead to comprised pharmacokinetics of the tablets. More comprehensive education of the public through available channels is necessary to make people aware of the importance of anemia and the measures to prevent and control the condition. Subsequent field surveys in different areas of the country are recommended to achieve better public health control in the future. Moreover, the fact that the woman who bore a female fetus had a 3.75-times increased risk of being anemic during their third trimester of pregnancy emphasizes the importance of especially rigorous adherence to anemia prevention and control methods for women with female fetuses.

In addition to low hemoglobin concentration, several researchers[27] have found an association between high blood hemoglobin concentration and low mean birth weight. However, the available data in the current study were not sufficient to make a worthwhile conclusion regarding high hemoglobin concentration. Regardless, maintaining a healthy hemoglobin level during pregnancy can promote a favorable neonatal birth weight.

Limitation

Women who are anemic may have other factors in common in addition to their dietary iron intake and compliance with iron supplementation.

Conclusion

Maternal anemia is associated with neonatal birth weight. Our results indicated that only third-trimester maternal anemia and not first-trimester maternal anemia caused a low mean birth weight. No difference in maternal dietary intake was found between the third-trimester anemia and non-anemia groups for energy, carbohydrate, protein and iron. The high prevalence of third-trimester maternal anemia among Sri Lankan women cannot be explained solely by macro- and micronutrient deficiencies. Further large scale studies are recommended to identify the possible underlying causes of maternal anemia and measures of control in the Sri Lankan scenario.

Competing interests

The authors have no financial relationships and no potential conflicts of interest to disclose relevant to this article.

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Declaration of Conflicting interests

The authors declare no conflict of interest.

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