



# Effects of Food Supplementation During Pregnancy on Maternal Weight Gain, Hemoglobin Levels and Pregnancy Outcomes in Iran

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## Abstract

**Objectives** In this study, the effects of food supplementation during pregnancy on maternal weight gain, hemoglobin (Hb) levels, and pregnancy outcomes were evaluated. **Methods** In this randomized controlled trial, we recruited 1360 pregnant women with a gestational age of 10 weeks who had BMI < 18.5 and hemoglobin < 10.5/dL from rural areas of the east Azerbaijan province in Iran. Rural areas were randomly assigned into two groups: food-supplemented and control areas. In food-supplemented areas the food supplement was provided (1500 kcal/d) from 10 weeks of pregnancy through to the end. Information on demographic data were collected and anthropometric and Hb measurements were taken using standard instruments. **Results** The average weight gain was  $9.1 \pm 1.8$  kg and  $7.9 \pm 1.6$  kg in supplemented and control groups respectively, which was significantly different ( $p=0.001$ ). Also, a significant time  $\times$  treatment interaction in maternal average weight gain ( $p=0.001$ ) was observed. The mean Hb decreased from 12 mg/dl and 12.1 mg/dl in week 10 to 11.9 mg/dl and 11.7 mg/dl in week 20 in the supplemented and control groups respectively, which was significant only for the control group. Between-group comparisons revealed significant differences in the rates of low birth weight (LBW) infants ( $p=0.001$ ) and preterm births ( $p=0.013$ ). **Conclusion for practice** Food supplementation significantly reduced the prevalence of poor maternal weight gain, infants with low birth weight, and preterm births compared to no intervention.

**Keywords** Food supplementation · Pregnancy · Maternal weight gain · Hemoglobin · Low birth weight

## Significance

*What is already known on this subject?* The relationship between maternal nutrition status and fetal growth is complex and various types of interventions to improve maternal nutrition have yielded modest and conflicting results. No data from large-scale food intervention programs for pregnant women in Iran have been reported. *What this study adds?* In this pilot study, the effects of a food supplementation program during pregnancy on maternal weight gain,

hemoglobin levels, and pregnancy outcomes were evaluated in Iran.

## Introduction

Maternal diet during pregnancy is one of the most important factors associated with maternal weight gain during pregnancy and infants' birth weight (Liberato et al. 2013). Poor nutrition during pregnancy not only leads to high maternal morbidity and mortality, but also results in high perinatal, infant, and child mortality rates, intrauterine growth restriction, and subsequent LBW (Imdad and Bhutta 2011). Studies showed that a pre-pregnancy BMI of 20–25 and meeting guidelines for expected gestational weight gain both have positive effects on fetal growth (Carmichael and Abrams 1997; Kramer 1987). Recently, population-wide increases in gestational weight gain are probably responsible for the increase in mean birth weight and the modest decline in low-birth-weight rates (Kramer 1990).

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The relationship between maternal nutrition status and fetal growth is complex (Osrin and Anthony 2000) and various types of interventions to improve maternal nutrition have yielded modest and conflicting results (Huybregts et al. 2009; Kramer 1993). A metaanalysis showed only modest increases in maternal weight gain and fetal growth after food supplementation (Kramer 1993). However, other recent studies have shown benefits (Liberato et al. 2013; Ortolano et al. 2003). The results of a recent review showed that protein energy supplementation given to pregnant women with energy or protein deficits appears to improve fetal growth, increase birth weight and height, and decrease (by 6%) the percentage of infants with low birth weight (Liberato et al. 2013).

In developing countries, the primary role of low birth weight and prematurity in perinatal mortality and morbidity—and its association with maternal under-nutrition and malnutrition—has motivated policy makers to make various attempts to improve pregnancy outcomes through food supplementation (Karim et al. 2011). Given the global health impact of maternal malnutrition on maternal health and fetal development, the continuing high rates of LBW infants, particularly in Asia, and the absence of data from large-scale food intervention programs for pregnant women in Iran, this pilot study aimed to evaluate the effects of food supplementation during pregnancy on maternal weight gain, hemoglobin levels, and pregnancy outcomes.

## Methods

The research sample included all mothers in a defined population of ten rural areas who were admitted for pregnancy care in health houses. Health house, usually the only health facilities accessible to the rural population, are the most basic units of the Iranian PHC network. Tasks performed by health houses include record keeping and data collection; public health education and the promotion of community participation; antenatal, perinatal, and postnatal care; the care of children under five and of school-age children; family planning services; immunization; and disease control services. The geographical areas, which were included in this study, were chosen by geographical clustered sampling method and these regions were randomly assigned to be supplemented or control areas. Therefore, all women in the supplemented regions received food supplementation and no women in control regions got any supplementation. Every woman that met the study inclusion/exclusion criteria (660 subjects in the supplemented group and 700 subjects in the control group) was recruited and followed up to end of the study.

All procedures performed in this study were in accordance with the ethical standards of the Ethics Committee of

the Tabriz University of Medical Science (Ethics number: 1394.365) and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Also, the procedures were registered in the registration center for clinical trials in Iran (code: IRCT14688). A written informed consent was obtained from all individual participants included in the study.

The criteria for inclusion of mothers were as follows: the fetus was viable, the gestational age was 10 weeks confirmed by ultrasound examination, there was no severe illness, the pre pregnancy BMI was < 18.5 or the hemoglobin level was less than 10.5 g/dl, and consent was given to participate. In total, 1360 pregnant women were enrolled and completed the study between April 2014 and July 2014.

Food supplementation was supplied by an ongoing non-government-supported program (Bonyad Alavi), which provides energy-protein supplements to malnourished pregnant women in some rural villages through the primary health-care system. In this trial, the food supplement and nutrition education (pamphlets included dietary recommendations during pregnancy and nutritional recommendations by healthcare staff for pregnant mothers) was offered to eligible pregnant women in the intervention areas. In rural areas that were selected as control groups, nutritional education without food supplementation was provided in the health houses.

The food supplement was given every 2 months and contained 10 kg of rice, 1400 g of pasta, 5 kg of frozen chicken, 6 cans of tuna, 4 kg of lentils, 2 kg of soybeans, 2 kg packaged palm, 2 kg packaged cheese, 2.5 kg of oil, 1 kg of honey and 2 kg of sugar.

The supplement provided 1500 kcal/d from 10 weeks of pregnancy through to the end. The assumption is that the amount actually consumed by the women was significantly less than 1500 kcal/d due to food sharing with other family members in these poor households. Hence, the estimation is that the supplement provided nearly 300–500 kcal per day particularly for the women depending on their family size (mean family size = 4).

This food was distributed in homes every 2 months through home visits by the interviewers. In these monthly home visits, the interviewers asked a series of questions to assess compliance with food supplementation in the previous 60 days. All the mothers reported that they consumed the supplemented food in at least equal amounts as their other family members.

In all regions, maternal weight was measured in weeks 10, 20, 30, 34, 38, and in all of the visits nutrition education was given.

## Socioeconomic Measurements

All socioeconomic information was collected at the time of enrollment. This information included household structure

and family characteristics such as the age of the mother, parity, parental educations, and employment.

### Anthropometric Outcomes

Anthropometry at birth was part of the primary outcome of this trial. In both groups, birth anthropometry was performed within 12 h after birth. All birth weights were measured by SECA electronic or beam scales (SECA GmbH & Co, Hamburg, Germany) to a precision of 10 g. Maternal weight and height were measured upon enrollment at the tenth week of gestation. Maternal weight was measured by electronic scales (Uniscale, UNICEF, Copenhagen), with a precision of 100 g, and height was measured to the nearest 0.1 cm with a stadiometer. Weight gain status during pregnancy was estimated based on IOM (Institute of Medicine) in the present study (Institute of Medicine 1990). The recommended weight gain was also calculated based on the BMI before the period of pregnancy. These recommendations are for BMI < 19.8 kg/m<sup>2</sup> total weight gain between 12.5 and 18 kg; for BMI = 19.8–26.0 kg/m<sup>2</sup> total weight gain between 11.5 and 16 kg; for BMI > 26.0–29.0 kg/m<sup>2</sup> total weight gain between 7.0 and 11.5 kg, and for BMI > 29.0 kg/m<sup>2</sup> total weight gain of 7.0 kg. The babies weighing less than 2500, between 2500 and 4000 and more than 4000 g are generally considered, in turn, as LBW, normal, and macrosomia, according to the IOM (Institute of Medicine 1990).

### Hb Measurements

Two Hb measurements were performed for routine antenatal care. The first sample was collected at 10 weeks of gestation (early Hb) and the second at 20 weeks of gestation. Hb levels were measured with a calibrated laboratory machine (ADVIA 2120 hematology system, SIEMENS health care) immediately after blood sample collection. A venous sample was used for the blood analyses. These samples were taken and analyzed in health houses. Anemia was defined as Hb < 10.5 g/dL, according to the World Health Organization definition (Stoltzfus 2001).

### Statistical Analysis

SPSS v18 statistical computer software was used for all statistical analyses. Means and standard deviations (SD) were calculated for continuous variables, and proportions were calculated for categorical variables. Between-group comparisons were made by independent *t* test and Chi square test. The differences between variables before and after intervention were compared by paired *t* test, McNemar and Friedman tests. Repeated measures ANOVA, with group as a factor, was performed to assess the change over time in the mean maternal weight gain between the two groups.

Repeated measures ANOVA was then used to assess for significant differences between various time points in the subjects of both groups independently. Greenhouse-Geisser epsilon values were used in all analyses. The main effect of treatment was compared by using Bonferroni's procedure for CI adjustment. A significance level of 0.05 was used.

### Results

As presented in Table 1, at the baseline, the two groups were similar with respect to maternal age, family size, amount of parity and education, and pre-pregnancy BMI ( $p > 0.05$ ).

Table 2 shows the comparison of maternal weight gain and anemia status before and after intervention in the food-supplemented and control groups. Average of weight gain was  $9.1 \pm 1.8$  kg and  $7.9 \pm 1.6$  kg in supplemented and control groups respectively, which was significantly different ( $p = 0.001$ ). None of the women gained more weight than the recommended values based on their BMI before pregnancy during this period. A significant time trend was observed in maternal weight gain in the supplemented ( $p = 0.001$ ) and control ( $p = 0.04$ ) groups. Also, a significant time  $\times$  treatment interaction in maternal average weight gain ( $p = 0.001$ ) was observed. On the other hand, the rate of poor maternal weight gain decreased significantly during the study in both groups; however, between group comparisons showed that in the supplemented group, the poor maternal weight gain rate in weeks 30, 34 and 38 was significantly less than that in the control group in similar weeks ( $p = 0.001$ ).

The mean Hb decreased from 12 and 12.1 mg/dl in week 10 at enrollment to 11.9 and 11.7 mg/dl in week 20 in the supplemented and control groups respectively, which was significant only for the control group. Nineteen percent and 23.5% percent of participants were anemic at early pregnancy in the supplemented and control groups respectively. These values increased to 25% and 32.5% in mid-pregnancy, which was significant in the control group.

Figure 1 depicts the comparison of pregnancy outcomes in the food-supplemented and control groups. The rates of low birth weight, spontaneous abortion (non-induced embryonic or fetal death or passage of products of conception before 20 week gestation), and preterm births (birth that happens before 37 weeks gestational age) were 12%, 0.3%, and 2.1% in the supplemented group and 40%, 0.6%, and 6.3% in the control group. Between-group comparisons revealed significant differences in the rate of low birth weight infants ( $p = 0.001$ ) and preterm births ( $p = 0.013$ ). In addition, the mean birth weight was significantly ( $p = 0.01$ ) higher in the supplemented group ( $3141 \pm 462$  g) compared to the control group ( $2954 \pm 440$  g).

Odds ratios for maternal poor weight gain and anemia, LBW, and preterm births for demographic, socio-economic,

**Table 1** Comparison of baseline characteristics in the food supplemented and control groups

Variables	Supplemented group (n=660)	Control group (n=700)	p Value
Maternal age, year (mean±SD)	24.7±5.5	25.8±5.9	0.09*
Family size (%)			
< 3	61	58	
3–5	35	38.5	0.43 <sup>a</sup>
> 5	4	3.5	
Number of parity (%)			
1	41.4	37.8	0.26 <sup>a</sup>
2	42.3	44.8	
> 2	16.3	17.4	
Infants' sex, boy/girl (%)	56/44	55/45	0.90 <sup>a</sup>
Undergraduate/graduate (%)	98.7/1.3	98.4/1.6	0.65 <sup>a</sup>
Pre-pregnancy BMI, kg/m <sup>2</sup> (mean ± SD)	18.33±2.75	18.47±2.80	0.77*
Pre-pregnancy underweight (%)	78.2	75.9	0.83 <sup>a</sup>
Birth weight, g (mean ± SD)	3141±462	2954±440	0.01*

\*Independent *t* test<sup>a</sup>Chi-square test

and health indices were presented in Table 3. The results of logistic regression analysis, controlled to confounders (all variables in the table), showed that the risk of poor weight gain and preterm births was higher in anemic women and lower in food-supplemented women. The risk of maternal anemia was increased with maternal poor weight gain and decreased with maternal food supplementation. In addition, food supplementation was associated with a lower risk of preterm births. Maternal age, educational status, family size, parity, and pre-pregnancy weight were not associated with any of the dependent factors.

## Discussion

In this randomized controlled trial, the effects of food supplementation during pregnancy on maternal weight gain, hemoglobin levels, and pregnancy outcomes was investigated. The results of this study showed that food supplementation significantly reduced the prevalence of maternal poor weight gain, low birth weight, and preterm births. Once compared with the control group, food supplementation prevents significant increases in the rate of anemic women. In this group of rural women, irrespective of supplementation status, the total weight gain was 8.5 kg, which was higher than the 4.8 kg weight gain reported in Bangladesh, 7.6 kg in Taiwan, 6.5 kg in India, and 6.0 kg in East Java (Nahar et al. 2009). This discrepancy between studies may be due to partner/family and social support, socioeconomic status, ethnic group to which the mother belongs, and the geographical area (Rasmussen and Yaktine 2009).

The results of our study showed that food supplementation significantly reduced the prevalence of maternal poor weight gain, even after adjusting for confounders. This result was similar to the results of a study in Bangladesh (Ortolano et al. 2003), which found that the absolute weight gain and monthly weight gain were higher in supplemented than in non-supplemented women (7.5 kg vs. 6.3 kg). Conversely, in another study, Nahar et al. (2009) reported a small impact of food supplementation on maternal weight gain. These differences may be explained by the time supplementation starts, the compliance to supplements, regular monitoring and supervision, and the energy content of the supplements.

Derived from our results, supplementary foods, when given during pregnancy, did not decrease the rate of maternal anemia. However, the results of logistic regression showed that the risk of maternal anemia was decreased with food supplementation. In Tanzania, anemia prevalence was reduced by approximately one-third in fortified beverage studies (Makola et al. 2003), and hemoglobin concentration increased by 4–7 g L<sup>-1</sup> in an earlier fortified milk powder study in Chile (Mardones et al. 2008). It seems that micro-nutrient-fortified products had greater benefits for reducing anemia in pregnant women. Based on these results, it was concluded that products to be consumed during pregnancy should be formulated to improve either maternal micronutrient status or birth outcomes.

In the present study, the effects on birth weight were closely similar to those observed in Gambia, where a complex and expensive supplement was provided under tightly controlled conditions (Ceasay et al. 1997). Most of the studies examining balanced protein energy supplementation showed improved birth weight of infants (Ceasay et al. 1997;

**Table 2** Comparison of maternal weight gain and anemia status before and after intervention in the food supplemented and control groups

Variables	Supplemented group (n = 660)					Control group (n = 700)					p Value
	Week 10	Week 20	Week 30	Week 34	Week 38	Week 10	Week 20	Week 30	Week 34	Week 38	
Mean average weight gain	–	1.4 ± 1.1	2.5 ± 2.6	2.3 ± 1.7	3.0 ± 2.3	–	1.2 ± 1.1	2.1 ± 1.9	2.1 ± 1.5	2.5 ± 1.9	0.04*
Poor weight gain (%)	70.6	53.3	26.4	29.8	27.7	69.8	51.2	42.8	42	56.3	0.001 <sup>a</sup>
Anemia (< 10.5 g/dL)	19	25				23.8	32.5				0.01 <sup>b</sup>

\*Repeated measures ANOVA

<sup>a</sup>Friedman test<sup>b</sup>McNemar test**Fig. 1** Comparison of pregnancy outcomes before and after intervention in the food supplemented and control groups. \*Chi-square test, between group comparison ( $p=0.013$ ), <sup>¥</sup>Chi-square test, between group comparison ( $p=0.001$ )

Huybregts et al. 2009). The results of this study showed that food supplementation increased mean birth weight by approximately 180 gr, which was higher than the previous reports. Yang and Huffman (2011) found that supplementary foods during pregnancy increased mean birth weight by around 60–73 g. In another report, a supplement led to an increase in mean birth weight of 115–330 g (Huybregts et al. 2009). The differences may be explained by the energy and protein content of the supplements, maternal weight gain, and nutritional status (Gaemmaghami et al. 2013). Higher proportions of low-birth-weight infants have been observed among short, malnourished, and anemic women (Antonio et al. 2009; Gebremariam 2005; Mahajan et al. 2004). When the women are both anemic and malnourished, their babies' birth weight are even less (Mahajan et al. 2004). It seems that in this study, anemic and malnourished women in the supplemented group got enough benefit from food supplementation to subsequently have positive effects on the prevalence of low birth weight infants and preterm births.

The following limitations should be considered when interpreting the results of the present study: in this study, potential confounders such as food security, economic status, health status/inflammation, and other variables that could be important to the outcomes were not included in the model. Dietary record did not collected and the amount of energy intake from supplements was assumed based on family size and women's statements.

## Conclusion

This pilot study shows that a simple dietary supplementation program through a primary healthcare system in rural villages can reduce the prevalence of maternal poor weight

**Table 3** Logistic regression analysis for the association of maternal poor weight gain, maternal anemia, LBW and preterm births, and demographic, socio-economic and health indices

Variables	Maternal poor weight gain Adjusted OR (95% CI)	Maternal anemia Adjusted OR (95% CI)	LBW births Adjusted OR (95% CI)	Preterm births Adjusted OR (95% CI)
<b>Age groups</b>				
<20	1.00	1.00	1.00	1.00
20–30	0.99 (0.40, 2.41)	1.04 (0.69, 1.57)	1.67 (0.45, 6.21)	0.96 (0.78, 1.82)
>30	1.13 (0.59, 2.16)	0.87 (0.48, 1.58)	1.99 (0.37, 10.66)	0.84 (0.51, 1.87)
<b>Family size</b>				
<4	1.00	1.00	1.00	1.00
>4	2.17 (0.73, 6.40)	1.57 (0.69, 3.57)	1.36 (0.67, 3.97)	1.22 (0.79, 2.39)
<b>Education</b>				
Under graduate	1.00	1.00	1.00	1.00
College	0.56 (0.39, 1.30)	0.74 (0.36, 1.80)	0.85 (0.51, 2.14)	0.67 (0.26, 1.59)
<b>Number of parity</b>				
<2	1.00	1.00	1.00	1.00
>2	2.35 (0.88, 5.89)	1.10 (0.60, 1.98)	1.26 (0.26, 6.05)	1.29 (0.85, 1.94)
<b>Prepregnacy BMI</b>				
Underweight	1.00	1.00	1.00	1.00
Normal	1.19 (0.60, 2.33)	0.34 (0.20, 0.57)	0.76 (0.24, 2.38)	0.73 (0.26, 1.86)
Over weight	0.81 (0.35, 1.83)	0.40 (0.22, 0.73)	0.63 (0.15, 2.65)	0.58 (0.11, 3.90)
<b>Maternal weight gain</b>				
Normal	–	1.00	1.00	1.00
Poor	–	1.67 (1.06, 2.85)*	1.11 (0.68, 2.99)	1.96 (0.10, 36.3)
<b>Anemia</b>				
Normal	1.00	–	1.00	1.00
Anemic	1.68 (1.14, 2.88)*	–	1.37 (0.85, 3.15)	1.48 (1.02, 3.67)*
<b>Food supplemented</b>				
No	1.00	1.00	1.00	1.00
Yes	0.27 (0.18, 0.41)***	0.54 (0.31, 0.93)*	0.59 (0.12, 3.45)**	0.19 (0.08, 0.83)**

\* $p < 0.05$ , \*\* $p < 0.01$ , \*\*\* $p < 0.001$ , Multiple logistic regressions considering the simultaneous effect of all the explanatory variables

gain, low birth weight, and preterm births when targeted at a population in whom real evidence of nutritional deprivation during pregnancy exists. Despite the limitations of this study, public health policy-makers can translate the results into decisions, as it seems that in poor households, irrespective to the total amount of energy received, mothers and infants could benefit from food supplementation. Long-term follow-up is required to determine whether any of the observed benefits have functional importance, especially regarding their effects on child development.

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