Public Health Nutrition: 12(8), 1205–1212 doi:10.1017/S1368980008003765

Impact of targeted food supplementation on pregnancy weight gain and birth weight in rural Bangladesh: an assessment of the Bangladesh Integrated Nutrition Program (BINP)

Shamsun Nahar†, CG Nicholas Mascie-Taylor* and Housne Ara Begum‡
Department of Biological Anthropology, University of Cambridge, Pembroke Street, Cambridge CB2 3RA, UK

Submitted 29 May 2007: Accepted 18 August 2008: First published online 7 October 2008

Abstract

Objectives: To assess whether the Bangladesh Integrated Nutrition Programme (BINP) correctly identified which pregnant women should be enrolled in the food supplementation programme, whether supplementation commenced on time and was taken on a regular basis. A second objective was to determine whether food supplementation led to enhanced pregnancy weight gain and reduction in the prevalence of low birth weight.
Design: A one-year community-based longitudinal study.
Setting: A rural union of Bhaluka Upazila, Mymensingh, located 110 km north-west of Dhaka City, the capital of Bangladesh.
Participants: A total of 1104 normotensive, non-smoking pregnant women who attended Community Nutrition Centres were studied from first presentation at the centre until child delivery.
Results: Pregnant women who had a BMI of $<18{\cdot}5\,kg/m^2$ on first presentation should have been selected for supplementary feeding (2512 kJ (600 kcal)/d for six days per week) starting at month 4 (16 weeks) of pregnancy. However, of the 526 women who had $BMI < 18{\cdot}5\,kg/m^2$, only 335 received supplementation; so the failure rate was 36·3 %. In addition, of those receiving supplementation, only 193 women (36·7 % of 526 women) commenced supplementation at the correct time, of whom thirty-two (9·6 % of 335 women) received supplementation for the correct number of days (100 % days). There were no significant differences in mean weight gain between $BMI < 18{\cdot}5\,kg/m^2$ supplemented or non-supplemented groups or between the equivalent groups with $BMI \geq 18{\cdot}5\,kg/m^2$. Weight gain was inversely related to initial weight, so lighter women gained relatively more weight during their pregnancy than heavier women. The mean birth weight in the supplemented and non-supplemented groups was 2·63 kg and 2·72 kg, respectively. Mothers with $BMI < 18{\cdot}5\,kg/m^2$ who were or were not supplemented had almost equal percentages of low-birth-weight babies (21 % and 22 %, respectively).
Conclusion: The study raises doubt about the efficiency of the BINP to correctly target food supplementation to pregnant women. It also shows that food supplementation does not lead to enhanced pregnancy weight gain nor does it provide any evidence of a reduction in prevalence of low birth weight.

Keywords
Pregnancy weight gain
Food supplementation
Low birth weight

Intra-uterine growth and development is one of the most vulnerable periods in the human life cycle. The weight of an infant at birth is an important indicator of maternal health and nutrition prior to, and during, pregnancy, and a powerful predictor of infant growth and survival(1). Approximately 25 million babies are born each year weighing less than 2500 g, the WHO cut-off for low birth weight (LBW), of which 90 % are born in developing countries(2). Bangladesh is one such country, where 50 % of childbearing women are suffering from malnutrition defined by $BMI < 18{\cdot}5\,kg/m^2$ and more than 20 % are severely stunted(3). Bangladesh has the highest world-wide prevalence of LBW with rates estimated at between 20 % and 60 %(4,5).

The high prevalence of LBW in Bangladesh has enormous implications for its future population. The World Bank estimates that the rate of 40 % LBW and the corresponding

† Current address: National Institute of Preventive and Social Medicine, Dhaka, Bangladesh.

‡ Current address: Institute of Health Economics, University of Dhaka, Dhaka, Bangladesh.

*Corresponding author: Email nmt1@cam.ac.uk

level of stunting alone will cost Bangladesh $US 10 billion in lost productivity over a 10-year period[6]. The Government of Bangladesh, with financial support from The World Bank, initiated a supplementation programme known as the Bangladesh Integrated Nutrition Programme (BINP) in 1995 with the aim of increasing weight gain in pregnancy up to 7 kg in 50 % of pregnant women and reducing LBW by half from its then-current rate.

The BINP was implemented in forty out of a total of 460 thanas (administrative areas) in the country. The aim of the programme was to reduce malnutrition, particularly among women and children, by ensuring household food security and through behavioural changes related to food intake, infant feeding, growth monitoring and caring practice. All children below 2 years of age were targeted for monthly growth monitoring and for determination of nutritional status. Pregnant women were also identified primarily within the first trimester for regular monthly weighing. All severely malnourished children or growth-faltering children as well as malnourished pregnant mothers (defined by BMI $< 18\cdot5$ kg/m^2) received daily supplementary feeding for six days per week. The malnourished pregnant women received a ration of 2512 kJ (600 kcal)/d for six days per week for up to 6 months during pregnancy and weekly Fe supplementation and vitamin A within 14 d of delivery[7]. The services were provided through Community Nutrition Centres (CNC) located in villages.

The BINP Mid Term Evaluation[8] reported that, since its inception, the programme has had notable success in reducing the prevalence of malnutrition among young children. Its effect on pregnant women, a second key target group, has however been less clear to date. The present study was designed to evaluate two main aspects of the BINP: (i) the efficiency of the BINP in identifying which women should be supplemented, whether supplementation commenced on time and whether mothers were compliant; and (ii) whether supplementation led to greater maternal weight gain and fetal weight gain, thereby reducing LBW prevalence.

Participants and methods

A one-year, longitudinal, rural community-based study was conducted on all pregnant women who registered between their second and sixth month of gestation as part of the routine BINP assessment. The data were collected from a rural union of Bhaluka Thana, Mymensingh, located 110 km north-west of Dhaka City, the capital of Bangladesh. A total of 1104 pregnant women were studied from first presentation until child delivery. At first registration women were weighed and had their height measured. Thereafter weight was measured at approximately monthly intervals until delivery.

Pregnant women who have BMI $< 18\cdot5$ kg/m^2 on first presentation should receive supplementary feeding starting at 4 months (16 weeks). Women who register later in pregnancy with BMI $< 18\cdot5$ kg/m^2 should start supplementation immediately. The 2512 kJ (600 kcal)/d food supplement consisted primarily of a cereal–pulse mixture containing raw sugar (jaggery) and oil, which comprises 80 % carbohydrate, 12 % protein and 8 % fat. The food was prepared at the village level. Pregnant mothers had to consume the supplement at a local CNC.

All anthropometric measurements were carried out using standard methodology as described by Lohman *et al.*[9]. The measurements were made with the subjects wearing a minimum amount of clothing. Height was measured by using a locally made stadiometer. The woman was asked to maintain an upright and erect posture with her feet together and the back of her heels touching the pole of the anthropometer. The horizontal headpiece was lowered onto the woman's head (maintained in the Frankfurt plane) and the measurement was taken to the nearest 0·1 cm. The UNICEF UNI-Scale was used to measure the weight of the pregnant women and newborn babies. Newborn babies were weighed within 24 h of delivery at the birth place. The weighing machine was calibrated with known weights up to 70 kg at the beginning of each weighing session. The women's BMI was calculated using the formula: weight (kg)/[height (m)]^2.

The inter-observer error for height and weight were computed at four different times during the study: before starting the study, at months 5 and 9, and at the end of the study. Ten subjects were used each time and the technical error of measurement (TEM) and reliability were determined. The TEM was obtained by measuring the same subject by each research assistant. Reliabilities for all measurements were all above 0·98 and higher than the 0·95 threshold given by Ulijaszek and Kerr[10]. Thus the TEM was acceptable and was not incorporated in the statistical analysis.

One of the problems with longitudinal data is that, in order to examine incremental weight changes over time, the numbers of days between visits need to be very similar. Although this is potentially achievable in strictly research projects, in operational programmes this is much less likely to occur. Brush *et al.*[11] overcame the monthly variation in days between measurements by computing the curvilinear relationship between the anthropometric variable, e.g. weight, and the actual days between measurements. As the polynomial fits (adjusted R^2) were very good, they calculated the weight at fixed intervals. The same procedure was used here because the 'monthly' variation between measurements was between 22 and 35 d. Consequently an individual polynomial regression curve was computed for each woman, and like Brush *et al.* we found that the fit was very good, with adjusted R^2 ranging from over 95 % to nearly 100 %. As a result, the predicted weight at 28 d intervals was computed and these predicted weights were used in all subsequent analyses.

Gestational age was assessed by the Parkin method[12], which scores four external characteristics: skin colour, skin texture, ear firmness and breast development. The scheme is simple, easy to use, less time-consuming and appropriate for field workers.

A power test showed that these sample sizes were sufficient to detect about a 10 % difference in the percentage of supplemented and non-supplemented women gaining >1 kg per month during pregnancy or gaining >7 kg at the end of pregnancy. A variety of statistical tests was used, including univariate ANOVA and repeated-measures ANOVA.

Results

BINP programmatic issues

Four indicators were used to measure the efficacy of the BINP supplementation programme: (i) receiving supplementation if BMI < 18·5 kg/m^2; (ii) commencing supplementation at the correct time; (iii) receiving daily supplementation six days a week until the birth of the child; and (iv) achieving targeted weight gain set by BINP of >1 kg per month or >7 kg at the end of pregnancy.

As the women registered in different months the amount of time they received supplementation varied. In order to make comparisons, the extent of supplementation was computed (the number of days a women received supplementation/the total number of possible days of supplementation). The mean percentage compliance was 91·0 (SD 9·9) % (range 54–100 %).

Table 1 presents a breakdown of supplementation status by BMI cut-off. As can be seen, of the 526 women with BMI < 18·5 kg/m^2 only 63·7 % were supplemented while 4 % of women with BMI ≥ 18·5 kg/m^2 were incorrectly supplemented. Even so, of the 63·7 % who received supplementation, only 193 (36·7 % of 526 women) commenced supplementation at the correct time, of whom thirty-two women (9·6 % of 335 women) received the full supplementation. Women with BMI < 18·5 kg/m^2 who registered in months 3 and 4 were more likely to receive supplementation than those registering later.

Sociodemographic and nutritional status of the pregnant women at registration and outcome of pregnancy

The primarily Muslim pregnant women and their families living in this rural area of Bangladesh were mainly poor with three-quarters of families spending £10–20/month, mostly on food. About 20–25 % of husbands and wives had received no education and the majority of husbands were working as either day labourers or farmers. Most of the pregnant mothers were between 20 and 34 years of age. Over one-third of the women were nulliparous while 12·8 % were multiparous (≥4 births). Most (93 %) mothers registered between the third and fifth month of pregnancy and only 7 % registered in the sixth month. The average birth interval, based on the last child, was about 2·5 years. About 47 % of women had BMI < 18·5 kg/m^2 on first registration, of whom 6 % were in the chronic energy deficiency group (CED) III (BMI < 16·0 kg/m^2), 11 % in CED II (BMI = 16·0–16·9 kg/m^2) and 30 % in CED I (BMI = 17·0–18·5 kg/m^2). There were no significant associations between BMI status and any of these sociodemographic variables. Women with BMI < 18·5 kg/m^2 had significantly (P < 0·001) lower mean weight (on average 6·8 kg), but their height was just significantly greater (+1·1 cm) than that of women with BMI ≥ 18·5 kg/m^2. There was no significant difference between the supplemented and non-supplemented groups with BMI < 18·5 kg/m^2 in initial weight or stature nor was there any difference between the two groups in weight gain during pregnancy or birth outcome.

About 97 % of the 1104 deliveries occurred at home, of which 95 % were live born, 3·3 % stillborn and 1·5 % were perinatal deaths. Of the newborn babies 50·6 % were male. No significant association was found between any of the sociodemographic variables and birth outcome and supplementation status.

Weight gain during pregnancy by BMI and supplementation status groups

The existence of the four groups of women (see Table 1) allowed more detailed comparisons between women with BMI < 18·5 kg/m^2 and either correctly supplemented (<18·5 sf) or incorrectly not supplemented (<18·5 nsf), as well as between women with BMI ≥ 18·5 kg/m^2 correctly not supplemented (≥18·5 nsf) and those incorrectly supplemented (≥18·5 sf). Table 2 presents the overall mean weight gain of these four groups by month of registration. As expected, the weight gain declined with later registration month and was consistent across all four BMI/supplementation status groups. ANOVA revealed that only for mothers who registered in month 3 were there significant differences between the four means, with women with BMI < 18·5 kg/m^2 showing higher mean

Table 1 BMI cut-offs and supplementation status: rural, non-smoking, pregnant women enrolled in the Bangladesh Integrated Nutrition Programme, studied from first presentation at the community nutrition centre until child delivery

	BMI < 18·5 kg/m^2		BMI ≥ 18·5 kg/m^2		Total	
Supplementation status	*n*	%	*n*	%	*n*	%
Yes	335	30·3	23	2·1	358	32·4
No	191	17·3	555	50·3	746	67·6
Total	526	47·6	578	52·4	1104	100·0

Table 2 Total (absolute) weight gain (kg) by registration month according to BMI and supplementation status group: rural, non-smoking, pregnant women enrolled in the Bangladesh Integrated Nutrition Programme, studied from first presentation at the community nutrition centre until child delivery

	BMI (kg/m^2) and supplementation status group									
	<18·5 sf		<18·5 nsf		≥18·5 nsf		≥18·5 sf			
Registration month	Mean	SD	Mean	SD	Mean	SD	Mean	SD	*F*	*P*
3	6·71	1·6	6·41	1·6	6·10	1·7	6·04	2·1	4·60	0·003
4	5·90	1·9	5·86	1·8	5·41	1·9	5·97	1·7	1·77	NS
5	4·58	1·6	4·83	1·5	4·68	1·5	4·95	1·4	1·97	NS
6	2·80	1·3	3·45	1·0	3·42	1·6	–	–	1·06	NS

sf, supplemented; nsf, non-supplemented.

Table 3 Pregnancy weight gain in relation to the programmatic targets (% of women achieving the target) by BMI and supplementation status group: rural, non-smoking, pregnant women enrolled in the Bangladesh Integrated Nutrition Programme, studied from first presentation at the community nutrition centre until child delivery

BMI (kg/m^2) and supplementation status group	Total weight gain >7 kg	Weight gain >1 kg/month
<18·5 sf	35	45
<18·5 nsf	28	39
≥18·5 nsf	21	33
≥18·5 sf	18	45

sf, supplemented; nsf, non-supplemented.

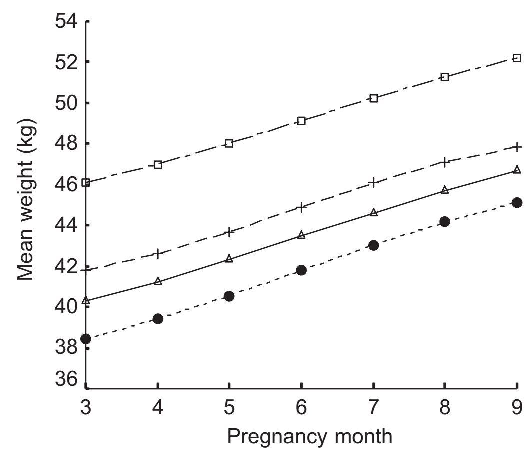

Fig. 1 Monthly weight according to BMI (kg/m^2) and supplementation status group (- - ●- -, <18·5 supplemented (sf); —△—, <18·5 non-supplemented (nsf); — -□— -, ≥18·5 nsf; – –+– –, ≥18·5 sf) in month 3: rural, non-smoking, pregnant women enrolled in the Bangladesh Integrated Nutrition Programme, studied from first presentation at the community nutrition centre until child delivery

weight gains than women with BMI ≥ 18·5 kg/m^2 whether supplemented or not. *Post hoc* tests showed that the overall difference in means was mainly accounted for by the greater weight gain of women in the BMI < 18·5 kg/m^2 and supplemented group compared with women in the BMI ≥ 18.5 kg/m^2 and non-supplemented group ($P = 0·002$). There were no significant differences in mean weight gain between supplemented and non-supplemented women with BMI < 18·5 kg/m^2 or between the equivalent groups with BMI ≥ 18·5 kg/m^2. After correction for initial weight, the difference in weight gain between BMI < 18·5 kg/m^2 supplemented and BMI ≥ 18·5 kg/m^2 non-supplemented groups fell further to only 100 g and was not significant.

The BINP sets weight gain targets of >1 kg per month and overall weight gain of >7 kg at the end of pregnancy in 50 % of pregnant women. However, as Table 3 shows, these women failed to meet these targets especially for >7 kg weight gain in pregnancy.

Repeated-measures ANOVA were used to examine the change in monthly weights of the four BMI/supplementation status groups and, as can be seen from Fig. 1, the mean weights of the four groups tracked each other and were more or less parallel. Thus there was no evidence of any significant catch-up or catch-down, which indicates that the food supplement was not impacting on pregnancy weight gain.

The relationship between initial weight and weight gain was examined for each registration month separately and negative regression coefficients were found in all analyses, i.e. women who had a higher initial weight tended to show a lower weight gain. The magnitude of the coefficients declined from registration months 3 to 6 as would be expected (−0·41, −0·38, −0·22 and −0·18, respectively). There were no significant differences in regression coefficients between supplemented and non-supplemented women at each registration month.

Birth weight and relationship with sociodemographic variables and supplementation status of the mother

The overall mean birth weight of both boys and girls was 2·69 kg (SD 0·36 kg and 0·37 kg, respectively). Analysis of the birth weight of the newborn babies using the four BMI/supplementation status groups revealed significant heterogeneity in mean birth weights between them ($P < 0·001$). One-way ANOVA showed that the overall difference in means was mainly accounted for by the lower birth weight of the babies whose mothers were in the BMI < 18·5 kg/m^2 groups irrespective of supplementation status (Table 4).

However, there was no significant difference in mean birth weights of babies born to mothers with BMI $< 18\cdot5\,kg/m^2$ whether supplemented or non-supplemented, or between the means of the equivalent BMI $\geq 18\cdot5\,kg/m^2$ supplemented and non-supplemented groups.

The pattern of birth weight in the four BMI/supplementation status groups was consistent (insignificant interaction between sex of the baby and BMI groups, $P = 0\cdot43$). When the analyses were repeated for each sex separately, the significant heterogeneity remained, more so in females than males. In both sexes the main difference was the higher mean in mothers with BMI $\geq 18\cdot5\,kg/m^2$ *v.* those with BMI $< 18\cdot5\,kg/m^2$.

Low birth weight, supplementation status and sociodemographic variables

Overall 17 % of babies were born with LBW (defined by WHO as <2·5 kg), and there were almost equal numbers of LBW male and female (17·0 % *v.* 16·3 %) babies. Gestational age calculated using the Parkin score revealed that 96·4 % were born after 37 weeks of gestation, and so intra-uterine growth retardation appears to be the major contributor to LBW. No significant association was found between LBW and any of the sociodemographic variables. Women who had BMI $< 18\cdot5\,kg/m^2$, irrespective of supplementation status, had a significantly higher rate of LBW babies than women who had BMI $\geq 18\cdot5\,kg/m^2$ and were not supplemented (Table 5, $P < 0\cdot001$). A sequential logistic regression analysis which adjusted for the effect of BMI (<18·5 and ≥18·5 kg/m²) first of all, and then tested for the effect of supplementation status, confirmed the insignificant effect of food supplementation on birth weight.

In addition, malnourished women gained significantly more weight during pregnancy (6·3 kg, 6·2 kg and 5·9 kg, CED grades III, II and I respectively; Table 6) than non-malnourished women (5·4 kg). When the birth weight and proportion of LBW in these groups were compared, malnourished women in all three CED categories had a lower mean birth weight and a higher proportion of LBW babies than non-malnourished women.

Table 4 Birth weight (kg) by sex of the newborn according to BMI and supplementation status group: rural, non-smoking, pregnant women enrolled in the Bangladesh Integrated Nutrition Programme, studied from first presentation at the community nutrition centre until child delivery

	BMI (kg/m²) and supplementation status group													
	<18·5 sf			<18·5 nsf			≥18·5 nsf			≥18·5 sf				
Sex	*n*	Mean	SD	*n*	Mean	SD	*n*	Mean	SD	*n*	Mean	SD	*F*	*P*
Male	174	2·65	0·37	90	2·62	0·37	274	2·74	0·35	11	2·73	0·36	3·65	0·012
Female	136	2·60	0·40	91	2·64	0·35	239	2·77	0·33	12	2·70	0·36	7·33	<0·001
Total	310	2·62	0·37	181	2·63	0·36	513	2·75	0·34	23	2·71	0·35	10·76	<0·001

sf, supplemented; nsf, non-supplemented.

Table 5 Birth weight by BMI and supplementation status group: rural, non-smoking, pregnant women enrolled in the Bangladesh Integrated Nutrition Programme, studied from first presentation at the community nutrition centre until child delivery

BMI (kg/m²) and supplementation status group	Low birth weight		Normal birth weight			
	n	%	*n*	%	χ^2	*P*
<18·5 sf	65	21·0	245	79·0	15·76	<0·001
<18·5 nsf	40	22·1	141	77·9		
≥18·5 nsf	62	12·1	451	87·9		
≥18·5 sf	4	18·2	18	81·8		

sf, supplemented; nsf, non-supplemented.

Table 6 Weight gain, birth weight and percentage of low birth weight (LBW) by level of chronic energy deficiency (CED): rural, non-smoking, pregnant women enrolled in the Bangladesh Integrated Nutrition Programme, studied from first presentation at the community nutrition centre until child delivery

		Weight gain (kg)		Birth weight (kg)		
	n	Mean	SD	Mean	SD	LBW (%)
CED III (BMI < 16·0 kg/m²)	59	6·30	1·80	2·53	0·36	28·8
CED II (BMI = 16·0–16·9 kg/m²)	119	6·21	1·89	2·61	0·42	19·8
CED I (BMI = 17·0–18·4 kg/m²)	313	5·91	1·89	2·65	0·36	20·2
Normal (BMI ≥ 18·5 kg/m²)	535	5·38	1·95	2·75	0·34	12·3

Discussion

The present study, in keeping with a recent World Bank report[13], highlights serious deficiencies in the implementation of the BINP in this rural area with over 40 % of women either not receiving supplementation or receiving it incorrectly. In addition, of those receiving food supplementation, nearly half started late and only about one in ten women received the full supplementation. In the BINP Monthly Monitoring Report[14] (June 2000), the seven non-governmental organizations working for the BINP had examined 107 845 pregnant women of whom 53 922 had BMI $<$ 18·5 kg/m^2. If the results of the present study are extrapolated to the whole BINP, then over 50 000 women would either not have been supplemented or, if so, would not start supplementation on time or would not receive the full supplementation.

In this group of rural women, irrespective of supplementation status, the total weight gain was 5·6 kg, which is higher than the 4·8 kg weight gain recorded by Krasovec[15] for Bangladeshi rural women but lower than values reported in other south Asian countries (Taiwan, 7·6 kg; India, 6·5 kg; East Java, 6·0 kg).

A recent study in Bangladesh[16] using monitoring data from the BINP found that the absolute (total) weight gain and monthly weight gain were higher in supplemented (BMI $<$ 18·5 kg/m^2) than non-supplemented women (7·5 kg *v.* 6·3 kg and 1·4 kg *v.* 1·3 kg, respectively). However, the weight gains and the monthly weight gains in the present study were lower than those observed by Ortolano *et al.*[16]. This may be because the latter study[16] did not take into account when mothers first registered at the CNC and so its two groups are not strictly comparable. More crucially, as noted by Kramer[17], the comparison of these two groups does not indicate success of the programme since Ortolano *et al.*'s study did not control for women with BMI $<$ 18·5 kg/m^2 and not supplemented or women with BMI $\geq$ 18·5 kg/m^2 and supplemented. As the present study has demonstrated, comparison of all four groups of women was able to show that women with BMI $<$ 18·5 kg/m^2 whether supplemented or not gained more weight than women with BMI $\geq$ 18·5 kg/m^2.

The targets set by the BINP of a weight gain $>$1 kg per month and $>$7 kg at the end of pregnancy in 50 % of women were also used by Ortolano *et al.*[16] to monitor the success of the BINP. They reported that, overall, 74·9 % of women in the supplemented group gained $>$1 kg per month and 61·8 % of the women in the non-supplemented group gained $>$1 kg per month. They also reported that 69·5 % of the women in the supplemented group gained $>$7 kg at the end of pregnancy while 49·0 % of the non-supplemented group gained $>$7 kg, and was more likely to be observed in primigravids. The present study, in keeping with the Monthly Monitoring Report[14], observed much lower percentages: only 45·0 % of the women in the supplemented group gained $>$7 kg at the end of pregnancy while in the non-supplemented only 34·7 % gained $>$7 kg at the end of pregnancy in the present study.

The effect of supplementation on pregnancy weight gain using BMI as an indicator for undernutrition needs to be interpreted with caution, keeping in mind that pre-pregnancy BMI or even early-pregnancy BMI is often inversely associated with gestational weight gain[18], presumably as a physiological compensatory mechanism for pre-pregnancy undernutrition. In the present study weight gain was inversely correlated with BMI and initial weight. Lighter women gained relatively more weight during their pregnancy than heavier women, a result in keeping with other studies in East Java, Indonesia[19], Pakistan[20] and Taipei, Republic of China[21].

The present study showed that supplementation had an insignificant effect on birth weight and LBW, in keeping with some studies[22–27], while other studies have reported a significant impact of supplementation on birth weight[12,28–32]. The most recent food supplementation trial on undernourished women from the Gambia[12] reported considerably larger effects on birth weight. The present study, however, was unable to show significant improvement in birth weight and reduction in LBW prevalence. The difference may be explained by the much higher energy (4258 kJ (1017 kcal)) and protein content (22 g) of the Gambian supplement compared with that used in Bangladesh (2512 kJ (600 kcal) and 8·0–9·4 g, respectively). The second explanation may be that the food supplementation in the BINP may be a replacement not a supplement, which is supported by the findings of BINP operational research[33] that 30 % of the women substituted at least part of their domestic food intake by BINP food supplements. A WHO collaborative study[34] showed that weight gain of 1·5 kg/month during the last two trimesters is consistent with good pregnancy outcomes. However, the average monthly weight gain in the present study was considerably lower, averaging only 0·92 kg/month in the second and third trimesters.

In his meta-analysis Kramer[35] showed no evidence that supplementation had a larger effect in undernourished women and concluded that the increment in birth weight due to supplementation was no larger in those women who were undernourished prior to or during pregnancy. Several researchers have argued that the degree of maternal undernutrition may affect the response to supplementation[20,36,37]. They suggest that supplementation of moderately malnourished women produces an increase in birth weight but has little impact on maternal weight gain. However, when seriously malnourished women are supplemented they cannot 'afford' to direct the energy to the fetus and therefore such supplementation improves maternal weight gain more than birth weight. The results of the present study also show that although malnourished women gained significantly more weight in pregnancy, they had a higher proportion of LBW babies compared with non-malnourished women.

In conclusion, the present study found that the food supplementation programme in Bangladesh is inefficient in targeting eligible women, failed to start on time and did not achieve full compliance. Regular monitoring and supervision of field staff is essential, as is motivating the community to participate. There was a small but positive impact of food supplementation on maternal weight gain, but supplementation did not lead to improvement in birth weight and there was no indication of a reduction in prevalence of LBW babies. Further research is needed to determine the appropriate quality and quantity of food and micronutrient supplementation needed to reduce LBW prevalence.

Acknowledgements

Financial support for the study was provided by the Department for International Development administered by The British Council and University of Cambridge. We are very grateful to PROSHIKA (national non-governmental organization in Bangladesh) who gave us permission to work in their field centres, the officers who worked in Bhaluka for the Bangladesh Integrated Nutrition Programme and the field workers involved in the study. We also thank the women who participated in the study. There are no conflicts of interest. All three authors designed the study. The fieldwork was carried out by S.N. and H.A.B. The analyses were carried out primarily by S.N. and C.G.N.M.-T. and the writing up of the results was a joint effort by all three authors.

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